BIODIVERSITY DESIGN GUIDELINES

GREEN ROOFS & WALLS

5

Context

Numerous guidelines exist that provide engineering specifications for construction of green roofs and walls. This module provides additional information relating to biodiversity-targeted enhancements that can be included in base engineering designs.

Green (living) roofs are vegetated structures built on a flat or gentle sloping roof. They include a growing medium and waterproof membranes. **Green (living) walls** are vertical structures with specially designed growing mediums installed to support a diversity of plant species. Green roofs and walls can enhance the urban environment by naturalizing surfaces, providing a number of benefits to people, wildlife and building performance.

Co-benefits of Green Roofs and Walls:

- ☑ Manage stormwater runoff.
- ☑ Improve air quality.
- ☑ Moderate the urban heat island effect.
- ☑ Reduce ambient air temperature.
- ☑ Reduce building energy use and electricity demand for heating and cooling.
- ☑ Attenuate noise.
- ☑ Beautify cities.
- ☑ Add public space.
- ☑ Improve health and well-being.
- ☑ Support biodiversity.[1]

City Hall Green Wall, Surrey
Credit: City of Surrey

Biodiversity Benefits of Green Roofs and Walls

Green roofs and walls support biodiversity by creating new habitat within the urban matrix. The organisms present in these habitats are a mix of generalist and specialist species, and some of them are considered Species of Conservation Concern. Studies in Europe have recorded over 300 species of vascular plants, mosses, and lichens, and almost 200 species of invertebrates (including beetles and spiders) on walls and buildings.[2] While most vertebrate species recorded on green roofs are birds, other species make use of these spaces too. For example, more bat diversity and activity has been associated with green roofs compared to conventional roofs.[2] A UK study showed that green roofs provide locally unique habitat that support a proportionately high diversity of invertebrates, and that over 10% of species are nationally rare or scarce.[3]

Opportunities and Constraints for Biodiversity

Opportunities and constraints to enhance biodiversity on green roofs and walls vary depending on the type of structure and the environmental conditions that exist. Green roofs, for example, typically have shallow, nutrient-poor soils and dry, windy, exposed conditions. As a result, these artificial habitats most often resemble grassland or post-industrial landscapes (e.g., grey/brownfields). Green walls, generally approximate cliff or waterfall habitats depending on aspect and amount of moisture/irrigation available. Due to their vertical orientation, green walls provide fewer ecological niches than green roofs for plants and animals to establish. The associated organisms (fungi, insects, birds) in green roofs and walls are often more specialized and will reflect the habitat features and functions available.[4]

Depending on the type of green roof or wall and their engineering requirements, there may be more or less opportunities to support biodiversity. Since these structures are typically above ground, colonization by terrestrial species may be minimal and will generally be limited to those animals (e.g., birds and invertebrates) that can locate and access the habitat, and have traits that make them better adapted to use these habitats.[5]

Green roofs and walls support the City's Green Infrastructure Network by creating more available living spaces within fragmented urban areas; these structures can be important stepping stones and migratory pathways for wildlife and help improve connectivity to greenways and other natural and semi-natural areas.[6] The amount of biodiversity they support will be dependent on the specific design applied along with other factors; in general, the more structurally diverse the habitat, the greater the number of species a green roof/wall can support.

Relevant Surrey Documents:

- ☑ Climate Adaptation Strategy (2013)
- ☑ Biodiversity Conservation Strategy (2014)
- ☑ Official Community Plan (2013)
- ☑ Integrated Stormwater Management Plans

ICON LEGEND:

Small Mammals | *Bats* | *Birds* | *Plants* | *Invertebrates* | *Insects* | *Pollinators*

Cost Legend: Relative Cost: $ (low), $$ (medium), and $$$ (high).

Module linkages:

Key Considerations:

- ☑ Current and future climatic conditions (i.e., temperature, wind, and precipitation), solar exposure, moisture availability/irrigation, and aspect will determine the types of vegetation that can be established.
- ☑ Large green roofs that are low and located close to natural areas will be more beneficial to biodiversity than small, isolated green roofs on high rooftops in denser urban areas.[8]
- ☑ Building green roofs and walls simultaneously on the same building can increase patch size and may reduce the barrier effects of buildings.[2]
- ☑ Increasing the amount of green space in surrounding areas will support greater biodiversity on green roofs/walls.
- ☑ Habitat design (e.g., vegetation, soil, etc.) and accessibility/mobility will determine what organisms (e.g., insects, birds) occur.
- ☑ Flat roofs have more homogenous conditions and less moisture variability, leading to fewer habitat niches and a lower diversity of plants. Plant diversity may be increased by varying soil depth (where possible) on flat roofs or modifying sloped roofs. Topography and natural drainage on sloped roofs can create variable moisture conditions (dry to wet) to suit different plant species.[9]
- ☑ Walls are generally hotter and drier than the surrounding ground plane, particularly east, south, and west-facing walls. North-facing walls are good candidates for green-walls, as they are less susceptible to drying (or desiccation) and generally require less irrigation.
- ☑ Establishing multiple vegetation layers and a variety of native plants including wildflowers and sedums supports greater biodiversity. While native plants may be preferred as they are adapted to local conditions, non-native, non-invasive species that support biodiversity may also be suitable, particularly if they are adapted to harsher (e.g., drier) conditions associated with green roofs and walls.
- ☑ Variable substrate depth and composition (e.g., fine/coarse texture; organic/mineral/mixed) supports more plant diversity, which in turn will support more invertebrates and birds.
- ☑ Habitat structures and features including downed wood, rocks, bare areas (mud/gravel), nest boxes, bee houses, shelters, etc., can be added to create different micro-habitats and micro-climates to enhance biodiversity. Water availability is a limiting factor for species persistence; integrating a water source (pumped or collected) into the design, if possible, can be extremely beneficial for biodiversity.
- ☑ Roof tops and walls can expose plants to conditions (e.g., sun exposure, wind, shade, and shallow soils) that are challenging for maintenance and growth. Drainage

and irrigation may be required to establish and maintain plant growth. The amount of irrigation will depend on the conditions and the type and number of plants. Drainage and irrigation (e.g., recirculating) systems should be monitored frequently to ensure their effectiveness and avoid water waste and/or overwatering.

- ☑ Integrate biodiversity measures with health, well-being, and aesthetic objectives where possible.[10] If a green roof is designed to be accessible to people, disturbance may reduce biodiversity values, requiring customized management approaches to reduce these effects.
- ☑ Structures should be monitored and maintained to assess wildlife use and ensure structures and vegetation are in a suitable condition.
- ☑ Regular monitoring and maintenance may be required to address potential establishment and spread of invasive species (e.g., seeds deposited by birds or by wind).

5.1 GREEN ROOFS

5.1.1 INTENSIVE GREEN ROOF (ROOFTOP GARDENS)

Intensive green roofs have deep planting mediums (typically more than 15cm) that can support a diversity of ground cover, grasses, flowers, shrubs, and small trees. These green roofs are generally found on larger commercial structures and may be accessible to the public, and include park features like paths, benches, and other amenities.

Design Guidelines:

- ☑ Include a diversity of native and non-native plant species adapted to climate. Emphasize native plants and avoid invasive plants.
- ☑ Mosses, herbaceous plants, grasses, shrubs, and small trees can be appropriate.
- ☑ Include grasses and herbaceous plants with prolific seed heads.
- ☑ Create micro-habitats by varying topography, including dry hills and shallow, wetter depressions.
- ☑ Include bare areas to promote colonization of different species.
- ☑ Vary the planting medium from fine to coarse and rocky textured soil.
- ☑ Introduce habitat structures like nest boxes, insect hotels, downed wood, and wildlife trees.

Focal Guilds and Species:

Cost: $$$

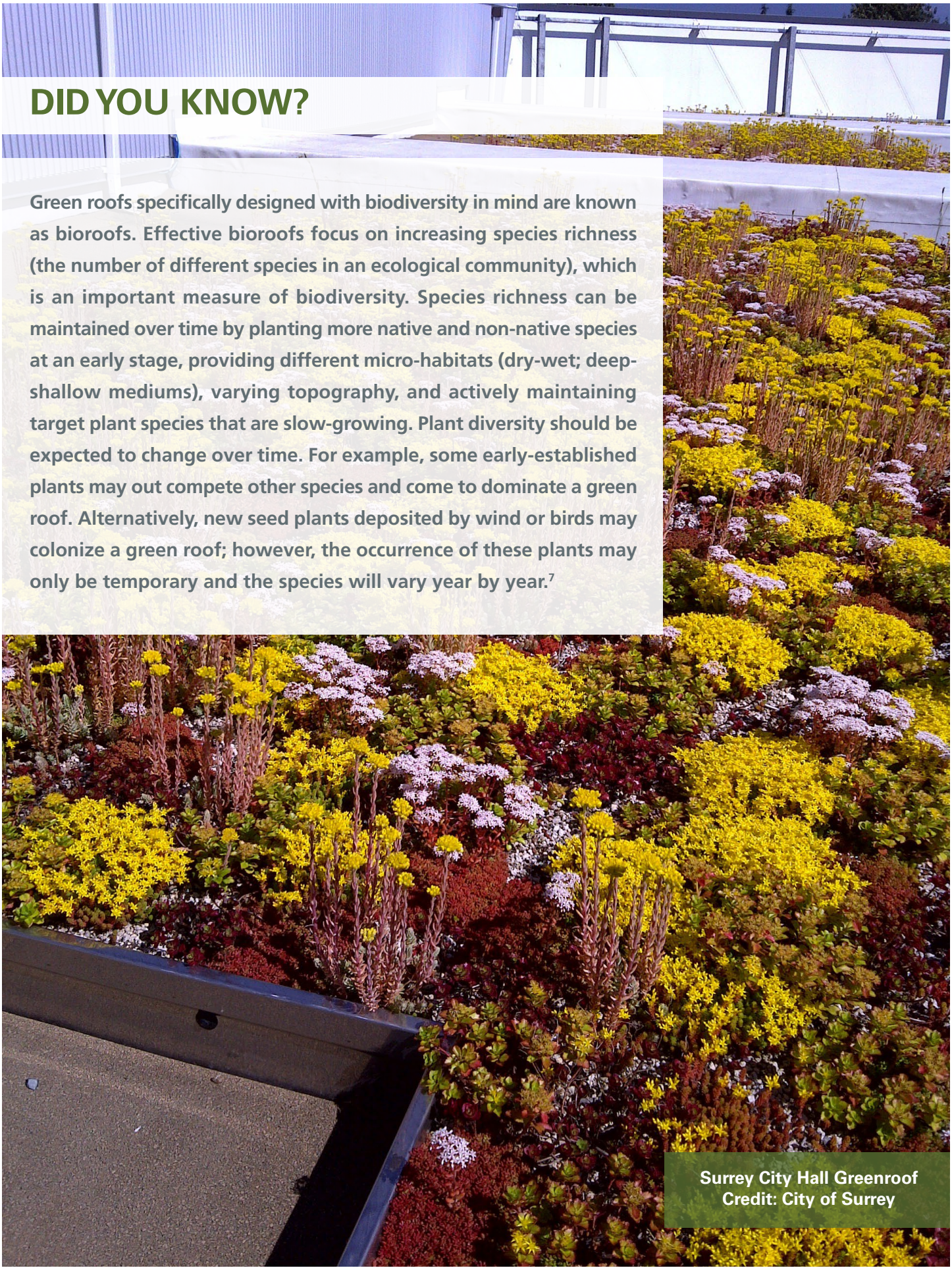
Where to Implement: Urban Matrix.

What to know:

- ☑ Isolation can provide nesting birds security from predators.
- ☑ Requires significant structural engineering and maintenance.
- ☑ Provides more opportunities to support habitat features and functions.
- ☑ Typical micro-climates are dry, hot, and sunny, but shaded and moist zones may be created.
- ☑ Green roofs are typically designed to drain water quickly. Systems designed to detain water and manage rainwater on site, such as blue-green roofs, can be beneficial; however, engineering and maintenance requirements, in addition to the need for high moisture-tolerant plants, should be considered.
- ☑ Requires intensive care (e.g., watering and fertilizing year-round).
- ☑ Deeper soil substrate provides buffer for extreme drought.
- ☑ Pruning/cutting back of dominant plants may be required.
- ☑ May require maintenance of target-species to manage competition.

DID YOU KNOW?

Green roofs specifically designed with biodiversity in mind are known as bioroofs. Effective bioroofs focus on increasing species richness (the number of different species in an ecological community), which is an important measure of biodiversity. Species richness can be maintained over time by planting more native and non-native species at an early stage, providing different micro-habitats (dry-wet; deep-shallow mediums), varying topography, and actively maintaining target plant species that are slow-growing. Plant diversity should be expected to change over time. For example, some early-established plants may out compete other species and come to dominate a green roof. Alternatively, new seed plants deposited by wind or birds may colonize a green roof; however, the occurrence of these plants may only be temporary and the species will vary year by year.[7]



Surrey City Hall Greenroof
Credit: City of Surrey

5.1.2 EXTENSIVE GREEN ROOF

Extensive green roofs have shallow planting mediums (typically less than 15cm), which support a lower diversity of more drought-tolerant and shallow-rooted plants including sedums and grasses. Extensive green roofs are generally found on smaller buildings and/or added to existing roofs, and public access is limited or non-existent.

Design Guidelines:

- ☑ Include a diversity of native and non-native species adapted to climate and conditions
- ☑ Emphasize native plants and avoid invasive plants.
- ☑ Prioritize heat, drought, and wind-resistant plants including mosses, grasses, and succulents. Sedum and Allium genera are common.
- ☑ Install habitat structures to support biodiversity in areas where soil is limited.

Focal Guilds and Species:

Cost: $$-$$$

Where to Implement: Urban Matrix.

What to know:

- ☑ Isolation can provide nesting birds security from predators.
- ☑ Soil loads may be distributed to areas with greater structural support.
- ☑ Fewer opportunities to support habitat features and functions.
- ☑ Typical micro-climates are dry, hot, and sunny.
- ☑ Once established, extensive green roofs are largely self-sustaining and require comparatively little maintenance compared to intensive green roofs.
- ☑ Periodic watering and supply of nutrients required during dry summer months.
- ☑ Pruning/cutting back of dominant plants may be required.
- ☑ May require maintenance of target-species to manage competition.

Co-benefits for Intensive and Extensive Green Roofs:

- ☑ Capture and filter rainwater.
- ☑ Assist stormwater flow management.
- ☑ Reduce building heat gain/loss (increases energy efficiency).
- ☑ Reduce the urban heat island effect.
- ☑ Improve air quality.
- ☑ Reduce noise.
- ☑ Improve health and well-being.

FURTHER READING:

City of Toronto Guidelines for Biodiverse Green Roofs.[9]
Green Roofs as Habitats for Biodiversity. [12]
Biodiversity and Green Roofs – Green Roof Services.[4]

A - Fig. 1: Intensive Green Roof Section
B - Green roof with enhancements for biodiversity - Credit: ZinCo Green Roofs UK

5.1.3 VEGETATED MATS

Vegetated mats are light-weight, self-contained systems that can be installed at grade and on green roofs. They are drought resistant, require little soil, and can be easily cut and installed, even on slopes and embankments. Vegetated mats are designed to support a diversity of hardy plants (e.g., sedum) that can attract pollinators.[13]

Pre-grown plant/soil systems cut out the challenges and irrigation requirements normally associated with the establishment phase of a green roof. They save time and bring biodiversity benefits in faster.

Design Guidelines:

- ☑ Look for systems that ensure soils are connected across the roof to better manage stormwater.
- ☑ A variety of plants can be used, but sedums are a popular and hardy choice.
- ☑ Choose sites that are well-drained and will not be saturated over the winter.

Focal Guilds and Species:
Cost: $

Where to Implement: Urban Matrix.

What to Know:

- ☑ Select the right plant for the right place. While native plants are preferred, non-native plants can be used provided they are not invasive and their water requirements are minimal.
- ☑ Sedum mats are sensitive to compaction and should only be used in low-traffic conditions.
- ☑ Vegetated systems can be designed for specific soil composition, various soil depths, climates, and rooftop microclimates.
- ☑ Lower maintenance and water consumption compared to sod installations.

Co-benefits:

- ☑ Capture and filter stormwater.
- ☑ Improve aesthetics.
- ☑ Control erosion.
- ☑ Reduce building heat loss/gain.
- ☑ Reduce the urban heat island effect.
- ☑ Reduce noise.
- ☑ Improve air quality

FURTHER READING:
NATS Nursery (Langley)
Sedum Master (Toronto)

A - Extensive Green Roof, Samuel Brighouse Elementary school - Credit: NATS Nursery Ltd.
B - Round-headed garlic, *Allium sphaearocephalon* - Credit: West Coast Seeds
C - Sedum turf - Credit: NATS Nursery Ltd

5.2.1 GREEN FACADES

Green facades are exterior walls covered with vegetation including vines, evergreen and deciduous climbing plants, and cascading ground covers.

Climbing plants are either rooted at the base of the wall in beds and grow upwards along the wall, or may grow on supporting structures (e.g., lattices) or attached to the wall itself. Green facades constructed of stone or masonry can approximate cliff ecosystems.

Design Guidelines:

- ☑ Encourage connectivity with surrounding green areas.
- ☑ Incorporate diversity of non-living habitat components where possible (e.g., variability in surfaces, ledges, hollows) to enhance habitat.
- ☑ Select plants based on light-shade tolerance according to architectural and environmental conditions.
- ☑ Include diversity of plant traits (e.g., deciduous/evergreen, perennial/annual, variable flowering periods, etc.) to target more biodiversity.
- ☑ Herbaceous and woody lianas are common plants.
- ☑ Avoid use of invasive vines that may colonize adjacent naive habitats.

Focal Guilds and Species:

Cost: $-$$

Where to Implement: Urban Matrix.

What to know:

- ☑ Can support generalist and specialist species.
- ☑ Provide food, perching, and breeding sites for birds.
- ☑ More birds are found on evergreen facades in winter.

Co-benefits:

- ☑ Reduce building heat gain/loss (increases energy efficiency).
- ☑ Reduce the urban heat island effect.
- ☑ Improve air quality.
- ☑ Reduce noise.
- ☑ Provide aesthetic and therapeutic benefits.

CASE STUDY

Semiahmoo Public Library and RCMP Facility Green Wall

Surrey, BC

This living wall was the largest and most biologically diverse green wall in North America at the time of its construction in 2010. Covering approximately 250m^2, this green wall is composed of over 120 species of plants including ground covers, shrubs, and small trees. Many of the plants were specifically selected to support pollinators including bees, butterflies, and hummingbirds. Plants receive water and nutrients from the vertical supports, and require no soil. The wall provides co-benefits including improved air quality and building insulation, and improves aesthetics by basing its design on Coast Salish artwork. Other notable green walls include installations at City Hall and Guildford Mall.

Credit: City of Surrey

5.2.2 LIVING WALL

A living wall is a self sufficient vertical garden installed on the exterior or interior of a building. The vegetation of a modern living wall is rooted into the media contained in the wall structure. Living walls approximate vegetated waterfalls due to the amount of moisture required, which is generally supplied by an automatic watering and nutrient supply system.

Design Guidelines:

- ☑ Include a large diversity of native plants (preferred) and some less preferred non-invasive, exotic species.
- ☑ Select plants based on light-shade tolerance according to architectural conditions.
- ☑ Mosses, herbaceous plants, grasses, and shrubs can be appropriate.
- ☑ Permit growth of spontaneous plants (e.g., colonizers).
- ☑ Plant based on ecological conditions of the wall (e.g., exposure, wind, etc.) that varies from top to bottom.
- ☑ Choose plants with low nutrient and water requirements.

Focal Guilds and Species: 

Cost: $$-$$$

Where to Implement: Urban Matrix.

What to know:

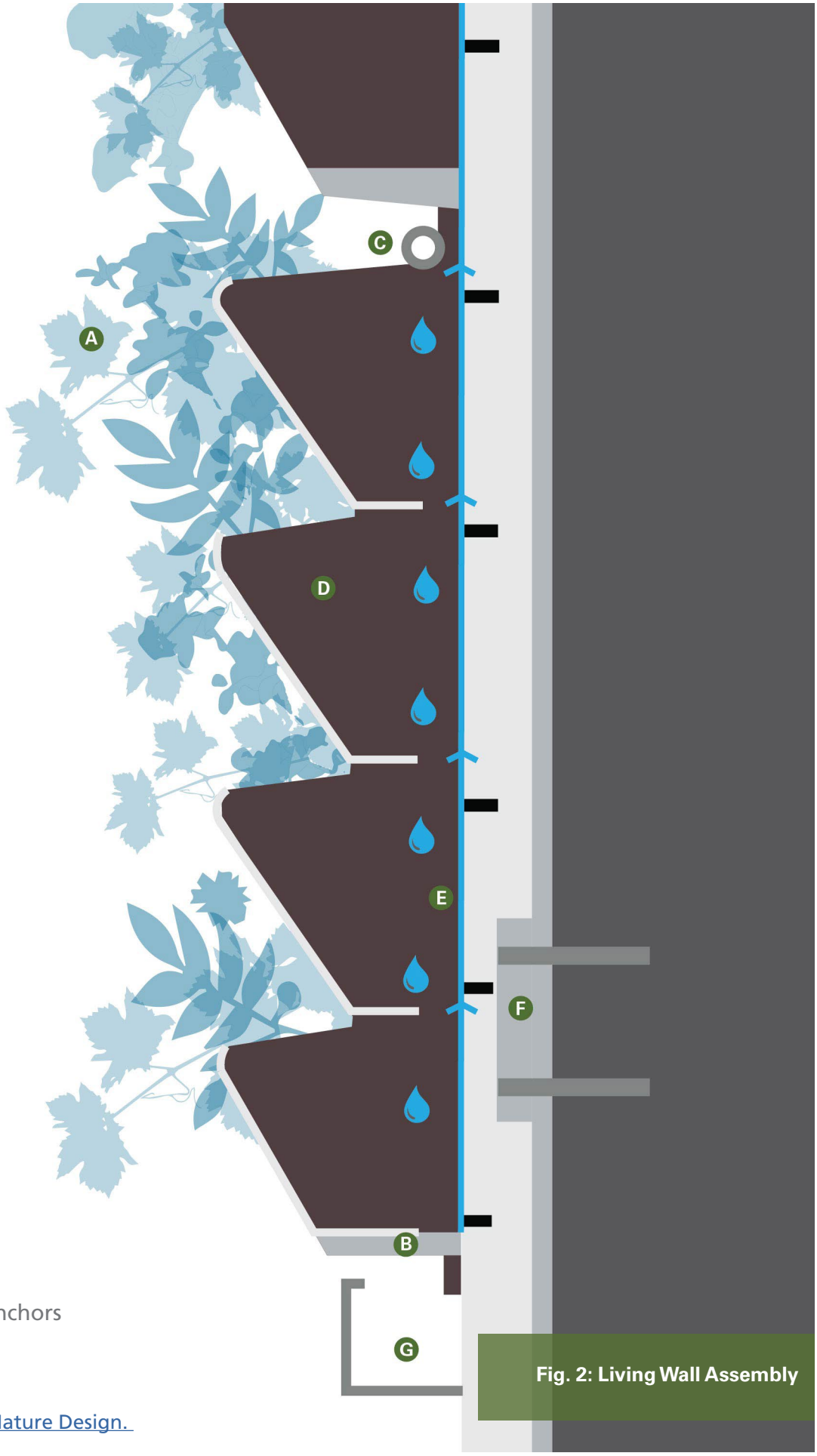
- ☑ Can support a high occurrence of spiders and beetles.
- ☑ Can integrate a wider variety of plants compared to other vertical systems.
- ☑ Maintenance requirements (and potential disturbance to wildlife associated with maintenance) can be minimized if colonizing species (that do not compromise safety) are retained.
- ☑ Require little maintenance once established.
- ☑ High irrigation requirements.
- ☑ Recirculating (i.e., closed) irrigation systems or manual irrigation may be preferred for smaller installations to reduce water waste.
- ☑ Direct (i.e., open) irrigation may be required for larger walls, but excess water is not recirculated.

Co-benefits:

- ☑ Reduce building heat gain/loss (increases energy efficiency).
- ☑ Reduce the urban heat island effect.
- ☑ Improve air quality.
- ☑ Reduce noise.
- ☑ Provide aesthetic and therapeutic benefits.

FURTHER READING:

Vertical Greening Systems as Habitat for Biodiversity.[14]



A - Select plants based on climate and aspect.
B - Drainage
C - Irrigation
D - Planting medium
E - Water recirculation
F - Building appropriate anchors
G - Excess water trough

Fig. 2: Living Wall Assembly

* Diagram adapted from [ByNature Design.]

5.2.2 GREEN RETAINING WALL

Green retaining walls are covered with vegetation. The walls are often modular and use geo-textiles to support soil and vegetation. Green retaining walls may approximate habitat such as exposed rock faces, cliffs, and bluffs, where there is less demand for water and nutrients.

Design Guidelines:

- ☑ Encourage connectivity with surrounding natural areas.
- ☑ Choose plants with low nutrient and water requirements.
- ☑ Mosses, herbaceous plants, grasses, and shrubs can be appropriate.

Focal Guilds and Species: 

Where to Implement: Urban Matrix.
Cost: $ - $$

What to know:

- ☑ May be difficult to establish vegetation depending on climatic conditions, slope, soil, etc.
- ☑ Invasive plants can establish.
- ☑ Leave parts of decaying plants to accumulate organic matter.
- ☑ Typically easy to maintain.

Co-benefits:

- ☑ Improve air quality.
- ☑ Reduce noise and ambient temperature.
- ☑ Increase aesthetics and sense of well-being.
- ☑ Reduce urban heat island effect.
- ☑ Reduce vandalism.

FURTHER READING:
Vertical Greening Systems as Habitat for Biodiversity.[14]

A - Select plants based on climate and aspect.

B - Planting medium

C - Structural elements

D - Gravel or drainage course

E - Native soil

F - Tiebacks

* Diagram adapted from Furbishco.

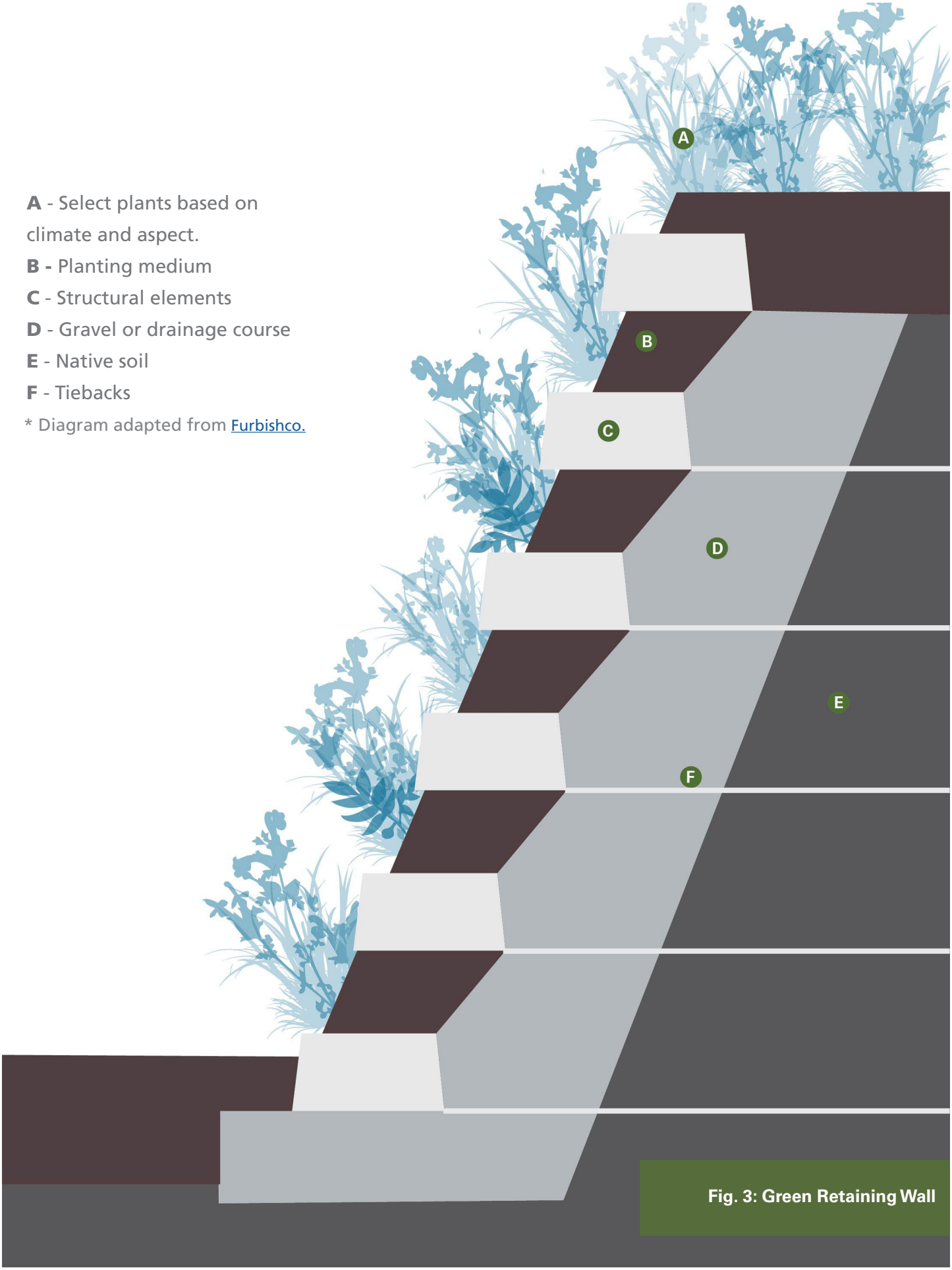


Fig. 3: Green Retaining Wall

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