SUMMARY

URBAN HABITAT BENEFITS of Green Stormwater Infrastructure

GSI Impact Hub

WHAT YOU NEED TO KNOW

GSI can support biodiversity by:

- Providing food and refuge for birds, amphibians, bees, butterflies, and other species.
- Creating habitat for insects and birds that enhance pollination and seed dispersal.
- Providing landscape connectivity and encouraging the movement of species between habitat patches.
- Improving water quality and maintaining hydrology that supports instream habitats.

Green stormwater infrastructure (GSI), including rain gardens, bioretention facilities, trees, retention ponds, and constructed wetlands, contribute to the network of green spaces in urban and suburban areas that support ecosystems and biodiversity. Reducing the volume of polluted stormwater runoff that enters local waterways can also provide important habitat benefits.

Not all GSI is created equal when it comes to creating habitat and promoting biodiversity.

This is a summary of a full guide produced as part of the GSI Impact Hub, a larger project that provides resources and support related to specific GSI co-benefits. Please visit the GSI Impact Hub website to explore these resources including:

- Compendium of GSI Co-benefits Valuation Resources
- GSI Impact Calculator, a block-level tool for quantifying and monetizing co-benefits
- Full-length guides related to flood risk reduction, green jobs and economic development, heat risk reduction, habitat and biodiversity, and transportation.

The GSI Impact Hub is a collaboration between The Nature Conservancy, Green Infrastructure Leadership Exchange, One Water Econ, government agencies and technical partners.

Please see the full guide to “Understanding and Quantifying the Urban Habitat Benefits of Green Stormwater Infrastructure” for citations to the sources referenced in this summary.

The extent to which GSI provides these benefits depends on several factors, including the characteristics and needs of key species, proximity to other natural areas, design and management of the surrounding built environment, local environmental conditions, and the characteristics of individual GSI projects.

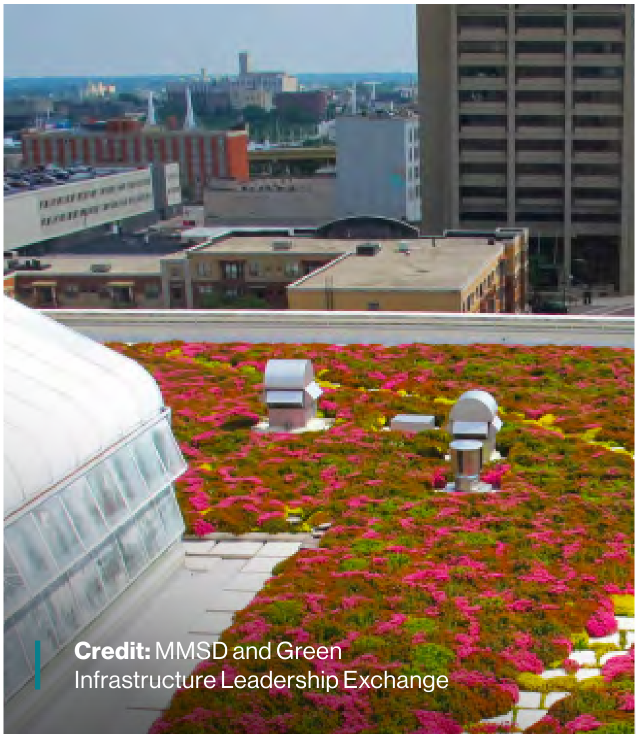
IDENTIFYING KEY BENEFITS

Available research indicates that various GSI practices have the potential to create or expand habitat, especially for arthropods and other pollinators. Strategically located ground-level GSI can enhance local ecosystems by providing habitat connectivity, essentially creating wildlife corridors. Areas that provide this benefit can help to prevent local extinction, facilitate re-colonization, and maintain vital biological interactions (e.g., plant-pollinator interactions and plant-seed dispersal). Table 1 on page 5 summarizes current research on the habitat benefits for different GSI interventions.

Outside of vegetated practices themselves, GSI can also benefit instream species by improving water quality, enhancing streamflow, and/or reducing unnatural peak flows or flashiness. The water quality benefits of GSI are well documented and water quality parameters are often used as indicators for healthy streams and habitat.

Maximizing biodiversity benefits

To maximize habitat and biodiversity benefits, GSI planning should occur within the context of the overall landscape when possible, identifying areas where projects can create critical habitat for priority species. This requires an understanding of surrounding land uses, existing habitat areas, and target species requirements. The text box on page 4 provides a framework for planning, designing, and managing GSI to achieve and maximize habitat and biodiversity benefits. It was adopted from a framework originally developed by the Milwaukee Metropolitan Sewerage District (MMSD).



Credit: MMSD and Green Infrastructure Leadership Exchange

Why do we care about pollinators and arthropods?

Pollinators like birds, bats, bees, butterflies, beetles, and other small insects, travel from plant to plant carrying pollen on their bodies and facilitating the transfer of genetic material that is critical to the reproductive system of most flowering plants. Approximately 75% of the world's flowering plants and about 35% percent of the world's food crops depend on animal pollinators to reproduce. Pollinators also support healthy ecosystems that clean the air, stabilize soils, protect from severe weather, and support other wildlife. Across the world, pollinator populations are in decline in large part due to a loss in feeding and nesting habitats.

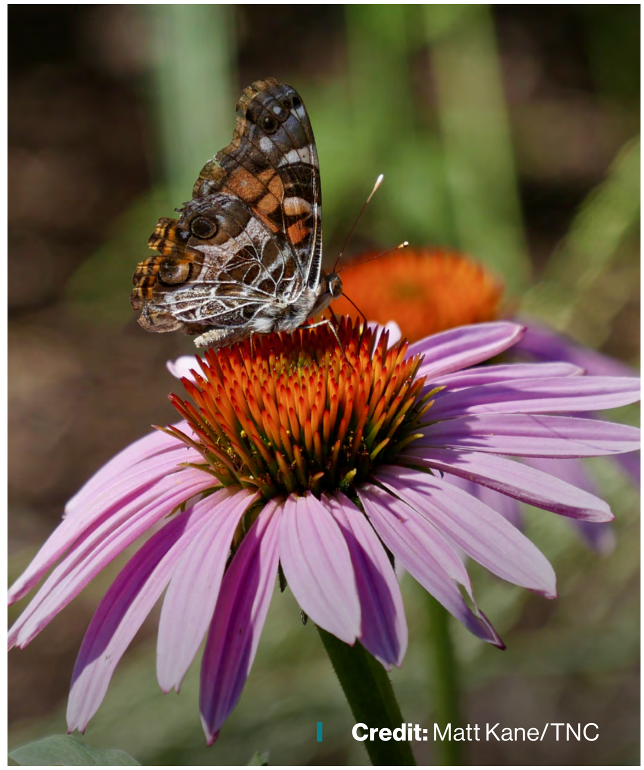
Arthropods are invertebrates with jointed legs – including spiders, mites, insects, centipedes, ants, and millipedes. They make up about 75% of all animals on Earth and have a major role in maintaining ecosystems as pollinators, recyclers of nutrients, scavengers, and food for birds, fish, and mammals.

Sources: Pollinator partnership, USDA (2022)

Location matters

Isolated GSI interventions will have limited value to biodiversity if organisms are unable to disperse to and from the habitat; however, if strategically placed near existing habitat patches or corridors, the same intervention can increase available habitat or provide important connectivity benefits. In general, factors to consider when assessing the context of your project location include:

- ✔ Opportunities to link or expand existing habitat corridors
- ✔ Areas that are also high priority for stormwater management
- ✔ Size of the project area
- ✔ Intended use of the project area
- ✔ Sun exposure and intensity
- ✔ Water availability and frequency of floods



Credit: Matt Kane/TNC

Design considerations

Site-level design considerations also affect habitat benefits. In general, a diversity of species, vegetative structures, and substrates benefit biodiversity. Design elements to consider include prioritizing native plant species that will help support pollinators, birds, and other target species; creating opportunities for wildlife to hide from predators in wood or rock crevices; and providing conditions for a replenishing water and food supply. Projects can include flowering plants that bloom at various times of the year to support more species.

Habitat and biodiversity benefits can be enhanced with an understanding of the various factors that affect successful implementation for this purpose. This varies by GSI practice type.

Urban Ponds and Wetlands. The types of habitats that can thrive in urban ponds and wetlands depend on multiple factors:

- Proximity to major transportation corridors, impervious surfaces, buildings, or large treated turf areas. Locations close to these conditions are likely to carry heavy metal and nutrient loads, which will affect the design and type of plants the project can support. Project sites with higher nutrient loads are ideal for native plants or animals that can survive, or even filter out, nutrients.
- Proximity to other ponds, wetlands, or natural green spaces. Projects close to other areas are more likely to benefit from cross-pollination and species interaction.
- Design elements including surface area, depth, bank slope, shoreline consistency, and the availability of shade will affect the project's ability to provide habitat for different species.

Green roofs. Intentional green roof siting and design can support a diversity of insects - especially pollinators and spiders, which can in turn support a network of secondary consumers. Green roofs are more effective when surrounded by other green roofs and natural green spaces. Green roofs on taller buildings appear to be less effective at supporting biodiversity, bee nesting, and bat activity than roofs on shorter buildings. A deeper and richer substrate will support broader and more complex plant diversity. Selecting native and blooming plants also generally helps to support greater biodiversity.

Other GSI. Other GSI practices, such as urban gardens, rain gardens, bioretention, and tree planting can also support habitat and biodiversity. Larger bioretention basins with more leaf litter, vegetation structure, and number of flowering plants support more insect diversity than other basins. Native trees and larger tree species support higher diversities and abundance of insect and bird species compared with non-native and smaller urban trees.

Framework for Planning, Designing, and Managing GSI to Achieve Habitat and Biodiversity Benefits

1. **Prioritize GSI strategies that provide habitat/biodiversity benefits.** Determine the relative value of individual GSI strategies in terms of biodiversity and other triple bottom line (TBL) benefits.
2. **Identify locations where GSI is likely to best promote urban biodiversity and improve habitat for priority species** (i.e., areas where GSI might be able to help expand and connect existing wildlife corridors and natural areas). Cross-reference for overlap with areas that are high priority for stormwater management.
3. **Partner with relevant agencies/organizations and experts to identify priority or desired species and cross-reference this list with species that are likely to benefit from the types of habitat provided by GSI practices.** For each species, identify habitat needs such as minimum habitat size/patch areas, colonization distance and height requirements, and other relevant factors.
4. **Incorporate relevant design criteria into GSI planning and design guidelines.** For example, provide guidance for maximizing structure and complexity of plants and physical habitat in GSI design (e.g., include diverse native species, flowering plants that bloom at various times of year) and for prioritizing projects that provide connectivity benefits.
5. **Look for partners and opportunities to incorporate GSI into other ongoing activities** to improve biodiversity within the region (e.g., potential opportunities to integrate GSI into planned restoration projects or other initiatives).
6. **Engage with the public to raise awareness** about 1) urban biodiversity and its importance to the region; 2) existing programs and activities they can implement to improve and protect urban biodiversity.
7. **Engage with local and statewide programs already conducting regional monitoring** of both aquatic and terrestrial systems to produce data that can be used to assess regional improvement. Engage with these programs to inform them of ongoing GSI projects as they are implemented so the cumulative density of practices on the watershed scale can be related to regional measures of diversity.

Source: MMSD (2018)

Table 1. Select studies exploring habitat benefits associated with vegetated GSI practices

GSI Practice	Region	Description	Results
Native plants	Mid-Atlantic	Compared biodiversity (species richness and abundance) associated with native and non-native landscapes	Study confirmed the connection between native plants and suburban biodiversity, providing evidence that the landscaping choices affect populations of birds and the insect food they require.
Rain gardens	Pennsylvania	Examined plant selection for increases in biodiversity values	Rain gardens can provide food (fruits, seeds, and nectar) and shelter for birds and other species, increasing biodiversity.
Pollinator habitat	Northern Italy	Investigated aspects of pollination along urbanization gradient of landscape and climate; quantified hoverfly and bee abundances, pollen transported, and nectar at 40 sites	Pollinator abundances peaked at 22% impervious cover. Pollinators are negatively affected by a thermally harsh climate in highly urbanized areas with isolated green areas and large parks. Suburban landscapes demonstrated the highest pollinator presence. Patterns from this study served as a basis for pollinator-friendly planning, mitigation, and management of urban landscapes.
Urban trees	Unknown	Tracked bats daytime roosts in trees and buildings	Urban trees provided 50% of the roost sites for several species of bats, serve as hosts for flora, and provide nutrients to various levels of the food chain through leaf litter and decaying materials.
Green roofs	Mid-West	Counting survey on twelve green roofs over two bird breeding seasons of bird behavior	Green roofs provide feeding, breeding, and resting grounds for local and migratory birds.
Green roofs	Toronto, CA	Discussion of using green roofs to promote biodiversity	Green roofs facilitate dispersal of wildlife by connecting fragmented habitats.
Green roofs	Mostly Europe	Literature review of ecological and technical specificities of green walls and green roofs considering key factors concerning urban wildlife (patch size, quality, abundance, and isolation)	Role of green roofs in urban wildlife corridors remains questionable because of limited patch size, distinct habitat quality at the building scale, and limited redundancy of the patch quality within the landscape. Potential habitat and biodiversity benefits also seem to depend on building height.
Retention ponds	Various	Review of publications for promoting biodiversity in urban ponds	Biodiversity of urban ponds, measured by species richness, is generally lower than in rural ponds but that urban ponds often support threatened species.
Highway ponds	Europe	Compared aquatic macroinvertebrates in highway stormwater ponds with ponds in the wider landscape	Highway ponds support aquatic macroinvertebrate communities at least as rich and diverse as surrounding ponds.
Constructed wetlands	Toronto	Investigation of a delta marsh restoration project on urbanized river	Wetland stored contaminated runoff, resulting in a concentration of toxic environments in vegetation and sediments; wetlands not suited for the dual purpose of water quality improvement and aquatic habitat enhancement.
Wetlands		Compared macroinvertebrate populations in wetlands receiving stormwater runoff and not receiving runoff.	Water chemistry differed significantly between the two but biodiversity in the richest wetlands receiving runoff matched biodiversity in the wetlands not receiving runoff.

QUANTIFYING THE VALUE OF GSI HABITAT BENEFITS

The value of habitat improvements can be difficult to quantify because habitat is generally not bought and sold in a market. Economists have developed several methods for valuing "non-market" goods and services, including habitat for various species and improvements in water quality that benefit aquatic species. For example, stated preference methods use advanced survey techniques to elicit estimates of willingness-to-pay (WTP) for specified improvements in - or avoided degradation of - habitat or water quality, based on the species affected, nature of the improvements, and other local factors. Units are typically in terms of WTP per household or totaled to produce total WTP per acre of habitat. These methods are intended to measure the intrinsic value that individuals place on environmental goods and services.

In addition to the GSI Impact Calculator housed on the GSI Impact Hub, there are other publicly accessible resources that project developers can use to quantify the habitat and biodiversity benefits of GSI projects, such as those highlighted in Table 2.

Table 2. Resources available for monetizing the habitat benefits of GSI

Resource	Summary / metrics	Benefits based on	Range of values
Water Research Foundation (WRF) GSI TBL Tool	$ per acre of habitat for different GSI practice types. WTP per household for water quality improvements that result in "good" fish and wildlife habitat.	Meta-analysis of studies estimating household willingness to pay for habitat. Meta-analysis of studies estimating WTP for specific water quality improvements. Controls for household income, geographic region, and other variables.	$976 - $4,881 per acre for green roofs and wetlands, respectively, depending on characteristics of interventions. $42 - $111 per household, depending on level of improvement and U.S. region.
FEMA Benefit Cost Analysis (BCA) Tool	$ per acre values for habitat, pollination, and total ecosystem services benefits.	Values ecosystem services associated with different land cover types by applying estimates from the academic literature.	$1,416 - $6,240 per acre for relevant land use types (inland wetlands and urban green space, respectively) for habitat and pollinator services.
InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) Tool	Tool allows users to apply spatially based models to estimate values associated with pollination and habitat quality.	Contains suite of models used to map and value ecosystem service benefits of natural capital and nature-based infrastructure.	N/A

FUNDING AND PARTNERSHIPS FOR ACHIEVING GSI HABITAT BENEFITS

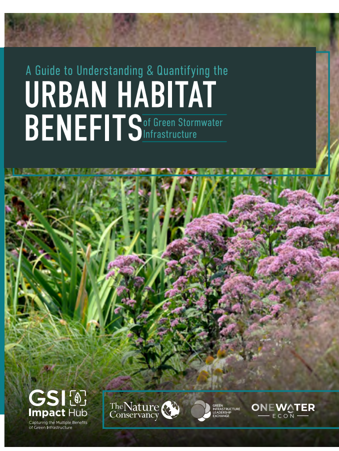
Designing GSI projects with habitat benefits in mind can open additional funding and partnership opportunities. Table 3 below provides examples of options available from government agencies, as well as some private funding and partnerships ideas to explore.

Table 3. Example funding opportunities for GSI that creates or improves habitat

Resource type	Example Resource/Funding Opportunities	Organization
Discovery tools	Grants.gov	U.S. Government
	Nature-based Funding Solutions Database	National Wildlife Federation
	Green Infrastructure Funding Opportunities	U.S. EPA
Federal	Environmental Sustainability Grant Program	National Science Foundation
	Transformational Habitat Restoration and Coastal Resilience Grants	National Oceanic and Atmospheric Administration
	Urban and Community Forestry Program	U.S. Forest Service
Private Philanthropy	Biodiversity Conservation Grant	National Environmental Education Foundation
	Community Schoolyards	Trust for Public Land
	Community foundation locator tool	Council on Foundations

As with many other GSI co-benefits, the design of GSI to support urban habitat requires multi-disciplinary action. These efforts need not be extensively formal—partnering with relevant city departments or regional wildlife organizations to identify priority areas and target species is a good first step. Academic institutions can offer local expertise and resources, including student-led research. Local botanic gardens, museums, non-profits, and watershed groups are also potential partners, as they offer local experience, community recognition, and the potential for additional funding. The benefits associated with urban habitat and biodiversity also resonate with the private sector and local residents and can help further calls to action.

Credit: Lyndon DeSalvo/TNC



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For more information visit:
gsiimpacthub.org

Please see the full guide to "Understanding and Quantifying the Urban Habitat Benefits of Green Stormwater Infrastructure" for citations to the sources referenced in this summary.

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