Environmentally-Friendly Park Management

Case Studies and Best Practices for Sustainable Public Space Operations

NRPA

NATIONAL
RECREATION AND PARK
ASSOCIATION

October 9, 2025

Authors: Chris Hardy, Landscape Architect, Sasaki Associates

Alison Nash, Architect, Sasaki Associates

Reviewers:

Michele White, NRPA
Ayanna Williams, NRPA
Stephanie Whyte, NRPA
Samantha Serrano, NRPA
Dianne Palladino, NRPA
Melissa May, NRPA
Todd Burley, Sustainability Advisor Seattle Parks & Recreation
Clement Lau, Senior Analyst, Los Angeles County Chief Sustainability Office.
Paul Gilbert, Executive Director, Northern Virginia Regional Park Authority
Subhajeet Seve Ghose, Cpre/Mo, Executive Director, Yerba Buena Gardens Conservancy
Victoria Hardy, RCFM, ASHRAE Associate
Andrew Sell, Ecologist & Landscape Architect, Sasaki Associates

Sponsor: National Recreation and Parks Association (NRPA)

Table of Contents

Foreword

Park staff are dedicated to the care, curation, and stewardship of public landscapes for the benefit of our communities' mental and physical health and safety. They work cleaning up the messes of storms, family barbecues, and festivals. They work to control invasive species, protect critical habitats, and maintain beautiful green spaces. They work to provide moments of joy and connection through providing places to play, opportunities for cultural expression, and supporting the exploration of nature. This guide is for these workers and administrators, bringing together survey feedback, contemporary research, and lessons learned from interviews to provide a state-of-the-industry set of recommendations for maintaining and operating environmentally friendly parks. This guide adopts the concept of a ‘land ethic,’ as articulated by Aldo Leopold (https://www.aldoleopold.org/about/the-land-ethic), and examines the various ways park operations can be managed to maximize ecological health and resilience, minimize waste and emissions, reduce chemical usage, and optimize energy efficiency.

The purpose of this guide is to provide a central location for operators to review and gain background on key sustainability themes, find recommendations on tips and tricks, and understand the trade-offs or feasibility of new systems or management practices at a conceptual level. This guide is not a park operations manual or the basis for a certification program; it is a review across park systems of the state of the industry in terms of environmentally friendly practices.

This guide is structured by subject, with each subject including a short narrative explanation, strategies, and references, and occasional case studies from example projects and departments. The references include key public sector, academic, and industry links to help interested parties further explore the subjects discussed.

Several key universal themes have emerged from research that informed the preparation of this guide. One is the concept of **sufficiency** - what does the park need? Simply doing less:, less mowing, less fertilizing, and being efficient with investments in new facilities. This concept directly connects to another - **maximize passive design**. This concept encompasses passive buildings that don’t require HVAC, as well as passive natural areas that may only require quarterly or annual maintenance. Investing in smart systems gives operators the tools to understand the performance of the systems they are responsible for and deploy labor more efficiently where it is needed. Consider concentrating on areas that require high-touch maintenance investment and seek ways to create truly low-maintenance natural areas. Ultimately, many of these recommendations emphasize the restoration of nature, encompassing initiatives such as supporting healthy, living soils, planting trees, and restoring entire ecosystems.

Care of our public spaces is a service of stewardship for our communities and the environment. Adequate funding and investing in systems to make operations more informed, efficient, and environmentally responsible have immediate, tangible benefits for communities. Once departments establish best practices, train staff, deploy thoughtful management systems, and deliver public education campaigns, well-maintained, high-performance park facilities can find returns on investment. This can be achieved by avoiding high capital costs to replace degraded facilities, utilizing staff hours and energy more efficiently, or reducing expensive supply purchases. Maintaining places people love takes time and money, and environmentally friendly practices can help funding-strapped parks departments achieve their missions to support the community and protect the essential landscapes in their care.

For park operators who have additional statistics, lessons learned, or stories they would like to contribute, please don't hesitate to contact Resilience@nrpa.org so we can continue to update and refine this document periodically to stay relevant in our evolving world.

Thank you for the work you do to protect our parks, steward our natural places, and enrich our communities.

This work would not be possible without lead authors Chris Hardy and Allison Nash, including support from key NRPA staff.

A note on references

This document is a compilation of best practices and recommendations derived from a literature review, surveys, interviews, and case studies. This is not an academic publication. As a living resource, we welcome feedback. Regarding references and citations, during the writing of this document, some references were removed from federal websites, and additional references may be removed in the future. If you find missing links, we recommend using the links and titles to search Internet Archive resources, such as https://web.archive.org/, or Data Rescue Projects.

Banner images acknowledgement

The banner images in this document were created using a combination of OpenAI ChatGPT-generated graphics, Adobe Generative Content & Stock images, and subsequently modified, montaged, and added to with Adobe Photoshop and Adobe Illustrator programs.

Chapter 1: Horticulture & Ecology

Organic Land Management

Background

How park operators maintain lawns and horticultural landscapes can be the difference between a landscape that has net greenhouse gas emissions year after year or one that net-sequesters greenhouse gas emissions in soils and plants (‘Carbon Positive’ Landscapes). Organic land management is a holistic approach to maintaining landscapes without the use of synthetic chemicals. This method emphasizes the health of soil, plants, and surrounding ecosystems by relying on natural processes and materials. In agricultural land uses, seemingly low price points and high yield requirements create economic pressure to adopt synthetic chemicals. Organic agricultural products can require higher production costs, thus requiring certification programs. For parks, this can be very different, as net primary productivity isn't generally the bottom-line metric for success; instead, it's the net health and functionality of the system. Many parks may already have organic land management simply by avoiding costs associated with chemicals all together. Over-reliance on fertilizers can result in 'dead soils', leading to lower micronutrient availability and reduced water-holding capacity, which necessitates the use of more fertilizers and irrigation. Over-fertilized gardens and lawns are more susceptible to pests, characterized by rapid and weak growth, and encourage the development of more weeds, necessitating the use of additional insecticides, fungicides, and herbicides, thereby creating a vicious and expensive cycle of chemical treatments. Opting out of this cycle can have numerous co-benefits for park operators, including avoiding the fossil fuel emissions and embodied carbon associated with chemical inputs and downstream consequences—particularly nitrogen and phosphorus—into surrounding watersheds.

These excess nutrients often come from the overapplication of synthetic fertilizers. When they enter rivers, lakes, and coastal zones, they contribute to eutrophication, which causes harmful algal blooms, oxygen depletion, and massive fish kills. This degrades water quality, harms aquatic ecosystems, and can even increase treatment costs for drinking water systems. Maintaining land organically often requires more labor-intensive work and a staff trained in ecological principles. Instead of applying broad-spectrum herbicides or pesticides, organic teams manually weed, prune, and use targeted biological or cultural interventions. This means larger or more skilled crews may be necessary, especially during transition periods. In contrast, chemically managed landscapes often rely on fewer workers and more machinery or spray regimens. However, long-term organic management can reduce labor intensity once soil health and plant resilience are established, offsetting initial staffing demands. As a result, many communities across the country, from South Portland, Maine, to Durango, Colorado, have adopted Organic Land Management practices within their parks departments.

That said, even within departments with organic land management standards and integrated pest management certifications, challenges often arise that necessitate chemical application. These challenges can include the management of noxious weeds, highly resilient and aggressive invasive species, or extremely eutrophic systems where other practices are insufficient or infeasible. Clearly defining department policies for the right time and reasons for chemical application can provide clarity to the maintenance workforce and consistent messaging to the public.

Invest in human resources

A successful organic land management program depends on continuous education for maintenance teams. Workers must understand soil biology, plant health indicators, and pest life cycles to make informed decisions. This contrasts with the rote application of chemical treatments that follow set schedules regardless of actual site needs. Training in composting, aeration, and natural pest deterrents fosters a more adaptive and environmentally responsive workforce. Many local community colleges and extension services have added horticultural programs and IPM certification programs. In turn, this investment can lead to a more engaged and knowledgeable maintenance team with a deeper understanding of ecosystem services. For municipalities that directly maintain their parks, this means that many of the landscape maintenance positions shift from 'low-skilled labor' to skilled workers, providing more complex and higher-value career opportunities for staff.

Reduce dependency on chemicals

One of the key strategies behind organic land management is replacing synthetic fertilizers with those derived from natural sources such as compost, manure, bone meal, seaweed extracts, fish emulsion, or even cover crops or mixed planting, like overseeding lawns with clover. These materials add nutrition to the soil, as well as soil organic carbon, and feed soil microbes, which in turn release nutrients slowly, minimizing the risk of runoff if applied appropriately. There are numerous approaches to organic soil enrichment, ranging from low-tech mixes of compost and mulch as soil top dressing to the sophisticated production and distribution of compost teas. See the section on soil management for recommendations on soil amendments.

Partnered with nutrition, organic land management replaces the use of fungicides, insecticides, and herbicides with a combination of practices under the definition of Integrated Pest Management (IPM). IPM combines biological, cultural, mechanical, and chemical practices to control pests with minimal environmental impact. Under IPM, chemical pesticides are used only as a last resort and in the most targeted manner possible. Instead, strategies like crop rotation, beneficial insect release, habitat manipulation, and plant selection are prioritized. IPM aligns closely with organic principles, offering a balanced method for pest control that minimizes risks to people, pollinators, and ecosystems. There are various IPM training programs, including EcoWise, Green Shield, and GreenPro, as well as robust credentialing programs, such as the Certified Integrated Pest Management Technician (CIT), offered by the Entomological Society of America.

Biological controls

Organic land management can also include biological controls for pest and weed management, as well as programs that encourage community and family participation, such as ladybug releases or using goats to clear invasive plants. The thoughtful use of living systems to achieve maintenance goals can, over the long term, reduce the material and labor inputs into a system, thereby mimicking the stability and resilience of natural ecosystems.

There are numerous potential benefits to adopting organic land management standards and eliminating the routine use of synthetic chemicals in parks results in cleaner air and water, safer soils, and healthier spaces for community use. Children and pets are especially vulnerable to pesticide exposure, and chemical runoff can impact surrounding habitats and waterways. Organic methods, by contrast, reduce these risks while enhancing biodiversity, particularly improving pollinator populations. Organic land management requires investments in training, but the result can be an enhancement of the park's contributions to broader environmental and ecological goals. These goals need not be ideological or political in nature. Creating places for human recreation and environmental resilience involves creating self-sustaining landscapes that require fewer inputs over time, providing healthier environments for both people and wildlife, all of which are goals inherent to the fundamental idea of parks.

Case Study: Organic Land Management, City of Boulder, CO

By Denise Dawson

Park East Park turf, Boulder, CO. Image attribution: City of Boulder. Contact:dawsond@bouldercolorado.gov

Rather than relying on herbicides to control weeds, the City of Boulder Parks and Recreation Department embraces natural turf care practices that prioritize soil health, community safety, and long-term resilience. Grass in city parks is kept at a height of three inches, a strategic level that strengthens root systems and helps the turf access deep water reserves. This taller grass also shades out weed seeds, reducing their ability to germinate. While dandelions may persist, their presence signals a thriving lawn, one that's maintained without compromising environmental integrity. Central to Boulder's approach is its commitment to Ecological Integrated Pest Management (EIPM). This ecosystem-based strategy minimizes chemical exposure by emphasizing non-chemical land management tools such as mowing, aeration, and soil restoration. When pesticides are deemed necessary, they undergo a rigorous screening process and are applied using targeted methods to reduce risk to people, pets, and pollinators. This approach reflects a long-term investment in soil health and turf resilience. Instead of relying on chemicals to mask underlying issues, Boulder is restoring the natural processes that make grass strong and self-sustaining. It's a transition that takes time and patience, but the payoff is profound: safer parks, cleaner air and water, and a landscape that supports biodiversity. This natural turf care philosophy reflects Boulder's broader values: protecting public health, supporting biodiversity, and fostering a deeper connection between people and the land. Restoring soil and turf processes takes time, but the benefits, cleaner air and water, safer play spaces, and a more resilient urban ecosystem, are well worth the effort.

Case Study: Community Education and Integrated Pest Management, Cleveland, OH

By Constance E. Hausman, Ph.D.

Cleveland Metroparks staff scrape egg masses from a tree while the Spotted Lanternfly dog hunter Bronco and his handler Paige look on.
Website:https://www.clevelandmetroparks.com/about/conservation/current-issues/spotted-lanternfly
Contact: ceh@clevelandmetroparks.com

Cleveland Metroparks has adopted a unique, community-engaging and service-focused approach to combating the spread of Spotted Lanternfly into our region. Staff and volunteers began conducting early detection surveys in 2020. When SLF was discovered in our area in 2022, that effort shifted to rapid response, involving catching or squashing the insect whenever it was found. With ever-growing population numbers, a new team of volunteers was recruited to help combat this invasive pest. SLF egg mass sniffing dog hunters were deployed to hunt and locate egg masses across the park district. These dog teams were part of an SLF research and training program developed by Virginia Tech. Once located, their human handlers would use scrapers to destroy the eggs. Over the course of the 2024 winter season, the four dog teams found and destroyed ~ 3,500 egg masses. Plans are underway to continue utilizing these dog teams to help reduce the impact and spread of SLF within our park system.

Additionally, Cleveland Metroparks hosted 'The Big Squish' event to educate the public about SLF and provide recommendations and resources for people to implement in their own backyards and communities. In 2025, the inaugural event was held at three parks in our urban areas where SLF populations are the largest. About 120 people attended The Big Squish, where they met our SLF dog hunters, learned about control options, picked up fly swatters and egg mass scrapers, and took an active part in finding and squishing SLF. This invasive pest can thrive in urban environments, and it is up to an engaged and active community to pitch in and help reduce the population. While our goal is not full eradication, our goal targets a reduced SLF population in key public spaces to maintain access and enjoyment across our parks.

Key Strategies & Considerations

- Develop a training policy to start building the knowledge resources to implement IPM and organic land management approaches
- Conduct a chemical input audit for landscape maintenance teams and develop a substitution transition plan. Gradually eliminate synthetic chemical inputs by phasing in natural alternatives, including compost, mulch, and biological controls.
- Support staff in pursuing IPM certification and then centralize pesticide, fungicide, and herbicide decision-making with an IPM lead manager.
- Develop a park system-specific composting plan and park system-wide soil amendment and management standards. Conduct a comprehensive soil health assessment to establish baseline conditions and tailor organic practices to park-specific needs.
- Monitor and adjust practices over time using data-driven evaluation criteria to ensure ongoing improvement. Living systems are not static, and with climate change and invasive species pressure, managers must constantly adapt to new conditions, diseases, and risks for their park systems.

Helpful Resources and References

Bengtsson, J., Ahnström, J., & Weibull, A.-C. (2005). “The Effects of Organic Farming on Biodiversity: A Meta-Analysis.” Journal of Applied Ecology, vol. 42, no. 2, pp. 261–269. https://besjournals.onlinelibrary.wiley.com/doi/10.1111/1365-2664.12219

Birkhofer, K. et al. (2008). “Long-Term Organic Farming Fosters Below- and Aboveground Biota: Implications for Soil Quality, Biological Control and Productivity.” Soil Biology & Biochemistry, vol. 40, no. 10. pp. 2297–2308. https://www.mdpi.com/2077-0472/3/3/464

Brede, D. (2000). Turfgrass Maintenance Reduction Handbook: Sports, Lawns, and Golf. Wiley.

Institute for Local Self-Reliance. (2022). Community Composting Best Management Practices: A Guide for Cities and Counties. Institute for Local Self-Reliance. https://ilsr.org/articles/govt-support-for-community-composting-jurisdictions/

National Recreation and Park Association (NRPA). (2019). “Managing City Parks Without Synthetic Pesticides or Fertilizers.” Parks & Recreation Magazine. https://www.nrpa.org/parks-recreation-magazine/2019/march/managing-city-parks-without-synthetic-pesticides-or-fertilizers/

National Recreation and Park Association (NRPA). (2022). Parks and Pollinators: Taking Action and Advancing Sustainability, https://www.nrpa.org/globalassets/research/parks-and-pollinators-resource.pdf

Blockinger, B., Hendon, R. (2020). *Restoring an Urban Prairie.* National Recreation and Park Association (NRPA). https://www.nrpa.org/blog/restoring-an-urban-prairie/

National Recreation and Park Association (NRPA). (n.d.). *Integrated Pest Management.* https://connect.nrpa.org/viewdocument/integrated-pest-management-nrpa?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

National Recreation and Park Association (NRPA). (n.d.). *Climate Change Mitigation and Adaptation in Urban Park Landscapes,* webinar. https://connect.nrpa.org/viewdocument/climate-change-mitigation-and-adapt?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

National Recreation and Park Association (NRPA). (n.d.). *Identifying Easy Conservation Strategies to Strengthen Environmental Resilience in Urban Greenspaces,* webinar. https://learning.nrpa.org/products/identifying-easy-conservation-strategies-to-strengthen-environmental-resilience-in-urban-greenspaces

Costelle, A. (2023). *Thriving Parks: More Habitat, Less Lawn.* National Recreation and Park Association (NRPA). https://ezine.nrpa.org/nrpa/ParksRecreationMagazine/june-2023/index.php#/p/24

Pedigo, L., et.al. (2021). Entomology and Pest Management. 7th ed., Waveland Press. https://a.co/d/8yBYA1V

Radcliffe, E., Hutchison, W., and Cancelado, R., eds. (2009). Integrated Pest Management: Concepts, Tactics, Strategies and Case Studies. Cambridge University Press.

Rathfon, R., Skye, M. and Jenkins, M. (2021). “Effects of Prescribed Grazing by Goats on Non-Native Invasive Shrubs and Native Plant Species in a Mixed-Hardwood Forest.” Restoration Ecology, vol. 29, no. 4, Wiley. https://onlinelibrary.wiley.com/doi/10.1111/rec.13361

Talal, T., & Santelmann, M. (2020). “Vegetation Management for Urban Park Visitors: A Mixed Methods Approach in Portland, Oregon.” Ecological Applications, vol. 30, no. 2. https://esajournals.onlinelibrary.wiley.com/doi/10.1002/eap.2079

Turgeon, A. (2012). Turfgrass Management. 9th ed., Pearson Prentice Hall.

U.S. Environmental Protection Agency. (2024). “Compost Made From Recovered Organic Materials.” Comprehensive Procurement Guidelines for Landscaping Products. https://www.epa.gov/smm/comprehensive-procurement-guidelines-landscaping-products

Van Emden, H. F., and D. B. Peakall, eds. (1996). Beyond Silent Spring: Integrated Pest Management and Chemical Safety. Chapman & Hall.

Soil Management

Background

Terrestrial soils are estimated to hold approximately 80% of the world's global organic carbon stocks, with vegetation and animal biomass accounting for the remaining 20%. In many ecosystems, such as tallgrass prairies, red maple swamps, or oceanic temperate rainforests, the amount of carbon stored in the soil (soil organic carbon, or SOC) can be an order of magnitude greater than the carbon stored in the biomass above the soil. Soil is fragile and susceptible to erosion and compaction in the presence of construction activities, overuse, traffic, or mechanical disturbance. Damaged soils, such as tilled fields or drained wetlands, can release large amounts of emissions through accelerated decomposition of SOC. If we ignore the soils of our parks, we overlook both the potential for emissions drawdown and the risks associated with emissions. These same risks also threaten plant health; low SOC results in less nutritious soils that generally have lower available water-holding capacity. Highly compacted soils can be impenetrable to tree roots. Eroded soils can reduce potential rooting volume in areas of scour or smother tree crowns in areas of sedimentation. To paraphrase Franklin D. Roosevelt - a nation (or parks department) that destroys its soils destroys itself.

The recommendations abbreviated in this guide are derived from a concurrent research effort conducted by Regenerative Design Group, Sasaki, AD MakePeace, and others, funded by the Massachusetts Executive Office of Energy and Environmental Affairs, as well as the Massachusetts Healthy Soils Action Plan and Healthy Soils Guide. For more details than is summarized below, please review the guide here: https://masshealthysoils.org/guide/. Please note the guide is focused on the state of Massachusetts, while some of the recommendations are universal, some are state policy focused, or northern temperate ecosystem relevant.

Protect What's There

Protecting and nurturing park soils starts with understanding what the parks have. While soil mapping is available through the Soil Survey Geographic Database (SSURGO) managed by the USDA's Natural Resources Conservation Service (NRCS), in urban and peri-urban areas, this data can be very inaccurate, primarily because the soils mapping is extrapolations based on soil parent material (bedrock), and has been field verified more rigorously in agricultural regions. Custom site inspections will be much more accurate. These can include simply walking the sites and observing where there are likely soils that haven't been disturbed for a long time and supplementing with a few soil tests in key areas. This can provide a more robust basis for developing a soil management plan, with a site survey and gridded soil testing plots to build park-specific soil maps serving as a Comprehensive Soil Assessment (CSA). A CSA goes beyond a soil test to evaluate the physical, chemical, and biological properties of the soil and how it varies across the site. This work can help departments establish a baseline understanding of the typical condition, identify priority areas for protection and conservation, and pinpoint areas of particular disturbance or contamination.

Park managers should take care to evaluate the soil test results and recommendations in light of the fact that the test lab's recommendations are usually focused on optimizing plant health and productivity for either agricultural land uses, lawns, or ornamental landscaping. If the landscape is managed for native plant communities, these recommendations may provide overly nutritious soil, which can create optimal conditions for weeds and invasive plants. In addition, if certain characteristics require significant or ongoing amendment to change, it may be easier and more cost-effective to re-evaluate the proposed planting plan to accommodate existing soil conditions. One common example of this is the soil pH. It is extremely difficult to change and maintain the change of soil pH without large and consistent amendments or wholesale replacement. Instead, selecting plants and plant communities that are adapted to the pH can be simpler and have a higher reliability of long-term success.

Long-term management strategies that reduce compaction and prioritize a healthy soil microbiome are among the most effective ways to ensure optimally functioning soils for carbon sequestration, productivity, ecosystem services, and long-term sustainability. Many chemical amendments and treatments have a short duration in soils and require consistent inputs to manage the targeted optimal state.

Significantly disturbed soils, such as those with very high salt content, very high pH, or irredeemably compacted (usually with bulk densities above 1.7 g/cm^3) can require excessive mechanical and amendment processes to restore. These soils should be evaluated for health and human safety for use as clean fill and be replaced within the rooting profile with healthy imported soils.

Soil Management Plan

Given the importance of soils for parks, developing a soil management plan can be a valuable exercise for both newly constructed projects and general operations. Each of these uses has a slightly different context/definition. For new works, a soil management plan will incorporate soil studies, planting plans, hydrological design, and vegetation protection plans, providing detailed drawings and specifications that include site management requirements as part of the project contract drawings. This creates a legally binding contract that clearly communicates the goal of maximizing soil health to the contractor, and can include incentives and penalties. The Sustainable Sites Initiative (SITES) rating system requires soil management plans and includes excellent guidance on soil protection and management considerations. For park operators, a soil management plan can include mapping, soil protection specialty areas, amendment routines, erosion control standards, and risk areas, salting limitation plans, and plant nutrition management schedules.

For many parks, the focus on soil management will be on protecting existing healthy soils or rehabilitating impacted soils. Soil protection in natural areas typically involves restrictions on access and use, which can include signage campaigns, no-drive areas, trail-bound access, or even boardwalks. These considerations are of critical importance in sensitive habitat areas, such as wetlands. The importance of protecting healthy natural areas soils isn't limited to landscapes that appear lush or even soils with high SOC - there are living soils all across the United States. Desert landscapes can have cryptobiotic soils, where a cyanobacteria, lichens, and fungi create a living crust that stabilizes the soil - which can be destroyed with a single step. Thin alpine soils are incredibly fragile and can pose a high erosion risk if vegetation cover is damaged. For many park systems, these may sound like exotic outliers, but the same principles apply to natural areas. For recreational spaces, such as sports fields or picnic areas, the soil protection policies focus on optimizing plant health in the context of the anticipated use. In these cases, soil protection may include using wide tires with low pressure (10-15 PSI) for maintenance vehicles that drive on the soil and limiting heavy-impact events, such as concerts.

Reducing or Repairing Compaction

Many park operators are already familiar with 'rest periods,' the ideal timing between different activities for maintaining turf health. These rest periods are also important for allowing some recovery of soil structure. Unfortunately, for many soil types and climates, even conservative rest periods can be insufficient to protect soil and turf - such as clayey soils in climates without extensive freeze-thaw. In cases where parks have consistent soil-degrading impacts, soil management plans should include soil recovery processes as part of standard operations, such as aeration, introducing organic amendments (e.g., compost and biochar), and mulching. In extreme cases, such as sports fields, wholesale tilling with sand and compost amendment, fine grading, and reseeding or sodding can become expensive periodic maintenance exercises. In these cases, especially for living turf sports fields, more sustainable options include building the field from the beginning to support the anticipated use intensity, providing sufficient underdrainage, high perc, compaction-resistant sandy loam, and irrigation. For more on turf alternatives, please see the section on Smart Turf.

As in all things, moderation is important in soil management. It is essential for park operators responsible for managing natural areas to understand their soil in the context of healthy reference ecosystems with similar soils in their region. Some healthy soils may have very high SOC; others may not. These guidelines recommend optimizing SOC as is relevant for a given soil. Excess organic amendments can have unintended consequences, such as excessive nutrients or potentially toxic levels of nutrients in extreme cases, or create anaerobic conditions that can lead to root rot. The best soil amendments will serve the site's functional needs while simultaneously optimizing soil health. Managing parks for healthy soils is the foundation for healthy plants. Healthy plants are more resilient to disease and drought. Investing in soil health can ultimately reduce maintenance costs by preventing costly remedial actions in the future.

Case Study: A Teaching Opportunity Along Euclid Creek, Cleveland, OH

By Josh Philipps

Cleveland Metroparks staff & volunteers after planting Euclid Beach bioretention cell. Image attribution: Cleveland Metroparks.
Website:www.clevelandmetroparks.com
Contact: jjp@clevelandmetroparks.com

In 2022, Cleveland Metroparks received a property previously occupied by the former Euclid Central Middle School. Through a master planning process, the Park District identified this property as a conservation priority, taking into account the riparian habitat along Euclid Creek and the parcel's connectivity to existing parkland. The property also advanced plans for a future trail that would connect the cities of Cleveland and Euclid, including the more than 36,000 nearby residents to parks, jobs, schools, businesses, and Lake Erie. With the legacy of school demolition and the classification of soils as "Urban land", it was evident that significant disturbance and mass grading had created soil conditions unconducive to reforestation success. To achieve the land management goal of returning the floodplain area to a forested state, Cleveland Metroparks applied for and was awarded a Great Lakes Restoration Initiative grant to improve the site by: Decompacting and amending 5.5 acres of the former athletic fields; Planting 1,150+ native trees and shrubs; Engaging volunteers in 500+ hours of service; Intercepting 122,314 gallons of rainfall/year. The Park District accomplished the above targets and partnered with Dr. Stu Schwartz, soil scientist at the University of Maryland, Baltimore County, to monitor soil conditions in the treated and untreated areas, to advise on proper soil amendment and decompaction processes, and to collaborate on technical presentations and workshops for contractors, stormwater engineers, consultants, and land managers. A total of 114 professionals were trained on soil decompaction through this project. Ultimately, the soil decompaction and reforestation project has resulted in improved stormwater management and enhanced long-term survival of trees and shrubs on the banks of Euclid Creek, a tributary to Lake Erie.

Key Strategies & Considerations

- Investigate the existing park soils to understand the distribution, physical, chemical, and biological properties of the soils in the park or park system.
- Develop a soil management plan for park operations that focuses on maintaining plant health, supporting recreational activities, protecting soil organic carbon, and minimizing routine remedial or rehabilitation requirements.
- Develop activity schedules with adequate 'rest periods' for soils to recover
- Include soil protection requirements for natural areas, and consider low-pressure spray maintenance vehicles for those that drive on natural soils.
- For new projects, require designers to submit soil protection plans and include soil management plans, erosion control plans, specifications, and details as part of any proposed works.

Helpful Resources and References

Adamu, H., Umar, Y. A., Akanang, H., & Sabo, A. (2021). Evaluation of Carbon Sequestration Potential of Soils—What Is Missing? *Journal of Geoscience and Environment Protection*, *09*(08), 39–47. https://doi.org/10.4236/gep.2021.98003

Brevik, E., Fenton, T., & Moran, L. (2002). Effect of soil compaction on organic carbon amounts and distribution, South-Central Iowa. *Environmental Pollution*, *116*, S137–S141. https://doi.org/10.1016/S0269-7491(01)00266-4

Burgos Hernández, T. D., Slater, B. K., & Shaffer, J. M. (2019). Characterizing Minimally Disturbed Soils in a Highly Disturbed Urban Environment. *Agrosystems, Geosciences & Environment*, *2*(1), 190053. https://doi.org/10.2134/age2019.07.0053

Charlop-Powers, Z., et al. (2016). "Urban Park Soil Microbiomes Are a Rich Reservoir of Natural Product Biosynthetic Diversity." Proceedings of the National Academy of Sciences, vol. 113, no. 51, pp. 14811–14816. https://www.pnas.org/doi/full/10.1073/pnas.1615581113

Hu, T., Malone, S. L., Rumpel, C., & Chabbi, A. (2024). Maximizing soil organic carbon stocks through optimal ploughing and renewal strategies in (Ley) grassland. *Communications Earth & Environment*, *5*(1), 1–10. https://doi.org/10.1038/s43247-024-01202-3

Kuittinen, M., Hautamäki, R., Tuhkanen, E.-M., Riikonen, A., & Ariluoma, M. (2021). Environmental Product Declarations for plants and soils: How to quantify carbon uptake in landscape design and construction? *The International Journal of Life Cycle Assessment*, *26*(6), 1100–1116. https://doi.org/10.1007/s11367-021-01926-w

Kumar, P., et al. (2016). "Soil in the City: Sustainably Improving Urban Soils." Journal of Environmental Quality, vol. 45, no. 3. https://doi.org/10.2134/jeq2015.11.0589

Malone, Z., Berhe, A. A., & Ryals, R. (2023). Impacts of organic matter amendments on urban soil carbon and soil quality: A meta-analysis. *Journal of Cleaner Production*, *419*, 138148. https://doi.org/10.1016/j.jclepro.2023.138148

Millward, A., Paudel, K., and Briggs, S.. (2011). "Naturalization as a Strategy for Improving Soil Physical Characteristics in a Forested Urban Park." Urban Ecosystems, vol. 14, pp. 261–278. https://doi.org/10.1007/s11252-010-0153-4

NRCS. (n.d.). *National Soil Survey Center | Natural Resources Conservation Service*. https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soil/national-soil-survey-center

NRCS. (n.d.). *SSURGO Portal | Natural Resources Conservation Service*. https://www.nrcs.usda.gov/resources/data-and-reports/ssurgo-portal

O'Riordan, R., Davies, J., Stevens, C., Quinton, J. N., and Boyko, C. (2021). The ecosystem services of urban soils: A review. *Geoderma*, *395*, 115076. https://doi.org/10.1016/j.geoderma.2021.115076

Pataki, D. E., Alig, R. J., Fung, A. S., Golubiewski, N. E., Kennedy, C. A., Mcpherson, E. G., Nowak, D. J., Pouyat, R. V., & Romero Lankao, P. (2006). Urban ecosystems and the North American carbon cycle. *Global Change Biology*, *12*(11), 2092–2102. https://doi.org/10.1111/j.1365-2486.2006.01242.x

Pouyat, R., Yesilonis, I., & Golubiewski, N. (2009). A comparison of soil organic carbon stocks between residential turf grass and native soil. *Urban Ecosystems*, *12*, 45–62. https://doi.org/10.1007/s11252-008-0059-6

Schlesinger, W. (1999). Carbon Sequestration in Soils. *Science*, *284*, 2095–2095. https://doi.org/10.1126/science.284.5423.2095

Shaw, R., et al. (2018). "Promoting Soil Science in the Urban Environment—Partnerships in New York City, NY, USA." Journal of Soils and Sediments, vol. 18, pp. 352–357. https://doi.org/10.1007/s11368-016-1456-8

The Resilient Lands Initiative. (2022). *Healthy Soils Action Plan*. https://www.mass.gov/info-details/resilient-lands

The Sustainable Sites Initiative. (n.d.). *From the ground up: Sustainable sites start with healthy soils*. https://www.sustainablesites.org/ground-sustainable-sites-start-healthy-soils

Wohldmann, E., et al. (2022). "Building Soil by Building Community: How Can an Interdisciplinary Approach Better Support Community Needs and Urban Resilience?" Frontiers in Sustainable Cities, vol. 4. https://doi.org/10.3389/frsc.2022.941635

Tree and Vegetation Protection

Background

The trees, shrubs, and herbaceous plants in parks face numerous challenges. Developing tree and vegetation protection standards and requirements is crucial for both major disturbances, such as new construction, and routine operations. Some activities (such as dumping chemicals or fill, or cutting or carving into trees) are obviously detrimental to plant health, and should (in theory) be easy to avoid with reasonable park use and operations standards and signage. Other activities, such as informal trails cut through sensitive habitats, can be harder to anticipate and lead to less obvious plant degradation through soil compaction and species competition with introduced weeds.

Critical Root Zones

Tree and vegetation protection standards aim to prevent harm to plants from all these potential impacts. Parks operators can require designers and contractors to specify and implement tree and vegetation plans and specifications. These typically involve defining the critical root zone (CRZ) of trees and identifying healthy plants to be protected during construction. Critical root zones (CRZ) are the areas where roots have the highest density and where soil disturbance should be minimized to protect plant health. Operators can protect trees from high-impact disturbance through a combination of fencing, trunk armoring, mulching, supplemental irrigation, and controlled site access. Tree protection can even include more complex arborist operations, such as using air spades to expose roots to allow new utility pipes to thread through the roots without having to cut them. For day-to-day operations, understanding the CRZ and sensitivity of various plants can help operators shift high-impact programs away from these areas.

Protecting CRZs is crucial for preserving plant health, enhancing carbon sequestration, and maintaining the overall ecosystem functions on the site. CRZs around naturalized areas can have the added benefit of protecting native plant seed banks within their limits. The International Society for Arboriculture (ISA) defines CRZs in a few ways; the most common is a circle with a radius of no less than 1 foot for every inch of tree diameter, with a radius of no less than 5 feet. Another method uses just the tree dripline as a minimum CRZ, but in reality, an additional 3 feet beyond the dripline is significantly better. It is not uncommon for tree roots in an unbound condition, like a forest or open field, to extend roots three times the distance from the trunk to the drip line. For shrubs, a reasonable protection zone is twice the radius of the shrub. For non-threatened herbaceous materials, the dripline/plant diameter + 1' is often sufficient. Wetland vegetation protection areas often need custom designation based on site drainage patterns- with best practices starting with 10 to 50', or even 100' in particularly sensitive areas. Plant protection areas should be evaluated and adjusted based on probable root barrier zones as well. For instance, if a building's basement wall blocks part of what would be a CRZ, preventing roots from growing in that area, adding additional space to viable rooting areas is a good best practice. As a general arborist rule of thumb, if you can sufficiently protect in place at least 70% of the CRZ, and 100% of the area within 5' of the tree trunk, then you have a high chance of tree survival.

Avoiding Compaction

Protecting trees and sensitive vegetation from soil compaction is essential for maintaining healthy park landscapes. Soil compaction occurs when pressure from equipment, vehicles, or foot traffic compresses the soil, reducing pore space and making it more difficult for roots to access air and water. This can lead to stunted growth, increased susceptibility to disease and pests, and, in severe cases, the death of trees and plants. Trees, especially mature ones, rely on uncompacted soil to maintain a robust and expansive root system capable of supporting their large canopies and physiological functions.

For normal operations, the trunk armoring, fencing, and other temporary measures to limit access to vegetation protection areas during construction are not relevant and may be harmful. Even tree grates, if not cut back as the tree grows, can ultimately kill street trees by girdling the tree. That said, even a single instance of compaction around the root zone can significantly alter the soil structure, inhibiting water infiltration and nutrient cycling. Protective measures such as a thick layer of wood chips or mulch over tree root zones, clear trail signage, providing trails and pathways where people want to go (path design to follow desire lines), and enforcing exclusion zones are critical for long-term park plant health. Documenting and communicating staff and equipment parking areas during construction is essential. For more detail on wood chips, please refer to the Green Waste section of this document.

Penalty And Bonus Policies

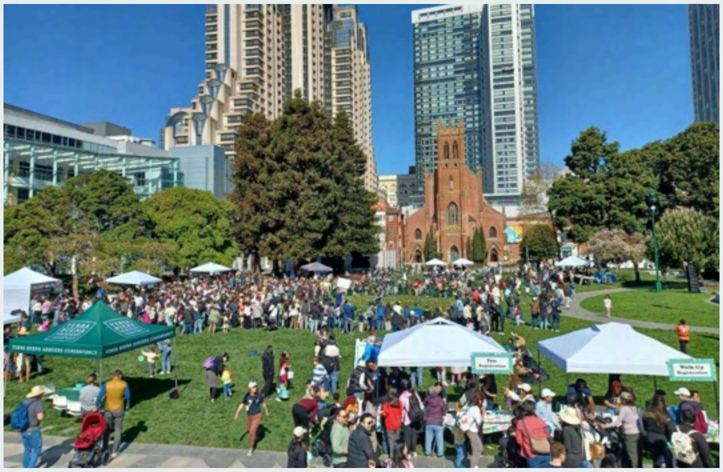
As the client, and potentially as regulators and partners in plan review, parks departments can also guide penalty and bonus policies to encourage suitable tree and plant protection. These policies can be as simple as penalty deductions from a contractor's payment application for killing trees or non-conformance with tree protection requirements in the contract. They can be as complex as developing heritage tree preservation ordinances or having urban forestry be part of the plan review process.

A starting point for departments that do not already have a penalty system is to review the municipality's regulations for tree damage and removal valuation assessments, to establish a fair baseline for standards and penalties.

In some municipalities, including San Francisco and New York City, plans, zoning ordinances, or other local laws regulate environmental impacts resulting from shade created by new construction. The potential shift in on-site conditions from full sun exposure to full or partial shade can be enough to damage or kill species unsuited to the new conditions.

Damaged trees and vegetation often require increased maintenance or expensive replacement. Compromised tree health reduces the ecosystem services they provide, such as cooling, stormwater management, air purification, and aesthetics. Park managers can promote environmental resilience by proactively protecting soil and root zones from compaction, vandalism, and other forms of disturbance. This charge can be a challenge when attempting to balance the high recreational demands with plant protection. Finding the right places for the right activities, matching the design of the park landscape to its intended uses, and adapting to changing uses are perhaps the most effective strategies for protecting plants over time—but they can be the most challenging from a cultural perspective.

Case Study: Plant Protection at Yerba Buena Gardens, San Francisco, CA



By Subhajeet Ghose

Yerba Buena Gardens - plant protection challenged by high use. Image attribution: Subhajeet Ghose.
Website: www.yerbabuenagardens.org
Contact: sghose@ybgardens.org

Our urban trees at Yerba Buena Gardens welcome over five million visitors annually. The foot traffic causes significant soil compaction and related damage in the midst of a heat island. The temperatures vary by around seven degrees from the shade to the open areas. Our guests tend to congregate under the trees when the days are sunny, and the UV index is high in San Francisco. We began the process of expanding the mulch zone under the trees to cover nearly the entire width of the canopy. The results have shown new foliage growth on branches and some gain in size, attributable to the adopted change, noting the prior years of docility. Our Gardens, being located in a high-wind area, present unique challenges for caring for our valued trees, including several 80-foot-tall redwoods. We thinned them with the guidance of our Arborist while retaining the shape and aesthetic presence. Whenever we have large construction projects on our campus, we protect our trees with wood-stake fences. With the Mediterranean climate, trees can grow quickly. That brings with it challenges in keeping them well-trimmed and shaped to encourage growth and health. We employ a comprehensive trimming program, where all our trees are examined, documented, and work authorized annually based on their needs. Over the last year, we have also implemented a tree replacement program that only allows native trees, improving our ability to manage them in the face of profound climate change, and moving away from relying on one or two varieties to a multitude. All of these efforts in the last two years have created a more sustainable garden and brought some life back to the area with noticeably more birds, bees, and other pollinators.

Case Study: Tree Protection in Virginia Beach, VA

By Michael Kirschman

Flexible paving installed around existing large trees.
Image attribution: Michael Kirschman
Website: https://parks.virginiabeach.gov/
Contact: mkirschman@vbgov.com

We have implemented several strategies, ranging from lightning protection and fencing around signature trees to pruning and deep root fertilization. Additionally, we have utilized CIP funds for non-traditional protection/improvements, such as using flex-paving for sidewalks around large trees where roots are causing concrete/pavement issues.

Key Strategies & Considerations

- For new construction, require designers and contractors to include and implement tree and vegetation protection plans and specifications, based on International Society for Arboriculture (ISA) standards for Critical Root Zones (CRZ).
- Consult your municipality's ordinance on tree valuation assessment and replacement and shade impacts.
- For operations, develop plant protection standards that include mulching, access limitations, signage standards, and program or use restrictions and exclusions to sufficiently protect the plants from vandalism, dumping, and compaction.
- Investigate the potential mulch and soil amendments available within the park system and see a reliable source of high-quality, cost-effective materials, such as wood chips or ground hardwood. Develop an application schedule matched to the product and plant communities under management.

- Consider developing a tree or urban forestry ordinance or plan review process that ensures new development within the jurisdiction complies with tree and vegetation preservation and protection requirements.
- Consider mulch rings or perennial/shrub beds offset from tree trunks in turf areas to reduce damage from mowers and line trimmers.

Helpful Resources and References

American Society of Agronomy. (2018). *Corn with straw mulch builds yield, soil carbon: Increasing yield, carbon storage with mulch options*. ScienceDaily. https://www.sciencedaily.com/releases/2018/04/180425093807.htm

ASC. (2024). ANSI A300 Tree Care Standards. *Tree Care Industry Association, LLC.* https://treecareindustryassociation.org/business-support/ansi-a300-standards/

Bajoriene, K., Jodaugiene, D., Pupaliene, R., & Sinkeviciene, A. (2013). Effect of organic mulches on the content of organic carbon in the soil. *Estonian Journal of Ecology*, *62*(2), 100–107. https://doi.org/10.3176/eco.2013.2.02

Clark, J., et al. (2021). “Why Definitions Matter: The Tree Protection Zone and the Critical Root Zone.” https://www.researchgate.net/publication/357128085_Why_Definitions_Matter_The_Tree_Protection_Zone_and_the_Critical_Root_Zone

International Society of Arboriculture. (2016). Best Management Practices: Managing Trees During Site Development and Construction. 2nd ed. https://www.isa-arbor.com/store/product/139/cid/127/

International Society of Arboriculture. (2023). Best Management Practices: Root Management, 2nd ed. https://www.isa-arbor.com/store/product/4291

McPherson, E. G., Kendall, A., & Albers, S. (2015). Life cycle assessment of carbon dioxide for different arboricultural practices in Los Angeles, CA. *Urban Forestry & Urban Greening*, *14*(2), 388–397. https://doi.org/10.1016/j.ufug.2015.04.004

Millward, A. A., Paudel, K., & Briggs, S. E. (2011). Naturalization as a strategy for improving soil physical characteristics in a forested urban park. *Urban Ecosystems*, *14*(2), 261–278. https://doi.org/10.1007/s11252-010-0153-4

National Recreation and Park Association (NRPA). (2025). *Guardians of Greenspaces Episode 9: Trees and Riparian Zones: Green Instrastructure in Houston*, Podcast. https://www.nrpa.org/our-work/Three-Pillars/environmental-resilience/guardians-of-greenspaces-podcast/episode-9-trees-riparian-zones-green-infrastructure-in-houston/

National Recreation and Park Association (NRPA). (n.d.). *Trees: Resources on the care and maintenance of tree populations.*

https://connect.nrpa.org/viewdocument/trees-nrpa?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

Oregon State University Extension Service. (2024). Protecting Trees on Construction and Development Sites, EM-8994. https://extension.oregonstate.edu/es/catalog/em-8994-protecting-trees-construction-development-sites

Smetana, S. M., & Crittenden, J. C. (2014). Sustainable plants in urban parks: A life cycle analysis of traditional and alternative lawns in Georgia, USA. *Landscape and Urban Planning*, *122*, 140–151. https://doi.org/10.1016/j.landurbplan.2013.11.011

The Sustainable Sites Initiative. (n.d.). *From the ground up: Sustainable sites start with healthy soils*. https://www.sustainablesites.org/ground-sustainable-sites-start-healthy-soils

Wang, J., Fu, X., Zhao, F., & Sainju, U. M. (2018). Response of Soil Carbon Factions and Dryland Maize Yield to Mulching. *Soil Science Society of America Journal*, *82*(2), 371–381. https://doi.org/10.2136/sssaj2017.11.0397

Smart Turf Management

Background

Turf grass is the most cultivated, studied, and managed ornamental planting type in the world. The story of how this came to be is a convoluted one, best summarized in the book "American Green" by Ted Steinberg. Suffice it to say lawns are a cultural idea, taken from temperate European landscapes and imposed across the United States. According to Rebecca Harrington, in 2016, the continental United States had approximately 40 million acres of turf lawn - that is, more than any irrigated food crop, and even more than land under corn cultivation. There are several problems with this approach - the least of which is that most turf lawns require significant nutrition, irrigation, and good drainage to perform well. Additional inputs can include herbicides and fungicides. Coupling these inputs with regular mowing using gas engines can suddenly make a landscape filled with plants become a net source of greenhouse gas emissions.

Right Turf In The Right Place

But it doesn't have to be that way. Lawn turf in the right climates can require little or no supplemental irrigation. "Low or No Mow" turf blends can dramatically reduce mowing requirements. The trick is to use the right turf in the right place - to be smart with turf. Rugged, low-input utility turfs, such as tall or sheep fescue, can be effective filler turf, requiring limited or no supplemental irrigation and only a few mowings per year in the right climate. However, these species are not suitable for high-traffic areas due to their tendency to bunch. For high-use areas, rhizomatous turfs, such as Bermuda grass or bluegrass, can be more durable. Active recreational fields, sports, or regular events may require and justify high inputs to enable the turf to recover quickly and grow rapidly enough to withstand heavy use. Even prioritizing mowing policies, such as higher frequency in high-traffic or front-of-house lawns, and infrequent mowing in passive back-of-house lawns, can reduce emissions and maintenance time.

Turf Conversion & Synthetic Turf

Other strategies can include converting low-active program turf lawns to other locally relevant plant communities, such as the Denver Parks Department's recent experience converting passive lawns to native shortgrass prairie. Turf lawn conversions can reduce operational material and water inputs and even increase the potential carbon storage capacity of the land use over time.

Another alternative is replacing turf lawns with synthetic lawns. Synthetic turf is an engineered system that includes the blades, padding, and infill. For sports fields that experience high usage, making it difficult for natural turf to recover between play events, synthetic lawns can serve as a replacement, allowing for seemingly endless touch and play points. While synthetic turf has substantial savings on irrigation use, it can have a number of hidden environmental and monetary costs. Synthetic turf requires below-grade water retention infrastructure to reduce the flow of chemicals and microplastics into potable water sources and ensure adequate drainage. The biggest challenge with synthetic turf is its relatively short lifespan. UV degrades synthetic turf, limiting the functional lifespan to ~ 8 to 10 years. Additionally, synthetic lawns require annual maintenance and performance testing to ensure the fill layers remain intact and prevent injury. Due to its high embodied carbon and relatively short lifespan, synthetic turf is best suited for very high-use lawns or areas facing extreme water scarcity.

If synthetic turf lawns are the best option for performance, specifiers and parks departments should also investigate the end-of-life plans for the material, as many artificial turf products cannot be chemically or mechanically recycled and often end up in landfills. Material decisions, such as for the infill, can have significant consequences - crumb rubber has been found to off-gas harmful volatile organic compounds (VOCs) in high heat for example, while organic infill such as cork has a low environmental impact and can biodegrade at the end of its useful life, which has already been implemented in Seattle’s park system.

Smart Turf Management

The current default for many departments is to use standard, regionally common turf blends and commit to a regimen of watering, fertilizing, mowing, and occasionally applying weed and pest treatments.   This is a habit formed over the last century of lawn culture in America, as green, cut lawns provide a clear cultural cue of care for public spaces. There is a perception that managing turf is low-maintenance, but with all the mowing, blowing, irrigation, and treatments, it is at least medium-maintenance. Smart Turf Management requires more consideration and specificity in terms of where to prioritize high maintenance in active areas, and low maintenance in passive areas. There can be many challenges to implementing Smart Turf Management, from neighbors who might mistake shaggy low-mow blends for an abdication of care, to maintenance crews who accidentally mix up seeding blends. Still, in the end, it can result in fewer resources expended in both materials and staffing time and can support a healthier, more environmentally friendly landscape.

For some recreational programs, such as field, pitch, golf, and diamond sports, turf will often be the best fit for the program. In addition to the other notes mentioned above, there are innovative training programs and certification programs for managing sustainable lawns. The Audubon Cooperative Sanctuary Program for Golf Courses (ACSP) is a certification program that helps golf courses protect the environment. The key to managing these spaces with minimal herbicides and fertilizers is a focus on soil health. Healthy soil with proper pH and organic matter will take less chemicals to manage. The same approach can be applied to any landscaped area. Please refer to our sections on Organic Land Management and Soil Management for more information. In the right climate and with proper irrigation, living turf lawns, including sports turf, can be managed as a climate solution using electric equipment and organic land management techniques.

Case Study: Reconsidering Turf, Henderson, NV

By Amie Wojtech

A turf conversion example. Image attribution: City of Henderson.
Website: https://www.cityofhenderson.com
Contact: amie.wojtech@cityofhenderson.com

The City of Henderson began removing selected sections of non-recreational turf and replacing it with drought-tolerant, native plants, trees, or other landscape materials and amenities, and converting the existing Fescue grass to a drought-tolerant grass, such as Hybrid Bermuda. As part of the grass removal process, City staff conduct an assessment to determine the health and longevity of existing trees. Trees that are currently unhealthy, susceptible to disease, and/or are struggling to adapt to our desert environment will be replaced. This will help maintain and expand our community's urban tree canopy, providing shade and aesthetics that complement the public's use of the park. The City of Henderson is committed to the beautification and saving of resources in our Parks. As a result, we will always replace the removed trees with as many or more trees, plants, and amenities to provide recreational opportunities for our residents and ensure the future sustainability of our parks. We will continue the project for our remaining parks through 2026. Upon completion, we estimate that this project will save our community 150 million gallons of water per year. At the close of FY24, 160,307 square feet of turf had been removed, equivalent to three NFL-sized football fields, and over 8.8 million gallons of water were conserved annually (approximately). This is equivalent to thirteen Olympic-sized pools.

Key Strategies & Considerations

- Conduct a turf quality and use assessment and map lawns by high, medium, and low-use categories. Observe turf grass species used, maintenance challenges, and the quality of the fields.
- Conduct climate and soil-specific research on optimal turf blends for use in these areas and investigate alternative landscape solutions to passive lawns.
- Develop test plots to match improved seed blends per use category and test mowing frequency.
- Include signage and community education campaigns when replacing lawns with either shaggier turf types or 'wilder' appearing plant communities to communicate the effort and the anticipated benefits of the management change.
- Match turf cultivation needs a sustainable irrigation strategy, such as the use of reclaimed water.

Helpful Resources and References

Brede, D. (2000). *Turfgrass Maintenance Reduction Handbook*. Sleeping Bear Press.

Harrington, R. (2016). "America's Biggest Irrigated Crop Is Grass, Study Found." Business Insider, 19 Feb. 2016. https://www.businessinsider.com/americas-biggest-crop-is-grass-2016-2

Lerman, S. B., & Contosta, A. R. (2019). Lawn mowing frequency and its effects on biogenic and anthropogenic carbon dioxide emissions. *Landscape and Urban Planning*, *182*, 114–123. https://doi.org/10.1016/j.landurbplan.2018.10.016

Pirchio, M., et.al. (2019). Energetic Aspects of Turfgrass Mowing: Comparison of Different Rotary Mowing Systems. *Agriculture*, *9*, 178. https://doi.org/10.3390/agriculture9080178

Portmess, R. E. (2009). Reducing Chemical Use on Golf Course Turf: Redefining IPM. *New York State Integrated Pest Management Program, Publication No. 617*.

Qian, Y., & Follett, R. (2002). Assessing Soil Carbon Sequestration in Turfgrass Systems Using Long-Term Soil Testing Data. *Agronomy Journal - AGRON J*, *94*. https://doi.org/10.2134/agronj2002.0930

National Recreation and Parks Association (NRPA), (2025). Guardians of Greenspaces Episode 7: Sustainable Turf in Sioux Center, podcast. https://www.nrpa.org/our-work/Three-Pillars/environmental-resilience/guardians-of-greenspaces-podcast/episode-7-sustainable-turf/

Rossi, F. (2020). *PUTTING GREEN MANAGEMENT WITHOUT CHEMICALS*. Cornell University. https://archive.lib.msu.edu/tic/mitgc/article/200399.pdf

Selhorst, A., & Lal, R. (2013). Net carbon sequestration potential and emissions in home lawn turfgrasses of the United States. *Environmental Management*, *51*(1), 198–208. https://doi.org/10.1007/s00267-012-9967-6

Smetana, S. M., & Crittenden, J. C. (2014). Sustainable plants in urban parks: A life cycle analysis of traditional and alternative lawns in Georgia, USA. *Landscape and Urban Planning*, *122*, 140–151. https://doi.org/10.1016/j.landurbplan.2013.11.011

Steinberg, T. (2006). American Green: The Obsessive Quest for the Perfect Lawn. *Faculty Publications*. https://scholarlycommons.law.case.edu/faculty_publications/1351

Townsend-Small, A., & Czimczik, C. (2010). Carbon sequestration and greenhouse gas emissions in urban turf. *Geophysical Research Letters - GEOPHYS RES LETT*, *37*. https://doi.org/10.1029/2009GL041675

Wang, R., Mattox, C. M., Phillips, C. L., & Kowalewski, A. R. (2022). Carbon Sequestration in Turfgrass–Soil Systems. *Plants*, *11*(19), Article 19. https://doi.org/10.3390/plants11192478

Watkins, E., Fei, S., Gardner, D., Stier, J., Bughrara, S., Li, D., Bigelow, C., Schleicher, L., Horgan, B., & Diesburg, K. (2011). Low-Input Turfgrass Species for the North Central United States. *Applied Turfgrass Science*, *8*(1), 1–11. https://doi.org/10.1094/ATS-2011-0126-02-RS

Zirkle, G., Lal, R., & Augustin, B. (2011). Modeling Carbon Sequestration in Home Lawns. *HortScience*, *46*, 808–814. https://doi.org/10.21273/HORTSCI.46.5.808

National Recreation and Parks Association (NRPA), (n.d.). *Turf Talk: Best Practices In Turf Management,* webinar. This webinar is about how Denver Parks and Rec sets expectations, meets standards, and manages priorities set forth by the organization as it relates to turf management. https://www.nrpa.org/our-work/Three-Pillars/environmental-resilience/guardians-of-greenspaces-podcast/episode-8-green-stormwater-infrastructure-in-raleigh-and-tucson/

Urban Forestry and Restoration Ecology

Background

We assume that the targeted audience for these guidelines—park operators and managers—already understands the ecological, climatic, and cultural value of the trees and living ecosystems in their care. In our 2025 survey, 'urban forestry and restoration ecology' was the most widely understood and implemented strategy across the entire study. This section will highlight a few key ideas and tools that park operators can utilize in their urban forestry and restoration ecology advocacy work.

Maximize Passive Space Potential

The first strategy is reconsidering passive park spaces. Anywhere where a mown lawn is maintained that is not used for sports, play, or any type of active recreation can be a great candidate for increasing tree canopy or restoring native plant communities. These changes can upset community members who associate the mown lawn as a cue of care. Developing thoughtful designs that consider ecological performance, maintenance, and adaptation, as well as principles of safety in public space, and making estimates of impact metrics for revisions can be helpful tools for the basis of an engagement campaign with the public. Post-installation tours, signage, and blogs can all help (some) community members understand the reasoning and benefits of the changes and potentially even inspire volunteerism to assist with maintenance. Meadow restoration, tree-planting campaigns, and pollinator gardens can all be effective interventions if clearly and inclusively communicated.

Species And Age Diversity

The second strategy is to manage park canopies as biodiverse, mixed-age stands. Individual trees can have a wide range of anticipated lifespans, depending on their species, climate change, disease, or impacts from human activities. Treating trees as static elements, like park furnishings, can lead to widespread failures, such as monocultural plantings all being susceptible to a new disease or pest or many trees reaching the end of their life space in close succession. Managing a park's forest with a wide diversity of ages and species enables the intergenerational replacement of trees, similar to natural forests. Why habitats and regional values vary, park operators can look to local reference ecosystems for understanding reasonable age distributions. However, it is also essential to be aware of the local history of land use changes to understand potential variation. One example is from New England mesic hardwood forests, where an age distribution of stems can fall roughly between 5-15% for seedlings, 30-40% for saplings and small caliper trees (<6"), and 40-50% for medium to large caliper trees (6-18"), and 2-10% for very large/heritage trees (>18"). Parks need to maintain a continuous tree-planting program to achieve the same stand resilience as these natural systems. Mono-aged stands are typically found in managed timber forestry, serotinous ecosystems, parks, and streetscapes, where all the trees are planted at the same time. In the case of parks and streetscapes, no one wants to see all the trees cut down at once.

Contiguous Planting Areas

The third strategy is promoting contiguous planting areas. Trees do better with adequate soil volume and when they share a common rooting area. Florida ecologists have learned that planting groups of at least five canopy trees together at a time can double the stand's resistance to hurricanes. In Germany, we have learned that trees sharing root zones will warn each other of pest attacks, triggering the release of chemical defenses and tannins in nearby individuals not directly impacted. Planting a stand-alone tree pit isolates that tree, and the success or failure of that tree is entirely dependent on the designed system. In most ecosystems, trees grow together in forests - the image of the lone tree in a grassy field is a cultural idea evoking remnant trees or 'motts' left in pastures.

Continuity can be straightforward in horticultural spaces, defining clear boundaries for tree and understory planting. From an ecological perspective, the larger the patch of an ecosystem, the more likely it is to support ecosystem-specific animal and bird species and overall higher biodiversity across trophic levels. This applies as much to stands of trees as clumps of understory planting, contributing to cohesive ecological systems.

Isolated planting areas can be challenging. Park and public space users will always want to have bosques of trees and curated gardens in urban plazas and hardscapes for cooling, shade, and biophilia. Designers can plan for connectivity to overcome those risks of isolation. Designers may need to connect the horticultural soils, even under pavements and structures, using structural soils or soil systems. Designers may need to open up our sidewalks to allow for bigger planting beds to include supportive understory species. Adequate soil volume and contiguous planting can dramatically increase the lifespan of urban trees.

Carbon Credit Programs Background & Potential

Cities, companies, and individuals have started investing in carbon offset programs to balance their emissions. This investment has inspired the global voluntary carbon market, where tradable carbon credits are sold as virtual commodities that certify actions, ranging from reforestation to burning off excess methane. This unregulated market has experienced extreme swings in confidence, with the rapid pace of investor enthusiasm often outpacing capacity or verifiability. Today, there is a vast range of potential strategies and associated premiums. On one end of the spectrum, the premium carbon credits have clear 'additionality': they reduce the amount of carbon in the atmosphere, and high 'durability: the carbon is unlikely to be emitted again. On the other end of the spectrum, credits with low additionality and durability are cheap, such as credits that 'do less harm', reducing emissions that would otherwise be emitted due to lax environmental regulations, or credits that may be unverified.

Between these extremes are the verifiable natural systems credits, which include investments in reforestation, wetland restoration, and improved soil management regimes. These natural systems credits vary widely in program design, ecological management, and legal frameworks. Some simply focus on protecting existing resources, such as the Family Forest Credits Program, https://familyforestcarbon.org/, which serves as a revenue tool to support small-scale conservation easements. Some support mass planting of trees to support reforestation, either in support of future timber industry (such as many Verra-certified Gold Standard Forestry Credits), or in support of long-term restoration ecology goals, such as credits created by SavingNature.org. Some support urban forestry activities, often undertaken by City governments, non-profits, and park departments, such as City Forest Credits https://www.cityforestcredits.org/.

Connecting investments in reforestation with carbon credit programs can capitalize on the interest of carbon investors in supporting urban forestry and provide much-needed supplementary funding for operations.

These strategies can be integrated into design, planning, and operations by park departments through ongoing maintenance, capital investments, and standard design requirements. Combining these strategies with recommendations on soil management and organic land management can shift horticultural operations toward an ecologically sophisticated, climate-responsible, and adaptive management regime.

Case Study: Stewarding the Urban Forest, City of Boulder, CO

By Kathleen Alexander

2024 Community Tree Planting Event. Image attribution: City of Boulder. Contact:alexanderk@bouldercolorado.gov

The City of Boulder Parks and Recreation Forestry team manages approximately 51,000 public trees across parks and street rights-of-way, forming the backbone of Boulder's urban forest.

These trees provide shade, beauty, and vital environmental benefits that support the community's well-being. The team's mission focuses on maintaining a healthy, safe, and diverse urban canopy for current and future generations. A strong tree cover enhances air quality, supports wildlife, reduces urban heat, and contributes to Boulder's visual appeal. Thanks to these efforts, Boulder has proudly held the Tree City USA designation from the National Arbor Day Foundation since 1984 and has been recognized as one of the Tree Cities of the World for the past six years. Boulder Forestry's responsibilities include planting, pruning, watering, and inspecting trees through its Public Tree Maintenance Program. Residents can request street trees or participate in memorial plantings through Public Tree Planting Programs. Safety is central to the team's work. The Tree Risk Assessment Program (TRAP) identifies hazardous trees for timely intervention, while the Integrated Pest Management (IPM) strategy minimizes environmental impact while addressing long-term pest control. This includes effective emerald ash borer management through tree replacement, selective pesticide use, biocontrol releases, and prompt removal of infested trees. The team also responds promptly to storm-related damage and oversees arborist licensing to ensure adherence to professional standards. Behind the scenes, Boulder Forestry maintains a detailed public tree inventory and uses an asset management system to track maintenance and guide strategic planning. Together, these efforts ensure that Boulder's urban forest continues to thrive by providing ecological, aesthetic, and community benefits year-round.

Case Study: Urban Tree Canopy Assessment, Atlanta, GA

By Taryn Heidel

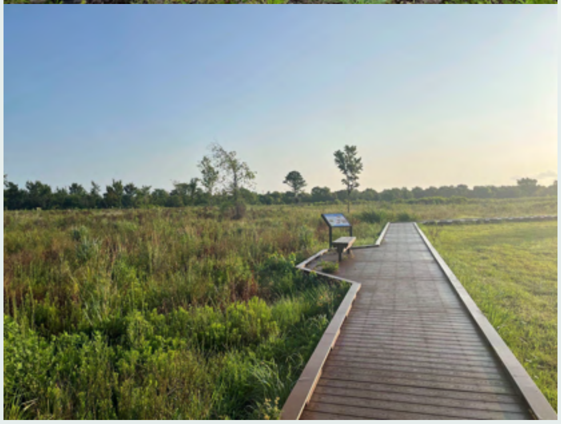
The City's first carbon credit project in Lake Charlotte Nature Preserve. Image attribution: City of Atlanta Department of Parks and Recreation.
Website:
https://www.cityforestcredits.org/

In 2022, the City of Atlanta Mayor's Office of Sustainability and Resilience, in partnership with the Department of Parks and Recreation, launched its Carbon Credit Program with Lake Charlotte Nature Preserve, generating verified urban carbon credits through the City Forest Credits registry.

Carbon credits quantify the tons of carbon stored in soil and trees, and the sale of these credits allows the City to generate revenue as it continues to acquire and preserve forested land within the city. The project is projected to generate $1.2 million over five years. Carbon credit revenue will help fund maintenance and stewardship of the property. The preservation of the forest prevents emissions that would result from development, and the forest and its carbon stock will continue to grow over time. Forest preservation projects not only reduce carbon dioxide from the atmosphere but also provide ecosystem services that can be quantified as co-benefits. The co-benefits from the Lake Charlotte Nature Preserve project represent a savings of $100,560 per year and $4,022,400 over 40 years, due to savings from stormwater management, improved air quality, and energy savings from cooling and heating. In 2025, we expanded the program to include four additional properties encompassing approximately 252 acres of urban forest: Southwest Nature Preserve, South River Nature Preserve, Mount Zion Nature Preserve, and Utoy Creek Nature Preserve. The expanded program is projected to generate an additional $1.4 million in total gross revenue. This initiative supports the City's commitment to reducing greenhouse gas emissions and providing access to green spaces within a half-mile walking distance for all Atlanta residents.

Case Study: Prairie Restoration & Management, Houston, TX

By Kelli Ondracekl



Sylvan Rodriguez Park restored prairie and boardwalk. Image attribution: Houston Parks and Recreation Department.

Contact: kelli.ondracek@houstontx.gov

The Houston Parks and Recreation Department's (HPARD) Natural Resources Division led a multi-phase restoration of 72 acres at Sylvan Rodriguez Park in Houston, TX. The goal was to return the site to its historic coastal prairie and riparian forest habitats. The project involved removing the invasive Chinese tallow-dominated forest and establishing a diverse mix of native grasses and forbs in the prairie, along with native trees and shrubs planted along the riparian corridor bordering the adjacent bayou. HPARD propagated native plants from hand-collected seed sourced from nearby remnant prairies and utilized them in the restoration plantings to ensure the use of locally adapted ecotypes suited to regional soil and climate conditions. Ongoing invasive species management and community volunteer planting events continue to support the long-term health of the habitat. Interpretive signage and an elevated boardwalk provide visitors with educational opportunities and safe access to experience the restored ecosystems while minimizing disturbance. This restoration enhances critical ecosystem services, including floodwater absorption, water quality improvement, carbon sequestration, and wildlife habitat connectivity, creating a resilient natural area within the urban environment. The project stands as a valuable model for reclaiming degraded prairie ecosystems across the Houston region.

Key Strategies & Considerations

- Manage urban forestry in parks as biodiverse, mixed-age stands, and include consistent tree planting campaigns as part of park maintenance.
- Instead of relying on 'tree lawns' as the dominant passive land use within parks, convert these landscapes, where feasible, to more ecologically valuable, lower-maintenance native plant communities.
- Manage and plant trees with adequate soil volume and in shared rooting areas, ideally with complementary understory planting, to mimic natural systems and gain shared resilience benefits.

Helpful Resources and References

National Recreation and Park Association (NRPA). (n.d.). *Preserving Natural Areas,* webinar. https://connect.nrpa.org/viewdocument/preserving-natural-areas?CommunityKey=33a261e5-5285-44ff-a31d-cce5b35d1317&tab=librarydocuments

National Recreation and Park Association (NRPA). (n.d.). *Nature-Based Solutions for Environmental Resilience Programs,* webinar. https://www.nrpa.org/contentassets/f076b898c6fb4f6b939156e28d45a22d/2023-citgo-resource.pdf

National Recreation and Park Association (NRPA). (n.d.). *Naturalization:* Resources on restoring natural habitats and communicating changes to the community. https://connect.nrpa.org/viewdocument/naturalization-nrpa?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

Lau, C. (2022.) Environmental Restoration for Parks and Recreation. National Recreation and Park Association (NRPA). https://www.nrpa.org/blog/environmental-restoration-for-parks-and-recreation/

Jones, C., Sutton, R. (2020). How Biodiversity Creates Healthy Communities. National Recreation and Park Association (NRPA). https://www.nrpa.org/blog/how-biodiversity-creates-healthy-communities-december-bonus-episode/

Sustainable Practices for Central & Transition Hardwood Forests. (n.d.). *New England Forestry Foundation*. https://newenglandforestry.org/forest-management/exemplary-forestry/central-and-transition-hardwoods/

ASC. (2024). ANSI A300 Tree Care Standards. *Tree Care Industry Association, LLC.* https://treecareindustryassociation.org/business-support/ansi-a300-standards/

Shadman, S., et.al., (2022). The carbon sequestration potential of urban public parks of densely populated cities to improve environmental sustainability. *Sustainable Energy Technologies and Assessments*, *52*, 102064. https://doi.org/10.1016/j.seta.2022.102064

SER. (2023). *Restoration Resource Center A project of the Society for Ecological Restoration*. https://www.ser-rrc.org/

Simard, S. (2018). *Mycorrhizal Networks Facilitate Tree Communication, Learning, and Memory* (pp. 191–213). https://doi.org/10.1007/978-3-319-75596-0_10

Wohlleben, P. (2016). *The hidden life of trees: What they feel, how they communicate : discoveries from a secret world* (J. Billinghurst, Trans.). David Suzuki Institute ; Greystone Books Ltd.

Nowak, D. J., Greenfield, E. J., & Ash, R. M. (2019). Annual biomass loss and potential value of urban tree waste in the United States. *Urban Forestry & Urban Greening*, *46*, 126469. https://doi.org/10.1016/j.ufug.2019.126469

Let Trees Connect. (n.d.). *Sasaki*. Retrieved June 22, 2025, from https://www.sasaki.com/voices/let-trees-connect/

Alvarez, S., Soto, J. R., Escobedo, F. J., Lai, J., Kibria, A. S. M. G., & Adams, D. C. (2021). Heterogeneous preferences and economic values for urban forest structural and functional attributes. *Landscape and Urban Planning*, *215*, 104234. https://doi.org/10.1016/j.landurbplan.2021.104234

Technical University of Munich. (2018). Mixed forests: Ecologically and economically superior. https://www.sciencedaily.com/releases/2018/05/180509105008.htm

Steiner, F. (2008). The Living Landscape: An Ecological Approach to Landscape Planning. McGraw-Hill.

Hansen, G. (2022). Urban Ecology for Citizens and Planners. University Press of Florida.

Myers, R., and Ewel, J. eds. (1990). Ecosystems of Florida. University of Central Florida Press.

Plant Procurement

Background

Buying seeds, plugs, shrubs, and trees is an area where a park department's purchasing power is inherently environmentally friendly. Still, environmental impacts should be considered when evaluating nursery production and material transportation methods. Several academic life cycle assessment (LCA) studies have found that shrubs and trees can often sequester more carbon when grown in nurseries than is expended on irrigation, nutrients, and maintenance activities for field- and container-grown plants. These seemingly 'carbon positive' materials can become net-emitting materials depending on the method and distance of transportation to the site.

Unfortunately, not all nursery cultivation practices are equally environmentally friendly. At the time of writing these guidelines, there is no ISO-defined product category rule (PCR) that enables the development of product-specific or industry-class-specific environmental product declarations (EPDs). While formal methods and third-party verification processes would be ideal for evaluating nursery production, they simply do not exist. Therefore, for now, we recommend a few proxy policies or preferences that target low-emissions plant procurement standards. These proxies are based on reviewing the available literature on nursery LCAs and in-house research reviewing procurement and transportation considerations for a few select projects. Below, in order of magnitude of impact, are our recommendations for park departments interested in optimizing the climate benefits of the plants they procure.

Buy Local And/Or Small

The most significant source of emissions will be from transporting heavy plant materials to the site. Including local procurement requirements, ideally within 100 miles of a project site, can significantly reduce these emissions; however, the availability of such requirements must be verified to ensure they are a viable policy. Transportation emissions are produced by the fuel necessary to move the mass of the material shipped the required distance. Therefore, reducing the mass moved will also reduce emissions. For instance, a 1" caliper balled-in-burlap (B&B) tree can weigh 175 lbs, versus a 4" caliper B&B tree, which can weigh 1,200 lbs—almost seven times as much. Since the caliper is a measure of stem diameter, increases in the mass of the tree are geometric when considering the volume of soil needed for the rootball. Purchasing low-mass plants should include buying smaller trees (whips, liners, and low-caliper trees) and opting for bare-root trees when feasible. Bare-root trees are dug or lifted and prepared so that the soil is washed or blown from the roots, the roots are coated in hydrogel (preferably), and then shipped. The benefit of bare-root trees is that only the tree itself is shipped, which can reduce the shipment's mass by an order of magnitude. This means a bareroot tree order shipped a thousand miles can be potentially more efficient than a B&B tree shipped 100 miles. A significant co-benefit of buying smaller trees is reduced transplant stress. Research at Cornell University showed that transplant recovery periods were significantly faster for 1 to 2" caliper trees of the same species compared to 4 to 6" caliper trees, resulting in the smaller trees catching up with the larger caliper trees within a decade or so. Given the lower costs, it can be more climate and cost-efficient to plant more smaller trees.

Value Seed

For herbaceous materials, the seed is generally the most emissions-friendly material for transportation, but bulbs, sprigs, and washed rhizomes are also highly efficient. For container planting, opting for more, smaller containers is a good general rule of thumb. For turf, sod will always be higher emissions due to the costs of transporting the inch of soil cut with the sod.

Biodiverse, Native Planting

After transportation, the next most significant consideration is ecological suitability and density. Biodiverse, structurally complex ecosystems sequester and store more carbon since there is more life per unit area – such as woodlands with overstory, understory, herbaceous, and geophytic layers of plants and associated fungi and animal life. Some ecosystems are highly productive in terms of carbon capture, including wetlands, salt marshes, and tallgrass prairies.

While native plants don't necessarily sequester more carbon than non-native species, adequately cared-for native plants can be significantly less maintenance than introduced ornamental species and are adapted to the local climate. Planning for self-sufficient planting can reduce operational emissions, lower replacement costs, and help park operators maintain overall horticultural health with limited resources. Careful selection of native plants can produce landscapes that thrive without human intervention and provide critical habitat for wildlife. If we shift the perspective of park landscape maintenance from a 'grounds management' perspective to 'managers of living systems,' many common practices start to make less sense. This conceptual shift can relate to small decisions, such as ending 'meatball' shrub pruning and letting shrubs grow in their natural habitat, with pruning to promote health and mitigate obstructions. This shift can relate to significant decisions – such as planting only straight species from local genotypes and encouraging self-seeding in park natural areas. This shift can be about a maintenance approach that focuses on the whole ecosystem rather than keeping each plant or tree 'tidy' in appearance.

Cultivation Standards

The final strategy involves investigating the cultivation standards of the purchased plants. Most park departments will already require nursery material to be compliant with the American Standard for Nursery Stock, Z-60.1, the industry quality standard focused on the health, size, and physical characteristics of the plants. What is missing from Z-60.1 are requirements on how the plants are grown. There is a vast range of practices in the nursery industry, from highly chemical and resource-heavy production facilities to extremely sensitive organic practices. Generally, buyers do not ask about cultivation practices, and as a result, there is limited financial support or clear premiums for environmentally friendly nursery products.

Park departments that wish to encourage environmentally friendly plant procurement practices could consider requiring nurseries to provide affidavits disclosing their cultivation practices and prioritizing nurseries that comply with key criteria as defined by the department. This could be a commitment to integrated pest management (IPM) with IPM-certified personnel. This could be a declaration of commitment to organic land management practices. Unfortunately, organic certification for tree and plant propagation has generally been limited to agricultural species, and any such certification requirement at this time would exclude most horticultural and native species growers.

Plant procurement and installation may be one of the most enjoyable and rewarding activities of park operations, and is work that community members will often be willing to volunteer for or contribute to. Developing strong standards to promote long-term plant health and procurement practices that reflect the department's environmental goals will only strengthen park operators' role as stewards of these living systems. To paraphrase the proverb - society grows wise when people plant trees whose shade they shall never sit in.

Case Study: Houston Parks and Recreation Department's Native Plant Propagation Program, Houston, TX

By Kelli Ondracekl

Native plants grown in the HPARD Greenhouse from staff and volunteers. Image attribution: Houston Parks and Recreation Department.

Contact: naturalresources@houstontx.gov

The Houston Parks and Recreation Department's (HPARD) Natural Resources Division administers one of the region's most extensive native plant propagation programs, strategically designed to support ecologically sound restoration of urban prairies and forests. With management responsibility of over 17,000 acres of natural habitat, HPARD recognized a significant deficiency in the availability of locally adapted, native plant material suitable for large-scale ecological restoration.

To address this, HPARD hand collects seeds from remnant prairies and old-growth forests throughout the Houston region. These local ecotypes, adapted to Houston's unique conditions, are then propagated in the department's greenhouse. Working alongside a dedicated network of volunteers, HPARD produces over 10,000 native prairie plants annually. These include a wide variety of native grasses and forbs, which are grown to 1-gallon size before being installed in prairie restoration sites throughout the city.

Forest restoration efforts similarly prioritize genetic integrity and local adaptation. Following a region-specific assessment, HPARD compiled a list of 91 native tree species historically present in the Houston area. Seed is collected from old-growth trees in Houston's undisturbed forests, ensuring that the trees planted in Houston's reforestation projects are regionally adapted, genetically diverse, and more likely to withstand future threats like disease, pests, and drought. To increase capacity, HPARD also utilizes select vendors that specialize in locally sourced plant material.

By emphasizing the use of locally sourced, diverse, native species, HPARD's Native Plant Propagation Program supports native wildlife, strengthens ecosystem resilience, and curbs the spread of invasive species. These efforts safeguard Houston's natural spaces as authentically native, biologically diverse, and uniquely Houston.

Key Strategies & Considerations

- Develop plant procurement standards based on regional availability and supply chain considerations.
- Consider local sourcing preferences for heavy planting materials, such as boxed or balled-in-burlap trees.
- Prioritize smaller and lighter planting materials, such as bare-root trees with small calipers, seed mixes, whips, plugs, or sprigs, over those in large containers or with large calipers.
- Consider requiring IPM or organic land management cultivation standards for nursery material.

Helpful Resources and References

American Nursery and Landscape Association. (2014). American Standard for Nursery Stock (ANSI Z60.1).

Grossnickle, S. C., & El-Kassaby, Y. A. (2015). Bareroot versus container stocktypes: A performance comparison. *New Forests*, *47*(1), 1.

Ingram, D., Hall, C., & Knight, J. (2016). Carbon Footprint and Variable Costs of Production Components for a Container-grown Evergreen Shrub Using Life Cycle Assessment: An East Coast U.S. Model. *HortScience*, *51*, 989–994. https://doi.org/10.21273/HORTSCI.51.8.989

Ingram, D. L. (2012). Life cycle assessment of a field-grown red maple tree to estimate its carbon footprint components. *The International Journal of Life Cycle Assessment*, *17*(4), 453–462. https://doi.org/10.1007/s11367-012-0398-7

Kendall, A., & McPherson, E. G. (2012). A life cycle greenhouse gas inventory of a tree production system. *The International Journal of Life Cycle Assessment*, *17*(4), 444–452. https://doi.org/10.1007/s11367-011-0339-x

Kendall, A., & McPherson, E. G. (2012). A life cycle greenhouse gas inventory of a tree production system. *The International Journal of Life Cycle Assessment*, *17*(4), 444–452. https://doi.org/10.1007/s11367-011-0339-x

McPherson, E. G., Kendall, A., & Albers, S. (2015). Life cycle assessment of carbon dioxide for different arboricultural practices in Los Angeles, CA. *Urban Forestry & Urban Greening*, *14*(2), 388–397. https://doi.org/10.1016/j.ufug.2015.04.004

Petri, A., Koeser, A., Ingram, D., & Lovell, S. (n.d.). *How Green Are Trees? —Using Life Cycle Assessment Methods to Assess Net Environmental Benefits* https://www.researchgate.net/publication/311536163_How_Green_Are_Trees_-_Using_Life_Cycle

Trowbridge, P., and Bassuk, N. (2020). Urban Eden: Landscapes for the Future. 2nd ed., John Wiley & Sons.

Chapter 2: Water Conservation

Water-Efficient Buildings

Background

Water-efficient buildings help park operators reduce costs, meet sustainability goals, and enhance their environmental reputation. Recreation centers often have high water demands—from locker room showers to toilets, pools, irrigation, and equipment cleaning. Park restrooms can have very high water usage, considering their small architectural footprints, especially in parks with significant athletic programs, playgrounds, or community event spaces. Implementing water-efficient systems enables operators to reduce utility expenses, alleviate strain on local infrastructure, and support regional water conservation, all of which are crucial for environmentally friendly park operations, especially in drought-prone areas. Reducing water waste also aligns with growing expectations among community members who value sustainable operations and responsible resource use.

Water conservation isn't just about the water itself but also the environmental impacts of the water used. Potable water has energy and infrastructure behind it to harvest, clean, store, and transport the water. Saving potable water also helps reduce greenhouse gas emissions. While the embodied carbon of water is usually relatively low due to the scale and efficiency of municipal water systems (a reasonable proxy being 0.38 to 0.46 kgCO2e/CM based on a national study by Dr.

Louis Zib III of the US Air Forest Institute of Technology), the vast quantity of water used by parks and buildings adds up.

Effective water efficiency in recreation buildings is achieved through either holistic water-efficient design for new facilities or a combination of technology upgrades, system redesigns, and user behavior management for existing facilities. Key strategies can include installing water-efficient plumbing fixtures and rainwater harvesting systems. Operators may also consider water reuse systems. Regular maintenance and leak detection are equally important, as unnoticed water loss can undermine even the best-designed systems and cause significant damage.

Water Budget Analysis

The starting point for understanding the potential retrofit needs is conducting a water budget analysis to assess the project's water resources, needs, and opportunities to minimize potable water use. This can involve considering both indoor and outdoor water systems as a unified whole. A few key strategies that could help reduce water use are described below.

Efficient Toilets

Toilets are among the highest indoor water users in most facilities. Installing low-flow (1.28 gallons per flush (GPF)) or dual-flush toilets can cut water use by 20%–60% compared to older models. For high-traffic recreation buildings, this can translate to thousands of gallons saved per month. Dual-flush models offer users flexibility while maintaining high standards of hygiene. Some systems utilize pressure-assisted flushing, which provides strong performance even at lower flow rates—a key consideration in busy facilities where reliability is critical. For buildings or projects with restricted access to potable water, water-free composting toilet systems can provide significant water savings. Pint-flush urinals (0.125 GPF) are ideal for high-traffic men's restrooms in gyms and sports venues, as they significantly reduce water usage and minimize maintenance on plumbing systems.

Another option, particularly viable for rustic park facilities, is composting toilets. Composting toilets employ a range of methods to safely decompose human waste into usable compost, thereby minimizing water usage and environmental impact. These are not septic systems - those use anaerobic decomposition and result in large amounts of methane gas emissions. Methane gas is 86 times more potent a greenhouse gas on a twenty-year timeline than carbon dioxide, so avoiding septic is one of the most critical emissions reductions parks departments can make regarding their human waste management. Composting toilets, on the other hand, rely on aerobic decomposition, which produces carbon dioxide emissions but reduces methane. The most common systems include self-contained and central composting toilets. These toilets feature composting chambers directly beneath the bathroom. They are ideal for low-use or remote locations, offering an environmentally friendly alternative to transporting portable toilets and their associated waste.

Key considerations for these toilets include being realistic about capacity, tracking against decomposition time, and determining whether they are open or closed systems. Open systems are more like an outhouse and must be carefully designed and located to avoid inadvertent contamination through seepage. Closed systems are more flexible in terms of location but often have capacity tied to volume. Both approaches require ventilation and active management to minimize or eliminate the smell, such as adding bulking agents like sawdust, ground leaves, or wood chips. Some require periodic microbial inoculations. This management can successfully absorb excess moisture, improve aeration & aerobic decomposition, and balance the carbon-to-nitrogen ratio in the resulting compost.

Due to human nature, composting toilets present an additional challenge for individuals who dispose of inappropriate waste in the facility, often necessitating the sieving and mechanical processing of fully decomposed compost before it is viable for distribution. There are common placement recommendations, or sometimes local laws, that require compost distributors not to place human waste-derived compost (or biosolids) within 100 feet of playgrounds, food crops, and areas at risk of flooding. While, in many ways, these toilets are the best for environmentally friendly purposes, they can be challenging in the wrong location, if overused, or if they have a user population that doesn't respect the sensitive nature of the composting ecosystem.

There are also larger, more robust biodegrading toilet systems, such as central systems that transport waste (often from low-flow toilets) to a separate processing unit. These are suitable for higher-traffic settings. Aerobic decomposition is central to most designs, with ventilation systems ensuring the flow of oxygen to support microbial activity and control odors. Some models incorporate mixing mechanisms or worms (vermicomposting) to accelerate the breakdown process. Depending on the design, additional treatments such as heat, evaporation, or biofilters may be used to enhance sanitation and reduce volume. These systems operate like an off-grid micro sewage treatment plant.

Efficient Fixtures

For sinks and other fixtures, installing WaterSense-certified fixtures can be a reasonable baseline water efficiency policy. Fixtures labeled with WaterSense are independently tested to ensure performance and efficiency, using at least 20% less water than standard models. For example, WaterSense showerheads use no more than 2.0 gallons per minute (GPM), and faucets are limited to 1.5 GPM or less. Recreation operators can prioritize WaterSense-labeled products to ensure reliable water savings without sacrificing usability. Showers, especially in locker rooms and aquatic facilities, can be a major source of water use. Retrofitting with low-flow showerheads can reduce flow from 2.5 to 1.5 GPM, with no noticeable drop in user comfort. Push-button or timer-activated showers and sinks further reduce unnecessary use by limiting session time. For sports centers, these features also promote equity by discouraging excessively long showers. Smart sensors can also be used to regulate shower use and inform maintenance needs.

This guide also includes additional systems relevant to water-efficient buildings and landscapes. Please refer to the sections on greywater and smart irrigation for more information on these strategies.

Even with the best technology, human behavior and ongoing maintenance determine how much water is ultimately saved. Operators should train staff on leak detection, proper cleaning methods and products, and fixture care. Posting educational signage in showers and restrooms can encourage responsible use among visitors. Maintenance crews should conduct regular audits to catch hidden leaks, faulty sensors, or stuck valves. Involving both staff and park visitors in water-saving efforts creates a culture of conservation and accountability.

Key Strategies & Considerations

- Conducting a water budget analysis to understand the project's water resources, needs, and opportunities to minimize potable water use.
- Prioritize low-flow, push-button, or timer-activated fixtures for retrofits and new installations. At a minimum, require EPA WaterSense-certified fixtures.
- Consider composting toilet facilities and investigate whether they are viable from a local regulatory and staffing perspective.

Helpful Resources and References

Anand, C. K., and Apul, D. (2014). “Composting Toilets as a Sustainable Alternative to Urban Sanitation.” Waste Management, vol. 34, no. 2, pp. 329–343. https://serc.carleton.edu/integrate/teaching_materials/energy_sustain/compost_toilet.html

Berger, W. (2013). “Basic Overview of Composting Toilets (with or without Urine Diversion).” Journal of Environmental Management, vol. 119,pp. 29–35. https://sswm.info/sites/default/files/reference_attachments/GTZ%202010%20Basic%20Overview%20on%20Composting%20Toilets.pdf

Bundrick, C., and Hutchinson, D. (2022). “The Future of Sustainable Building Restoration with Deep Energy Retrofits.” Building Enclosure.

Green Building Alliance, (2024). “Composting Toilets.” https://gba.org/resources/green-building-methods/interior-solutions/composting-toilets

Mayer, Paul W., et al. (2003). “Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Home” Water Engineering and Management.

Metz, Barbara, et al. (2015). “Evaluating the Potential of Improving Residential Water Balance at Building Scale.” Water Science and Technology, vol. 72, no. 6, 2015, pp. 895–903, https://pubmed.ncbi.nlm.nih.gov/24238880/.

Michigan Department of Environment, Great Lakes, and Energy. (2022). General Guidelines for Calculating a Water Budget. https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/Hydrologic-Data/water-budget.pdf

U.S. Environmental Protection Agency. (2022). “WaterSense Performance Overview: Ensuring Products Perform.” https://www.epa.gov/system/files/documents/2022-05/ws-products-perfomance-overview.pdf

U.S. Environmental Protection Agency. (2024). Lean and Water Toolkit: Chapter 3, Developing a Water Balance. https://www.epa.gov/sustainability/lean-water-toolkit-chapter-3

U.S. Environmental Protection Agency. (2024). WaterSense Labeled Toilets Fact Sheet. https://www.epa.gov/sites/default/files/documents/ws-products-factsheet-tank-type-toilets.pdf

Vermont Dept. of Environmental Conservation, (2020). “Composting and Incinerating Toilets Guidance Document.” https://anr.vermont.gov/doc/sites/anr/files/documents/DEC%20Composting%20Toilet%20Guide_2020.02.24.pdf

Weber Tompson Associates. (2010). “The Terry Thomas Building.” Weber Thompson Case Study, 2010. https://www.weberthompson.com/archives/

Zib, L., Byrne, D. M., Marston, L. T., & Chini, C. M. (2021). Operational carbon footprint of the U.S. water and wastewater sector’s energy consumption. *Journal of Cleaner Production*, *321*, 128815. https://doi.org/10.1016/j.jclepro.2021.128815

Greywater and Reclaimed Water Reuse

Background

Greywater systems capture and treat relatively clean wastewater—such as water from sinks, showers, and laundry—for non-potable reuse. For recreation centers with high shower volumes, greywater reuse can significantly reduce the need for fresh municipal water by using shower water for toilets. These systems typically include filtration and disinfection processes and require thoughtful integration into the plumbing infrastructure. In some states, limited treatment (secondary) may be allowed, while in others, tertiary treatment may be required. Though the upfront investment is higher, savings over time and resilience in times of water scarcity make Greywater systems increasingly attractive, with a return on investment (ROI) ranging from 5 to 15 years, depending on local water costs.

Greywater Restrictions

While Greywater can be a fantastic solution for toilets, these approaches are not approved in all states. While California has a comprehensive Greywater plumbing code, States like West Virginia and Massachusetts only allow Greywater to be used with composting toilets. Greywater or reclaimed water for irrigation is also a great strategy to reduce potable water usage, but it may have restrictions based on the state, such as not being allowed in recreational landscapes, in sprinklers, or, in the case of Florida, not being permitted for irrigation at all.

Reclaimed Water

Reclaimed water is different. While there are various definitions by state, reclaimed water is generally treated domestic wastewater. Reclaimed water is typically cleaned to the point of being safe for public contact, but it does not meet the same water quality standards as potable water. Reclaimed water can also include sources such as chiller water or industrial process wastewater that may already meet local standards but do not require treatment through sewage treatment facilities. Reclaimed water isn't prohibited for use in toilets or irrigation in any state; however, variations exist in plumbing codes from state to state, so use needs to be reviewed in the local context. The primary cost of using reclaimed water for toilet facilities is the secondary plumbing requirement, which is most easily accommodated in new construction. Municipalities focused on reducing potable water reuse are setting up shared reclaimed water networks and programs, such as in Naples, FL.

Irrigation Considerations

For irrigation, reclaimed water can be a vital strategy for reducing potable water use. It is essential to consider the water quality of reclaimed water when designing irrigation systems that rely on it. Some reclaimed water sources may contain elevated levels of salts. Even low concentrations of elevated salts can, over time, accrue in the soils, creating inhospitable conditions for many plants. This is a particularly high risk in arid climates and sites with clayey or high bulk-density soils. To overcome this, the planting can prioritize salt-tolerant species, and/or the irrigation system can be designed to allow for periodic 'flooding' to wash the accumulated salts out of the soil profile. While Greywater is still relatively novel in most states, except California, reclaimed water is a common and well-vetted source of irrigation water.

Case Study: University Park Community Center, Portland, OR

By Subhajeet Ghose

Updating the University Park Community Center to be LEED certified included replumbing to allow for reclaimed water use. Image attribution: Subhajeet Ghose.
Website: www.portlandparks.com

Contact: sghose@ybgardens.org

In Portland, Oregon, in 2006, we undertook an update and upgrade of the existing University Park Community Center, funded by the Neighborhood Housing Project. The center has been renamed the Charles Jordan Center in honor of a former popular Director and Council Member. To make it a LEED-certified building, we chose to collect all the water from the large gymnasium roof and use it to help run the urinals and toilets in the restrooms. This work resulted in significant water savings while also capitalizing on the long rainy season in Portland, helping to fill the cisterns to account for usage during the three months of the dry season, from June through August. Some of the water was also used for irrigation when amounts allowed. Not only did this instill a sense of pride in the staff and community, but it also became an integral part of the existing environmental education program.

Key Strategies & Considerations

- When designing new systems, consider Greywater capture and reuse, as well as the use of reclaimed water, to reduce overall potable water needs. These installations must be vetted for feasibility in accordance with local codes.
- Prioritize using non-potable water for irrigation sources whenever possible, and design planting and irrigation systems to ensure that the plants' tolerance matches the properties of the water.
- Not all grey water and reclaimed water is equal. For example, chiller waste water can often have practically potable water quality. It is work checking in with local building codes to determine if lower contamination waste water, such as chiller water or bathroom sinks, can be separately diverted. These conditions can often require minimal or no filtration before being sufficient quality for supplemental irrigation.

- Investigate local and regional rules on greywater reuse. In some states and provinces, municipal purple pipe systems are common, others,Greywater reuse may be considered experimental or expressly against code even with all the sand filters and testing standards recommended within the International Plumbing Code (IPC), Chapter 13. For parks departments interested in advocating for grey water and reclaimed water use in regions where it is currently not permitted, this is the link to current IPC standards and this to the associated California Code that can be referenced in your advocacy work.

Helpful Resources and References

International Code Council. International Plumbing Code. 2018 Edition, Chapter 13, “Nonpotable Water Systems.” *Codes and Standards,* International Code Council, 2018, codes.iccsafe.org/content/IPC2018/chapter-13-nonpotable-water-systems

California Building Standards Commission. (2019). California Plumbing Code, Chapter 16A: Greywater Systems. California Code of Regulations, Title 24, Part 5. https://codelibrary.amlegal.com/codes/paloalto/latest/paloalto_ca/0-0-0-72324

Elhegazy, H. and Mahmoud, M. (2020). A state-of-the-art-review on grey water management: a survey from 2000 to 2020s. Water Science & Technology. 82. https://iwaponline.com/wst/article/82/12/2786/78152/A-state-of-the-art-review-on-grey-water-management

Tian, Z., et. al. (2025). Influence of Long-term Irrigation with Reclaimed Water on the Soil Quality of Different Land Use Types. Water Resources Management. 1-18. https://link.springer.com/article/10.1007/s11269-025-04232-4

Yu, Z., et al. (2014). "Critical Review: Regulatory Incentives and Impediments for Onsite Greywater Reuse in the United States." Journal of Environmental Engineering, vol. 140, no. 1.https://www.researchgate.net/publication/255953735_Critical_Review_Regulatory_Incentives_and_Impediments_for_Onsite_Greywater_Reuse_in_the_United_States

National Recreation and Park Association (NRPA). (n.d.). *Water Quality:* Resources on protecting the quality of existing freshwater sources and reduce our overall water consumption. https://connect.nrpa.org/viewdocument/water-quality-nrpa?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

National Recreation and Park Association (NRPA). (2025). Guardians of Greenspaces Episode 6: Grey Water Reuse in Purcell and Los Alamos County, podcast. https://www.nrpa.org/our-work/Three-Pillars/environmental-resilience/guardians-of-greenspaces-podcast/episode-6-grey-water-reuse/

Green Infrastructure

Background

Green infrastructure encompasses parks, forests, wetlands, and other natural or semi-natural areas that contribute to stormwater management, provide wildlife habitats, and offer recreational opportunities. Green infrastructure can be defined as replacing traditional infrastructure with Nature Based Solutions (NBS). As recently pointed out by Gary Lai at the California Green Building Conference, these terms are compelling, but everyone seems to have a different understanding of what they mean. Projects and systems labeled with green infrastructure and/or NBS may range from previous paving to algae-powered fuel cells. For this guide, we define green infrastructure as infrastructure that incorporates plants as a functioning part of the system.

Stormwater management green infrastructure can include systems such as rain gardens, bioswales, and green roofs. These systems utilize plants and soil to detain and purify water rather than relying on traditional (gray) infrastructure alternatives, such as media filters or cisterns. These installations save on the emissions associated with constructing equivalent grey infrastructure, such as replacing pipes with bioswales. They are generally designed to be passive filtration and treatment systems with low or no energy expenditures. Co-benefits can include aesthetics and contribution to ecological value.

Economically, green infrastructure can lead to significant cost savings. By reducing the need for expensive gray infrastructure projects, park departments can allocate those capital resources more efficiently. Green infrastructure can be an essential part of designing passive park systems but still requires upkeep, particularly for stormwater management elements. It is essential to match green infrastructure installations to reasonable maintenance expectations and anticipated wear and tear. The maintenance work often leans more toward managing plants and soils and less toward the periodic servicing of the gray infrastructure equivalents. In park environments, these systems can require more day-to-day maintenance to maintain the aesthetic value. That said, when stormwater gray infrastructure reaches the end of its lifespan or requires significant servicing, the replacement and repair costs can be significantly higher.

Water Harvesting

Green infrastructure can have particular benefits to parks when combined with a water harvesting strategy. Water harvesting is a good strategy for sustainable water management in parks, particularly in urban areas that face water scarcity or extreme weather events. By capturing, cleaning, or treating rainwater through green infrastructure and storing it, parks can reduce their dependence on municipal water supplies and better withstand drought conditions. This stored water can be used for irrigation, replenishing ponds, or supporting wetland habitats, making parks more resilient and self-sustaining.

As part of a park's green infrastructure, water harvesting complements other sustainable green infrastructure investments, such as rain gardens, bioswales, and permeable pavements. These elements work together to slow, capture, and filter rainwater where it falls, promoting groundwater recharge and reducing the load on urban drainage systems. For instance, harvested water from park roofs or paved surfaces can be directed into underground storage tanks or natural infiltration zones. This water can be used to dilute reclaimed or Greywater, or it can be used directly as a water source for landscape irrigation.

Systems that combine green infrastructure and water harvesting systems in parks provide educational and community engagement opportunities. Demonstrating how rainwater can be collected and reused shows visitors the value of conservation and sustainable design. Signage and interactive displays can explain the process, fostering environmental awareness and inspiring stewardship. By incorporating water harvesting into visible and functional parts of the park, such as decorative cisterns or irrigation systems for gardens, parks can showcase these systems as living laboratories. Perhaps the biggest impact of showcasing these systems in public parks could be normalizing them and inspiring other projects, as well as private homeowners, to consider these investments. Green infrastructure can demonstrate how parks can serve as models of environmental stewardship for their communities.

Site Commissioning

Some park operators may face challenges or require training to operate and maintain new green infrastructure and water collection systems. A very practical best practice is to require maintenance training for staff during the construction maintenance period by the contractor and to include a site commissioning scope that tests and validates the system's performance before handing it over to the parks department staff. For more information on Site Commissioning, please refer to the white paper on methods and best practices by Andropogon for the GSA, available here: https://www.andropogon.com/work/project-one-ephnc-az44a-5nngn-lxch4-6eny9.

Case Study: Green Infrastructure, Cleveland, OH

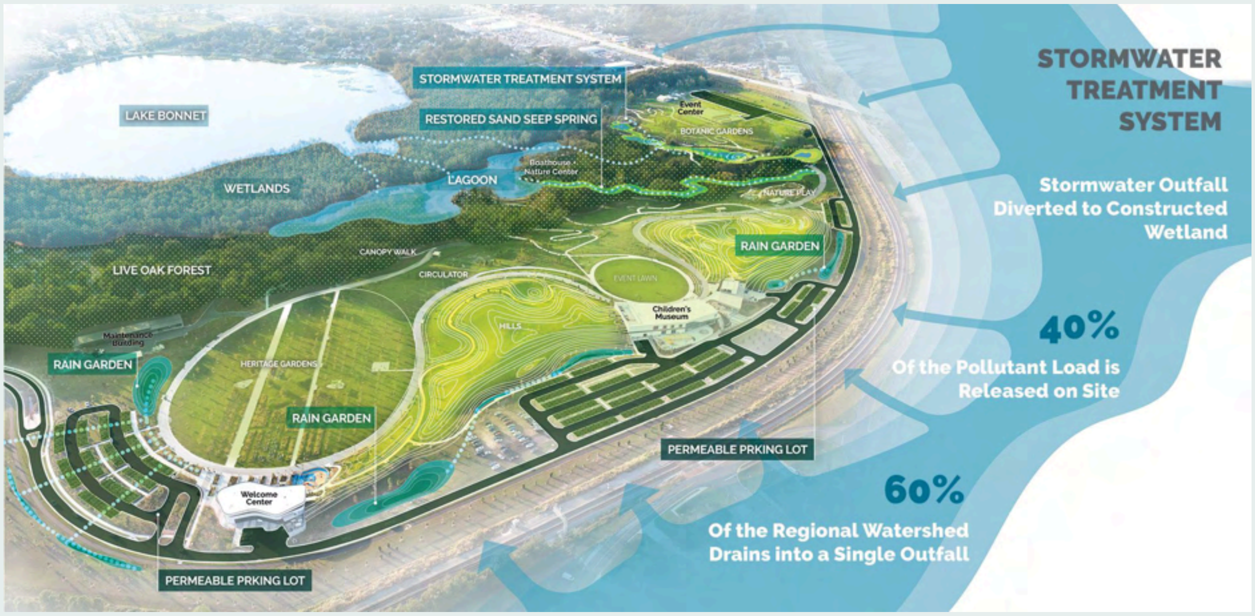
By Elizabeth Hiser

Cleveland Metroparks green infrastructure maintenance at Euclid Beach.
Image attribution: Cleveland Metroparks.
Website:www.clevelandmetroparks.com
Contact: eah@clevelandmetroparks.com

Cleveland Metroparks spans 25,000+ acres across Northeast Ohio, including 18 reservations, more than 325 miles of trails, nine golf courses, eight lakefront parks, dining and retail venues, and the nationally acclaimed Cleveland Metroparks Zoo. Cleveland Metroparks Comprehensive Green Infrastructure Program addresses stormwater runoff from all angles, including education, stewardship, design, construction, inspection, maintenance, monitoring, and workforce development. Locally, this reduces flooding and erosion in our neighborhood streams, while regionally contributing to the improved water quality in Lake Erie â€“ the source of drinking water for over 11 million people across Ohio, Michigan, Pennsylvania, New York, and Canada. Cleveland Metroparks has installed over 100 various stormwater control measures and established itself as an expert in watershed and stormwater education. In 2024, Cleveland Metroparks (CMP) further integrated its construction, park maintenance, natural resources, and outdoor experiences teams to address this issue and ensure long-term environmental stewardship and an engaged, conservation-minded community. From January 2024 through March 2025, CMP: Â·Constructed and planted a new "treatment train" of bioretention cells at Euclid Beach on Lake Erie that will capture 2.5 Million gallons of stormwater each year Â·Hosted 18 volunteer events focused on green infrastructure maintenance that engaged registered CMP volunteers as well as corporate, nonprofit and governmental entities Â·Utilizing an internally Conducted 109 green stormwater inspections to document and communicate the level of follow-up maintenance needed Â·Facilitated 4,000 hours of service from 250 Watershed Volunteers and recognized 32 individuals as Certified Watershed Stewards Â·Delivered 50+ interactive, hands-on programs for over 750 people that highlighted the impacts of stormwater runoff and ways to address it.

Case Study: Improving Water Quality at Bonnet Springs Park, Lakeland, FL

By Chris Hardy & Ashley Pelletier



Reconsidering the landscape as a water receiving and filtering system. Image Credit: Sasaki
Website: https://www.sasaki.com/projects/bonnet-springs-park/
Contact: zchrisco@sasaki.com

The two major water systems within the Bonnet Springs Park site faced environmental challenges. Lake Bonnet is the most polluted lake in Lakeland, and Bonnet Springs Valley, which drains into Lake Bonnet, was experiencing an accelerated rate of erosion along its banks.

In response to these challenges, a diverse set of green infrastructure strategies was employed to capture, redirect, and mitigate the on- and off-site impacts on the watersheds. The new hydrological regime diverts drained water into a new pipe and brings it to a lagoon, preventing erosion of the spring corridor. The first flush of contaminated stormwater is diverted from this pipe to undergo stormwater treatment before reaching Lake Bonnet. This runoff is routed through a structural treatment device for debris removal and primary treatment before being released within the Park's Botanical Garden, first into an armored forebay, then through a winding wet meadow composed of a mix of native and adapted species designed to slow the water, absorb nutrients, and facilitate hydrocarbon biodegradation. This water passes through a swale and into a primary settlement pond, which serves as an accent within the gardens. The water is then conveyed to a new, nearly seven-acre retention lagoon at the foot of the sloping woodland, where it can decelerate, settle, and percolate through a 1,300-linear-foot edge of forested wetlands before being released into Lake Bonnet.

This design approach improves water quality and helps restore a sensitive ecosystem. It also provides opportunities for park visitors to experience these new landscapes and be inspired to act in ways that promote clean water in our environment.

Key Strategies & Considerations

- Utilize green roofs, rain gardens, bioswales, and surface infiltration basins whenever possible, instead of traditional pipes and cisterns, for stormwater management. This approach focuses on minimizing the embodied carbon of built infrastructure and meeting performance criteria for slowing and cleaning stormwater runoff.
- Collect runoff on-site and reuse it for irrigation and non-potable water uses.
- Prioritize smaller and lighter planting materials, such as bare-root trees with small calipers, seed mixes, whips, plugs, or sprigs, over those in large containers or with large calipers.
- Consider requiring IPM or organic land management cultivation standards for nursery material.
- Consider adding site commissioning to the scope of new project construction projects.

Helpful Resources and References

Barbara, G. (2023). "A Beginner's Guide to Harvesting Rainwater." The Spruce, 8 Feb. 2023. https://www.thespruce.com/beginner-guide-to-rainwater-harvesting-7090759?utm

Berndtsson, J. (2010). "Green Roof Performance towards Management of Runoff Water Quantity and Quality: A Review." Ecological Engineering, vol. 36, pp. 351–360.

City Parks Alliance. (2025). Parks as Infrastructure. https://cityparksalliance.org/resource/parks-as-infrastructure/.

Dunnett, N., and Clayden, A. (2007). Rain Gardens: Sustainable Rainwater Management for the Garden and Designed Landscape. Timber Press.

Grafiati. (2017). Sustainable Stormwater Management: A Landscape-Driven Approach to Planning and Design. Timber Press.

Metropolitan Area Planning Council. (2018). Designing Parks and Playgrounds as Green Infrastructure for Stormwater and Climate Resilience. https://www.mapc.org/resource-library/parks-playgrounds-green-infrastructure/.

Monterusso, M. A., et al. (2004). "Runoff Water Quantity and Quality from Green Roof Systems." Acta Horticulturae, no. 639, pp. 369–376.

Morawski, B. (2023). "Rainwater Harvesting 101: Why You Should Try It—And How to Do It." Architectural Digest. https://www.architecturaldigest.com/story/rainwater-harvesting-101?utm

National Recreation and Parks Association (NRPA), (2015). *Green Infrastructure Evaluation Framework:* Collection of tools, research, and worksheets to help evaluate the benefits of GI projects.

https://www.nrpa.org/our-work/partnerships/initiatives/greener-parks/green-infrastructure-framework/

National Recreation and Parks Association (NRPA), (n.d.). *Green Stormwater Infrastructure Certificate Program.* https://learning.nrpa.org/products/green-stormwater-infrastructure-gsi-certificate-program

National Recreation and Parks Association (NRPA), (n.d.). *Green Infrastructure in Parks.* https://www.nrpa.org/siteassets/gupc-resource-guide.pdf

National Recreation and Parks Association (NRPA), (n.d.). *Resource Guide for Planning, Designing, and Implementing Green Infrastructure in Parks.* https://www.nrpa.org/siteassets/gupc-resource-guide.pdf

National Recreation and Parks Association (NRPA), (2025). Guardians of Greenspaces Episode 8: Green Stormwater Infrastructure in Raleigh and Tuscon, podcast. https://www.nrpa.org/our-work/Three-Pillars/environmental-resilience/guardians-of-greenspaces-podcast/episode-8-green-stormwater-infrastructure-in-raleigh-and-tucson/

National Recreation and Parks Association (NRPA), (2025). Guardians of Greenspaces Episode 1: Staff Engagement in San Antonio, podcast. https://www.nrpa.org/our-work/Three-Pillars/environmental-resilience/guardians-of-greenspaces-podcast/episode-1-staff-engagement/

National Recreation and Parks Association (NRPA), (n.d.). *Green Infrastructure:* Resources on how to implement green infrastructure. https://connect.nrpa.org/viewdocument/green-infrastructure-nrpa?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

National Recreation and Parks Association (NRPA), (n.d.). *Green Stormwater Infrastructure (GSI) Certificate Program.* https://learning.nrpa.org/products/green-stormwater-infrastructure-gsi-certificate-program#tab-product_tab_overview

Henaghan, J. (2017) —The Great Urban Parks Campaign Briefing Papers. American Planning Association. https://www.nrpa.org/siteassets/gupc-briefing-paper-financing-projects.pdf

Novotny, V., and Olem, H. (1994). Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold.

Saour, W. (2009). Implementing Rainwater Harvesting Systems on the Texas A&M Campus for Irrigation Purposes: A Feasibility Study. Texas A&M Theses & Dissertations, Texas A&M University,

College Station.
https://www.researchgate.net/publication/26904087_Implementing_Rainwater_Harvesting_Systems_on_the_Texas_AM_Campus_for_Irrigation_Purposes_A_Feasibility_Study

U.S. Environmental Protection Agency. (2017). Green Infrastructure in Parks: A Guide to Collaboration, Funding, and Community Engagement. EPA 841-R-16-112. https://npshistory.com/publications/conservation-stewardship/green-infrastructure-2017.pdf.

Smart Irrigation & Xeriscaping

Background

As mentioned in the section on water-efficient buildings, water conservation isn't just about the water itself but also the environmental impacts of the water used. Potable water has energy and infrastructure behind it to harvest, clean, store, and transport the water. Saving potable water also helps reduce greenhouse gas emissions. Improvements in irrigation efficiency can have a significant impact on the total operational water usage and emissions of a park over the system's lifespan. Across the country, many municipalities are championing low-water-use landscapes, trying to reduce and eliminate irrigation where possible. This effort is primarily focused on conserving water, but also on reducing costs for park departments. At the same time, some park programs (such as sports turf) will almost always benefit from having irrigation available. Some landscapes will require irrigation to achieve optimal planting performance, either due to cultural expectations or to support specific green infrastructure functions. With extreme drought risks, even native plants can be at risk of dying after establishment, particularly in regions where significant shifts in weather patterns are already underway. When considering whether to include or maintain irrigation for a given park program, park managers need to consider the risks associated with plant replacement. Suppose a planting plan fails and needs to be replaced due to poor irrigation or overly optimistic xeriscaping. In that case, the embodied emissions costs of planting replacement can potentially undo net water savings ambitions. It will also be increasingly important for park operators to carefully consider today's water needs and plan for a more unpredictable and extreme future.

Embodied Carbon of Potable Water

The embodied carbon of potable water has a significant range, depending on the calculation method and location. The highest carbon footprint is associated with desalination unless the energy is provided through renewable sources. Generally, water systems in water-scarce regions – which often require complex, large-scale infrastructure with multiple pump stations and treatment facilities – tend to have higher embodied carbon. Common carbon factors for municipal water in the U.S. range from 0.10 to 0.46 kgCO2e/CM. Decoupling irrigation systems from potable water can have the greatest impact on the system's lifespan. We recommend considering the use of water from on-site irrigation ponds, wells, or lakes. If done in an ecologically responsible manner, this can effectively negate these emissions.

Xeriscaping

The first step concept for operators to consider is if they can decouple landscapes from irrigation. Xeriscaping, also known as irrigation-free design, promotes landscapes that require low or no irrigation. A plant that is native to a region may not need supplemental irrigation to thrive after it is established.   Xeriscaping focuses on drought-tolerant native species that thrive in local conditions. A well-designed xeriscape can be just as lush and colorful as a traditional garden, with textures, blooms, and even pollinator-friendly plants that attract bees and butterflies. Some parts of the country that have significant drought stress have interesting, biodiverse landscapes where this approach can be combined with a celebration of local biodiversity.

However, it is important to note that, depending on the local climate, establishment irrigation may be necessary during the first one to two years to help trees and plants overcome transplant stress and develop healthy root systems. In Seattle, the Parks Department has extended establishment irrigation to 5 years due to climate change impacts and risks. This applies even to native plantings, as transplanting and softscape installation can significantly disturb root systems. For instance, balled-in-burlap field-dug trees may lose up to 90 percent of their roots when dug, making establishment irrigation critical to prevent mortality. To address this, consider specifying temporary, removable irrigation systems that can be used for the initial establishment period and then retrofitted for future projects requiring vegetation establishment. Water sourced from on-site sources or connected to municipal sources will typically have lower carbon impacts than diesel-powered water trucks. New and innovative products are making temporary irrigation easier, away from irrigation systems, including tree-specific slow-release water bags and products. However, operators need to plan and schedule the filling frequency of these products.

Reclaimed Water

After considering xeriscaping, park operators can prioritize using reclaimed and gray water wherever possible. Reclaimed water—typically treated wastewater—is ideal for landscapes since plants don't require drinking-quality water. The most efficient reclaimed water systems will be large-scale municipal systems and distribution networks; however, even local reclaimed water can be a potential source of carbon savings. When using reclaimed water, we recommend designing the system to allow for periodic flooding to help leach out potential salt buildup.

Retrofitting a potable water irrigation system to use reclaimed water is a practical upgrade. This process involves rerouting irrigation lines and installing backflow prevention devices to safely separate potable and non-potable supplies, often paired with purple piping to indicate reclaimed water use. While the retrofit may require upfront investment in infrastructure and permits, it pays off through lower utility costs and reduced strain on municipal water supplies. It's a smart move for drought-prone areas or large properties, such as parks, campuses, or golf courses, where irrigation accounts for a significant portion of water use.

When considering retrofitting an existing irrigation system, first conduct a water budget analysis and irrigation audit to understand where water is being spent and ensure the system operates as intended. Smart systems enable these audits to be much simpler; traditional irrigation systems require significant fieldwork to identify potential leaks and obstructions.

Water-Efficient Irrigation Retrofits

For all irrigation systems, considering where it is feasible to convert from spray to drip can significantly reduce water lost through evapotranspiration, thereby requiring less water to maintain plant health. Retrofitting a spray irrigation system to a drip and bubbler emitter delivers water slowly and directly to the root zone, minimizing waste. The retrofit usually involves capping off spray heads, installing pressure regulators and filters, and laying drip tubing or emitters near plants. This upgrade not only conserves water—often reducing use by 30 to 50 percent—but also helps control weed growth and runoff issues, making it especially effective in more garden-like planting areas, shrub beds, and ornamental planted areas with uneven terrain or clay-heavy soils. Drip irrigation comes with maintenance shifts; operations staff need to understand how to dig without disturbing emitter pipes safely. The lifespan of trip tubes can be greatly enhanced if they are placed on top of the soil but under a mulch layer, thereby protecting the tubes from UV degradation. In public parks, drip irrigation can be a high-touch system since the public can fairly easily damage it. We recommend using a smart system for drip irrigation, making it easier to monitor potential leaks or breakages from a central location.

Low Water Use Design

When designing new irrigation systems from the outset, we recommend following low-water-use design principles with the intention of delivering the minimum amount of water necessary to sustain plant health. To achieve low-water-use irrigation, designers must first design soils and planting to enable success with this approach. Parks departments can require "smart irrigation" systems with controllers that allow for remote monitoring to reduce impacts from driving to and from the site. We recommend specifying controllers that interact with flow sensors and master valves to monitor pipe breaks and shut system components as required to prevent water loss and site damage.

Similar to water efficiency recommendations for buildings, parks departments can also require the use of EPA WaterSense-certified products and that irrigation systems are designed, installed, audited, and maintained by professionals certified through EPA WaterSense-recognized programs. Properly designed irrigation systems should create and sustain hydrozones that align with site-specific conditions, such as hydraulic capacity, soil type, slope, and microclimate, to effectively meet the unique requirements of each planting. For more recommendations on environmentally friendly irrigation specifications, please refer to the ASLA Decarbonizing Specifications Guidelines, available here: https://www.asla.org/decarbonizingspecifications.aspx

For both new systems and retrofits, park operators should consider water-efficient irrigation systems with higher emission uniformity and experience less evaporation, such as drip irrigation. Be sure to match landscape needs and system maintenance expectations and training with the operation's staff capacity. Some irrigation system companies offer extensive training programs, and the Irrigation Association has a certification program for designers and operators. Consider having a dedicated Certified Irrigation Professional (CIP), Certified Irrigation Technician (CIT), and/or Certified Landscape Irrigation Auditor (CLIA), on staff to manage the irrigation system of a parks department can be one of the best ways to maintain and operate the improvements and repairs of parks irrigation over time.

Case Study: Smart Irrigation, City of Boulder, CO

By John Falkenberg

Irrigation team members working on mainline repair at Tom Watson Park. Image attribution: City of Boulder.
Contact:falkenbergj@bouldercolorado.gov

In the City of Boulder's Parks and Recreation Department, the Irrigation Team plays a pivotal role in conserving water while maintaining vibrant, healthy landscapes. This dedicated team works year-round to ensure that every park receives just the right amount of water through a combination of smart technology, strategic planning, and hands-on expertise. At the heart of their efforts is a central control system that manages irrigation across dozens of park sites. This system allows the team to remotely monitor and adjust watering schedules based on real-time data, including weather forecasts, flow rates, and seasonal needs. During peak watering season, the group fine-tunes irrigation programs to respond to changing conditions, reducing waste and preventing overwatering. One of the group's most impactful innovations is the installation of soil moisture sensors throughout many of the parks. These sensors measure the actual moisture content in the soil, providing precise data that informs when and how much to irrigate. By relying on this technology, the team avoids unnecessary watering and supports healthier root systems for turf and plantings. The Irrigation Team also conducts regular audits and refurbishments of aging systems, replacing inefficient components with high-efficiency sprinkler heads, pressure-regulated valves, and updated controllers. Their work ensures that every system operates at peak performance, conserving water while maintaining public spaces that residents love.

Key Strategies & Considerations

- Determine where irrigation is really necessary first, and evaluate an approach to temporary watering for water delivery efficiency and effectiveness.
- Conduct a water budget analysis and irrigation audit to understand where water is being spent and check that the system operates as intended.
- Evaluate the ability to use nonpotable water, such as reclaimed and or Greywater, or locally collected or harvested water.

- Consider water-efficient irrigation systems that typically have higher emission uniformity and experience less evaporation, such as drip irrigation. Ensure that landscape needs and system maintenance expectations align with the operator's capacity.
- Consider requiring education or certification for irrigation specialists on staff to ensure proper management and operations of the irrigation system.

Helpful Resources and References

Hunter. (n.d.). *Irrigation System Design*.
https://www.hunterindustries.com/sites/default/files/dg_student_guide_dom.pdf

Irrigation Association. (n.d.). Online Resources.
https://www.irrigation.org/ia/Education/Online_Classes.aspx

Irrigation Association Certifications, (2024).
https://www.irrigation.org/2024Show/Learn/Certification/2024Show/Learn/Certification.aspx?gad_source=1&gclid=Cj0KCQjwq_G1BhCSARIsACc7NxpwEf8xVUEzSeS7ZVpDm8giDUHlflKTcapcHQvn-xA0QKiMbq6KqMEaAvX1EALw_wcB

Karimi, P., Qureshi, A. S., Bahramloo, R., & Molden, D. (2012). Reducing carbon emissions through improved irrigation and groundwater management: A case study from Iran. *Agricultural Water Management*, *108*, 52–60. https://doi.org/10.1016/j.agwat.2011.09.001

Kendall, A., & McPherson, E. G. (2012). A life cycle greenhouse gas inventory of a tree production system. *The International Journal of Life Cycle Assessment*, *17*(4), 444–452.

Qualified Water Efficient Landscaper Program (QWEL) (n.d.).
https://qwel.net/files/QWEL_Reference_Manual_SMSWP_INTERACTIVE.pdf

Rainbird. (n.d.). *IrrigationDesignManual.pdf*.
https://www.rainbird.com/sites/default/files/media/documents/2018-02/IrrigationDesignManual.pdf

WaterSense Labeled Controllers, (2024).
https://www.epa.gov/watersense/watersense-labeled-controllers

Water Smart Gardens Maintenance Manual (n.d.).
https://www.savingwaterpartnership.org/programs_list/water-smart-gardens-maintenance-manual/

Xiao, C., Zhang, F., Li, Y., Fan, J., Ji, Q., Jiang, F., & He, Z. (2024). Optimizing drip irrigation and nitrogen fertilization regimes to reduce greenhouse gas emissions, increase net ecosystem carbon budget and reduce carbon footprint in saline cotton fields. *Agriculture, Ecosystems & Environment*, *366*, 108912. https://doi.org/10.1016/j.agee.2024.108912

Zib, L., Byrne, D. M., Marston, L. T., & Chini, C. M. (2021). Operational carbon footprint of the U.S. water and wastewater sector's energy consumption. *Journal of Cleaner Production*, *321*, 128815. https://doi.org/10.1016/j.jclepro.2021.128815

Sustainable Pool Management

Background

Municipal pools are community hubs, but they come with significant resource demands in terms of water, chemical additives, energy, and staff time. Managing them sustainably means balancing energy and water efficiency with safety and public satisfaction. With growing concerns about climate change and utility costs, cities are increasingly seeking more sustainable ways to operate pools without compromising hygiene or user experience. There is a leap of faith when people enter a shared pool that has had thousands of bodies in the same water - a belief and expectation that the management of that pool protects public health. Changing approaches to pools, such as altering their appearance, adjusting operating hours, revising cleaning methods, or implementing temporary closures, all pose significant public relations challenges for park departments. Consider this guide as a series of questions to ask and terminology to be acquainted with when considering municipal pool operations.

Sufficiency

The first consideration for a park department should always be sufficiency. Is a municipal pool needed? Does it have sufficient demand? Is there another natural alternative nearby? In Europe, many municipalities opt to create public swimming areas in harbors, rivers, or lakes to provide a safe environment for lap and recreational swimming without having to manage the swimmer-induced water quality requirements that are required for highly artificial, highly treated water bodies. These public pool docks are well-suited for areas with large bodies of water and consistent, mild, or even tidal water flow. As they say - *dilution is the solution to pollution*. These approaches are rare in urban areas of the United States, often due to a combination of public perception, risk avoidance, current or legacy water pollution, or the presence of combined sewer overflow (CSO) outlets.

Pool Heating

Pools are often much-loved and overused, and have fierce and opinionated champions in their communities. Assuming pools are necessary, the next consideration is whether it can be sufficient to have thermally passive outdoor pools that operate seasonally. Indoor heated pools present enormous energy challenges, both for heating the pools and ensuring adequate ventilation to create a comfortable environment and prevent mold growth in the building.

For outdoor pools, one of the simplest ways to reduce energy and water waste is to use a high-quality pool cover. Covers minimize heat loss overnight, significantly reduce water evaporation, and help retain chemical levels. For municipal pools, automatic or semi-automatic retractable covers are ideal, as they offer convenience and safety. Thermal bubble covers and liquid pool covers can also be effective, depending on the pool's usage patterns and budget. Evaporation accounts for a significant portion of the energy and water loss in outdoor pools. Apart from using covers, design strategies such as wind barriers, landscaping, and proper shading can also help. Installing physical barriers, such as fences or hedges, reduces wind across the water surface, thereby limiting evaporation. Trees can provide shade, but must be chosen carefully to avoid excess debris falling into the water.

Using black or dark-colored tiles in outdoor pools can passively increase water temperature by absorbing more sunlight, potentially reducing heating demands. However, there are trade-offs. In hot climates, this can lead to overheating and discomfort, and darker surfaces can make it harder to visually assess water clarity—a significant safety and hygiene factor. Dark basins are best suited for use in cooler climates, and maintenance staff must be trained to closely monitor water quality, as the obvious visual cue of turning green may be challenging to detect. At the same time, they can be beautiful because dark basins make the water surface more reflective - this is part of the reason why dark tile pools are more common in the high-end hospitality industry.

For indoor pools, heating is often the most significant energy draw in a public swimming facility. Traditional gas or electric heaters are effective, but they are also costly and carbon-intensive. Switching to solar thermal systems can drastically reduce heating costs and emissions, especially in sunny regions. These systems use rooftop or nearby solar panels to preheat pool water, reducing reliance on fossil fuels. For colder climates, high-efficiency heat pumps—which draw heat from the air—can be a cleaner, cost-effective solution over time, but may require a backup system to boost reliability.

Efficient Water Use

For pools in general, efficient water use in municipal pools involves both technological improvements and behavioral management. Regular leak detection, backwash optimization, and bathroom and shower upgrades can collectively save thousands of gallons of water annually. Encouraging patrons to shower before swimming not only reduces water contamination but also decreases the need for chemical top-ups and filter backwashing. Implementing smart water meters enables real-time tracking and early detection of leaks.

Many communities are interested in exploring alternatives to chlorine. Chlorine remains the gold standard for disinfection, but it's not without drawbacks: it's harsh on the skin, produces harmful byproducts like chloramines, and requires regular monitoring. Chlorine manufacturing is also a high-emissions process, with 2-4 tons of carbon dioxide emissions per ton of product. The trick with alternatives to chlorine is that chlorine is so reliable and, if properly managed, is also a relatively low-cost way to ensure public safety.

Salt Water Pools

Some municipal pools, particularly in Europe, are now exploring alternatives such as saltwater chlorination, ozone systems, and UV disinfection. These systems can either replace or complement chlorine, improving water quality and reducing chemical use. For instance, UV light systems inactivate pathogens, allowing for lower chlorine dosages while maintaining safety. With many states now requiring UV treatment systems as part of the codes needed for interactive recirculating public fountain design, we recommend that UV filtration should be more widely considered for pools, regardless of whether chlorine is used or not. UV filtration denatures proteins, making it one of the few water treatments that can also kill viral particles.

Saltwater pools have gained popularity as a gentler, lower-maintenance alternative to traditional chlorine systems. These pools use a chlorine generator that converts salt into chlorine through electrolysis, providing continuous, lower-level sanitation that reduces harsh odors and skin irritation. While saltwater pools still use chlorine, they require fewer chemical additions and produce fewer harmful byproducts. Saltwater pools can be delightful to swim in - the lower level of chemicals can be less irritating to the skin and eyes. Saltwater pools have drawbacks. The high salt content can be corrosive to pool equipment, metal fixtures, and even surrounding surfaces, such as stone or decking, if not properly maintained or if incorrect materials are used in the initial installation. Because of this, it is not recommended to attempt to convert traditional pools to saltwater without a complete replacement of all system components susceptible to salt corrosion.

Additionally, saltwater systems typically have higher upfront costs and require periodic replacement of salt cells, which can be expensive. Balancing the water chemistry in a saltwater pool still requires attention and care, especially to prevent scale buildup and maintain adequate sanitation. The hospitality industry has more commonly adopted saltwater pools due to these requirements.

Natural Pools

A more niche approach has been the natural swimming pool movement, which uses plant-based biological filtration zones instead of chemical disinfectants and/or direct connections to natural water bodies. Famous natural pools, like the Icebergs wave pool at Bondi Beach in Australia, simply pump in clean water from a lake or ocean (or let it crash in) and out. These systems have no chemical additives and are more like a basin version of the European dock approach mentioned above. The primary maintenance on these installations is cleaning - while there are decent anti-fouling surfaces, these open systems will still require weekly or daily scrubbing to keep clean. Another approach to natural pools relies on aquatic plants, beneficial bacteria, and gravel filtration beds to purify the water. Although not yet widely adopted in municipal use due to space and maintenance requirements, they offer a nearly chemical-free alternative that aligns with sustainable and biodiversity goals, especially in parks or naturalistic settings. These systems are often of a residential scale and have usage limits due to the capacity of the filtration systems.

Automation

For all pools, automation is key to efficient management. Digital controllers that monitor temperature, pH, chlorine levels, and flow rates help ensure optimal conditions with minimal human intervention. These systems can adjust heating and chemical dosages in real-time, reducing waste and enhancing safety. Investing in remote monitoring also enables maintenance teams to respond promptly to issues, thereby minimizing service downtime and energy inefficiencies.

Patron Management And Staff Training

Efficiency isn't just about hardware; it's also about habits. Training lifeguards and maintenance teams in sustainability practices—from cover usage to leak reporting—is essential. Public education also plays a role. Posting signs that encourage short showers, sunscreen alternatives (to reduce water contamination), and proper pool hygiene can have a measurable impact on both water and chemical conservation. One consideration for pool operators is to have their staff participate in Aquatic Facility Operator (AFO) certification.

AFO certification offers numerous benefits for pool operators, equipping them with the knowledge and tools necessary to manage aquatic facilities safely, efficiently, and in compliance with relevant health regulations. The AFO program covers key topics like water chemistry, filtration systems, risk management, and facility maintenance, equipping operators with a comprehensive understanding of how to keep pool water clean and equipment running smoothly. This expertise helps prevent costly mistakes, such as improper chemical use or equipment failures, and ensures a safe and healthy swimming environment for users. Certified operators are also better prepared to meet local and state regulatory requirements, which can reduce liability and improve inspection outcomes. Operating pools effectively, with the proper training and maintenance, can avoid emissions and expensive retrofits, improve efficiency, and extend the lifespan of municipal pool facilities. Sustainable pool management can reduce costs and environmental impacts for a much-loved civic amenity.

Case Study: Harold Alfond Athletics and Recreation Center, Waterville, ME

By Alison Nash

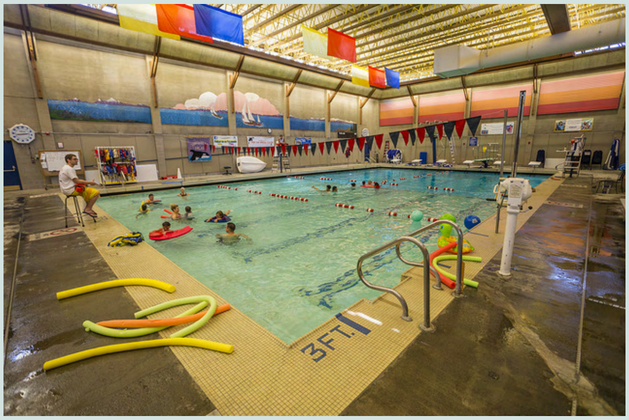
Innovative filtration to save water at the Harold Alfond Athletics and Recreation Center at Colby College. Image attribution: Sasaki
Contact: anash@sasaki.com

The Olympic-size Myrtha pool is the largest in the state of Maine and was designed to accommodate large championship events for the region. Designed for an abundance of light and no glare, the aquatics center is arguably the gem of the entire facility. This LEED Platinum multi-sport facility went beyond looking at only low-flow plumbing fixtures to conserve indoor water use. Typical natatorium filtration systems rely on sand filters for the backwash process. The Myrtha pool utilizes a regenerative media filtration system, which requires 80-90% less water than a conventional system, resulting in hundreds of thousands of gallons saved annually for this facility. Other benefits of this regenerative filtration system include a smaller physical footprint, taking up on average 10-25% less space within mechanical rooms, and requiring smaller piping diameters to discharge flushed wastewater into the sewer.

The new LEED v5 takes into account process water conservation. Thinking outside of the box in early phases of design using a “one water” approach, along with a detailed analysis to include the initial capital expenses, annual operating expenses, and projected maintenance & replacement costs enabled the Colby design team to realize the benefits of what was a less prevalent technology in 2016 when the system was proposed. Other benefits, which were not necessarily considered at the time, include the ability to filter smaller particle sizes, between 1-5 microns for a regenerative system, compared to an average of 25 microns for a sand system. The ability to filter to a smaller particle size means that the pool water is cleaner for swimmers. Today’s public is concerned about human health, social well-being, and equity, and demands transparency in the health and social impacts of their purchasing decisions by seeking third-party verified material information. Sharp Sand is one of the most at-risk materials globally for forced or exploitative labor practices. In contrast, diatomaceous earth and perlite, the raw ingredients of regenerative media, are mined in North America. Like the ripple effects on the surface of water, design decisions such as the selection of a filtration media can have a far-reaching impact, extending to include numerous positive effects on water conservation, space planning, human health, and social well-being.

Case Study: Comprehensive Pool Energy Efficiency Initiative, Seattle, WA

By Valerie Pacino



Seattle's municipal pools (including Southwest Pool, pictured here) are getting innovative upgrades that reduce energy use while maintaining comfortable swimming conditions for thousands of community members. Image attribution: Seattle Parks and Recreation.
Contact: Joelle.Hammerstad@seattle.gov

A model for aquatic facilities seeking to balance energy efficiency with exceptional community recreation, Seattle Parks & Recreation has transformed pool operations across seven indoor facilities and one outdoor pool through energy efficiency that addresses the unique challenges of aquatic facilities. As municipal pools rank among the most energy-intensive buildings in Seattle's portfolio, this comprehensive initiative demonstrates how strategic technology integration can achieve significant energy savings while maintaining optimal swimming conditions.

The foundational elements of the efficiency program began with pool covers, LED lighting, and variable-speed pool circulation pumps. Recent improvements include upgrading pool covers to be integrated with HVAC controls. This innovation automatically slows ventilation when covers are deployed, reducing humidity, heat loss, and chloramine production. First tested at Southwest Pool, the system achieved measurable electricity savings by allowing ventilation systems to operate at reduced levels during covered periods, while maintaining proper air movement with the use of circulation fans.

Additionally, Seattle installed enhanced ventilation systems at Madison Pool, Queen Anne Pool, and Rainier Beach Pool. These systems offer multifunctional benefits, including enhanced humidity control, building protection through negative pressure management, and energy recovery through heat pump technology, reducing reliance on gas boilers while preventing humid air and chloramines from entering other building areas.

Meanwhile, Pop Mounger Pool became Seattle's first facility with electric heat pump pool heating when its smaller pool's gas system failed. The innovative replacement successfully brought the teaching pool to temperature for opening weekend, demonstrating the viability of heat pumps for pool applications while eliminating direct fossil fuel combustion.

Each installation builds on lessons learned from previous projects, with pilot testing at facilities like Meadowbrook Pool informing refinements to the system. This methodical approach ensures optimal performance while supporting Seattle's Municipal Buildings Decarbonization Plan goal of eliminating fossil fuels from city facilities by 2042.

Key Strategies & Considerations

- First, consider if pools are necessary or if natural options are available.
- When considering a new pool, determine if an outdoor facility can suffice and if alternative pool systems, such as saltwater or natural pools, can accommodate the scale of use and budget.
- For indoor and outdoor pools, use pool covers to reduce evaporation and heat loss.
- For heated pools, consider solar and/or heat pump alternatives as energy sources and potentially necessary supplemental energy sources.
- Invest in automated smart systems.
- Consider Aquatic Facility Operator (AFO) certification for staff.

Helpful Resources and References

Bensould, Y., et al. (2023). “Thermal Performances Sensitivity Analysis for Solar Thermal Technology Integration to Swimming Olympic Pool: The Case of Morocco.” Applied Solar Energy, vol. 59, pp. 30–43.

Chertoff, J. (2018). “What Are the Pros and Cons of Saltwater Pools?” Healthline. www.healthline.com/health/salt-water-pool.

Faro, M., et al. (2021). “Swimming Pool Thermal Energy Storage, an Alternative for Distributed Cooling Energy Storage.” Energy Conversion and Management, vol. 230, pp. 113796.

Hoffman, M. C., Berghage, R., & Wu, H. (2023). Comparing Vegetation and Substrate Performances on Nutrient Removal and Biomass Establishment Using a Natural Swimming Pool Experiment. HortTechnology, 33(6), 499-511. https://journals.ashs.org/horttech/view/journals/horttech/33/6/article-p499.xml

National Recreation and Park Association (NRPA). (n.d.) Aquatic Facility Operator (AFO) Certification. https://www.nrpa.org/certification/AFO/

U.S. Department of Energy. (2024). Heat Pump Swimming Pool Heaters. Energy.gov., www.energy.gov/energysaver/heat-pump-swimming-pool-heaters

U.S. Department of Energy. (2024). Pool Covers for Energy and Water Conservation. www.energy.gov/energysaver/swimming-pool-covers

Environmentally Friendly Cleaning Products

Background

Switching to environmentally preferable cleaning products is one of the easiest and most impactful ways janitorial teams can lower their facility's climate footprint. Traditional cleaners often contain volatile organic compounds (VOCs), petroleum-based ingredients, and non-biodegradable surfactants, all of which contribute to greenhouse gas emissions during production, use, and disposal. In contrast, green-certified products—typically bearing third-party labels such as Green Seal or the EPA's Safer Choice—are formulated to minimize emissions, reduce harm to aquatic life, and break down more easily in wastewater treatment systems. For park operators and custodial teams, these swaps can align with broader sustainability goals without sacrificing performance.

Reducing Waste and Using Concentrates

Many departments that make the switch to climate-friendly cleaners start with the "low-hanging fruit." This often means replacing glass cleaners, general-purpose sprays, and floor cleaners with certified alternatives that exclude toxic ingredients and reduce embodied carbon. Concentrated formulations that are diluted on-site can drastically reduce emissions associated with transportation—resulting in fewer plastic jugs, less weight, and a lower frequency of delivery. Some systems utilize wall-mounted dispensers that mix precise amounts of cleaner with water, thereby reducing waste and helping staff avoid overuse, which in turn lowers costs.

Electrolyzed Water and Aqueous Ozone

Another shift gaining traction is the adoption of electrolyzed water and aqueous ozone systems, which allow janitorial teams to clean using water that has been electrically charged to create a short-lived, highly effective cleaning solution. This approach has been widely used in industrial and medical practices, where salt and water are combined to produce hypochlorous acid in solution, serving as a powerful disinfectant and cleaning agent. With the pandemic, these systems have gained popularity in many new sectors, including hospitality and the food industry. They could also be an interesting and innovative approach to the janitorial services of park departments. These technologies reduce the need for purchased chemicals entirely and eliminate most packaging waste. While the upfront equipment cost is higher, the long-term cost savings can be significant, and the environmental impact is significantly lower. These systems are especially useful in high-traffic facilities where cleaning occurs frequently and reliably, and could be particularly relevant for restrooms, visitor centers, and locker rooms.

Changing Practices

Of course, not all green cleaning efforts involve swapping products—changing practices also matters. Using microfiber cloths instead of paper towels, for instance, reduces waste and improves cleaning efficiency. Training janitorial staff in the right dosing, targeted cleaning (as opposed to indiscriminate spraying), and spot-cleaning rather than whole-area chemical use can reduce emissions and exposure while preserving indoor air quality. And with any change in operations, communication is key: helping staff understand why a new product or tool is being used can improve adoption. Change takes persistence and patience. Some team members may be skeptical of green products at first—especially if they've had bad experiences with "natural" cleaners in the past that didn't perform well. Piloting products and getting staff feedback before a full rollout can help build trust and buy-in. Ultimately, every spray bottle swapped and every paper towel saved adds up. While the challenge of reducing carbon in park operations is complex, cleaner cleaning is one step that's practical, visible, and, with the proper support, entirely doable.

Key Strategies & Considerations

- Consider adopting green-certified products—typically bearing third-party labels like Green Seal or the EPA’s Safer Choice—and trial-test them with your staff.
- If you're looking for innovative solutions, consider exploring electrolyzed water and aqueous ozone systems.
- Consider providing staff training, such as ‘sufficiency training’ like spot cleaning, and consider periodic monitoring to ensure new products are being used correctly.

Helpful Resources and References

U.S. Environmental Protection Agency. (2023). Safer Choice Standard. https://www.epa.gov/saferchoice/safer-choice-standard

Green Seal. (2024). Green Seal Standards for Cleaning Products. https://greenseal.org/standards

UL Solutions. (2023). ECOLOGO Certification Program. https://www.ul.com/resources/ecologo-certification-program

Salonen, H., Castagnoli, E., Täubel, M., & Morawska, L. (2024). Cleaning products: Their chemistry, effects on indoor air quality, and implications for human health. *Environment International*, *190*, 108836. https://doi.org/10.1016/j.envint.2024.108836

Khalid, N. I., Sulaiman, N. S., Ab Aziz, N., Taip, F. S., Nor-Khaizura, M. A. R., Sobri, S., & Abd Rahim, M. H. (2024). Assessing the efficacy of electrolyzed water for sanitizing contaminated stainless-steel surfaces in the meat industry. *Journal of Food Engineering*, *382*, 112199. https://doi.org/10.1016/j.jfoodeng.2024.112199

Albir, C. (2021). “The Environmental Impact of Traditional vs. Green Cleaning Products.” Facility Management Journal, vol. 35, no. 4, 2021, pp. 52–59. https://www.linkedin.com/pulse/environmental-impact-green-cleaning-facility-executive-magazine-gteae/

U.S. Green Building Council. (2022). LEED v4.1 Building Operations and Maintenance Guide. USGBC. https://www.usgbc.org/leed/v41

TRUE Zero Waste Certification. (2024).TRUE Rating System Guide. Green Business Certification Inc. https://true.gbci.org/resources

Leusink, J. (2020). “Cleaning With Liquid Ozone: What You Need to Know.” Oxidation Technologies News. https://www.oxidationtech.com/blog/cleaning-liqucleaning-with-liquid-ozone-what-you-need-to-knowid-ozone-need-know

Chapter 3: Zero Waste Planning

Diverted Stream Waste Management

Background

Diverted Stream Waste Management is one of the most well-known and implemented environmentally friendly park operations strategies. This can be as simple as separating recyclable materials from trash and managing each waste stream accordingly. This section will focus on collecting recyclable materials. Part of diverted waste management includes collecting green waste, which is outlined in this guide as a separate section.

Comingling Recycling

In many parks and municipalities, three-stream waste management is already well established. Three streams typically separate mixed recycling, trash, and green waste. The benefit of commingled recycling is that it lowers the barrier to participation and increases the overall mass of material included in the recycling collection. The difficulty lies in the downstream effort of processing and separating individual waste streams, such as cardboard, paper, aluminum, glass, and plastics. There are examples of highly sophisticated optical and robotic-assisted recycling separation plants that supplement human labor, such as programs by Recology in San Francisco, which manage to recycle high percentages (reporting as much as an 85% recovery) of materials captured in collections. These systems are relatively nascent; what is more common (at the time of writing these guidelines) are mechanical separators that comb out different materials from the mix. The downfall of these separators is often that whole batches of materials either gum up the machinery or are compromised by inappropriate materials that 'contaminate' batches. The EPA estimated that in the United States, the general percentage of recovered material from commingled recycling (represented by the overall recycling rate for Municipal Solid Waste (MSW)) was just 32.1 percent in 2018.

Material Specific Recycling

An alternative to commingled recycling is material-specific recycling. Material stream-specific recycling can be achieved simply by having can- or bottle-specific recycling containers and committing to recycling only one or two waste streams. This approach can make a lot of sense for public park landscapes, where the majority of the recycled content may be cans or plastic bottles, with a lesser need for paper and glass recycling. In states where deposits on bottles and cans can encourage recycling, some park departments and municipalities have adopted container toppers on top of trash or mixed recycling bins. These toppers encourage people to place their cans and bottles on top, allowing deposit hunters to retrieve the containers without having to dig through the bin. This can be a way to reduce the amount of material trash collectors have to pick up while servicing the bins ,and also reduce the temptation for deposit hunters to dump out the bin and root through the materials.

Separated Stream Waste Management

Another alternative is to have more waste stream separation options at the collection point. Some green building certification regimes, such as TRUE (Total Resource Use and Efficiency) Zero Waste Certification, reward separated stream waste management – including separate collection for aluminum, glass, plastic, paper, organic waste, and trash. The benefit of separated stream waste management is the efficiency of collection and higher material recovery rates. The downfall is the potential for patron confusion. Clear and intuitive signage, education campaigns, and waste stream-specific physical constraints are all helpful in separate stream collection. For park operators, separated stream waste management may be most effective in areas with cafes, event venues, or building facilities. In open recreational landscapes, two to three bins alone can be sufficient for most materials.

Managing Park Users

The biggest change for effectively collecting recycling is managing and educating the park users. Directly connecting stewardship and appreciation for the parks to respectful placement of trash and recyclables may be one of the greatest challenges for park operators. There seem to be many roots of the issue – convenience, inattention, nihilism - but the unfortunate reality is even with clear signage and high-quality receptacles, a percentage of the population will either litter or screw up what goes in which bin, regardless.

Park operators should consider opportunity and desire points for waste. Placing bins where they are easily seen, accessible, and near where people are likely to have waste immediately reduces the opportunity for litter. In parallel with this is the provision of adequate service – once trash bins fill up, the public immediately starts placing their trash in the recycling bins. Satisfactory service is made easier with clearly visible and easily accessible lined bins and rain-excluding lids. Smart waste solutions can improve efficiency. Many departments have already started using products like Big Belly trash receptacles that share information with a central collection facility on fullness and include compaction functionality. There are simpler smart systems on the market now, such as SensorWorks, where sensors can be added to the roof of the receptacle, reporting on the percentage filled. These systems communicate when bins require service, allowing for more targeted service rotations, more frequent service during high-use periods, and less frequent service during low-use times.

The final strategy is shame and fines. The challenge with litter and inappropriate waste disposal is a tragedy of the commons – a public space offers no immediate tangible reward for good behavior. Therefore, some operators must adopt more aggressive strategies. On the mild end, having more maintenance staff and park ambassadors visible in high-use areas can reduce these behaviors. On the more aggressive end, working with local law enforcement or park rangers to distribute fines can be effective. A personal favorite once observed abroad was a ‘pinboard of shame’ featuring local litterbugs caught on security cameras.

Case Study: Diverted Waste Management at Yerba Buena Gardens, San Francisco, CA

By Subhajeet Ghose

Website:www.yerbabuenagardens.org
Contact: sghose@ybgardens.org

The City and County of San Francisco requires all city sites to recycle and sort 100% of their refuse. At Yerba Buena Gardens, we accomplish this enormous task with a contract worth nearly $300,000 annually. All the refuse collected on our Gardens campus is hand-sorted and recycled, thereby reducing the total amount that ends up in landfills. Knowing the statistics of available landfills and landfill space, this work is gratifying. There were over 3,000 operational landfills in the mainland US forty years ago. Now there are fewer than a thousand active ones left, and most of them are not in the high-waste-generating States. Why that statistic is essential is that with a full or no available landfill in your State, you will have to drive far to find one and pay a lot to dispose of waste. Our sorting is conducted through a professional services contract with a private firm, and we are very close to achieving a 100% recycling goal.

Case Study: Plan For Environmentally Friendly Events And Meetings, Dallas, TX

By Frances McGee

Dallas Park and Recreation Employee Awards.
Image attribution: Frances McGee
Website: https://www.dallasparks.org
Contact:frances.mcgee@dallas.gov

Dallas Park and Recreation is working to have environmentally friendly events and meetings. Here is an example of actions taken for our annual employee's award ceremony. It is wonderful to gather employees together for events, but these gatherings can have a significant environmental impact in terms of the amount of waste generated. Here are some changes the Park and Recreation Department is implementing for employee events to make them more eco-friendly. Select decorations that can be recycled or reused. Instead of purchasing excessively packaged or single-use decorations, natural elements such as plants, flowers, fallen leaves, or twigs are used for table centerpieces. In place of balloon arches, paper garlands, fans, flowers, or pom poms can be used to create a festive environment.

Additionally, lights are a great option that can be reused. Plastic, single-use tablecloths are replaced with cloth ones that can be reused for other events. Cloth tablecloths elevate the atmosphere of the event.

Dishware - Single-use dishes, plastic utensils, and paper napkins generate a significant amount of waste. Opt for washable, reusable dishware to prevent excess waste. If reusable options aren't available, consider using paper or compostable plates and avoid using styrofoam. Finding eco-friendly utensils can be more challenging, but compostable, bamboo, or plant-based plastic utensils are a greener option. Provide compostable or paper coffee cups, opting once again not to use Styrofoam. Choose drinks that come in recyclable containers, like plastic bottles and aluminum cans, and encourage attendees to recycle them. Provide recycling containers to collect recyclable items, such as plastic bottles, aluminum cans, and paper programs, generated during the event.

Key Strategies & Considerations

- Identify the viable recycling waste streams available in your local area.
- Determine the capacity for managing mixed versus separated stream waste.
- Anticipate park patrons' desired locations for disposing of waste and ensure there are sufficient bins to minimize the risk of litter.
- Consider adopting smart systems to monitor fullness and be more selective with trash removal rounds where possible.

Helpful Resources and References

Honeyager, M. (2015). "Single Stream Versus Source Separation Recycling." RecycleNation, 13. recyclenation.com/2015/03/single-stream-versus-source-separation-recycling/.

Kar Parivartan LLP. (2023). "Benefits of Waste Segregation." www.karparivartan.com/benefits-of-waste-segregation/

Lakhan, C. (2015). "A Comparison of Single and Multi-Stream Recycling Systems in Ontario, Canada." Resources, vol. 4, no. 2, 2015, pp. 384–97.

The Park and Facilities Catalog. (n.d.) Buyers Guide for Trash Receptacles. https://www.theparkcatalog.com/trash-receptacles-buyers-guide?srsltid=AfmBOorImknmf2_xudvJGbGTphEEPyXqVZbw7zZyLA41xK9pwmFLgqf5

U.S. Environmental Protection Agency. (2024). Contracting Best Practices: Source Separation Requirement or Preference. www.epa.gov/transforming-waste-tool/source-separation.

National Recreation and Park Association (NRPA). (n.d.).*Reducing Waste and Recycling*:Resources for agencies to advance efforts in reducing waste and recycling. https://connect.nrpa.org/viewdocument/reducing-waste-and-recycling-nrpa?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

National Recreation and Park Association (NRPA). (2025). Strategies for how FiveRivers Metro of Dayton, Ohio improved waste management practices, webinar. https://connect.nrpa.org/viewdocument/improving-waste-management-practice?CommunityKey=33a261e5-5285-44ff-a31d-cce5b35d1317&tab=librarydocuments

National Recreation and Park Association (NRPA). (2022). Tree of Life: How an Urban Wood Program Can Add Another Stage to a Tree's Life Cycle and Build a Circular Economy, conference session. https://learning.nrpa.org/products/tree-of-life-how-an-urban-wood-program-can-add-another-stage-to-a-trees-life-cycle-and-build-a-circular-economy

National Recreation and Park Association (NRPA). (2022). Automated Waste Collection in Denver Parks, conference session.
https://learning.nrpa.org/products/247-automated-waste-collection-in-denver-parks

Pritchard, R. (2023). Composting for Waste-Free Programs and Events. Parks & Recreation.
https://ezine.nrpa.org/nrpa/ParksRecreationMagazine/april-2023/index.php#/p/18

Kapustin, B. (2025). Parks and Recreation: Advancing Colorado's Sustainability Movement. OPENSpace. National Recreation and Park Association (NRPA).
https://www.nrpa.org/blog/parks-and-recreation-advancing-colorados-sustainability-movement/

Circular Economy

Background

Material circularity is about rethinking the way we use resources—designing systems where materials flow in a continuous loop rather than being used once and then discarded. In a circular system, products are designed to be reused, repaired, remanufactured, or recycled, ensuring that materials remain in use for as long as possible. It's the opposite of the traditional "take-make-waste" model, where raw materials are extracted, made into products, and then end up in landfills. The goal of material circularity is to reduce waste, conserve natural resources, and minimize environmental impacts. When selecting products and materials for our parks, we want to consider what happens at the end of their lifecycle: can we reuse, repurpose, downcycle, or refurbish them? How can we prevent these materials from entering waste streams?

There is a hierarchy of decisions for circular economy - the highest priority is to use and reuse. Park operators can take inspiration from the cobble streets of New York, which have been relaid since the 19th century when they were imported from Belgium as ballast. There is inspiration in many traditional and vernacular materials, such as dry-stacked stone wall traditions from around the world. If reuse is not feasible, repurposing or 'downcycling' can reduce landfill waste and associated transportation emissions. This can involve crushing concrete sidewalks for road base, or chipping old deck boards for a wood chip mulch. Below this priority is material recycling, and the scenario to avoid is trash.

Deconstruction

One of the best-known examples of material circularity is in the deconstruction movement. Thoughtful deconstruction of products, furniture, and buildings could enable potential demolitions to be disassembled and reused in new projects, mirroring the natural cycles of generation and decomposition instead of being demolished and sent to landfills.

For park operations or facilities management, circularity may involve reusing crushed concrete for pathways, composting green waste into mulch for landscaping, or selecting supplies from vendors that offer take-back programs. There are many considerations that park operators and designers can take into account when detailing for circularity. Some best practices include using monolithic materials, such as concrete sidewalks without rebar, so it's easier to cut out a panel for repair or future reuse. Others include having accessible fasteners, for example, decking screws on the face of the board, so it's easier to replace and salvage the decking.

Cradle to Cradle

The key is to look beyond just recycling—true circularity means designing waste and toxins out of the system from the start. This may require upfront planning or new purchasing policies, but it pays off in the long term through reduced emissions, decreased waste, and cost savings. This can pertain to long lifecycle materials - such as planning for the end of life for paving materials, or short lifecycle materials - such as moving away from disposable serving materials in park concessions.

There are several helpful guides on selecting products with long life cycles, the most significant one being the Cradle to Cradle certification. Coined by William Mcdonough, author of the seminal sustainability charge The Hannover Principles in 1992, Cradle to Cradle (C2C) is a design framework (and book and website) that promotes a closed-loop system where waste is eliminated and materials are continuously circulated as nutrients for new products.

Key Strategies & Considerations

- Design for use, reuse and disassembly.
- Develop procurement standards for furnishings and products that include a clear end-of-life management plan, such as the ability to be returned to the manufacturer for refurbishment or recycling.
- Use monolithic natural materials that can be reset, or upcycled into other construction elements, such as stone or mass timber.
- Avoid using disposable containers or products in maintenance activities, such as replacing paper towels with microfiber rags for cleaning purposes.

Helpful Resources and References

Schneider, D. (2024). “Circular Economy in the Construction Industry.” Drees & Sommers. https://www.dreso.com/de/en/news/details/circular-economy-in-the-construction-industry

Ellen MacArthur Foundation, (2021). “City Hall from Cradle to Cradle: Venlo.” https://www.ellenmacarthurfoundation.org/circular-examples/city-hall-from-cradle-to-cradle-venlo

Addis, B. (2006). *Building with Reclaimed Components and Materials: A Design Handbook for Reuse and Recycling*. Routledge.

Brown, Z. (2022). *Design for Deconstruction: Nexii Circular Economy Case Study* | Nexii Building Solutions | Green Construction Company. Nexii Building Solutions.

McDonough, W. (2002). *Cradle to Cradle: Remaking the way we make things.* North Point Press.

Plevoets, B., & Van Cleempoel, K. (2019). *Adaptive Reuse of the Built Heritage: Concepts and Cases of an Emerging Discipline.* Routledge.

Stone, S. (2019). *UnDoing Buildings: Adaptive Reuse and Cultural Memory.* Routledge.

U.S. Environmental Protection Agency. (2016). Sustainable Management of Construction and Demolition Materials. https://www.epa.gov/smm/sustainable-management-construction-and-demolition-materials

Wong, L. (2016). *Adaptive Reuse: Extending the Lives of Buildings.* Birkhäuser.

Green Waste & Biomass Management

Background

The Green Waste generated by park operations, such as lawn clippings, pruned branches, and collected food waste, is all potential resources for enhancing the health, resilience, and experience of the park landscape. These materials can be collected and processed to produce mulches, soil amendments, or, in some cases, furnishings. These materials can be collected and processed to produce mulches, soil amendments, or, in some cases, furnishings. Municipalities across the country are reconsidering how they manage their waste wood, from salvage and upcycling to biochar. The Urban Wood Network has been formed to share lessons learned and provide an information-sharing platform for urban wood utilization. The implementation of these strategies can benefit from multi-agency collaboration, as seen in Harrisonburg, VA, where the Virginia Department of Forestry sponsored a program to support local municipalities. This support jump-started the program, which has now evolved into a successful urban wood reuse and upcycling initiative. In that case, the work was initiated in response to the loss of large numbers of ash trees due to the emerald ash borer, and has since grown in complexity and scope. Other cities with clear and well-established urban wood reuse programs include Baltimore, Milwaukee, and Cincinnati.

Material Reuse

Creative uses of green waste can immediately catch the public's eye and often be appreciated. Using chainsawed logs as benches or art can require significant skill, as seen in the recent work of Demetrio Braceros in Cayuga Park, San Francisco. This can be a great way to memorialize a loved one's fallen tree. The construction of hibernaculum (animal wintering shelters) out of debris, logs, and soil can create a great ecological function and educational exhibit.

These kinds of informal reuse of green waste can be taken to a more refined level with the production of real finished projects. Small local mills and innovative companies, such as Carbon Smart Wood, can harvest cut trees from a park, for instance, after extreme weather, and process them into usable timber, including thermally modified timber in some cases, which is suitable for outdoor applications.

Mulch

The most common (in terms of mass) green waste product is often mulch or wood chips. As mentioned earlier in this guide, wood chips are a beneficial soil top dressing for tree protection and moisture retention. Regarding mulching, best practices vary widely depending on the type of tree and planting conditions. Using wood chips or ground hardwood mulch can be crucial for enhancing water retention, reducing compaction, suppressing weeds, and gradually contributing to soil organic carbon (SOC). These top dressings mimic the natural decomposition of organic material that falls on the ground in forests and begins to decompose, referred to as 'duff' by ecologists. Duff is an essential source of humic acids (complex recalcitrant organic compounds) in natural systems and plays a crucial role in plant and soil health in some plant communities.

Humic acids enhance nutrient availability, improve soil structure, and improve microbial activity, ultimately contributing to a healthier and more fertile soil environment. Wood chips, ground mulch, and composted and ground leaf litter all provide humic acids and can contribute to soil SOC, but they have different durations. Leaf mulch can blow away/decompose in less than a full growing season; ground mulch may last a couple of years if placed in at least a 2" layer. Wood chips can last 4 years or more. A common misconception has arisen that woodchip mulch depletes soil fertility, leading many municipalities to avoid its use. This myth is based on a well-documented decrease in nitrogen levels at the wood chip-soil interface as saprotrophic fungi begin to decompose the wood chips. This depletion is short-term and only occurs at that interface; it does not extend down into the soil rooting volume and serves as part of the weed suppression character of wood chip applications by decreasing the nutrients available to surface seeds. The primary concern when using wood chip mulch should be ensuring that the chips do not contain poison ivy, sumac, or oak in the potential wood sources, and that any potential invasive seeds, such as kudzu or Chinese bittersweet, are also excluded from the material stream. With these simple avoidances, wood mulch can be the best option for cost-constrained mulch needs.

Please note that wood mulches are not appropriate for all plant communities. Mediterranean climates, for example, do not naturally accumulate large layers of duff. Excessive wood mulch can even become a fire hazard. In those cases, a layer of light-colored, gap-graded, fine gravel, such as white crushed stone mulch that only passes through a 2mm to 5mm sieve, can still reduce soil water evaporation, provide weed suppression, and mitigate impacts from footsteps or temporary loading on the soil itself.

Managing Herbaceous Waste

For herbaceous materials, such as dropped leaves, cut-back vegetation, and collected grass clippings, composting in an aerobic environment reduces methane emissions and produces a soil-enriching amendment. The first management option is to mulch in place when possible and with suitable soil conditions, such as mulching mowers, or mulching leaf vacuums. Mulching in place allows for quick aerobic decomposition and nutrient cycling. There are several centralized composting methods that parks departments can integrate into their operations. Traditional aerobic composting involves combining organic waste, such as grass clippings, leaves, and food scraps, in windrows or static piles. These piles are periodically turned and watered to maintain aeration and temperature. This method is well-suited for larger parks with ample space and a consistent flow of organic waste. Aerobic composting can efficiently break down materials into nutrient-rich humus that can be reused in landscaping and soil enrichment. Preparing compost in windrows on an asphalt or concrete slab can create an opportunity to collect seepage for use in a composting tea production facility.

Compost Tea

Compost tea involves steeping finished compost in water to extract beneficial microorganisms and nutrients and preparing a liquid fertilizer that can be sprayed on plants or soil to enhance growth and improve soil biology. Compost tea can be a valuable source of fertilizer for parks under organic land management operations, particularly for sports fields and active turf lawns. Compost tea at a large scale often requires specialized hoopers and tanks. It needs to be brewed by trained staff, as it usually involves key amendments and monitoring to ensure the right microbial activity is achieved. For large-scale park operations, investing in a commercial compost tea brewer with integrated aeration and mixing systems can streamline production and ensure consistent quality. It's essential to use the tea immediately after brewing, as microbial populations decline rapidly once aeration stops.

Vermicomposting

Vermicomposting, or composting with worms, offers an alternative, sustainable method ideal for smaller parks or visitor centers where space is limited. This method uses worms (usually red wiggler or equivalent) to process food scraps and sometimes even paper waste, producing high-quality worm castings. While vermicomposting requires more controlled conditions for temperature and moisture, it can be an engaging process that can be incorporated into public programming and school outreach.

Vessel Composting

Another option for parks departments is in-vessel composting, which utilizes enclosed containers or drums to process organic waste. This method is faster and more controlled than traditional composting, minimizing odors and pests, and is particularly useful for urban parks departments with limited space. In-vessel systems can be part of a closed-loop waste management strategy, integrating with municipal food waste programs and landscaping operations to reduce waste disposal costs and environmental impact. As a general note on compositing, operators will want to balance 'carbon,' such as leaves and wood chips, and 'nitrogen,' such as food waste and grass clippings, to develop a balanced soil amendment.

Compost Certification

To ensure high-quality compost that is safe for public use in parks and gardens, departments can pursue compost certification programs, such as the US Composting Council's Seal of Testing Assurance (STA) program. This certification requires regular testing and provides a guarantee of compost quality, which is especially important if the compost is being distributed to the public or used in sensitive environments, such as children's play areas or pollinator gardens. Certification also helps standardize compost quality across and facilitates compliance with municipal and state regulations. While this certification is unusual for park departments (commercial producers are more likely to use it), it can be a great way to ensure a clear quality and safety standard for the materials produced.

An alternative to certification is available through simpler composting training programs, such as those offered by the US Composting Council's Compost Operator Training Course. Many local cooperative extension services also provide hands-on education in compost science, pile management, pathogen reduction, and equipment operation. Such training not only improves operational efficiency and safety but also empowers parks departments to engage the community in composting initiatives, turning organic waste into a valuable resource while advancing municipal sustainability goals.

Biochar

Sometimes, parks departments produce so much green waste that there is no clear use for all the timber, woodchips, clippings, or compost generated. Sometimes, mountains of this material can build up in the hidden back-of-house areas of parks. This author once visited a park where, after the contractor excavated the compost pile placed in the ravine, the compost depth turned out to be over twenty feet deep. This excess waste in deep piles, even those only six feet deep, can begin to undergo anaerobic decomposition, resulting in methane emissions. Methane gas is 86 times more potent a greenhouse gas on a twenty-year timeline than carbon dioxide, so avoiding deep, long-term storage of biomass is important. Excess biomass that ends up in landfills can also contribute significant amounts of methane. Even burning this material is preferable to anaerobic decomposition, such as using waste-to-energy facilities to generate electricity by burning municipal solid waste (MSW) or other biomass materials.

A novel soil amendment utilizes excess biomass, specifically biochar. Biochar is a type of charcoal that is produced by heating organic material (like wood, crop residues, or manure) in a low-oxygen environment—a process called pyrolysis. Incomplete combustion results in a material that is almost pure carbon arranged in an open lattice matrix. This unique structure of biochar features high porosity, a large surface area, and a stable carbon composition. The purity of the material and its structure result in a high sorption capacity (the ability to bind molecules) and a strong resistance to decomposition. So much so that biochar that is suitably prepared (greater than 85% carbon and in a facility that processes the pyrolysis at 700 degrees Celsius), can last for decades as a soil amendment without decomposition. This durability in the environment has justified considering biochar a 'biogenic carbon' material, similar to wood locked up in durable structures. See the section on Reducing Embodied Carbon for more information on the benefits and LCA implications of biogenic carbon. Essentially, it counts as a negative carbon emission for the carbon bound in a stable organic material.

Biochar can also serve as a beneficial soil amendment, particularly in soils of low quality. Biochar can enhance soil texture, increase water-holding capacity, and improve soil microbiological activity. Biochar's sorption capacity makes it an excellent amendment for green infrastructure systems, helping to bind both heavy metals and hydrocarbons from stormwater runoff. For more information on biochar, please refer to MA Healthy Soils Action Plan and Healthy Soils Guide, https://masshealthysoils.org/guide/, or US Biochar Initiative (USBI) https://biochar-us.org/.

This material has great promise in providing a valuable use for green waste that cannot otherwise find a productive way out of a landfill or yard-midden waste stream. Small-scale pyrolysis plants are feasible but require significant investment in staff time for the amount of material produced. Large-scale pyrolysis plants may require an investment of several million dollars to establish the necessary infrastructure. Still, they can then produce relatively large amounts of high-quality material at a more reasonable cost per unit mass. There are lessons learned from the small community of large-scale biochar producers in the United States, such as the City of Minneapolis. For reaching out to a community of producers, the United States Biochar Coalition (USBC) is a valuable resource, available at https://usbiocharcoalition.org/.

Ideally, biochar production facilities would become a standard part of city infrastructure, ensuring that no excess green waste ends up in landfills, and there will be an abundance of this soil amendment available for implementation in both horticultural and agricultural landscapes.

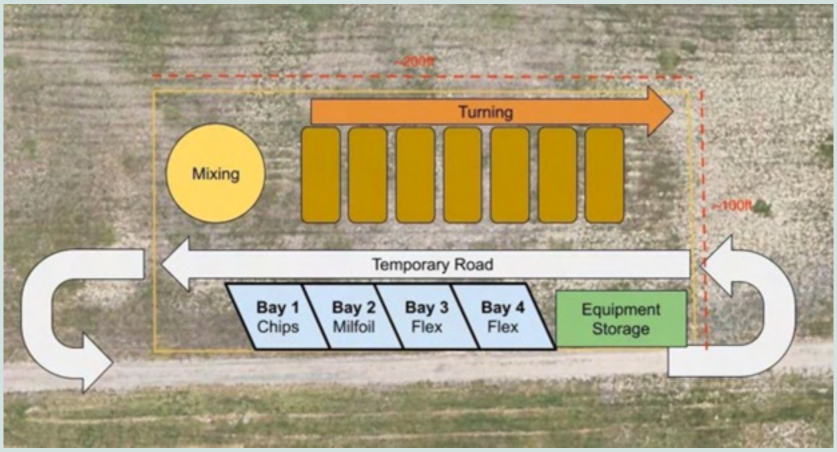
Biomass Consumption

The last and timeless way to manage biomass to avoid green waste is consumption by animals or by fire. Using goats to clear the land of invasives can be a low-cost way to remove difficult vegetation completely. Goats can eat poison ivy, blackberry brambles, thistle, kudzu, and even bracken. If using animals to clear invasive species, intensively grazing goats in a confined space to remove above-ground biomass, followed by grazing pigs to upturn the soil and remove below-ground biomass, can effectively clear and grub a site for invasive species. Controlled burns are effective methods for simulating natural systems and removing excess amounts of accumulated biomass. Researchers have found that landscapes with regular, controlled burns store more carbon in older, fire-resistant trees and in soil organic carbon (SOC) than those that avoid burning and then experience very hot, catastrophic burns that consume all trees and the soil carbon stores. These methods may be more viable for parks located at the interface between urban and rural areas or those adjacent to large-scale natural areas. The US Department of the Interior has clear recommendations and best practices for those considering adopting controlled burns near communities or urban areas at:
https://www.doi.gov/wildlandfire/prescription-safety-burning-wildland-urban-interface.

Green waste can be the largest source of waste and waste-associated emissions for park departments, or it can be the source of valuable materials, including mulch, soil amendments, and even goat cheese. Managing green waste to prevent biomass from entering waste streams is one of the most crucial strategies for a park department to achieve environmentally friendly operations.

Case Study: Considering Biomass Management From Managed Waterways, City of Boulder, CO

By Stacy Cole



Boulder Reservoir composting site map. Image attribution: City of Boulder.
Website: https://bouldercolorado.gov/
Contact: coles@bouldercolorado.gov

Managed by the City of Boulder Parks and Recreation Department, Boulder Reservoir is a vital multi-use resource that provides drinking water, supports diverse recreational activities, and serves as an important ecological habitat. In 2022, Eurasian Water Milfoil (EWM), an invasive aquatic plant, was detected and quickly spread to an estimated 90% of the littoral zone by 2023. EWM poses a threat to recreational safety, marine habitats, and critical water delivery infrastructure. To address the infestation without relying on herbicides, the City of Boulder is developing a non-chemical control program that builds on current manual hand-pulling efforts and incorporates Diver-Assisted Suction Harvesting (DASH), guided by community environmental priorities and restricted by water delivery timing. Modeled after successful national programs, this strategy positions Boulder as a potential regional leader in large-scale, non-chemical management of aquatic weeds. A key innovation is the integration of on-site composting for the removal of plant biomass. Crews hand-pull and transport collected EWM to a city-owned composting site on reservoir property. Here, milfoil is mixed with carbon-rich bulking agents such as wood chips, as well as collected goose droppings from reservoir beaches and picnic areas. This combination not only prevents EWM regrowth but also creates a nutrient-rich compost, reducing landfill use and turning waste into a valuable soil amendment for city landscaping and habitat restoration projects. The inclusion of goose waste helps close multiple waste-management loops by addressing another persistent maintenance challenge at the reservoir. This initiative not only reduces EWM biomass in Boulder Reservoir but also strengthens Colorado's long-term capacity to manage invasive species through skilled field crews, tested operational protocols, and a replicable non-chemical management model. By integrating hands-on removal, on-site composting, and public education, the project builds institutional knowledge, fosters interagency collaboration, and trains the next generation of environmental stewards, creating lasting benefits for water bodies across the state.

Case Study: Treecycling, Dallas, TX

By Frances McGee

Image attribution: Dallas Park and Recreation Forestry Division
Website: https://www.dallasparks.org
Contact: frances.mcgee@dallas.gov

The Dallas Park and Recreation Forestry Division continues to progress in sustainable park maintenance standards with its Treecycling Program, which diverts wood chips from landfills. A trommel sorts wood chips into two piles, one with bigger pieces and one with smaller pieces. The bigger pieces are used as tree grove mulch, and the smaller pieces are used for landscaping beds. In fiscal year 2024-2025, 580 cubic yards were processed and used as mulch for soft trails, "Branching Out" Tree Planting events, trail respite areas, planter beds, and to address soil cracking due to drought conditions. The program not only reuses resources but also saves money. In fiscal year 2024-2025, the production of 580 cubic yards of mulch resulted in approximately $17,400 in savings. Since the program began, 1,080 cubic yards of mulch have been produced, resulting in roughly $32,400 in savings.

The Dallas Park and Recreation Forestry Division continues to progress in sustainable park maintenance standards with its Treecycling Program, which diverts wood chips from landfills. A trommel sorts wood chips into two piles, one with bigger pieces and one with smaller pieces. The bigger pieces are used as tree grove mulch, and the smaller pieces are used for landscaping beds. In fiscal year 2024-2025, 580 cubic yards were processed and used as mulch for soft trails, "Branching Out" Tree Planting events, trail respite areas, planter beds, and to address soil cracking due to drought conditions. The program not only reuses resources but also saves money. In fiscal year 2024-2025, the production of 580 cubic yards of mulch resulted in approximately $17,400 in savings. Since the program began, 1,080 cubic yards of mulch have been produced, resulting in roughly $32,400 in savings.

Key Strategies & Considerations

- Reuse green waste when you can.
- Utilize green waste to produce mulch, compost, or biochar, if possible.
- Managing green waste through grazing or controlled burns has a lower environmental impact than landfills, as it reduces methane emissions associated with anaerobic decomposition.

Helpful Resources and References

Bajoriene, K., Jodaugiene, D., Pupaliene, R., & Sinkeviciene, A. (2013). Effect of organic mulches on the content of organic carbon in the soil. *Estonian Journal of Ecology*, *62*(2), 100–107. https://doi.org/10.3176/eco.2013.2.02

Bergman, R. D., Gu, H., Page-Dumroese, D. S., & Anderson, N. M. (2017). Life cycle analysis of biochar [Chapter 3]. *In: Bruckman, Viktor; Varol, Esin Apaydin; Uzun, Basak; Liu, Jay, Eds. Biochar: A Regional Supply Chain Approach in View of Climate Change Mitigation. Cambridge, UK: Cambridge University Press. p. 46-69.*, 46–69. https://doi.org/10.1017/9781316337974.004

Hand, Carol. (2020). Controlling Invasive Species with Goats. Core Library, Abdo Publishing.

Joseph, S., Cowie, A. L., Van Zwieten, L., Bolan, N., Budai, A., Buss, W., Cayuela, M. L., Graber, E. R., Ippolito, J. A., Kuzyakov, Y., Luo, Y., Ok, Y. S., Palansooriya, K. N., Shepherd, J., Stephens, S., Weng, Z. (Han), & Lehmann, J. (2021). How biochar works, and when it doesn't: A review of mechanisms controlling soil and plant responses to biochar. *GCB Bioenergy*, *13*(11), 1731–1764. https://doi.org/10.1111/gcbb.12885

Lord, R., & Sakrabani, R. (2019). Ten-year legacy of organic carbon in non-agricultural (brownfield) soils restored using green waste compost exceeds 4 per mille per annum: Benefits and trade-offs of a circular economy approach. *Science of The Total Environment*, *686*, 1057–1068. https://doi.org/10.1016/j.scitotenv.2019.05.174

Lund, Danielle. (2025). "Harrisonburg Implements a Second Life for Fallen Trees." The Municipal. https://www.themunicipal.com/2025/01/harrisonburg-implements-a-second-life-for-fallen-trees/

Malone, Z., Berhe, A. A., & Ryals, R. (2023). Impacts of organic matter amendments on urban soil carbon and soil quality: A meta-analysis. *Journal of Cleaner Production*, *419*, 138148. https://doi.org/10.1016/j.jclepro.2023.138148

Malone, Z., Berhe, A. A., & Ryals, R. (2023). Impacts of organic matter amendments on urban soil carbon and soil quality: A meta-analysis. *Journal of Cleaner Production*, *419*, 138148. https://doi.org/10.1016/j.jclepro.2023.138148

McPherson, E. G., Kendall, A., & Albers, S. (2015). Life cycle assessment of carbon dioxide for different arboricultural practices in Los Angeles, CA. *Urban Forestry & Urban Greening*, *14*(2), 388–397. https://doi.org/10.1016/j.ufug.2015.04.004

Piccolo, A. (Ed.). (2012). *Carbon Sequestration in Agricultural Soils: A Multidisciplinary Approach to Innovative Methods*. Springer. https://doi.org/10.1007/978-3-642-23385-2

Saer, A., Lansing, S., Davitt, N. H., & Graves, R. E. (2013). Life cycle assessment of a food waste composting system: Environmental impact hotspots. *Journal of Cleaner Production*, *52*, 234–244. https://doi.org/10.1016/j.jclepro.2013.03.022

Schlickman, Emily, and Brett Milligan. *Design by Fire: Resistance, Co-Creation and Retreat in the Pyrocene*. Routledge, Aug. 31, 2023. *Routledge*, www.routledge.com/Design-by-Fire-Resistance-Co-Creation-and-Retreat-in-the-Pyrocene/Schlickman-Milligan/p/book/9780367767617.

Susskind, Jonah, et al. Playbook for the Pyrocene: Design Strategies for Fire-Prone Communities. XL Lab, SWA Group, Oct. 2023. SWA Group, www.swagroup.com/stories/playbook-for-the-pyrocene/

Wang, J., Fu, X., Zhao, F., & Sainju, U. M. (2018). Response of Soil Carbon Fractions and Dryland Maize Yield to Mulching. *Soil Science Society of America Journal*, *82*(2), 371–381. https://doi.org/10.2136/sssaj2017.11.0397

Chapter 4: Energy & Emissions

Enhance Energy Efficiency in Buildings

Background

Globally, building operations are estimated to account for between 25% and 30% of annual global GHG emissions, according to the AIA, Architecture 2030, and the Carbon Leadership Forum. For parks departments, the conditioned buildings, such as recreation centers, can often account for the majority of utility bills and energy resource allocations compared to the landscape spaces. Parks departments can address these operational emissions through a range of strategies, but each has its nuances and must be evaluated in the context of the specific facility. These are a few considerations that capital improvement managers can consider when evaluating their recreation building facilities. This section focuses on conditioned buildings (those with a sealed envelope, typically equipped with ventilation, heating, and air conditioning.

The first decision should evaluate if the facility or program is needed, and if so, if the program can be accommodated in an existing facility. If the building is in good enough condition to be considered for a retrofit or refurbishment, for the most part, retrofitting a building will have fewer total project emissions than reconstruction, as it avoids the emissions associated with a new structure. However, it can pose many challenges for incorporating new systems. For particularly complex retrofits, these investments can be comparable to building new facilities. Energy efficiency retrofits are a powerful way to enhance building performance, lower operational costs, and minimize the overall environmental impact. For conditioned buildings, one of the most effective retrofit strategies is upgrading the building envelope. This includes sealing air leaks around doors, windows, and other penetrations, which minimizes both heat loss in winter and heat gain in summer. Tightening the envelope helps reduce the workload on mechanical systems, resulting in lower energy use and improved occupant comfort. The focus on air-sealing must be balanced with natural or mechanical ventilation strategies to prevent sick building syndrome and address any existing water management issues with the facade, roof, foundation, or windows. Air sealing is often a low-cost measure with a fast return on investment, especially in older buildings with poor thermal performance.

Energy Efficiency For Conditioned Buildings

For conditioned buildings, insulation upgrades are another critical retrofit that can significantly improve a building's energy efficiency. Insulation increases thermal resistance, allowing buildings to maintain stable indoor temperatures with less reliance on heating and cooling systems.. For existing buildings that are wood frame, blown-in cellulose insulation in walls or unconditioned attics can be a cost-effective way to add insulation value while also being the lowest GHG emissions of all insulation types. Spray foam or plastic-based insulations should be limited in use for specific applications, such as below-grade or isolated air sealing approaches, as these insulations have a significantly higher global warming potential (GWP). For the construction of new facilities, numerous best practices, methods, and materials are available to design for passive facilities. Insulation materials such as mineral wool insulation, wood-based insulation, cellulose, straw bale panels, green roofs, or designing with thermal masses like rammed earth walls can all be strategies that provide similar thermal benefits to foam insulation, but with petroleum-free materials. Window upgrades can also play a major role in reducing energy consumption. Replacing single-pane or poorly insulated windows with high-performance double- or triple-glazed models can significantly improve both comfort in interior spaces and prevent condensation and mold, which can form on the interior surfaces of poorly insulated windows. Low-emissivity (low-E) coatings further enhance window efficiency by reflecting infrared heat while allowing visible light to pass through. Adding either interior or exterior mounted storm windows or applying window films may offer cost-effective alternatives to full replacements, especially when existing windows are wood or historic. Care should be taken to balance the embodied emissions (those associated with producing the materials) of glass with the benefits of a complete window replacement. Double and triple glazing can dramatically reduce heat loss in windows, but the more glass used, the higher the retrofit embodied emissions.

For conditioned buildings in cold or hot climates, energy-efficient ventilation, heating, and cooling systems are crucial for reducing energy consumption, providing healthy indoor air quality, and enhancing occupant comfort. One common retrofit strategy is replacing in-kind an outdated HVAC equipment with a high-efficiency system, such as condensing boilers or high-efficiency furnaces that use the same fuel source, typically natural gas. Another option that is increasingly required in energy codes is switching to an all-electric system, utilizing heat pumps or other refrigerant-based systems, such as Variable Refrigerant Flow (VRF). These newer systems operate with less energy and much higher efficiencies: for natural gas-based systems, around 98%, and for heat pump and electric technologies, around 200% efficiency (COP 2.0). Ductwork sealing and insulation also enhance system performance by reducing energy losses and ensuring that conditioned air reaches intended spaces effectively.

Retrofitting Considerations

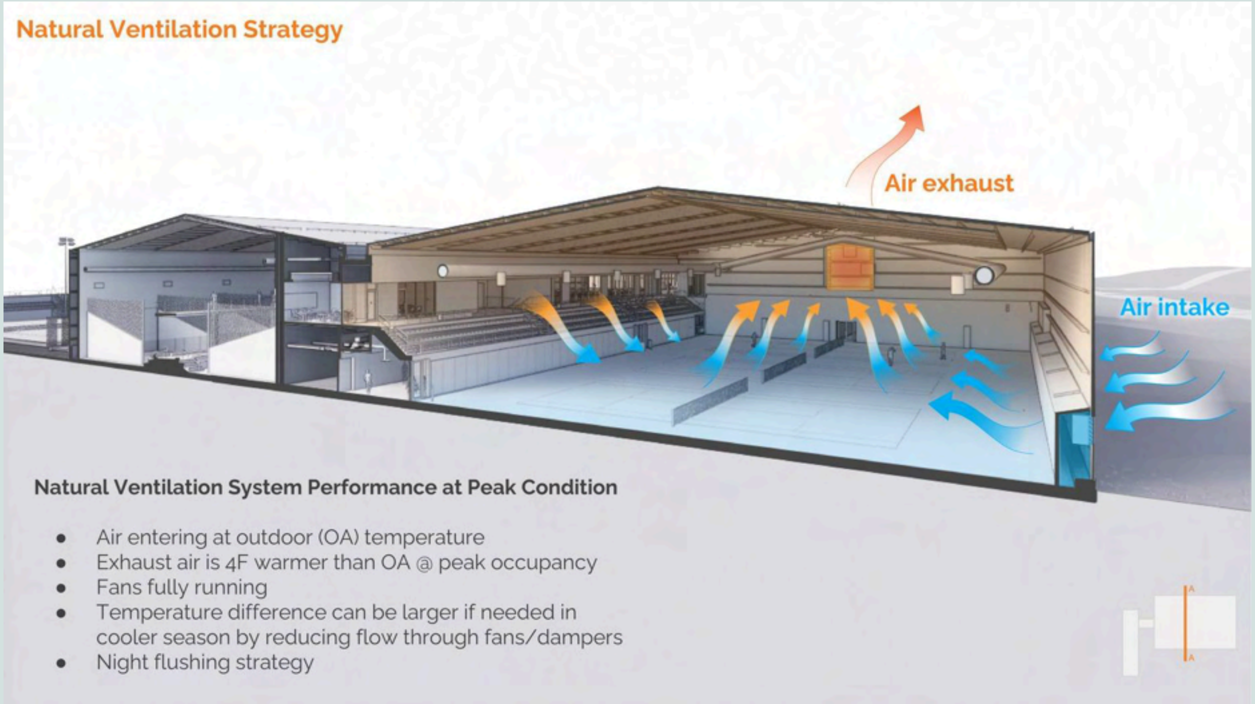
Another retrofit approach involves integrating smart controls and thermostats to optimize system operation. Programmable or occupancy sensor-connected thermostats can automatically adjust temperature settings based on occupancy patterns, reducing unnecessary heating or cooling during unoccupied hours. In larger buildings, advanced building automation systems (BAS) enable facility managers to remotely monitor and control HVAC equipment, providing opportunities to fine-tune performance, identify inefficiencies, and reduce peak energy loads. These controls not only enhance comfort but also result in significant reductions in energy costs over time.

A more holistic strategy includes shifting to low-carbon or renewable-based heating and cooling solutions. For example, retrofitting with air-source or ground-source (geothermal) heat pumps can dramatically reduce reliance on fossil fuels while providing efficient, low-cost year-round climate control. In some cases, thermal energy storage or radiant heating and cooling systems can be incorporated to further enhance efficiency and occupant comfort. When combined with envelope improvements, these systems can significantly reduce a building's Energy Use Intensity (EUI) and greenhouse gas emissions, enabling a more cost-effective transition to net-zero operations with a reduced annual requirement for renewable energy.

A wide range of tools and expertise is available to help park operators evaluate existing facilities, understand what is feasible and cost-effective for retrofitting, and support decisions on the threshold between prioritizing retrofit and considering new facilities. When considering new facilities, as energy codes approach net-zero requirements in many parts of the US, using passive design strategies, such as optimal solar orientation, all-electric systems, heat pumps, insulation, ventilation, and windows, has become business as usual. Park capital investment teams should expect architects and engineers to be able to design to net-zero energy, or fossil fuel-free, requirements in most park facility cases. There are exceptions, such as large heated indoor and outdoor pools, as well as other recreational facilities. Still, even these can have efficiency considerations and can be designed to net-zero operational energy - see the section on sustainable pool management further in this guide.

Case Study: Engineering Athletic Environments for Performance, Princeton, NJ

By Alison Nash & Amrit Pilo



Natural Ventilation Strategy, Princeton Racquet Center. Image attribution: Sasaki
Website: https://www.sasaki.com/projects/princeton-racquet-and-recreation-center/
Contact: vgorgati@sasaki.com

Indoor athletic facilities, such as tennis and squash centers, with high ceilings and large volumes, tend to have a significant energy and carbon footprint, driven by high energy demands for ventilation and lighting, as well as large facade and roof areas, and extended operational hours. Designing such a facility to be energy-efficient and environmentally responsible involves addressing a distinct set of architectural, mechanical, and operational challenges. These stem from the building's expansive scale, its specialized programmatic functions, and the need to provide precise playing conditions that support high-level athletic performance.

Employing a highly insulated envelope, triple-glazing, and connected to a geo-exchange campus loop, the building is designed for optimal energy efficiency. Competition tennis and squash courts require high-intensity, uniform, and glare-free illumination over large areas. The absence of natural light and extended operating hours contribute to significant electricity use from lighting, making energy efficiency for all other building systems more critical in reducing overall energy consumption. The project is on track for LEED Gold certification and is net-zero ready with an optimized roof profile. The project also utilized low-carbon concrete mixes, a material known for significantly reducing carbon emissions compared to conventional concrete.

The indoor tennis courts utilize an advanced natural ventilation system designed to enhance environmental sustainability and user comfort while reducing the building's reliance on traditional cooling methods during the summer months. During the colder months, the indoor tennis courts utilize radiant floors to ensure even and efficient heating, making it the first Division 1 indoor tennis center to feature radiant floors for enhanced comfort and energy efficiency. Strategically placed, mechanically operated louvers along the north and south facades enable the facility to adapt to varying climatic conditions, thereby maximizing natural airflow efficiency.

Key Strategies & Considerations

- Investigate the necessary programs and determine if existing facilities can be retrofitted to accommodate the required uses or if new construction is needed.
- Investigate upgrading the building envelope and determine insulation, sealing, and window replacement needs and priorities.
- Consider upgrading HVAC systems to non-fossil fuel equipment, such as heat pumps, or utilizing geothermal systems.
- For new construction, consider incorporating passive design strategies and utilizing natural materials, such as straw insulation, green roofs, and thermal masses, to make buildings inherently more energy-efficient in their fundamental design.

Helpful Resources and References

National Recreation and Park Association (NRPA). (n.d.) *Achieving Net-Zero Emissions in Park Spaces,* https://connect.nrpa.org/viewdocument/achieving-net-zero-emissions-in-par?CommunityKey=33a261e5-5285-44ff-a31d-cce5b35d1317&tab=librarydocuments

National Recreation and Park Association (NRPA). (n.d.) *Equipment and Fleet: Information and resources on how to transition to more energy efficient equipment and fleet.* https://connect.nrpa.org/viewdocument/equipment-and-fleet-nrpa?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

Feller, G. (2024). *What Energy Future for Parks?,* National Recreation and Park Association (NRPA). https://www.nrpa.org/parks-recreation-magazine/2024/august/what-energy-future-for-parks/

Al-Sallal, K., Passe, U., Lentz, T., Mahdavi, A., Ip, K., Miller, A., Fernandez-Gonzalez, A., Grondzik, W., Koester, R., Cole, R., & Oliver, A. (2016). Low Energy Low Carbon Architecture: Recent Advances & Future Directions.

American Council for an Energy-Efficient Economy (ACEEE). (2018). Smart Thermostats: Navigating the Rapidly Changing Market. https://www.aceee.org/research-report/a1801

CARE Tool – Architecture 2030. (n.d.). https://architecture2030.org/caretool/

Chan, Wai L., et al. (2018). "Energy Efficiency Improvements Through Retrofitting of Existing Buildings in Urban Areas: A Case Study." Journal of Building Engineering, vol. 20, pp. 327–336. https://doi.org/10.1016/j.jobe.2018.07.012

Crawford, R., Stephan, A., & Prideaux, F. (2019). *EPiC Database*. University of Melbourne. https://doi.org/10.26188/5dc228ef98c5a

EHDD. (2023). *EPIC Assessment*. https://epic.ehdd.com/

Feist, W. (2016). *Passive House Basics: Introduction to Passive House and Energy Efficient Construction Standards*. Passive House Institute.

Kolokotsa, D., et al. (2011). "A Roadmap towards Intelligent Net Zero- and Positive-Energy Buildings." Solar Energy, vol. 85, no. 12, pp. 3067–3084. https://doi.org/10.1016/j.solener.2010.09.001

Kosny, J. (2015). Thermal Insulation and Radiation Control Technologies for Buildings. Springer.

Lechner, N. (2015). Heating, Cooling, Lighting: Sustainable Design Methods for Architects. 4th ed., Wiley.

Mazria, E. (1979). The Passive Solar Energy Book: A Complete Guide to Passive Solar Home, Greenhouse, and Building Design. Rodale Press.

National Renewable Energy Laboratory. (2020). Guide to Energy-Efficient Commercial Equipment. U.S. Department of Energy. https://www.nrel.gov/docs/fy20osti/75235.pdf

Passive House Institute US (PHIUS). (2021). PHIUS+ 2021 Passive Building Standard. https://www.phius.org/phius-certification-guidebook

Rupp, R., et al. (2015). "A Review of Human Thermal Comfort in the Built Environment." Energy and Buildings, vol. 105, 2015, pp. 178–205. https://doi.org/10.1016/j.enbuild.2015.07.047

Schnieders, J., and Feist, W. (2008). "Passive Houses in South-Western Europe." *Energy and Buildings*, vol. 40, no. 4, pp. 437–446. https://passiv.de/downloads/02_ph_southwesteurope_sample.pdf

Straube, J., and Burnett, E. (2005). Building Science for Building Enclosures. Building Science Press.

U.S. Department of Energy. (2000). Passive Solar Design Strategies: Guidelines for Home Building. Prepared by Sustainable Buildings Industry Council.

U.S. Department of Energy. (2014). Retrofitting HVAC Systems for Energy Efficiency. National Renewable Energy Laboratory. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://docs.nrel.gov/docs/fy14osti/61218.pdf

Renewable Energy Production

Background

Renewable energy derives from sources that do not compromise future generations' access to that source or contribute directly to emissions of greenhouse gases. Renewable energy sources include solar, wind, geothermal, and hydroelectric power. Park landscapes have a significant advantage when considering the implementation of renewable energy infrastructure over buildings: the availability of space.

Solar

Even in northern states like Maine, solar panels can produce over 500,000 kWh per year. This source is at its highest in the summer months, during the most intensive use of park facilities, with power generation reduced by as much as 70 to 80 percent in winter months in states such as Minnesota or Washington. As a result, many local, state, and national park systems have adopted small and landscape-scale solar installations, from self-sufficient solar lighting products to solar fields to power building facilities. With parkland uses, solar fields can often share land with other uses, such as solar-covered parking lots, agrovoltaic fields where crops are grown under and between solar panels, or even carefully curated, restored prairie meadows, or simulated part-shade ecosystems like those along forest margins.

Wind

Industrial-scale wind power requires much more active curation, maintenance, and specialized technology than solar farms; however, micro-wind installations, such as helical urban windmills, can generate significant kWh with strong, regular, prevailing winds. The cost of these systems and the inconsistency have limited their widespread use except as demonstration concepts in locations with very reliable wind resources.

Geothermal

There are multiple forms of geothermal power to consider. Geothermal systems, also known as ground-source heat pumps, utilize thermal mass to harness the relatively constant temperature of the Earth as a heat exchange medium. These systems are connected to heat pumps, which use the continuous temperature and refrigerant cycle for heating and cooling buildings, such as at Falls Church Community Center, in Virginia. This is the most common and low-cost form of energy production, which is helpful in cooling and heating park building facilities, and can also be used to create outdoor cooling stations in sheltered areas. High energy demand facilities, such as ice rinks, can have significant energy savings, such as the geothermal program at the City of Brooklyn Park for the arena. Water-source heat pumps function similarly, using water from ponds, lakes, or other bodies of water as the exchange medium. Geothermal energy can also be used to produce electricity; however, this typically requires a large-scale plant that utilizes either dry steam, flash steam, or binary cycle turbine systems, and often relies on specific geologic resources, such as local volcanic activity or faults.

Hydro

Parks systems have generally moved away from the use of hydroelectric power in recent generations to avoid the environmental impacts of damming. Hydroelectric power harnesses the potential energy of water at elevated levels to generate electricity as it flows through turbines. The environmental impacts of damming have been well-documented, with significant effects on anadromous fish, such as salmonids, plant communities, and amphibian populations. However, smaller-scale micro-hydro installations have been gaining traction since the 1970s, powering individual buildings or even small districts. Numerous studies have found that micro-hydro installations operating through partial stream diversion, which produce 5 to 100 kW of energy, have no measurable effect on local stream biodiversity. In Scotland, micro-hydro facilities are now powering whole communities where connecting to the national grid was infeasible. While underutilized in American park systems, micro-hydro could offer the benefit of a more reliable energy source year-round, with the right hydrological resources, and is a comparatively low-cost and straightforward technology.

Considering Return on Investment

For all these renewable energy systems in areas with access to existing grid utilities, park operators will need to balance the return on investment (ROI) based on park-specific local energy costs, infrastructure requirements, incentive programs, and local energy costs. A good rule of thumb for evaluating ROI is whether the capital and operational costs of the system are repaid within the investment's half-life. So, if a solar panel has a life expectancy of 30 years, targeting a minimum ROI of 15 years is a reasonable benchmark. If payback periods are faster, that only increases the argument and value of the particular investment. Please note that the nuances of ROI can be complex, depending on local regulations. Some states and countries highly incentivize net metering (where the energy bill deducts the amount of energy added by the renewable system). In contrast, others disincentivize renewables through reduced rates for locally produced energy or even specialty taxes on renewable energy production.

In locations where infrastructure costs to connect to an existing grid are high or where local laws disincentivize renewables, then energy self-reliance through a microgrid or disconnecting from local utilities may be the best solution to achieve the ROI for renewable energy investments. When systems disconnect from the grid, specialty considerations such as batteries, backup generators, and having the institutional capability to operate and repair critical local energy infrastructure are necessary.

Case Study: Net Zero Retrofit at the Carroll Center, Oak Park, IL

By Nelson Acevedo

Solar panels at the Carroll Center generate more energy than the building consumes annually, showcasing visible sustainability. Image attribution: Village of Oak Park & Hausman Photography
Website: www.pdop.org/crc
Contact: Nelson.Acevedo@pdop.org

The Carroll Center, operated by the Park District of Oak Park, is a pioneering example of net-zero energy renovation in Illinois. Initially built in 1916, the facility underwent a transformative retrofit and expansion completed in 2020, becoming the second verified net-zero building in the state. The project was driven by community values of sustainability and supported by a $577,800 grant from the Illinois Clean Energy Community Foundation.

The renovation included a 7,700 sq ft expansion, featuring two new classrooms and a host of energy-efficient upgrades. Passive House standards guided the design, resulting in a highly insulated envelope, triple-glazed windows, LED lighting, and a ground-source heat pump. A 24.1 kW solar array with 78 Mission Solar panels generates approximately 26 MWh annually—more than the building consumes.

Innovative features, such as daylighting, energy recovery ventilators, and real-time energy monitoring, contribute to both comfort and efficiency. The building's airtight envelope and advanced HVAC systems ensure stable indoor temperatures and excellent air quality, even during full occupancy.

The Carroll Center's success is a testament to collaborative design and operational commitment. Staff were involved in air sealing and continue to monitor energy use via a public dashboard. The project not only meets environmental goals but also serves as a model for retrofitting historic buildings to meet modern sustainability standards.

Key Strategies & Considerations

- Investigate and understand the potential for renewable energy sources for new or existing park facilities. Conduct ROI studies to know where to prioritize investment.
- When considering energy needs in locations with high costs to connect to existing infrastructure or where local laws and regulations reduce economic viability, consider going 'off-the-grid' and evaluate institutional capacity for those systems.
- Solar cells on building roofs is a cost effective renewable energy source in most municipalities.
- Landscape spaces, such as parking lots and meadows, can provide significant space assets to enable additional solar and geothermal energy production.
- Even short elevation drops, such as 10 feet, can enable significant micro-hydro energy production with consistent streams and rivers but must be carefully designed to avoid impacts to local plans and animal communities.
- Micro-wind can be a visually charismatic source of energy, but the ROI can be challenging unless there is consistent, sufficient wind.

Helpful Resources and References

Boroomandnia, A., Rismanchi, B., & Wu, W. (2022). A review of micro hydro systems in urban areas: Opportunities and challenges. Renewable and Sustainable Energy Reviews, 169, 112866. https://doi.org/10.1016/j.rser.2022.112866

El Haj Assad, Mamdouh & Rosen, Marc & Aliehyaei, Mehdi. (2021). Design and Performance Optimization of Renewable Energy System. https://doi.org/10.1016/B978-0-12-821602-6.00001-8

Green Coast. (2020). "Solar ROI Calculator: An Easy Way to Determine Your Payback." https://greencoast.org/solar-roi-calculator/.

Investopedia. (2010). "ROI: Return on Investment Meaning and Calculation Formulas." https://www.investopedia.com/articles/basics/10/guide-to-calculating-roi.asp.

Morley, D., eds. (2014). Planning for Solar Energy. American Planning Association, https://www.planning.org/publications/report/9117592/

National Renewable Energy Laboratory. (2013).Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills. Prepared in partnership with the U.S. Environmental Protection Agency. https://docs.nrel.gov/docs/fy13osti/52615.pdf.

Permana, A.S., Potipituk, C. (2024). Harmonizing Power Generation and Environmental Conservation Through Micro-Hydro Systems. In: Ting, D.SK., Vaselbehagh, A. (eds) Brightening

Tomorrow Together 2024. TELAC 2024. Springer Proceedings in Energy. Springer, Cham. https://www.springerprofessional.de/en/harmonizing-power-generation-and-environmental-conservation-thro/50258666

The Nature Conservancy. (2023). Principles of Low-Impact Solar Siting and Design. https://www.nature.org/content/dam/tnc/nature/en/documents/2023SolarGuidanceTNCNC.pdf

U.S. Department of Energy. (2023). Solar Power in Your Community: A Guidebook for Local Governments. 3rd ed..https://www.energy.gov/sites/default/files/2023-03/Solar_Power_in_Your_Community_Guidebook_March2023.pdf.

U.S. Department of Energy. (n.d.). Renewable Energy Basics. Better Buildings Initiative, https://betterbuildingssolutioncenter.energy.gov/renewables/basics.

Walch, A., Li, X., Chambers, J., Mohajeri, N., Yilmaz, S., Patel, M., & Scartezzini, J.-L. (2022). Shallow geothermal energy potential for heating and cooling of buildings with regeneration under climate change scenarios. Energy, 244, 123086. https://doi.org/10.1016/j.energy.2021.123086

Walch, Alina, et al. (2025). “Shallow Geothermal Energy Potential for Heating and Cooling of Buildings with Regeneration under Climate Change Scenarios.” arXiv, 2021, https://arxiv.org/abs/2112.01183.

Wang, T., O’Neill, D., & Kamath, H. (2014). Dynamic Control and Optimization of Distributed Energy Resources in a Microgrid (No. arXiv:1410.0054). https://doi.org/10.48550/arXiv.1410.0054

Zohuri, B. (2018). Hybrid Renewable Energy Systems. In: Hybrid Energy Systems. Springer, Cham. https://doi.org/10.1007/978-3-319-70721-1_1

“Latest Renewable Energy Updates, Trends & Insights.” Renewable Energy World, https://www.renewableenergyworld.com/news/.

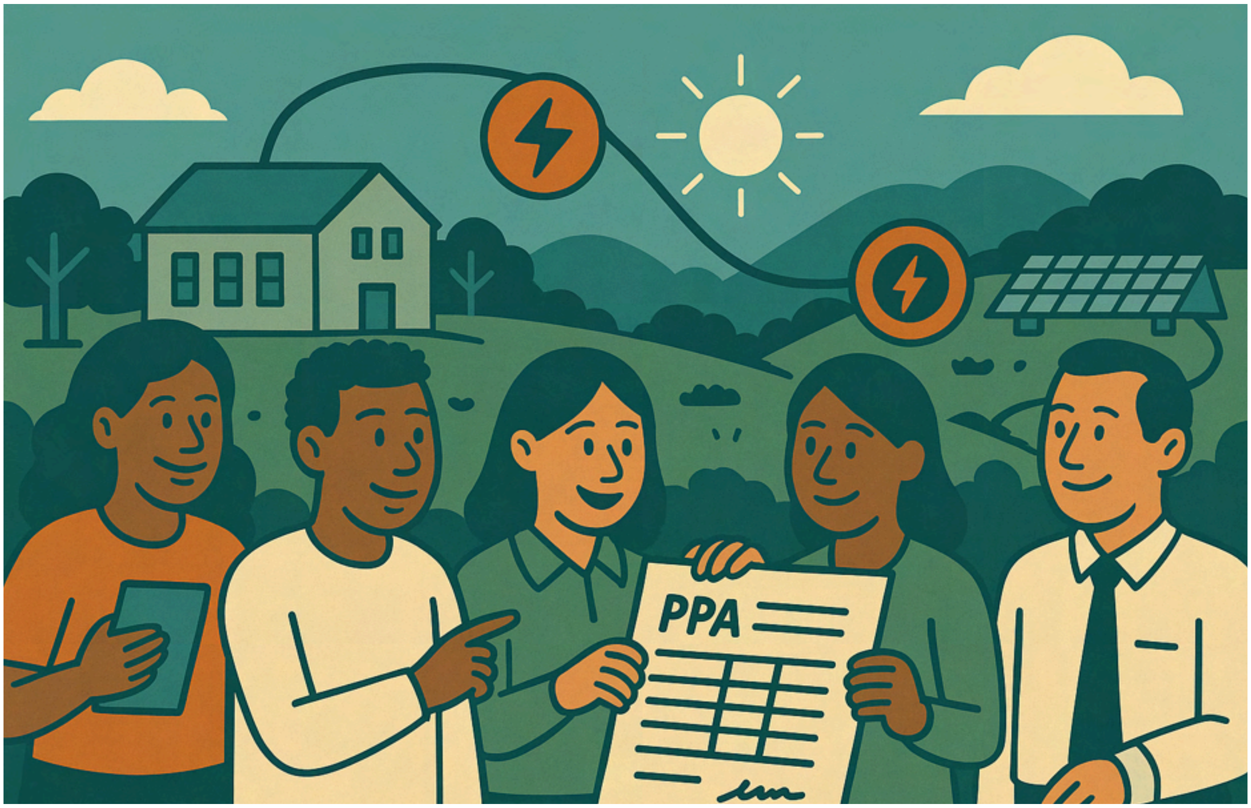
“Renewable Energy: Wind Turbines, Solar Cells, Small Hydroelectric Plants, Biomass, and Geothermal Sources of Energy.” David Publisher, https://www.davidpublisher.com/Public/uploads/Contribute/5cf4c80639387.pdf.

“Solar vs. Wind vs. Hydro vs. Geothermal (Renewable Energy Sources).” Tag Vault, https://tagvault.org/blog/solar-vs-wind-vs-hydro-vs-geothermal/.

“The Renewable-Energy Revolution Will Need Renewable Storage.” The New Yorker, https://www.newyorker.com/magazine/2022/04/25/the-renewable-energy-revolution-will-need-renewable-storage.

"Types of Renewable Energy." Renewable Energy World, https://www.renewableenergyworld.com/types-of-renewable-energy/.

"World Small Hydropower Development Report 2022." United Nations Industrial Development Organization & International Center on Small Hydro Power, 2022. https://www.unido.org/WSHPDR2022.



Third-Party Renewable Energy

Background

This section focuses on the use of third-party renewable energy. For many facility operators, especially those with existing park buildings that may not have the natural or capital resources to invest in on-site renewable energy production infrastructure, the only viable alternative to achieving a 'net zero' climate impact energy target is through the procurement of energy from a third party. This can be simple, where the local electrical grid is already sourced from 100% renewable or nuclear energy. This can be more complex when the grid has a mix of power sources, which is the most common situation for most parts of the United States.

Power Purchase Agreement

One way to overcome capital investments is through a Power Purchase Agreement (PPA). PPAs are contracts between a power provider and a customer, where the provider installs, owns, and maintains a renewable energy system—typically solar—on the customer's property. The customer agrees to purchase the electricity generated at a fixed rate, typically lower than local utility rates, for a specified term (usually 10–25 years). PPAs enable park operators to benefit from clean energy without incurring upfront capital costs, while the provider benefits from tax incentives (which vary by state) and revenue from energy sales. This model is especially popular with institutions seeking to reduce energy expenses and carbon footprints but who lack the capital to fund the system themselves. A relevant example is the Star Island Corporation, a NGO that operates a retreat and conference center on an island off the coast of New Hampshire. It operates the largest solar microgrid in New England, which was initially funded by a PPA. PPAs are dependent on local laws; however, as of the writing of this document, only twenty-nine states and the District of Columbia have laws that allow or incentivize PPAs. Seven states (Florida, Georgia, Kentucky, North Carolina, Oklahoma, South Carolina, and Alabama) have laws that restrict or prohibit power purchase agreements.

Renewable Energy Credits

Another approach that also avoids up-front capital but usually comes with higher energy costs is the voluntary purchase of Renewable Energy Credits (RECs) or enrolling in local green power purchasing programs. Each of these voluntary programs has similar strengths and weaknesses. The benefit is that these investments enable the development of new renewable energy sources; the drawback is that these sources generally add to the grid in general rather than for your specific facility.

Key Strategies & Considerations

- If a park or facility cannot afford the capital costs of constructing on-site renewable energy systems, investigate if there are local power purchase programs (PPAs) available. Often, PPAs will build and operate the infrastructure on-site and charge the landowner an equal or reduced rate for electricity compared to standard utility rates.
- If PPAs are not available (due to local laws, availability, space requirements, etc.), consider renewable energy credits (REC) or green power purchasing programs. We recommend checking with your existing utility provider first, as they may offer REC or green programs to opt into, although these often come with a premium rate.

Helpful Resources and References

BKV Energy. (2024). "Renewable Energy Certificates: Pros and Cons." https://bkvenergy.com/learning-center/renewable-energy-certificates/.

EnergySage. (2023). "Renewable Energy Credits (RECs): What You Need to Know." https://www.energysage.com/other-clean-options/renewable-energy-credits-recs/.

ENGIE Impact. (2024). "Understanding Power Purchase Agreements: A Guide." https://www.engieimpact.com/insights/power-purchase-agreements-guide.

LevelTen Energy. (2020). "Common Terms and Conditions in a Virtual Power Purchase Agreement: A Guide for Corporate Buyers." https://www.leveltenenergy.com/post/power-purchase-agreement-terms

Shah, C. (2010). High-Level Project Plan for Solar PV with PPA Financing. National Renewable Energy Laboratory.. https://docs.nrel.gov/docs/fy10osti/46668.pdf

U.S. Department of Energy. (2024). "Power Purchase Agreements." Federal Energy Management Program Checklist. https://www.energy.gov/femp/articles/power-purchase-agreements.

U.S. Environmental Protection Agency. (2024). "Customer Power Purchase Agreements." EPA State and Local Energy. https://www.epa.gov/statelocalenergy/customer-power-purchase-agreements.

U.S. Environmental Protection Agency. (2024). "Renewable Energy Certificates (RECs)." EPA Green Power Partnership.https://www.epa.gov/green-power-markets/renewable-energy-certificates-recs.

Lighting

Background

Lighting can be the primary source of energy expenditure for outdoor park spaces and is a significant contributor to energy consumption in passive buildings. The first step in evaluating lighting is understanding what constitutes sufficient lighting. Many public facilities have high code-based lighting requirements for egress and public safety. Still, these requirements can be considered in more detail when evaluating against operational hours and lighting photometric (the amount of light on a given surface). Minimizing the amount of required lighting for an area begins with a thoughtful design that prioritizes natural daylight and efficient fixture placement. In park buildings, we can maximize daylight utilization through strategic window placement, skylights, or clerestories, thereby reducing lighting needs during daytime hours. Sometimes, designers will refer to the space inside a building with artificial lighting that is not needed during daylight hours as 'passive volume'. Passive volume is dependent on building orientation and window layouts and is best considered during initial construction, as retrofits to enhance passive lighting can be structurally complex and expensive. Passive volume depths from the facade vary based on latitude and potential adjacent shading. They can be modeled and optimized by designers, ranging from just 8' from a window to 21', depending on these factors.

Where interior artificial lighting is necessary, using task-specific lighting rather than uniform general lighting can further reduce energy consumption. For both interiors and exteriors, incorporating lighting controls such as occupancy sensors, dimmers, and daylight-responsive systems ensures that lights are used only when and where needed, thereby preventing unnecessary energy consumption. Together, these strategies reduce both energy demand and maintenance costs, as well as unnecessary light pollution. For outdoor lighting, the impacts on energy savings will be proportional to the light use intensity, with night-time sports fields and well-lit parking areas having high energy demands in comparison with pedestrian walkways or trails.

The Value Of Lighting Surveys

Conducting a lighting survey on existing facilities can be a powerful way to understand where prioritizing investments can have the biggest impact. Lighting Power Density (LPD) analysis is a method used to assess the energy consumption of lighting systems in buildings or outdoor spaces. It measures the total lighting power (in watts) connected to a specific area (typically square footage or square meters). This analysis helps identify areas for improving energy efficiency.

LED Fixtures

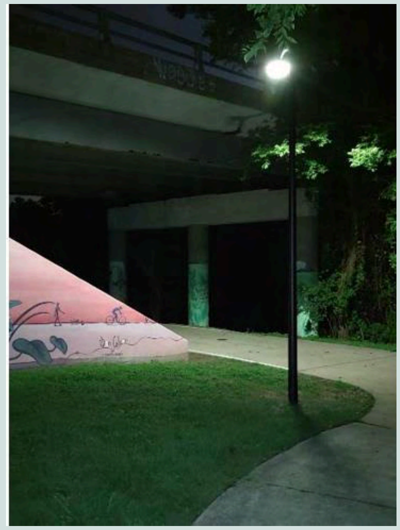
One of the most impactful energy-saving strategies for parks is the conversion of traditional light fixtures to Light-Emitting Diode (LED) fixtures. Invented in the 1960s, it wasn't until the 2000s that product development advanced sufficiently to make them cost- and lifespan-competitive for exterior applications. LED lights are a type of solid-state lighting that uses a semiconductor to convert electricity into light. Unlike traditional incandescent bulbs, which produce light by heating a filament, LEDs emit light through electroluminescence—a process that generates minimal heat and significantly reduces energy waste. They come in a variety of shapes, sizes, and color temperatures, making them suitable for park lighting, often with higher performance capacities, such as a better color rendering index (CRI) or better backlight, uplight, and glare (BUG) ratings.

The most compelling benefit of LED lights is their energy efficiency. LEDs use up to 75–80% less energy than traditional incandescent bulbs and last 25 times longer. In comparison with outdoor lighting fixtures, LED bulbs can last 2 to 3 times longer than a High-Pressure Sodium (HPS) bulb and can have a vastly better CRI (LED streetlights are commonly above 70 CRI, while most HPS bulbs are below 25 CRI). With lighting being the highest, or one of the highest, energy demands for parks and outdoor public spaces, LED lighting is one of the best strategies to reduce electricity consumption.

The initial cost of LED lighting landscape luminaires is typically higher than that of conventional bulbs, often 2-3 times higher; however, the lower operating costs and longer lifespan result in substantial savings over time. On average, most LED bulbs pay for themselves within 2 years through energy savings alone, with further savings accumulating over their 10- to 25-year lifespan.

Case Study: Energy Efficiency through LED Lighting at Tennis Centers, Dallas, TX

By Frances McGee



Upgrading to LED lighting at the LB Houston Tennis Center & new LED/Solar, Dark Sky compliant Lighting at the Sante Fe Trail.
Image attribution: Dallas Park and Recreation Forestry Division
Website: https://www.dallasparks.org
Contact: frances.mcgee@dallas.gov

Serving Up Energy Efficiency at Dallas Tennis Centers. Whether you're serving up aces or enjoying a casual game, visit Fretz, Kiest, L.B. Houston, and Samuell-Grand tennis centers and see how energy-efficient improvements can improve your game. New, environmentally friendly lighting has been installed at the city's four full-service tennis facilities, replacing outdated metal halide fixtures. Brighter LED lights consume less energy, reduce utility costs, and provide superior court illumination for better play. The new lighting offers several additional benefits: longer lifespans, minimal maintenance requirements, and 100% recyclability. Since the pandemic, Dallas' tennis centers have seen a significant increase in play, with an average annual attendance of 130,799, compared to pre-pandemic attendance of 77,797. In addition to Dark Sky Lighting, the Dallas Park and Recreation Department is committed to upgrading its LED and Solar initiatives. The Dallas Park and Recreation Department utilizes LEDs for cost savings and environmental benefits by installing them in projects involving new, damaged, and replacement lighting. The newly renovated Kidd Springs Japanese Garden is a wonderful place to visit this summer, and there are now opportunities to see at dusk/night for more superb walks on the beautiful paths. Among the renovations, LED lights were installed along the pathways and on structures found along the trail. Sharrock Park features a Dark Sky designation and is 100% solar-powered. This lighting will help reduce our environmental impact while also enhancing the ambiance and the spectacular nature of these parks.

Case Study: Lighting Upgrade For Efficiency, Lexington, MA

By Melissa Termine Battite

The Center Recreation Complex, as shown with the new outdoor recreation athletic lighting systems. Image attribution: Town of Lexington, MA Contact:mbattite@lexingtonma.gov

The Town of Lexington, Massachusetts, Recreation and Community Programs Department has upgraded all of the outdoor athletic lighting at its Recreation facilities. Funding was used to replace lighting at four tennis courts, two basketball courts, four swimming pools, one baseball field, one softball field, and three multi-use rectangular fields, and to add new lights at six courts and the track and field. The funding was through Community Preservation and Grant funding. The new systems are fully automated through a mobile app, having multiple brightness settings, and have significantly reduced light spillage to adjacent neighbors and conservation areas. Even with the new systems being added, there has been a significant reduction in the utility costs per year by approximately 30%

Key Strategies & Considerations

- Conduct a lighting audit, including Lighting Power Density (LPD) analysis for park facilities to understand existing infrastructure, energy use, and maintenance costs, and determine where replacement with LEDs is most impactful.
- Consider sufficiency - where is lighting not needed, or could be required less?
- Consider dark-sky requirements and require a good Backlight, Uplight, Glare (BUG) rating for light poles, meaning a rating closer to B0, U0, and G1 or G2, as this minimizes light spill into undesirable areas, reduces light pollution, and improves visibility for drivers and pedestrians.
- Focus initial upgrades on areas with high lighting intensity, such as buildings, building entrances, walkways, sidewalks, playgrounds, and parking lots, particularly during night hours.
- When implementing LED lighting, consider also using smart controls and motion sensors to enhance efficiency further.

- A co-benefit to using LED lighting is to choose fixtures with a good color rendering index (>75), color temperatures tailored to ecological conditions (such as turtle-safe lighting), and a balance of visibility and minimizing glare.
- In some states, rebates and grants can help offset the upfront costs of installing energy-efficient fixtures.

Helpful Resources and References

Chiradeja, P., & Yoomak, S. (2023). Development of public lighting system with smart lighting control systems and internet of things (IoT) technologies for smart city. *Energy Reports*, *10*, 3355–3372. https://doi.org/10.1016/j.egyr.2023.10.027

Dutt, G. S., & Mills, E. (1994). Illumination and sustainable development Part II: Implementing lighting efficiency programs. *Energy for Sustainable Development*, *1*(2), 17–27. https://doi.org/10.1016/S0973-0826(08)60028-9

Illuminating Engineering Society. (2011). The Lighting Handbook: 10th Edition. Illuminating Engineering Society.

International Energy Agency. (n.d.) Energy-Efficient Street Lighting Technologies. IEA, https://www.iea.org/reports/energy-efficient-street-lighting.

Lee, SuJung & Yoon, Heakyung. (2020). LED lighting system for better color rendition space: The effect of Color Rendering Index. Journal of Asian Architecture and Building Engineering. 20. 10. https://www.researchgate.net/publication/343192098_LED_lighting_system_for_better_color_rendition_space_The_effect_of_Color_Rendering_Index

Mills, E., & Piette, M. A. (1993). Advanced energy-efficient lighting systems: Progress and potential. *Energy*, *18*(2), 75–97. https://doi.org/10.1016/0360-5442(93)90092-R

Mills, E. (1993). Efficient lighting programs in Europe: Cost effectiveness, consumer response, and market dynamics. *Energy*, *18*(2), IN1-144. https://doi.org/10.1016/0360-5442(93)90097-W

Navigant Consulting. (2017). Adoption of Light-Emitting Diodes in Common Lighting Applications. U.S. Department of Energy. https://www.energy.gov/sites/prod/files/2017/07/f35/led-adoption-report_2017.pdf.

Rea, M., eds. (2000). The IESNA Lighting Handbook: Reference and Application. 9th ed., Illuminating Engineering Society of North America.

U.S. Department of Energy. (n.d.) LED Lighting. https://www.energy.gov/eere/ssl/led-lighting.

Maintenance Equipment

Background

The primary emissions associated with public park landscape maintenance are from large and small motor equipment, including trucks, skid-steers, mowers, and leaf blowers. This is categorically different from most agricultural emissions literature, where the primary emissions come from tilling and the embodied carbon of fertilizers, pesticides, and other chemical applications. In contrast, public parks are rarely tilled, and excessive chemical use is often an unnecessary expense. Accordingly, park departments that want to reduce operational emissions of landscape maintenance need to tackle the fuel use of their equipment to have the most significant impact. This is a challenging task, likely requiring a mixed approach, such as reducing the need for equipment (e.g., reducing the amount of mown turf in a park - see our Turf Reduction Section), adopting selective electric equipment, and replacing fuel types with others.

Electric Vehicles

Electric vehicles (EVs) and mowers typically have lower fuel and maintenance costs due to their fewer moving parts and the use of electricity instead of fossil fuels. Transitioning large equipment and vehicle fleets is a significant and challenging expense. This can be tied to specific funding applications, such as parks bonds, or rolled out slowly, such as need-based or replacement-based upgrades, where departments replace items only when they fail or reach the end of their useful lifespan, rather than on a fixed schedule. For cars, golf carts, and all-terrain vehicles, there are well-established EV alternatives available in the marketplace. These types of EVs are increasingly being integrated into municipal fleets nationwide, offering significant benefits alongside notable challenges. Cities like Seattle and South Pasadena have adopted EVs for various services, including public works. High upfront costs for vehicles and charging infrastructure can strain municipal budgets despite long-term savings. Partnering EV replacements with investments in suitable and convenient charging infrastructure development is critical. There is also potential for negotiated City and State programs and grants to help reduce these up-front investments, depending on context. Some key considerations when it comes to EVs include budget, range requirements, distance and duration, and the provision of sufficient and convenient charging stations. EV performance can be affected by factors such as cold weather, which reduces battery range. Evaluating these factors is best done in consideration of the local climate. However, for most types of vehicles described within local municipal parks departments, sufficient ranges are available even in colder climates. Cities with cold winters, such as Dublin, Ohio, or St. Paul, Minnesota, have already integrated EVs into their city fleets. Electric riding mowers are typically more expensive upfront, costing an average of $2,000 to $3,000 more than gas-powered riding mowers (at the time of writing these guidelines). However, this can vary by brand and features. However, the higher initial purchase price is offset by significantly lower operating costs due to cheaper electricity compared to gas and reduced maintenance needs, such as no oil changes or spark plug replacements. Assuming an electric riding mower is used 1,000 hours a year, this can result in a return on investment (ROI) of between 2 and 5 years. Based on this, some cities and towns are already replacing their mowing fleets with all-electric equipment, such as Lexington, Massachusetts.

Electric Tools

Electric Tools (ETs) offer similar benefits to EVs, albeit on a smaller scale. ETs have experienced rapid advancements over the last two decades. The duration and power of high-quality ET batteries have been revolutionized, with lifespans now regularly extending to 5 years, and for the total power (AH or "amp-hour"). For example, in the past, 4.0AH was considered exceptional for a hand drill. Today, contractors can purchase 8.0-12.0AH batteries, often requiring only a single charge for multiple days of work. Most of today's battery-powered trimmers, blowers, and mowers can run long enough for a full day of work - but even then, it's a good idea to keep a few extra batteries charged and ready to go.

Switching to ETs for park landscape maintenance has multiple benefits for the maintenance staff. Not only are ETs becoming more powerful and reliable, but they're also significantly quieter, which makes a substantial difference in residential areas or early morning jobs. Residents and park visitors appreciate the reduced noise, and it helps avoid complaints or restrictions in noise-sensitive neighborhoods. ETs start up with the push of a button—no more pulling cords or dealing with finicky engines. There is no need for oil changes, spark plug replacements, or trips to the gas station; ETs can save time and money in the long run. Advice from Paul Gilbert, the Executive Director of the NOVA Parks system, "Consider the time a tool is used before converting to electric. A tool like a blower that is used for a few hours a day might be a great candidate for replacement. One that is used for periods of time that would equate to multiple battery changes, might be less ideal. Every year, the quality and power of electric tools is increasing."

The associated emissions reductions can be the difference between a net carbon-emitting landscape, such as a mown turf lawn, and a net carbon-sequestering landscape. This is also a public health consideration, as most small, 2-stroke engines, such as blowers, line trimmers, chainsaws, and mowers, burn a mixture of oil and gasoline, which results in incomplete combustion and the release of high levels of unburned hydrocarbons, carbon monoxide, and fine particulate matter into the air. A 2015 study by the EPA revealed that gasoline-powered lawn and garden equipment emitted approximately 26.7 million tons of air pollutants. A single gas-powered leaf blower running for an hour can emit as much smog-forming pollution as a car driving hundreds of miles.

These pollutants can contribute to smog and respiratory issues for individuals who operate consistently. Masks can offer some protection to workers exposed to this pollution, but the level of protection depends heavily on the type of mask used. Basic cloth or surgical masks are not effective against the fine particulate matter and harmful gases emitted by two-stroke engines. To truly reduce exposure, workers should wear respirators with filters rated N95 or higher, and ideally, those that also include activated carbon filters to help capture volatile organic compounds (VOCs) and gases such as carbon monoxide. Due to the discomfort and the fact that OSHA has not adopted masks as part of its personal protective equipment (PPE) standards, masks are not commonly used. The occasional bandana is insufficient, as it only blocks large particles and debris. Additional workplace health benefits include noise reduction impacts on hearing and vibration reductions that can help mitigate fatigue and repetitive task injuries.

Switching to ETs involves several practical considerations that need to be evaluated. The first factors are cost, performance quality, duration, and warranty, as with any other equipment. The second factors are standardization, deployment, and, for specialty equipment, possibly training. Brands now offer interchangeable batteries for multiple tools, so investing in battery banks allows workers to have backup batteries in their trucks, reducing complaints when switching over. Having charging sheds at each park could also help reduce friction from untimely battery outages.

Some equipment needs a short orientation and training, such as electric chainsaws. Some recent brands of small electric chainsaws no longer have a throttle lock, making it as simple as pressing a button to use the saw. (Larger electric chainsaws more commonly include throttle locks, as well as chain brakes, and the rest of the relevant typical safety features.) Training can also acculturate workers, helping them overcome old habits, such as relying on idling during pauses, and introducing new ones, such as remembering to charge batteries at the end of the day.

Large Equipment Considerations

The more specialized heavy equipment, such as tractors, front-end loaders, compactors, and excavators, has limited EV/ET options in the market. Major brands such as Volvo, Caterpillar, John Deere, and Komatsu now offer electric or hybrid models, particularly in the compact and mid-size categories. These medium-sized 'heavy' equipment EVs are available, but they can have a 20-50% higher purchasing cost than their fossil fuel competitors. These machines offer the same benefits as other EVs, including emissions savings, fuel reductions, and quieter operations. Depending on the cost of electricity, some of these companies estimate ROI on the scale of 5 to 10 years of consistent use, based on savings from fuel and equipment maintenance, which is still competitive when considering a 15 to 20-year life span.

Larger equipment, like large construction equipment, due to the high torque demands, would require extraordinary battery power. For parks departments, this equipment may be less frequently owned and used by the maintenance staff, as opposed to being mobilized for short-term rentals or by contracted work. While the technology isn't there for these machines to be replaced by EV alternatives, the best solution for now for reducing emissions is through the adoption of biofuels.

Biofuels

The most commonly used biofuel is ethanol. Ethanol is primarily made from corn or sugarcane. It is frequently blended with gasoline to power cars and medium-sized vehicles, most often in mixtures such as E10 (10% ethanol) or E85 (85% ethanol for flex-fuel vehicles). It burns cleaner than pure gasoline, reducing air pollutants. Since it is sourced from current agricultural products, it doesn't contribute to greenhouse gas emissions like fossil fuels. (The concept is that each year, the corn/sugarcane sequesters the carbon that would be burned as fuel, creating a closed-loop cycle). Unfortunately, ethanol has a lower energy content than gasoline, which can slightly reduce fuel economy, and its production has been criticized because of food crop competition. Still, for operators where switching to EVs is not currently economically viable, ethanol offers a practical step toward cleaner operations. One practical consideration is that the best benefits are derived from E85 vehicles, which are presently primarily limited to passenger cars. Even then, park departments may need to establish their own fueling stations, as E85 is not widely available on the market. E10 is the most common, and in many parts of the country, it is part of the de facto gas mix, making it compatible with typical gasoline-powered vehicles and equipment. If biofuels are not feasible for some mowers and heavy equipment, there are liquid natural gas options (LNG). While LNG may have limited reduced CO2 emissions, it has significantly less sulfur dioxide (SO2) and nitrogen oxides (NOx) emissions compared with typical diesel fuel.

Adopting biodiesel for heavy construction equipment can be a relatively straightforward process for most diesel-powered machines, especially those manufactured recently. Biodiesel is a renewable fuel typically made from vegetable oils, animal fats, or recycled cooking grease, and it can often be used in blends like B20 (20% biodiesel, 80% petroleum diesel) without any engine modifications (it is essential to check with the specific vehicle manufacturer, as this is not universally true).

In some cases, equipment may be able to run on B100 (pure biodiesel) with minor modifications, such as replacing rubber components that may degrade more quickly. Transitioning typically involves sourcing high-quality biodiesel, verifying engine compatibility, and ensuring proper fuel storage and handling to prevent contamination or degradation. This process takes specialized knowledge and training of maintenance personnel. The primary advantages of biodiesel include its ability to reduce greenhouse gas emissions, lower particulate matter, and offer a more sustainable, domestically produced alternative to fossil fuels. Because it's often used in blends, it allows operators to gradually transition without overhauling their replacement fleet. Academic papers have noted that additional benefits of switching to biodiesel (for appropriate equipment) can include improved air quality, as biodiesel can have higher combustion rates and thus lower emissions of unburned hydrocarbons and particulates, as well as extended engine life due to the often improved lubricating properties.

Biodiesel adoption does come with some risks and drawbacks. Cold-weather performance can be a concern, as biodiesel tends to gel at higher temperatures than petroleum diesel, which may cause starting issues or clogged filters. Improperly stored biodiesel can lead to fuel degradation or microbial growth in tanks. While most manufacturers support the use of biodiesel blends, it's essential to verify warranty coverage and follow recommended maintenance schedules to avoid operational issues. With proper management, biodiesel can be a practical and environmentally friendly fuel option for heavy-duty maintenance equipment, which is often the most challenging aspect of any maintenance fleet in terms of emissions reductions.

Case Study: Switching To Electric Landscape Equipment, City of Boulder, CO

By Denise Dawson & Aaren LeMieux

Small Electric Landscaping Equipment. Image attribution: City of Boulder.
Website: https://bouldercolorado.gov/government/departments/parks-recreation
Contact:dawsond@bouldercolorado.gov

The City of Boulder Parks and Recreation Department's Urban Parks workgroup has completed its transition to fully electric landscaping equipment with an engine size of 10 horsepower or less, marking a significant milestone in the department's commitment to sustainability and environmental stewardship. This initiative not only enhances Boulder Parks and Recreation's (BPR) eco-friendly practices but also ensures full compliance with Colorado State Regulation 29, which mandates the use of electric landscaping equipment with a horsepower rating of 10 or less during the peak ozone season, from June through August. The journey toward electrification began in 2016, when forward-thinking work groups within BPR took the first steps by investing in electric chainsaws and string trimmers. These early adopters laid the groundwork for a broader departmental shift, demonstrating the practicality and benefits of electric tools in daily operations. Over the years, BPR steadily expanded its electric equipment inventory, supported in part by the Partnerships for a Clean Environment (PACE) Voucher initiative. This county program offers financial assistance to organizations that adopt cleaner technologies. This transition plays a crucial role in reducing emissions, improving air quality, and fostering healthier communities throughout Boulder. The move to electric equipment reflects BPR's broader vision for a more sustainable future. Electric tools are quieter, produce zero direct emissions, and contribute to a safer and more pleasant experience for both staff and park visitors. As climate concerns continue to grow, BPR's leadership in adopting clean technologies sets a powerful example and reinforces Boulder's reputation as a forward-thinking, environmentally conscious city.

Scythe M.52 electric mower in operation at a ball field. Image attribution: Aaren LeMieux

Since also launching its robotic mowing pilot in 2024, the City of Boulder Parks and Recreation Department has seen transformative results with the Scythe M.52 autonomous mower. Performance Snapshot: 2024: 235 hrs 8 mins running time | 324.85 acres mowed. 2025: 372 hrs 17 mins running time | 494 acres mowed.

Beyond the impressive stats, the M.52 has redefined efficiency in sports turf maintenance. Fully electric and built for precision, it has taken over routine mowing, allowing staff to focus on specialized tasks such as field preparation, turf repairs, irrigation, and overall turf health. The result is improved field conditions and greater operational productivity. One of the mower's standout features is its ability to produce clean, consistent mow lines. Athletic fields now showcase a more uniform, professional appearance, enhancing the experience for athletes and visitors alike, while reflecting the city's commitment to excellence in public space management. Sustainability is another win. Powered by renewable energy, the M.52 significantly reduces noise and emissions compared to traditional gas-powered equipment, aligning with Boulder's environmental goals. With two seasons of strong performance and clear benefits, the department is optimistic about expanding robotic mowing as a long-term solution for smarter, greener turf care.

Case Study: Electric Maintenance Equipment For Kiest Softball Complex, Dallas, TX

By Frances McGee

Updating equipment for electric maintenance. Image attribution: Frances McGee.
Website:https://www.dallasparks.org/112/Environmental-Stewardship
Contact: frances.mcgee@dallas.gov

The City of Dallas launched a new green initiative at Kiest Softball Complex, replacing traditional gas-powered landscaping equipment with eco-friendly electric alternatives. The sustainable equipment includes six robotic mowers, a zero-turn mower, a robotic line stripper, line trimmers, leaf blowers, and edgers. With an investment of approximately $250,000, Dallas Park and Recreation's transition to quieter, zero-emission equipment not only makes Kiest Softball Complex greener, but it also actively supports the city's Comprehensive Environmental Climate Action Plan (CECAP), created in 2020 to steer Dallas toward greater sustainability.   Watch here to see how Dallas is going green!
https://www.youtube.com/watch?v=RrESWjgPLoY

Key Strategies & Considerations

- Developing a landscape equipment emissions transition plan, evaluating existing equipment stocks, and categorizing by small vehicles, hand tools, mowers, medium-sized ‘heavy’ equipment, and large ‘heavy’ equipment. Determine age and replacement schedules and consider a phasing strategy for each category.
- For battery systems, strive to standardize brands and utilize interchangeable batteries to simplify charging and replacement. Consider creating centralized battery banks and

decentralized battery storage systems that are strategically located to facilitate easier adoption.

- Conduct awareness training for the replaced equipment during roll-out.
- For biofuels, specialized training with on-staff mechanics will be crucial in creating the necessary in-house expertise.
- Transitioning maintenance equipment away from fossil fuels can be the difference between park landscapes being net greenhouse gas-emitting landscapes and net carbon-sequestering landscapes, with the park systems becoming part of the solutions for climate action.
- Transitioning to EVs and ETs can dramatically reduce fuel and maintenance costs for maintenance fleets, with many products having a return on investment well within the life span of the products.

Helpful Resources and References

Ali, O. M., Mamat, R., Rasul, M. G., & Najafi, G. (2017). Chapter Eighteen—Potential of Biodiesel as Fuel for Diesel Engine. In M. G. Rasul, A. kalam Azad, & S. C. Sharma (Eds.), *Clean Energy for Sustainable Development* (pp. 557–590). Academic Press. https://doi.org/10.1016/B978-0-12-805423-9.00018-1

Arborist Now. (2024). How to Choose the Right Power Tools: A Complete 2024 Buying Guide. https://arboristnow.com/news/how-to-choose-the-right-power-tools-a-complete-2024-buying-guide/

California Air Resources Board. (2021). Small Off-Road Engines (SORE) Fact Sheet. https://ww2.arb.ca.gov/resources/fact-sheets/sore-small-engine-fact-sheet

CEG Buyer's Guides. (n.d.). https://www.constructionequipmentguide.com/buyers-guide/

Clean Air Partnership. (2023). Electric Fleets Take Off: How Municipalities are Overcoming Fleet Electrification Barriers. https://www.cleanairpartnership.org/electric-fleets-take-off-how-municipalities-are-overcoming-fleet-electrification-barriers/

Demirbas, A. (2009). Biofuels: Securing the Planet's Future Energy Needs. Springer.

Environment America Research & Policy Center. (2023). Lawn care goes electric. https://environmentamerica.org/center/resources/lawn-care-goes-electric/

Gupta, R., McRoberts, R., Yu, Z., Smith, C., Sloan, W., & You, S. (2022). Life cycle assessment of biodiesel production from rapeseed oil: Influence of process parameters and scale. *Bioresource Technology*, *360*, 127532. https://doi.org/10.1016/j.biortech.2022.127532

Hasan, M. M., & Rahman, M. M. (2017). Performance and emission characteristics of biodiesel–diesel blend and environmental and economic impacts of biodiesel production: A review.

Renewable and Sustainable Energy Reviews, *74*, 938–948.
https://doi.org/10.1016/j.rser.2017.03.045

Hill, Jason, et al. (2006). "Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels." Proceedings of the National Academy of Sciences, vol. 103, no. 30, pp. 11206–11210. https://doi.org/10.1073/pnas.0604600103

International Council on Clean Transportation. (2023). How Cities and Counties Can Electrify Their Fleets. https://rmi.org/insight/how-cities-and-counties-can-electrify-their-fleets/

International Council on Clean Transportation. (n.d.). Electrifying EU city logistics: An analysis of energy demand and charging cost.
https://theicct.org/publication/electrifying-eu-city-logistics-an-analysis-of-energy-demand-and-charging-cost/

McConnell, R. (2010).   National Emissions from Lawn and Garden Equipment. U.S. Environmental Protection Agency. /https://www3.epa.gov/ttnchie1/conference/ei21/session10/banks.pdf

National Renewable Energy Laboratory. (2021). Biodiesel Use in Heavy-Duty Equipment: Performance, Economics, and Emissions. U.S. Department of Energy.
https://afdc.energy.gov/files/u/publication/biodiesel_heavy_duty_equipment_nrel2021.pdf

Saidani, M., Kim, H. (2021). Quantification of the environmental and economic benefits of the electrification of lawn mowers on the US residential market. Int J Life Cycle pp.1267–1284.
https://doi.org/10.1007/s11367-021-01917-x

Searchinger, T, et al. (2008). "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change." Science, vol. 319, no. 5867, pp. 1238–1240.

Slanger, D. (2024). How Fleets Can Electrify Light-Duty Commercial Vehicles. Rocky Mountain Institute. https://rmi.org/how-fleets-can-electrify-light-duty-commercial-vehicles/

U.S. Department of Energy. (2021). Benefits of Electrification for Lawn Equipment. Office of Energy Efficiency and Renewable Energy.
https://www.energy.gov/eere/articles/electric-lawn-equipment-cleaner-smarter-option

U.S. Department of Energy. (2021). Electrification of Municipal Fleets: A Guide for Local Governments. Office of Energy Efficiency and Renewable Energy.
https://afdc.energy.gov/files/u/publication/fleet_electrification_guide.pdf

U.S. Department of Energy. (2022). Biofuels Basics. Office of Energy Efficiency and Renewable Energy. https://www.energy.gov/eere/bioenergy/biofuels-basics

U.S. Department of Energy. (2022). Electric Outdoor Equipment: Procurement Strategies for Municipalities and Contractors. Office of Energy Efficiency and Renewable Energy. https://www.energy.gov/eere/slsc/electric-outdoor-equipment-resources

U.S. Department of Transportation. (2023). Charging Ahead: How Government Agencies Can Support the Electrification of Private Fleet Vehicles. https://www.transportation.gov/sites/dot.gov/files/2023-12/OSTX-Momentum-Toolkit-EV-Fleets.pdf

U.S. Environmental Protection Agency. (2022). Reducing Air Pollution from Small Gasoline Engines. https://www.epa.gov/regulations-emissions-vehicles-and-engines/reducing-air-pollution-small-gasoline-engines

U.S. Environmental Protection Agency. (2023). Clean Landscaping Equipment: Buying and Using Electric Tools. https://www.epa.gov/greenacres/clean-landscaping-equipment

University of California, Riverside. (2022). Air Quality Impacts of Gas vs. Electric Lawn and Garden Equipment. Center for Environmental Research and Technology. https://pdc.ucr.edu/sites/default/files/2021-07/4.3%20Air%20Quality_0.pdf

Utility Arborist Association. https://www.gotouaa.org/

Wan Osman, W. N. A., Rosli, M. H., Mazli, W. N. A., & Samsuri, S. (2024). Comparative review of biodiesel production and purification. *Carbon Capture Science & Technology*, *13*, 100264. https://doi.org/10.1016/j.ccst.2024.100264

Womble, J., & Bird, L. (2023). Ways the US Can Electrify Its Public Fleets, from City Buses to Garbage Trucks. World Resources Institute. https://www.wri.org/insights/us-public-fleet-electrification

World Economic Forum. (2019). A Vision for a Sustainable Battery Value Chain in 2030 Unlocking the Full Potential to Power Sustainable Development and Climate Change Mitigation. https://www3.weforum.org/docs/WEF_A_Vision_for_a_Sustainable_Battery_Value_Chain_in_2030_Report.pdf

Yi, H., Cui, Y., Li, H., Huang, G., Liu, K., Qu, L., Yan, J., Nie, L., & Xue, Y. (2025). Assessing the Feasibility and Environmental Benefits of Electrifying Construction Machinery in Beijing, China. *Journal of Environmental Sciences*. https://doi.org/10.1016/j.jes.2025.03.030

Reducing Embodied Carbon

Background

While this guide focuses on environmentally friendly park operations and decarbonization, capital improvements have significant greenhouse gas emissions. As part of parks departments and individual park operations, there are often capital investments, ranging from new parks to minor sequential capital improvements, which result in construction emissions. For new buildings, Architecture 2030 estimates that half of the total greenhouse gas emissions over the facility's lifetime will be associated with the construction phase. These emissions are defined as "embodied carbon," or the equivalent greenhouse gas emissions, usually reported in carbon dioxide equivalent (CO_2e). Embodied carbon refers to the accumulated emissions associated with harvesting and processing raw materials, such as timber or cement, transporting those materials, fabricating them, and installing them in a project. Operational carbon refers to the emissions associated with operating a facility or project after it has been opened. According to Architecture 2030 and Climate Positive Design, for park landscape projects, embodied carbon can account for 80 to 90% of the total project emissions. The reduced amount of operational carbon in comparison to architecture is mainly due to the absence of heating and cooling costs over time. Parks departments that want to manage parks to minimize emissions can consider whole-project lifecycle management, targeting the reduction of both embodied carbon emissions and operational emissions.

There are best practices for reducing embodied carbon in construction for almost every material at every stage of the process. For a detailed guide for reducing embodied carbon in park construction, please refer to the American Society of Landscape Architects (ASLA) Decarbonizating Specifications Guidelines, available here: https://www.asla.org/decarbonizingspecifications.aspx

To summarize, the following are key conclusions from those guidelines.

Prioritize Material Reuse

Using materials found on site, refurbishing buildings, utilizing salvage materials, upcycling, downcycling, or repairing in place will always reduce embodied carbon, as new materials are not being created and shipped to the site.

Prioritize Local And Domestic Sourcing

Landscape materials are usually heavy, and for many landscape projects, half the embodied carbon can be attributed to the shipping, freight, and local transportation emissions required to bring products and materials to the site.

Prioritize Using 'Biogenic' Materials

In the context of this guide, biogenic refers to sustainably grown and harvested living materials, such as wood, straw, or hemp. Sustainably sourced living materials (preferably with associated certifications such as Forest Stewardship Council FSC Wood) assume that the carbon stored in the material, and being prevented from decaying in the natural environment by being locked up in construction, serves as a durable carbon store or 'negative emission.' When considered in the context of life cycle analysis, sustainably forested wood and fiber products can be regarded as climate-neutral or better. For detailed thoughts on this convention, please refer to the ASLA guide cited above or Climate Smart Wood https://www.climatesmartwood.net/. As a side note, a material standard strongly emphasized in these guidelines is the avoidance of using neotropical or tropical hardwoods, full stop. The recent revelations of rainforest-harvested wood products and falsified FSC certifications mean that specifiers cannot guarantee these wood types, such as IPE, are not from illegally harvested rainforest lands.

Use Low-Carbon Factor Materials And Products

'Carbon factor' refers to the comparable intensity of emissions per unit of material; some materials, like Portland cement or copper, have high ratios of emissions. Prioritize alternative low-carbon factor materials where possible for the same construction element, taking into account associated operations and maintenance adjustments. Examples include using asphalt over aggregate instead of concrete and using recycled steel instead of aluminum for a railing. For details on the comparative landscape of carbon factors across material classes, please refer to the CarbonConscience white paper by Sasaki, available here: https://www.carbonconscience.sasaki.com/research/, or for a more comprehensive reference, Professor Meg Calkins' book "Details and Materials for Resilient Sites: A Climate Positive Approach," published in 2025, available here: https://www.routledge.com/Details-and-Materials-for-Resilient-Sites-A-Climate-Positive-Approach/Calkins

Prioritize Materials With Long Life Cycles

Selecting products and materials with short lifecycles can undermine any environmentally friendly specifications. This can be a matter of both the materials and how they are detailed, installed, and maintained. Some materials can have life cycles that are twice or four times longer than those of other, lower-carbon materials. An example is metals that develop a superficial patina (like weathering steel or copper), compared with metals that corrode (like painted mild steel). Some detailing, such as thick-cut timber for benches, as opposed to thin wood slats, can last much longer and withstand wear and tear.

Enable Disassembly And Future Reuse

While this may seem obvious to park operators, this strategy is often overlooked during project design phases. This can be as simple as using visible fasteners, such as guardrails attached to concrete foundations with J-bolts and acorn nuts, or ensuring playground equipment has modular systems for easy repair and replacement of components. This strategy also applies to hardscape materials, such as avoiding the use of rebar and welded wire mesh in paving, making it easier to cut out panels for repairs or recycle old pavement into crushed roadbase.

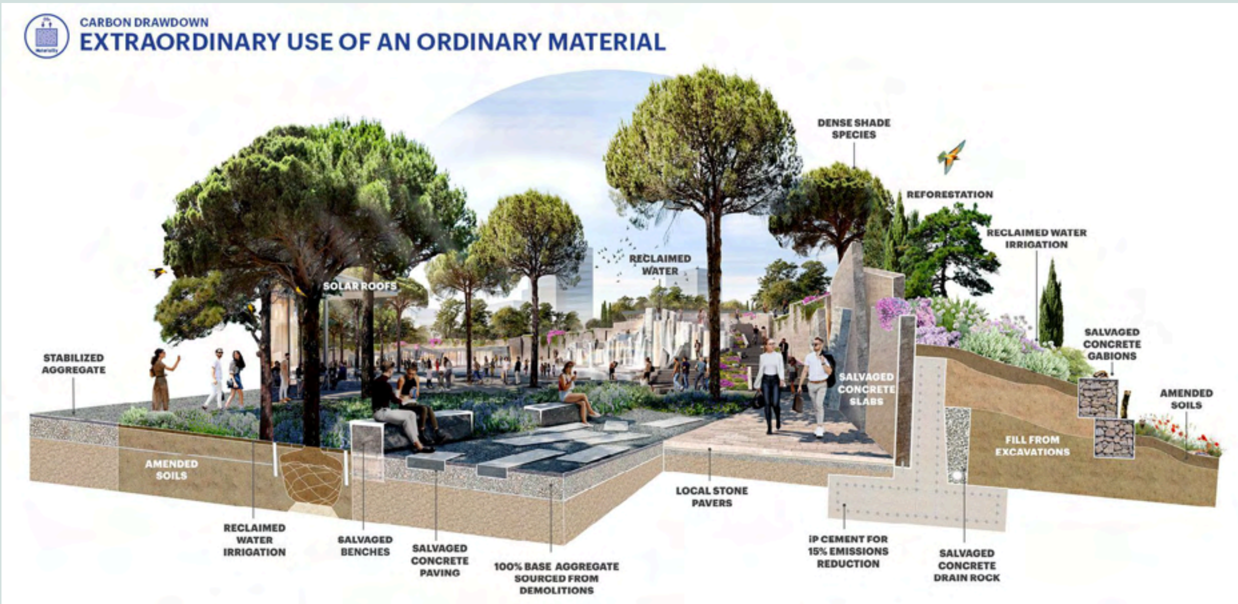
Establishing Emissions Expectations And Standards

Finally, as clients, ask designers to match their designs to your agency's environmental and sustainability goals. As park operators and in-house designers, park departments can match specifications to reflect and enforce emissions expectations and goals. The best way to reduce embodied carbon for constructed work is to vet every material decision with the same rigor given to climate costs as we give to financial costs.

Each of these strategies, when considered in isolation, addresses only certain aspects of what is needed to tackle embodied carbon emissions in construction. However, when combined, they provide a comprehensive strategy based on current best practices. If parks departments only focus on operational emissions associated with their project landscapes, they are missing the majority of the emissions related to their parks—the capital investments.

Case Study: Reducing Embodied Carbon at the Ellinikon Metropolitan Park, Athens

By Chris Hardy



Concrete from existing runways is reused playfully to tell the story of the site's past, reduce embodied carbon, and honor what used to be hidden. Image Credit: Sasaki
Location: Athens, Greece
Website:https://www.sasaki.com/projects/the-ellinikon-park/
Contact: crhardy@sasaki.com

The decommissioning of the original Athens International Airport—the site for the park—presented a generational opportunity to transform obsolete infrastructure into a resilient and performative landscape. Reducing the estimated embodied carbon of the park construction was one of the key goals of the client and design team. .

The primary factor in reducing embodied carbon was reducing the use of concrete. First, we converted approximately 74,000 square meters (SM) of new concrete-based paving to monolithic stone (or salvage slab) over an aggregate base (stone pavers without a concrete subslab), saving approximately 7,100 metric tons of carbon dioxide equivalent (MTCO2e). We converted another 75,300 SM of new concrete-based paving to stabilized aggregate (or resurfacing), saving approximately 8,800 MTCO2e. Similarly, we converted ~4,000 cm of new concrete retaining walls to either dry-stack stone walls, dry-stack salvage concrete walls, or gabions with salvage rip-rap, resulting in an estimated total savings of 699 MTCO2e. Together, our concrete reductions were on the magnitude of 16,600 MTCO2e for Phase 1, which would project to approximately ~41,500 MTCO2e for all phases. When we combined this with the anticipated 20% reduction due to using supplementary cementitious materials, we reduced our total embodied carbon footprint for the park by almost 50% simply by addressing the concrete in the design.

The secondary factor was material salvage. We have an estimated 150,000 CM of salvaged concrete used as either roadbase, rip rap, or upcycled as new paving, cladding or furnishing. In all phases, if we had used the equivalent material in imported aggregate base - that would have added ~11,400 MTCO2e, and if we replaced our upcycled concrete with precast, that would have added another ~535 MTCO2e. Not considering reused architectural elements, which we do not have good offset information on, our use of salvage hardscape is saving a combined potential of 11,935 MTCO2e across all phases.

As a general note, the salvage mentioned above represents a 100% replacement of road base and riprap with salvaged material, as well as about a 50% replacement of structural concrete elements (retaining walls or cladding) across all phases. The lowest grade salvage is being used as clean fill in the core of new topography - with the goal of no net export of site hardscape demolitions for both this site and also adjacent excavations for the district roadways and phase 1 works.

Key Strategies & Considerations

- Prepare a park or departmental material inventory and identify primary capital investments that require significant amounts of high embodied carbon, such as walls, paving, lighting, and furnishings. Investigate alternative product standards for these elements.
- If a department has a standard specification or detail library, conduct an embodied carbon review of those standards, evaluating each aspect in light of probable emissions.
- Use mock-ups or test plots to test alternative materials to existing high-embodied-carbon standard materials.
- Consider adopting local or domestic purchasing clauses in project contracts.
- Consider requiring environmental product data (EPD) submittals for all hardscape and furnishing materials (note the landscape material community is lagging behind architectural products for general availability of EPDs).
- Develop acceptable carbon benchmarks or caps for construction typologies within your parks system and charge designers and contractors to demonstrate compliance.
- Require contractors to track embodied carbon emissions through product data and on-site construction emissions and report the results periodically throughout the construction process. Consider financial bonuses for achieving carbon goals and penalties for non-compliance.

Helpful Resources and References

Architecture 2030. (2023). Carbon Smart Materials Palette – Actions for reducing embodied carbon at your fingertips. https://materialspalette.org/

Architecture 2030. (2023). Why The Building Sector? – Architecture 2030. https://architecture2030.org/why-the-building-sector/

ASLA. (2022). Climate Action Plan. https://www.asla.org/climateactionplan.aspx

ASLA. (2024). Decarbonizing Specifications: Guidelines for Landscape Architects, Specifiers, and Contractors. https://www.asla.org/decarbonizingspecifications.aspx

ASLA Webinar: *Decarbonizing Design: Best Practices and Strategies by Design Phase—1.0 PDH (LA CES/HSW)*. (n.d.). https://learn.asla.org/products/decarbonizing-design-best-practices-and-strategies-by-design-phase-10-pdh-la-ceshsw?packages%5B%5D=169613&in_package=169613&sort_by=package_order&ref=package&ref_id=169613

Calkins, M. (2009). Materials for sustainable sites: A complete guide to the evaluation, selection, and use of sustainable construction materials. *Choice Reviews Online*, *46*(07), 46-3868-46–3868. https://doi.org/10.5860/CHOICE.46-3868

CLF. (2024, June 7). Embodied Carbon 101. Carbon Leadership Forum. https://carbonleadershipforum.org/embodied-carbon-101-v2/

Climate Smart Wood Group. (n.d.). Home. Climate Smart Wood. Retrieved September 24, 2024, from https://www.climatesmartwood.net/

Conrad, P. (2020). Data Report—Metrics Behind Pathfinder—Climate Positive Design. https://climatepositivedesign.com/resources/data-report/

Conrad, P. (2023). Resources: Learn More To Make A Change. Climate Positive Design. https://climatepositivedesign.com/resources/

Hardy, C., & Frechette, M. (2023). Designing with a Carbon Conscience V2: A web-based application to inform planning and urban design projects on potential carbon impacts. Sasaki Associates.

Hardy, C., Conrad, P., & Carlisle, S. (n.d.). *ASLA Webinar: Introduction to Carbon and the Built Environment*. https://learn.asla.org/products/introduction-to-carbon-and-the-built-environment-10-pdh-la-ceshsw-10-gbci-sites-specific-ce?packages%5B%5D=169613&in_package=169613&sort_by=package_order&ref=package&ref_id=169613

Himes, A. (2021). AIA-CLF Embodied Carbon Toolkit for Architects. *Carbon Leadership Forum*. https://carbonleadershipforum.org/clf-architect-toolkit/

Kuittinen, M., Organschi, A., & Ruff, A. (2022). Carbon: A Field Manual for Building Designers. Wiley. https://www.wiley.com/en-us/Carbon%3A+A+Field+Manual+for+Building+Designers-p-9781119720768

Simonen, K., Droguett, B. R., Strain, L., & McDade, E. (2017). Embodied Carbon Benchmark Study: LCA for Low Carbon Construction [Technical Report]. University of Washington. https://digital.lib.washington.edu:443/researchworks/handle/1773/38017

Carbon Capture Technologies

Background

Carbon capture technologies, broadly referred to as carbon capture, utilization, and storage (CCUS), are rapidly evolving in response to the need to reduce greenhouse gas emissions, particularly from hard-to-abate industrial sectors such as cement, steel, chemical manufacturing, and construction. These technologies aim to capture carbon emissions from point sources, such as power plants, or directly from the atmosphere and then either store the captured carbon underground in geological formations or reuse it in industrial applications.

While the concept of carbon capture has existed for decades, recent advances in materials science, process design, and government incentives have reinvigorated its potential as a viable climate solution; however, at the time of research into these guidelines, the authors found no examples of currently viable carbon capture technologies that have reliable return on investments, or have implementation pathways relevant to parks departments.

This may change. The financial return on investment for carbon capture technologies will likely be a barrier until there are economy-wide carbon prices. For now, greenhouse gas emissions remain unregulated and untaxed, and the costs of climate change adaptation and mitigation are to be borne by the public. That being said, large companies, including ExxonMobil, Chevron, and Occidental, have announced multi-billion-dollar plans for CCUS investments, not only to decarbonize their operations but also to offer carbon management services to other industries. These investments suggest carbon capture technologies may one day be common. Innovations and startups in the US and EU have been gaining traction, with some already having functional installations, such as Climeworks (operating globally) and Carbon Engineering (partnering with Occidental Petroleum in Texas).

Consider Investing In Ecosystems Instead

Direct carbon capture (DAC) remains high; at the time of writing these guidelines, costs are estimated at $600–$1,200 per ton. Placing this in perspective, it is equivalent to $350–$700 worth of gasoline. That is also equivalent to three years of growth for a medium-sized red oak, according to the dataset used by i-Tree, as compiled by the US Forest Service. To paraphrase Dr. Stuart Pimm of SavingNature.org, trees have been sequestering carbon for a very long time, and are very good at it. This author adds that well-managed trees are self-repairing, self-replicating, and contribute net-zero waste. They are a perfect technology.

To quote Paul Gilbert, the executive director of the NOVA Parks System, “While carbon capture technology is interesting, the truly “proven technology” for absorbing and storing carbon is photosynthesis. Trees and other woody plants absorb carbon from the air and store it in the wood and roots of the tree. Converting an open field into a forest provides decades of carbon reduction.”

Key Strategies & Considerations

- Carbon Capture Technologies are not ready for general implementation, especially for municipal parks departments. Plant and care for trees instead.

Helpful Resources and References

Financial Times. (2024). Climate Tech Explained: Carbon Capture and Removal. https://www.ft.com/climate-tech-explainers

Kazemifar, F. (2021). “A Review of Technologies for Carbon Capture, Sequestration, and Utilization: Cost, Capacity, and Technology Readiness.” Greenhouse Gases: Science and Technology, vol. 12, no. 1, pp. 200–230, doi:10.1002/ghg.2131.
https://scijournals.onlinelibrary.wiley.com/doi/abs/10.1002/ghg.2131

Nowak, D. (2023). I-Tree Benefits. https://www.itreetools.org/

Nowak, D. J. (2021). Understanding i-Tree: 2021 summary of programs and methods. General Technical Report NRS-200-2021. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 100 p., 200–2021, 1–100.
https://doi.org/10.2737/NRS-GTR-200-2021

Microgrids

Background

The simplest conception of a microgrid is a fully disconnected facility where the power source is on-site, and there is no connection to external utilities. There are many approaches and types of microgrids, but in general, they are localized energy systems that can operate independently or in conjunction with the main utility grid. For small systems, this can be very simple, such as a park restroom with solar lighting. The complexity of microgrids stems from their scale, reliability, and flexibility. When systems require guaranteed power at all times, inconsistent power generation can necessitate expensive investments in battery systems. When peak loads exceed the system's capacity, it can become unstable and shut down, resulting in outages. For remote park facilities, microgrids may be the most reasonable approach to providing power, and backup systems may include fossil fuel generators or battery systems. For large microgrids, such as those with multiple conditioned buildings on the grid, sophisticated systems are available to achieve total energy independence through a combination of renewable energy sources, batteries, system controls, and backup generators.

One of the primary benefits of microgrids is their ability to enhance energy reliability and resilience. In traditional grid systems, outages can affect wide areas and disrupt critical services, especially in hospitals, emergency facilities, or remote communities. Microgrids can mitigate this by maintaining power locally even when the larger grid fails. Some microgrids operate with partial connectivity and participate in 'net metering' tracking of energy consumption. Having this capacity can be an important resilience strategy, allowing park facilities to operate when the grid is down and the park itself to continue functioning even when the local power source is unavailable. Microgrids may make particular sense for park facilities that are designated as refuge centers, such as urban parks that could serve as aid distribution hubs after earthquakes, floods, or wildfires.

Economically, microgrids can offer long-term savings by reducing demand charges, increasing energy efficiency, and potentially selling surplus energy back to the grid. However, large microgrids are generally expensive and complex to build. Although constructed examples exist in the United States, they are not a common approach yet and seem to still be in an early adoption phase.

Case Study: Microgrid Resilience: Community Recreation Center, Oak Park, IL

By Nelson Acevedo

Solar panels on the roof and parking canopy of the Community Recreation Center generate enough energy to meet the building's needs. Image attribution: Village of Oak Park & Perkins&Will
Website: www.pdop.org/crc
Contact: Nelson.Acevedo@pdop.org

The Community Recreation Center (CRC) in Oak Park, IL, is a 42,000-square-foot net-zero facility that exemplifies how microgrids can enhance community resilience and sustainability. Completed in 2023, the CRC was designed to exceed the goals of the Climate Ready Oak Park Plan by producing all its energy on-site through a comprehensive solar and battery storage system. The building features rooftop and wall-mounted photovoltaic arrays, as well as a solar canopy over the parking lot. These systems generate more electricity than the building consumes annually. A portion of the solar array is connected to an on-site battery storage system, forming a microgrid that ensures critical operations, such as elevator access and lighting, can continue during power outages.

This microgrid capability transforms the CRC into a community resilience hub. In emergencies, the facility can remain partially operational, providing a safe, climate-controlled space for residents. Real-time dashboards in the lobby display energy production, consumption, and battery status, educating visitors on the benefits of renewable energy and grid independence. Beyond energy, the CRC supports equity and inclusion with free after-school programs, mental health services, and accessible amenities like inclusive locker rooms and a lactation room. The building's design reflects community input, especially from youth, and includes an esports lounge, walking track, and multipurpose rooms.

The CRC demonstrates how microgrids can power not just buildings, but community well-being.

Key Strategies & Considerations

- Consider whether a facility requires reliable energy or if it can be disconnected from the grid without added complexity.
- Consider if energy independence is important enough for a facility to justify significant capital investments in creating a microgrid and battery system.
- If developing a microgrid, consider how connectivity to the main grid could provide backup power if needed.

Helpful Resources and References

Lasseter, R. (2007). "Microgrids and Distributed Generation." Journal of Energy Engineering, vol. 133, no. 3, pp. 144–149. https://doi.org/10.1061/(ASCE)0733-9402(2007)133:3(144)

Navigant. (n.d.). Microgrid Knowledge: Overview and Market Trends. https://www.microgridknowledge.com/players/navigant

U.S. Department of Energy. (2014). The Role of Microgrids in Helping to Advance the Nation's Energy System. Office of Electricity. https://www.energy.gov/oe/downloads/role-microgrids-helping-advance-nations-energy-system

Parhizi, S., et al. (2015). "State of the Art in Research on Microgrids: A Review." IEEE Access, vol. 3, pp. 890–925. https://doi.org/10.1109/ACCESS.2015.2443119

Energy Modeling, Commissioning, and Tracking

Background

Facilities management, building product manufacturing, and architecture, engineering, and construction professions have become adept at the design, production, delivery, and operations of energy-efficient products and buildings over the last two decades, leading to cost-effective 'net zero' facilities, certifications for products, and the prevalence of LED lighting and heat pumps for heating and cooling. While this revolution has occurred for buildings and products, the operations of park landscapes have lagged. This may be in part due to the relatively low energy needs for operating landscape systems, and in part to the staff capacity and background. While building codes, developers, and institutions have demanded energy efficiency for buildings, the professional class of building engineers and facility managers has enabled the adoption and operation of energy-efficient facilities. Landscape operations staff have traditionally focused on horticultural, irrigation, structural, and social services specialties. There is a need to extend the scope of building engineers and facility managers' expertise to consider the landscape systems as integral to their efficiency goals.

Considerations For New Construction

For new park landscapes and buildings, energy efficiency goals (such as ‘net zero’) can be incorporated into project design scopes, requiring the consultant team to conduct energy modeling at project milestones, along with the system design documentation and calculations. Energy models are computer simulations of a facility's likely energy demands. During the design phases, the design team can utilize reference projects, benchmarks, and standards to determine what reasonable Energy Use Intensity (EUI) metrics are for the specific construction typology. Depending on the building typology, a reasonable EUI for unconditioned, passive park buildings could range from 5 to 15 kBtu/ft^2/year (thousands of thermal units per square foot per year, a metric used to measure a building's EUI). It indicates the total amount of energy a building consumes annually relative to its total floor area, allowing for energy performance benchmarking and comparison with other buildings.. A conditioned building EUI can range significantly based on climate, energy loads, and occupancy schedules.

During construction, the contractor can be required to go through a commissioning process (the process of testing and verifying technical system performance) for park energy systems. While energy codes increasingly require these practices, many landscape contractors are unfamiliar with the concept of commissioning. For large projects, including a third-party commissioning agent as a subcontractor to independently verify performance and train the future park landscape and building operators on the systems, can be a way to ensure performance and avoid challenges in the handoff of the facility from contractor to operator. Commissioning can be a powerful tool for clients to ensure energy efficiency, that systems are functioning as designed, and to prepare their staff to operate the facility. Commissioning can apply to all park technical systems, including waste management systems, irrigation systems, audiovisual systems, high-performance green infrastructure, and telecommunications systems. After occupancy, the initial operations metrics from the first year can serve as key benchmarks for adjusting and modifying operations plans. Similar to the process for buildings, performance monitoring can be as simple as checking on energy expenditures and metering monthly, or conducting annual energy audits.

Considerations For Existing Facilities

Existing conditions can significantly challenge energy-efficient park operations, including a lack of separately metered data, deferred maintenance, and inefficient and outdated infrastructure. In this case, energy audits are best conducted on an individual facility basis to establish a baseline understanding of the loads and usage. The primary systems that generate the highest energy loads for buildings include heating, cooling, appliances, and lighting. The primary systems that typically contribute to park landscape energy demands include lighting, fountains and water features, irrigation systems and pumps, audiovisual / telecom equipment, and, increasingly, charging for electric vehicles, tools, and equipment. Specialty infrastructure, such as sump pumps, may also have significant energy demands for parks. The first step may be to install meters for the various energy and water loads. A comprehensive energy audit helps inform park operators about their most oversized energy loads and enables them to prioritize capital improvements for increased efficiency. With an initial audit serving as a benchmark, operators can track improvements against this baseline, with successive work including commissioning stages to demonstrate and verify progress.

Just as energy audits can provide site-specific data, park operators can also collect valuable data by tracking energy usage by type. NOVA Parks (Northern Virginia Regional Park Authority) utilizes its accounting system to track not only the cost of energy but also the units of consumption, such as gallons of fuel, kilowatts of electricity, or other units. With units of consumption, it is easy to track total energy usage and/or carbon footprint, since operators can convert consumption units to equivalent carbon emissions or BTUs. This historical data can also help identify issues to address if there is a noticeable shift in energy consumption. Noted by Paul Gilbert, NOVA Park Executive Director, "NOVA Parks tracks all the energy consumption across all facilities. We give an award to the facility that had the greatest percentage in energy reduction each year. Because it is by percentage, it is fair across large and small facilities. And because we track all energy it is also fair across facilities with different systems."

Living Systems For Energy Efficiency

Finally, there are numerous ways to harness living systems to minimize energy loads. For example, deciduous trees in hot climates reduce cooling energy loads when shading buildings. The urban heat island effect can be reduced for whole districts with sufficient canopy coverage, cooling through evapotranspiration. In cold climates, strategic wind breaks can reduce heating requirements for sheltered buildings. Natural ventilation, passive architectural design, and minimizing lighting hours and intensity are all ways to improve energy efficiency, and can all be incorporated into energy models to optimize park performance.

Key Strategies & Considerations

- When developing new park design contract requirements, including energy goals, modeling, and commissioning scopes and deliverables, and include future maintenance leaders and staff in the design review process.
- Assess internal operations team capacity and expertise to effectively manage and optimize park landscape energy efficiency, and consider training, internal reorganization, or hiring to fill potential skill set gaps.
- When developing new parks or after performing energy audits on existing parks, articulate park energy efficiency goals and priorities to help operators better understand expectations and how to provide metrics to evaluate success.
- Efficiency declines over time as equipment ages, and initial energy models are idealized projections that require ongoing monitoring and adjustment.

- Park use will have a considerable impact on energy demand. Peak loads and overall energy demand can fluctuate significantly with operational changes, such as increases in the number of specialty events, adjustments to operational hours for fountain use, or extended nighttime operating hours.
- The most impactful strategies for optimizing energy efficiency in park landscapes include passive design (energy-disconnected), energy-efficient lighting and equipment, and balancing energy demands with on-site renewable power. Operators require modeling, commissioning, and monitoring to understand what is needed fully and, later, to effectively evaluate success.
- Utilize the landscape to mitigate energy loads for buildings, such as positioning deciduous trees on the south and western sides of buildings or installing windbreaks in the direction of prevailing winds to reduce heating requirements in winter.

Helpful Resources and References

National Recreation and Park Association (NRPA). (n.d.) *Energy Audit* (Resources on the benefits of conducting energy audits), https://connect.nrpa.org/viewdocument/energy-audit-nrpa?CommunityKey=7bafe8ea-31b8-48d6-962f-dddfac853daa&tab=librarydocuments

Andropogon & U.S. General Services Administration. (2017). The Site Commissioning White Paper.https://www.gsa.gov/real-estate/design-and-construction/landscape-architecture/analytics-and-commissioning.

Calkins, M. (2012). The Sustainable Sites Handbook: A Complete Guide to the Principles, Strategies, and Best Practices for Sustainable Landscapes. Wiley.

cove.tool. (2023). Cove.tool: Energy Modeling & Embodied Carbon For Planning | Calculate and Evaluate Climate Impacts. https://cove.inc/

Crawley, D., et al. (2001). EnergyPlus: Creating a New-Generation Building Energy Simulation Program. U.S. Department of Energy.   https://www.energy.gov/eere/buildings/energyplus

Healey-Brudal, T. T., Andresen, I., & Gaitani, N. (2025). Integrated energy planning and design of neighbourhoods: A novel process derived from four real-life case studies in Europe. *Building and Environment*, *282*, 113289. https://doi.org/10.1016/j.buildenv.2025.113289

IESVE. (2023). Building Energy Modeling Software. https://www.iesve.com/software/building-energy-modeling

Knox, M., and Clevenger, C. (2013). “Energy Modeling: A Tutorial and Introduction to eQUEST.” Colorado State University, https://dl.icdst.org/pdfs/files3/824761a9c3beca09796269681bb22f1d.pdf.

McPherson, E. Gregory, et al. Energy-Saving Potential of Trees in Chicago. USDA Forest Service, 1994.

Norton, B., et al. (2015). “Planning for Cooler Cities: A Framework to Prioritize Green Infrastructure to Mitigate High Temperatures in Urban Landscapes.” Landscape and Urban Planning, vol. 134, pp. 127–138.

Reinhart, C., and Cerezo, C. (2016). “Urban Building Energy Modeling – A Review of a Nascent Field.” Building and Environment, vol. 97, pp. 196–202. https://doi.org/10.1016/j.buildenv.2015.12.001

Seyedzadeh, S., et al. (2018). Machine learning for estimation of building energy consumption and performance: a review. Visualization in Engineering. 6. 10.1186/s40327-018-0064-7.

U.S. Department of Energy. (2015). “Building Energy Modeling 101: What Is It and What Is DOE’s Role?” Office of Energy Efficiency & Renewable Energy, https://www.energy.gov/eere/buildings/articles/building-energy-modeling-101-what-it-and-what-does-role

UGREEN. (2023). “Energy Modeling: The Complete Guide for Building Professionals.” https://ugreen.io/how-to-conduct-energy-modeling-a-comprehensive-guide-for-building-professionals/

Watson, D., and Labs, K. (1983). Climatic Design: Energy-Efficient Building Principles and Practices. McGraw-Hill.

Environmentally-Friendly Parks Management Abbreviated Glossary

Biochar: a charcoal-like substance made from organic waste that's rich in carbon. It's used as a soil amendment and can help with climate change through long-term storage of carbon in soils.

Carbon capture technologies: processes designed to capture carbon dioxide (CO2) emissions from sources like power plants and industrial facilities, or directly from the atmosphere, to mitigate global warming by transporting and storing the captured CO2.

Carbon Emissions: Carbon dioxide emitted through an activity or process, such as material extraction, fabrication, transportation and assembly, and possible demolition.

Carbon Offsets: The investment in offsite carbon sequestration and storage measures to mitigate onsite carbon emissions.

Carbon Sequestration: The active storing of carbon from the atmosphere into vegetation or soils.

Carbon Stored or Biogenic Carbon: The mass of carbon locked up within building materials, vegetation, or soils that are not readily off-gassed into the atmosphere.

Circular Economy: an economic system based on the reuse and recycling of materials or products, especially as a means of continuing production in a sustainable or environmentally friendly way. End-of-life product and material plans that target a 'closed loop' seek to avoid any materials ultimately residing in landfills.

Climate Action Plan (CAP): a strategic document that outlines policies and actions to reduce greenhouse gas emissions and address climate challenges in a specific area, such as a city, institution, agency, or region.

Compost: a soil amendment rich in organic matter, sourced from decomposed organic material, often prepared as a blend to include target fertility, soil organic carbon, and soil structure improvements.

Compost tea: a liquid extract made by steeping compost in water, containing nutrients and microorganisms beneficial for plants, often used as an alternative for inorganic fertilizers to support soil fertility.

Embodied Carbon: Estimate of the probable carbon emission from a material or product's sourcing, fabrication, transport, and installation on a site.

Energy-Efficient Heating and Cooling: methods and systems that minimize energy consumption for HVAC (heating, ventilation, and air conditioning) operations, such as heat pumps and efficient air conditioners that prioritize energy performance while maintaining comfort.

Energy modeling: using computer simulations to predict and analyze a building's or system's energy consumption, helping to design and optimize energy efficiency and identify potential improvements. In the survey, we partner these simulations with commitments to commissioning - a process that intervenes at the final stage of facilities construction, involving procedures to check, inspect, and test every operational energy component to ensure compliance with the energy model and engineering.

Energy Use Intensity (EUI): a metric that measures a building's energy consumption relative to its size, expressed as energy per square foot per year, and is a crucial indicator of a building's energy efficiency.

Erosion Control Plan (ECP): is a strategy for reducing soil erosion on a property. It outlines how to prevent soil erosion from natural and human-caused factors and can be part of parks' maintenance management plans.

Green infrastructure: a network of natural and engineered spaces and strategies that manage water with living systems and provide ecological cobenefits. Examples are bioswales, rain gardens, and green roofs.

Grey (or reclaimed) water: safely diverting and repurposing water from non-toilet sources like showers, sinks, and laundry for uses like irrigation, toilet flushing, and car washing, reducing the need for fresh water.

Heat pump: a device that transfers heat rather than generating it, making it a more efficient and environmentally friendly alternative to traditional heating and cooling systems that rely on burning fossil fuels.

Heritage tree protections: policies that involve designating and safeguarding large, significant trees for their age, rarity, aesthetic, botanical, ecological, or historical value, often through ordinances that limit their removal or damage.

Integrated pest management (IPM): is a method of controlling pests that uses a variety of techniques, rather than solely relying on pesticides. IPM is an environmentally sensitive approach that aims to minimize the risk to people, property, and the environment.

LED Lighting: Lighting products that utilize light-emitting diodes (LEDs), which are semiconductor devices that convert electricity into light through a process called electroluminescence, offering energy efficiency and long lifespan compared to traditional lighting methods.

Life Cycle Assessment (LCA): A material or product data sheet or study that estimates a variety of impacts for that material on the environment over the material's life span. Generally, LCAs referred to in the Carbon Conscience Dataset conform to ISO 1040 standards.

Lighting Power Density Analysis (LPD): the measurement of the electrical load of lighting fixtures per unit area of a space, typically expressed in watts per square foot (W/ft^2), used to assess and potentially reduce energy consumption and lighting-related costs in buildings.

Low-no mow turf: Turf blends requiring no mowing or periodic (quarterly or seasonal) mowing to maintain turf health.

Microgrid: a localized, self-contained electrical network that can operate independently or connect to a larger grid, providing power to buildings or landscape facilities within a defined area, like a park, campus, or neighborhood.

Operational Carbon: Estimate of the probable carbon emission from the occupation and operations of a facility or landscape.

Organic Land Management: a landscape operations approach that nurtures healthy soils and ecosystems through natural processes, avoiding synthetic inputs like pesticides and fertilizers and prioritizing practices like composting and integrated pest management.

Power Purchase Program: an arrangement in which a third-party vendor installs, owns, and operates an energy system on a customer's property, often with the agreement of the customer or agency to purchase the power from the vendor at a negotiated rate.

Renewable energy: energy derived from natural resources like wind, sunlight, water, and heat from the Earth that are replenished naturally and can't be depleted, offering a low or zero-carbon footprint.

Smart Irrigation: an irrigation approach and system where devices use sensor feedback (like soil moisture, rain, and weather data) to adjust irrigation schedules and water usage, leading to more efficient and sustainable irrigation practices compared to traditional timers.

Soil Management Plan (SMP): is a site-specific plan that outlines how to manage soil health, potentially including contamination, carbon stocks, nutrition, and structure. SMPs are often required before development or soil disturbance can occur and can be part of parks' maintenance management plans.

Soil Organic Carbon (SOC): Solid carbon stored in soils through the living and dead biomass of the soil. This is distinct from mineral soil carbon; in general, mineral soil carbon is static, while SOC can accumulate.

Solar Lease: a contract where a company installs and owns solar panels on the property of the private land owner or agency, and the land owners pay a fixed monthly fee to rent the system and use the electricity it generates, without owning the panels.

Tree Protection Plans (TPP): a plan outlining standards designed to safeguard trees during construction, development, or operations that might impact their critical root zone (CRZ) and overall health, often involving specific guidelines, policies, and practices.

Water harvesting: the practice of collecting, storing, and using rainwater, snow, fog, and other water sources. It can be done through a variety of methods, including rain barrels, trenches, cisterns, reservoirs, and rooftop collection systems.

Whole Building Life Cycle Assessment (WBLCA): A study that calculates the environmental impacts of an entire building, including materials, construction, and operations, over the building's life span. WBLCAs can be completed with a variety of methods, with current best practices defined by EN15978, ASTM E2921, and/or ISO 21932.

Whole-Project Carbon Budget: The maximum amount of cumulative net global anthropogenic CO_2 emissions allowed for a given project, inclusive of embodied and operational emissions.

Whole Project Life Cycle Assessment (WPLCA): A study that calculates the environmental impacts of an entire project inclusive of site and building impacts, materials, construction, and operations over the project’s life span.

Xeriscaping: the practice of designing landscapes to reduce or eliminate the need for irrigation.

Diverted stream waste management: intentionally directing materials away from traditional landfills and into alternative management pathways, such as recycling, composting, or reuse, to reduce environmental impacts.