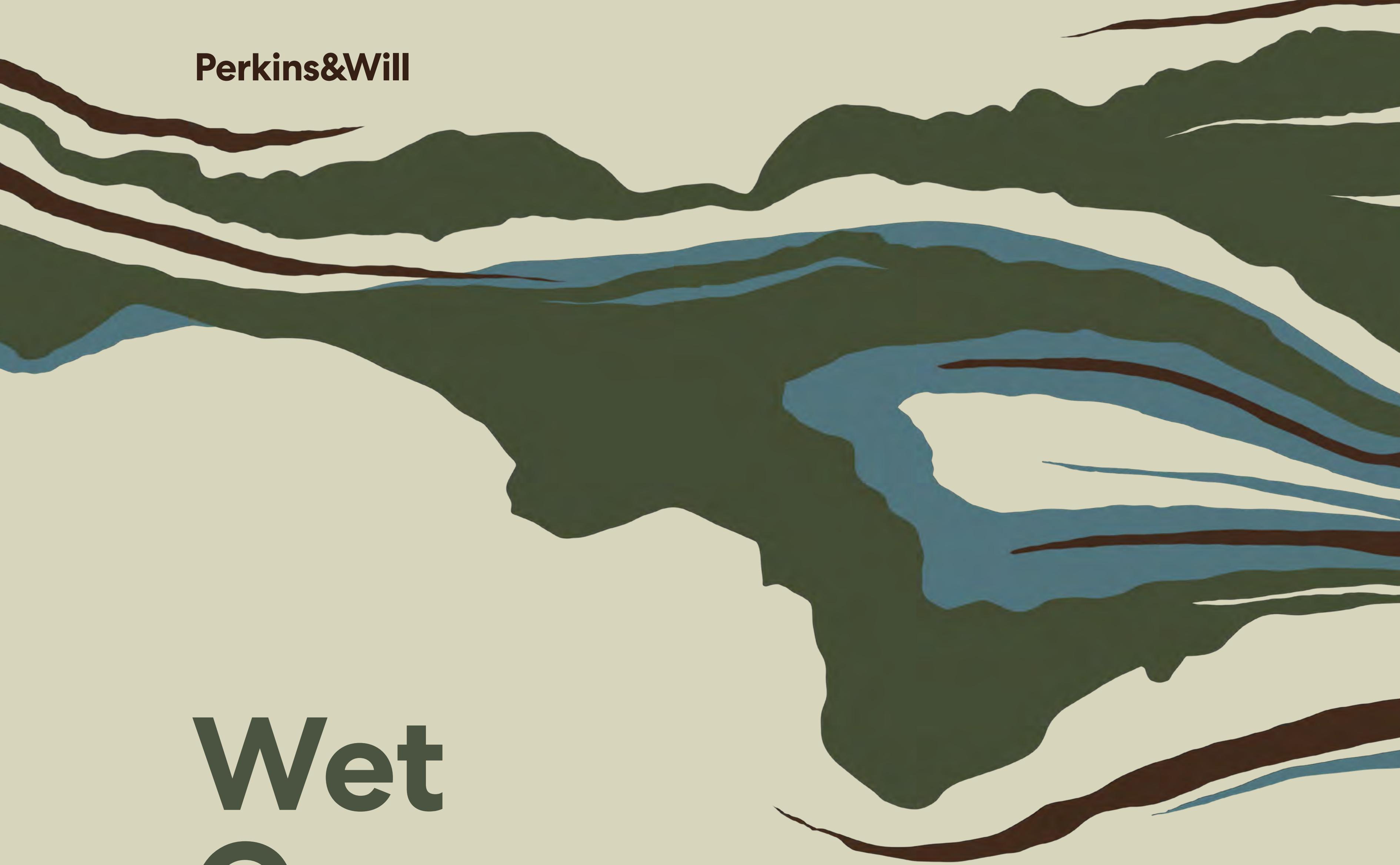
Perkins&Will



Wet Green Infrastructure

Preserving London’s Wetlands

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Innovation Incubator Spring 2024

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As architects and designers of green spaces, our current focus revolves around prioritizing biodiversity and aesthetics in our designs, creating vibrant spaces adorned with a diverse array of colorful native plant species. While this approach has proven successful in crafting appealing green spaces, it is no longer deemed sufficient for the creation of green infrastructure in the built environment.

Through this innovation incubator, we aim to develop a comprehensive framework to materialise the concept of Wet Green Infrastructure (WGI). The main goal is to create innovative WGI ideas and practical guidance that can easily fit into Perkins&Will projects. This contribution aims to help preserve vital wetland ecosystems through ecologically designed solutions tailored to suitable contexts in the built environment.

“No green space, no matter how large and well designed, is able to provide its citizens with all the natural benefits on its own”

- Frederick Law Olmsted, 1881

Olmsted, F.L. (1881)

1. Green Infrastructure

1. Green Infrastructure

1.1 Introduction

Modern metropolises are expanding rapidly, and as a result, millions of km2 of green open space are being converted into new city extensions each year. Alongside this expansion, the number of green spaces should increase proportionately, but that is not the case

Green infrastructure refers to the network of natural and semi-natural features designed to provide various ecological, social, and economic benefits to urban areas.

Unlike traditional, gray infrastructure (e.g. concrete buildings, roads, and stormwater drains), green infrastructure uses natural processes to manage water, reduce pollution, improve air quality, and enhance overall environmental sustainability and human well-being.

GI is crucial for protecting ecological processes and providing shelter to the city's biodiversity. Moreover, it is a global urban adaptation to climate change, aimed at protecting communities from heat waves, surface flooding, and stormwater, while also supporting the recovery of nature and mitigating greenhouse gas emissions.

In addition to its environmental benefits, GI provides numerous advantages to the human population living in cities. These benefits include improved health outcomes, such as lower premature mortality and longer life expectancy, as well as psychological, social, and economic benefits.

1.2 Types of Green Infrastructure

GI encompasses the network of green spaces and sustainable adaptations in a selected area, and within this network, these green spaces can take on many diverse approaches, designed with different specific purposes in mind. From enhancing biodiversity to managing stormwater or creating vibrant public spaces, the various types of GI serve distinct roles when weaving natural elements and habitats into the fabric of our built environment.

Types of GI *(based on function)*

Vegetated Surfaces on Structures

Green Walls

Shanghai Natural History Museum

Perkins and Will

Description: Vertical structures with planted vegetation.

Benefits: Aesthetic appeal, air purification, temperature regulation.

Green Roofs

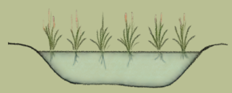
Newell Brands Atlanta Rooftop

Perkins and Will

Description: Vegetated surfaces on building rooftops.

Benefits: Improved insulation, stormwater management, biodiversity support.

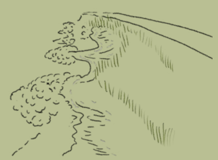
Water Treatment and Habitat Creation



Constructed Wetlands

Description: Engineered ecosystems for water treatment and habitat creation.

Benefits: Wastewater purification, biodiversity support.

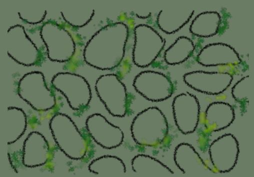


Living Shorelines

Description: Natural approaches to shoreline stabilization using vegetation.

Benefits: Erosion control, habitat creation, water quality improvement.

Stormwater Management



Permeable Pavements

Description: Surfaces that allow water to pass through, reducing runoff.

Benefits: Improved water infiltration, reduced surface runoff.

Bioswales

Description: Vegetated channels designed to manage stormwater.

Benefits: Erosion control, water filtration, habitat enhancement.

Open Spaces for Communities

Urban Parks and Greenways

Fowler Clark Epstein community center

Perkins and Will

Description: Planned open spaces with natural elements.

Benefits: Recreation, biodiversity support, improved mental well-being.

Community Gardens

Oklahoma City Central Neighborhoods

Perkins and Will

Description: Shared spaces for growing plants in urban settings.

Benefits: Local food production, community engagement, green space creation.

Since these are the different functions GI can have, these elements are not mutually exclusive. Our objective is to integrate constructed wetlands into urban environments. This involves incorporating this habitat and its biodiversity into common urban features like green roofs, green walls, open spaces for communities, or bioswales.

1.3 Connectivity of Green Infrastructure

Recent scientific research emphasizes the crucial role of integrating GI within the existing ecological network of a location. This implies that even if a green space thrives with native species and boasts high biodiversity, it must actively support the habitats in its surroundings to maximize its ecological benefits.

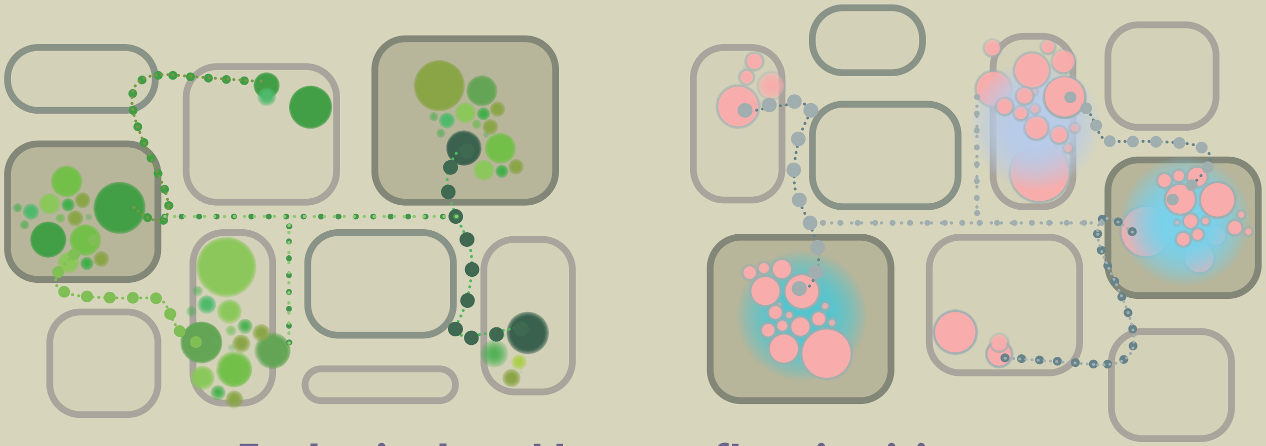
Adopting this holistic approach is particularly vital for elements like green roofs, which often experience a baseline degree of isolation due to their elevated location, height differences, and exposure to harsh climatic conditions. Ecologically isolated green roofs, when not context-specific, may exhibit low biodiversity and can potentially become ecological traps. These traps draw endangered species into challenging environments where they struggle to thrive.

Designers must ensure that green roofs function as ecological sources rather than ecological sinks. This involves a keen focus on the integration of green spaces into the broader ecological network of the site.

As architects, we recognize the significance of each GI element when contributing to the broader urban canvas and providing essential habitats for various species. However, while these individual green components deliver substantial ecological, social, and economic advantages, adopting an isolated approach to studying and designing GI must be updated: The true potential of GI lies in cultivating interconnection and establishing a network throughout our cities.

> **The vision is to transform our urban fabric into a living, breathing ecosystem where these interconnected green spaces collaborate seamlessly to provide successful habitats.**

In the same way humans travel from one hub to another, we must design cities where green spaces are interconnected so that through pollination, migration, seed dispersal and animal movement there is an active flow and exchange between these spaces. It is through this exchange that biodiversity flourishes, preventing genetic isolation, and fostering a resilient and thriving urban ecosystem.



Ecological and human flow in cities

The Lawton Report - Making Space for Nature is a report commissioned by the UK government in 2010 to assess the state of England's ecological network and recommend ways to improve its efficiency for conserving biodiversity. The report concluded that England's ecological network was fragmented and proposed a new approach to conservation based on creating a more extensive, connected and resilient ecological network. The report describes five components of a successful ecological network:

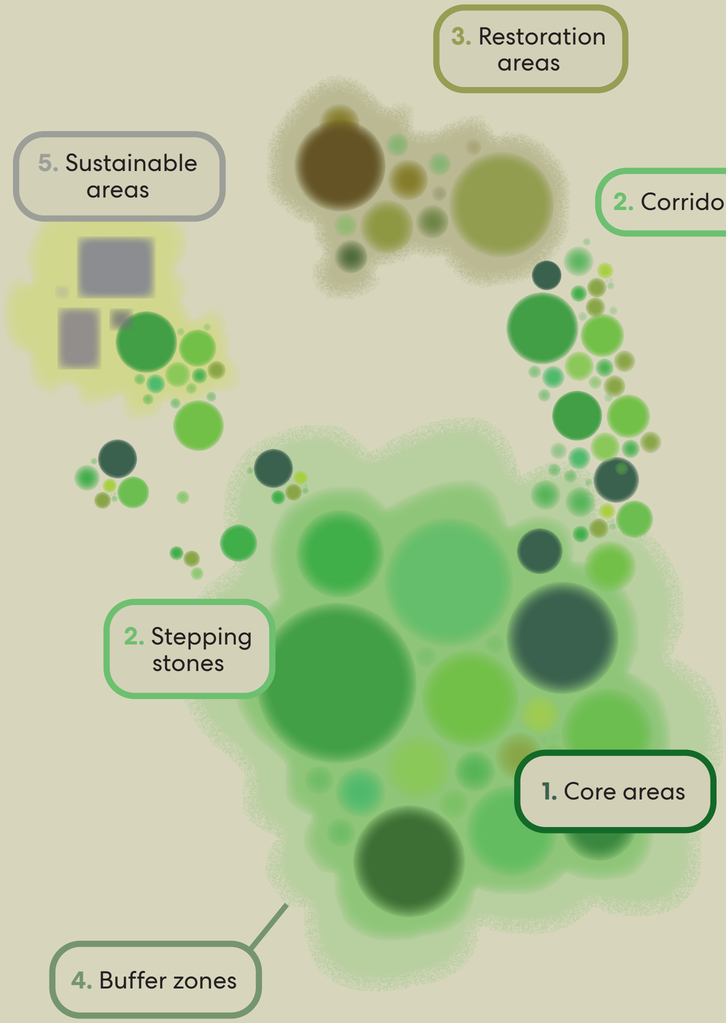
1. Core areas: Areas with high biodiversity and conservation value.

2. Corridors and stepping stones: Improve connectivity between core areas, allowing species to move from one to another, facilitating feeding, migration, dispersal and reproduction, preventing genetic isolation and protecting species.

3. Restoration areas: Areas undergoing restoration to create new core areas of high ecological value.

4. Buffer zones: In close proximity to core areas or stepping stones that protect them from the adverse effects of wider pollution.

5. Sustainable use areas: Sustainable use of natural resources, providing not only ecological but also economic and cultural benefits.



Department for Environment, Food & Rural Affairs (2010).

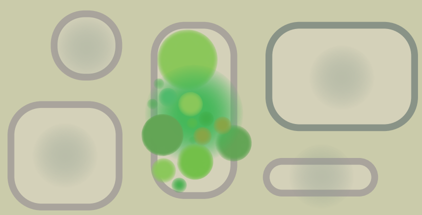
1.4 Green Infrastructure Concepts

Ecology

Scientific study of the relationships between organisms and their environments. It encompasses the distribution and abundance of organisms, and the interactions between living organisms (plants, animals, microorganisms) and the abiotic factors (climate, soil, water) in their surroundings.

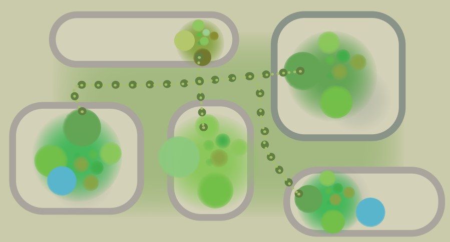
Ecological isolation

Lack of connection among different ecosystems or habitats, inhibiting the movement of species, energy, and nutrients, which can have significant implications for biodiversity and ecosystem resilience



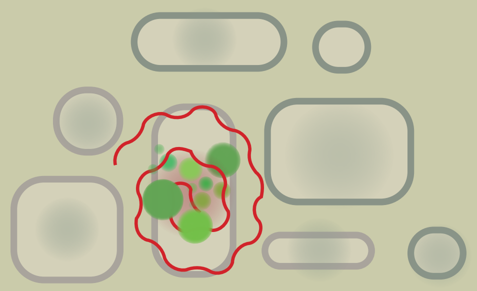
Ecological network

Linkage and interdependence among different ecosystems or habitats, facilitating the movement of species, energy, and nutrients, crucial for biodiversity and ecosystem resilience.



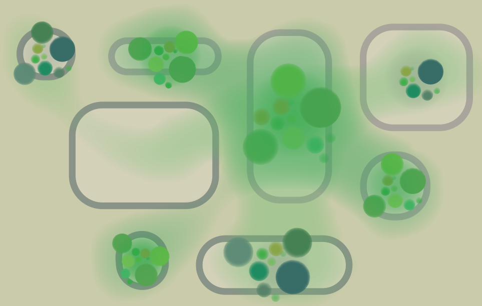
Ecological sink

Habitat that attracts species due to certain cues or characteristics but ultimately proves unsuitable for their survival, leading to population decline or mortality.



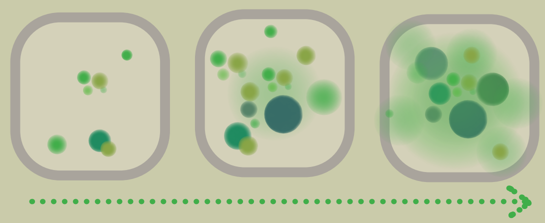
Ecomimicry

Emulating or imitating natural ecosystems and their processes in design, technology, or industry to create sustainable and environmentally-friendly solutions.



Ecological succession

Gradual process of ecosystem change over time. It begins with the colonization of pioneer species followed by the replacement of species until a stable and mature community is established.



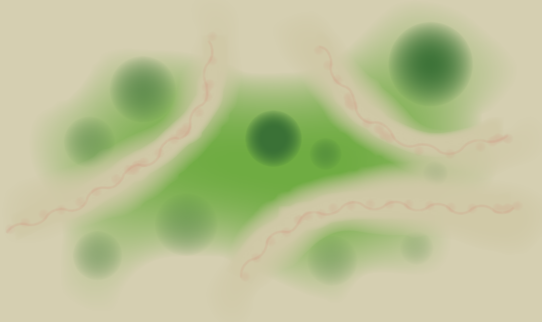
Nash, C., *et.al* (2015)

Habitat

Combination of physical and biological factors that provide the necessary conditions for a particular species to grow and reproduce successfully. Habitats encompass any environment where specific species can not only survive but also flourish, from small localized environments like a puddle to vast ecosystems such as the Arctic Ocean.

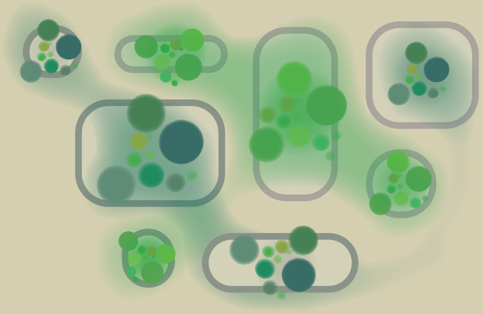
Habitat fragmentation

Process by which a large, continuous habitat is broken up into smaller, isolated fragments. This often occurs due to human activities and leads to the isolation of species populations.



Habitat redundancy

Existence of multiple similar habitats within an ecosystem, providing backup or alternative spaces for species to thrive, enhancing ecological resilience and adaptability.



Rationale for this framework

The urgency of addressing habitat loss is crucial in the current scenario, as ecosystems face threats leading to biodiversity decline. Despite our efforts in creating green spaces to offset this loss, a critical issue remains—they often lack **interconnectivity**. This deficiency makes green spaces somewhat ineffective, as they fail to form a cohesive network capable of effectively countering the decline in biodiversity within urban areas.

The **isolation** of these green spaces makes the challenge of providing a sustainable habitat for diverse species even more challenging, and the need for a more integrated approach is now more crucial than ever. One specific habitat that demands our attention is **Wetlands**.

2. Wetlands

Wetlands are vital for human survival. They are among the world's most productive environments; cradles of biological diversity and protection from extreme weather events.

In the UK, 90% of Wetlands have dissapeared in the last 100 years. Over 10% of freshwater and wetland species are threatened with extinction, and over 65% are in decline.

As architects and urban developers, we shape the landscape, therefore we must take responsibility for our role in habitat depletion and the well-being of the species affected. We must contribute to the solution by creating green spaces that not only address the environmental impact of our activities but also serve as habitats, offering shelter and sustenance for the diverse species affected by our urbanization efforts.

UNESCO (2021)

2. Wetlands

2.1 Introduction: What are Wetlands?

Wetlands are diverse ecosystems characterized by the presence of water, and they play a crucial role in supporting various forms of life. Freshwater wetlands encompass a wide range of watery habitats such as bogs, fens, reedbeds, ponds, wet meadows, wet woodlands, washlands, rivers, canals, and streams.

These habitats are integral parts of Britain's natural environment. However, due to human activities, many wetlands have undergone significant alterations, to the point where they have been left unrecognizable, and some others have been entirely destroyed, forgotten or displaced.

Wetlands are essential for human wellbeing, climate change mitigation, and biodiversity preservation. Despite their vital role, current data reveals a concerning state of wetlands and the species dependent on them. Wetland-dependent species, including fish, waterbirds, and turtles, are experiencing a severe decline, with approximately one-quarter facing the threat of extinction, particularly in tropical regions. There has been a 81% decline in inland wetland species populations and a 36% decrease in coastal and marine species since 1970.

This decline in wetland-dependent species poses a threat not only to the ecosystems themselves but also to the services they provide to humanity. from heat waves, surface flooding, and stormwater, while also supporting the recovery of nature and mitigating greenhouse gas emissions.

2.2 Ecological Functions and Ecosystem Services of Wetlands

Ecological functions refer to the roles and processes that organisms, populations, and ecosystems play in the natural environment. These functions sustain life and maintain the health and balance of ecosystems, and are often intrinsic to the performance of habitats and are not necessarily tied to human benefits.

Wetlands are one of the most biologically productive ecosystems.

Water Cycle Regulation

They play a major role in the water cycle by receiving, storing and releasing water, regulating flows and supporting life. Connected wetlands play significant roles in hydrology, but many geographically isolated wetlands are also important.

Ecological processes

Wetlands regulate nutrient and trace metal cycles and can filter these and other pollutants. They contribute to carbon storage and sequestration, and act as crucial carbon sinks

Hydrological Benefits

Wetlands help sustain groundwater levels acting as natural regulators, ensuring a steady stream flow. Additionally, they contribute to flood mitigation, improve water quality, and provide erosion control, contributing to shoreline stabilisation.

Biodiversity Support

Most importantly, wetlands are habitat for various species, ranging from fish and waterfowl to plants and all sorts of wildlife. They also serve as crucial sanctuaries for endangered species, offerring a lifeline for freshwater species and providing a space for millions of migratory birds to rest and refuel

Mayor of London (2019)

2.2 Ecological Functions and Ecosystem Services of Wetlands

Ecosystem services are the direct and indirect benefits that humans derive from ecosystems and their ecological functions.
These services can be categorized into provisioning services (food, water), regulating services (climate and disease control), supporting services (green space provision), and cultural services (recreational and aesthetic value).
They highlight the tangible and economic value that ecosystems provide to human well-being.

The ecosystem services of wetlands are far more extent than land green spaces:

- Wetlands provide critical supplies of food and materials, such as rice, fish, fibre and fuel.
- They provide regulating services that influence climate and hydrology, and reduce both pollution and disaster risk.
- They offer recreational possibilities and tourism benefits.
- They often have cultural and spiritual importance to many communities
- Urban wetlands offer both physical and psychological health advantages to the population.
- They store and sequester carbon, regulating the global climate. Peatlands are large carbon sinks, storing twice as much carbon as the world's forests while only being 3% of the world's habitats. However, freshwater wetlands are also the largest natural source of the greenhouse gas methane.

Southgate, F., (2024)

2.3 Wetlands in the UK

As an island nation with a wealth of rivers and canals snaking through our land, wetlands are a critical part of our natural environment. In the city of London wetlands play a crucial role: They store and purify water, reduce flood risk, and provide habitats for a diverse range of endangered plant and animal species. Moreover, as plant matter steadily accumulates and decays in them, they provide huge carbon sequestration benefits.

In England, wetlands are home to globally important populations of breeding wintering waders and wildfowl, making their conservation a priority. However, the rapid pace of urbanization has led to the destruction of wetlands and the replacement of natural land cover with impermeable surfaces like asphalt. Even when efforts are made to compensate for the loss of natural land cover, existing mechanisms, such as the Urban Greening Factor, often lack specificity when it comes to compensating for habitat loss.

As a result, the destruction of a wetland habitat might be offset by the creation a non-context-specific green roof, thereby leaving the species in the wetland habitat isolated and without a home

Wetlands are **3%** of **British land**, but are **home to 10%** of all our species.

Only **14%** of the United Kingdom's **rivers** are considered to be in **good ecological health**

The UK has **lost 90%** of wetland habitats in the last **100 years**

2/3 of existing wetland **species** are in **decline.**

Over **10%** of freshwater and wetland **species** are **threatened** with extinction.

Threats of Wetlands

Wetlands, often situated in the downstream regions of water bodies, are particularly vulnerable to pollution due to their ability to accumulate contaminants from extensive areas. This pollution can then build up and have a massive impact on its health.

Among the most concerning pollutants are fertilizers and pesticides, which can disrupt the reproductive cycles of flora and fauna, leading to a decline in biodiversity.

Human-made modifications to the landscape, such as roads or dikes, can disrupt natural freshwater flows and impede the movement of aquatic species, exacerbating the negative impacts on wetland habitats.

Environment Agency (2019)

2.4 Wetlands in London

The Thames contributes to a series of wetland habitats along its shores and ditches, yet many of these areas face erosion, embankment, or destruction due to urbanization. Among these habitats, the largest is Rainham Marshes, and other significant patches, like the Thames Estuary near Swanscombe, are threatened by development.

Other tributaries like the Rivers Fleet and Westbourne in the city center have been culverted and developed over, though some, like the Colne and the River Lee, still retain elements of ancient native flora. These natural waterways are complemented by canals, forming enclosed water bodies across London, which hold significant ornithological interest.

London serves as a global hub for waterfowl, with numerous water birds temporarily inhabiting on these water bodies. Some examples of these species are Gadwall and Shoveler, which thrive in internationally significant numbers.

Natural England (2013)

3. WGI

Given the crucial role of wetlands in London's ecosystem and the fact that GI is failing to support the habitats and species of its surroundings, we will develop the concept of Wet Green Infrastructure (WGI) as a practical solution to both these issues.

Wet-Green-Infrastructure combines green infrastructure principles with wetland-specific considerations, creating artificial wetlands integrated into urban landscapes. These WGI features not only provide vital new habitats for wetland species but also bridge the ecological gaps between fragmented natural wetlands.

Additionally, WGI enhances water management and carbon sequestration capabilities. By incorporating WGI, London can preserve its wetlands while simultaneously enhancing the city's resilience and ecological connectivity.

> **In this section we will develop on what WGI truly would encompass, and what elements would be necessary to create successful wetland habitats in pieces of Green Infrastructure**

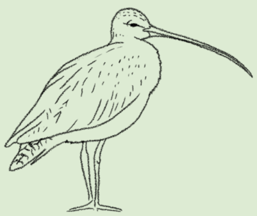
3. WGI

3.1 Ecology of Wetlands

In order to understand how to design green spaces that appeal to wetland species and provide habitat redundancy and connectivity to the wetlands of our country, we need to first define the ecology of this habitat and the species in it. This will help us define its elements and replicate them in urban contexts.

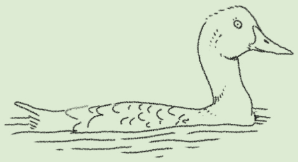
Animal Species in British Wetlands

British wetlands are home to a diverse array of animal species, adapted to the unique conditions of these environments. They support a rich diversity of animal life, playing crucial roles in both local ecosystems and global biodiversity conservation efforts. These are some of the endangered species that make the UK wetlands their home:



Curlew
(Numenius arquata)

Common crane
(Grus grus)



Madagascar pochard
(Aythya innotata)

Water vole
(Arvicola amphibious)

Wildfowl and Wetlands Trust (2020)

Plant Species in British Wetlands

Thousands of plant species grow in british wetlands, from mosses and grasses to shrubs and trees. The following are some examples of the most prevalent freshwater species:

Trees

Mature trees play a vital role in stabilizing and protecting vulnerable riverbanks with their extensive root systems, while also offering ideal habitat for numerous invertebrates.

Alder, willow and sallow

Submerged aquatic plants

They grow entirely underwater, with their roots anchored in the sediment and their leaves and stems extending into the water column.

Spiked water milfoil, curly pondweed, hornwort, water starwort

Emergent plants

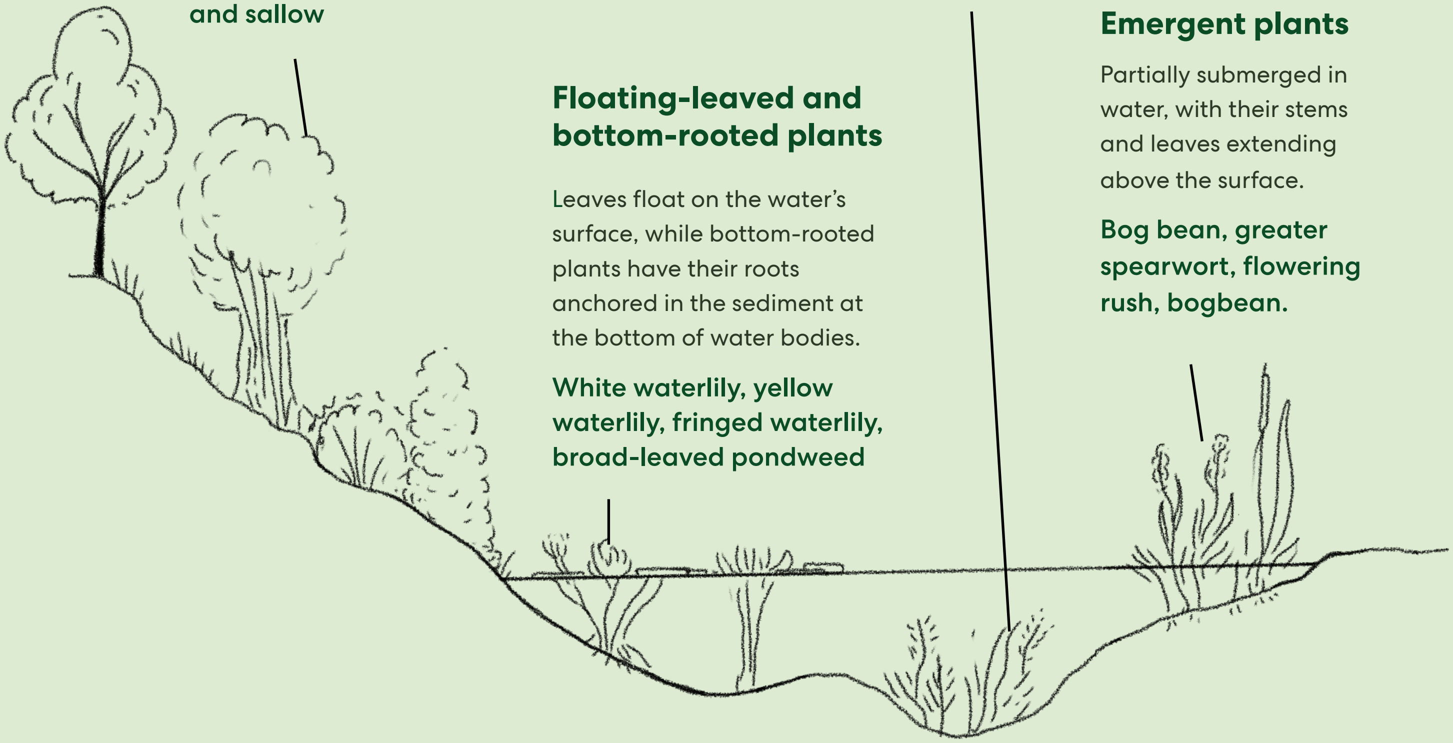
Partially submerged in water, with their stems and leaves extending above the surface.

Bog bean, greater spearwort, flowering rush, bogbean.

Floating-leaved and bottom-rooted plants

Leaves float on the water's surface, while bottom-rooted plants have their roots anchored in the sediment at the bottom of water bodies.

White waterlily, yellow waterlily, fringed waterlily, broad-leaved pondweed



3.2 How can we build Wetlands

Defining the species of animals and plants in british wetlands is crucial for their preservation, as the reason we are designing WGI is to protect biodiversity and reduce species decline. However, these species that need to populate our pieces of GI are only half of the story. In order to have a successful WGI we need to replicate the elements of natural wetlands that allow this biodiversity to flourish. These elements are varied in shape, function and complexity, but they all have been proven to attract animal and plant species and safeguard the equilibrium of wetland habitats.

In a structured approach, WGI is designed with a focus on engineered features and rigid design elements. This approach involves the use of built structures such as channels, ponds, and constructed wetlands. The aim is to replicate specific functions of natural wetlands in a controlled and predictable manner. These approaches may involve precise engineering techniques to control water flow or filtration. While structured approaches offer control and predictability, they may lack the dynamic and evolving characteristics of natural wetlands.

VS

On the other hand, a more naturalistic approach to WGI prioritizes mimicking the appearance, processes, and ecological functions of natural wetlands. This approach involves incorporating diverse vegetation types, varying topographical features, and promoting natural processes such as nutrient cycling and habitat creation. Naturalistic approaches aim to create habitats that are more resilient, self-sustaining, and supportive of a wide range of species. While they offer greater biodiversity benefits and aesthetic appeal, they are less engineered and more reliant on ecological processes.

3.3 Elements of Wetlands

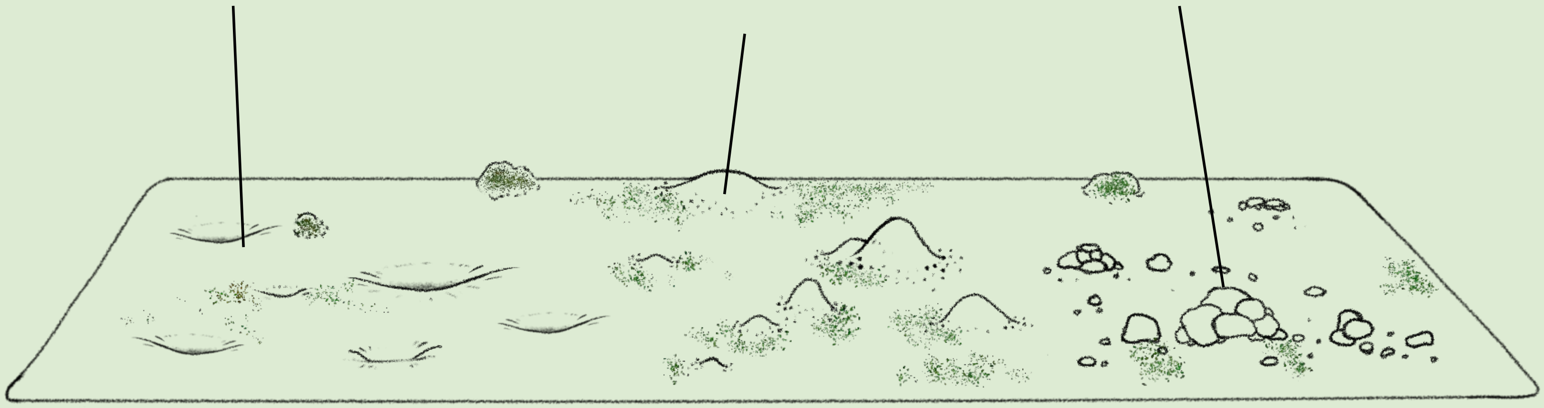
In this section, we will delve into some elements that could be integrated into green spaces to support wetalnd biodiversity, through mimicking natural elements that naturally ocurr in wetland habitats.

Microtopography: Mimic natural variations in ground elevation by creating small mounds and depressions to provide diverse habitats for plants and animals.

Shallow depressions: Dig shallow depressions or scrapes to collect water during rainy periods, providing habitat for aquatic invertebrates and amphibians.

Sand mounds: Create sandy patches or mounds to attract ground-nesting insects and provide basking spots for reptiles.

Rockeries: Incorporate rocks and boulders to provide sunning spots for reptiles and habitat for algae, mosses, and small invertebrates.



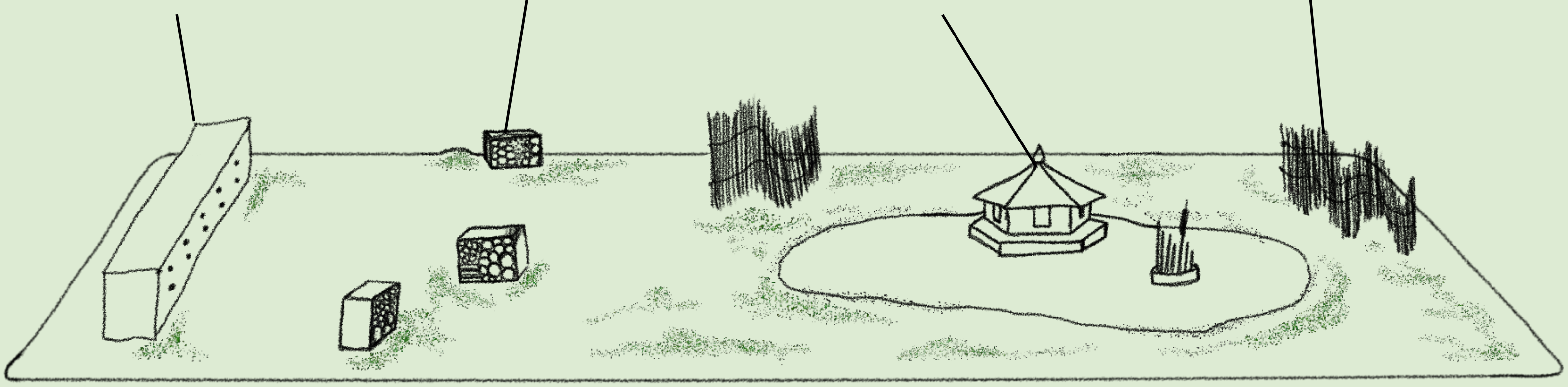
Artificial Structures: Crafted to replicate natural topography, these constructions offer diverse habitats for wetland organisms through strategic design and placement.

Nesting boxes: Install nesting boxes for cavity-nesting birds such as woodpeckers, ducks, and owls.

Bug hotels: Constructed shelters made of natural materials, such as logs, branches, and plant debris, designed to provide habitats for beneficial insects.

Floating platforms: Construct floating platforms or rafts to provide resting and nesting sites for waterfowl and nesting birds.

Brushwood fences: Build fences or barriers using brushwood to create sheltered areas for small mammals and nesting sites for birds.



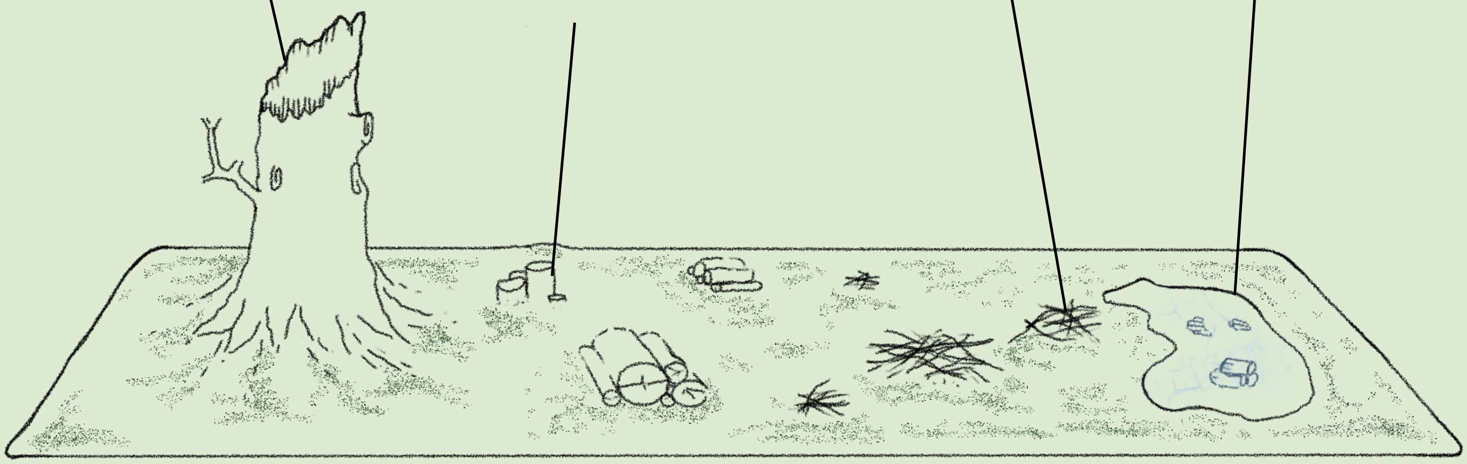
Dead Elements: Non-living organic materials integrated into wetland ecosystems, serving as vital habitats for various organisms by providing shelter, breeding sites, and food sources.

Deadwood habitat: Leave standing dead trees or logs in wetland areas to provide perches for birds of prey, nesting sites for cavity-nesting birds, and habitat for insects and fungi.

Log piles: Install logs or woody debris to create hiding places and habitat for amphibians, reptiles, and small mammals.

Brush piles: Stack branches and twigs to create shelter and nesting sites for birds and small mammals.

Sunken logs: Submerge logs or large branches to create underwater habitat for aquatic organisms and breeding sites for fish.



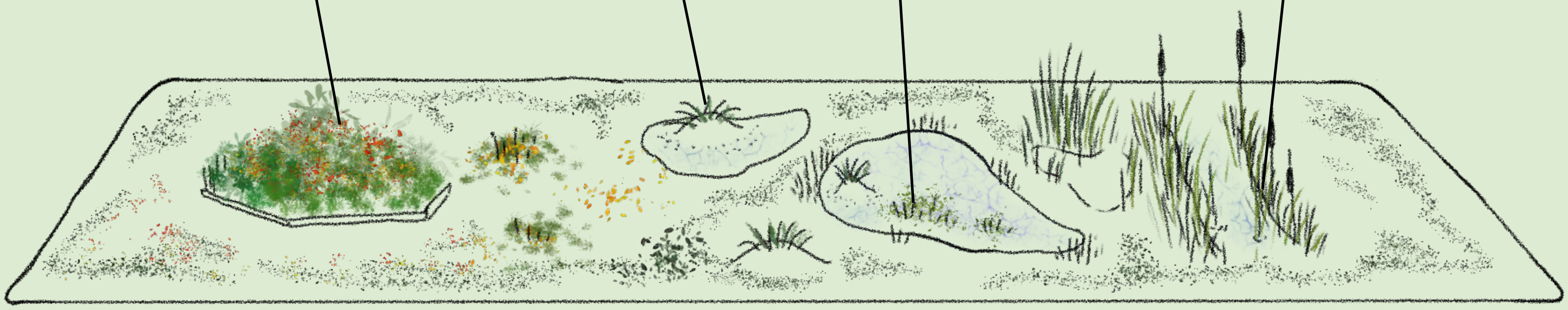
Biocoenosis: components of wetland ecosystems comprising diverse plant species specifically cultivated to attract pollinators, enhance biodiversity, and contribute to ecosystem resilience through their roles in nutrient cycling, soil stabilization, and habitat provision.

Submerged vegetation patches: Introduce submerged plants like waterweed or hornwort to provide cover for fish, oxygenate the water, and stabilize sediments.

Pollinator gardens: Plant native flowering species to attract pollinators like bees, butterflies, and moths, enhancing biodiversity and supporting ecosystem functioning.

Sedge islands: Plant clumps of sedges or grasses on small elevated islands within wetland areas to provide nesting sites for birds and habitat for small mammals.

Reed beds: Establish dense stands of reeds or bulrushes to create habitat for nesting birds, shelter for fish, and filtration of water pollutants.



Some final advice!

Measures to attract migratory birds

Install **bird feeders** stocked with a variety of seeds, nuts, and fruits to attract different bird species. Offering a diverse selection will cater to various dietary preferences and attract a wider range of migratory birds.

Incorporate natural **shelter features** such as dense shrubs, trees with thick foliage, and brush piles. These provide protection from predators and harsh weather conditions.

Set up birdhouses or **nesting boxes** designed for different bird species. Research the specific nesting requirements of migratory birds in your area and provide suitable nesting materials such as twigs or grass.

Measures to attract pollinators

Grow plenty of choice of **nectar-rich plants** with single and open flowers, as these give easy access to lots of nectar. Plants to consider are allium, bluebells, forget-me-not, marigolds, snap-dragons, geranium, buddleia, sedum, ivy and lavender.

Try to **avoid** using chemicals and **pesticides** wherever possible, as this will really help to keep your garden full of wildlife.

Don’t be too tidy, leave a few areas in the green space **undisturbed** and **untidy**. An area of overgrown planting, or a pile of leaves can provide shelter for bees and butterflies

Some final advice!

Health of Water Bodies

Create **shallow zones** where water will come into contact with plant roots and microbes and deeper zones where anaerobic processes can take place

Include a **littoral shelf** that promotes emergent macrophytes

Promote a **diversity of predators** to control mosquito populations

Health of visitors

Couple wetlands with **open space** to enhance recreation and social activities

Include **recreational infrastructure** and interpretative signs

Ensure the **safety** and perceived safety of wetlands and adjacent areas

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