OBAMA PRESIDENTIAL CENTER

Reinforcing Landscape Ecology

DESIGN DEVELOPMENT

STORMWATER

TREE + SOIL BIOLOGY

BIODIVERSITY

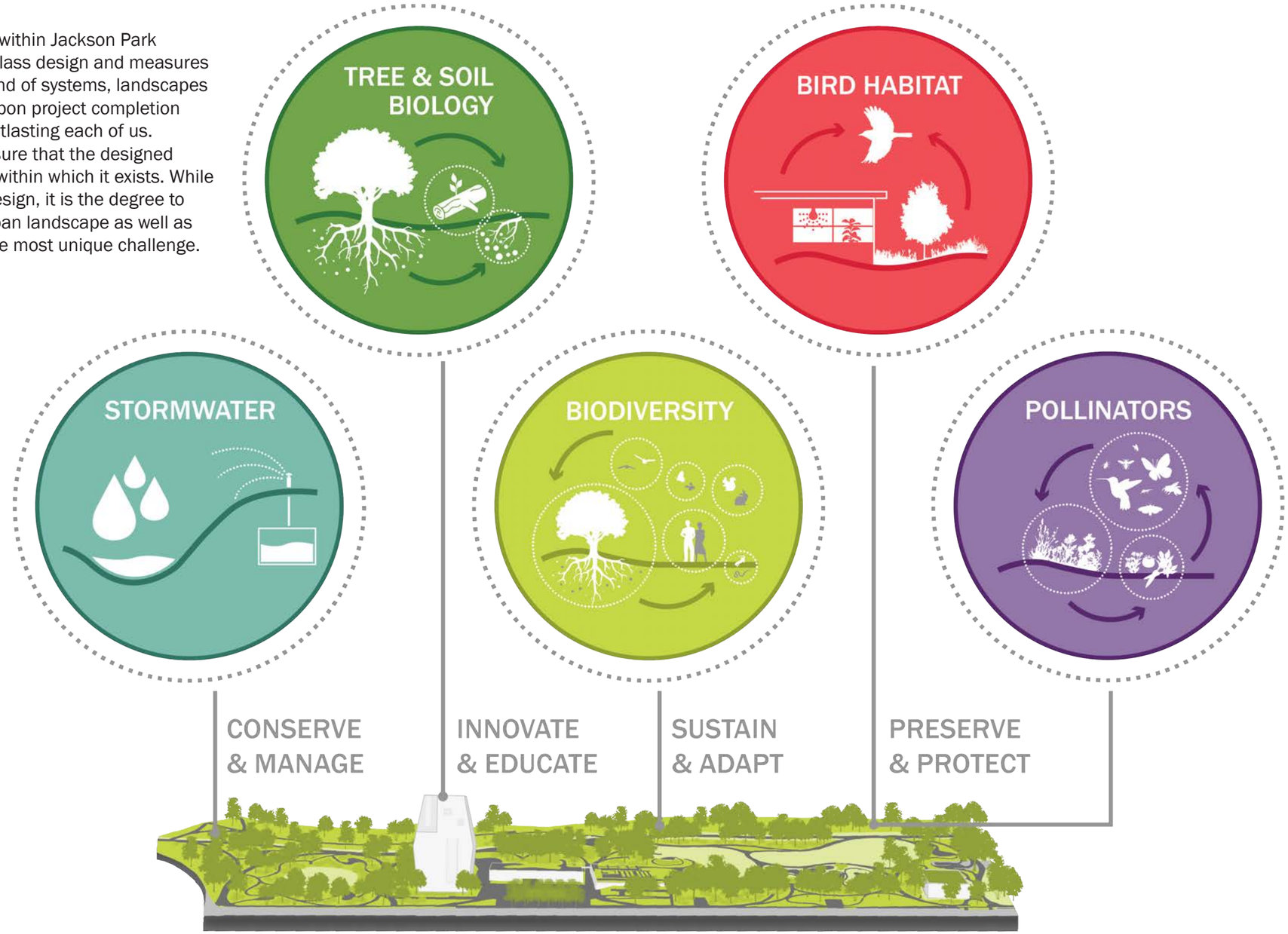
BIRD HABITAT

POLLINATORS

INTRODUCTION TO REINFORCING LANDSCAPE ECOLOGY

The design for the grounds of the Obama Presidential Center within Jackson Park combines the heritage of a beloved Chicago park with world-class design and measures to enhance vital ecological performance. As a study of time and of systems, landscapes are designed to anticipate not just the immediate aesthetic upon project completion but also how they will grow, mature, and evolve - ultimately outlasting each of us. The landscape team has purposefully crafted solutions to ensure that the designed landscape functions well as a part of the broader ecosystem within which it exists. While individual layers of the ecosystem all contribute to the final design, it is the degree to which they respond to the current pressures placed on an urban landscape as well as the projected impacts of our changing climate that present the most unique challenge.

This Reinforcing Landscape Ecology document includes graphics, text, and illustrations meant to communicate some of the more technical, and potentially less visible, elements of the design. This document highlights particular strategies that are integral to the design and the critical thinking that has informed and will continue to inform the design. While the project program and site plan have been developed to a point where the new landscape can clearly be visualized, ongoing detailed design refinements will continue until and through construction. The plans and images shown here represent a snapshot of the landscape design at the time of publication. Although significant changes to the overall landscape design are not anticipated, final site plans may reflect refinements beyond what is included here.



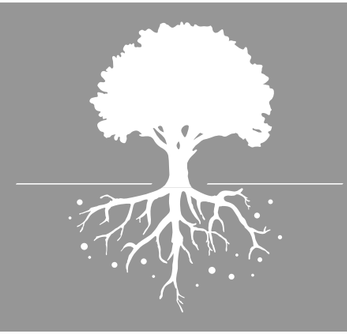
OBAMA PRESIDENTIAL CENTER

Reinforcing Landscape Ecology

DESIGN DEVELOPMENT

STORMWATER

TREE + SOIL BIOLOGY

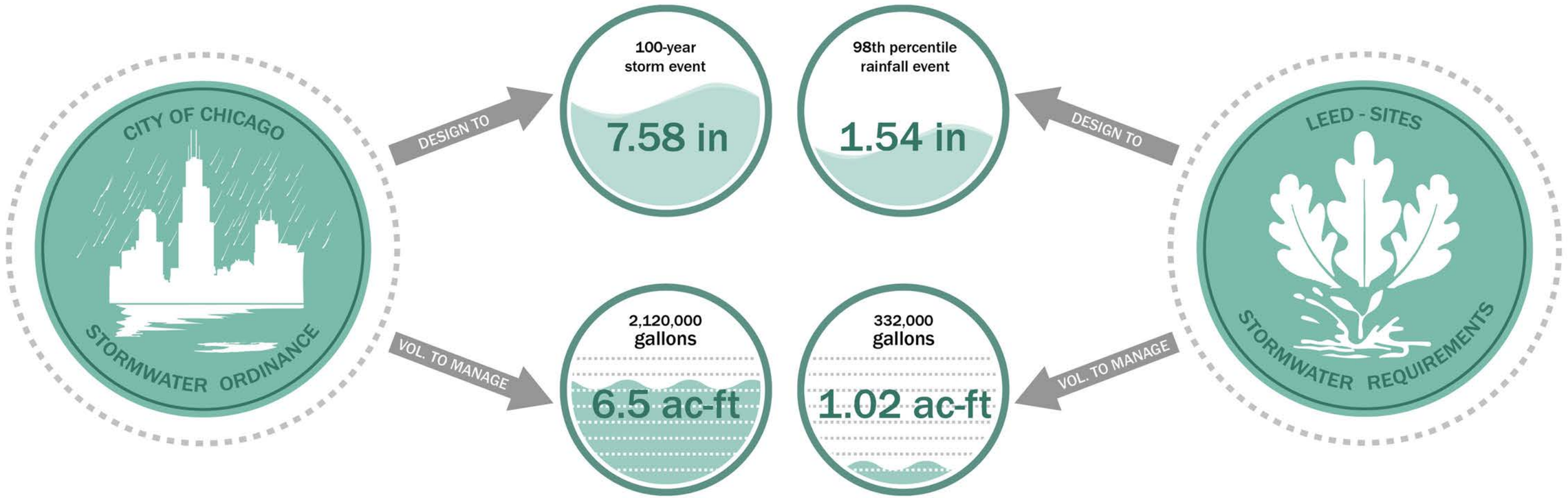


BIODIVERSITY

BIRD HABITAT

POLLINATORS

STORMWATER MANAGEMENT GOALS



SPECIFIC STORMWATER MANAGEMENT REQUIREMENTS

The Obama Presidential Center (OPC) stormwater strategy includes the City of Chicago Ordinance while also targeting LEED & SITES requirements to manage stormwater on site. In doing so, the project promotes natural infiltration, will improve the quality of water eventually entering the lagoon, and will reduce the impacts of stormwater on adjacent property.

City of Chicago Stormwater Ordinance:

- No adverse impacts to adjoining facilities or properties.
- Discharges to combined sewers are rate limited.
- Runoff from proposed site must not exceed existing flow.
- Detention must be provided for runoff from impervious areas exceeding 400 square feet draining into Public Right of Way.
- Runoff from created impervious areas exceeding 7,500 square feet and discharging into combined sewers must be controlled by rate and volume.
- Design must provide a minimum of 0.1 ft freeboard from detention facilities draining into Public Right of Way and at lowest overflow elevation into adjacent property.
- All regulated developments must be designed to manage the 100-year storm event and to provide means to manage and direct overflows to the public right of way.
- Design must manage 100-year flows, including the critical storm.
- IEPA/DNR regulate water impacts to Lake Michigan.

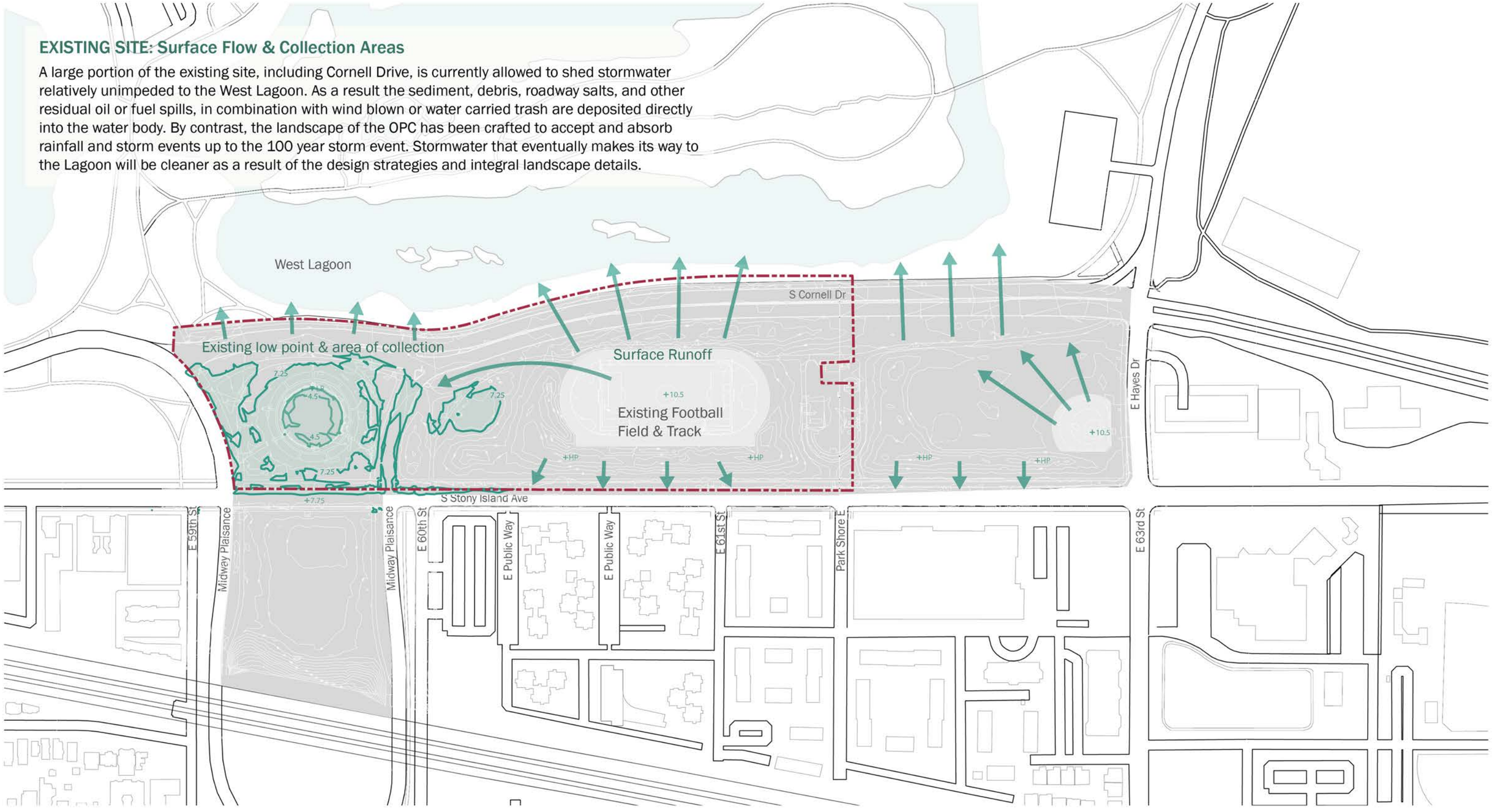
LEED/SITES Requirements:

- Manage precipitation on the project site.
- Targeting the 98th percentile storm event (LEED) / 95th percentile storm event (SITES).
- Treat any volume above target with appropriate technology.
- Ensure that volume beyond target will be not exceed discharge rate limits to adjacent water channels.
- Scale BMPs[1] to account for additional volumes of water entering from off-site areas.
- Develop site maintenance plan to ensure efficacy of stormwater features.

1. *BMP: Best Management Practices are strategies to manage land and mitigate pollution of surface and groundwater.*

EXISTING SITE: Surface Flow & Collection Areas

A large portion of the existing site, including Cornell Drive, is currently allowed to shed stormwater relatively unimpeded to the West Lagoon. As a result the sediment, debris, roadway salts, and other residual oil or fuel spills, in combination with wind blown or water carried trash are deposited directly into the water body. By contrast, the landscape of the OPC has been crafted to accept and absorb rainfall and storm events up to the 100 year storm event. Stormwater that eventually makes its way to the Lagoon will be cleaner as a result of the design strategies and integral landscape details.

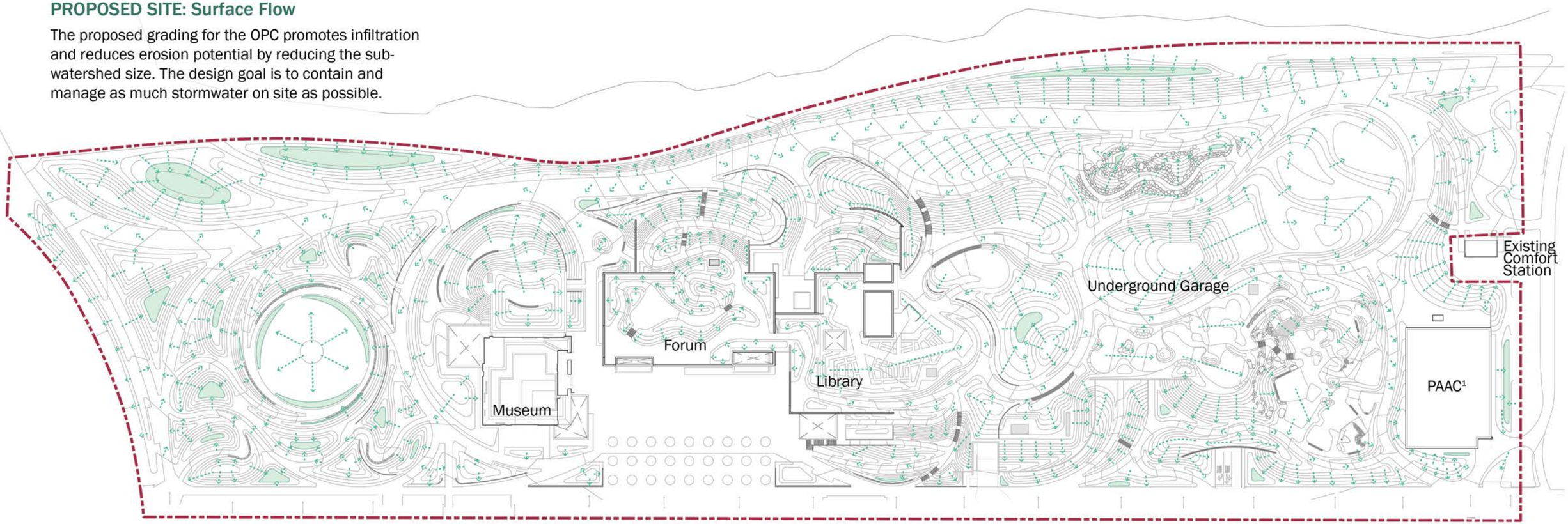


N

NTS

PROPOSED SITE: Surface Flow

The proposed grading for the OPC promotes infiltration and reduces erosion potential by reducing the sub-watershed size. The design goal is to contain and manage as much stormwater on site as possible.

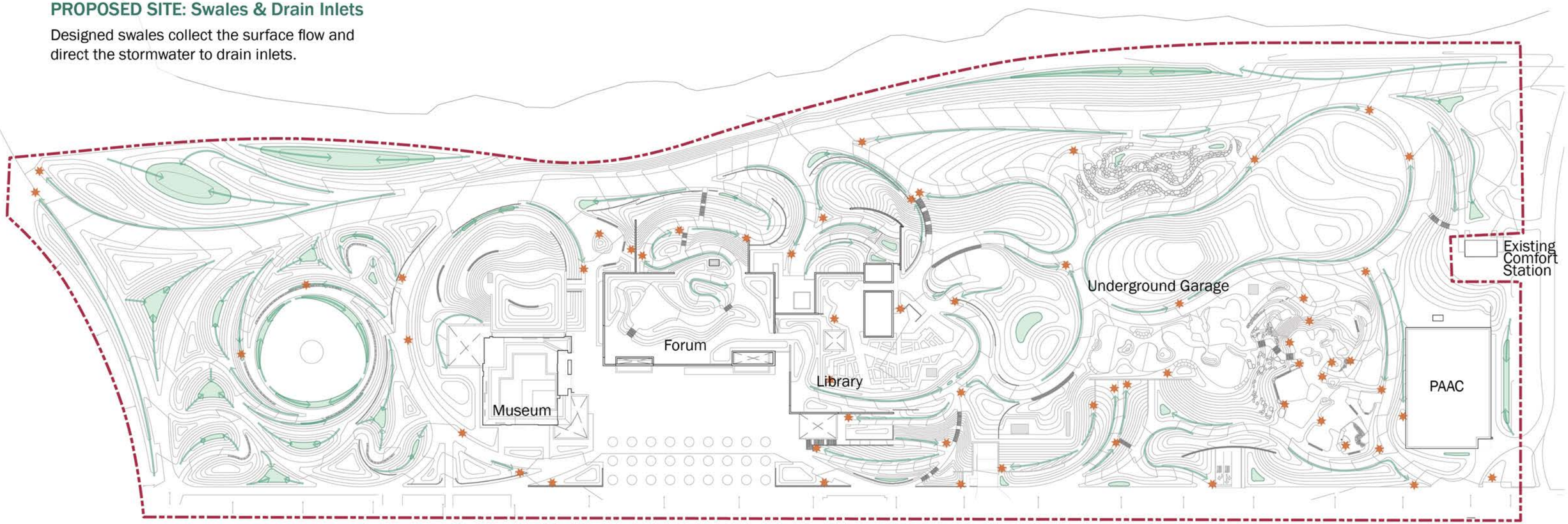


Direction of overland stormwater flow

1. *PAAC is the Program, Athletic, and Activity Center.*

PROPOSED SITE: Swales & Drain Inlets

Designed swales collect the surface flow and direct the stormwater to drain inlets.



Drain Inlet

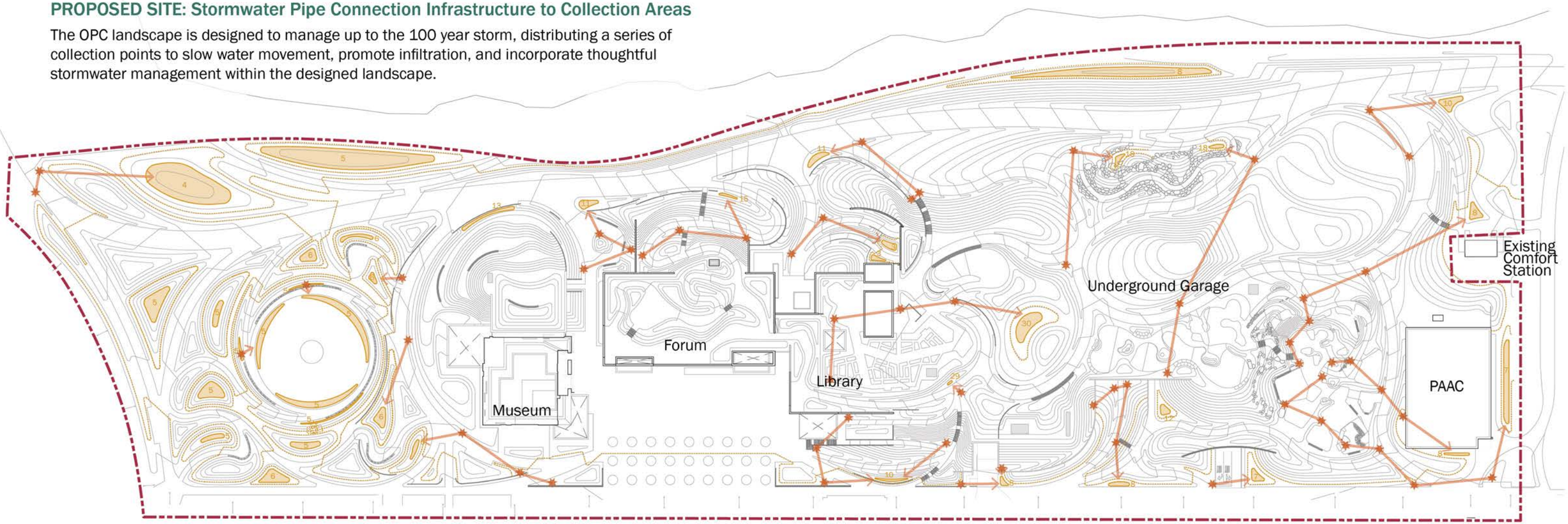
Surface Swale

N 120'

LIVING HABITATS

PROPOSED SITE: Stormwater Pipe Connection Infrastructure to Collection Areas

The OPC landscape is designed to manage up to the 100 year storm, distributing a series of collection points to slow water movement, promote infiltration, and incorporate thoughtful stormwater management within the designed landscape.



Water Flow Inlet Drain

Inlet Drain to Water Basin

Top of Surface Storage

Bottom of Surface Storage

N 120'

LIVING HABITATS

OBAMA PRESIDENTIAL CENTER

Reinforcing Landscape Ecology

DESIGN DEVELOPMENT

STORMWATER

TREE + SOIL BIOLOGY

BIODIVERSITY

BIRD HABITAT

POLLINATORS

TREE & SOIL ASSESSMENT

1. *Tree quality and characteristic descriptions as denoted in Bartlett Inventory Solutions 2018 report.*

TREE & SOIL ASSESSMENT

EXECUTIVE SUMMARY

- Trees within urban landscapes are often managed as single generation plants because traditional maintenance and intense park usage work together to restrict the natural succession of trees.

- In combination with sunlight and water, trees are sustained by a suite of microorganisms in the soil that cycle nutrients and sustain the health of the root system that feeds the tree.

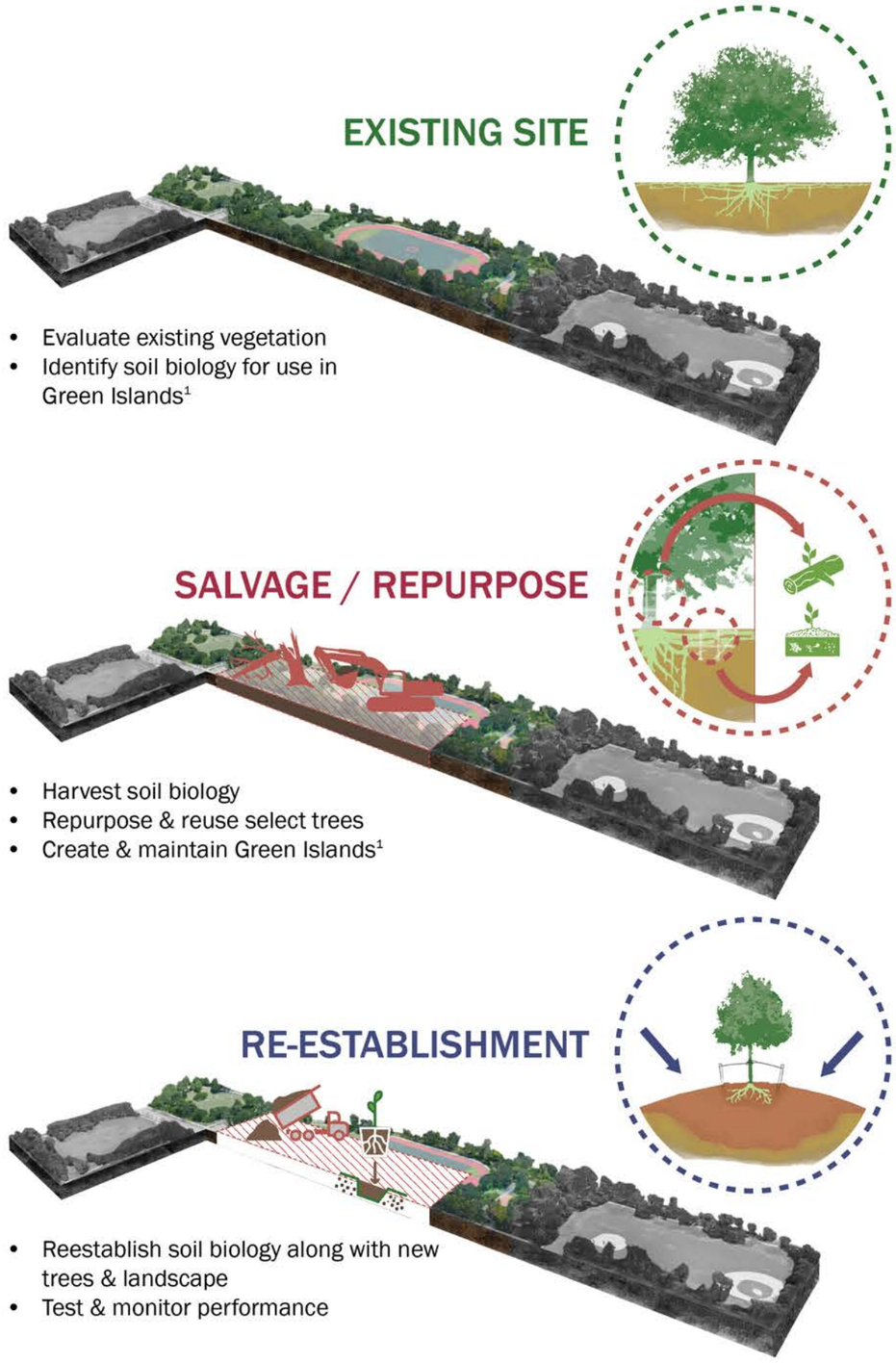
- The soil community consists of mycorrhizal fungi, nitrogen fixing bacteria, plant promoting rhizospheric bacteria and their microscopic predators. Unlike urban trees, the microorganisms and microscopic soil community are multi-generational.

- Preserving this soil community in Green Islands[1] on the site and re-introducing it back into the new landscape will elevate and accelerate the establishment of the designed landscape.

- Identifying and harvesting the soil biology prior to construction will be essential to establishing a baseline, formulating an effective approach, and documenting improvements. Testing and monitoring will be critical throughout.

- In addition to harvesting and repurposing the soil biology of the site, the Foundation has committed to a **minimum of a 1:1 replacement of trees** in the project site. This reestablishment of trees throughout the landscape will allow the soil biology to continue to develop over time.

1. *Green Islands: Contained batch of soil and vegetation to promote a concentrated solution of biological and ecological functions. The Green Island's benefits can then be applied at a wider scale through an inoculum.*



TREE ASSESSMENT

Assessment of Quality:

Initially, a large portion of the existing landscape located on the proposed site for the Obama Presidential Center will be removed, while select elements will be repurposed or replaced per design plans. To inform the design process, the site was examined and evaluated based on the existing landscape qualities and characteristics including plant species, ecological value, aesthetic value, overall health, age, maturity, size, and location. This includes recognition of Jackson Park's history and potential reuse and/or repurpose of ecologically beneficial trees within the proposed design.

This examination was performed with both a quantitative lens and a qualitative one to better evaluate and consider the potential for the existing site elements in the proposed landscape design.

- Bartlett Inventory Solutions: Tree Inventory and Management Plan "Quantitative Assessment"
- Ecological Landscape Management (ELM): Soil Biology and Existing Tree Assessment "Qualitative Assessment"

Typical Quality Characteristics Included in a Tree Survey / Vegetative Assessment:

Species:
Diverse native species increase efficiency and productivity of the ecosystem.

Health:
Effects length of life and productivity contribution in the ecosystem.

Age:
Long-term benefits may vary depending on the generation the tree was planted.

Size (DBH):
Tree trunk diameter at breast height, which indicates size of tree.

Maturity:
Tree's lifetime of establishment in its environment and growth potential.

Ecology:
Trees provide food and habitat for various organisms.

Aesthetic:
Tree characteristics provide visual appeal throughout the year.

Location:
Area in which the tree is rooted.

**Reference Bartlett and ELM Full Reports in Appendix.*

Bartlett Survey:

The risk and maintenance-based inventory of existing trees determined the age class through specialized equipment and software, which distinguishes tree characteristics and evaluates risk. The age class was determined based on establishment and growth potential of the trees evaluated. Using a modified version of the Trunk Formula Method published by the Council of Tree and Landscape Appraisers in The Guide for Plant Appraisal, 9th Edition (CTLA, 2000), Bartlett calculated an estimated monetary value for each individual tree and a cumulative total for all trees inventoried. This "value" is then able to be used by a client to determine how best to allocate their resources in the management of a site.

Species:
Bartlett measured the relative species desirability based on 100% scale for the tree in that geographical location. In most cases, species desirability ratings, published by the International Society of Arboriculture, are used for adjustment.

Size DBH:
Based on tree DBH (measured at 4.5 feet above grade).

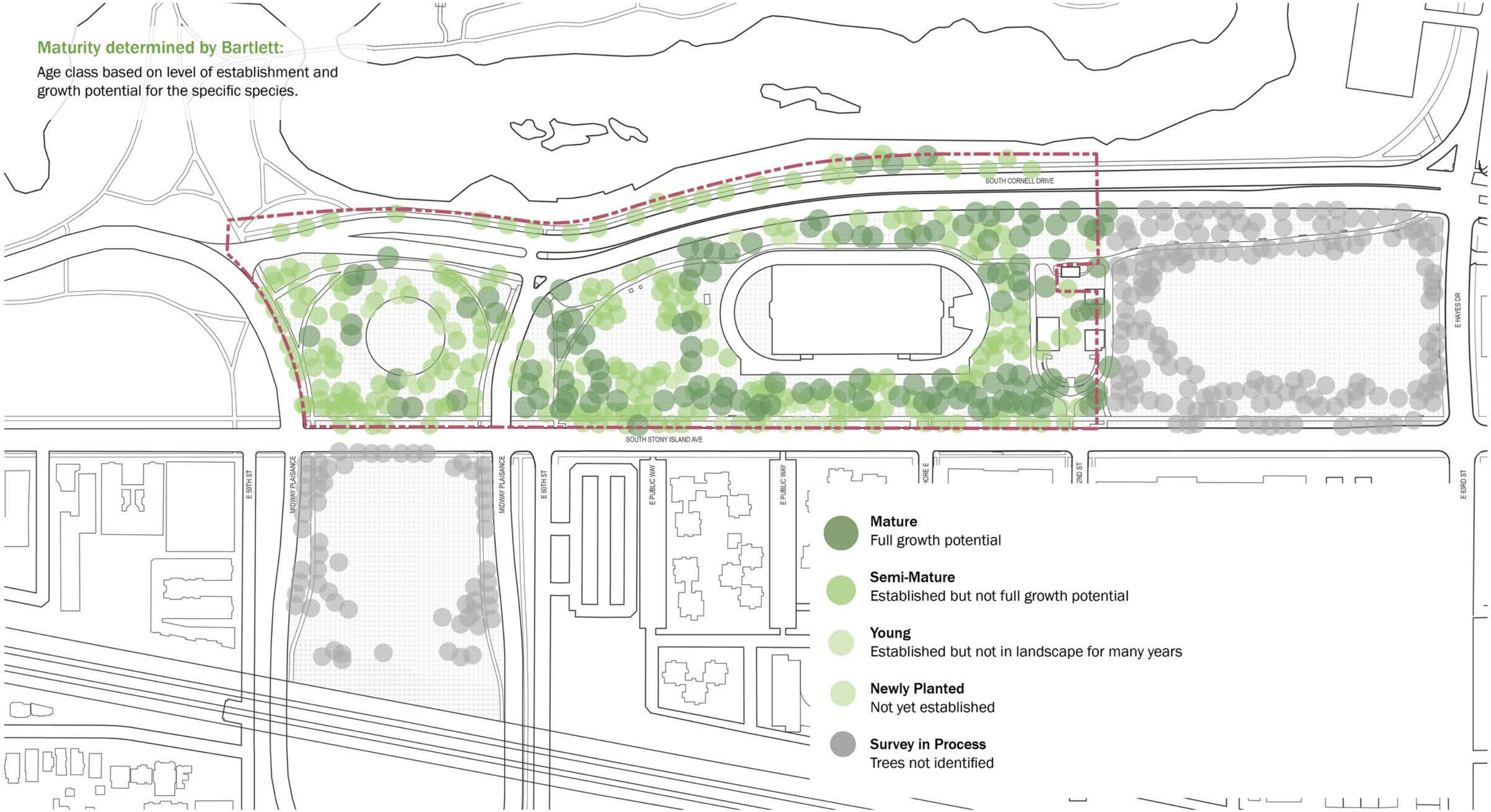
Health:
Rating of the tree's structure and health based on a scale out of 100%.

Location:
Average rating for the site and the tree's contribution and placement, based on a scale out of 100%.

**Reference Bartlett Full Report in Appendix.*

Maturity determined by Bartlett:

Age class based on level of establishment and growth potential for the specific species.



**Reference Bartlett Full Report in Appendix.*

N 0' 200'

ELM Assessment:

A certified arborist conducted a qualitative assessment of the existing trees, estimating the approximate age range of each tree and grouping these in generational categories. The report focuses on restorative methods that will enable the landscape to maintain its value through transitional stressors and highlight the preservation features. Overall assessment includes individual ecological value, aesthetic value, tree species, and approximate age range of each tree evaluated.

Bartlett Survey

Species:
Bartlett measured the relative species desirability based on 100% scale for the tree in that geographical location. In most cases, species desirability ratings, published by the International Society of Arboriculture, are used for adjustment.

Health:
Rating of the tree's structure and health based on a scale out of 100%.

Size DBH:
Based on tree DBH (measured at 4.5 feet above grade).

Location:
Average rating for the site and the tree's contribution and placement, based on a scale out of 100%.

ELM Survey

Ecology:
Trees that sustain migrating birds and measure higher in mycorrhizal colonization levels are ideal sources for establishing the natural ecosystem in the new site.

Generation:
Estimated age based on species and size.

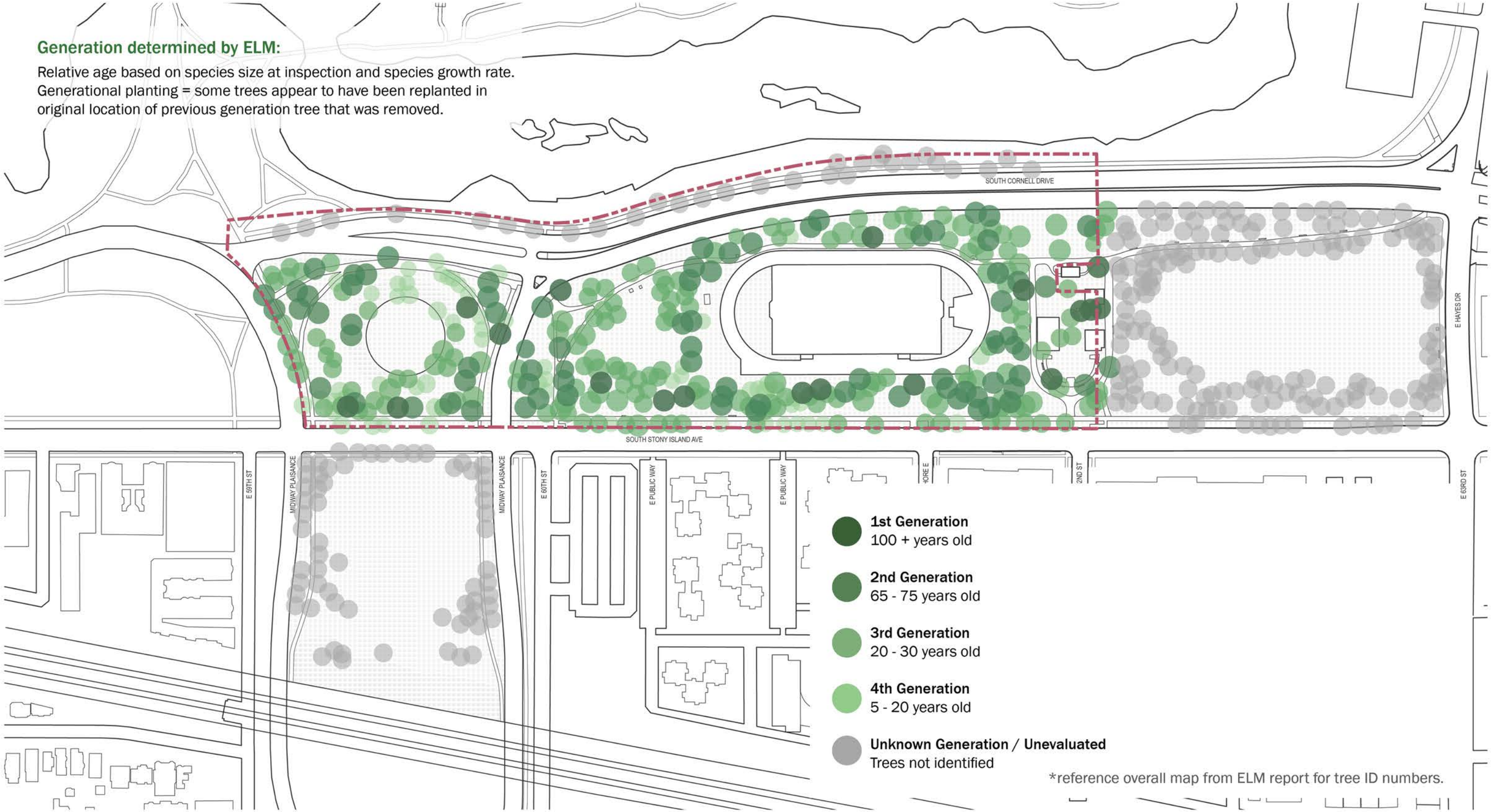
Aesthetics:
Based on size, density, and characteristics such as spring and summer flowering, autumn color, or winter fruiting

Maturity:
Level of establishment in environment and period in the species' growth potential.

**Reference ELM Full Report in Appendix.*

Generation determined by ELM:

Relative age based on species size at inspection and species growth rate.
Generational planting = some trees appear to have been replanted in original location of previous generation tree that was removed.



**Reference ELM Full Report in Appendix.*

N 0' 200'

REPURPOSE

Nurse logs ranging in length will be placed in designed locations that will have the highest impact on ecology in the new site development. The various log sections will be selected from the mature tree population while working with the project arborist. Placement and installation timeline will aide in regenerative microbe behaviors and optimize benefits of ecological and biological processes.

Quality Methodology:

Trees labeled as recommended nurse logs were determined by the following qualitative factors:

Species:
If the mature tree is in the right condition for nurse log development, species of tree is not the major factor. However, some species may influence log choice based on its properties.

Health:
Trees selected as nurse logs must be in a certain health condition for high activity of biotic function.

Age:
An older generation tree has had time to establish the properties for ideal nurse logs.

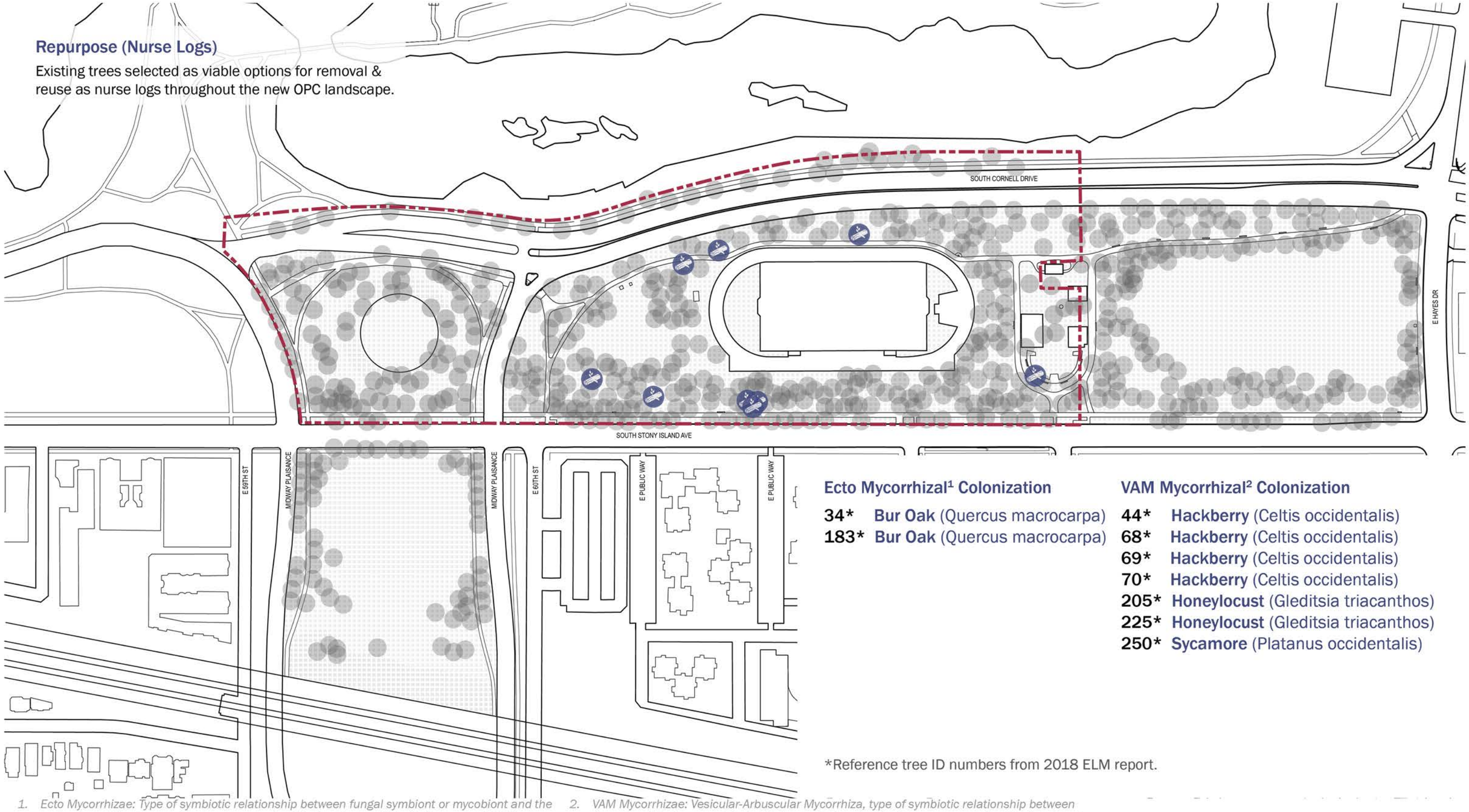
Maturity:
A mature tree or past maturity tree is key due to its biological function in its period of life.

Ecology:
The logs will provide a desired habitat for beneficial bacteria and fungi organisms. The organisms will continue to cycle nutrients into the next generation trees.

=

Repurpose (Nurse Logs)

Existing trees selected as viable options for removal & reuse as nurse logs throughout the new OPC landscape.



Ecto Mycorrhizal[1] Colonization

34* **Bur Oak** (Quercus macrocarpa)
183* **Bur Oak** (Quercus macrocarpa)

VAM Mycorrhizal[2] Colonization

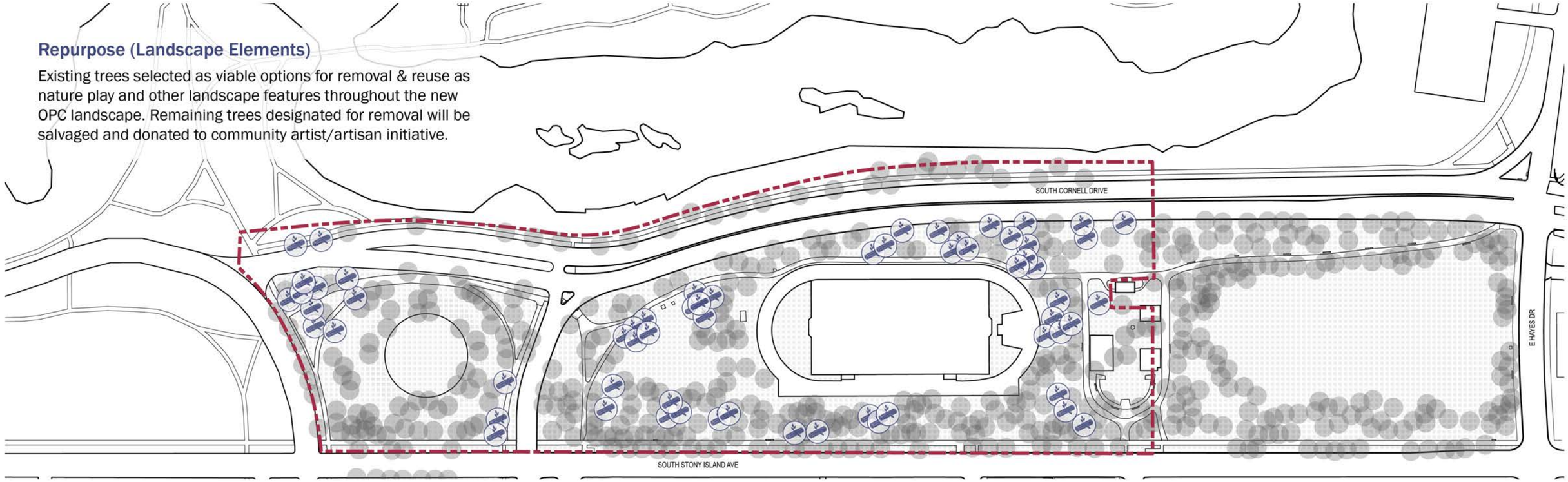
44* **Hackberry** (Celtis occidentalis)
68* **Hackberry** (Celtis occidentalis)
69* **Hackberry** (Celtis occidentalis)
70* **Hackberry** (Celtis occidentalis)
205* **Honeylocust** (Gleditsia triacanthos)
225* **Honeylocust** (Gleditsia triacanthos)
250* **Sycamore** (Platanus occidentalis)

*Reference tree ID numbers from 2018 ELM report.

1. *Ecto Mycorrhizae: Type of symbiotic relationship between fungal symbiont or mycobiont and the roots of specific plan species as a means of nutrient exchange (Oaks in the case of OPC).*
2. *VAM Mycorrhizae: Vesicular-Arbuscular Mycorrhiza, type of symbiotic relationship between fungal symbiont or mycobiont, which penetrates plant cells as a means of nutrient exchange.*

Repurpose (Landscape Elements)

Existing trees selected as viable options for removal & reuse as nature play and other landscape features throughout the new OPC landscape. Remaining trees designated for removal will be salvaged and donated to community artist/artisan initiative.



30* **Northern Red Oak** (Quercus rubra)
31* **Northern Red Oak** (Quercus rubra)
40* **Elm** (Ulmus Sp.)
41* **Elm** (Ulmus Sp.)
42* **Elm** (Ulmus Sp.)
45* **American Linden** (Tilia americana)
48* **Norway Maple** (Acer platanoides)
67* **Hackberry** (Celtis occidentalis)
71* **Hackberry** (Celtis occidentalis)
92* **Downy Hawthorn** (Crataegus mollis)
93* **Honey Locust** (Gleditsia triacanthos)
94* **Honey Locust** (Gleditsia triacanthos)
136* **Norway Maple** (Acer platanoides)
141* **Honey Locust** (Gleditsia triacanthos)
143* **Honey Locust** (Gleditsia triacanthos)
156* **Kentucky Coffee Tree** (Gymnocladus dioicus)
157* **Kentucky Coffee Tree** (Gymnocladus dioicus)
158* **White Ash** (Fraxinus americana)
159* **Honey Locust** (Gleditsia triacanthos)
160* **Honey Locust** (Gleditsia triacanthos)
172* **Northern Red Oak** (Quercus rubra)
173* **Northern Red Oak** (Quercus rubra)
174* **Northern Red Oak** (Quercus rubra)
175* **Northern Red Oak** (Quercus rubra)
176* **Norway Maple** (Acer platanoides)
180* **Silver Maple** (Acer saccharinum)
181* **Norway Maple** (Acer platanoides)
182* **Northern Red Oak** (Quercus rubra)
185* **Norway Maple** (Acer platanoides)
186* **Honey Locust** (Gleditsia triacanthos)
187* **Green Ash** (Fraxinus pennsylvanica)
188* **Green Ash** (Fraxinus pennsylvanica)
191* **Honey Locust** (Gleditsia triacanthos)
195* **Hackberry** (Celtis occidentalis)
196* **Norway Maple** (Acer platanoides)
192* **Hackberry** (Celtis occidentalis)
218* **Elm** (Ulmus Sp.)
219* **Elm** (Ulmus Sp.)
220* **Elm** (Ulmus Sp.)
221* **Elm** (Ulmus Sp.)
222* **Elm** (Ulmus Sp.)
233* **Elm** (Ulmus Sp.)
234* **Elm** (Ulmus Sp.)
235* **Elm** (Ulmus Sp.)
236* **Elm** (Ulmus Sp.)
237* **Elm** (Ulmus Sp.)
242* **Silver Maple** (Acer saccharinum)
260* **Green Ash** (Fraxinus pennsylvanica)
588* **Honey Locust** (Gleditsia triacanthos)
589* **Honey Locust** (Gleditsia triacanthos)
592* **Honey Locust** (Gleditsia triacanthos)
607* **Cherry** (Prunus sp.)
610* **Hackberry** (Celtis occidentalis)
652* **River Birch** (Betula nigra)
654* **River Birch** (Betula nigra)
656* **Norway Maple** (Acer platanoides)
657* **Norway Maple** (Acer platanoides)
658* **Norway Maple** (Acer platanoides)
659* **Norway Maple** (Acer platanoides)
680* **Downy Hawthorn** (Crataegus mollis)
684* **Hackberry** (Celtis occidentalis)
685* **Hackberry** (Celtis occidentalis)

*Reference tree ID numbers from 2018 ELM report.

N 0' 200'

PRESERVE

Trees on the existing site examined for potential preservation were determined by the estimated age/generation suggesting they were likely introduced to the site during the period of Frederick Law Olmsted Sr's influence on Jackson Park. A unique collection of mature trees are most likely connected together underground through their root systems, forming one harmonious ecosystem that has allowed the species to prosper. Trees identified to be from this generation will be analyzed for preservation in the landscape design and, if preserved, undergo a mature tree preservation and protection regime during site development.

Olmsted's Influence on Jackson Park:

Pre-Olmsted

Site described by early land surveyors as "vegetated primarily with marsh and wet to mesic prairie."

Frederick Law Olmsted, Sr. Period of Influence[1]

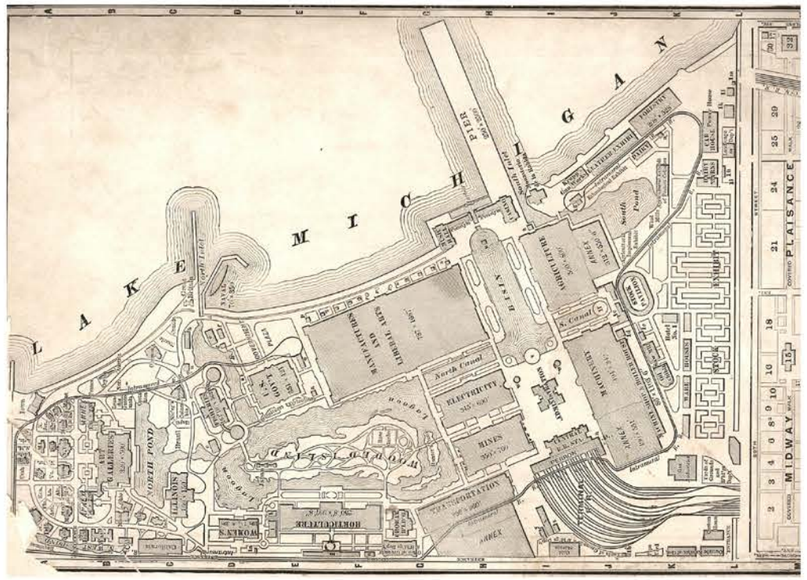
1871
Olmsted and Vaux Chicago South Park Commission Comprehensive Plan
(Never fully executed)

1893
World's Columbian Exposition

1895
Olmsted, Olmsted and Eliot Plan

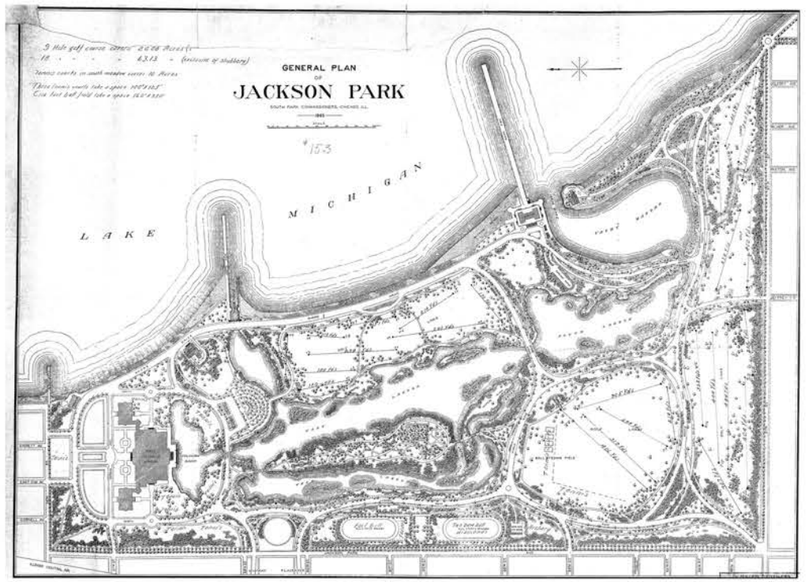
Olmsted Brothers and Others

1905
Updated Olmsted Brothers park plan



1893: World's Columbian Exposition Plan
F.L. Olmsted & Co. / Olmsted, Olmsted and Eliot

1895: Revised General Plan for Jackson Park
Olmsted, Olmsted, and Eliot



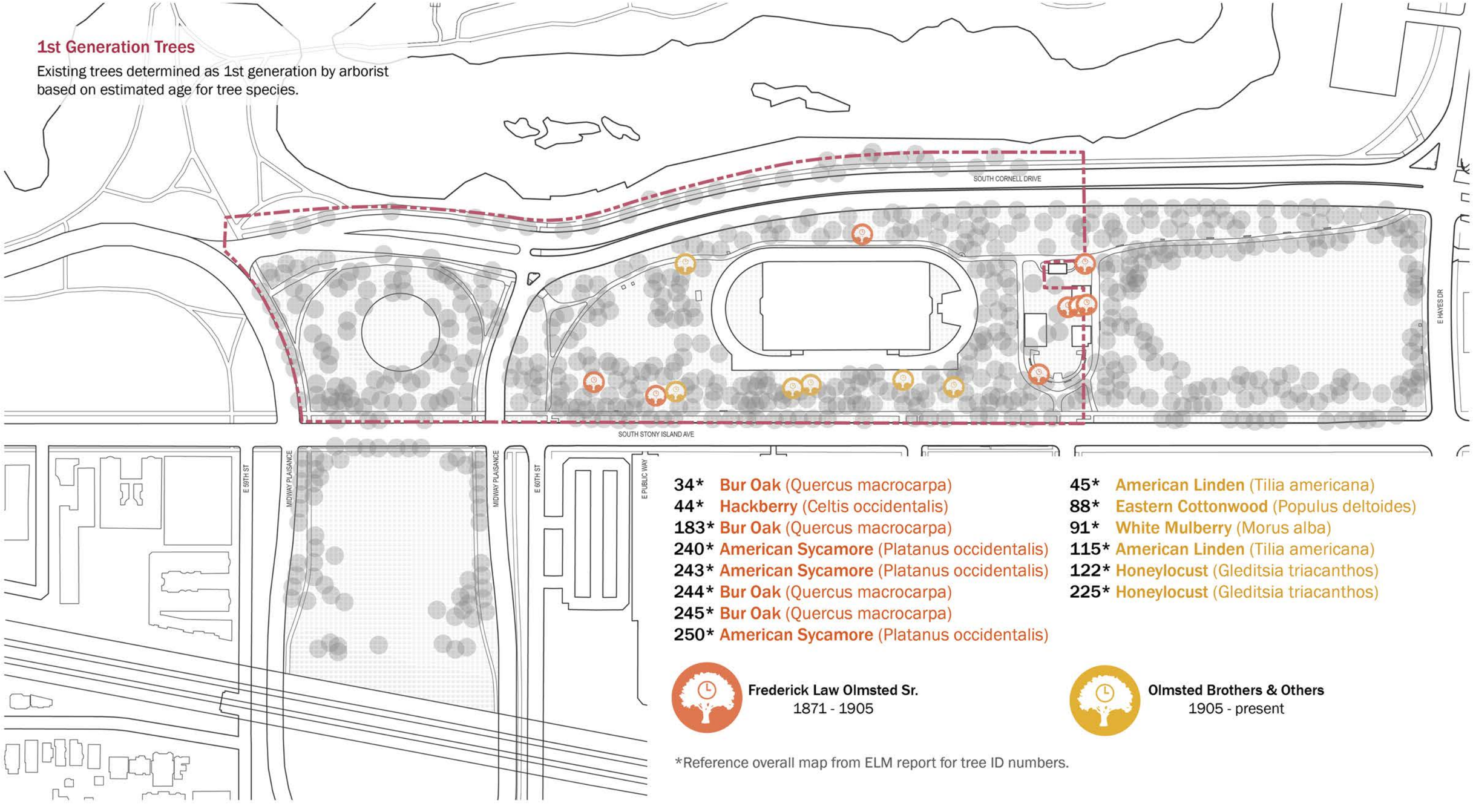
1905: General Plan of Jackson Park
Olmsted Brothers

1. *Frederick Law Olmsted Sr. left practice in 1895 and it is reasonable to assume that his ideas guided early park construction until a new plan was issued.*

N 0' 200'

1st Generation Trees

Existing trees determined as 1st generation by arborist based on estimated age for tree species.



34* **Bur Oak** (Quercus macrocarpa)
44* **Hackberry** (Celtis occidentalis)
183* **Bur Oak** (Quercus macrocarpa)
240* **American Sycamore** (Platanus occidentalis)
243* **American Sycamore** (Platanus occidentalis)
244* **Bur Oak** (Quercus macrocarpa)
245* **Bur Oak** (Quercus macrocarpa)
250* **American Sycamore** (Platanus occidentalis)

45* **American Linden** (Tilia americana)
88* **Eastern Cottonwood** (Populus deltoides)
91* **White Mulberry** (Morus alba)
115* **American Linden** (Tilia americana)
122* **Honeylocust** (Gleditsia triacanthos)
225* **Honeylocust** (Gleditsia triacanthos)

Frederick Law Olmsted Sr.
1871 - 1905

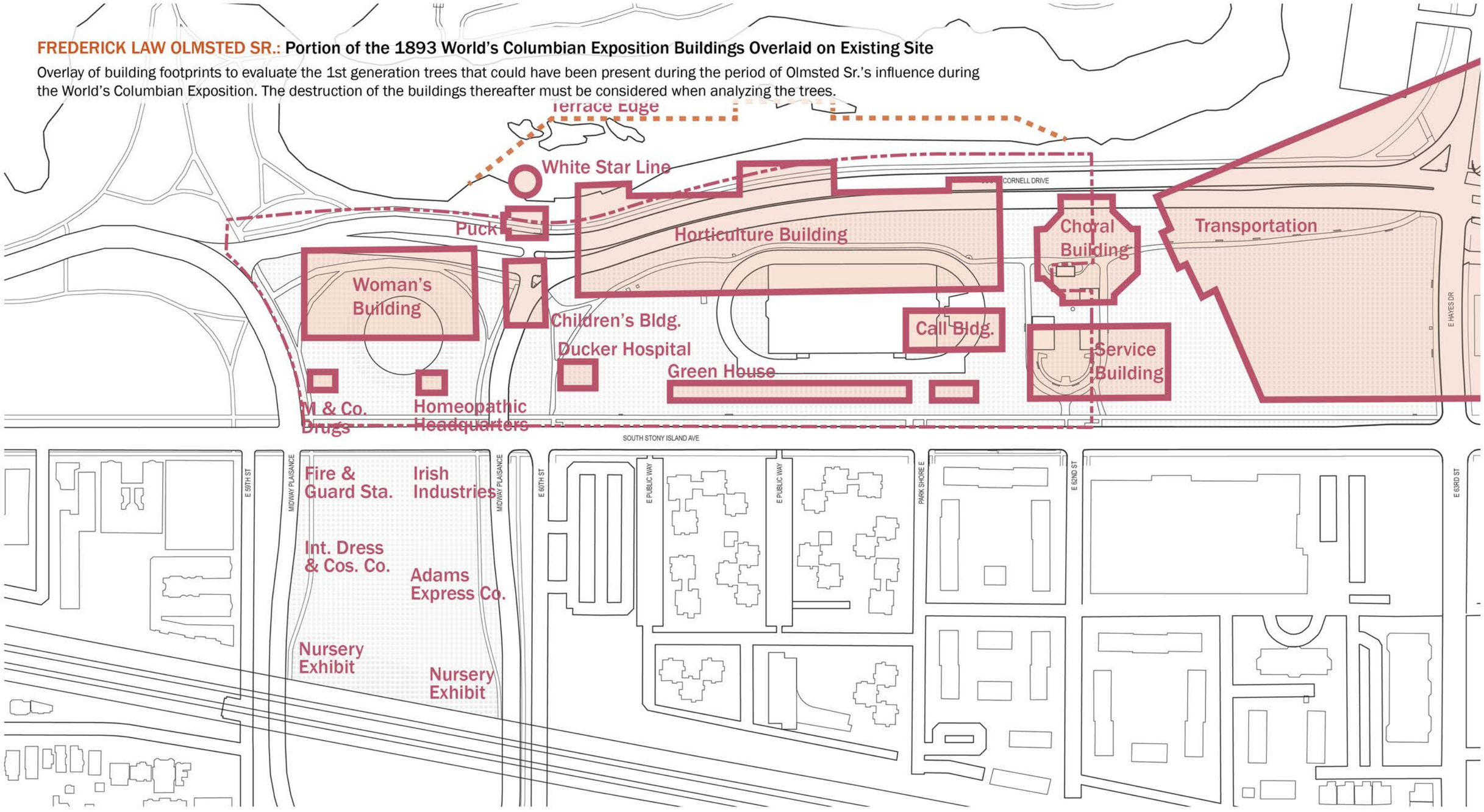
Olmsted Brothers & Others
1905 - present

*Reference overall map from ELM report for tree ID numbers.

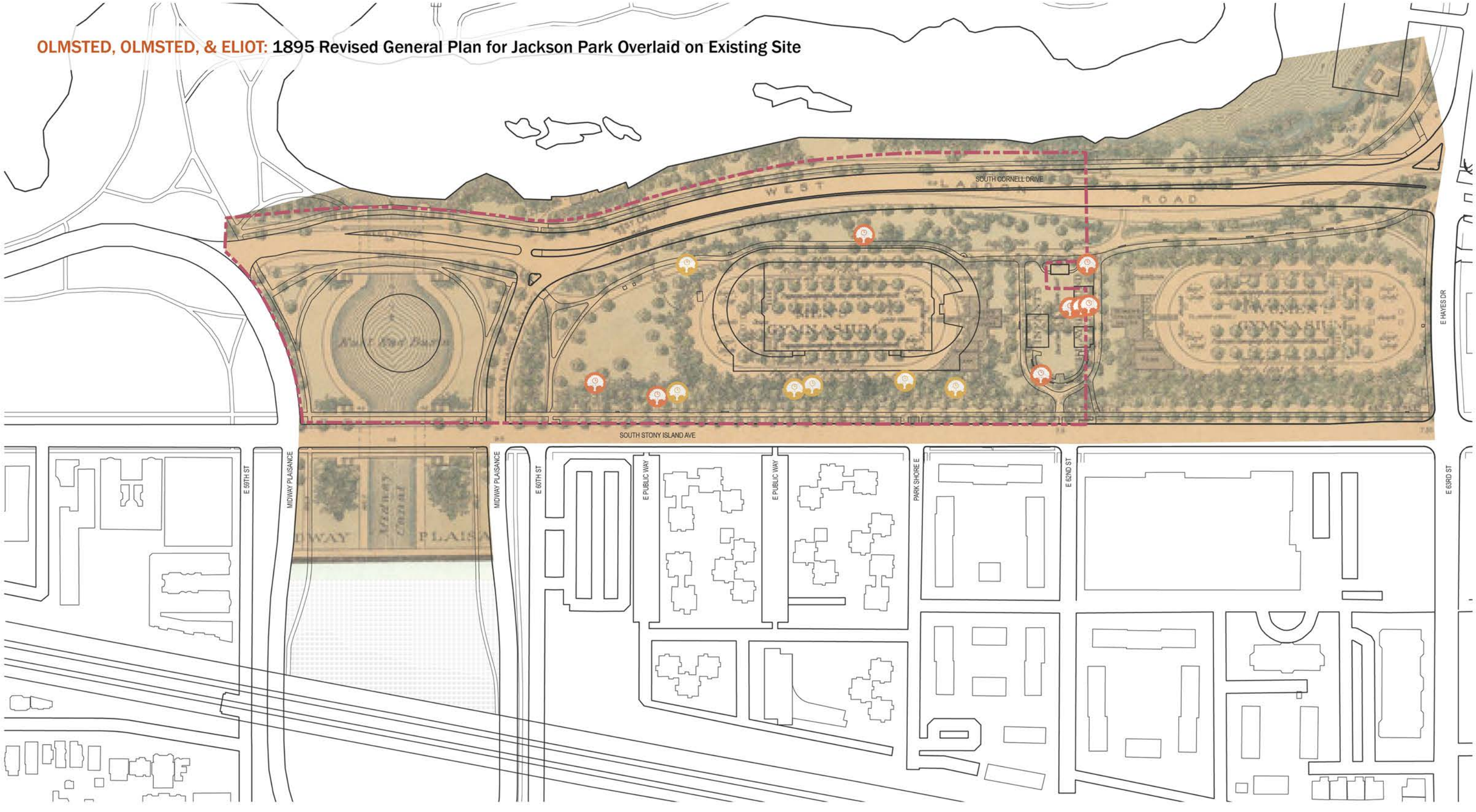
N 0' 200'

FREDERICK LAW OLMSTED SR.: Portion of the 1893 World's Columbian Exposition Buildings Overlaid on Existing Site

Overlay of building footprints to evaluate the 1st generation trees that could have been present during the period of Olmsted Sr.'s influence during the World's Columbian Exposition. The destruction of the buildings thereafter must be considered when analyzing the trees.



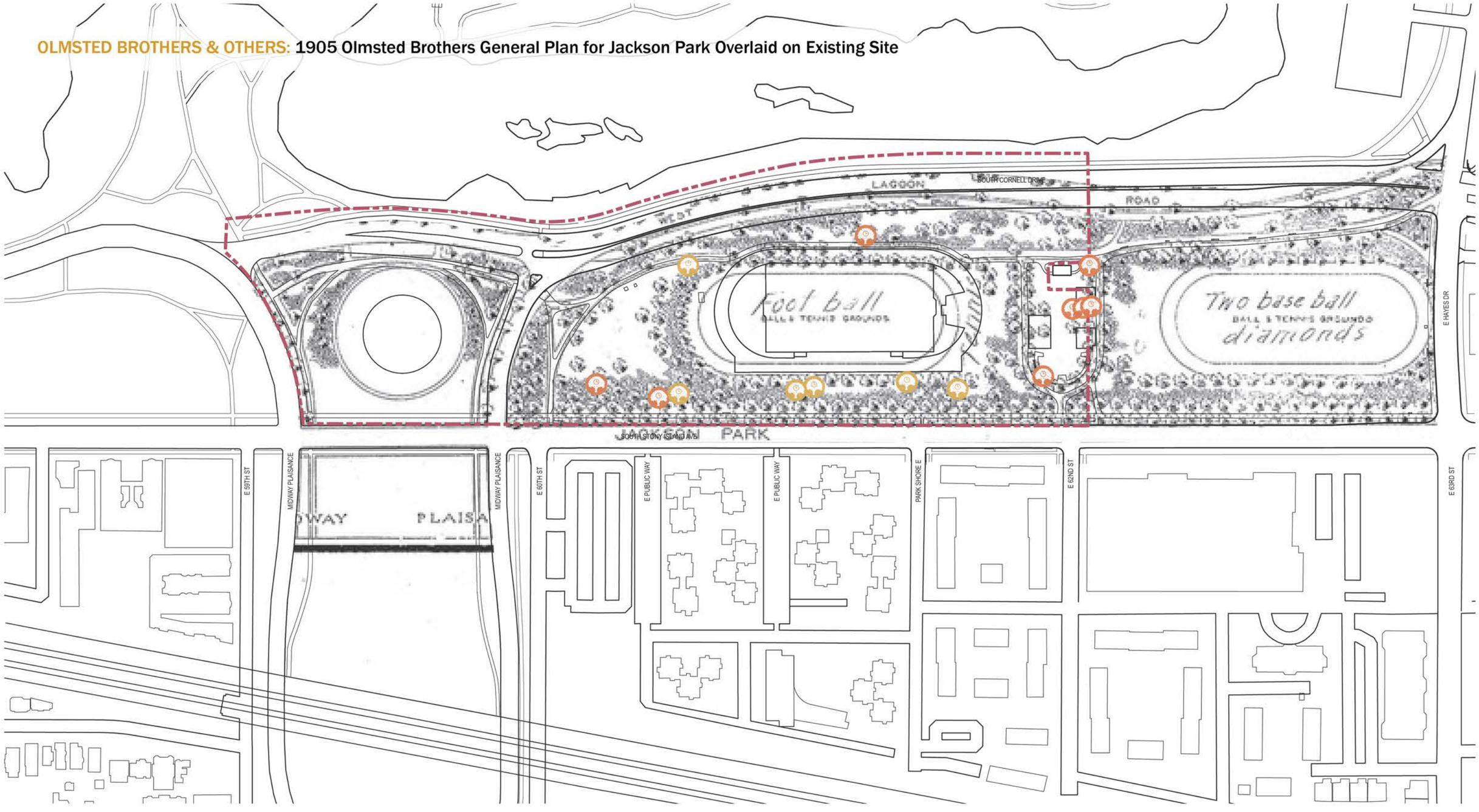
OLMSTED, OLMSTED, & ELIOT: 1895 Revised General Plan for Jackson Park Overlaid on Existing Site



N 0' 200'

LIVING HABITATS

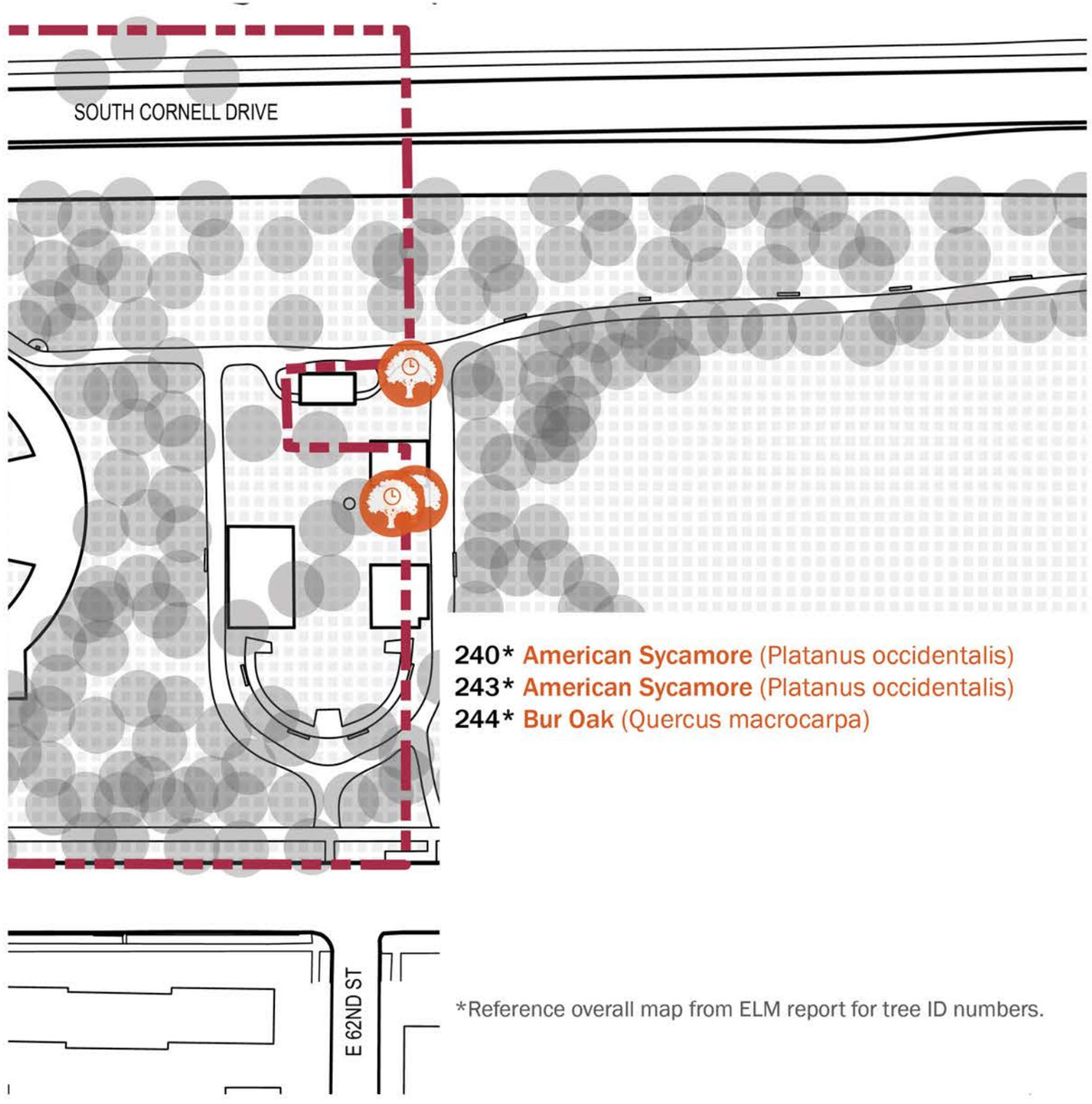
OLMSTED BROTHERS & OTHERS: 1905 Olmsted Brothers General Plan for Jackson Park Overlaid on Existing Site



N 0' 200'

LIVING HABITATS

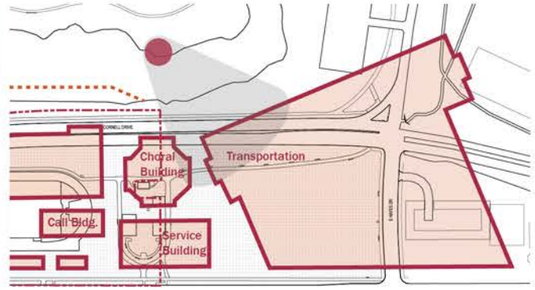
PRESERVE: One of the three existing 1st Generation Trees near the Comfort Station that will be preserved



240* **American Sycamore** (Platanus occidentalis)
243* **American Sycamore** (Platanus occidentalis)
244* **Bur Oak** (Quercus macrocarpa)

*Reference overall map from ELM report for tree ID numbers.

N 0' 100'



Transportation Building:

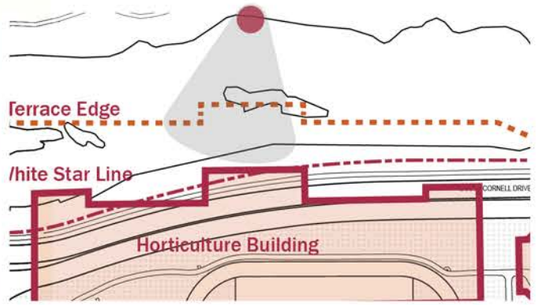
View of building entrance and terrace from Wooded Island.

Image reveals no trees and only sparse shoreline vegetation.

Image Source: Columbian Gallery. A Portfolio of Photographs of the World's Fair. The Werner Company, 1894.

COPYRIGHT, 1893, BY STONE, KASTLER & PAINTER.

HORTICULTURAL BUILDING.

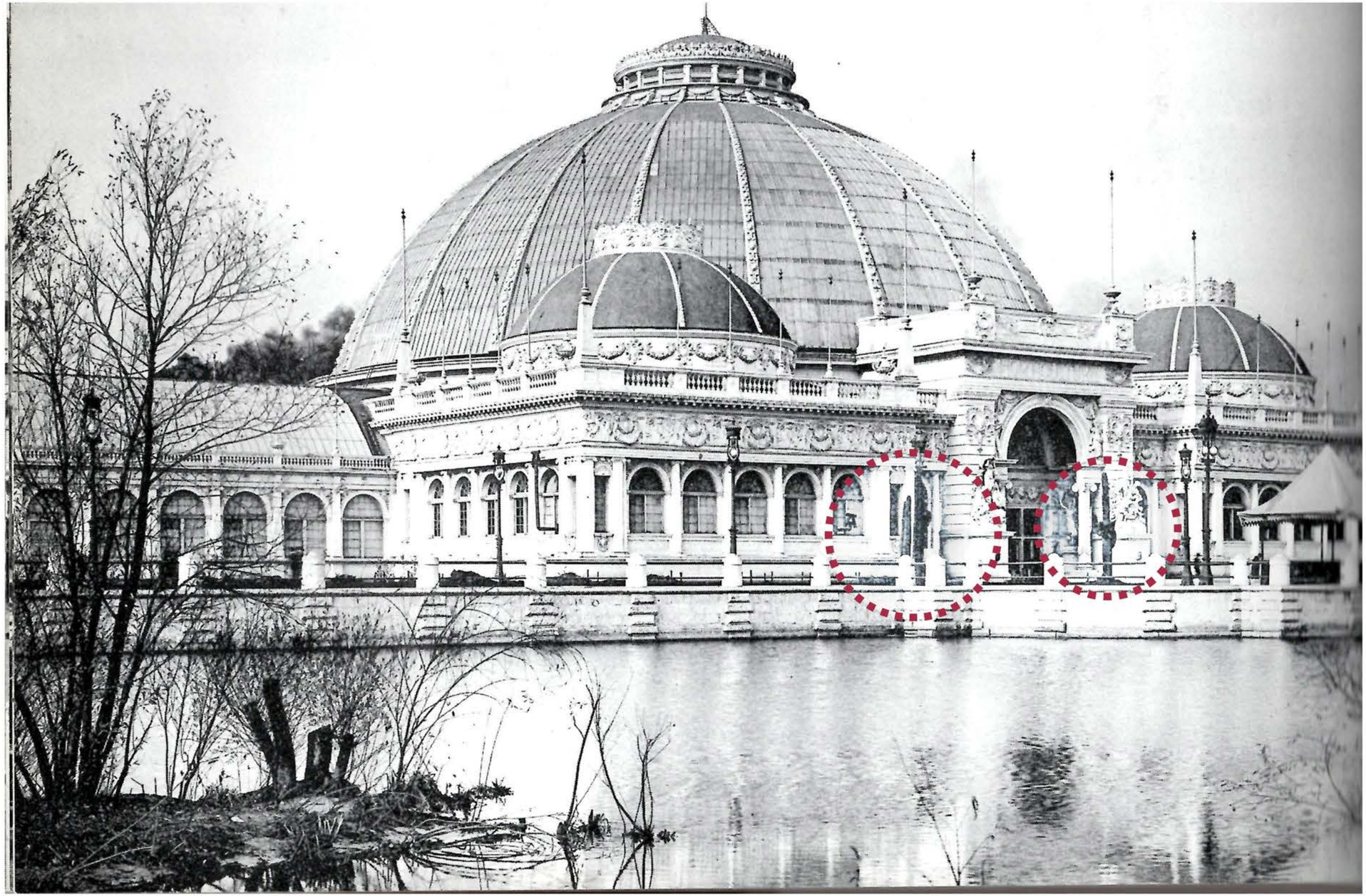


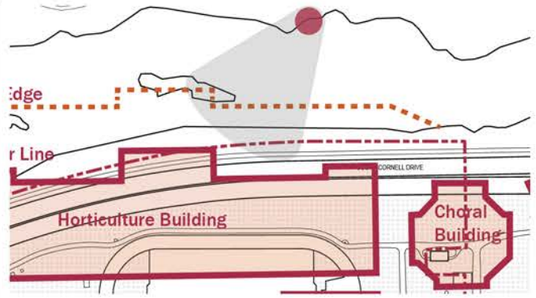
Horticulture Building:

View of building entrance and terrace from Wooded Island.

Image reveals Cacti in planters.

Image Source: Dedicatory and Opening Ceremonies of the World's Columbian Exposition. Historical and Descriptive. as authorized by Board of Control. page 87. Stone, Kastler & Painter, 1893.



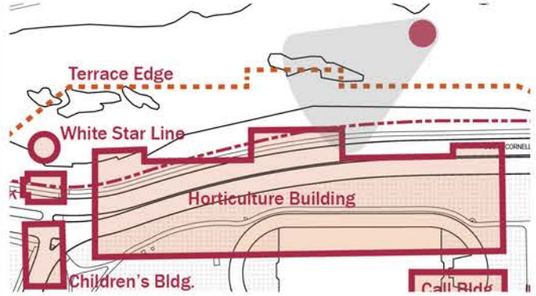


Horticulture Building:

View of building entrance and terrace from Wooded Island.

Image reveals Cacti in planters.

Image Source: The Chicago World's Fair of 1873. A Photographic Record. Photos from the Collections of the Avery Library of Columbia University and the Chicago Historical Society. Image 68. Dover Publications, 1980.



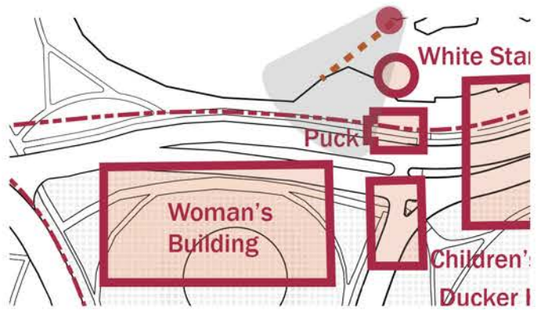
Horticulture Building:

View of building entrance and terrace from bridge connecting to Wooded Island.

Image reveals low shrubbery, grasses, and flowerbeds on the terrace that was later demolished.

Image Source: Columbian Gallery. A Portfolio of Photographs of the World's Fair. The Werner Company, 1894.

COPYRIGHT, 1893, BY STONE, KASTLER & PAINTER. WOMAN'S BUILDING.



Woman's Building[1]:

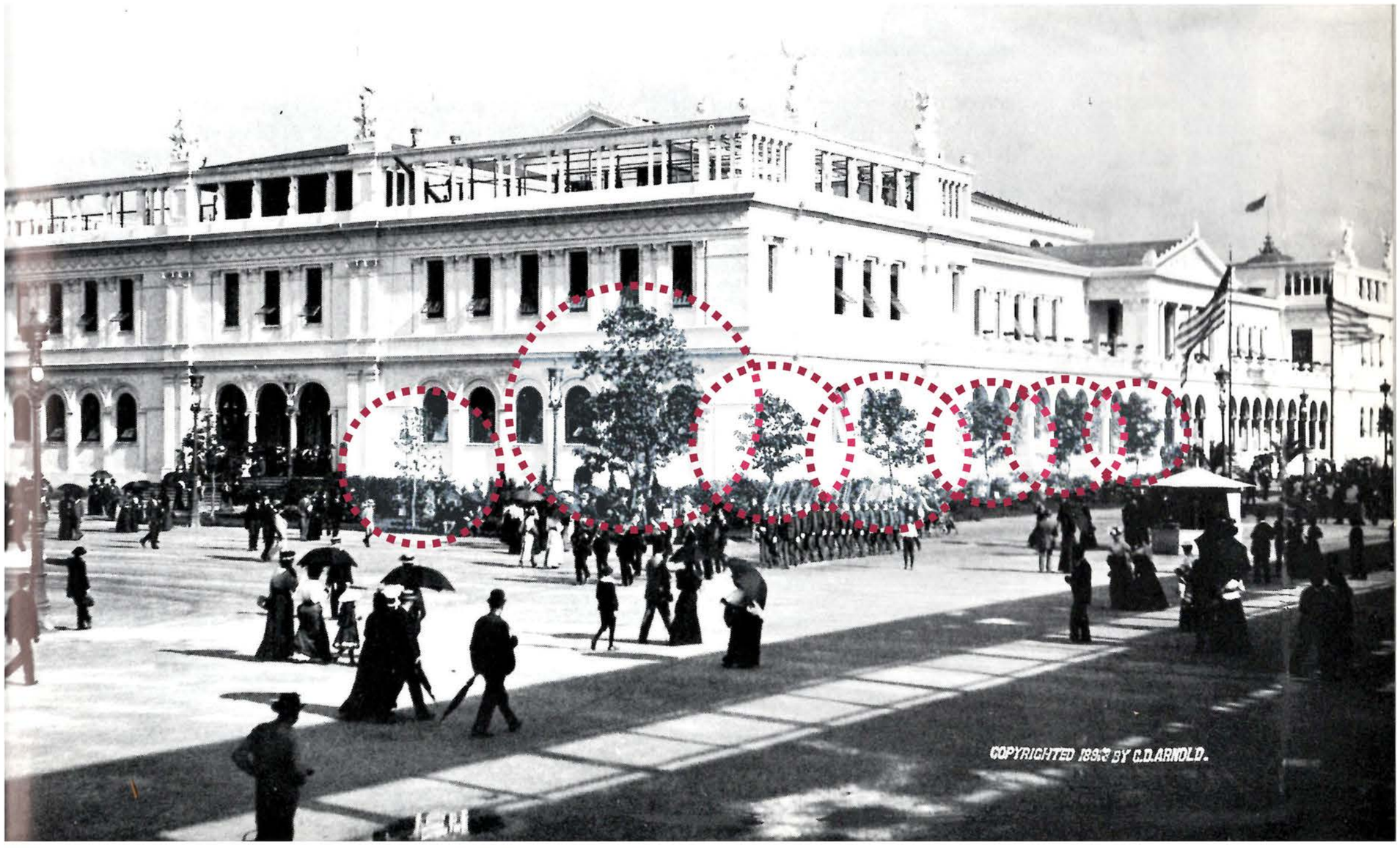
View of building entrance and terrace from Wooded Island/bridge.

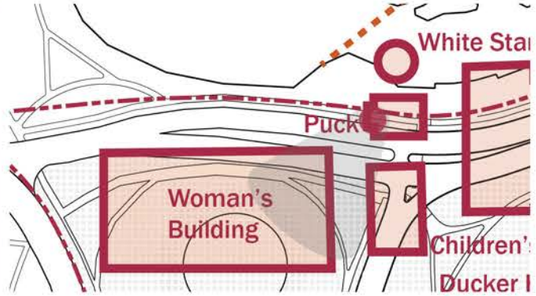
Image reveals young trees on terrace in an area that would have been demolished with the terrace.

Image Source: Dedicatory and Opening Ceremonies of the World's Columbian Exposition. Historical and Descriptive. as authorized by Board of Control. page 89. Stone, Kastler & Painter, 1893.

Image Source: Davis, George R. Picturesque World's Fair: An Elaborate Collection of Colored Views. Page 65, W.B. Conkey Company, 1894, https://worldsfairchicago1893.com/2018/09/28/picturesque-worlds-fair-entrance-to-womans-building-p-65/.

1. *"Woman's Building" and "Women's Building" is used interchangeably in various historical literature. "Woman's Building" is used in this document as it was inscribed on the building during the time of the fair (see photo).*



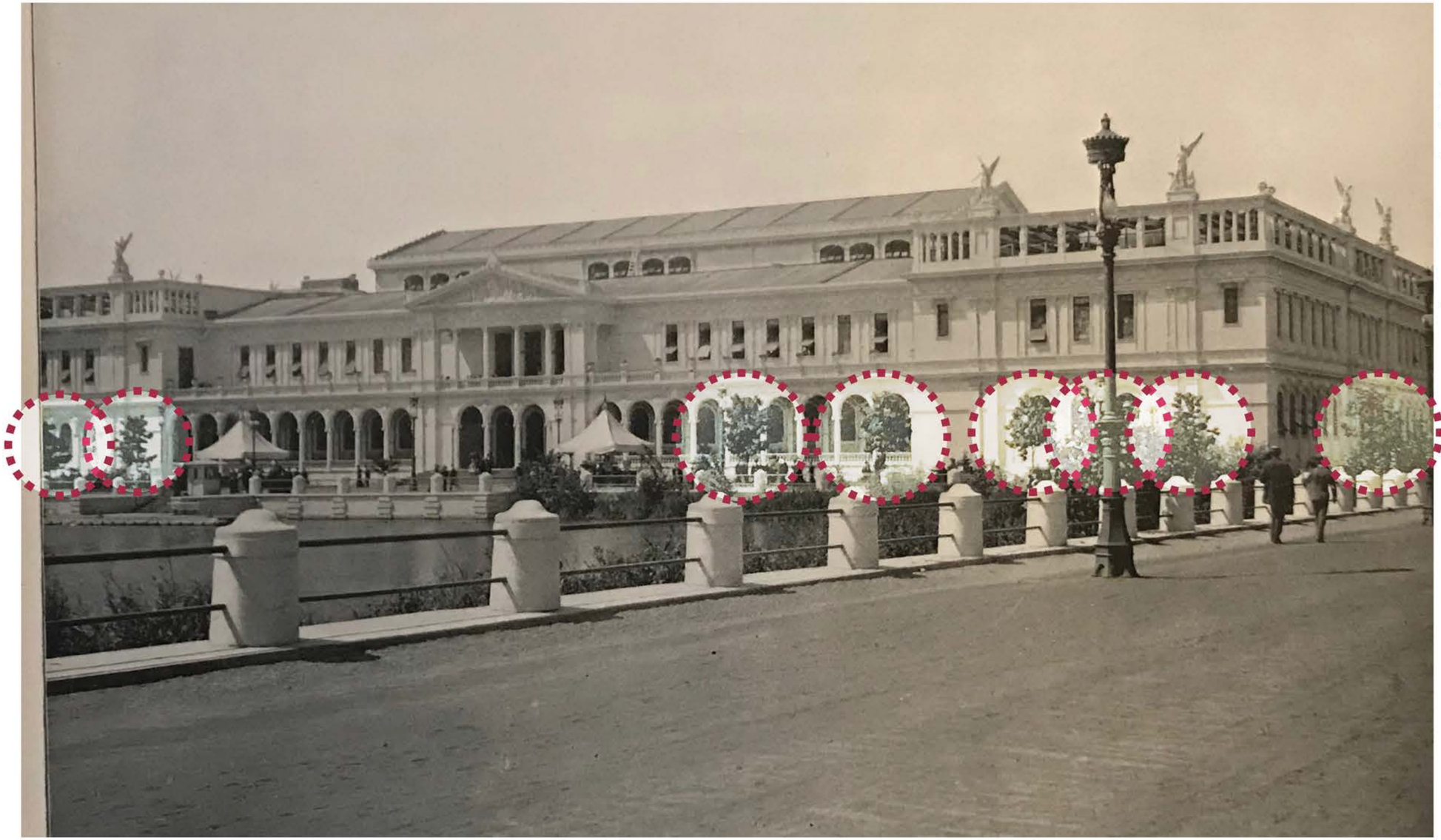


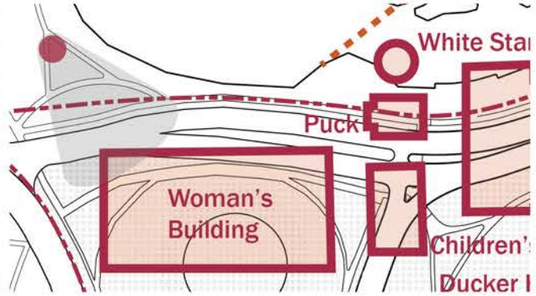
Woman's Building:

View looking to the northwest at the Woman's Building.

Image reveals row of young deciduous trees very close to building perimeter.

Image Source: The Chicago World's Fair of 1873. A Photographic Record. Photos from the Collections of the Avery Library of Columbia University and the Chicago Historical Society. Image 75. Dover Publications, 1980.



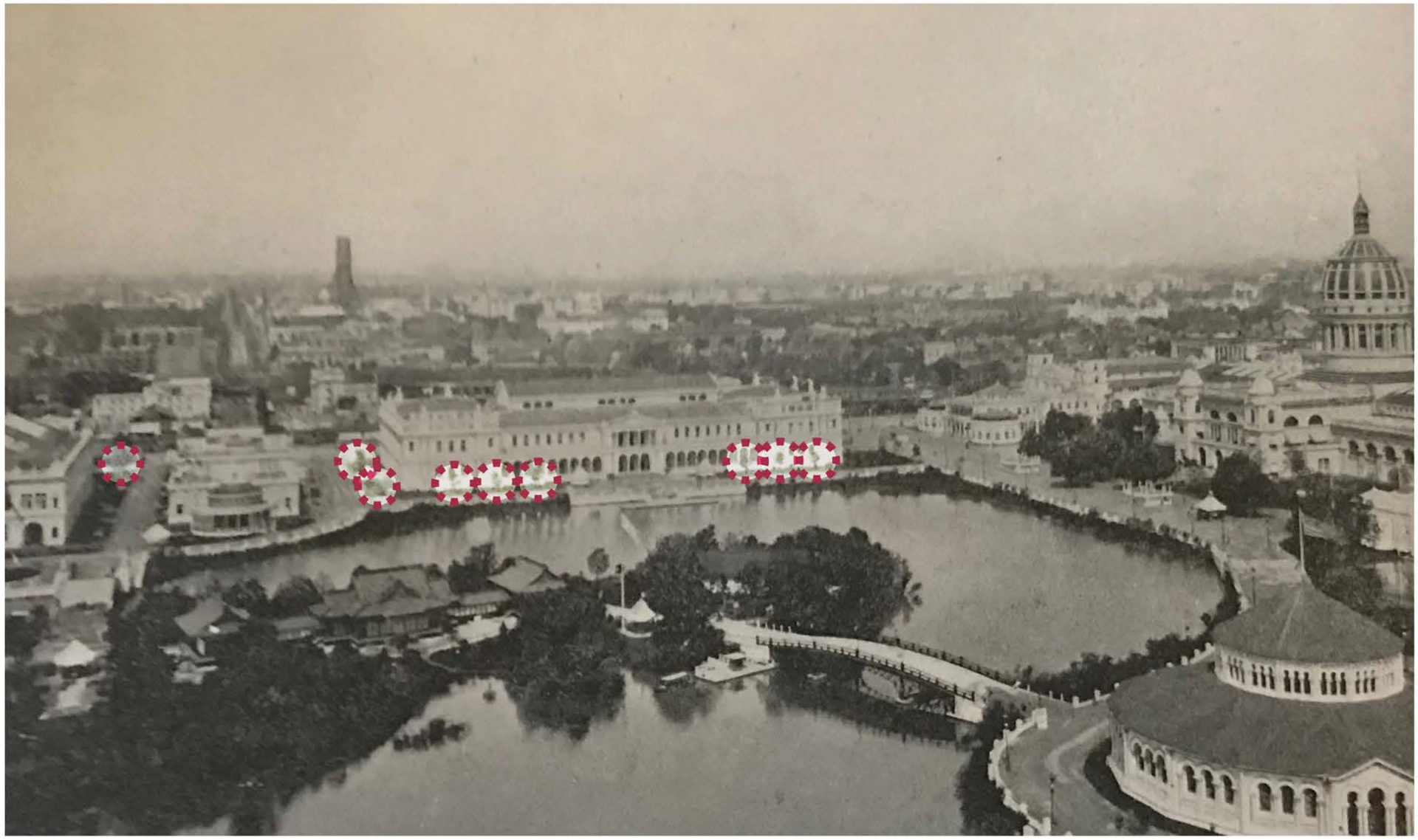


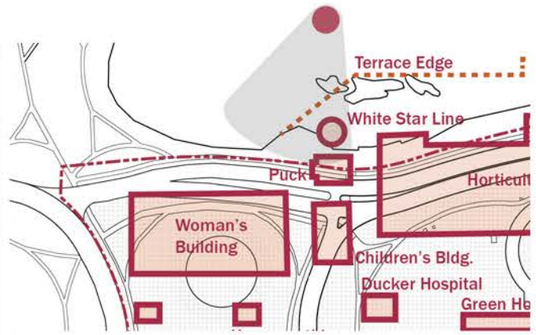
Woman's Building:

View of building entrance and terrace from north terrace.

Image reveals young deciduous trees and shoreline vegetation very close to building perimeter.

Image Source: Columbian Gallery. A Portfolio of Photographs of the World's Fair. The Werner Company, 1894.



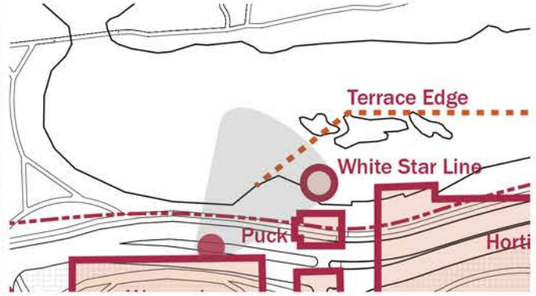


Woman's Building and Midway:

Aerial view of Woman's Building in relation to adjacent buildings and the Midway.

Image indicates more young deciduous trees along the perimeter of the building.

Image Source: Columbian Gallery. A Portfolio of Photographs of the World's Fair. The Werner Company, 1894.

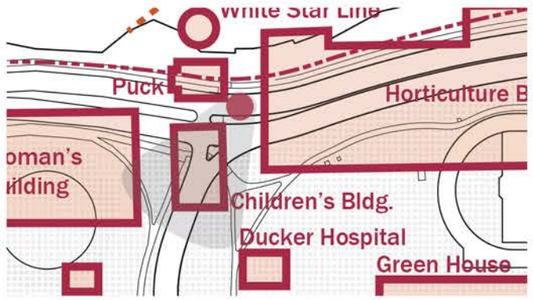


White Star Line:

View of White Star Line (right) and the Manufactures & Liberal Arts building beyond from the roof of the Woman's Building.

Image shows the contrast between the robust naturalistic planting of the Wooded Island and the architectural edge of the lagoons.

Image Source: Columbian Gallery. A Portfolio of Photographs of the World's Fair. The Werner Company, 1894.



Children's Building:

Southeast view of building revealing use of shrubs in lieu of trees at building limits.

Image Source: The Chicago World's Fair of 1873. A Photographic Record. Photos from the Collections of the Avery Library of Columbia University and the Chicago Historical Society. Image 74. Dover Publications, 1980.

SOIL ASSESSMENT

1. EXAMINE

Examine site information gathered in the fall 2017 and in the spring 2018 to identify the most highly active biological locations and potential areas for soil biology preservation. Assessment of this information provides a framework for project construction staging and logistics, and informs the strategy for re-establishing soil health post-construction.

2. IMPLEMENT

Implement strategy for temporary preservation of these biological Green Islands during construction and ensure culture and cultivation of preserved biological elements.

To aid with establishment, inoculate newly placed soils and vegetation with preserved biological elements from the existing site.

3. MONITOR

Monitor soil biology and plant health during and after construction so supplemental application can be deployed as necessary to sustain the health of the landscape.

GOAL:

Preservation of the existing soil biology in an effort to establish an ecologically healthy new landscape.

1. EXAMINE

Soil collections and root samples were taken from various locations throughout the project site to understand the existing soil biology. These locations were chosen based on species, maturity, and location.

PLANTS

Plants are an integral part of an ecosystem. Within areas of the Obama Presidential Center where vegetation is to be disturbed or removed, a more diverse plant community will be installed in its place. All portions of the site ecosystem would be considered in order to ensure success and establishment of the newly constructed plant community.

NUTRIENTS

Disruption of the soil on the site will impact the nutrient cycling capacity and disrupt the soil biology. Preserving select areas of existing soil biology for reuse will bolster establishment of the new plant community.

MICROORGANISMS

Soil consists of microbial biomass[1] and earth dwelling organisms such as earthworms, beetles and soil mites. Healthy microbes in the soil provide vegetation with available nutrients and support longer term plant health. Often, new soil brought on to a newly constructed site does not contain the beneficial soil organisms that facilitate restoration of nutrient cycling and plant establishment.

Value of Microbial Biomass within the soil:

Water Holding

Microbial biomass increases the water holding capacity of the soil.

Erosion

Microbial biomass improves soil texture and discourages erosion.

Nutrients

Microbial biomass increases the ability of soil to retain nutrients.

Stress & Disease

A healthy Microbial biomass increases the resistance of plants to stress and disease.

Carbon

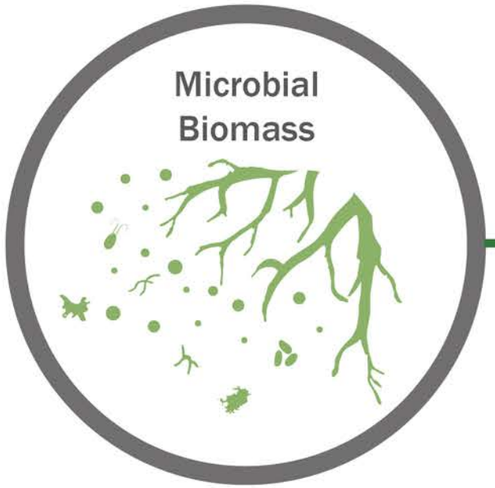
Microbial biomass sequesters carbon in the soil.

1. *Microbial biomass: measure of the mass of microorganisms, consisting of bacteria and fungi, living in soil organic matter. They assist in decomposition and providing plants with nutrients.*

1. EXAMINE: MICROBIAL BIOMASS

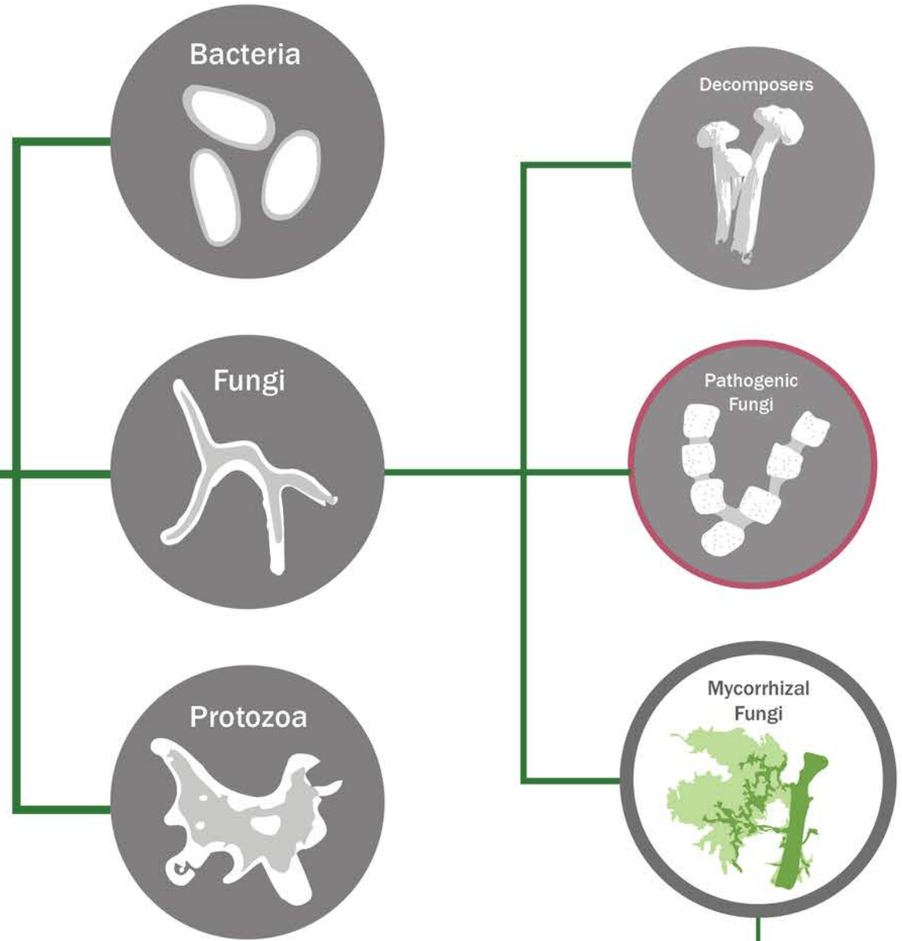
Microbial Biomass

The current microbial load is about one pound of living bacteria, fungi and protozoa to every 2000 pounds of bulk soil.



The Microbial Biomass was tested from select soil samples to determine biological function within the existing site.
Mycorrhizal Fungi, a subset of microbial biomass, was tested separately from root samples to understand fungi communities and colonization health.

High levels of microbial biomass indicate high soil fertility and quality.

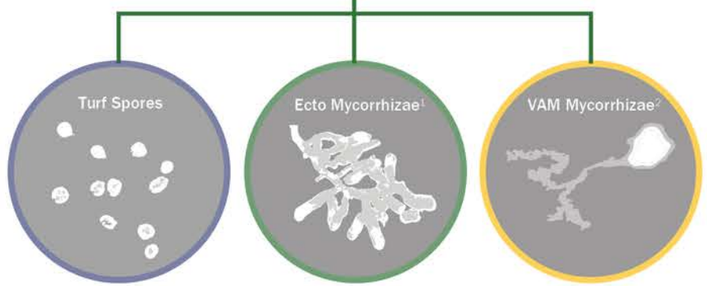


Decomposers are crucial in the formation of soil organic matter necessary for many chemical, physical and biological properties of the soil.

Pathogenic Fungi, while naturally occurring, are not wanted on the new landscape site.

Mycorrhizal Fungi form beneficial associations with most land plant roots and are extremely important for improved growth and survival of plant hosts. About 95% of vascular plant species in the world belong to families that are typically mycorrhizal.

Carbon compounds produced by the plant host are transferred to the mycorrhizal fungi in exchange for soil minerals. This symbiosis also serves to increase water uptake and helps in the protection against root pathogens.



High colonization of these fungi indicate excellent soil quality.

1. *Ecto Mycorrhizae: Type of symbiotic relationship between fungal symbiont or mycobiont and the roots of specific plan species as a means of nutrient exchange (Oaks in the case of OPC).*
2. *VAM Mycorrhizae: Vesicular-Arbuscular Mycorrhiza, type of symbiotic relationship between fungal symbiont or mycobiont, which penetrates plant cells as a means of nutrient exchange.*

MICROBIAL BIOMASS
Soil & Root Samples at Select Trees and Turf Areas

Microbial Biomass Quality
- Excellent
- Good
- Low

*Reference tree ID numbers from 2018 ELM report.

Value:
82% of samples have "in range" or "productive" microbial biomass. Many of which were sampled from 1st generation trees and/or have been designated as nurse log trees.

0-200 ug/g = Very Low
201-300 ug/g = Low
301-400 ug/g = Good
401 ug/g + = Excellent

MYCORRHIZAL FUNGI:

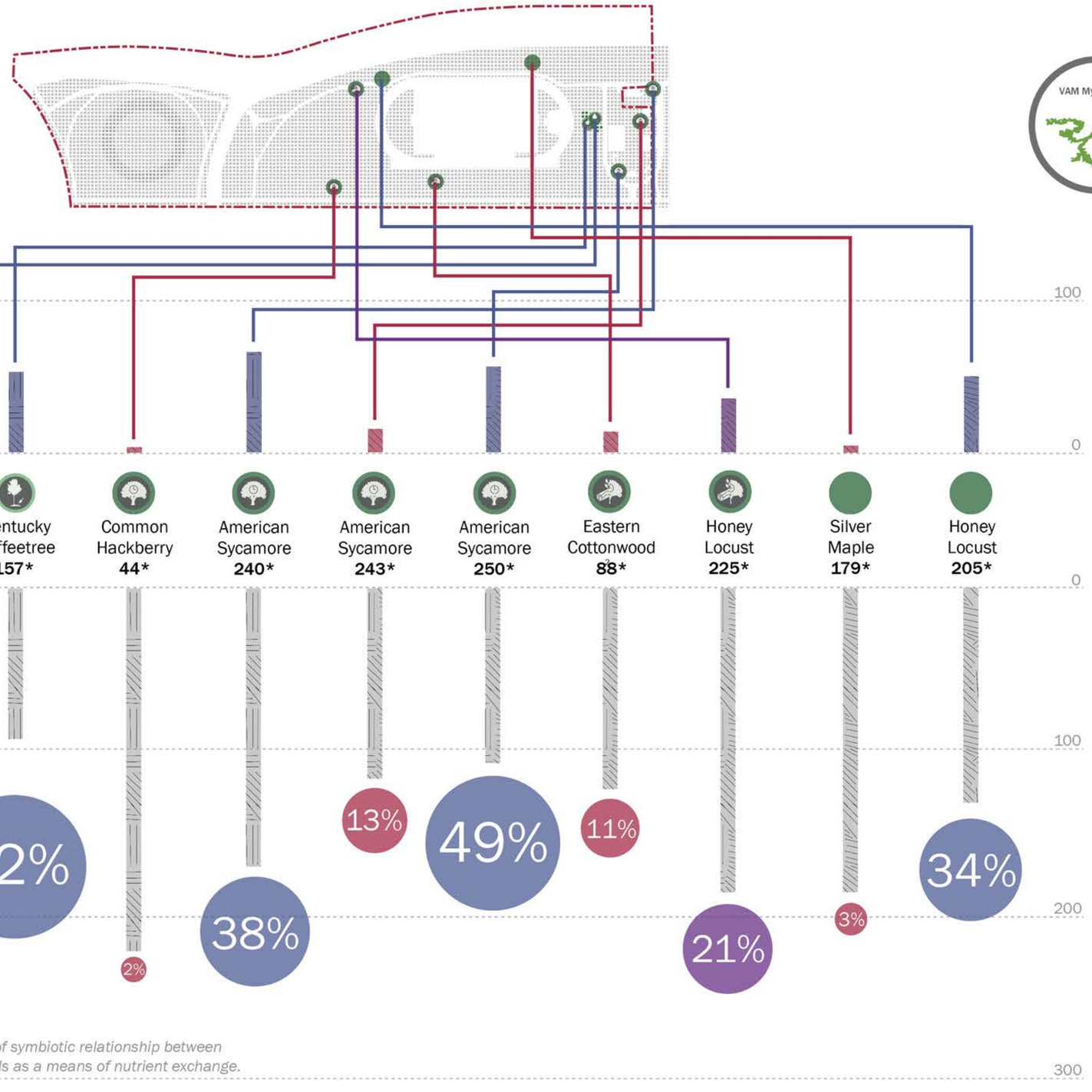
VAM MYCORRHIZAL[1] COLONIZATION

Soil & Root Samples at Select Trees and Turf Areas

Microbial Biomass Quality

- Excellent
- Good
- Low

*Reference tree ID numbers from 2018 ELM report.



Value:
Percentage of Mycorrhiza Colonization in the roots reveal the health of the sample tree and turf soil.

1% - 15% = Low
12% - 30% = Good
30% + = Excellent

1. *VAM Mycorrhizae: Vesicular-Arbuscular Mycorrhiza, type of symbiotic relationship between fungal symbiont or mycobiont, which penetrates plant cells as a means of nutrient exchange.*
2. *Turf sample data modified for clarity.*

MYCORRHIZAL FUNGI:
ECTO MYCORRHIZAL[1] COLONIZATION

Root Samples at Select Trees and Turf Areas

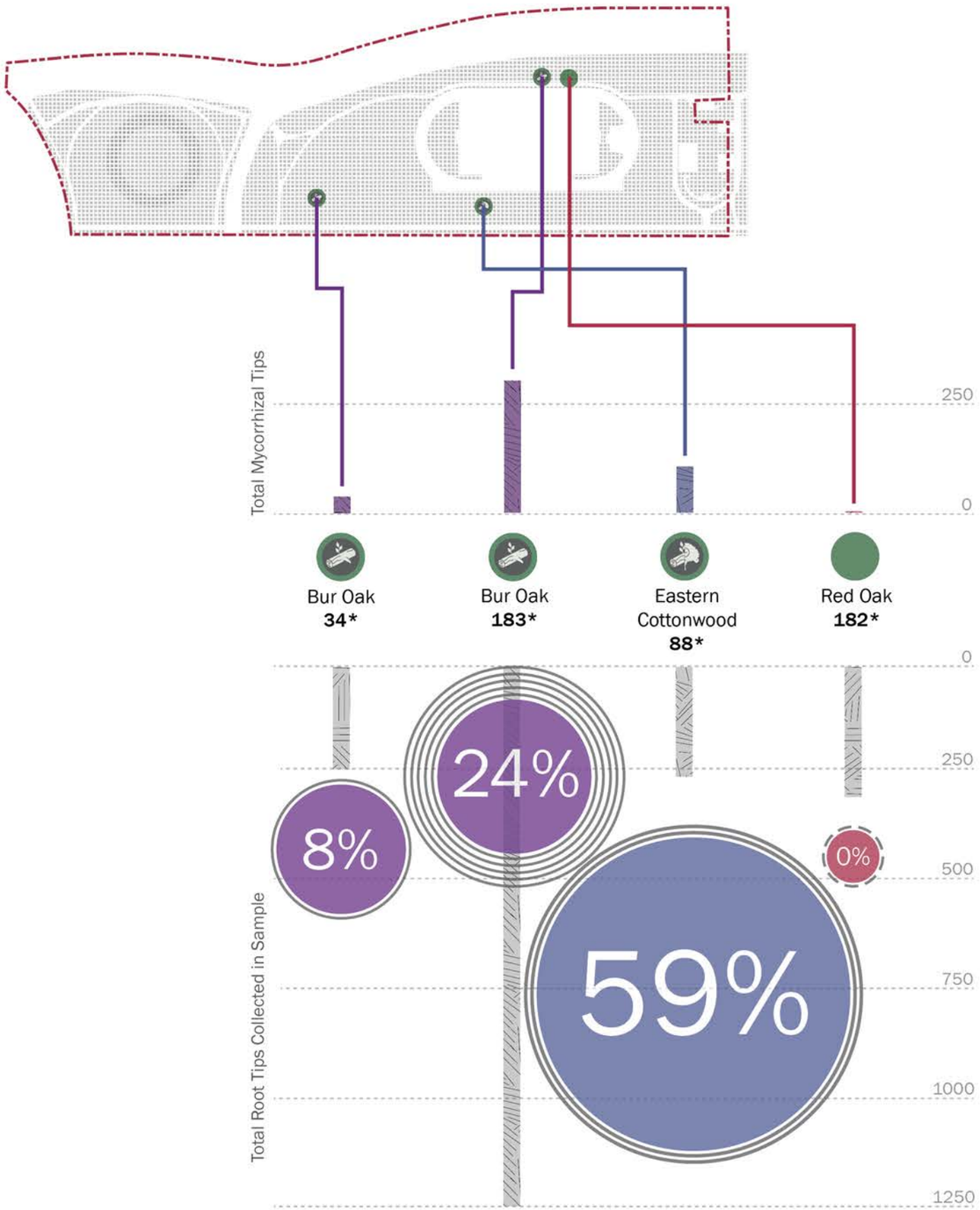
Microbial Biomass Quality

- Excellent
- Good
- Low

Mycorrhiza Types

- 0
- 1
- 2
- 3
- 4
- 5

*Reference tree ID numbers from 2018 ELM report.



Value:
Percentage of total Mycorrhiza root tips reveal the health of the sample tree.

1% - 15% = Low
12% - 30% = Good
30% + = Excellent

1. *Ecto Mycorrhizae: Type of symbiotic relationship between fungal symbiont or mycobiont and the roots of specific plan species as a means of nutrient exchange (Oaks in the case of OPC).*

2. IMPLEMENT

Imported compost is often comprised of organisms that are not indigenous to a given site. Research indicates that close to 70% of microbial biomass dies off within 24 hours in the application of traditional compost. This results in a release of carbon dioxide into the atmosphere. By examining the existing site soils and trees, steps can be taken to encourage the retention of microbial processes during and after construction.

PRESERVE (1ST GENERATION TREES & SOILS)

Trees determined to be over 100 years old and established during periods of significance for Jackson Park. The relationship of the soil biology of these trees can be defined as “heritage soil.”

REPURPOSE

Harvest healthy select soil profiles that will be stored and recycled back into new project soil blends.

In addition to soil reuse, mature nurse logs, created by repurposing 1st generation trees that must be removed, can aid regenerative microbe behavior in the new environment. Placement of these sections of tree trunk will be coordinated with the landscape design.

Green Islands[1]

Moderately-sized soil/compost mounds created using heritage soil and microbial communities combined with designed plant communities to support microbial inoculum[2] production for use in the final landscape design.

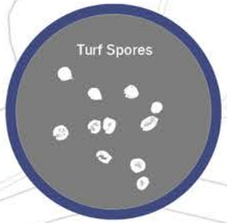
Nurse Logs

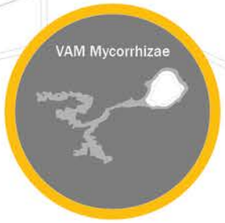
Repurpose and locate a series of nurse logs (select trees are identified in the tree assessment) in strategic locations throughout the site.

1. *Green Islands: Contained batch of soil and vegetation to promote a concentrated solution of biological and ecological functions. The Green Island’s benefits can then be applied at a wider scale through an inoculum.*
2. *Microbial inoculum: A small amount of substance containing bacteria, fungi, protozoa, and other microorganisms that is used to produce a culture.*

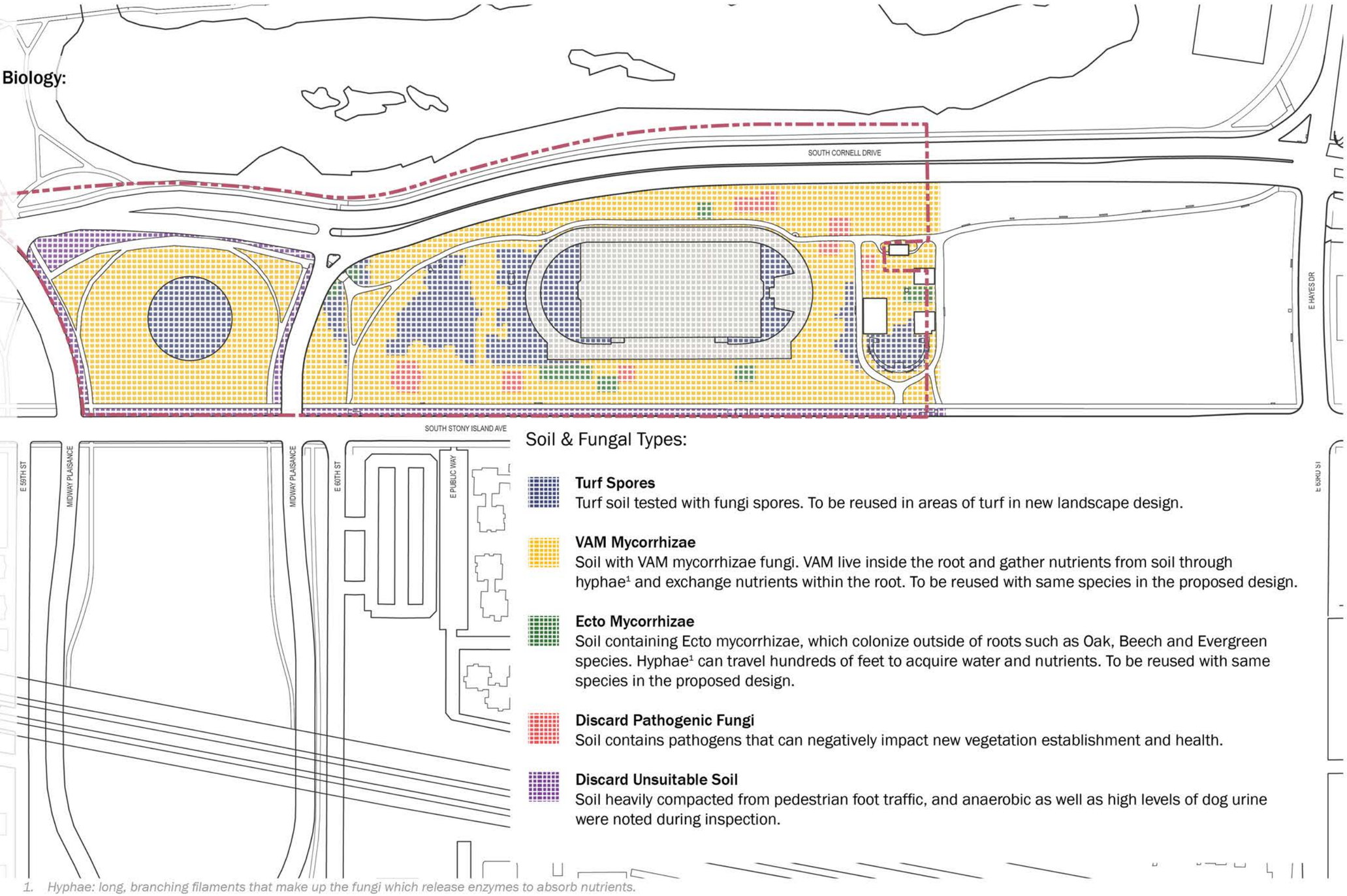
2. IMPLEMENT

Preserve and Reuse Soil Biology:





Discard Soils:



Soil & Fungal Types:

Turf Spores
Turf soil tested with fungi spores. To be reused in areas of turf in new landscape design.

VAM Mycorrhizae
Soil with VAM mycorrhizae fungi. VAM live inside the root and gather nutrients from soil through hyphae[1] and exchange nutrients within the root. To be reused with same species in the proposed design.

Ecto Mycorrhizae
Soil containing Ecto mycorrhizae, which colonize outside of roots such as Oak, Beech and Evergreen species. Hyphae[1] can travel hundreds of feet to acquire water and nutrients. To be reused with same species in the proposed design.

Discard Pathogenic Fungi
Soil contains pathogens that can negatively impact new vegetation establishment and health.

Discard Unsuitable Soil
Soil heavily compacted from pedestrian foot traffic, and anaerobic as well as high levels of dog urine were noted during inspection.

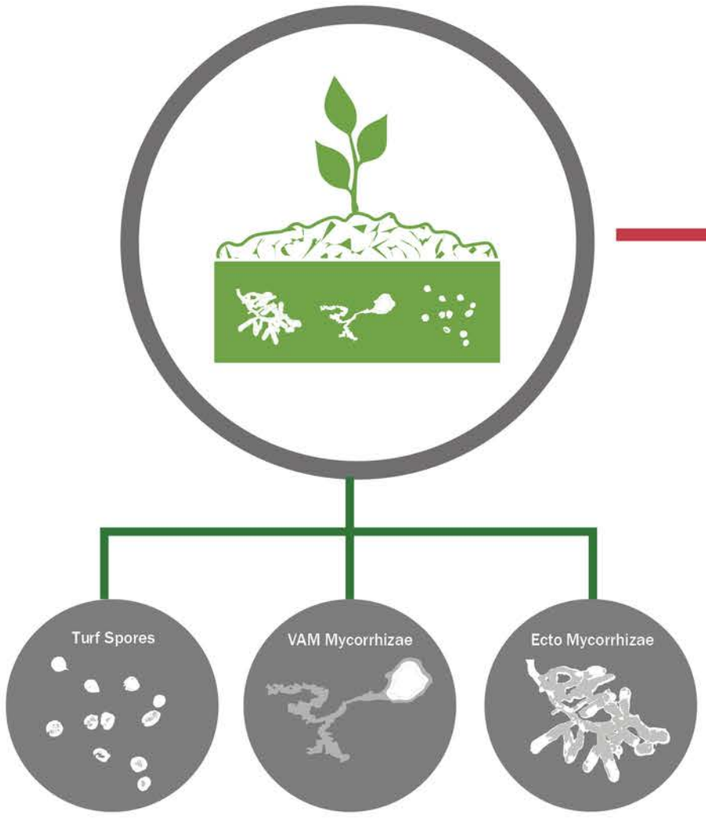
1. *Hyphae: long, branching filaments that make up the fungi which release enzymes to absorb nutrients.*

N 0’ 200’

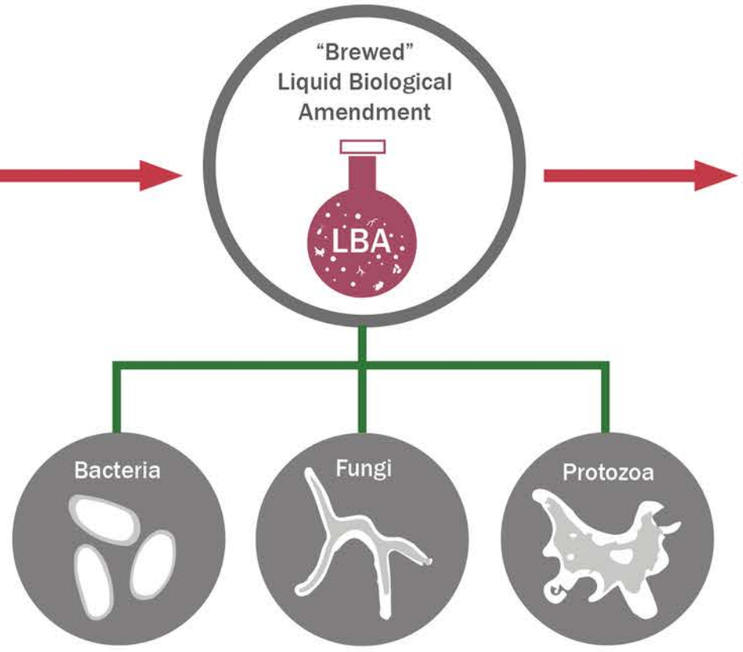
2. IMPLEMENT

Green Islands will be created by combining heritage soil and microbial communities with a collection of innoculant-supporting plants. These will aid in preserving and reproducing critical mycorrhizal spores and plant promoting microbes that are indigenous to the site.

The temporary plant palette applied to each “island” will consist of endemic flowering plants to attract local pollinators and beneficial insects, project anticipated and/or native grasses, and saplings of VAM trees. Some specific grasses and plants that are used in commercial production of mycorrhizal spores will be seeded as well.

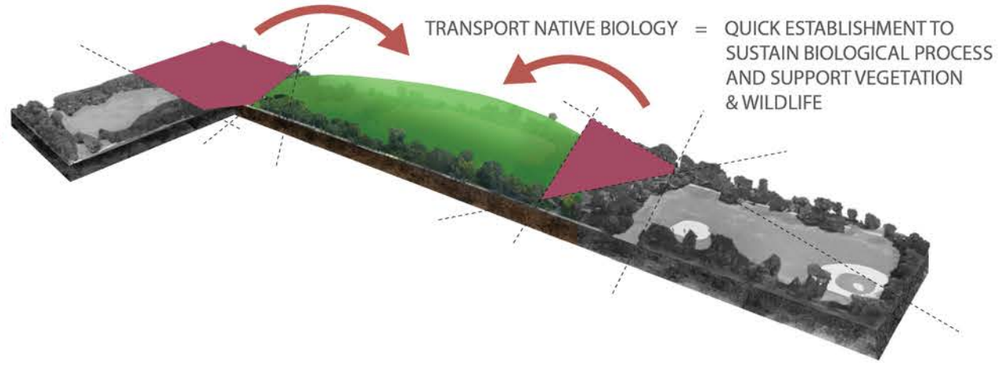


Once the Green Islands are established, the profile in which the chosen seedlings are germinating will serve as the source of microbial inoculum.



Fifty pounds of microbial inoculum[1] will be placed into the extraction system at one time; indigenous microbes will then be extracted from the growing medium into an aqueous solution.

This Liquid Biological Amendment (LBA) will be “brewed” in secure containers for 20-48 hours.



LBA will be applied to the landscape at various rates via low pressure hoses.

Solution will be tested using the Microbiometer™ to manage microbial density as well as through light microscopes and recorded to make sure solution contains bacteria, fungi and protozoa.

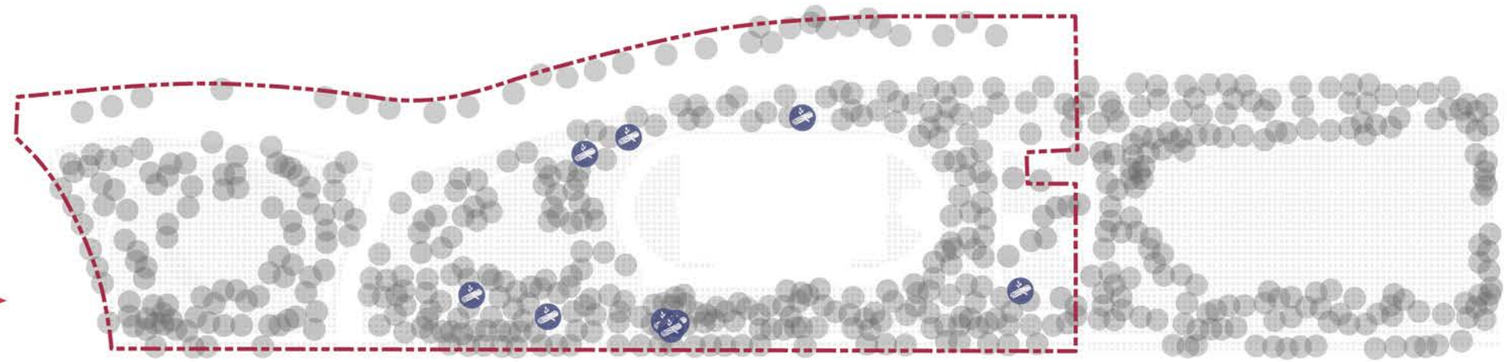
1. *Microbial inoculum: A small amount of substance containing bacteria, fungi, protozoa, and other microorganisms that is used to produce a culture.*

2. IMPLEMENT

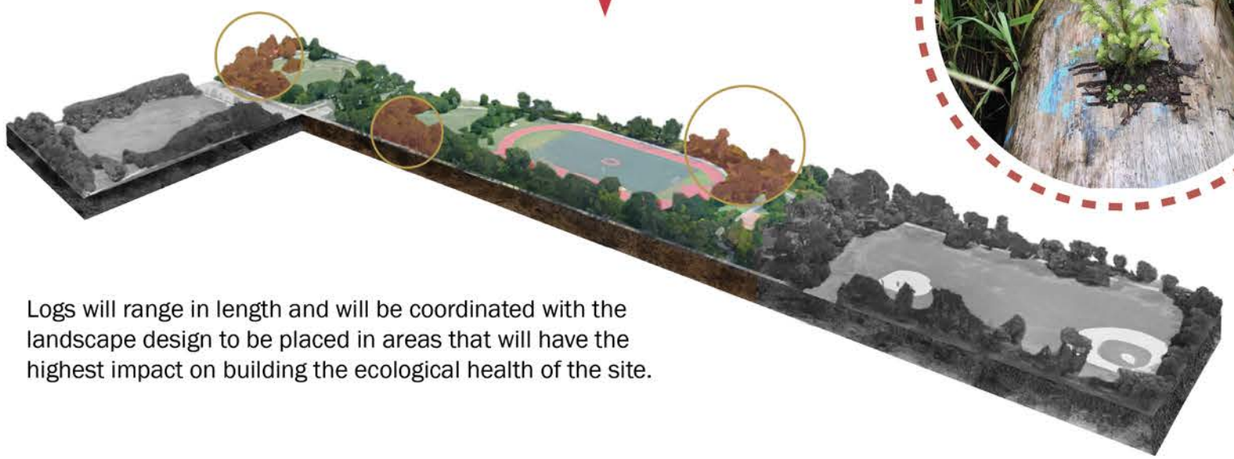
Nurse Logs will provide a food source for decaying fungi allowing them to grow and fruit. These fungi not only provide a spore source, but are also food for smaller animals to support the larger above ground food web.

EXAMINE

The arborist identified prospective mature 1st generation trees for use as nurse logs during the tree assessment.



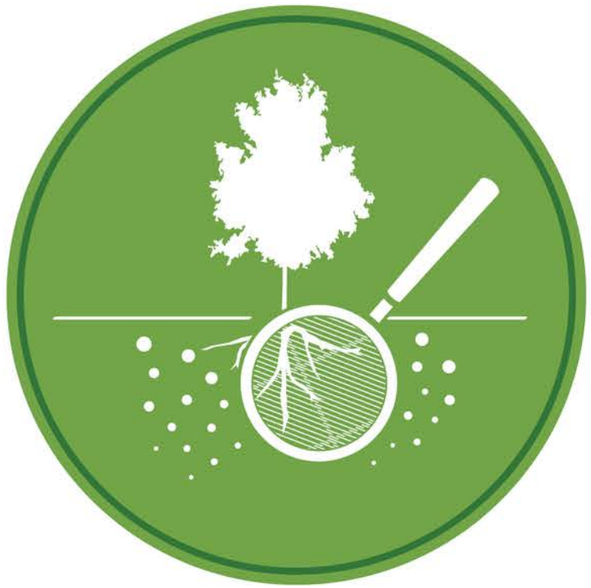
IMPLEMENT



Logs will range in length and will be coordinated with the landscape design to be placed in areas that will have the highest impact on building the ecological health of the site.

3. MONITOR

Following the inoculation of the site with preserved biological elements, the soil and plant health is to be monitored during and after construction. Supplemental applications can be deployed as necessary to sustain the health of the landscape.



MEASURE

By preserving and restoring the soil biology, we have the potential to track this living system across the duration of the project and see the impacts pre-construction, during construction, and post-construction

MAINTAIN

Develop and deploy a stewardship strategy for the site that incorporates the needs of the soil biology. This critical understanding of ecosystem function incorporates living soil into site evaluation, vegetation establishment and long-term sustainable strategies for landscape performance.

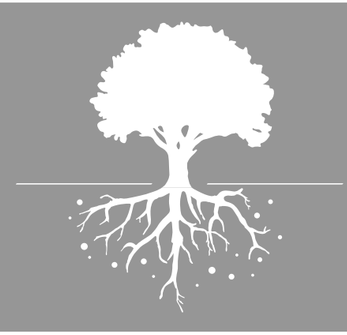
OBAMA PRESIDENTIAL CENTER

Reinforcing Landscape Ecology

DESIGN DEVELOPMENT

STORMWATER

TREE + SOIL BIOLOGY



BIODIVERSITY

BIRD HABITAT

POLLINATORS

BIODIVERSITY

Biodiversity is the foundation of all healthy ecosystems and as such is intimately connected to human well-being. By evaluating the degree of biodiversity on the OPC site, the potential benefits of reintroducing critical species within the designed landscape can be evaluated.

TAXONOMIC SCHEME: Sum or abundance of species within the site.

FUNCTIONAL TRAITS: Stratification of ecological type and function within the ecosystem.

COMMUNITY VALUE: Distribution and interaction among species and the habitat they provide.

GENE SEQUENCES: Diversity in native genotypes for culture, typical mortality (typmort), and hardiness as climate continues to shift.

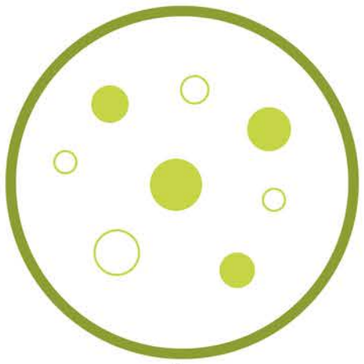
EVOLVING CHARACTERISTICS: Identified generations and their contribution to the site's native ecology.

LONG-TERM FUNCTION: Particular ecosystem benefits over an extended time period.

Existing site features and elements with high ecological value.

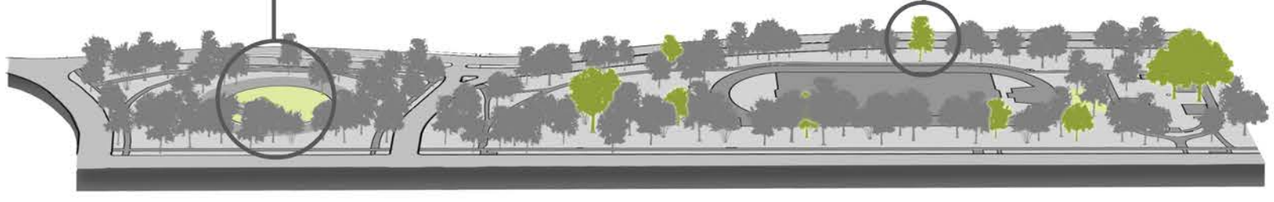
TREES WITH HIGH ECOLOGICAL VALUE

Mature trees identified with high microbial biomass and mycorrhizal fungi colonization, have been selected for reuse as nurse logs and source of native soil biology. These trees are also valuable native species within the region.



MICROORGANISMS

High levels of microbial biomass indicate high soil fertility and quality. Various areas in the site have been tested to confirm where healthy soil biology exists that can be retained for reuse in the new landscape.



EXISTING

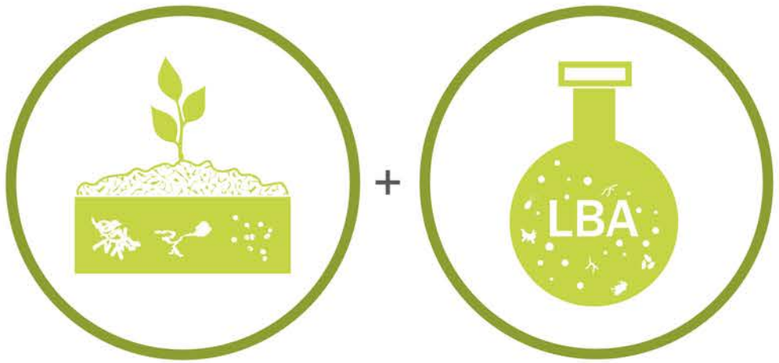
This proposed design utilizes existing biology while introducing new systems.

ECOLOGICAL TREES TO NURSE LOGS

Nurse Logs act as a food source for decaying fungi allowing them to grow and fruit. These fungi not only provide a spore source but are also food for smaller animals to support the larger above ground food web.

PLANT COMMUNITIES

The design team will strategically develop a plant palette that responds to local heritage and celebrates the design objectives of the OPC. Additionally, the OPC has made a **minimum 1:1 replacement commitment**, where the amount of new trees will be at least as much as the number of trees being removed. The development of each plant community is influenced by soil type, topography, climate, and historical characteristics.



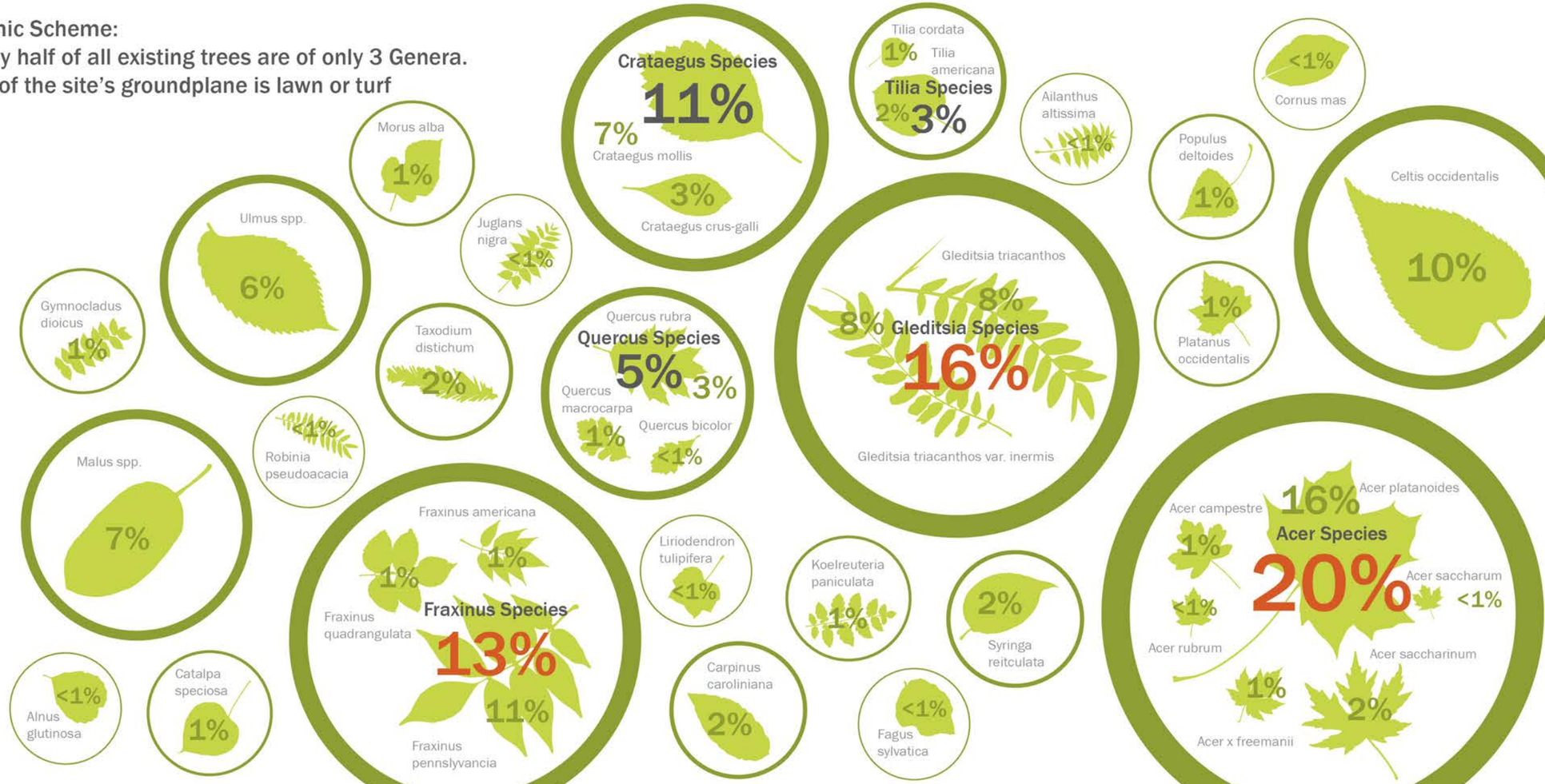
GREEN ISLANDS + LIQUID BIOLOGICAL AMENDMENT

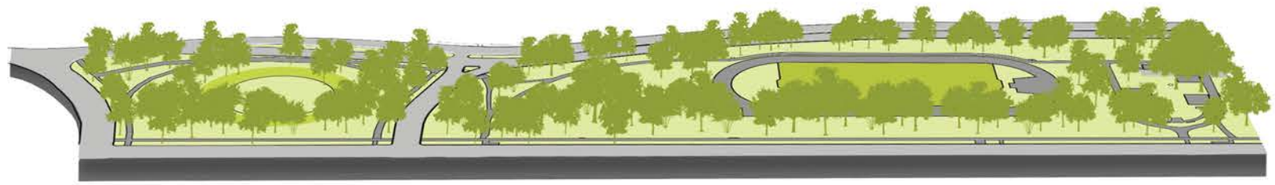
Green Islands, using legacy soil & microbial communities combined with a collection of pollinator-favored plants, will aid in reproducing critical mycorrhizal spores and plant promoting microbes that are indigenous to the site. Indigenous microbes will then be extracted from the growing medium into an aqueous solution that can be applied to areas disturbed by construction, thus catalyzing the establishment of new vegetation & microbial communities.

PROPOSED

Taxonomic Scheme:

- Nearly half of all existing trees are of only 3 Genera.
- 58% of the site's groundplane is lawn or turf





Design target: Diversify plant selection so that final design includes no more than 10% of any selected genus and total number of trees is equal or greater than the quantity removed.

Zelkova serrata 'Village Green'
Prunus virginiana
Prunus virginiana 'Canada Red'
Alnus hirsuta 'Harbin'
Alnus glutinosa
Alnus incana
Acer griseum
Acer saccharinum
Liriodendron tulipifera
Gymnocladus dioicus
Gleditsia triacanthos var. inermis 'Draves'
Syringa reitculata
Ostrya virginiana
Pinus koraiensis
Pinus mugo
Pinus strobus
Pinus strobus 'Fastigiata'
Aesculus octandra
Celtis occidentalis
Catalpa speciosa
Robinia pseudoacacia 'Chicago Blues'
Cercidiphyllum japonicum
Corylus colurna
Cladrastis lutea
Betula nigra
Taxodium distichum
Carpinus caroliniana
Carpinus betulus 'Fastigiata'
Betula populifolia 'Whitespire'
Betula nigra 'Fox Valley'
Ginkgo biloba
Sassafras albidum
Quercus rubra
Quercus muehlenbergii
Quercus macrocarpa
Quercus palustris
Quercus bicolor
Quercus imbricaria
Carya cordiformis
Carya ovata
Picea glauca 'Densata'
Picea pungens
Cercis canadensis
Populus tremuloides
Liquidambar styraciflua
Nyssa sylvatica
Chionanthus virginicus
Abies concolor
Styphnolobium japonicum
Metasequoia gylptostroboides
Thuja occidentalis 'Smaragd'
Platanus x acerifolia 'Exclamation'
Juniperus chinensis 'Mountbatten'
Juniperus scopulorum 'skyrocket'
Juniperus chinensis 'Hetzii Columnaris'
Magnolia lililflora 'Reflorescens' x 'Waterlily'
Magnolia stellata
Ulmus 'New Horizon'
Ulmus 'Morton Glossy'
Ulmus 'Patriot'
Asimina triloba
Tilia americana 'Redmond'
Amelanchier laevis
Amelanchier x grandiflora 'Autumn Brillance'
Cotinus coggygria
Cornus alternifolia
Cornus florida 'Cherokee Chief'
Cornus mas 'Golden Glory'
Malus 'Prairefire'
Malus x Red Jewel
Malus x zumi
Crataegus crus-galli var. inermis

35% Hardscape | 43% Perennials, Ornamentals, & Groundcover | 22% Lawn

PROPOSED

Layered: A healthy landscape is comprised of layers of vegetation and plant communities. Important middle layers are lacking on the existing site and reflect a lower functioning ecosystem.

FUNCTIONS OF A LAYERED LANDSCAPE

- Reduce Stormwater Impacts
- Cycling Nutrients
- Provide Habitat for Animals
- Provide Food for Animals
- Improve Air & Water Quality
- Store & Sequester Carbon
- Support & Preserve Soil Health
- Energy conservation due to direct shading

CANOPY + UNDERSTORY

Tree cover is important in the environment. Trees bring longevity to the site and play a significant role in moderating local micro-climate.

SHRUBS

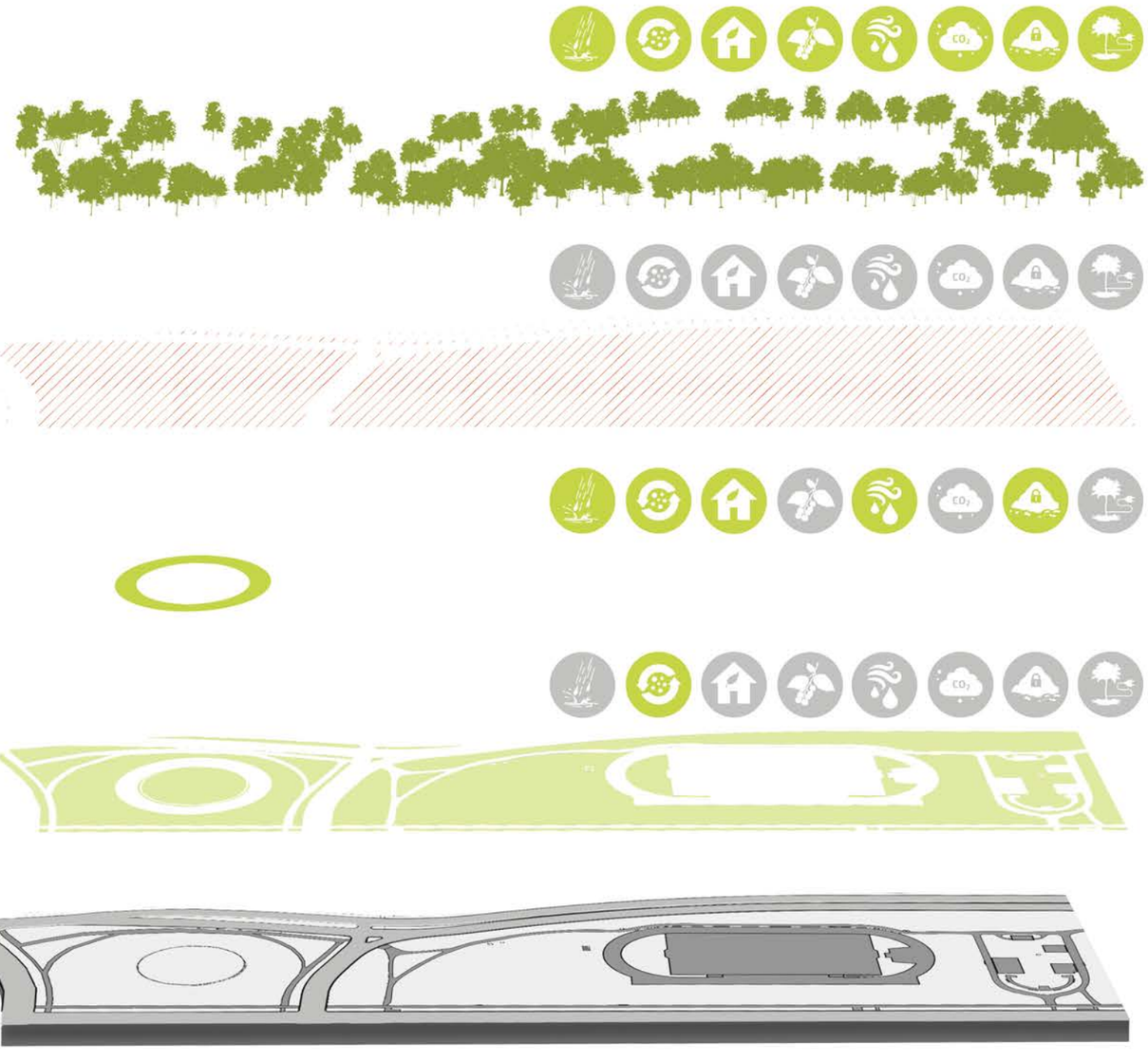
There are few shrub scaled plants on the site, which means that the site is currently missing a critical layer in the ecosystem. This planting layer typically provides cover, screening, and shelter from weather.

HERBACEOUS

Perennials are limited to the Women's Garden. Even as non-native and ornamental selections, they contribute to the ecological health of the site.

TURF

If managed properly, turf can carry microscopic spores that support nutrient cycling. However, most turf is typically maintained to perform as a recreational amenity for human use.



EXISTING

The proposed design looks to reinstate and enhance the middle layers in an effort to provide a healthy and vibrant ecosystem.

FUNCTIONS OF A LAYERED LANDSCAPE

- Reduce Stormwater Impacts
- Cycling Nutrients
- Provide Habitat for Animals
- Provide Food for Animals
- Improve Air & Water Quality
- Store & Sequester Carbon
- Support & Preserve Soil Health
- Energy conservation due to direct shading

CANOPY + UNDERSTORY

The proposed tree cover is more diverse and advances efforts to provide varied habitat for vital ecosystem function.

SHRUBS

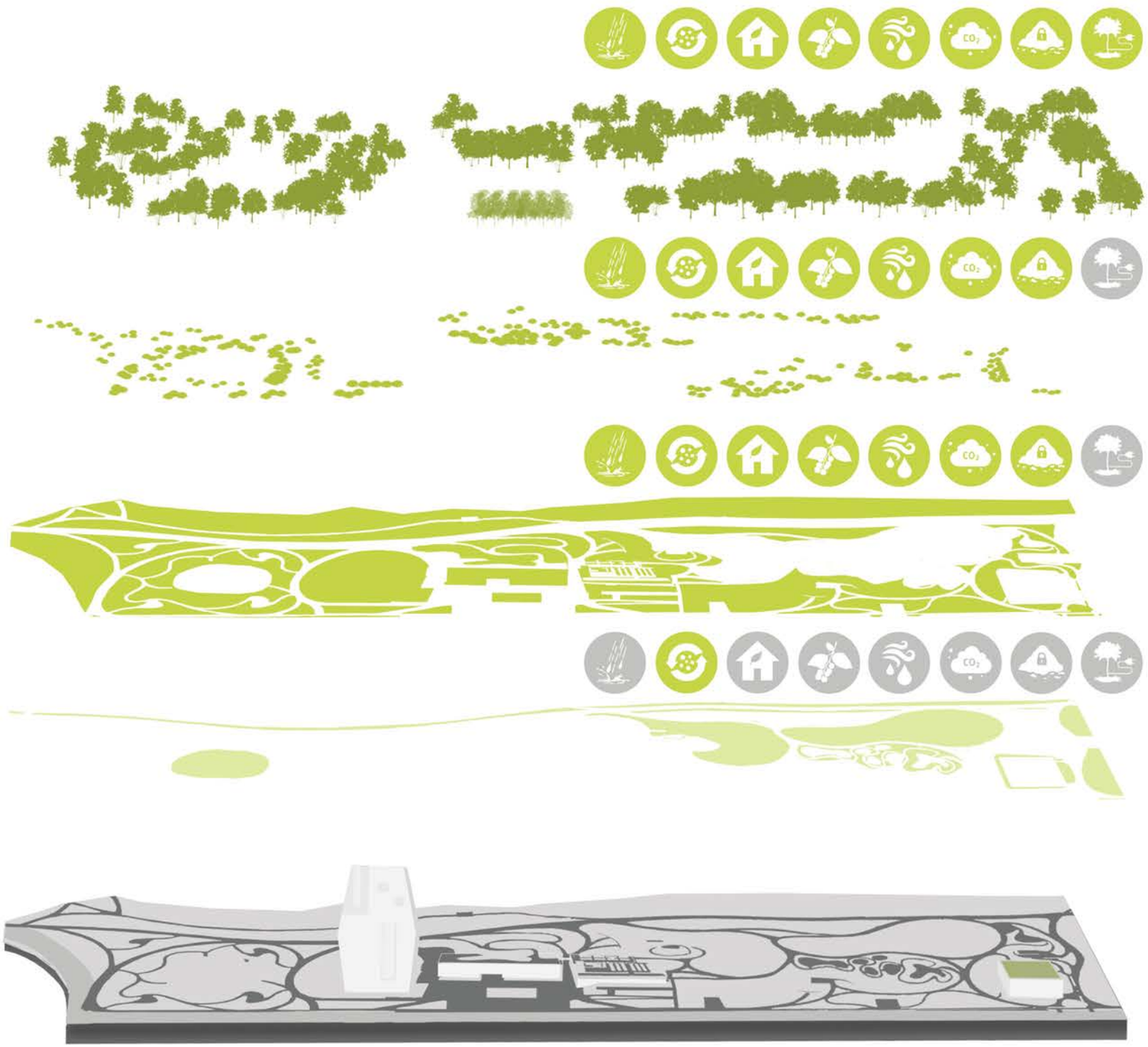
Shrubs are used strategically on the site to help develop soil structure, provide habitat, and serve as a source of food for wildlife.

HERBACEOUS

The herbaceous layer is enriched with a variety of native species that help support pollination & promote stormwater infiltration.

TURF

Turf is used selectively in areas of regular human use and is paired with an organic maintenance practice to support healthy nutrient cycling.



PROPOSED

Community Value: The proposed design provides habitat for local animal species through diverse vegetation and design considerations for birds, pollinators, and microorganisms.

HUMANS

Human interaction with site habitat is both ecological and cultural. With respect to ecology, human use needs to be managed so that it does not adversely affect landscape health and longevity. With respect to culture, humans benefit from both the recreation and learning opportunities the site provides.

MAMMALS

Most of Illinois's mammals are found in wooded landscapes and grasslands, including those in urban areas. Mammals include deer, rabbits, squirrels, foxes, prairie voles, some bats, and more.

BIRDS

7 million migrant birds pass through Chicago each year. Jackson Park's trees, shrubs, and herbaceous plants provide the birds with food & shelter during their long journey .

INVERTEBRATES

Of the known animal species, 95% are invertebrates, incorporating a broadly diverse range of animals. Local invertebrates eat plants at and below the soil's surface and are themselves an abundant food source for birds and other animal species.

HERPS

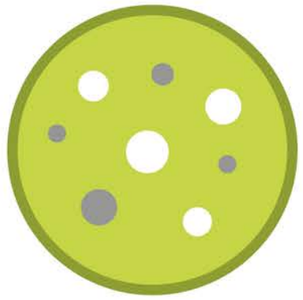
Made up of amphibians and reptiles whom occupy similar habitats, herps have critical roles in the local ecosystem including assisting in pollination, indicating climate change due to their temperature sensitivity, and forming an integral part of the food web.

AQUATIC

Freshwater inhabitants–both plants and animals–help with improving the quality of water and manage stormwater. Appropriate aquatic vegetation is vital to adequately support the fresh water ecosystem.

INSECTS

There are over 500 common insects in Illinois. Insects play crucial roles in ecosystems by pollinating plants, scavenging on decaying debris, recycling nutrients, and providing a food source for other animals.



MICROORGANISMS

Healthy microbes in the soil provide vegetation with available nutrients and support longer term plant health.

Gene Sequence: By analyzing the culture, mortality, and hardiness characteristics of the site's existing tree canopy and then comparing it to a draft of the proposed tree palette, one can begin to draw conclusions about the adaptability and resilience of the proposed vegetation. In many ways it is the range of hardiness for a selected tree species that predicts the ability for the tree to sustain the changes in our climate and the increase in environmental extremes. However, in choosing to combine this metric with the factors that govern the tree's growth and its typical mortality we are planning for and designing to a series of variables that support a sustainable long-term landscape solution.

CULTURE

There are a number of horticultural factors that govern successful plant growth, according to several sources, including Dr. Michael Dirr's Manual of Woody Landscape Plants. It is important to consider many characteristics of a tree species, such as ability to be transplanted, adaptation to new environments, flexibility in soil type, pollution tolerance, drought tolerance, soil compaction tolerance, potential impacts by disease or pests, and nitrogen fixing capabilities. Species that have more of these attributes indicate a potential to continue to adapt and be sustained as environmental pressures increase.

TYPMORT

Typical age of mortality, or life expectancy, of a tree species. Understanding a species' lifespan can reveal the generational qualities of a landscape as some species may have characteristics that allow them to adapt to environmental changes but will not live as long as another selected species. While this life expectancy is relative, urban conditions often serve to further impact the mortality of a given selection.

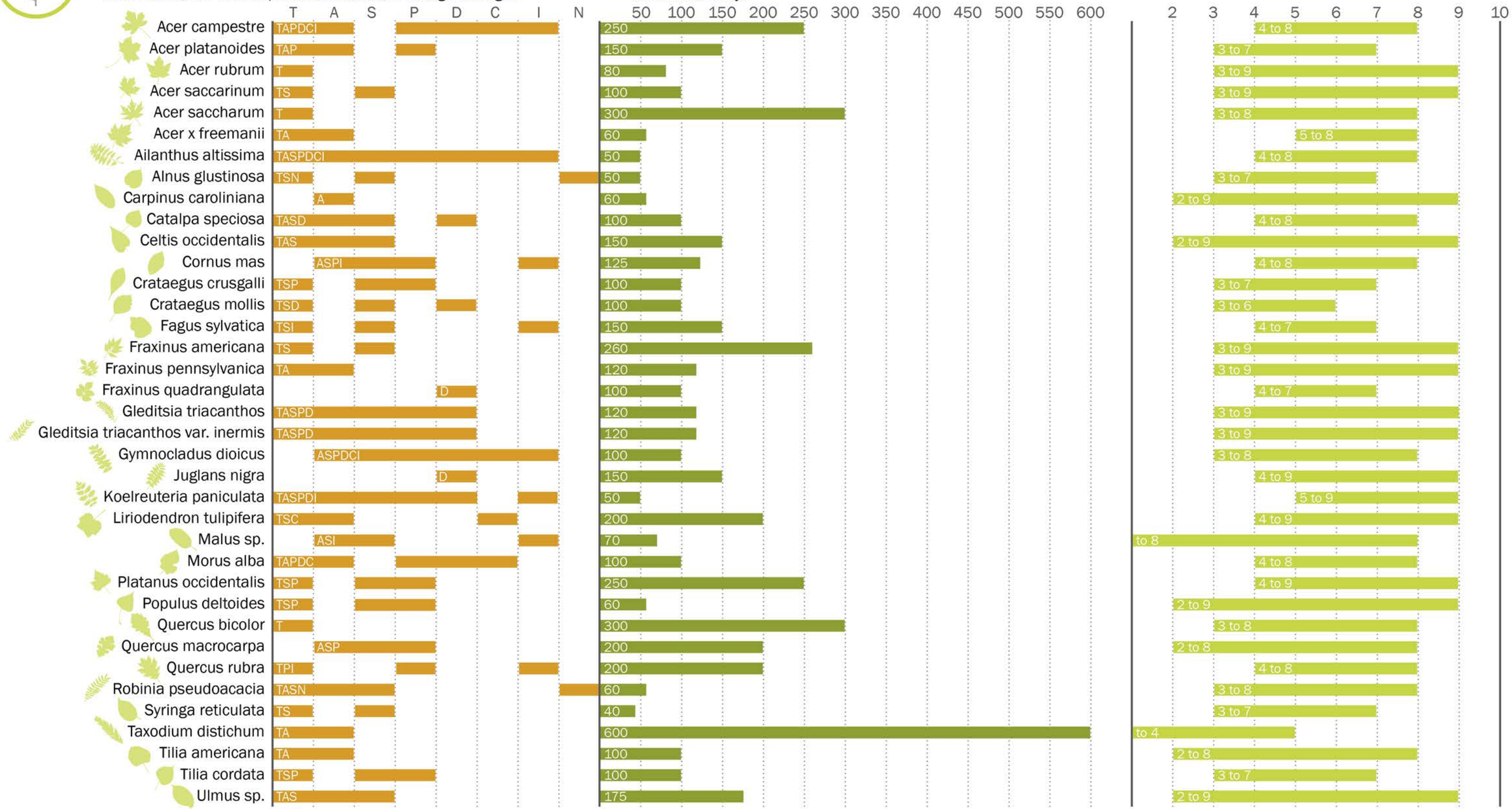
HARDINESS

Physical range in which a selected species is capable of growing, defined by its ability to withstand the minimum and maximum temperatures of the hardiness zone. These established zones are predicted to shift with the projected changes in climate. The greater range of hardiness zone a tree species has indicates its ability to adapt to changes in temperature and climate.

CULTURE: Factors that govern successful growth: ease of transplanting **T**; adaptablity **A**; soil flexibility **S**, pollution **P**, drought **D**, & compaction tolerance **C**; low disease/insects issues **I**; & nitrogen fixing **N**

TYPMORT: Typical age of mortality, however, urban trees are subjected to additional environmental pressures that impact overall mortality.

HARDINESS: Climate range in which plant life is capable of growing. Indicator for adaptability in the era of climate change.



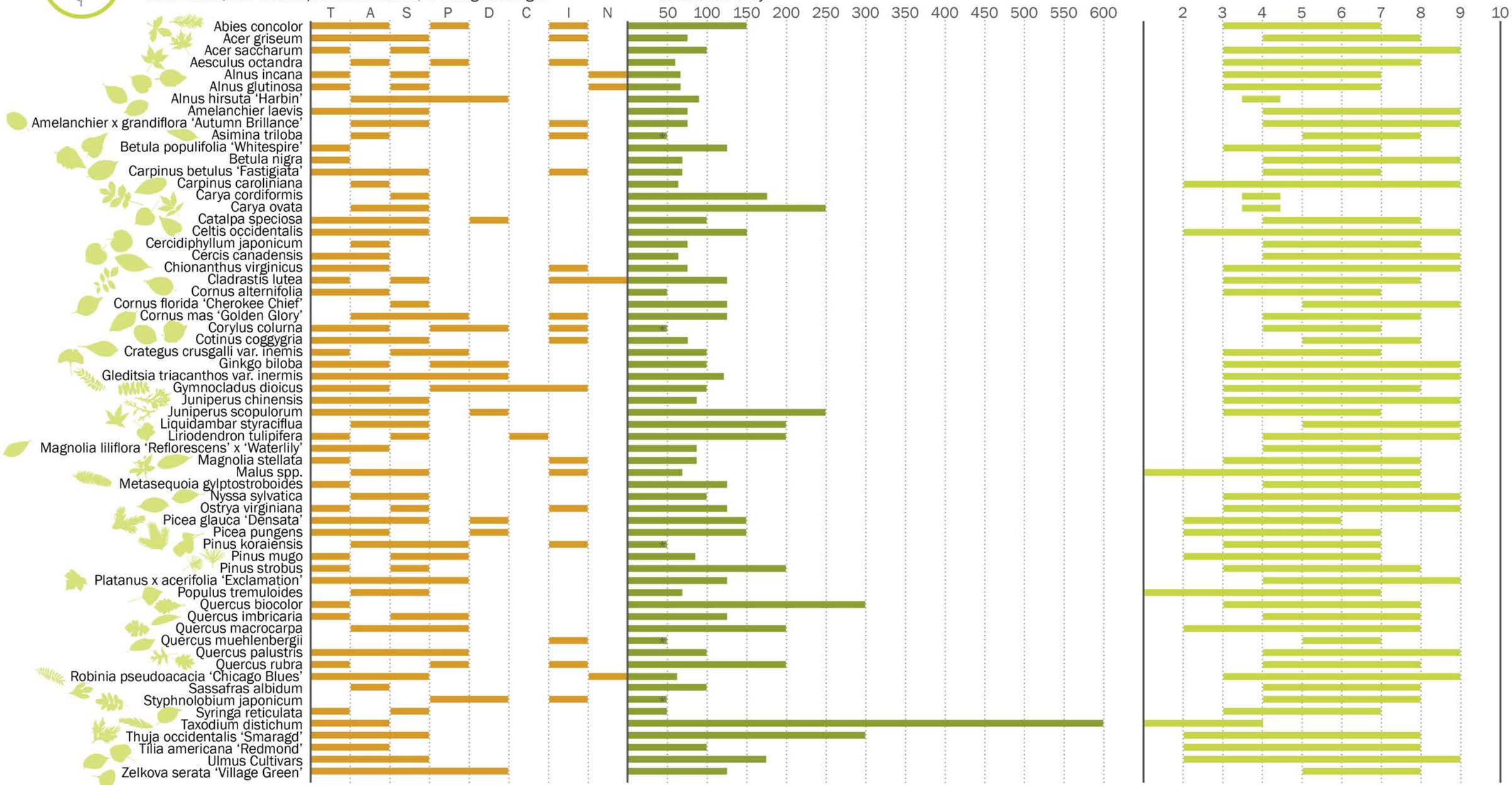
EXISTING TREES

** Research compiled from multiple sources; refer to appendix.

CULTURE: Factors that govern successful growth: ease of transplanting **T**; adaptablity **A**; soil flexibility **S**, pollution **P**, drought **D**, & compaction tolerance **C**; low disease/insects issues **I**; & nitrogen fixing **N**

TYPMORT: Typical age of mortality, however, urban trees are subjected to additional environmental pressures that impact overall mortality.

HARDINESS: Climate range in which plant life is capable of growing. Indicator for adaptability in the era of climate change.

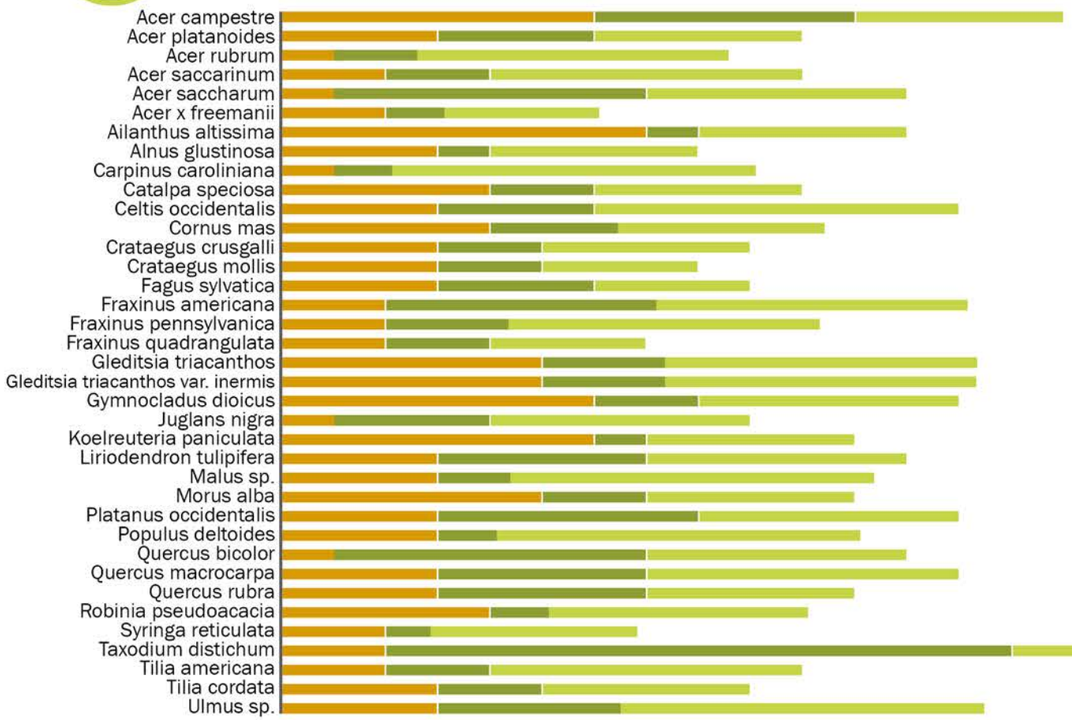


PROPOSED TREES

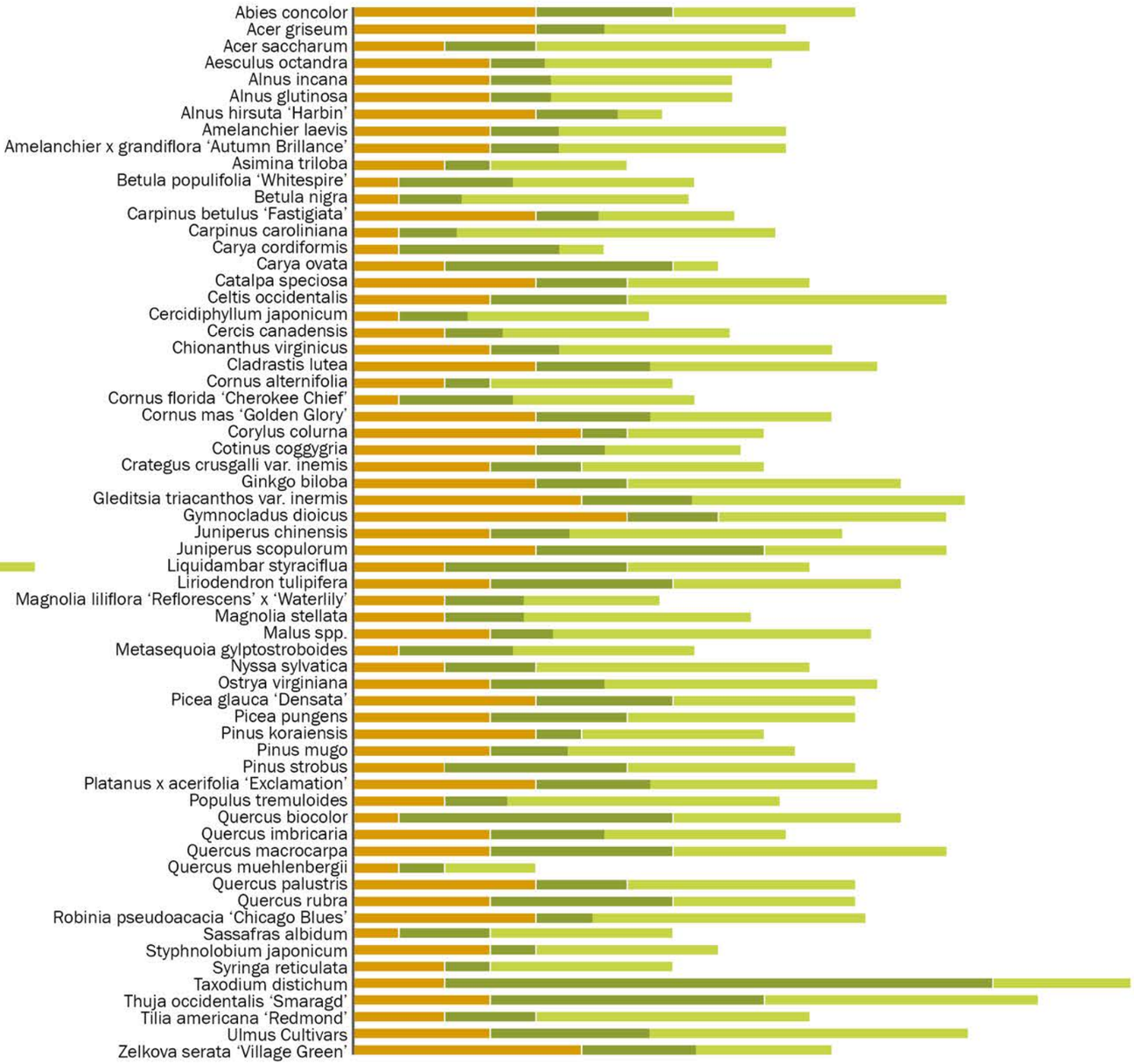
*Researching inconclusive ** Research compiled from multiple sources; refer to appendix.

Increasing the diversity of the canopy & potential for resiliency of the landscape through tree selection.

CULTURE + TYPMORT + HARDINESS



EXISTING TREES



PROPOSED TREES

- 3 Genera make up nearly half of the site's canopy.
- All of these species have reached semi-maturity to full maturity or have been replaced with a next generation of tree in the same location.

MATURE CANOPY TREES

With little diversity in tree species, over half of the site could reach the end of its life-cycle (disregarding other health factors) within the same time frame.

LOSS OF TREES DUE TO AGE OR ENVIRONMENTAL IMPACT

Although many factors are involved in the mortality of a tree, a large quantity of the same species on a site will share the same susceptibility to diseases and pests. This could result in many needing to be removed at the same time. Without diversity, all of the trees become vulnerable at the same time and could be completely wiped out.

i.e. Emerald Ash Borer, Dutch Elm Disease, etc.

REPLACEMENT PLANTINGS OF SAME SPECIES

This could result in dramatic shifts to canopy density and composition in the instance of mortality whether by age or infection.

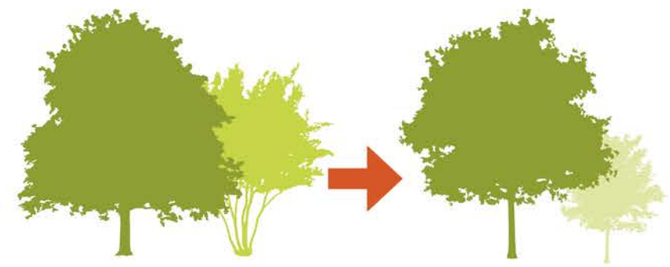
CONVENTIONAL

In the development of a diverse planting design, considerations of species selection, disease tolerance and hardiness have the potential of reducing dramatic impacts to mortality brought on by future pests and disease.

DIVERSIFIED CANOPY & UNDERSTORY SPECIES & SIZE

Diversifying species results in varied stratification and increased habitat potential.

LOSS OF TREES DUE TO AGE OR ENVIRONMENTAL IMPACT



Once a particular tree dies, whether due to age or disease, it can be removed with a degree of confidence that other nearby species will not be affected by the same fatal causes.

REPLACEMENT PLANTINGS PRESERVE DIVERSITY IN SIZE & SELECTION

When another tree nears its end, there is enough surrounding established tree canopy to support the local ecosystem.

The site's tree canopy maintains its diversity in a similar manner to that which was first installed.

PROPOSED

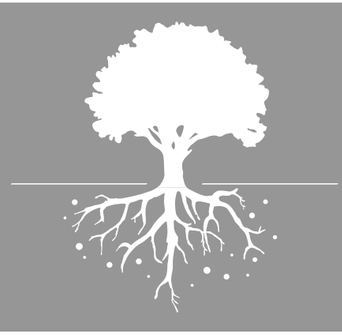
OBAMA PRESIDENTIAL CENTER

Reinforcing Landscape Ecology

DESIGN DEVELOPMENT

STORMWATER

TREE + SOIL BIOLOGY



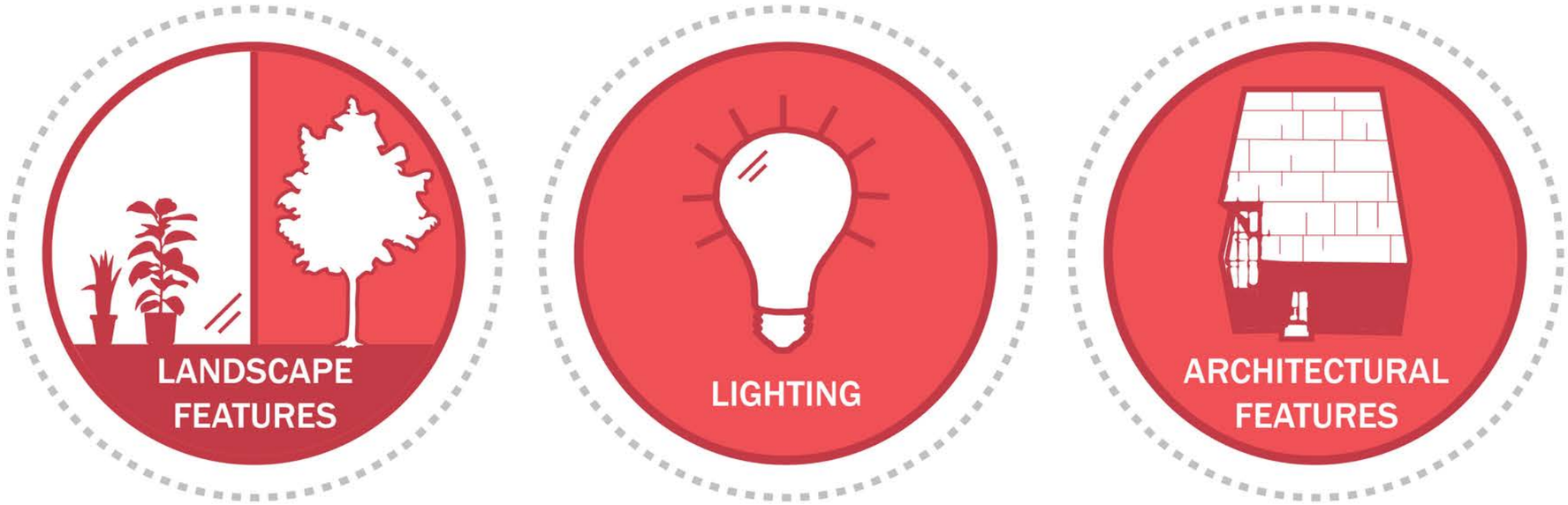
BIODIVERSITY

BIRD HABITAT

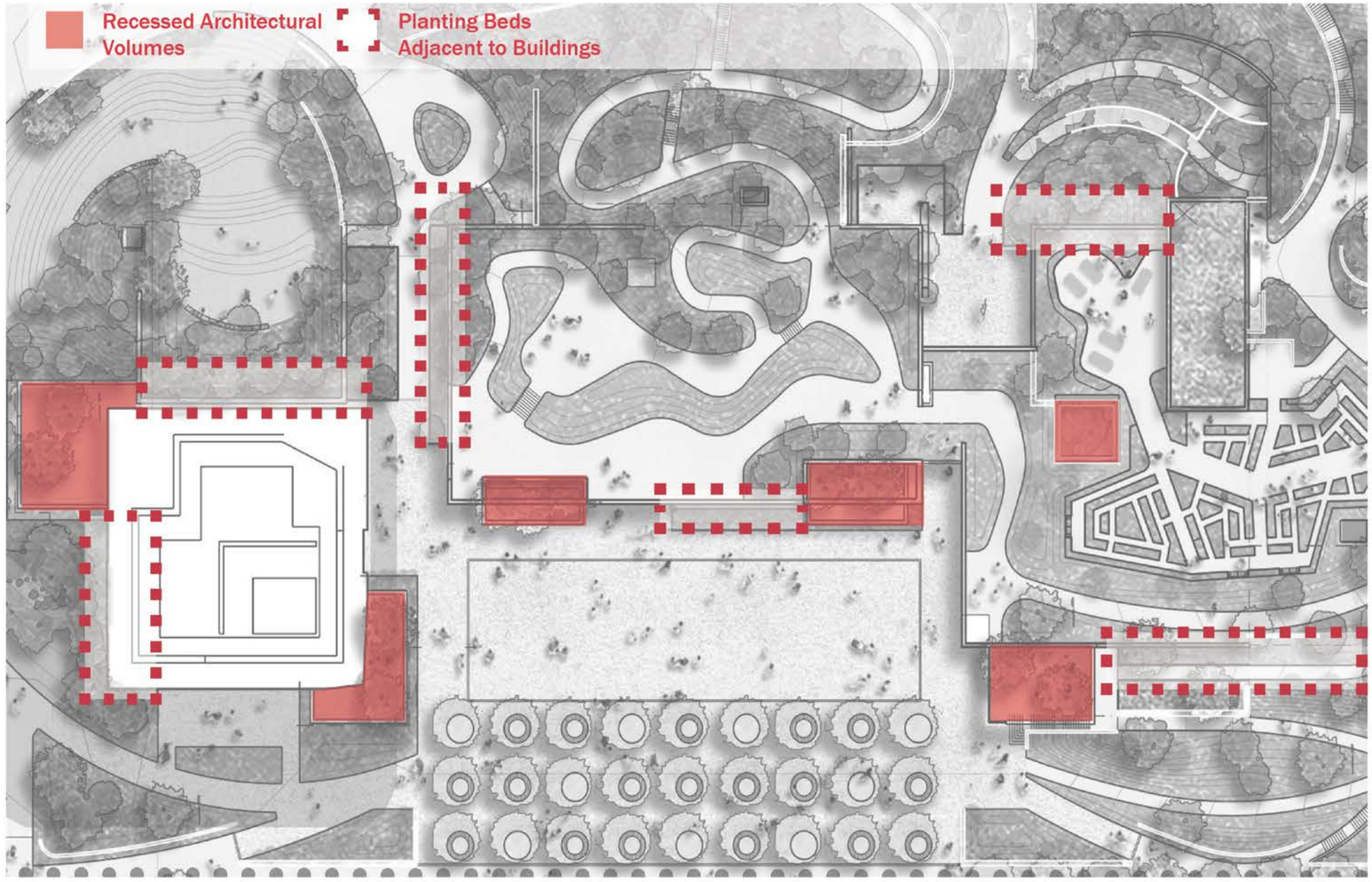
POLLINATORS

BIRD FRIENDLY DESIGN

There are multiple ways in which design selections can achieve a positive impact for migratory bird movement on the OPC site. The strategies that follow are based on published research, available product information, project precedents, and consultation with bird conservation experts.



LANDSCAPE FEATURES



LOCATING VEGETATION FOR BIRD SAFETY

- Most bird activity takes place at lower floors of buildings.
- Recessed volumes will likely draw in birds due to vegetation and shelter from the wind.
- Vegetation located near to the building can help minimize collisions if the canopy is located 4 feet or less from building.

Design Strategies and Considerations:

1. **Careful selection of plants to discourage birds seeking food and shelter in these recessed areas.**
2. **Avoid positioning interior plants near courtyard and ground level windows.**
3. **Plan for the location of exterior vegetation. Proximity to windows can help reduce potential strike distances.**

REDUCE “SEE-THROUGH” CORNERS

- Birds often fly through small gaps (between leaves or branches) and open corridors in the natural environment.
- Corner windows often cause a similar “see-through” effect and present a bird-strike threat.

Design Strategies and Considerations:

1. **Reduce the amount of direct window-to-window building corners wherever possible.**
2. **Avoid the placement of any interior plants in areas where birds may perceive them as continuation of canopy.**

TRANSPARENT MATERIALS IN THE LANDSCAPE

- Transparent wall elements and guardrails are very dangerous for birds because birds perceive them as an unobstructed route to habitat beyond.

Design Strategies and Considerations:

1. **Explore alternative railing materials that reduce or eliminate the use of transparent / reflective glass.**

LIGHTING

LIGHT POLLUTION REDUCTION: LEED

The design team is targeting the Light Pollution Reduction LEED Credit for the OPC project. The LEED requirements generally align with or exceed the requirements of the programs and guidelines highlighted below. The general intent and requirements of the credit include the following:

- **General:** Increase night sky access, improve nighttime visibility, and reduce the consequences of development for wildlife and for people.
- **Uplight:** Utilize luminaires that do not exceed the uplight ratings as defined in IES TM-15-11 Addendum A.
- **Light Trespass:** Do not exceed luminaire backlight and glare ratings as defined in IES TM-15-11 Addendum A, based on the mounting location and distance from the lighting boundary.
- **Exterior Signage:** Do not exceed a luminance of 200 cd/m2 (nits) during nighttime hours and 2000 cd/m2 (nits)during daytime hours.
- **Exterior Lighting** that is used solely for facade and landscape lighting in Model Lighting Ordinance User Guide lighting zones 3 and 4 and are automatically turned off from midnight to 6am (see also, Lights Out Program).

LIGHTS OUT PROGRAM

- A concentration of city building lights has been shown to attract birds to change their migratory path.
- The City of Chicago has detailed parameters to meet the Audubon Society's "Lights Out" goals.
- For buildings located by the lakefront, from March 15 to June 15 for the spring migration, and again from August 15 to November 15 for the fall migration, turn off lights after 1:00 a.m. until full daylight, except as required for safety and security.
- Bright lights particularly at lakefront buildings in the pre-dawn hours have been shown to cause the highest mortality in the region.

Chicago Skyline with exterior building lights on versus lights out in the transition of the morning sunrise

INTERNATIONAL DARK SKY ASSOCIATION (IDA)

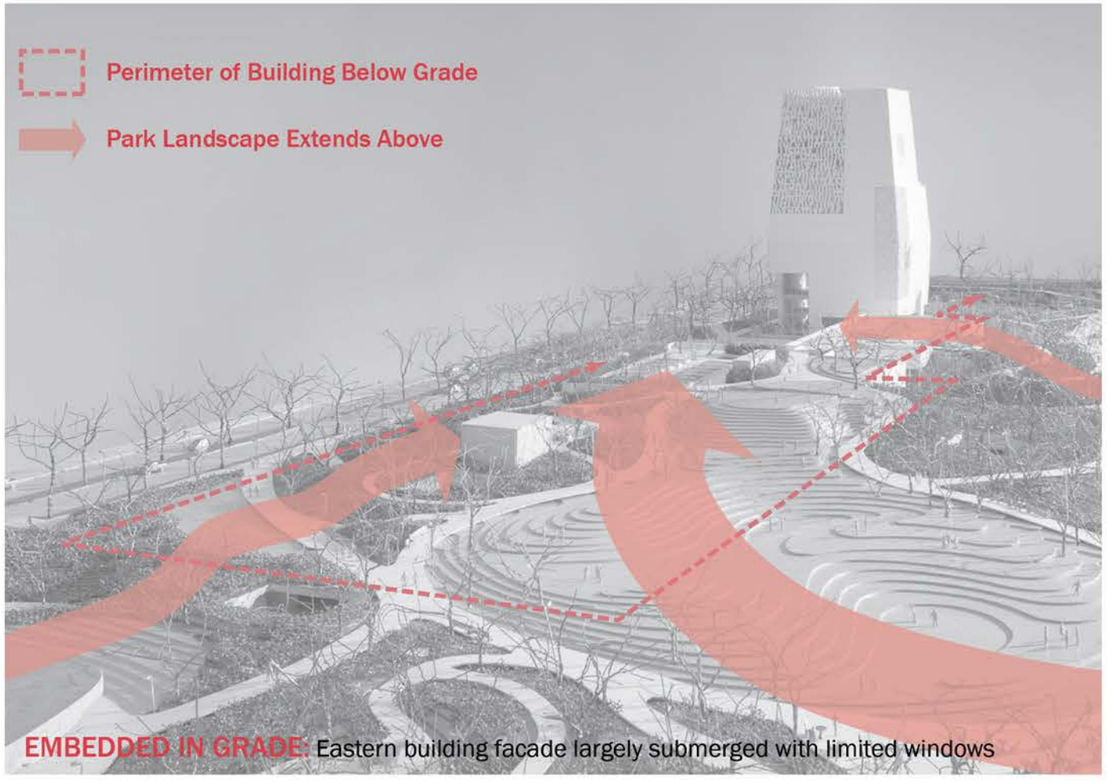
- Animals, such as birds, and plants depend on the daily rhythm of light and dark to govern life-sustaining behaviors.
- Major issues in artificial lights during nighttime include glare (excessive light) and skyglow (brightening of night sky).
- Dark Sky Approved Lighting with lower CCT (correlated color temperature) can help mitigate glare and protect wildlife.

ARCHITECTURAL FEATURES

ARCHITECTURAL DESIGN STRATEGIES FOR BIRD SAFETY

As a high-profile architectural project, the OPC seeks to set an example and has been thoughtfully designed to reduce the amount of reflective and transparent surfaces in several ways:

- Large portions of the OPC are embedded within the park landscape. (See image below)
- Over 90% of the building facade is comprised of opaque surfaces.
- The Museum Building makes use of a large artistic screen element as a means of mitigating for the glass beyond. (See image to the right)
- In areas where windows exist at a pedestrian level the design uses overhangs and recessed volumes in an effort to reduce the potential for reflective surfaces.



EMBEDDED IN GRADE: Eastern building facade largely submerged with limited windows

GRILLES/SCREENS: Incorporated in Tower Design

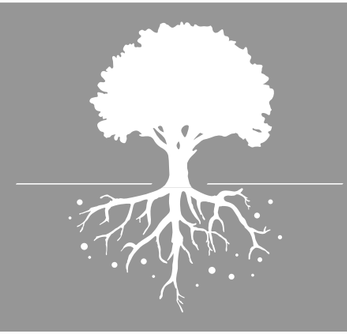
OBAMA PRESIDENTIAL CENTER

Reinforcing Landscape Ecology

DESIGN DEVELOPMENT

STORMWATER

TREE + SOIL BIOLOGY

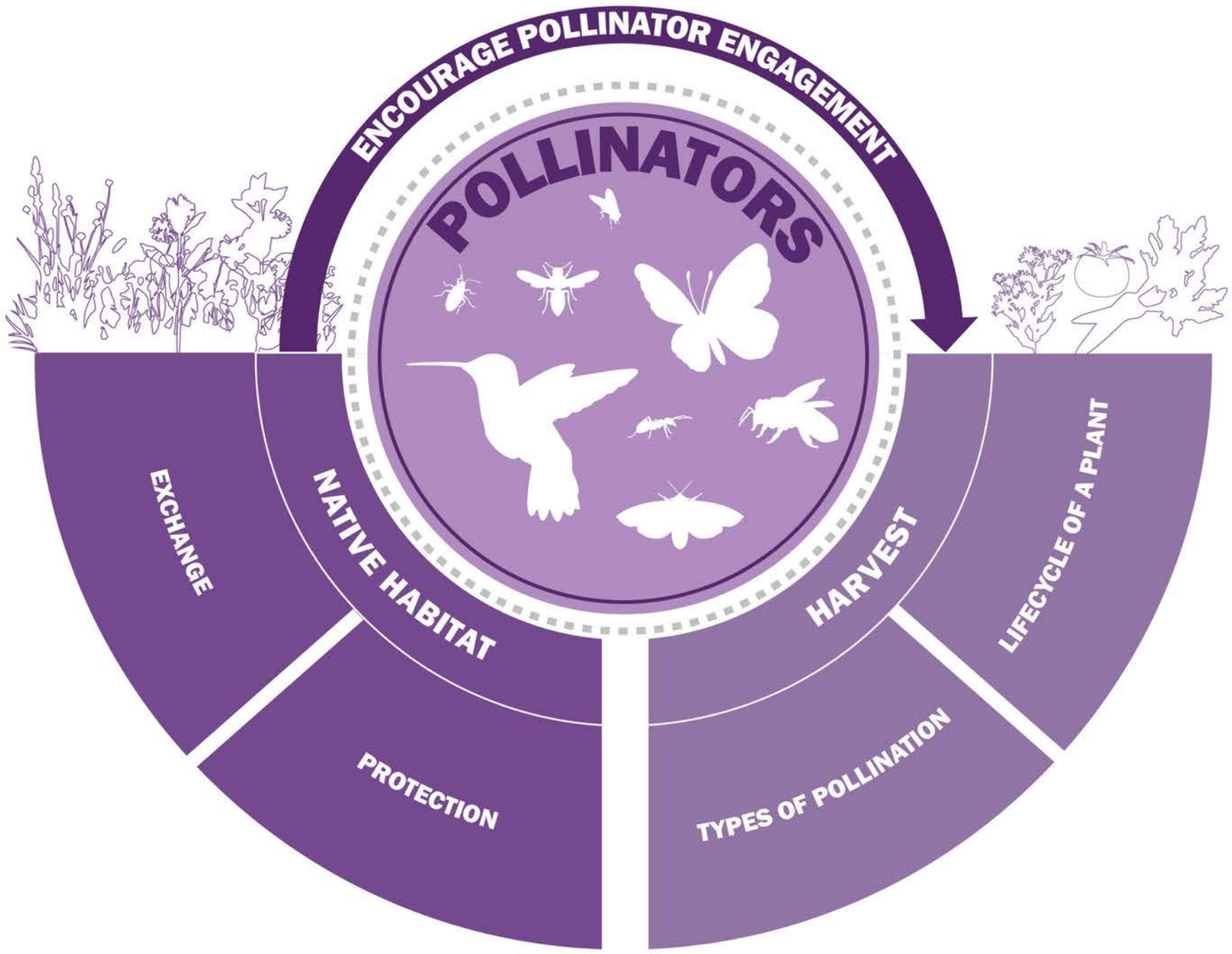


BIODIVERSITY

BIRD HABITAT

POLLINATORS

POLLINATORS



POLLINATORS

EXECUTIVE SUMMARY

POLLINATION AND POLLINATORS

What is pollination?

- Pollination is a mutually beneficial process of exchange and protection between plant and animal.

Why is pollination important?

- Pollination serves as the foundation of the terrestrial food chain and is essential to ecosystem function and ultimately the survival of humans.

What are the different types of pollinators?

- The pollinator network consists of two fundamental types of pollinators; specialists and generalists.

What are the different types of pollination processes?

- There are two primary types of pollination processes, self and cross pollination.

What does an effective pollinator's habitat consist of?

- Pollinator networks rely on native habitats defined by six factors: odor, nectar, pollen, structure, color and protection.

POLLINATION AND FOOD PRODUCTION

Why is pollination beneficial to harvesting crops?

- Although some crops, like leafy and root vegetables, do not depend on cross pollination others like squash and berries do. Pollinators help to improve crop yields and promote long-term sustainability.

How do I attract pollinators to a fruit and vegetable garden?

- Inter-planting fruits and vegetables with flowers is a great way to attract pollinators to a vegetable garden.

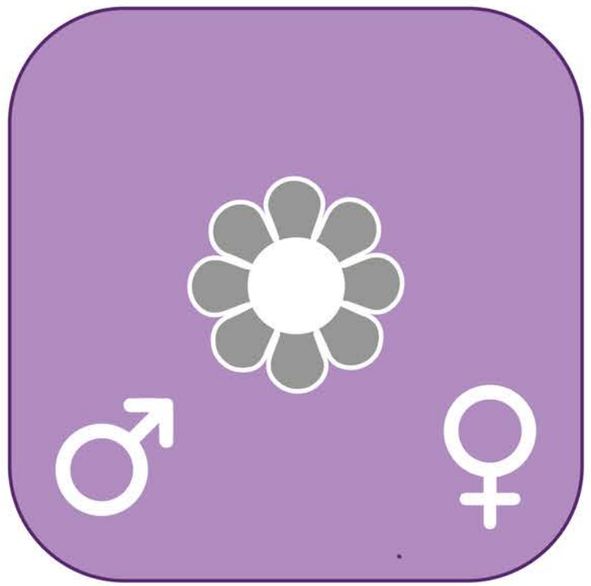
How does the life-cycle of a plant help with crop pollination?

- Understanding life-cycles of plants (annual, biannual and perennial), can help propagation and preservation of species diversity. For example, carrots are usually harvested before they are allowed to flower. Instead of harvesting the carrot, if we allow it to flower for that season it will invite pollinators and help to increase yield the following year.

EXAMPLES OF POLLINATORS RELEVANT TO THE PROJECT

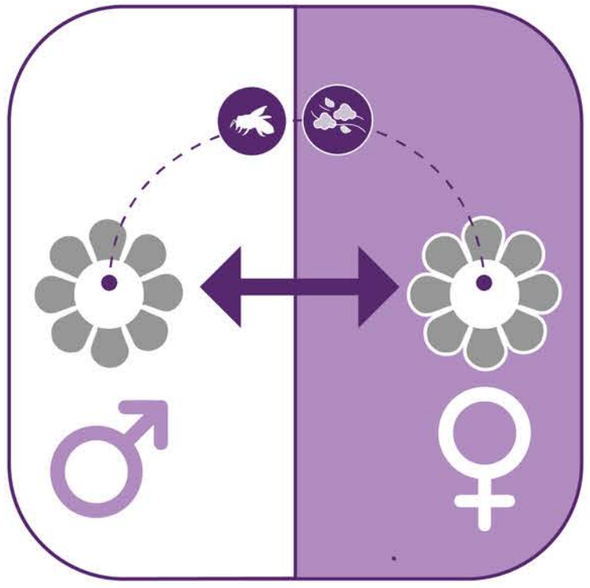
Using specific pollinators as examples, the pages within the third portion of this document highlight the benefits of inter-planting native species with harvest crops. Additionally, these examples illustrate how the proposed plants create an effective pollinator network to attract these species.

TYPE OF POLLINATION



SELF POLLINATORS

Plants that produce flowers that are usually fertilized by their own pollen.



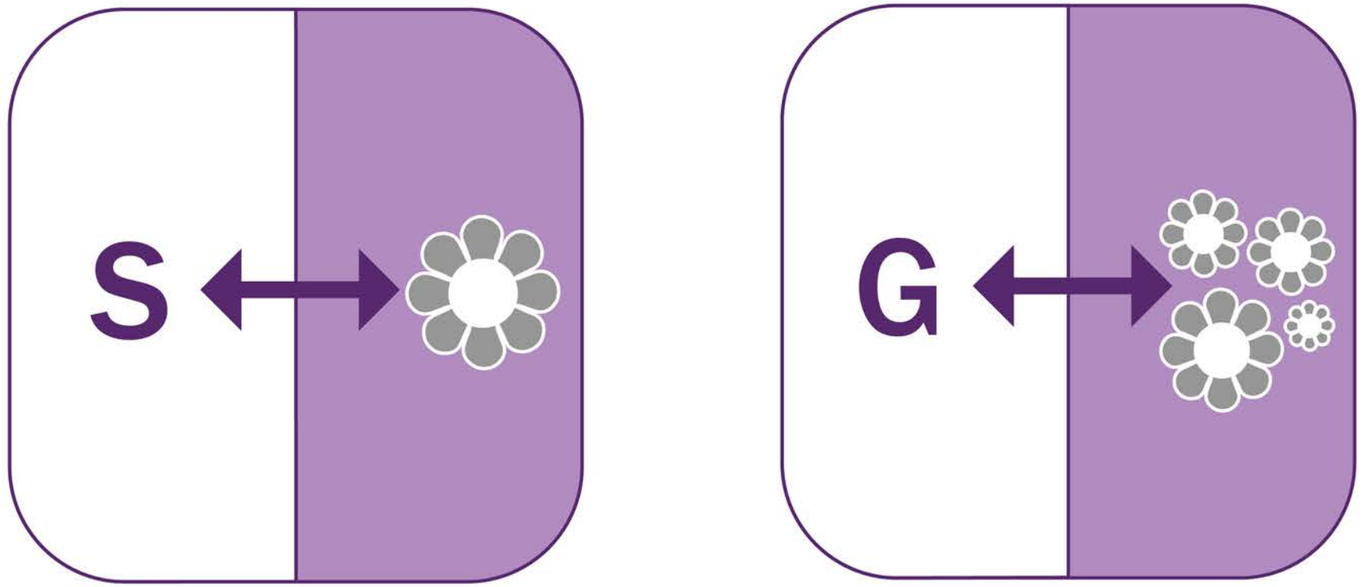
CROSS POLLINATORS

Plants with flowers that require pollen from another flower, via wind or insects and animal.

TYPE OF POLLINATOR

Approximately 80-95% of our plant species found in natural habitats rely on animal-mediated pollination to support healthy ecological communities and ecosystem services. Pollinators are an integral part to supporting biological diversity.

The native plants within the Midwest support a large range of pollinators including thousands of native bees, butterflies, beetles, flies, wasps and moths.



SPECIALIST
Species with narrow niches that can only tolerate a specific range of conditions.

GENERALIST
Species who are non-specific when foraging and can tolerate a wide range of conditions.

RELATIONSHIP BETWEEN PLANTS AND POLLINATORS

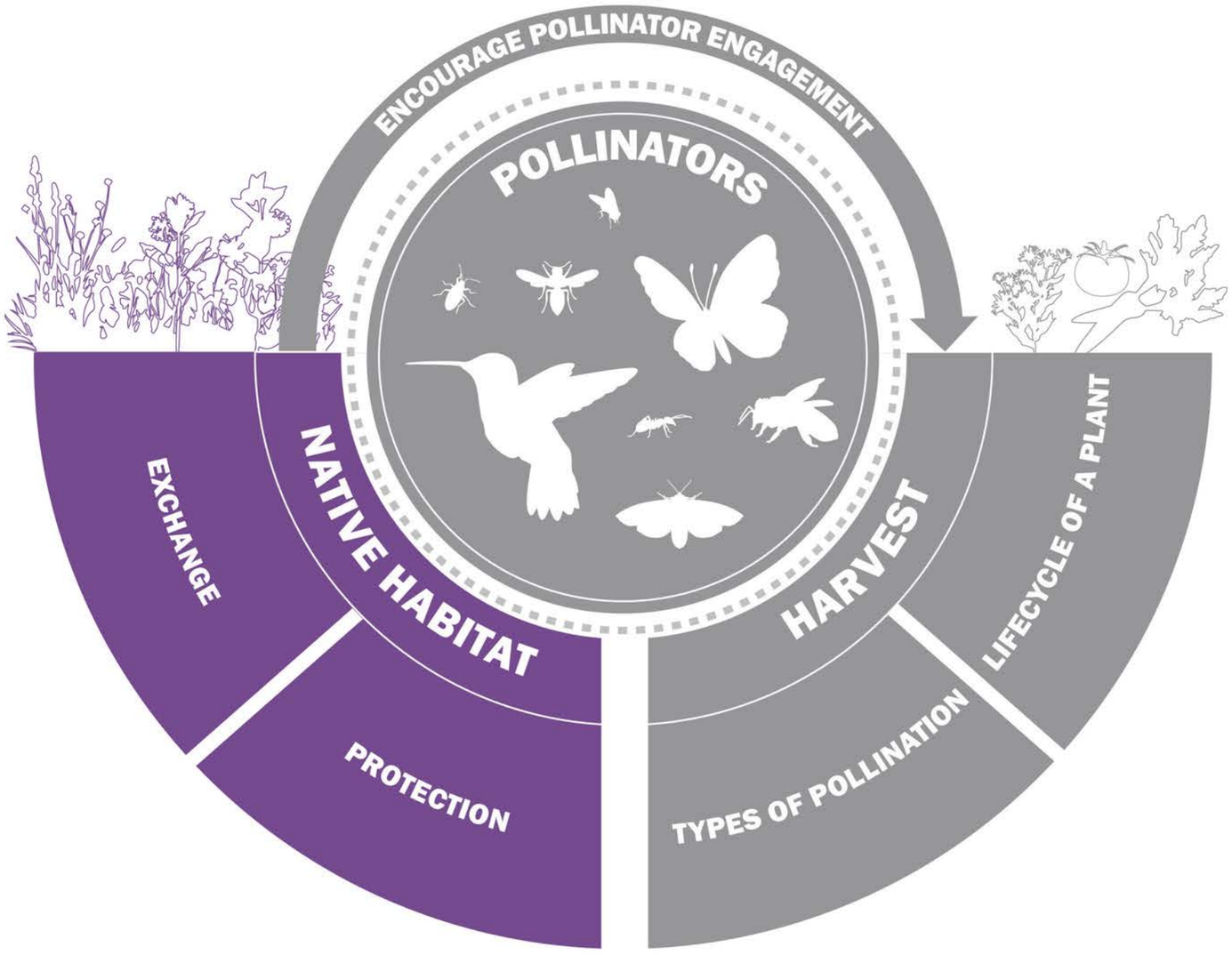
Native habitat provides year round supply of food and shelter that are essential for pollinators. Pollinators have evolved with native plants, which are best adapted to the local growing season, climate, and soils. Most pollinators feed on specific plant species. Non-native plants may not provide pollinators with enough nectar or pollen, or may be inedible to butterfly or moth caterpillars.

EXCHANGE

- Effective networks depend on a balance of sufficient food, nectar and pollen from diverse and abundant flowers.
- Flower traits are a direct result of the intimate relationship between plants and pollinators.
- The association between floral characteristics and pollination method is called a pollination syndrome.

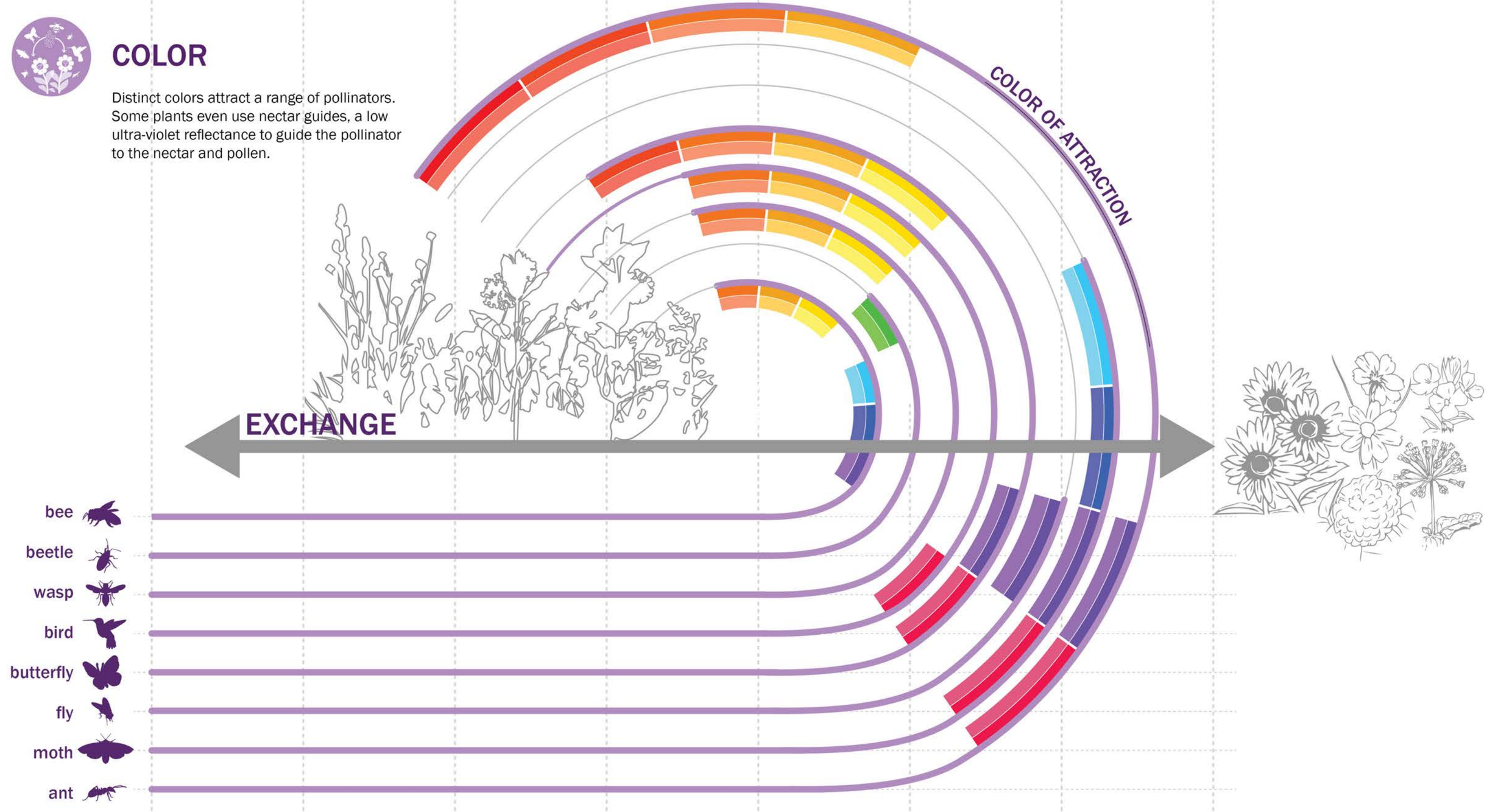
PROTECTION

- Most pollinators have a small home range from the plants they pollinate.
- This requires them to have undisturbed shelter sites for resources such as overwintering and hiding from predators.
- The lifecycle of a pollinator must be considered to enhance long-term pollination of native landscapes.
- Larvae often need shelter and food that is separate from that of an adult.



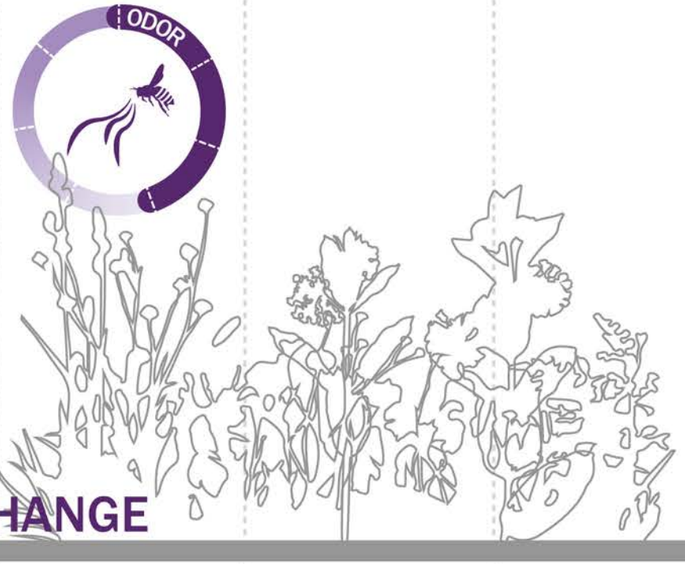
COLOR

Distinct colors attract a range of pollinators. Some plants even use nectar guides, a low ultra-violet reflectance to guide the pollinator to the nectar and pollen.

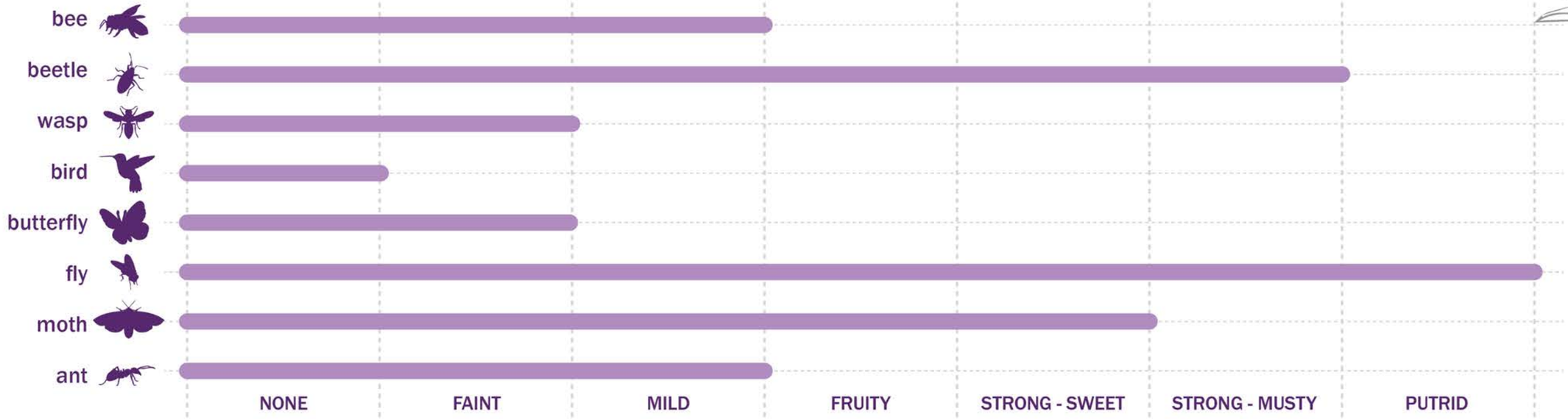


ODOR

If a pollinator is odor-sensitive, the odor emitted from a plant invites the pollinator.



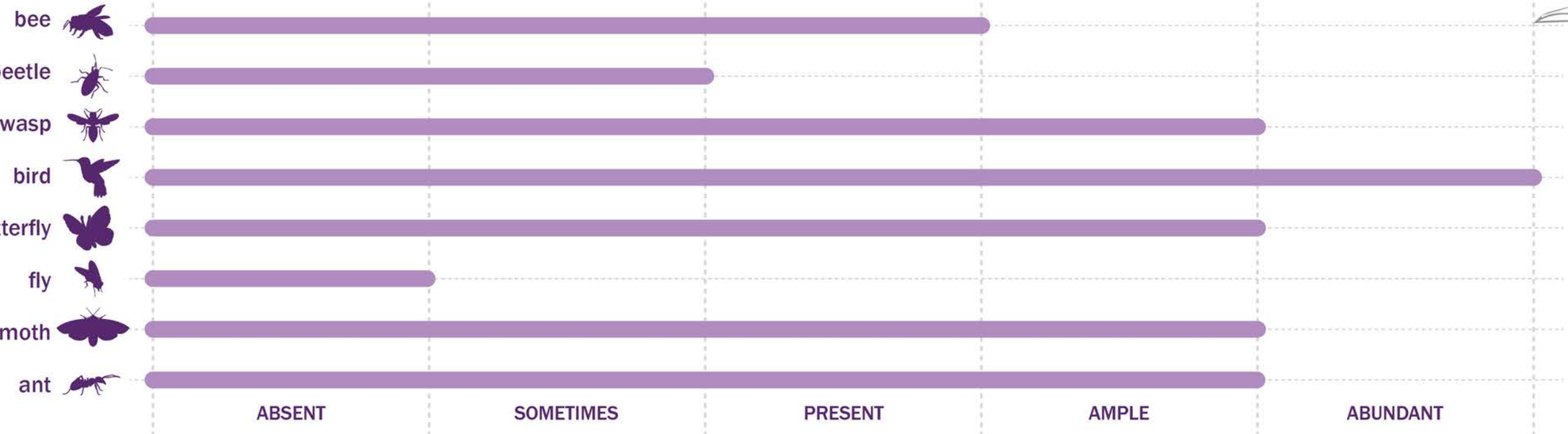
EXCHANGE



NECTAR

Nectar is high in sugar and amino acids and is used by adult pollinators as the primary food source.

EXCHANGE



POLLEN

Pollen is high in protein and often collected for offspring, if not used as food by the adult.

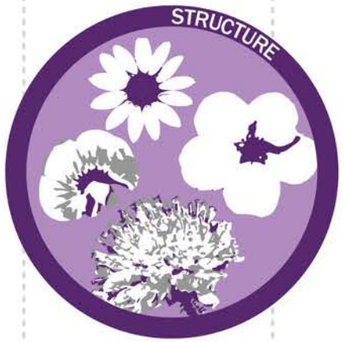
EXCHANGE

bee
beetle
wasp
bird
butterfly
fly
moth
ant

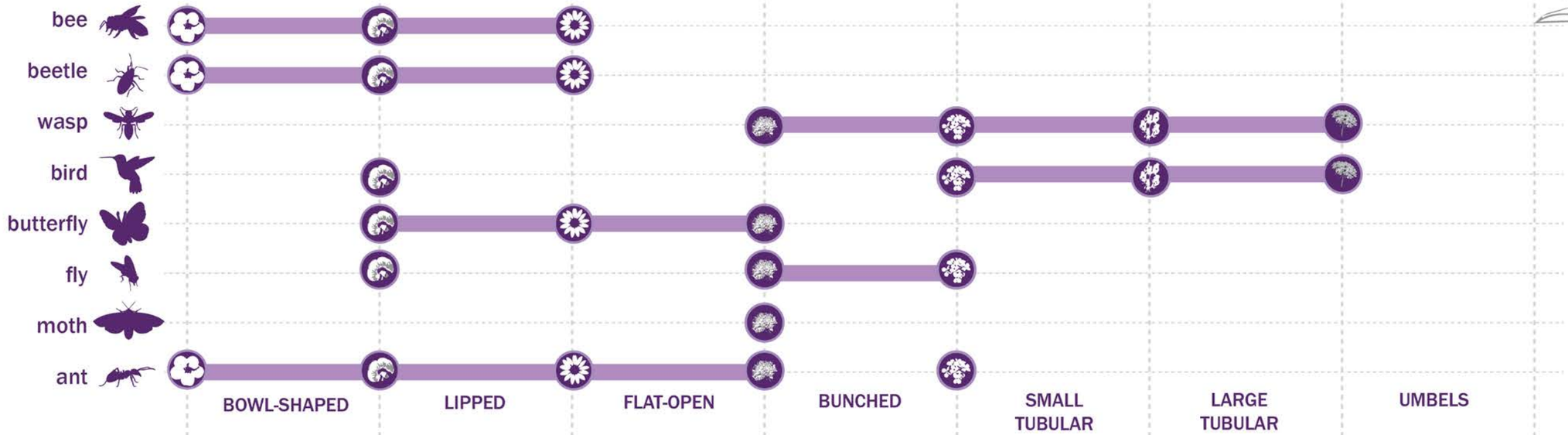
LIMITED
MODEST
AMPLE

STRUCTURE

The architecture of a plant acts as support to specific pollinators, such as a landing pad or area for perching.



EXCHANGE

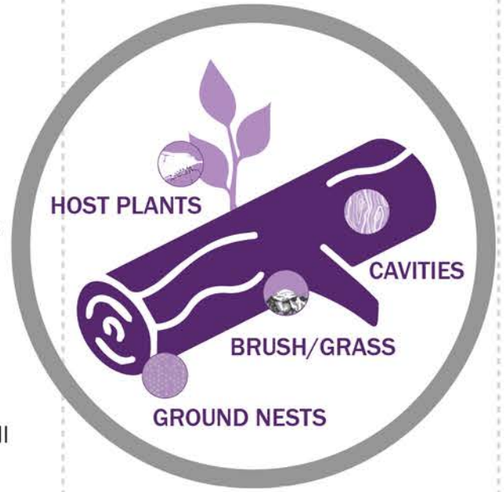


PROTECTION

Pollinators need a place to nest, or hide from predators and severe weather. This can be accommodated through ground nests, cavities, left over brush/grass and establishing host plants that adhere to the pollinators lifecycle.

The nurse logs are an integral part of providing opportunity for protection habitats along with other strategies.

- Logs can act as a barricade for open space so ground nests may be in loose, well-drained soil and sun.
- The decaying wood will allow many cavities available for nesting and nursing.
- The logs can also provide shelter and contribute litter to brush/grass nests for overwintering.
- And finally, the nurse logs will support saplings and other plant life that is crucial for larvae-specific plant species.

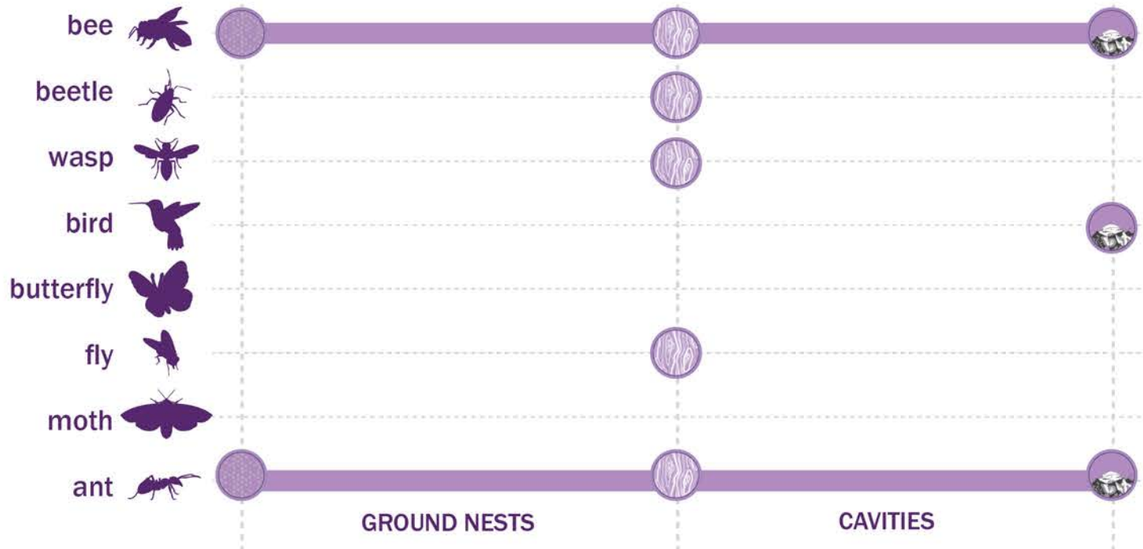


GROUND NESTS: Can be burrows, resembling ant holes. Leaving areas of soil uncovered can encourage nearby nesting.

CAVITIES: Usually decayed wood, dead snags and fallen fruit that can host nesting and nursing for pollinators.

BRUSH/GRASS: Leaf litter can provide overwintering sites and a place to hide from predators.

HOST PLANTS: Occasionally, the larvae rely on plants for food and shelter, that may be different than the ones that provide food and shelter to adults.



POLLINATION AND FOOD PRODUCTION

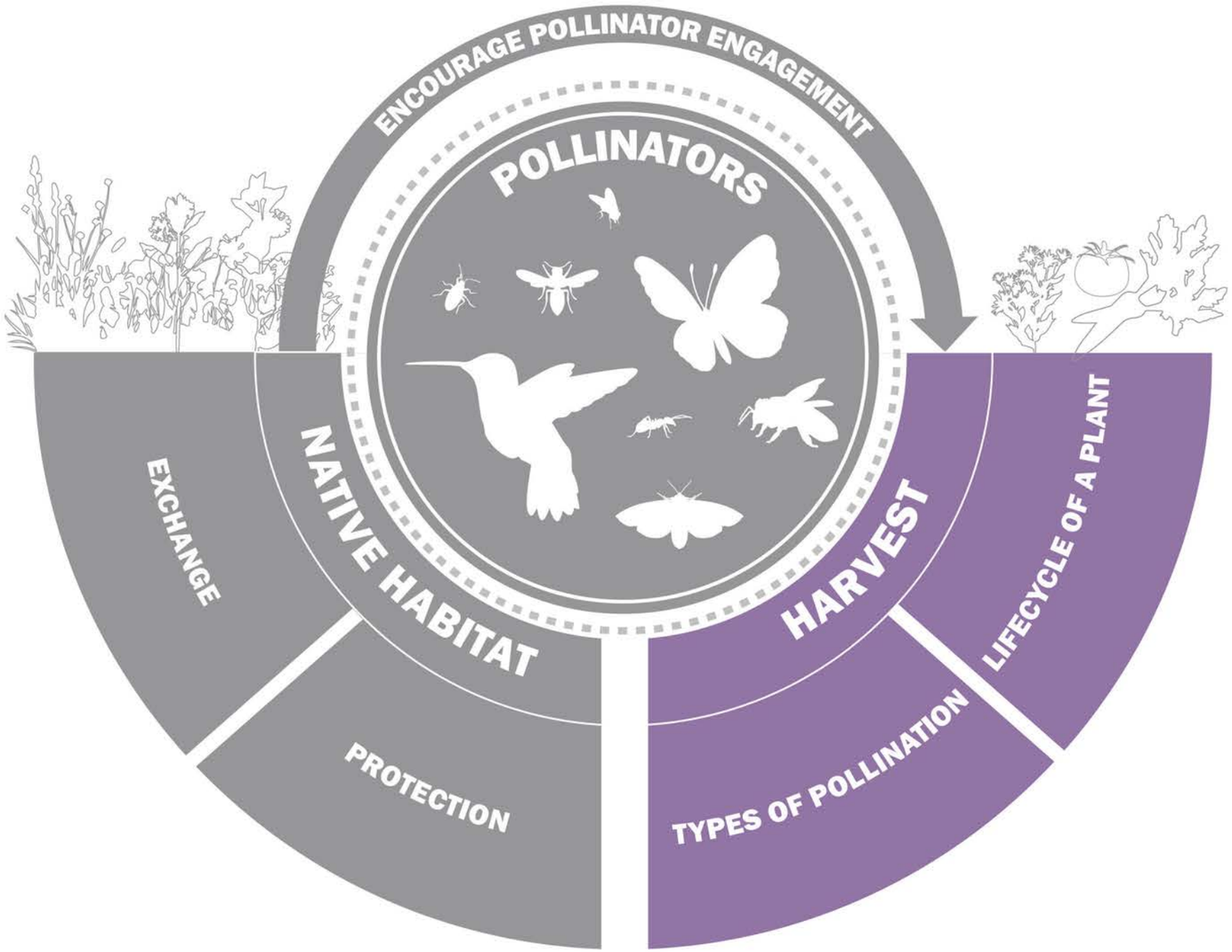
The Fruit & Vegetable Garden is an important piece of landscape opportunity to illustrate connection of pollination and food production in the project. The harvest of fruits and vegetables in a garden depend on two main factors -- type of pollination and the lifecycle of the plant.

TYPE OF POLLINATION

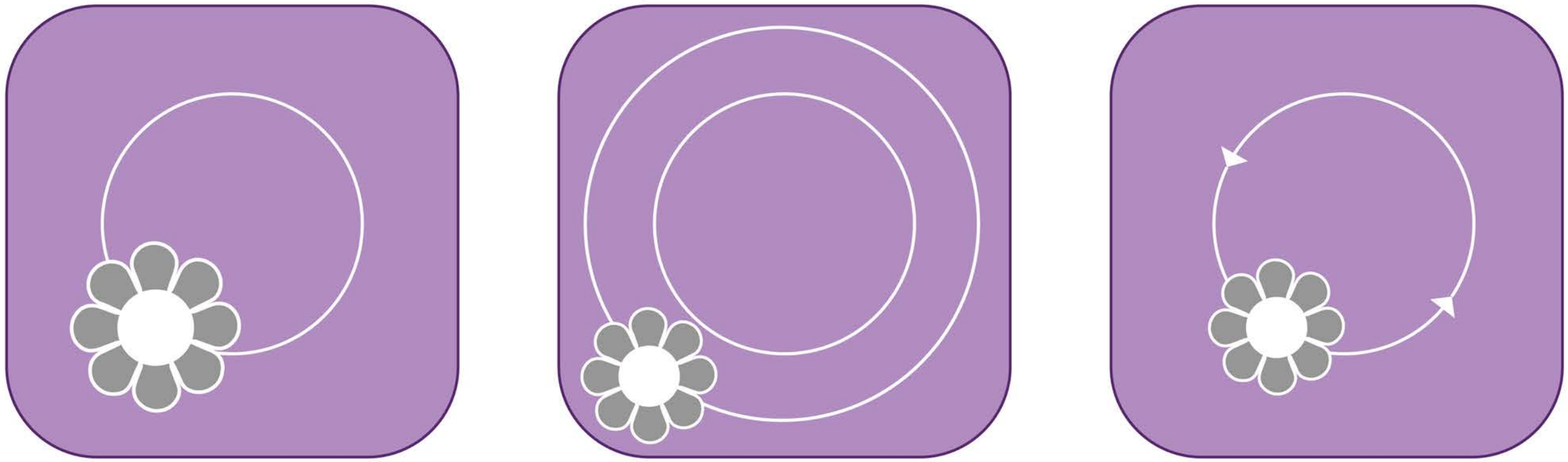
- Not only are pollinators an essential part of the native herbaceous, shrub and tree layer to the Midwest, but they are also key players in our crop production.
- Scientists estimate pollinators are responsible for 1 out of 3 bites of food we take each day.
- Although crops pollinate differently, they can always benefit from insect and animal pollination.
- Crops are more productive and show higher yield when pollinated by insects and animals.

LIFECYCLE OF A CROP IN THE MIDWEST

- Understanding the lifecycle of a crop can help support biological diversity.
- Some crops may be harvested before the flower cycle completes (i.e. carrots) or may be harvested multiple times during flower (i.e. cucumber).
- Leaving some foliage or a portion to flower in their second year of life, creates the space for pollinators to come.



LIFECYCLE OF A CROP IN THE MIDWEST



ANNUAL

Plants have a full life cycle (germinate, bloom and die) within one year.

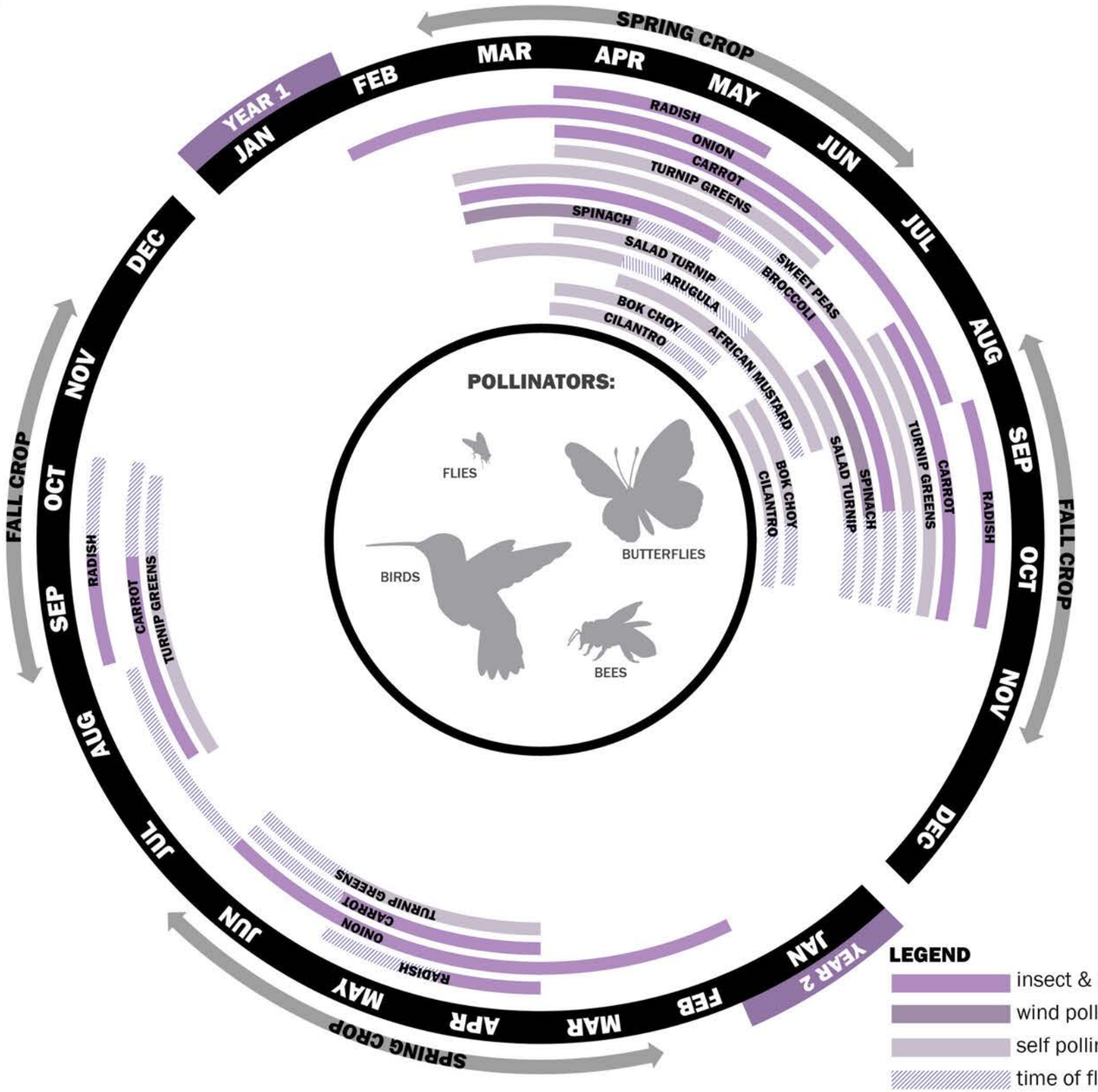
BIANNUAL

Plants that take two years to complete their life cycle. Surviving through one winter and dying the second year.

PERENNIAL

Plants that persist for many growing seasons with regrowth happening from the root system. In the Midwest, most perennial crops are treated like annuals.

SPRING/FALL CROP POLLINATION FOR ANNUALS & BIANNUALS




[Amaranthaceae/ Amaranth Family]

[Amaranthaceae/ Amaranth Family]
- Spinach


[Fabaceae/ Legumes Family]

[Fabaceae/ Legumes Family]
- Snap Pea


[Amaryllidaceae/ Amaryllis Family]

[Amaryllidaceae/ Amaryllis Family]
- Onion


[Violaceae/ Viola Family]

[Violaceae/ Viola Family]
- Viola


[Asteraceae/ Aster Family]

[Asteraceae/ Aster Family]
- Calendula


[Umbellifers/ Carrot Family]

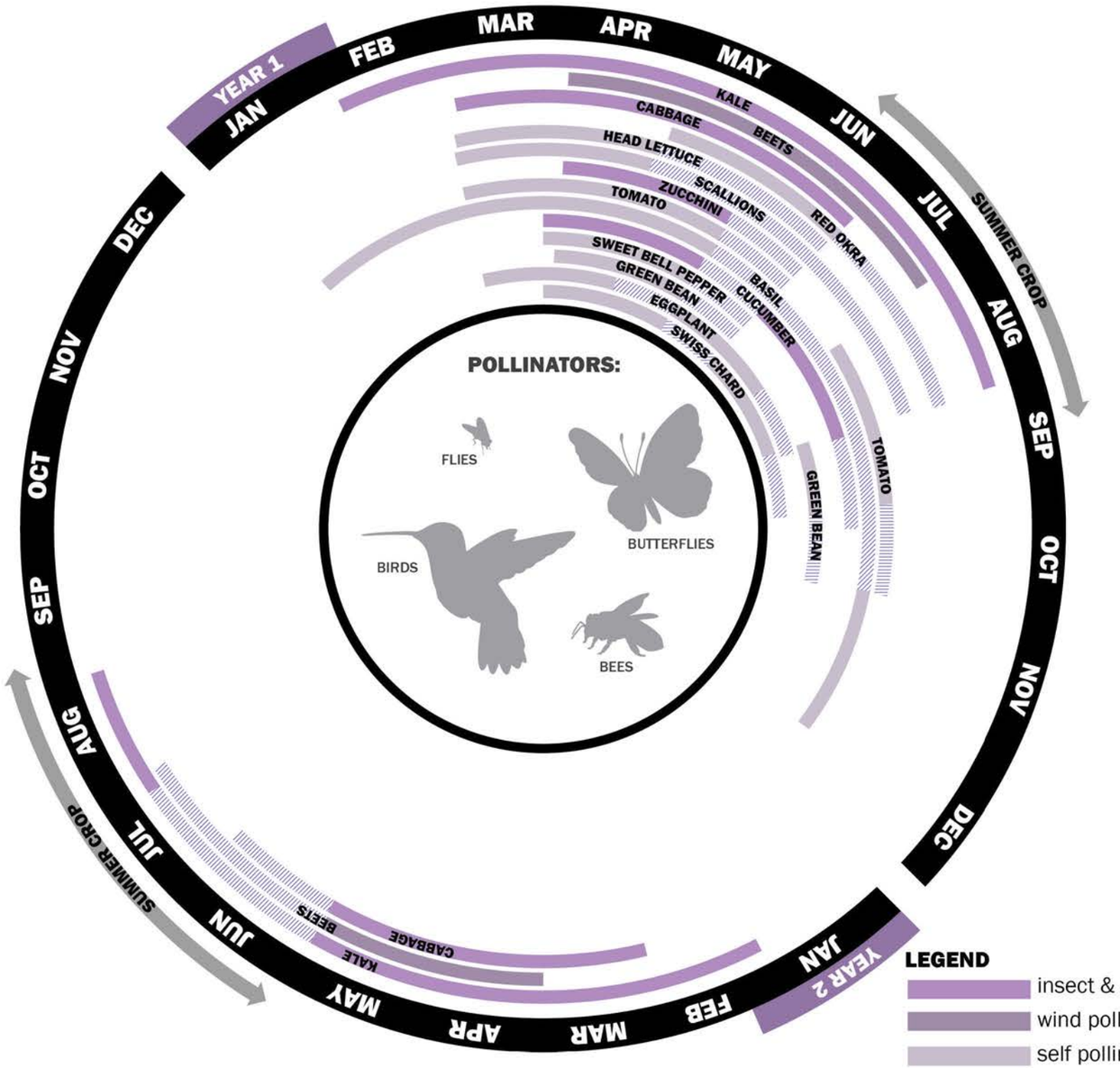
[Umbellifers/ Carrot Family]
- Cilantro
- Carrot


[Brassicaceae/ Mustard Family]

[Brassicaceae/ Mustard Family]
- Broccoli
- Radish
- Salad Turnip
- Arugula
- Turnip Greens
- African Mustard
- Bok Chou
- Stock

LEGEND
- insect & animal pollinated
- wind pollinated
- self pollinated
- time of flowering

SUMMER CROP POLLINATION FOR ANNUALS & BIANNUALS



[Amaranthaceae/ Amaranth Family]
- Beets
- Swiss Chard

[Amaryllidaceae/ Amaryllis Family]
- Scallions

[Asteraceae/ Aster Family]
- Sunflower
- Zinnia
- Head Lettuce
- Marigold

[Brassicaceae/ Mustard Family]
- Sweet Alyssum
- Alyssum
- Kale
- Cabbage

[Cucurbitaceae/ Gourd Family]
- Cucumber
- Zucchini

[Fabaceae/ Legumes Family]
- Green Bean

[Lamiaceae/ Mint Family]
- Basil

[Malvaceae/ Mallow Family]
- Red Okra

[Plantaginaceae/ Plantain Family]
- Snapdragon

[Plumbaginaceae/ Leadwort Family]
- Statice

[Solanaceae/ Nightshade Family]
- Tomato
- Eggplant
- Sweet Bell Pepper

[Tropaeolaceae/ Nasturtium Family]
- Nasturtium

LEGEND
- insect & animal pollinated
- wind pollinated
- self pollinated
- time of flowering

SPECIFIC POLLINATOR EXAMPLES

MONARCH BUTTERFLY (SPECIALIST)

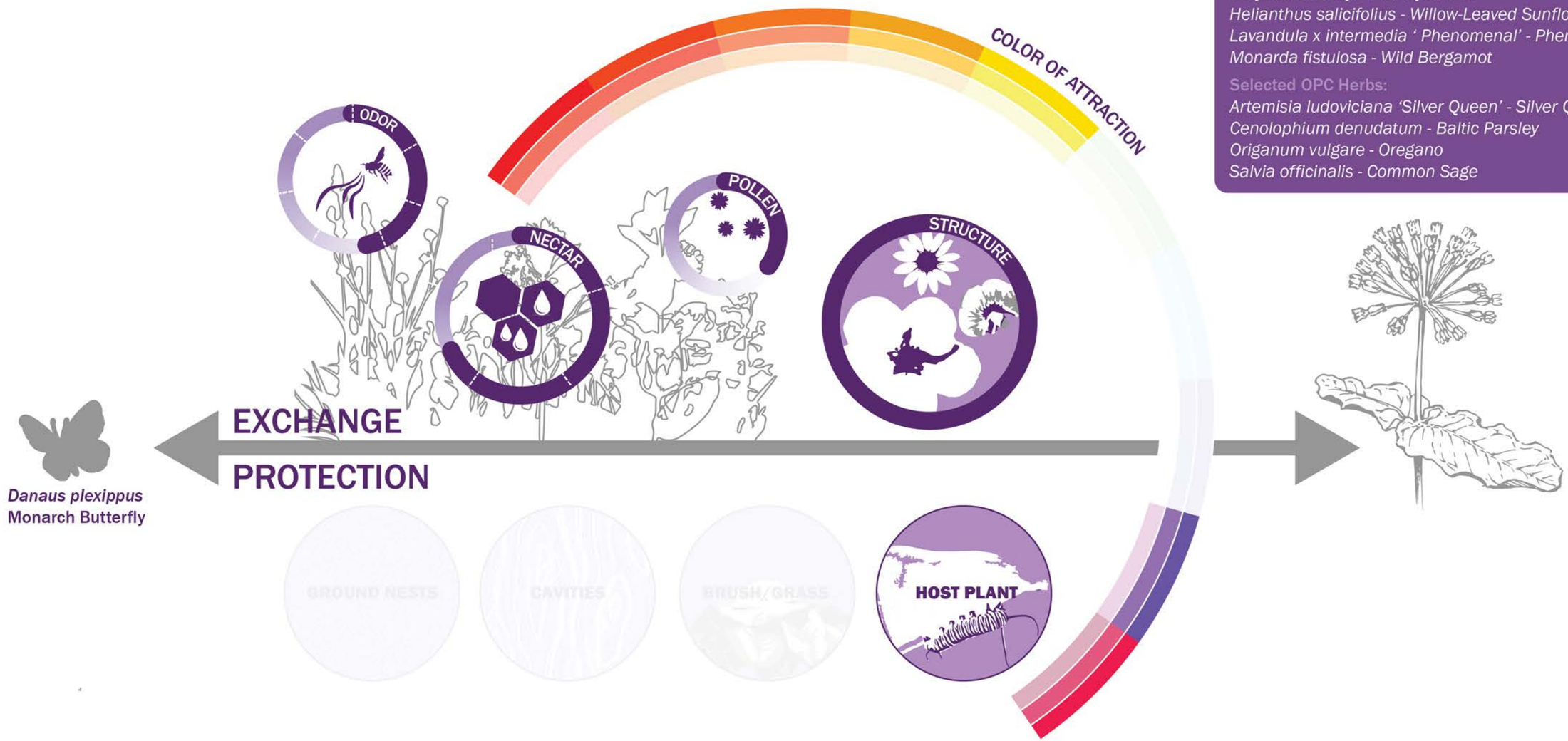
Dependent on the Milkweed plant for reproduction, the Monarch Butterfly is a specialist species and serves as key pollinator that feeds on nectar. This butterfly searches for plants that are brightly colored, have flat surfaces for landing pads, and form in clusters. Though Monarchs feed on the nectar of many plants, the food source provided by the Milkweed is required for their larvae. Without Milkweed leaves to feed on, the larvae would not be able to develop into a butterfly.

Selected OPC Natives:

Agastache foeniculum - Giant Hyssop
Echinacea pallida 'Hula Dancer' - Pale Purple Coneflower
Echinacea paradoxa - Yellow Coneflower
Eurybia x herveyi - Hervey's Aster
Helianthus salicifolius - Willow-Leaved Sunflower
Lavandula x intermedia ' Phenomenal' - Phenomenal Lavendar
Monarda fistulosa - Wild Bergamot

Selected OPC Herbs:

Artemisia ludoviciana 'Silver Queen' - Silver Queen Artemisia
Cenolophium denudatum - Baltic Parsley
Origanum vulgare - Oregano
Salvia officinalis - Common Sage



Danaus plexippus
Monarch Butterfly

RUSTY PATCH BUMBLE BEE (GENERALIST)

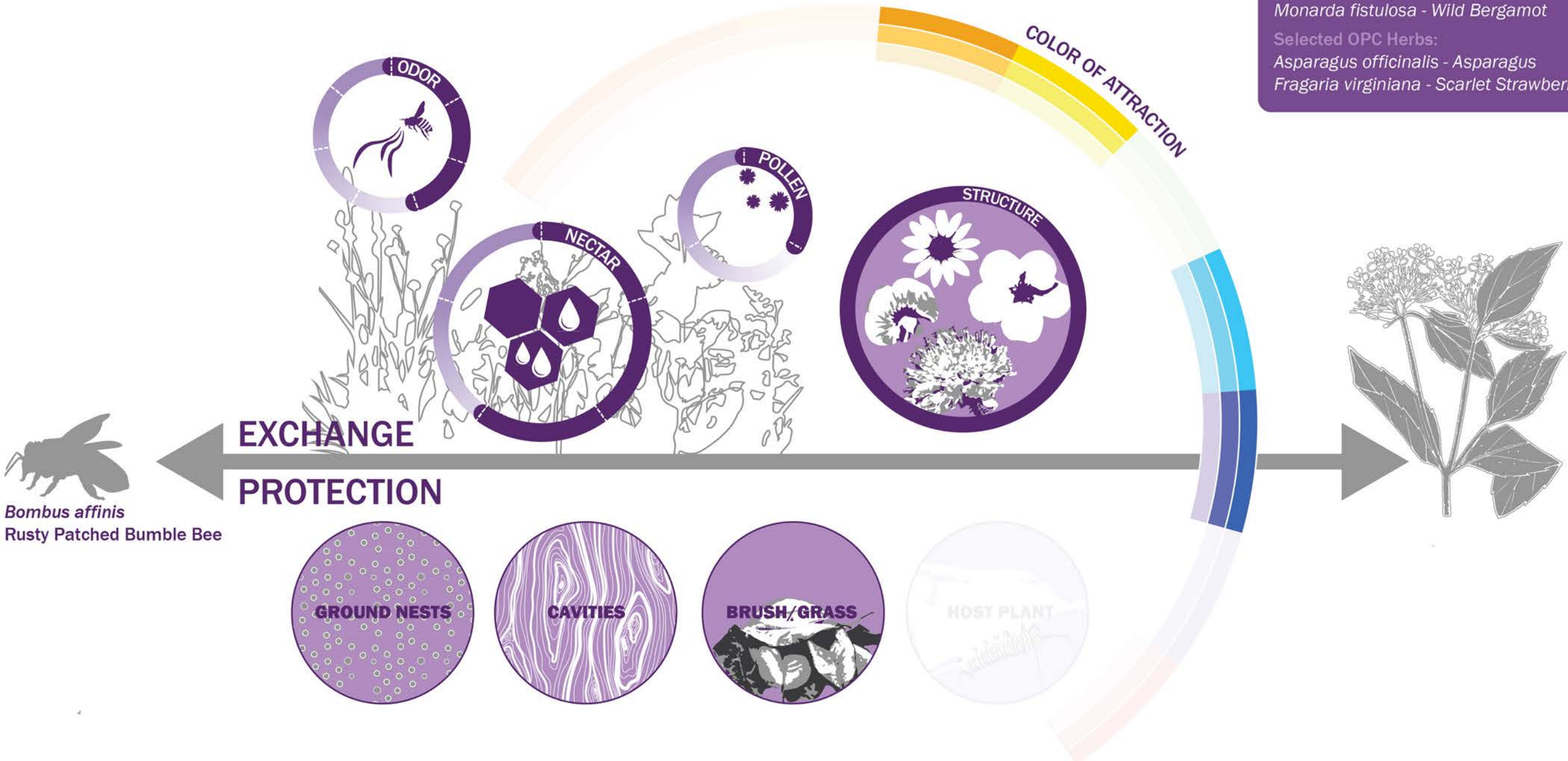
The Rusty Patched Bumble Bee is a species native to eastern North America that have seen a large decrease of habitat in the last 20 years. Though they are habitat generalists, they require areas that support sufficient food (pollen for their larvae and nectar for adults) and undisturbed nesting sites as an overwintering resource for hibernating queens. Diverse flowering plants are required to ensure that nectar and pollen are available throughout the colony's long active flight season (from March/April through October). The rusty patched bumble bee is one of the first bumble bees to emerge early in the spring and the last to go into hibernation, so to meet its nutritional needs, the species relies on a diverse composite of food and shelter.

Selected OPC Natives:

Agastache foeniculum - Giant Hyssop
Echinacea pallida 'Hula Dancer' - Pale Purple Coneflower
Echinacea paradoxa - Yellow Coneflower
Helianthus salicifolius - Willow-Leaved Sunflower
Monarda fistulosa - Wild Bergamot

Selected OPC Herbs:

Asparagus officinalis - Asparagus
Fragaria virginiana - Scarlet Strawberry



PAINTED LADY BUTTERFLY (GENERALIST)

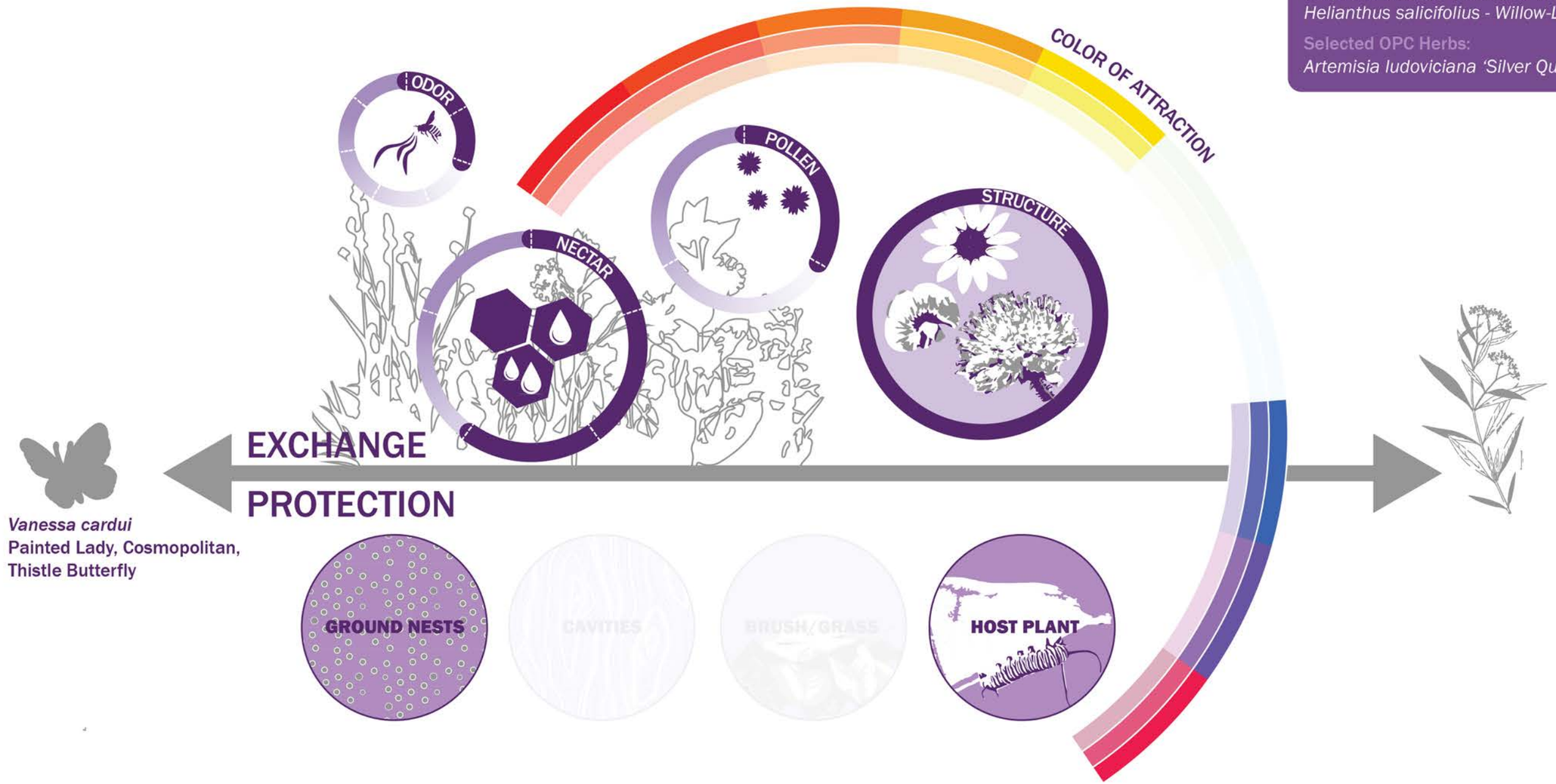
Painted Lady Butterflies are habitat generalists that rely on plant species for both food and shelter. Larvae shelter in silk tents and feed off of host plants such as mallow and thistle. Once in the adult stage, Painted Ladies consume nectar from plants such as asters, cosmos, blazing star, ironweed, joe-pye weed and milkweed. On heavy overcast days, Painted Ladies huddle in small depressions in the ground.

Selected OPC Natives:

Echinacea pallida 'Hula Dancer' - Pale Purple Coneflower
Echinacea paradoxa - Yellow Coneflower
Echinops ritro - Small Globe Thistle
Eurybia x herveyi - Hervey's Aster
Helianthus salicifolius - Willow-Leaved Sunflower

Selected OPC Herbs:

Artemisia ludoviciana 'Silver Queen' - Silver Queen Artemesia



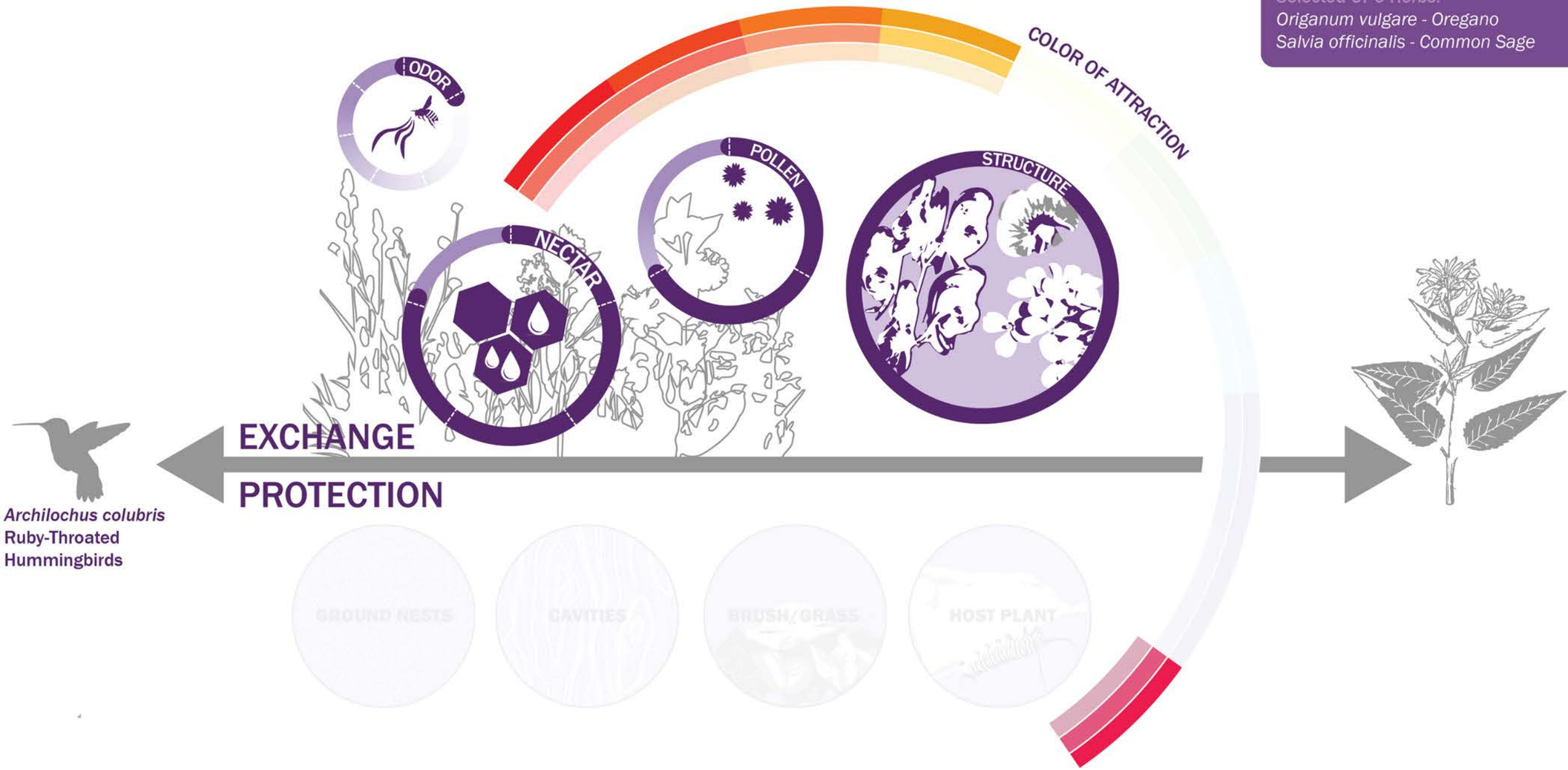
Vanessa cardui
Painted Lady, Cosmopolitan, Thistle Butterfly

RUBY-THROATED HUMMINGBIRDS (GENERALIST & SPECIALIST)

Ruby-Throated Hummingbirds are considered both specialists and generalists. They are adapted to a broad geographical range but mostly eat nectar and tiny insects. Some scientists have noted a correlation between the tubular shape of certain flowers and the length and shape of a hummingbird's bill. Unlike some other pollinators, they will not nest near the food source; instead nesting on tree branches along their migration corridor. Due to the corridor ranging thousands of miles in habitat, they rely on abundant supplies of nectar for their energy. Wildflowers that appeal most to hummingbirds include species with red or orange coloration.

Selected OPC Natives:
Agastache foeniculum - Giant Hyssop
Monarda fistulosa - Wild Bergamot
Salvia officinalis - Common Sage

Selected OPC Herbs:
Origanum vulgare - Oregano
Salvia officinalis - Common Sage

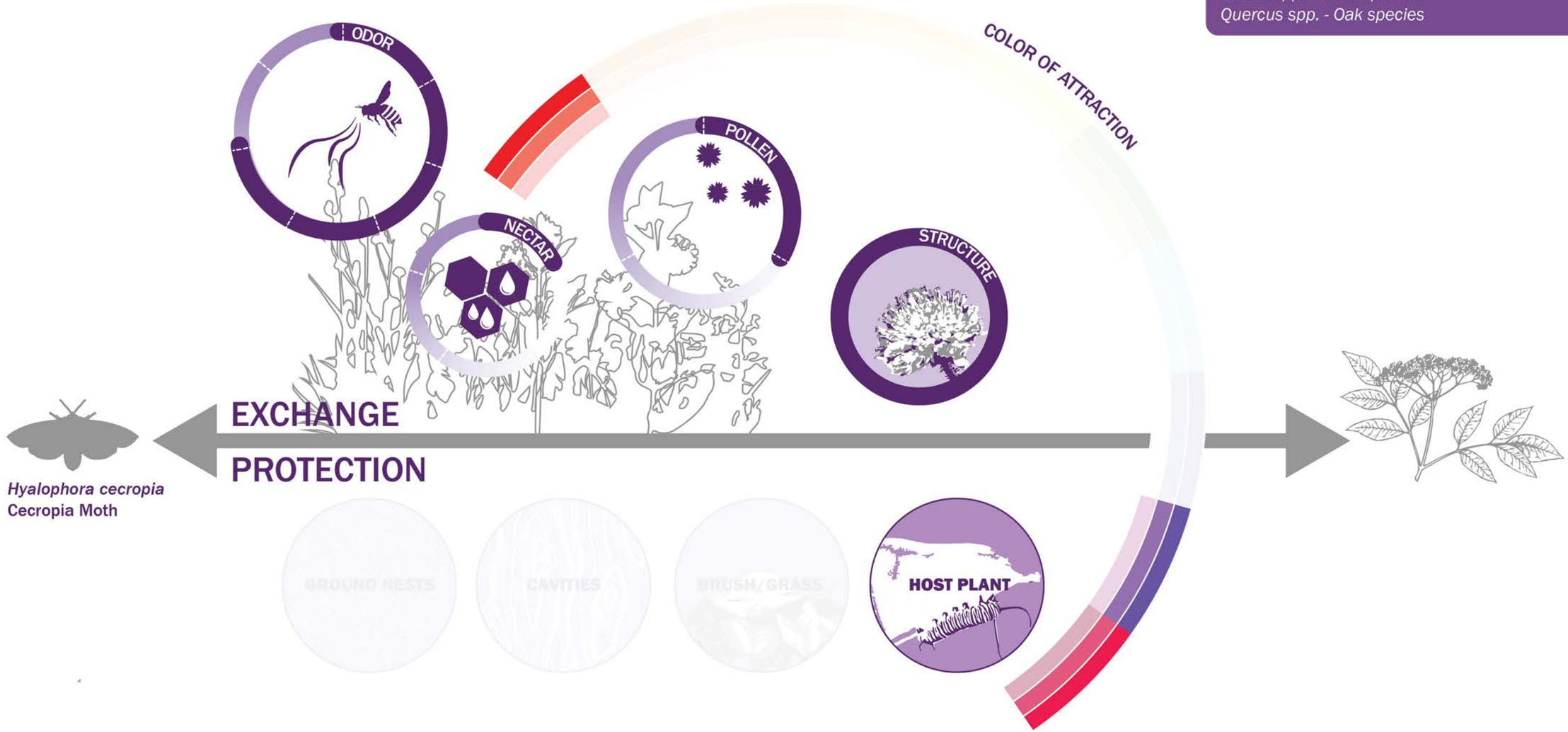


CECROPIA MOTH (GENERALIST)

Cecropia Moth's are habitat generalists that 'accidentally' pollinate by picking up pollen on their legs and wings when they visit flowers and depositing them on subsequent floral visits based on odor, structure and color. Only the larvae within this species feeds on host plants throughout the late summer. Adult moths do not feed on nectar, instead having a sole purpose to mate and lay eggs.

Selected OPC Herbs:
Fragaria virginiana - Scarlet Strawberry

Selected OPC Host:
Acer spp. - Acer species
Betula spp. - Birch species
Quercus spp. - Oak species



Hyalophora cecropia
Cecropia Moth

RED-NECKED FALSE BLISTER BEETLE (GENERALIST)

Avid pollen eaters, this group of beetles relies on pollen for food and species reproduction. Both sexes feed on pollen, which acts as an attractant for mating on flower heads. In order for the female to accept the male, her gut must be packed full of pollen. She then stores the pollen in a special intestinal sack in which an enzyme causes the pollen to partially germinate, this causes the indigestible covering of the pollen grain to rupture. After digesting the contents of the pollen grain, she uses them to manufacture eggs. A young larvae will bore tunnels into decomposed wood for shelter. Once at the adult stage, the Beetle will feed on flowers and leaves of plants of such diverse families such as the Asteraceae, Fabaceae, Lilicaea and Solanaceae.

Selected OPC Natives:
Veronicastrum virginicum 'Lavendelturm' - Culver's Root

Selected OPC Herbs:
Cenolophium denudatum - Baltic Parsley
Fragaria virginiana - Scarlet Strawberry

FLOWER FLY (GENERALIST)

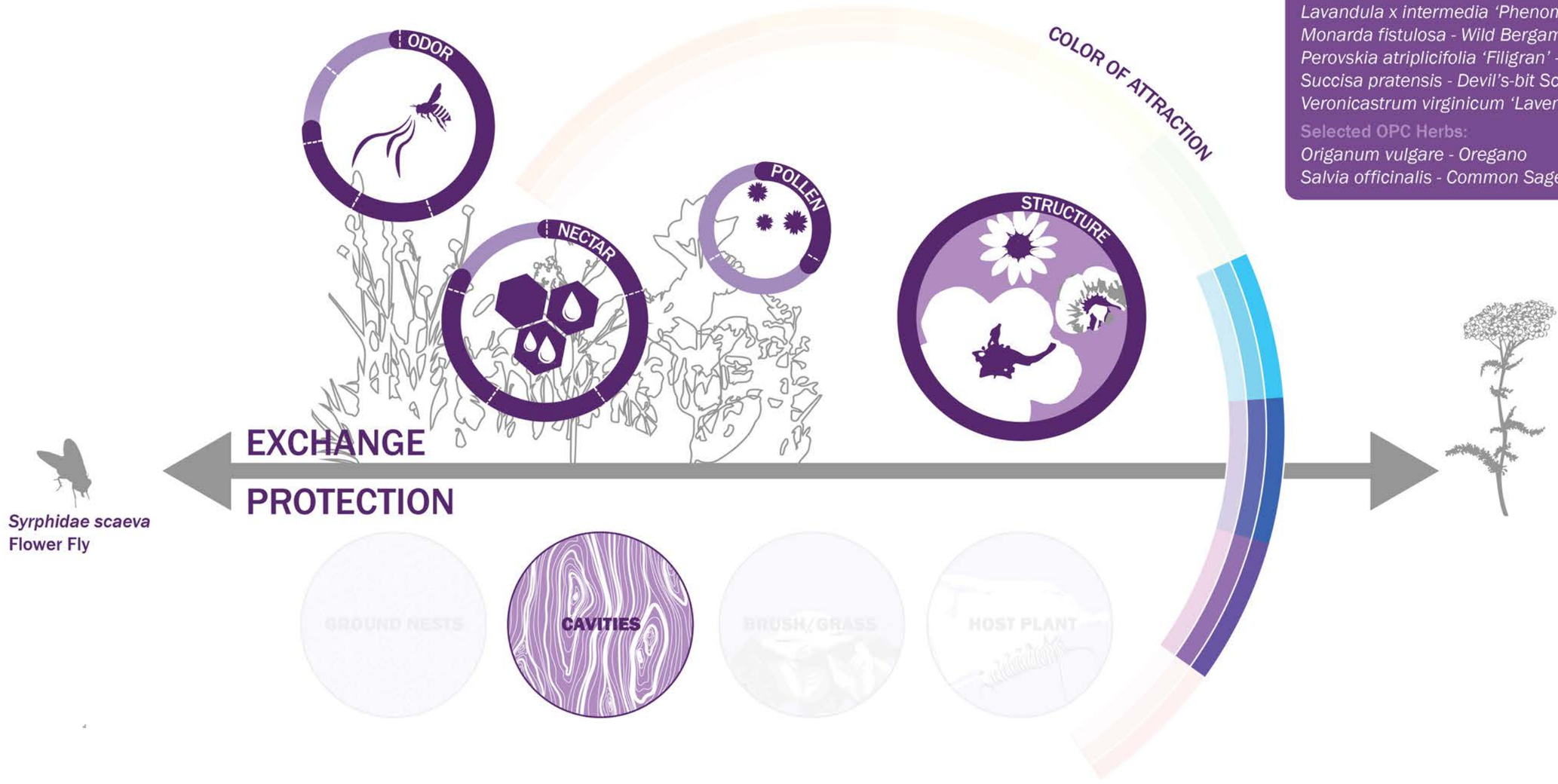
Each Flower Fly species has special mouth features that help reach the nectar in different shapes of flowers, making pollinating easier and quicker for a broader range of plant life. The adult Flower Fly is attracted to flowers based on odor and color, enjoying putrid-smelling blossoms and dark-colored blooms. Both adult and larvae Flower Flies are beneficial to the plant community; the adults feed on nectar, and the larvae feed on harmful insects like aphids and small caterpillars.

Selected OPC Natives:

Agastache foeniculum - Giant Hyssop
Echinacea pallida 'Hula Dancer' - Pale Purple Coneflower
Echinops ritro - Small Globe Thistle
Eurybia x herveyi - Hervey's Aster
Lavandula x intermedia 'Phenomenal' - Phenomenal Lavendar
Monarda fistulosa - Wild Bergamot
Perovskia atriplicifolia 'Filigran' - Russian Sage
Succisa pratensis - Devil's-bit Scabious
Veronicastrum virginicum 'Lavendelturm' - Culver's Root

Selected OPC Herbs:

Origanum vulgare - Oregano
Salvia officinalis - Common Sage



RED WOOD ANT (GENERALIST)

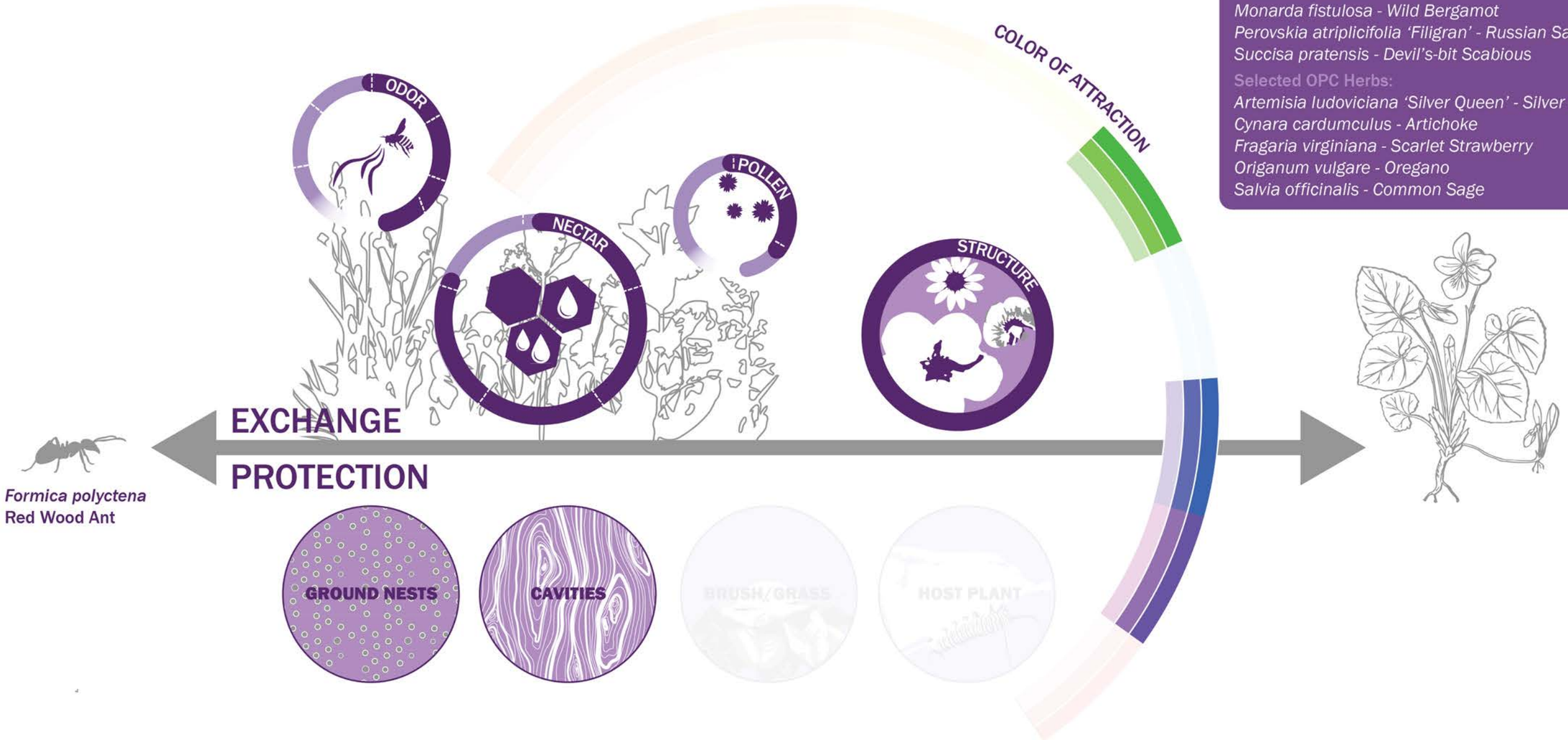
As one of the most abundant groups of insects, Red Wood Ants have the opportunity to become quick and busy pollinators. Though most ants do not make excellent pollinators because they are low to the ground and are not efficient at carrying pollen, some ants like the redwood ant will visit flowering plants to hunt other insects and collect nectar. Some plants will secrete unique nectar to attract ants and often have specialized glands for the ants to locate.

Selected OPC Natives:

Agastache foeniculum - Giant Hyssop
Echinacea pallida 'Hula Dancer' - Pale Purple Coneflower
Echinacea paradoxa - Yellow Coneflower
Eurybia x herveyi - Hervey's Aster
Monarda fistulosa - Wild Bergamot
Perovskia atriplicifolia 'Filigran' - Russian Sage
Succisa pratensis - Devil's-bit Scabious

Selected OPC Herbs:

Artemisia ludoviciana 'Silver Queen' - Silver Queen Artemesia
Cynara cardumculus - Artichoke
Fragaria virginiana - Scarlet Strawberry
Origanum vulgare - Oregano
Salvia officinalis - Common Sage



Formica polyctena
Red Wood Ant

PAPER WASP (GENERALIST)

Like bees, wasps are one of the most engaged pollinators. Though their hairless bodies make it more challenging to pollinate, their active lifestyles make it essential to collect pollen in order to survive. The paper wasp is attracted to flowering perennials that are orange, yellow, and green but will get its pollen and nectar from a range of plants. The plant material is not only crucial for providing an energy source, but the paper wasp also uses dead wood and plant stems to create its nest. This nest is where they will lay their eggs and store some nectar byproduct which their larvae will eat.

Selected OPC Natives:

Echinacea paradoxa - Yellow Coneflower
Echinops ritro - Small Globe Thistle
Euryvia x herveyi - Hervey's Aster
Helianthus salicifolius - Willow-Leaved Sunflower
Monarda fistulosa - Wild Bergamot
Perovskia atriplicifolia 'Filigran' - Russian Sage

Selected OPC Herbs:

Asparagus officinalis - Asparagus
Salvia officinalis - Common Sage

OBAMA PRESIDENTIAL CENTER

Reinforcing Landscape Ecology

DESIGN DEVELOPMENT

APPENDIX

STORMWATER SOURCES:

CITY OF CHICAGO STORMWATER ORDINANCE

- City of Chicago , and Dept. of Water Management. Stormwater Management Ordinance Manual. Jan. 2016, https://www.chicago.gov/content/dam/city/depts/water/general/Engineering/SewerConstStormReq/2016StormwaterManual.pdf.
- City of Chicago, and Department of Water Management. 2016 REGULATIONS FOR SEWER CONSTRUCTION AND STORMWATER MANAGEMENT. Jan. 2016, https://www.chicago.gov/content/dam/city/depts/water/general/Engineering/SewerConstStormReq/2016StormwaterRegulations.pdf.

LEED + SITES REQUIREMENTS

- LEED v4. “Rainwater Management.” USGBC, https://www.usgbc.org/credits/neighborhood-development-plan-neighborhood-development/v4-draft/gibc-7.
- Seliem, Karema. “How LEED Works to Manage Stormwater.” LEED, USGBC, 21 Oct. 2019, https://www.usgbc.org/articles/how-leed-works-manage-stormwater.
- Sustainable SITES Initiative. SITES v2 Rating System For Sustainable Land Design and Development. 2014, https://www.asla.org/uploadedFiles/CMS/AboutJoin/Copy of SITESv2_Scorecard Summary.pdf.

TREE + SOIL BIOLOGY SOURCES:

SUPPORTING DATA - MYCORRHIZAL INOCULANT

- In a study by Haro et. al. 2017, it was concluded that cowpea productivity was significantly improved by dual inoculation with native rhizospheric microbes and mycorrhizal strains, reaching the same level as the application of commonly used synthetic fertilizers.
- Morrison et. al. 2017, researchers found that “mycorrhizal inoculation increases genes associated with nitrification and improved nutrient retention in soil” in a maize rhizosphere and hyphosphere (fungal hyphae zone).
- Teste 2016 and Koziol and Bever 2017, concluded that native arbuscular fungi were the driving force on the restoration of grasslands by increasing plant diversity and succession.
- Disturbed or new engineered soils used in urban landscapes are usually devoid of active or beneficial microbes or mycorrhizal fungi necessary for the establishment of new vegetation. This usually leads to failures of the new landscape. Soil transfer has been used as a practical application to restore or accelerate the establishment of new plantations. Amaranthus and Perry 1989, found that soil from well stocked plantations of Douglas fir into seedling planting holes on old non-reforested clear-cuts rapidly stimulated root-tip formation, abundant mycorrhiza formation, and seedling survival.

REFERENCES

- Amaranthus, M.P.; Perry, D.A. 1987. Effect of soil transfer on ectomycorrhiza formation and the survival and growth of conifer seedlings on old, nonreforested clear-cuts. Canadian Journal of Forest Research 17:944-950.
- Amaranthus, M.P.; Perry, D.A. 1989. Rapid root tip and mycorrhiza formation and increased survival of Douglas-fir seedlings after soil transfer. New Forests 3. Research Notes.
- Amaranthus, M.P.; Page-Dumroese, D.; Harvey, A.; Cazares, E.; Bednar, L.F. 1996. Soil compaction and organic matter affect conifer seedling nonmycorrhizal and ectomycorrhizal root tip abundance and diversity. Res. Pap. PNW-RP-494. Portland, OR:U.S. Department of Agriculture, Forest Service, PNW Research Station. 12 p.
- Amaranthus, M. P., E. Cázares and D. Perry. 1998. The role of soil organisms in restoration. Gen. Tech. Rep. PNW-GTR-461. Portland, OR; U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 179-189.
- Brundrett MC. 1991. Mycorrhizas in natural ecosystems. In: Macfayden A, Begon M, Fitter AH, eds. Advances in ecological research, vol. 21. London, UK: Academic Press, 171 – 313.
- Harley, J. L. and S. E. Smith. 1983. Mycorrhizal Symbiosis. Academic Press, London.
- Haro, Hadou, Kadidia Sanon, Christine Le Roux, Robin Duponnois, and Alfred Traoré. 2017.
- Improvement of cowpea productivity by rhizobial and mycorrhizal inoculation in Burkina Faso. Symbiosis 74: 107-120.
- Morrison, E., L. Lagos, A. Al-Agely, H. Glaab, Winston Johnson, Milko Jorquera, and A. Ogram. 2017. Mycorrhizal inoculation increases genes associated with nitrification and improved nutrient retention in soil. Biology and Fertility of Soils 53: 275-279.
- Teste, F. 2016. Restoring grasslands with arbuscular mycorrhizal fungi around remnant patches. Applied Vegetation Science. 19:3-4.
- Trappe, J. M. 1987. Phylogenetic and ecologic aspects of mycotrophy in the angiosperms from an evolutionary standpoint. In Safir, G. R. (ed), Ecophysiology of VA mycorrhizal plants. CRC Press, Boca Raton, Florida, pp. 2-25.
- Council of Tree and Landscape Appraisers (CTLA). 2000. Guide for Plant Appraisal, 9th Edition. International Society of Arboriculture, Champaign, IL. 143 pp.

IMAGES

- Columbian Gallery. A Portfolio of Photographs of the World’s Fair. The Werner Company, 1894.
- Dedicatory and Opening Ceremonies of the World’s Columbian Exposition. Historical and Descriptive. as authorized by Board of Control. page 87, 89. Stone, Kastler & Painter, 1893.
- The Chicago World’s Fair of 1873. A Photographic Record. Photos from the Collections of the Avery Library of Columbia University and the Chicago Historical Society. Image 68, 74, 75. Dover Publications, 1980.
- Nurse Logs. (n.d.). Retrieved from https://temperaterainforest101.weebly.com/nurse-logs.html.

BIODIVERSITY SOURCES:

GENERAL INFORMATION

- Duraiappah, A. K., Naeem, S., & Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-being (J. Sarukhan & A. Whyte, Eds.). *Biodiversity Synthesis.* Retrieved September 6, 2018, from http://www.millenniumassessment.org/documents/document.354.aspx.pdf
- Kumar, A. (n.d.). *Concept and Characteristics of Biodiversity.* Lecture. Retrieved September 6, 2018, from https://www.slideshare.net/Anilkumar2120/concept-and-characteristics-of-biodiversity
- McLendon, R. (2018, April 26). 5 reasons why biodiversity is a big deal. Retrieved September 6, 2018, from https://www.mnn.com/earth-matters/wilderness-resources/blogs/why-biodiversity-big-deal

TAXONOMIC SCHEME

- Bartlett Tree Experts. (2015). *Jackson Park Tree Inventory & Management Plan* (pp. 26-27, Rep.). Bolingbrook, IL: Bartlett Inventory Solutions.

FUNCTIONAL TRAITS

- Anna Lawrence; William Hawthorne (2006). *Plant Identification: Creating User-friendly Field Guides for Biodiversity Management.* Routledge. pp. 138–. ISBN 978-1-84407-079-4.
- Levine, Carol. 1995. *A guide to wildflowers in winter: herbaceous plants of northeastern North America.* New Haven: Yale University Press. page 1.
- Martin, Franklin; Sherman, Scott (2007). "*Agroforestry principles*" (PDF). Echo technical notes. Retrieved 06 September 2018.
- Patrick Whitefield (2002). *How to Make a Forest Garden.* Permanent Publications. pp. 113–. ISBN 978-1-85623-008-7.
- Petit, Rémy J.; Hampe, Arndt (2006). "Some Evolutionary Consequences of Being a Tree" (PDF). Annual Review of Ecology, Evolution, and Systematics. 37: 187–214.
- Solomon, E.P.; Berg, L.R.; Martin, D.W. (2004). Biology. Brooks/Cole Thomson Learning. ISBN 978-0-534-49547-3.
- *Trees and Ecosystem* (pp. 1-3, Issue brief No. 10632). (n.d.).Washington,DC: American Forests.
- Flora of the British Isles, Clapham, Tutin, and Warburg, 2nd edition
- Revolvy, L. (n.d.). *Herbaceous plant.* Retrieved from https://www.revolvy.com/page/Herbaceous-plant
- Revolvy, L. (n.d.). *Shrub.* Retrieved from https:// www.revolvy.com/page/Shrub
- Revolvy, L. (n.d.). *Tree.* Retrieved from https:// https://www.revolvy.com/page/Tree

COMMUNITY VALUE

- 5 Ways Amphibians and Reptiles Impact Our Planet. (2015, December 1). Retrieved from https://gladitood.com/blog/5waysamphibiansandreptilesimpactourplanet
- CityofChicago.org. (n.d.). *Birds of Chicago.* Retrieved from http://ilbirds.com/Environment/BirdMigration/sub/birds_of_chicago.html
- Ecological Landscape Management. (2018). *Obama Presidential Center Soil Biology and Existing Tree Assessment* (Rep.). Smithtown, NY.
- Friends of the Chicago River. (n.d.). Herps and Bugs. Retrieved from https://www.chicagoriver.org/about-the-river/river-ecology-and-wildlife/herps-and-bugs
- INHS Publications. (n.d.). *Insects.* Retrieved from http://wwx.inhs.illinois.edu/outreach/animals/insects/
- INHS Publications. (n.d.). *Invertebrates.* Retrieved from http://wwx.inhs.illinois.edu/outreach/animals/inverts/
- Zachariah, T., & Mitchell, M. A. (2009). *Invertebrates.* In Manual of Exotic Pet Practice (pp. 11-38). Elsevier Inc.. DOI: 10.1016/B978-141600119-5.50006-8

GENE SEQUENCES

- Acer Campestre. (n.d.). Retrieved from http://treeandlandscape.ie/Tree-A-Z/field-maple-acer-campestre.html
- Ailanthus altissima. (n.d.). Retrieved from https://www.fs.fed.us/database/feis/plants/tree/ailalt/all.html
- Autumn Blaze® Maple. (n.d.). Retrieved from https://www.chicagobotanic.org/plantinfo/tree_alternatives/autumn_blaze_maple
- Average Lifespans for Garden Trees. (2018, August 04). Retrieved from https://laidbackgardener.blog/2017/08/27/average-lifespan-for-garden-trees/
- British Hardwood Tree Nursery. (n.d.). *Tree Life Expectancy.* Retrieved September 6, 2018, from http://www.britishhardwood.co.uk/tree-life-expectancy/67/
- Chinquapin Oak. (n.d.). Retrieved from http://www.wimbishtreefarm.com/index_files/ChinquapinOak.htm
- City of Tacoma Environmental Services Department. (n.d.). (Rep.). Retrieved from http://cms.cityoftacoma.org/surfacewater/UrbanForestManual/APPENDIX 7.pdf
- Dirr, M. (1983). *Manual of Woody Landscape Plants.* Champaign, IL: Stipes Publishing.
- GoldenraintreeKoelreuteria paniculata. (n.d.). Retrieved from https://www.arborday.org/trees/treeguide/treedetail.cfm?itemID=841
- Sassafras. (n.d.). Retrieved from https://sites.google.com/site/sassafrastho/
- Illinois Wildflowers. (n.d.). Woodland. Retrieved from http://illinoiswildflowers.info/woodland/woodland_index.htm
- Loehle, C. (1988). "*Tree life history strategies: the role of defenses.*" Canadian Journal of Forest Research 18(2): 209-222.
- Minnesota Tree Resources. (n.d.). Kentucky coffee-tree. Retrieved from http://www.mntreeresources.com/kentucky-coffee-tree.html
- Minnesota Tree Resources. (n.d.). Japanese tree lilac. Retrieved from http://www.mntreeresources.com/japanese-tree-lilac.html
- Missouri Botanical Garden. (n.d.). Plant Finder. Retrieved from http://www.missouribotanicalgarden.org/plantfinder/plantfindersearch.aspx
- Native Tree Society. (n.d.). Basswood longevity. Retrieved from http://www.nativetreesociety.org/species/sp_threads/basswood_longevity.htm
- Plant Information. (n.d.). Retrieved from https://www.chicagobotanic.org/plantinfo/
- Prairie Horizon Alder (Alnus hirsuta 'Harbin') at Gertens. (n.d.). Retrieved from http://plants.gertens.com/12070009/Plant/4299/Prairie_Horizon_Alder
- Spengler, T. (2016, October 07). Estimated Lifespan of an Ash Tree. Retrieved from https://homeguides.sfgate.com/estimated-lifespan-ash-tree-95985.html
- Revolvy, L. (n.d.). Morus alba. Retrieved from https://www.revolvy.com/topic/Morus alba&item_type=topic

EVOLVING CHARACTERISTICS & LONG-TERM FUNCTION

See the following citations:

- Bartlett Tree Experts (under Taxonomic Scheme)
- Ecological Landscape Management (under Community Value)

BIRD HABITAT SOURCES:

INTERNATIONAL DARK SKY ASSOCIATION (IDA)

- **IDA Approved Dark Sky Friendly Lighting:**
  http://darksky.org/fsa/retailers/
  http://darksky.org/fsa/
- **IDA Wildlife Effects:**
  http://darksky.org/light-pollution/wildlife/
- **The Chicago Alley Lighting Project:**
  http://darksky.org/wp-content/uploads/2014/09/Chicago-Alley-Lighting-Project.pdf
- **Artificial Light at Night (ALAN) Research Literature Database:**
  http://alandb.darksky.org/

COLOR TEMPERATURE

- **National Audubon Society:**
  http://www.audubon.org/magazine/may-june-2013/what-makes-bird-vision-so-cool

- **American Bird Conservancy:**
  http://collisions.abcbirds.org/
  http://collisions.abcbirds.org/pdf/Birds_and_light_bibliography_Feb2014.pdf

- ***Poot**, H., B. J. Ens, H. de Vries, M. A. H. Donners, M. R. Wernand, and J. M. Marquenie, 2008. Green light for nocturnally migrating birds. Ecology and Society*
  https://www.ecologyandsociety.org/vol13/iss2/art47/

- ***Wiltschko**, Roswitha, Katrin Stapput, Hans-Joachim Bischof and Wolfgang Wiltschko, 2007. Light-dependent magnetoreception in birds: increasing intensity of monochromatic light changes the nature of the response. Front Zool. 2007*
  https://frontiersinzoology.biomedcentral.com/articles/10.1186/1742-9994-4-5

SITE/LANDSCAPE & ARCHITECTURAL FEATURES

- **Bird-Friendly Building Design Guide:**
  https://abcbirds.org/wp-content/uploads/2015/05/Bird-friendly-Building-Guide_LINKS.pdf
- **LEED Credit55 & Threat Factor Ratings:**
  https://www.usgbc.org/credits/core-shell-existing-buildings-healthcare-new-construction-retail-nc-schools/v2009/pc55
  https://www.usgbc.org/sites/default/files/Threat%20factor%20values%20%204%2019%202016.pdf

LIGHTS OUT PROGRAM

- **National Audubon Society:**
  http://chicagoaudubon.org/content/lights-out-0
- **City of Chicago:**
  https://www.cityofchicago.org/city/en/progs/env/lights_out_chicago.html
- **American Bird Conservancy:**
  http://collisions.abcbirds.org/light.html
- **McCormick Place Case Study:**
  https://www.eurekalert.org/pub_releases/2002-05/fm-tob050802.php

POLLINATORS SOURCES:

GENERAL INFORMATION

- Bees & Beyond. (2019). Retrieved from https://www.chicagobotanic.org/beesandbeyond
- Bring Back the Pollinators: 5 Ways to Increase Nesting Habitat for Native Bees. (2017). Retrieved from https://xerces.org/2017/03/17/bring-back-the-pollinators-5-ways-to-increase-nesting-habitat-for-native-bees/
- Million Pollinator Garden Challenge. (2019). Home - Million Pollinator Garden Challenge. Retreived from http://millionpollinatorgardens.org/
- Pollinators. (2019). Retrieved from https://www.chicagobotanic.org/pollinators
- Pollinator Gardens.org. (2019). Designing Pollinator-Friendly Landscapes. Retrieved from https://pollinatorgardens.org/2016/01/12/design-ideas-for-gardeners/
- Pollinator Plants Midwest Region (2014). Designing Pollinator-Friendly Landscapes. Retrieved from https://xerces.org/wp-content/uploads/2014/09/MidwestPlantList_web.pdf
- The Importance of Pollinators. (n.d.) Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/pa/plantsanimals/?cid=nrcs142p2_018171

POLLINATORS

- All About Birds Guide. (n.d.). Retrieved from *https://www.allaboutbirds.org/guide/Palm_Warbler/id*
- Cedar Waxing. (n.d.). Retrieved from *https://www.audubon.org/field-guide/bird/cedar-waxwing*
- Flower Flies. (n.d.). Retrieved from *https://www.fs.fed.us/wildflowers/pollinators/pollinator-of-the-month/flower_flies.shtml*
- *Hicks DM, Ouvrard P, Baldock KCR, Baude M, Goddard MA, Kunin WE, et al. (2016) Food for Pollinators: Quantifying the Nectar and Pollen Resources of Urban Flower Meadows. PLoS ONE 11(6): e0158117. https://doi.org/10.1371/journal.pone.0158117*
- *Johnston, J. (2016, October 2). Habitat Feature: Logs. Retrieved from https://content.yardmap.org/learn/logs/*
- Monarch Butterfly. (n.d.). Retrieved from *https://www.nps.gov/articles/monarch-butterfly.htm*
- *Nesting Habitat. (2014, April 15). Retrieved from http://greatpollinatorproject.org/management/nesting-habitat*
- Perennials for Pollinators. (2017). Retrieved from https://www.mortonarb.org/news/perennials-pollinators
- Pollinator of the Month. (n.d.). Retrieved from *https://www.fs.fed.us/wildflowers/pollinators/pollinator-of-the-month/hawk_moths.shtml*
- Ruby Throated Hummingbird. (n.d.). Retrieved from https://www.fs.fed.us/wildflowers/pollinators/pollinator-of-the-month/ruby-throated_hummingbird.shtml
- Rusty Patched Bumble Bee. (n.d.). Retrieved from https://www.fws.gov/pollinators/Features/rusty_patched_bumble_bee.html

CROP POLLINATION

- (2017). Retrieved from Bee Aware: https://beeaware.org.au/pollination/pollinator-reliant-crops/onions/
- Attractive Pollinators to Your Garden. (2011). Retrieved from U.S. Fish & Wildlife Service: https://www.fws.gov/pollinators/pdfs/pollinatorbookletfinalrevweb.pdf
- BeeAware. (2019). BeeAware. Retrieved from www.beeaware.org.: https://beeaware.org.au/pollination/pollinator-reliant-crops/onions/
- cals.arizona.edu. (2019). cals.arizona.edu. Retrieved from Broccoli Seed: https://cals.arizona.edu/fps/sites/cals.arizona.edu.fps/files/cotw/Broccoli_Seed.pdf
- Gardenia. (2019). Gardenia creating- Garden. Retrieved from www.gardenia.net: https://www.gardenia.net
- Kazuhiro Takemoto, M. I. (2019). Pollination Network. Encyclopedia of Bioinformatics and Computational Biology, Pages 1131-1141. Retrieved from Science Direct: https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/pollination-network
- Mahr, S. (2008). Calendula, Calendula officinalis. Retrieved from University of Wisconsin, Master Gardner Program: https://wimastergardener.org/article/calendula-calendula-officinalis/
- Missouri Botanic Garden. (2019). Plant help. Retrieved from Missouri Botanic Garden: http://www.missouribotanicalgarden.org
- ModernAg. (2019). The Economics of Insect Pollination. Retrieved from https://modernag.org/biodiversity/beeconomy-economic-value-pollination/
- Richard J. Gill, .. S. (2016). Ecosystem Services: From Biodiversity to Society, Part 2. Advances in Ecological Research.
- Seed Saving Guideline No. 11 Radishes. (2016). Retrieved from Garden Organic: https://gardenorganic.org.uk/sites/www.gardenorganic.org.uk/files/resources/hsl/11_Radishes.pdf
- Sweet Violet. (n.d.). Retrieved from http://www.luontoportti.com/suomi/en/kukkakasvit/sweet-violet
- Veggieharvest.com. (2008-2019). Veggie Harvest- Your Definitive Source for Vegetable and Herb Gardening Information. Retrieved from Veggieharvest.com: https://veggieharvest.com/vegetables/