

Evaluating long term ecological performance in DC's residential rain gardens

Water Science and Policy Seminar — March 18, 2026

Emma Ruggiero, Water Science and Policy PhD student

Dr. Carolyn Voter, Assistant Professor in Civil and Environmental Engineering



Rain Garden:

A form of green stormwater infrastructure (GSI) that uses grading, vegetation, and engineered soils to infiltrate storm water in place before it runs off, so that it doesn't contribute to flooding or pollution.

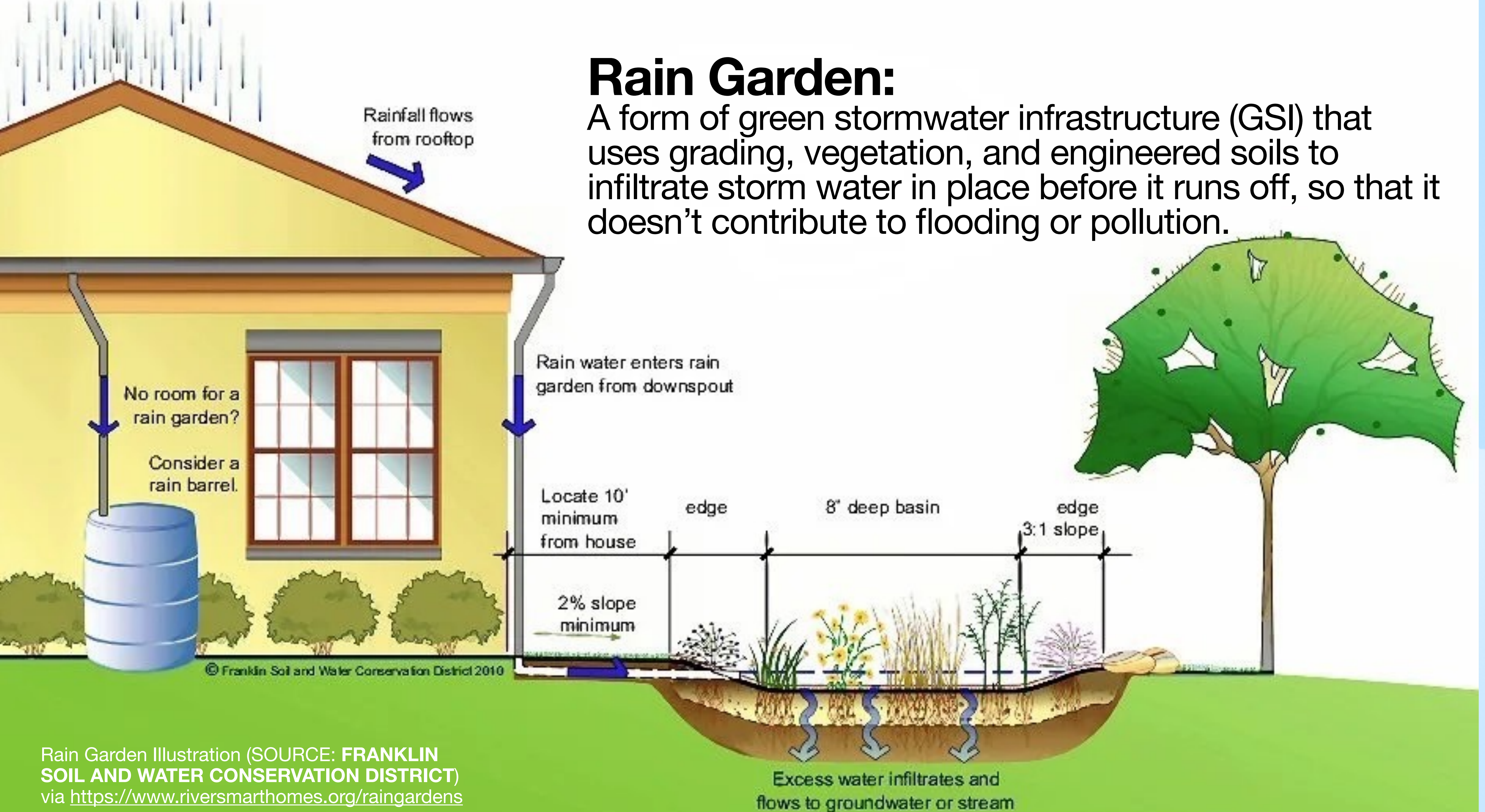
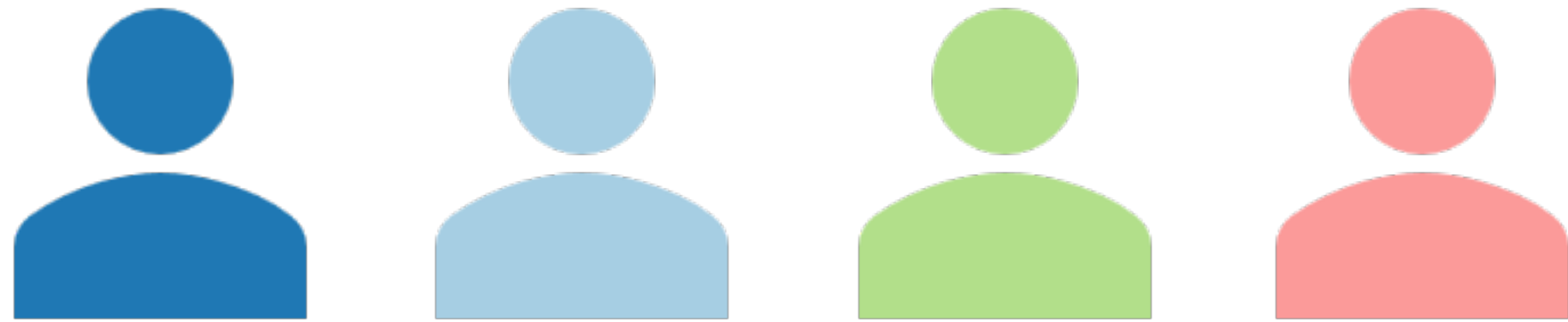




Image via VA Association of Soil &
Water Conservation Districts
<https://vaswcd.org/rain-garden/>

Why Study Aging GSI?



Chesapeake Bay stormwater professionals
(private consulting, gov't, community groups, nonprofits, etc.)

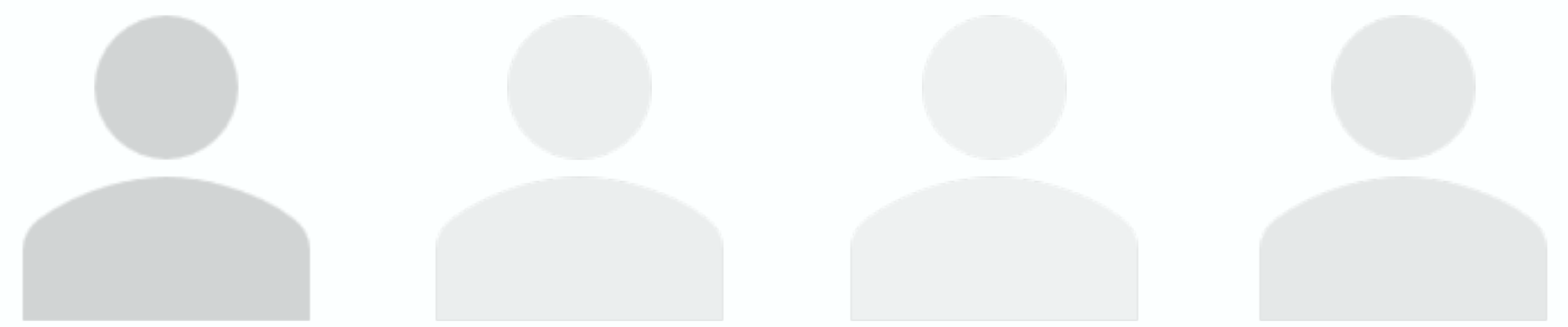


1. Insufficient funding
2. Lack of stakeholder buy-in
3. Poor plant selection and management



For more information, see: [Voter, C. B., Nixon, R., Imhoff, P., Slocum, A., Zobel, R., and Hu, Y. \(2024\). Effective and Equitable Green Stormwater Infrastructure in the Chesapeake Bay: Current Challenges and Next Steps. University of Delaware.](#)

Why Study Aging GSI?



Chesapeake Bay stormwater professionals
(private consulting, gov't, community groups, nonprofits, etc.)

#1
Maintenance of GSI is emerging as top concern.

1. Insufficient funding
2. Lack of stakeholder buy-in
3. Poor plant selection and management

For more information, see: Voter, C. B., Nixon, R., Imhoff, P., Slocum, A., Zobel, R., and Hu, Y. (2024). Effective and Equitable Green Stormwater Infrastructure in the Chesapeake Bay: Current Challenges and Next Steps. University of Delaware.

Literature Gaps

- **Age** — very few studies on rain garden performance past 5 years
- **Focus** — most on water quality or quantity, lacking ecologic and social influence



Application

- Help meet stormwater **regulations**
- Improve **design** / siting
- Determine **maintenance requirements** + enhance **cost-effectiveness**
- Inform **policy**
- **Plan** for future change

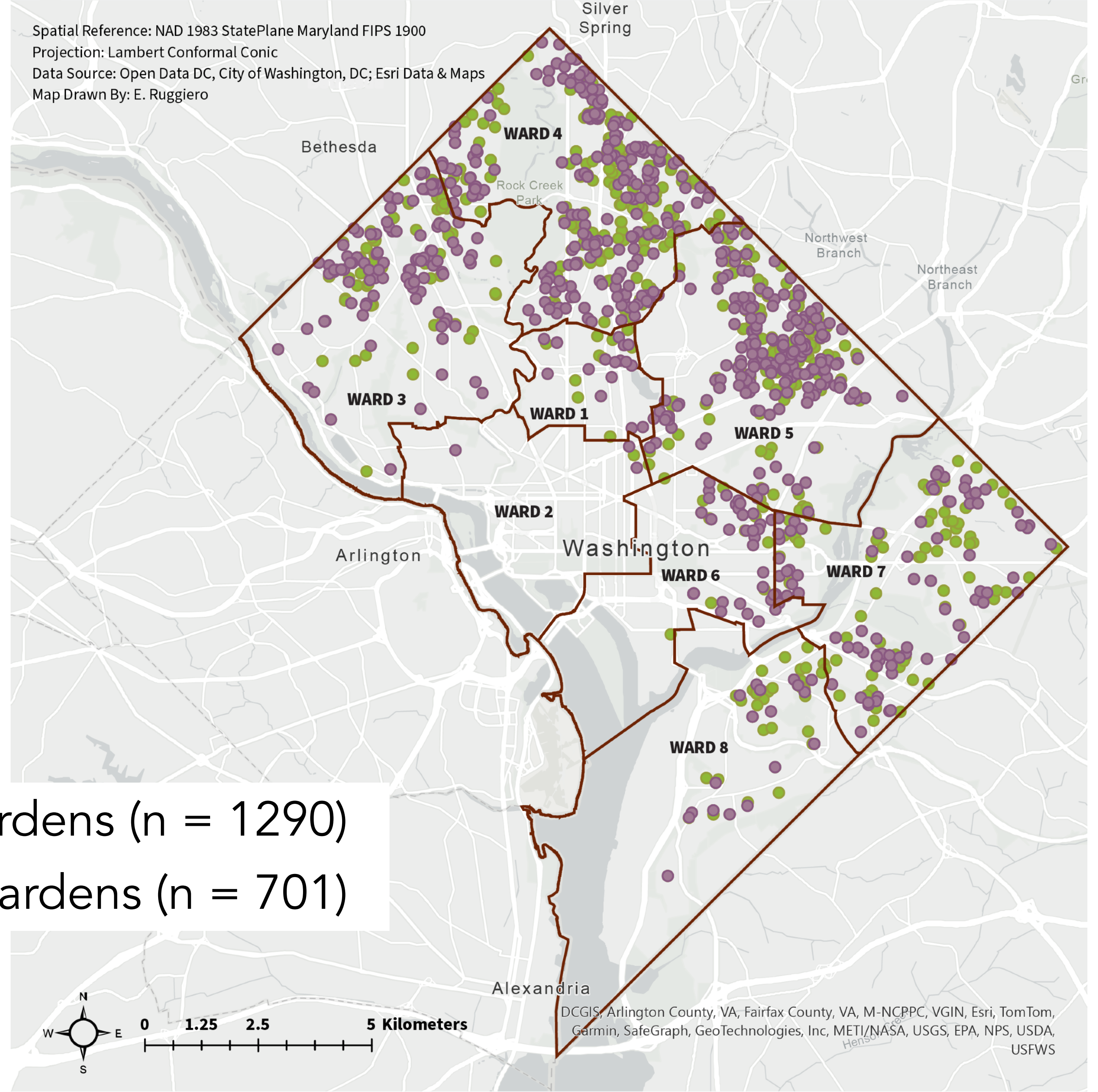
Why Ecology:

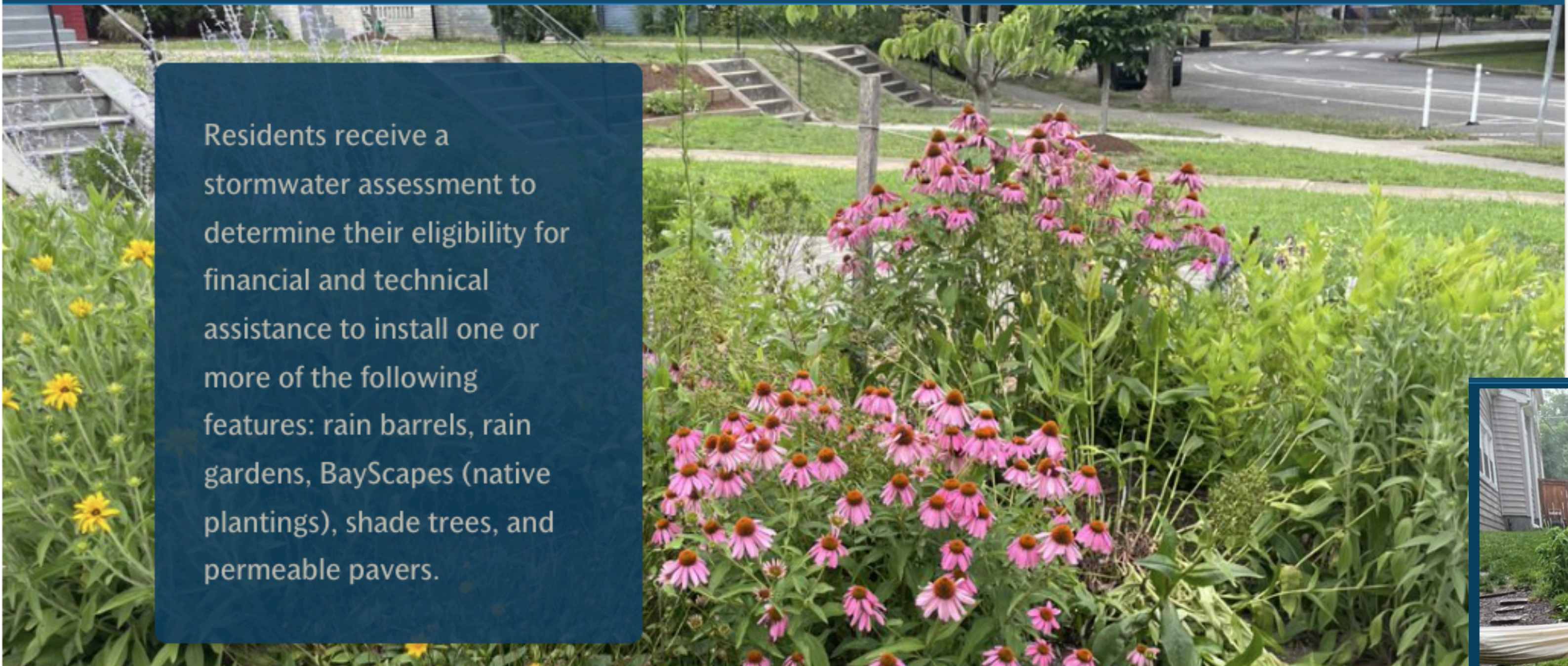
- Vegetation drives infiltration function, erosion control, aesthetics, habitat
- Performance will reflect maintenance behaviors and changing site conditions

Study Area

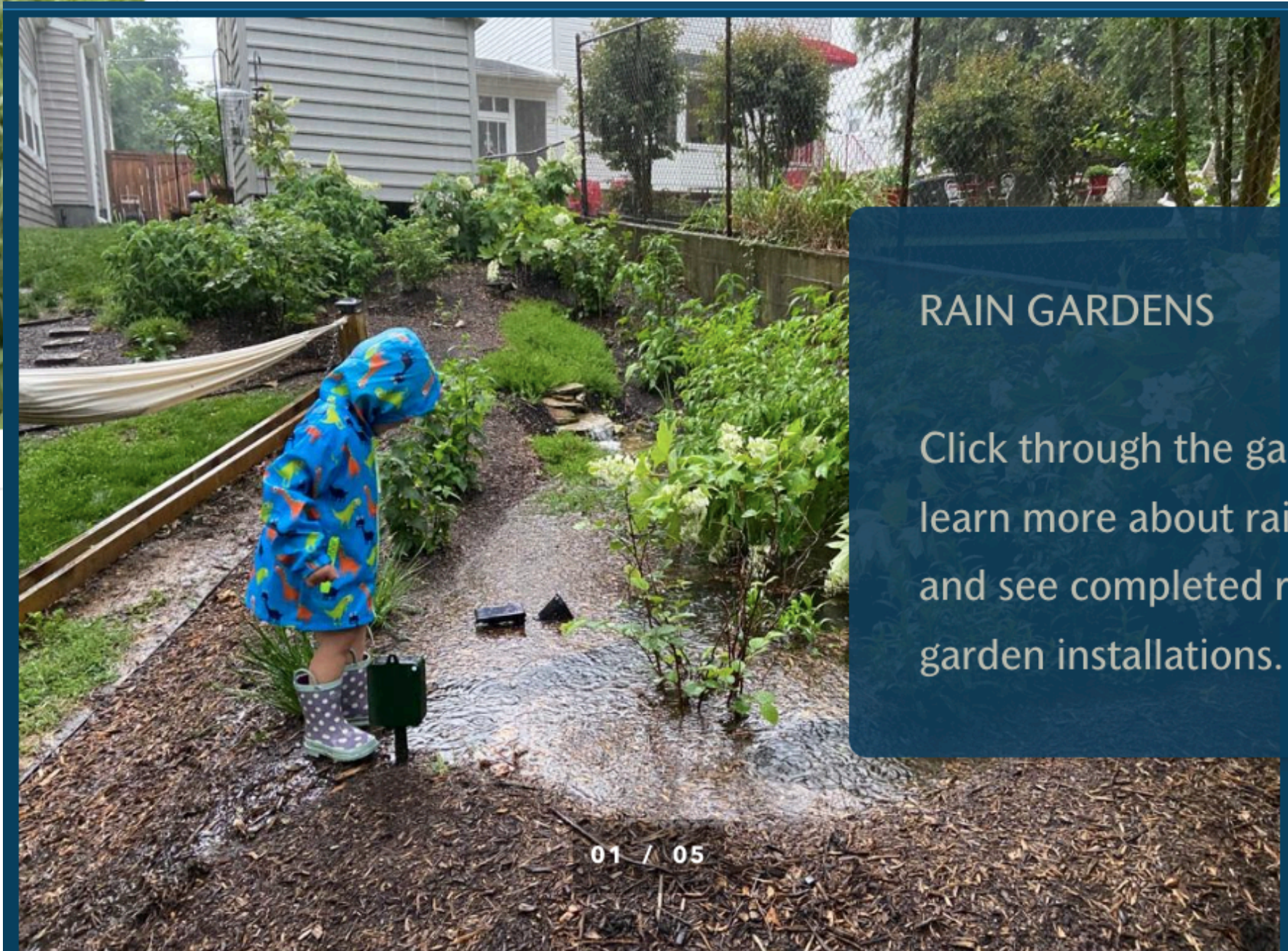
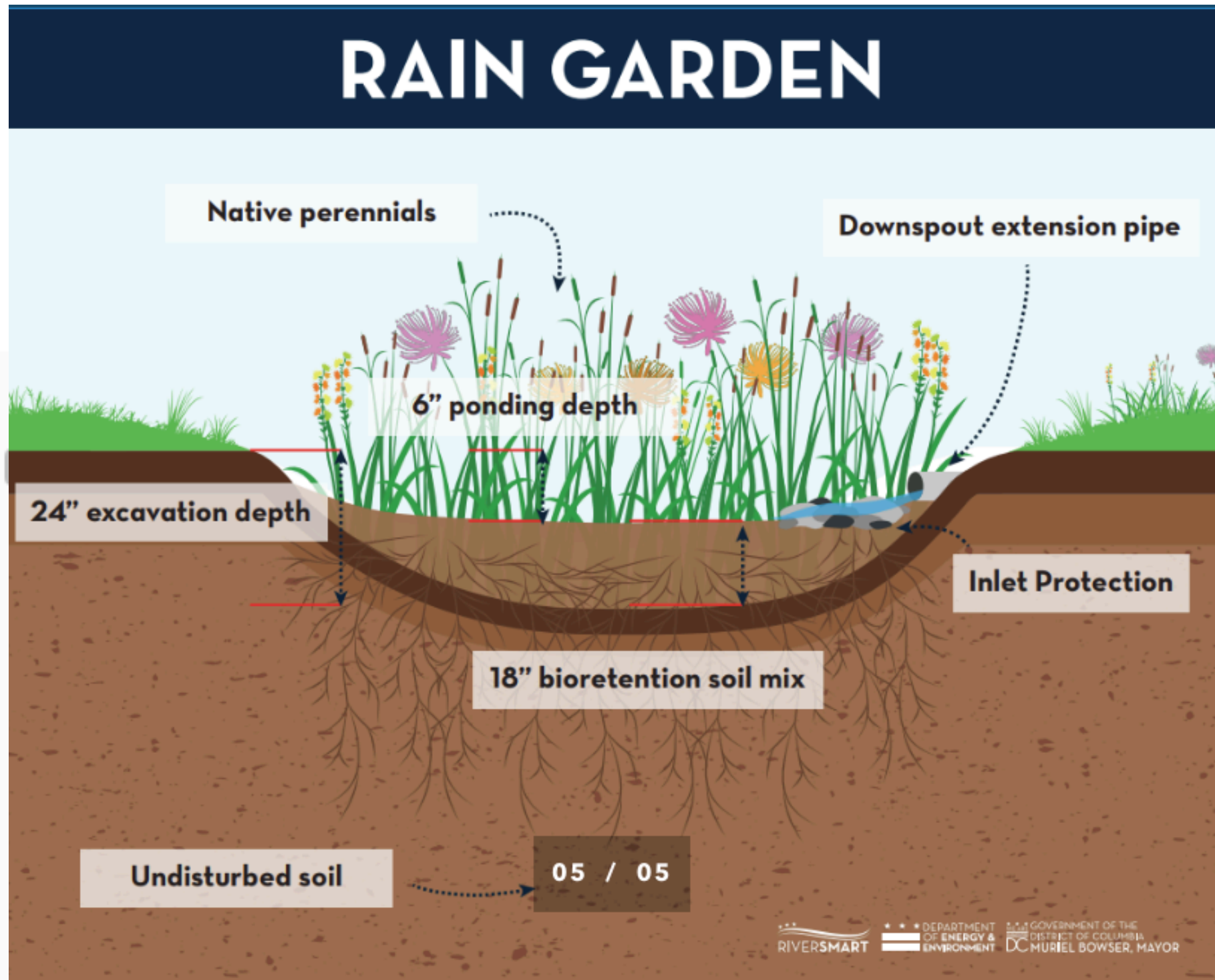
- RiverSmart Homes program (Washington D.C. Department of Energy and Environment – DOEE)
- Implemented **1,652 rain gardens** since 2008

- 5+ year old rain gardens (n = 1290)
- 10+ year old rain gardens (n = 701)





Residents receive a stormwater assessment to determine their eligibility for financial and technical assistance to install one or more of the following features: rain barrels, rain gardens, BayScapes (native plantings), shade trees, and permeable pavers.



RAIN GARDENS

Click through the gallery to learn more about rain gardens and see completed rain garden installations.

- \$100 co-pay per 50 square foot rain garden (limit 2 rain gardens per property)



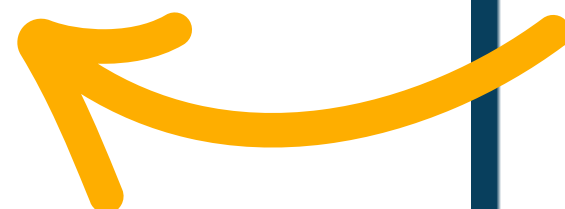
Images via <https://www.riversmarthomes.org>



STEPS TO BECOMING A RIVERSMART HOMEOWNER



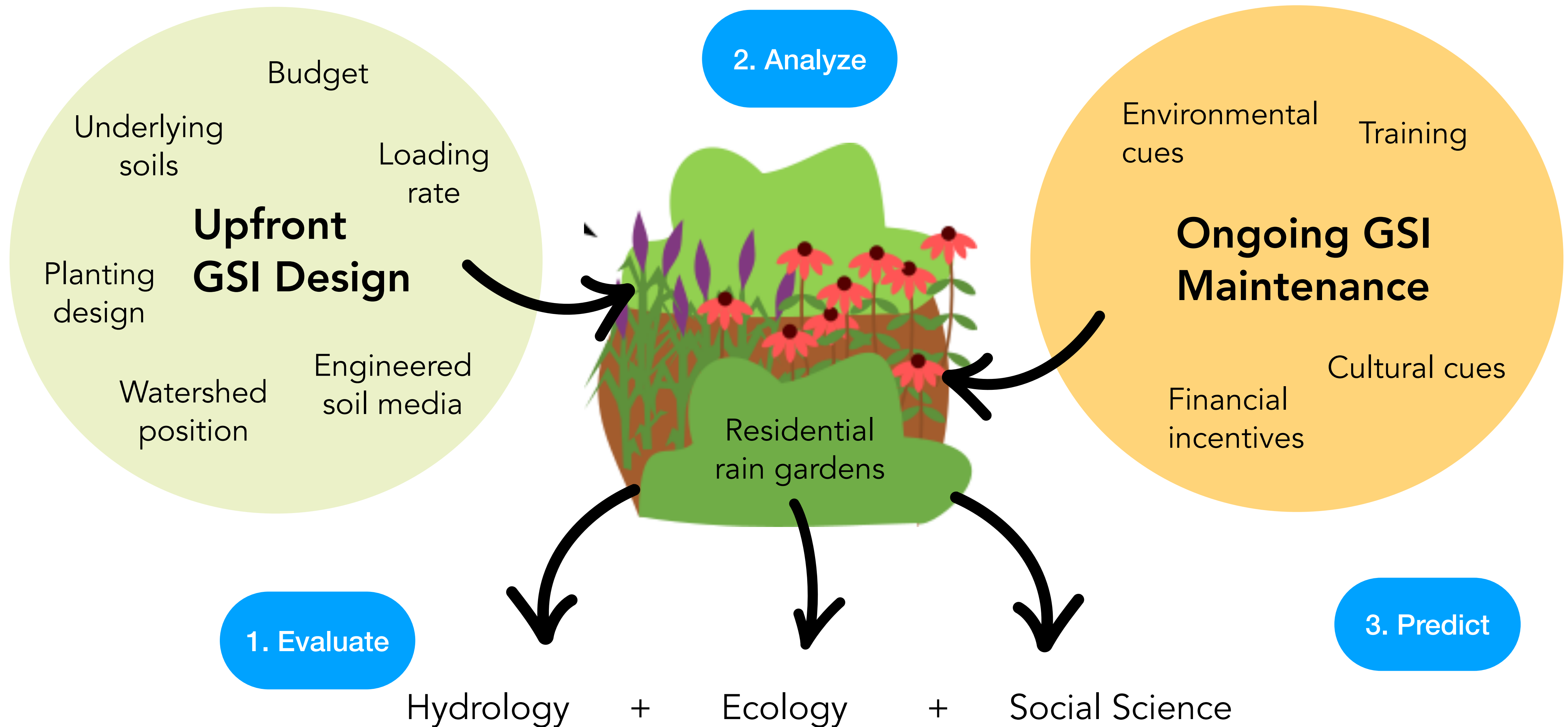
Maintenance



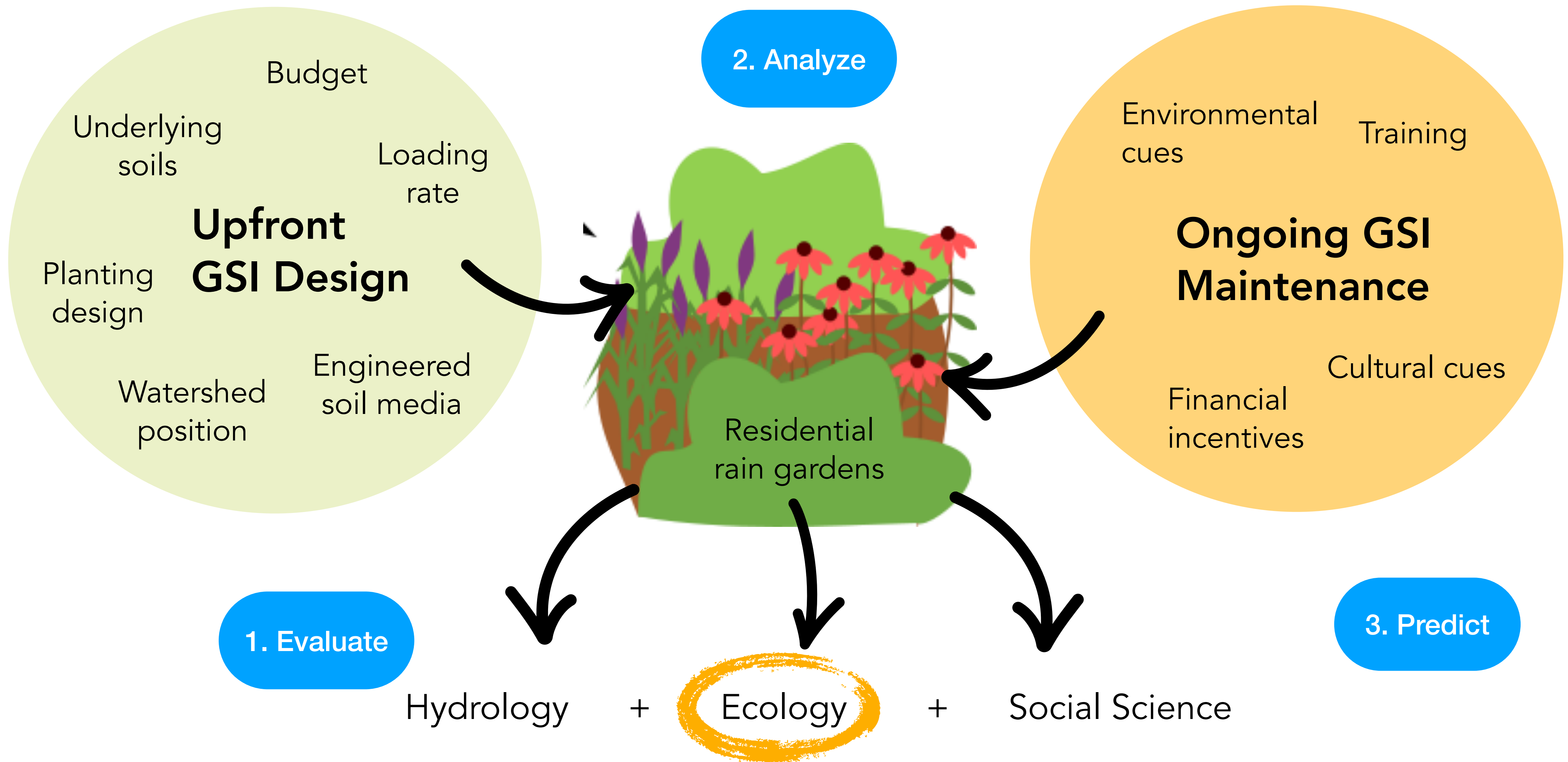
CONTACT US:
Email: riversmarthomes@dc.gov
Phone: (202) 535-2252
Website: doee.dc.gov/service/riversmart-homes



Painting a picture of GSI “success”



Painting a picture of GSI “success”



	Category	Indicator	Success Threshold / Metric
ECOLOGICAL SUCCESS	Plant health	Vegetation coverage	(Conceptual) Rain garden maintains [>50% / 10-50% / <10%] vegetation coverage.
		Establishment and condition	Vegetation appears in [healthy / sparse / dying or absent] condition and [well-suited / partially suited / not suited] to it's light conditions.
	Plant community diversity	Structural layer diversity (ground cover, perennials, shrubs, trees)	Rain garden exhibits [2+ / 1 / 0] different vegetation layers.
		Root structure diversity	Rain garden exhibits [2+ / 1 / 0] different root structures.
	Species diversity	Species richness	Rain garden supports [5+ / 2-4 / <2] unique native species.
		Invasive pressure	Rain garden is [free of invasive species / 0-25% invasive coverage / > 25% invasive coverage].

Field Work

- Contacted **1,114** residents with rain gardens to fill out an online social science survey
- **168** online survey respondents
- Visited each online survey respondent through DOEE inspections process

RAIN GARDEN CHECK UP!



Did you know you have a rain garden? Take our short survey to help us learn how rain gardens are performing across D.C.! *The first 200 participants will receive a \$15 Amazon gift card!*

Survey conducted by the University of Delaware with support from the National Science Foundation.

Scan here to start the survey.

Why We Need You:

Your rain garden—a small planted area designed to catch and soak up rainwater from your roof—is part of a city-wide effort to manage stormwater and protect our rivers. By completing a quick survey, you'll help researchers learn how rain gardens are working over time.

What's Involved:

- A short *10–15 minute online survey*
- Share your experiences as a resident with a rain garden

Optional: Sign up for a community science project to track your rain garden's drainage after storms (and earn a free rain gauge!).

Reward: The first 200 residents to complete the survey will receive a *\$15 Amazon gift card* as a thank you for your time.

How to Participate:

- Scan the QR code or visit <https://tinyurl.com/RainGardenDC>.
- Complete the survey online.
- Receive your gift card by email if you're among the first 200 respondents.

Questions? Contact:

Dr. Carolyn Voter, University of Delaware, cvoter@udel.edu



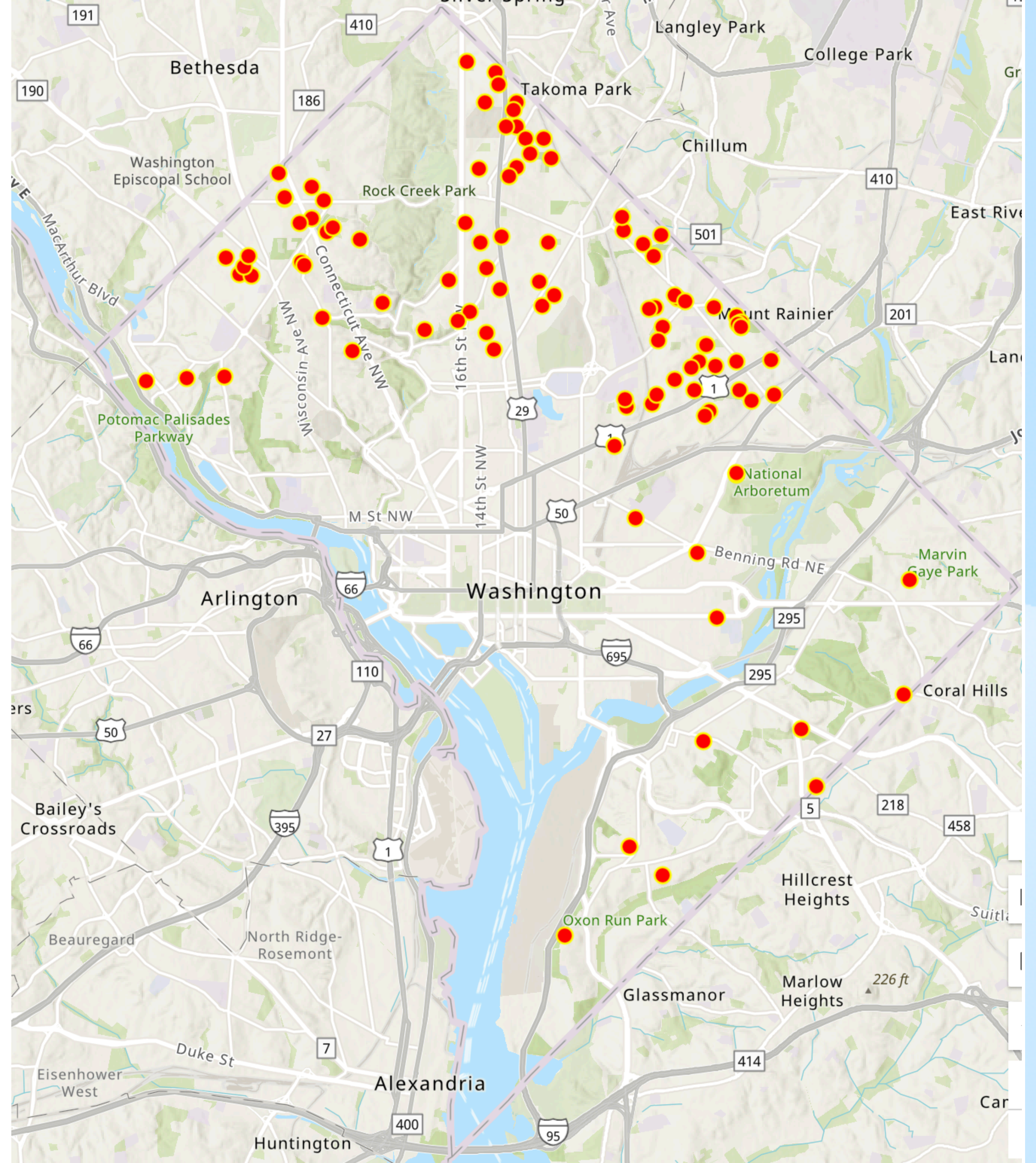
UNIVERSITY OF DELAWARE
DELAWARE ENVIRONMENTAL
INSTITUTE



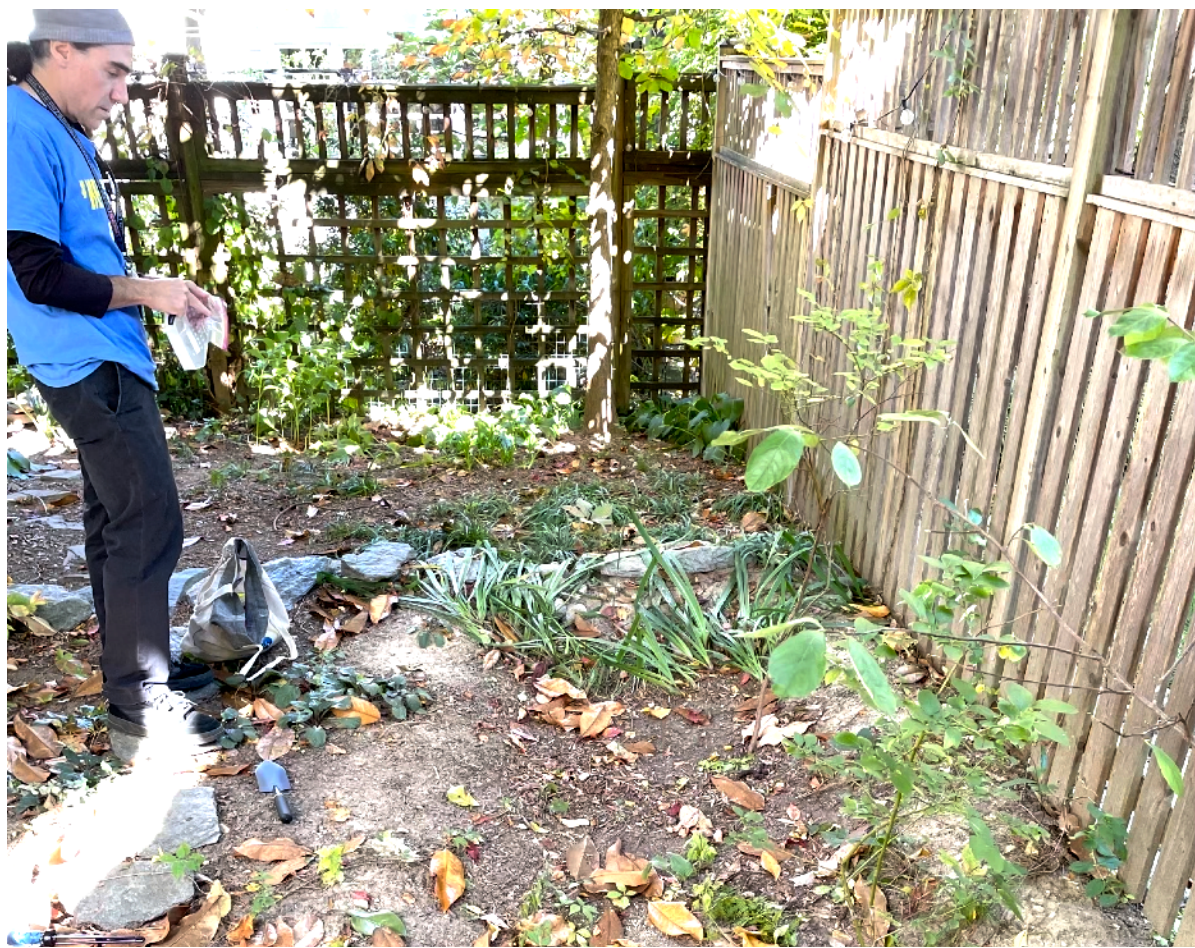
This survey is part of a research project on long-term rain garden performance, led by the University of Delaware and funded by the National Science Foundation (NSF) Award #2425112.

Field Work

- October 16-18, 2025
- Collected field observation data and soil samples at **103 rain gardens**



Field Work



Data sources

DC Rain Garden Physical Assessment

Rain Garden ID*

Date and Time of Site Visit*

Name of Assessors*

Rain Garden Location*

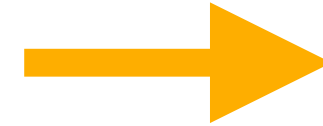
Please input the location of this rain garden.

Find address or place

There was an error. Please check the location permissions on your browser and operating system.

Lat: Lon:

ArcSurvey123
Field Form



Images:

Rain garden wide/
overhead
Inlet
Individual plants



Photo-based Plant ID:

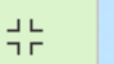
Finalized species list
Native vs. invasive presence
Species richness
Root structure categorization



Drop down/select:

Plant coverage
Plant layers
Preliminary plant ID
invasives / natives est.
Sun exposure
Comments

● Photograph close up of all unique plants you notice. *

Gallery 



Images: 451

657 photos

In Process / Future* Data sources

Soil Samples - from inlet and low point

- **Soil texture** (laser diffraction + sieve): clogging, infiltration
Topic of Brayden Rochester's senior thesis
- **Soil organic matter** content*: infiltration, vegetation condition
- **Soil microplastic content***: water quality

Infiltration rate* - Spring field work with MPD infiltrometer

Overhead Imagery - GIS

- Canopy cover - shade (maintenance)
- House orientation / distance to rain garden - shade (design)

Citizen Science - drainage performance

- Does the rain garden **drain within 72 hours** of a storm event?
- Plants tolerance for soil moisture

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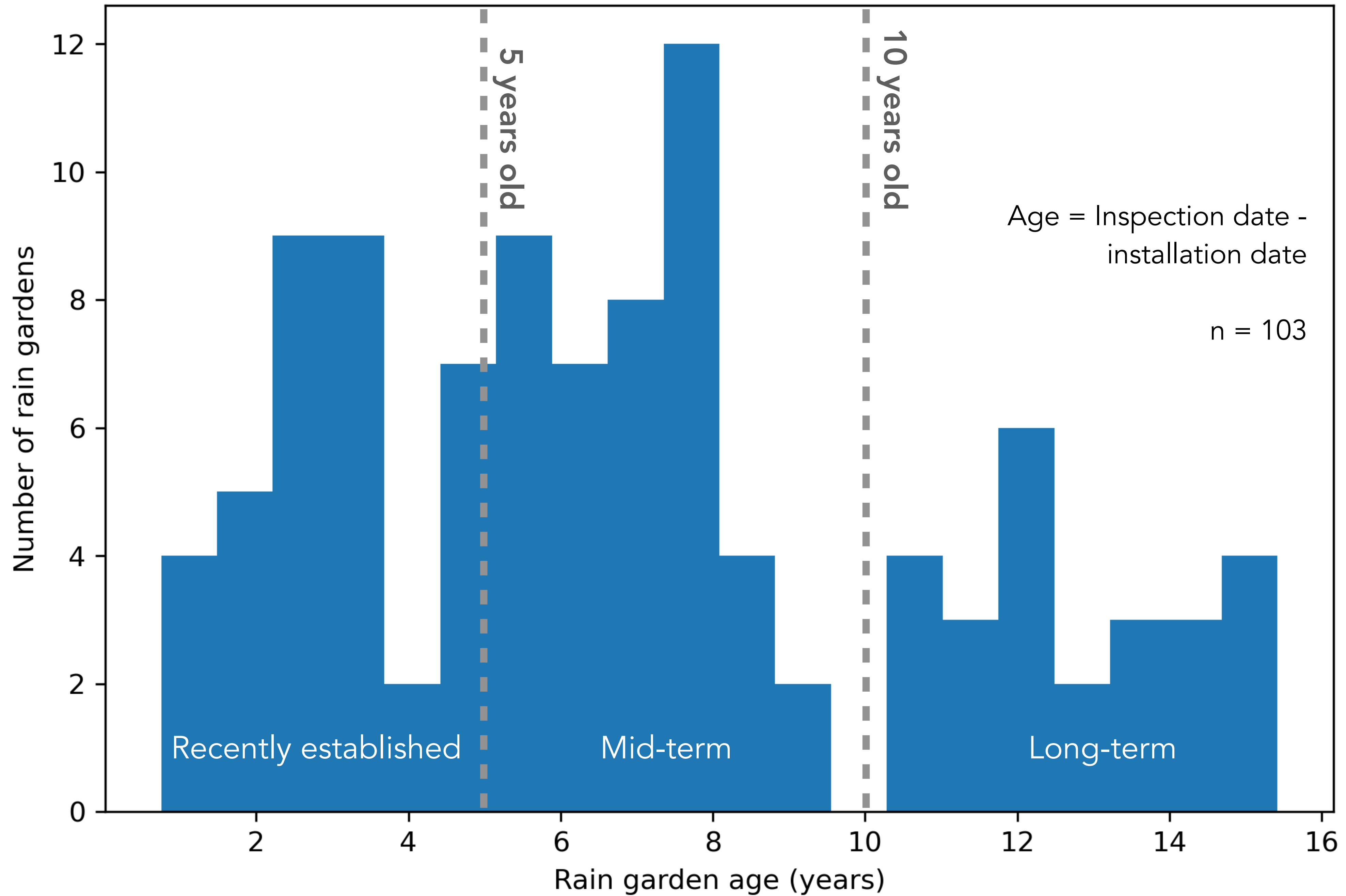
Research Questions

- How do vegetation coverage, species richness, and invasive pressure **vary with rain garden age**?
- How do **site condition differences (such as sun/shade exposure)** impact vegetation coverage, species richness, and invasive pressure?

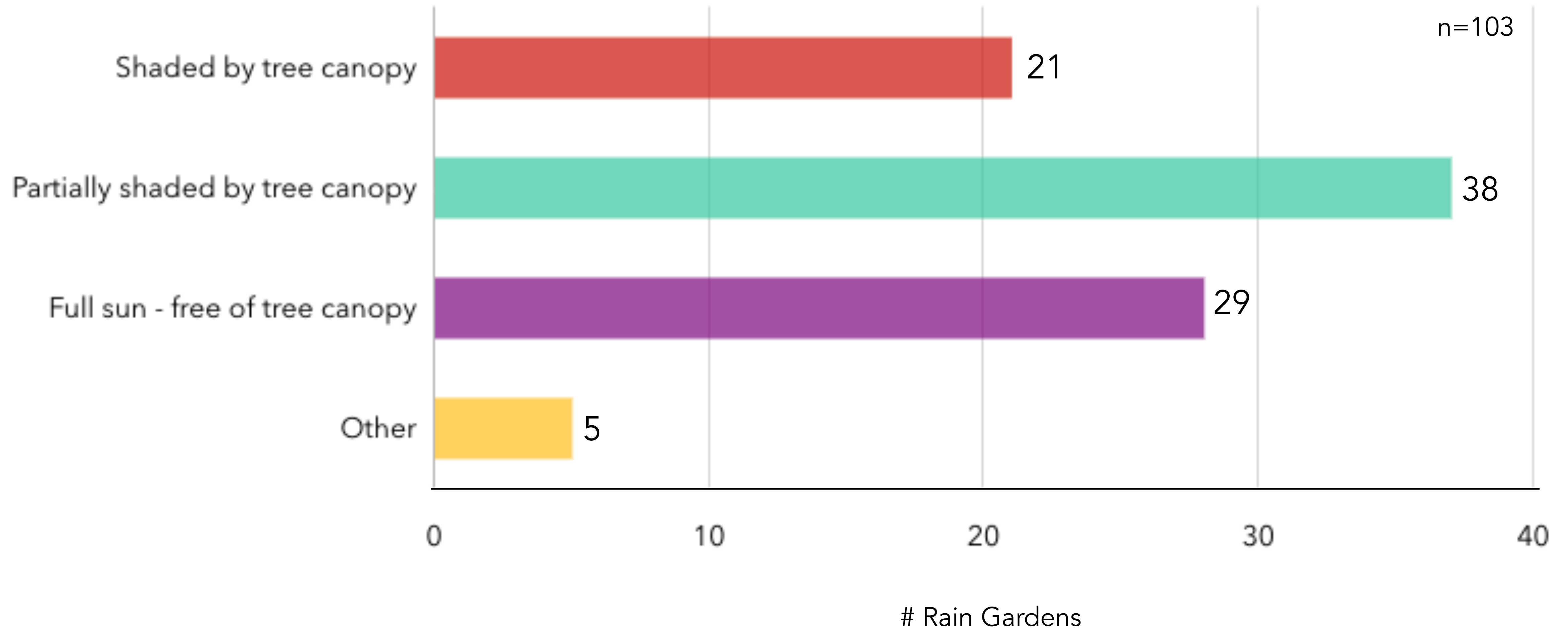
Preliminary Results:

Rain garden characteristics

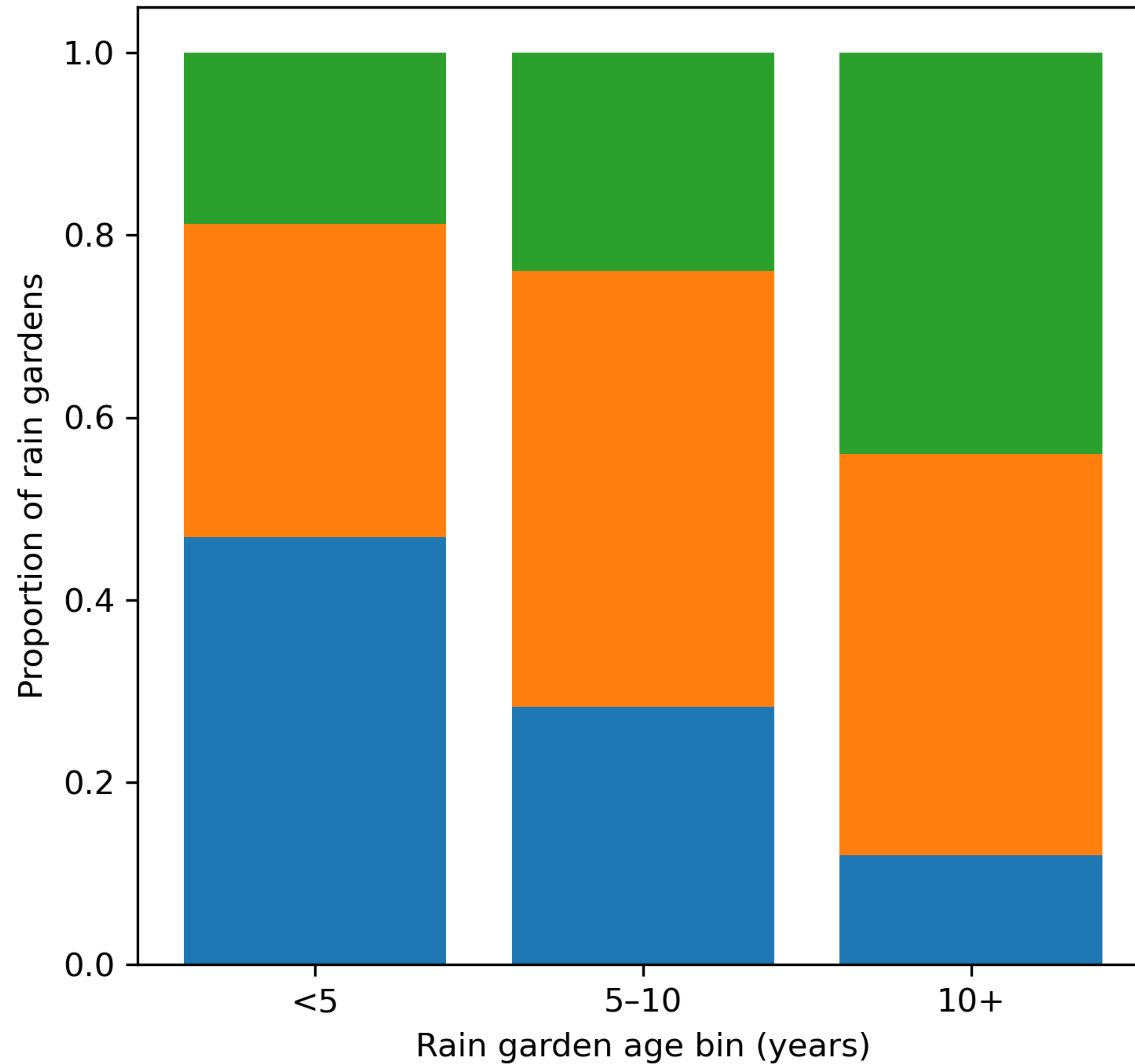
Rain garden age distribution



Rain garden shade level



Sun exposure across rain garden age bins



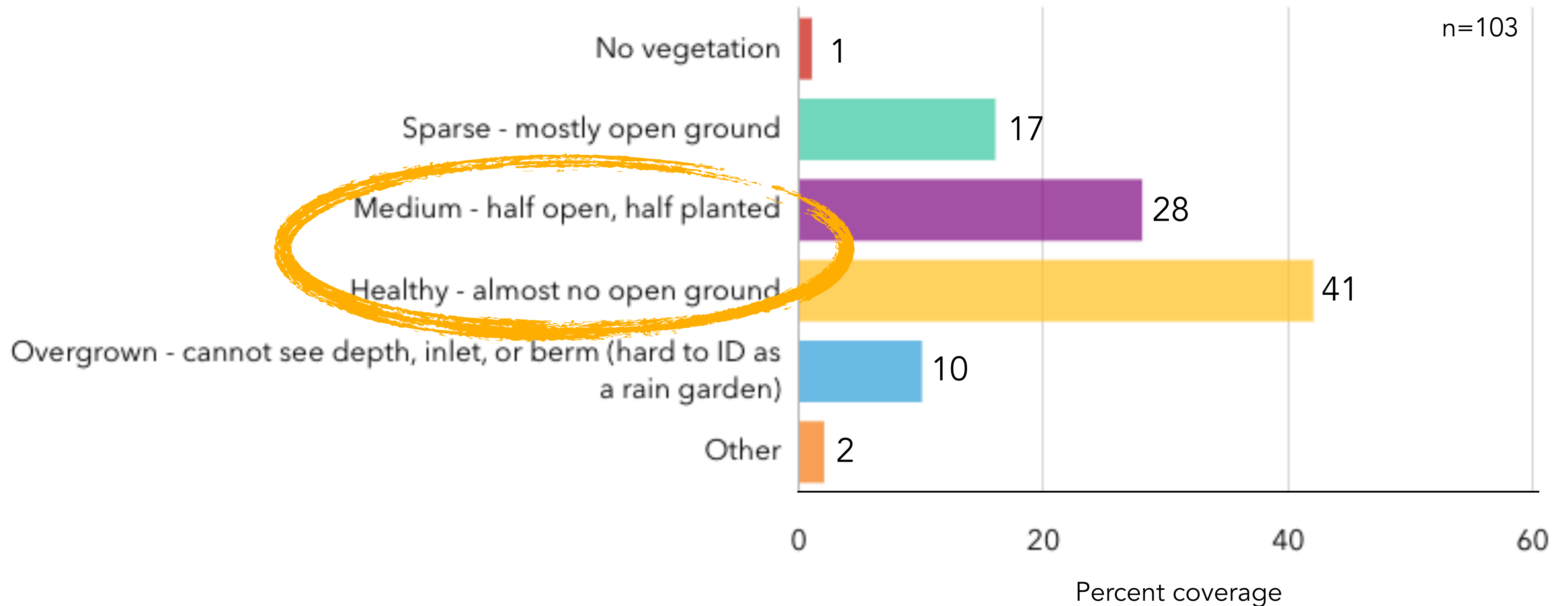
Older rain gardens tend to be more shaded.

Preliminary Results:

Existing Vegetation

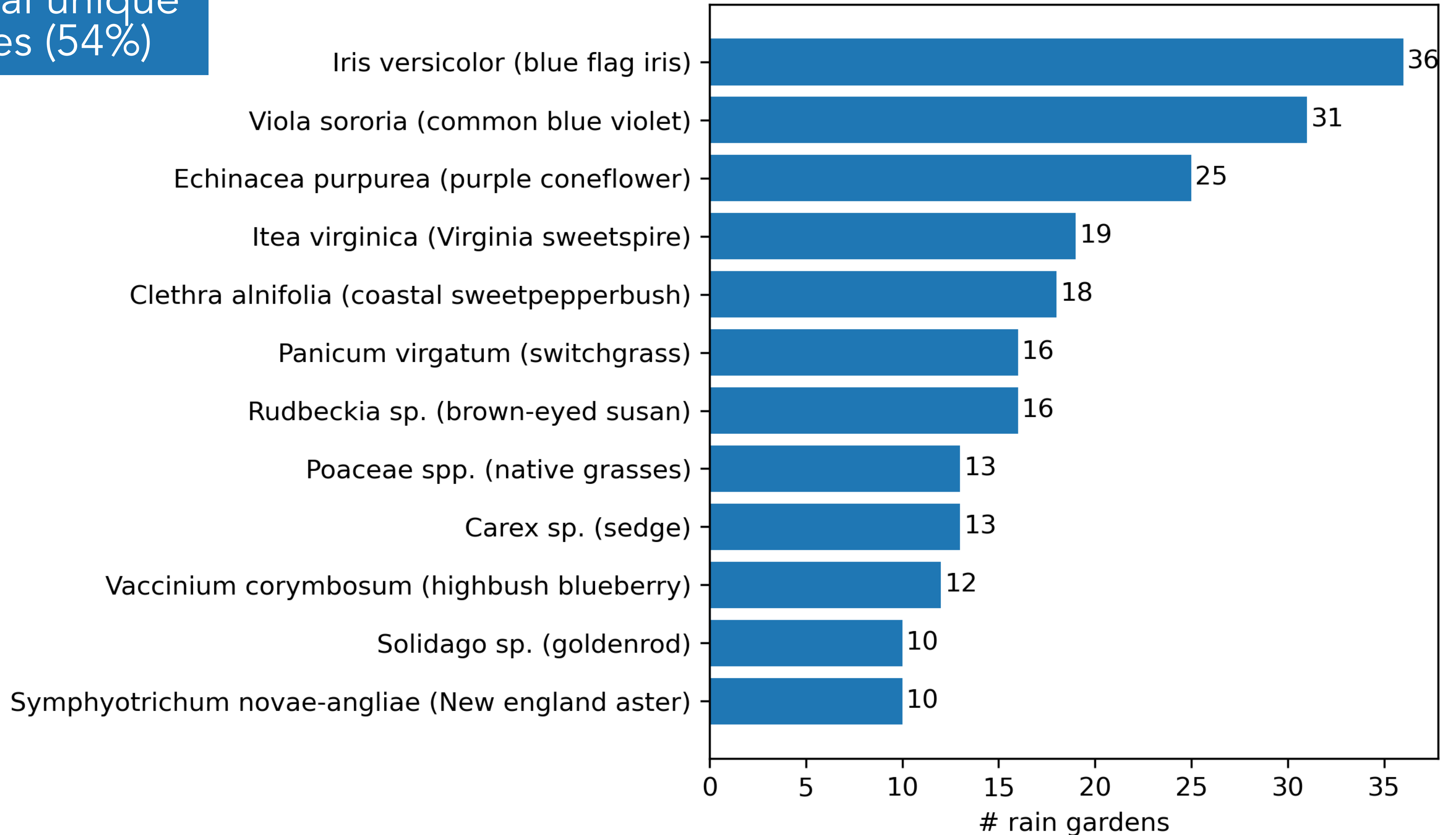
Vegetation Density - Overall

Q: How much of the garden is covered with live plants?



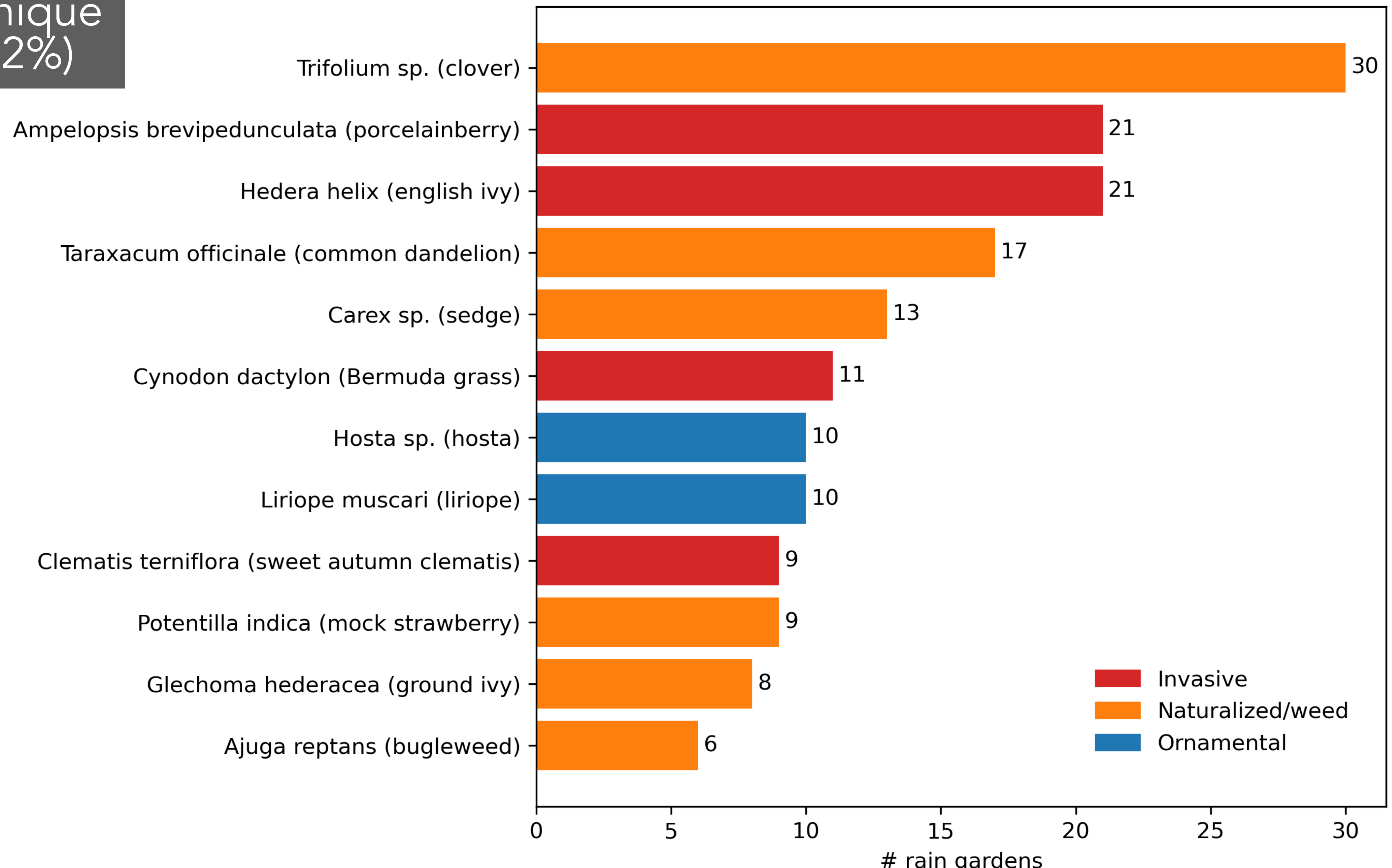
172 native /
297 total unique
species (54%)

Most frequent native species



125 non-native /
297 total unique
species (42%)

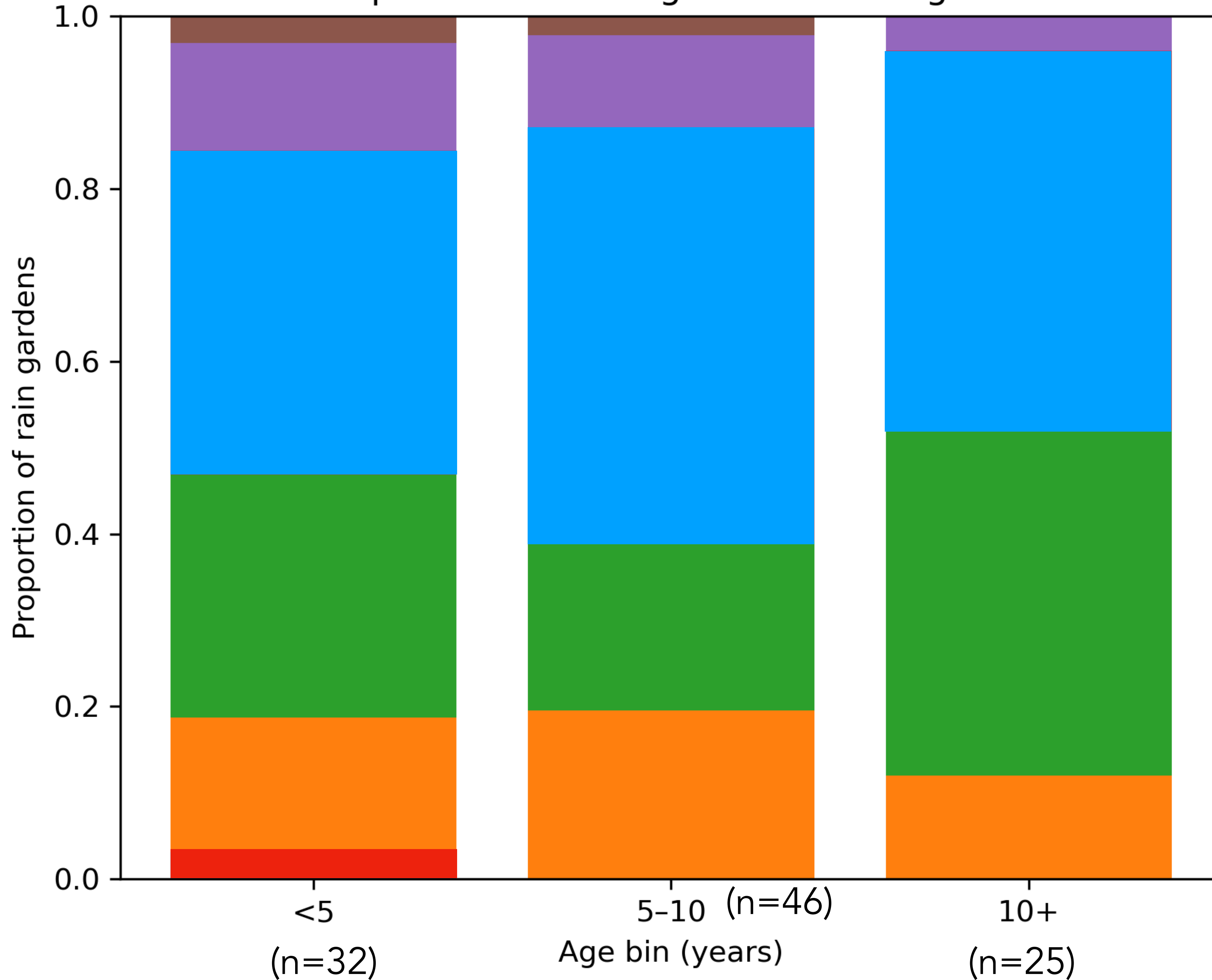
Most frequent non-native species (all categories)



Preliminary Results:

**How does vegetation
performance vary by **age**?**

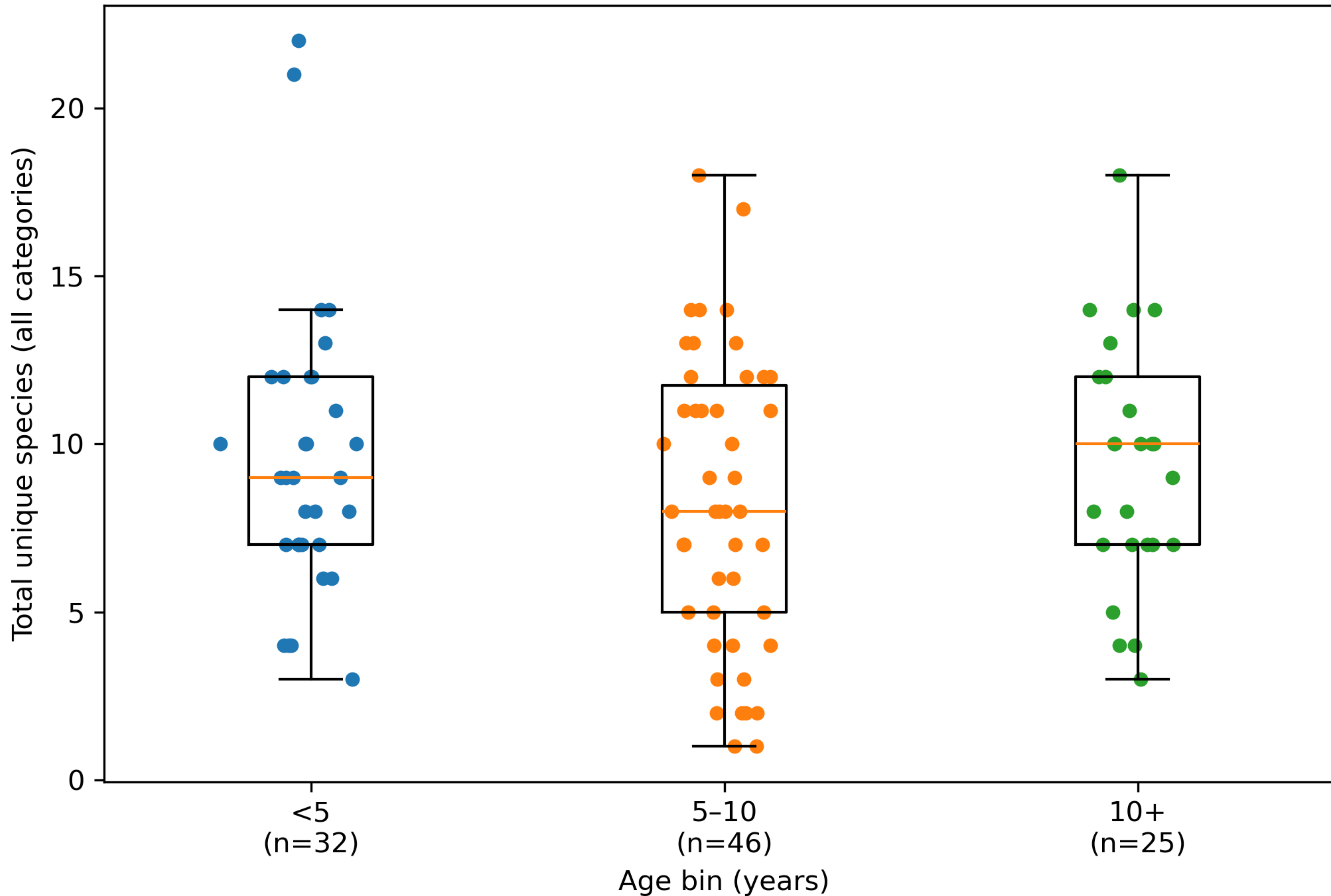
Live plant cover categories across age bins



Long-term rain gardens maintain healthy coverage (plant density). They are less overgrown and less sparse.

Potential drivers: rain gardens that survive longer are well-maintained by residents?

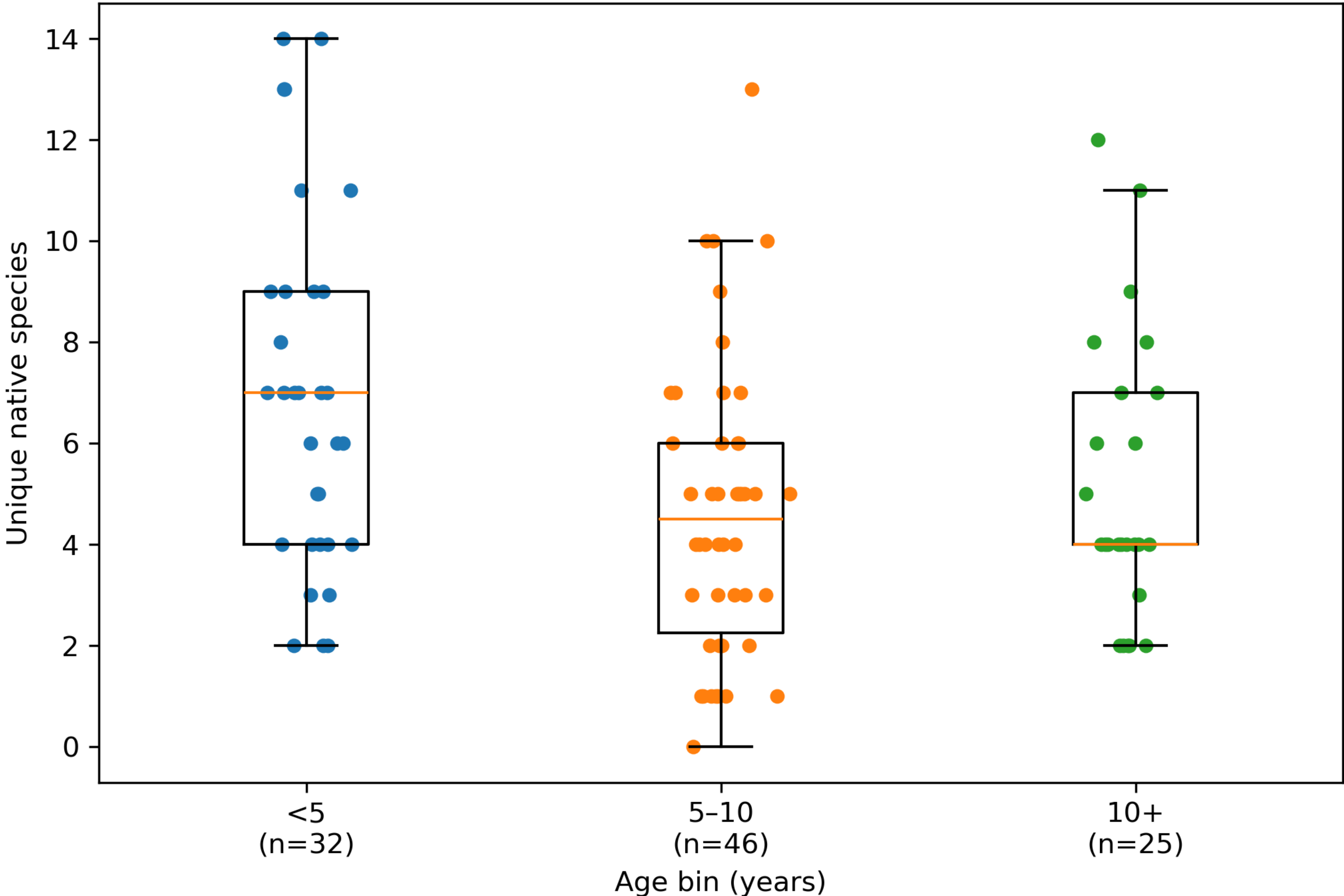
Total unique species (all categories) across age bins



Richness = #
unique species

**About the same
richness of all
types of species
over age range.**

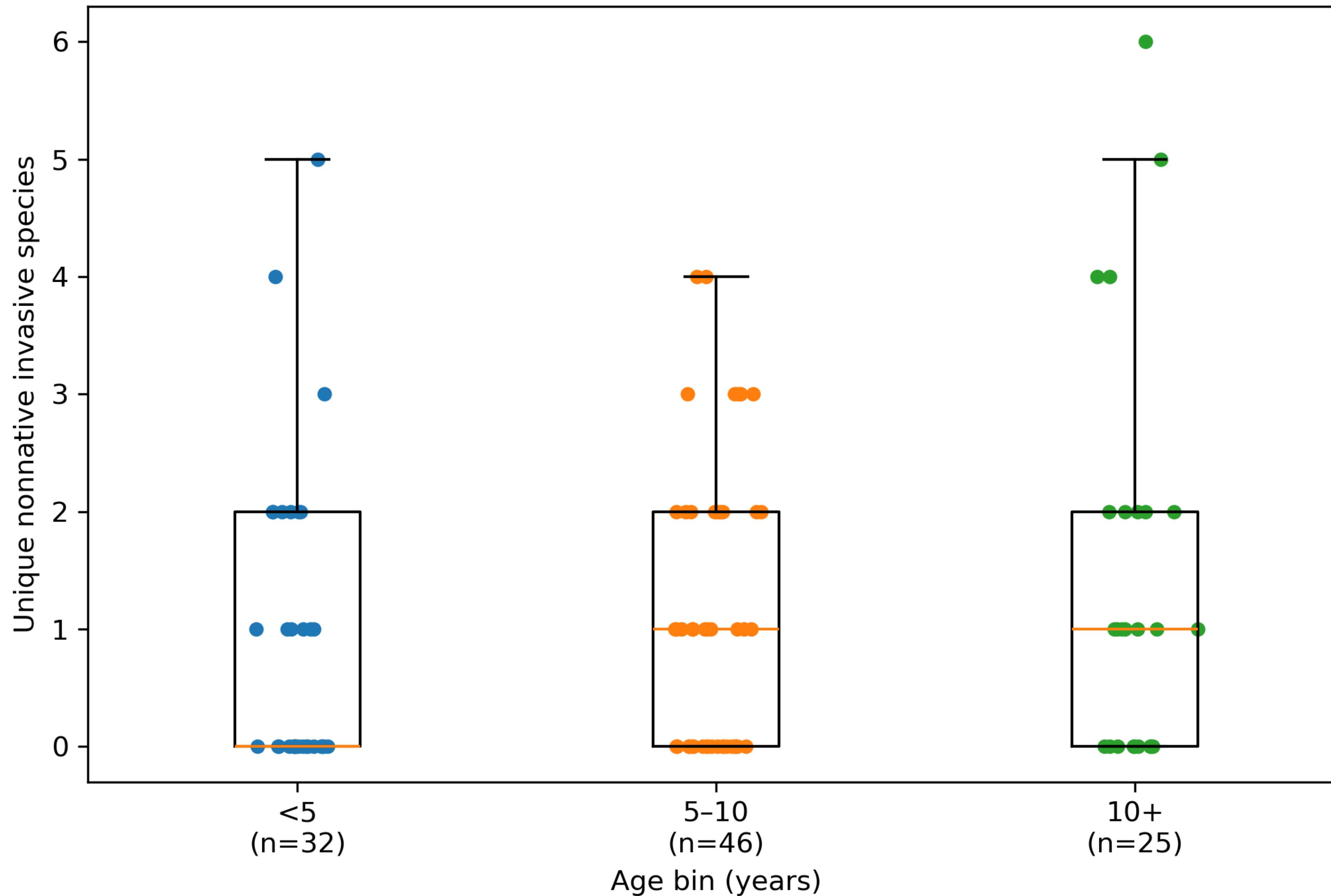
Unique native species across age bins



Loss of native richness after establishment.

Potential drivers:
non-surviving native species are not replaced; social drivers like cost barriers, gardening/maintenance interest; lack of knowledge on species

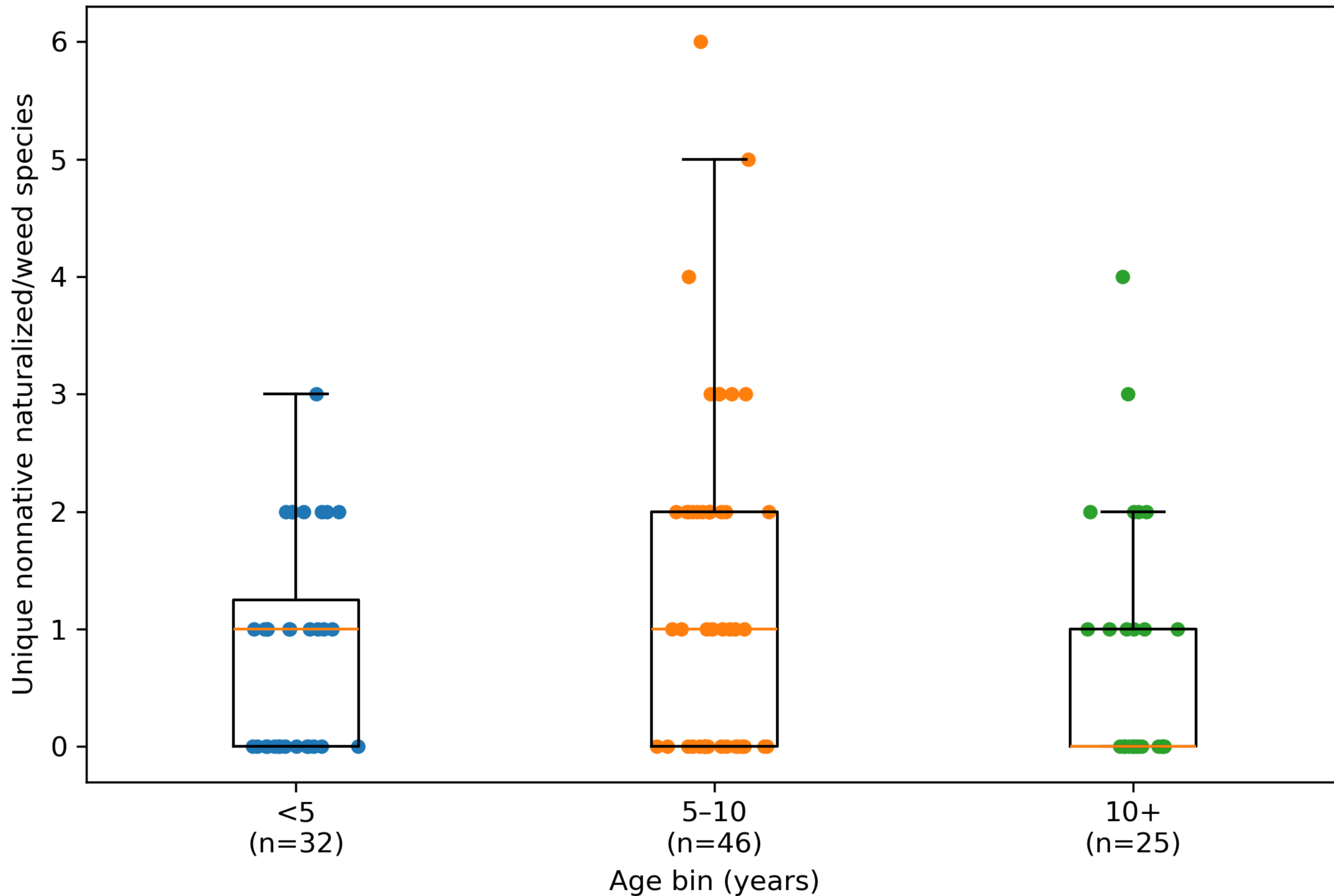
Unique nonnative invasive species across age bins



Invasive species richness remains fairly constant from establishment to long-term.

Potential drivers:
open ground and proximity to invasives invites colonization after installation

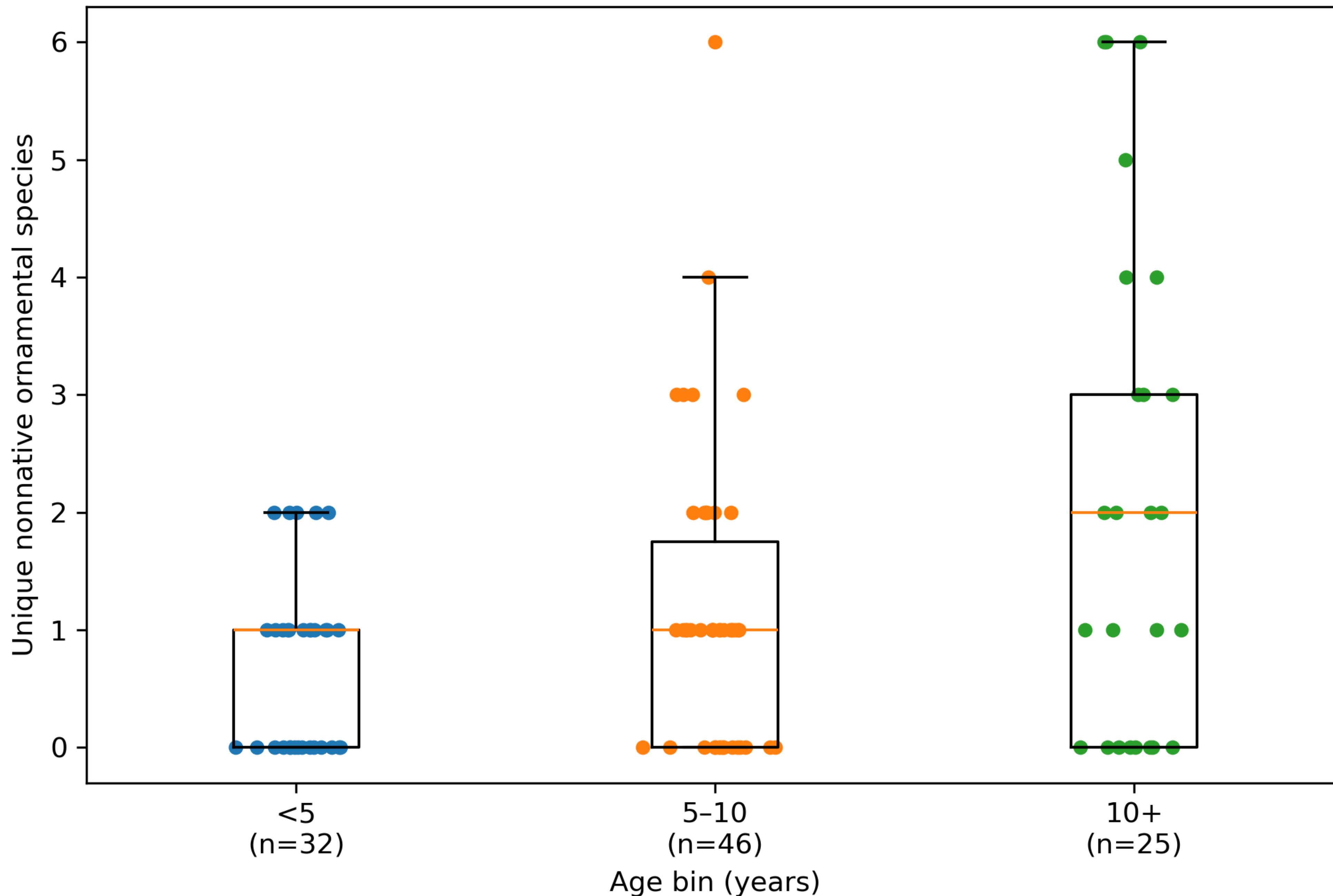
Unique nonnative naturalized/weed species across age bins



Non-native naturalized weedy species richness remains fairly consistent among age groups.

Potential drivers:
open ground and proximity to weedy species invites colonization after installation

Unique nonnative ornamental species across age bins

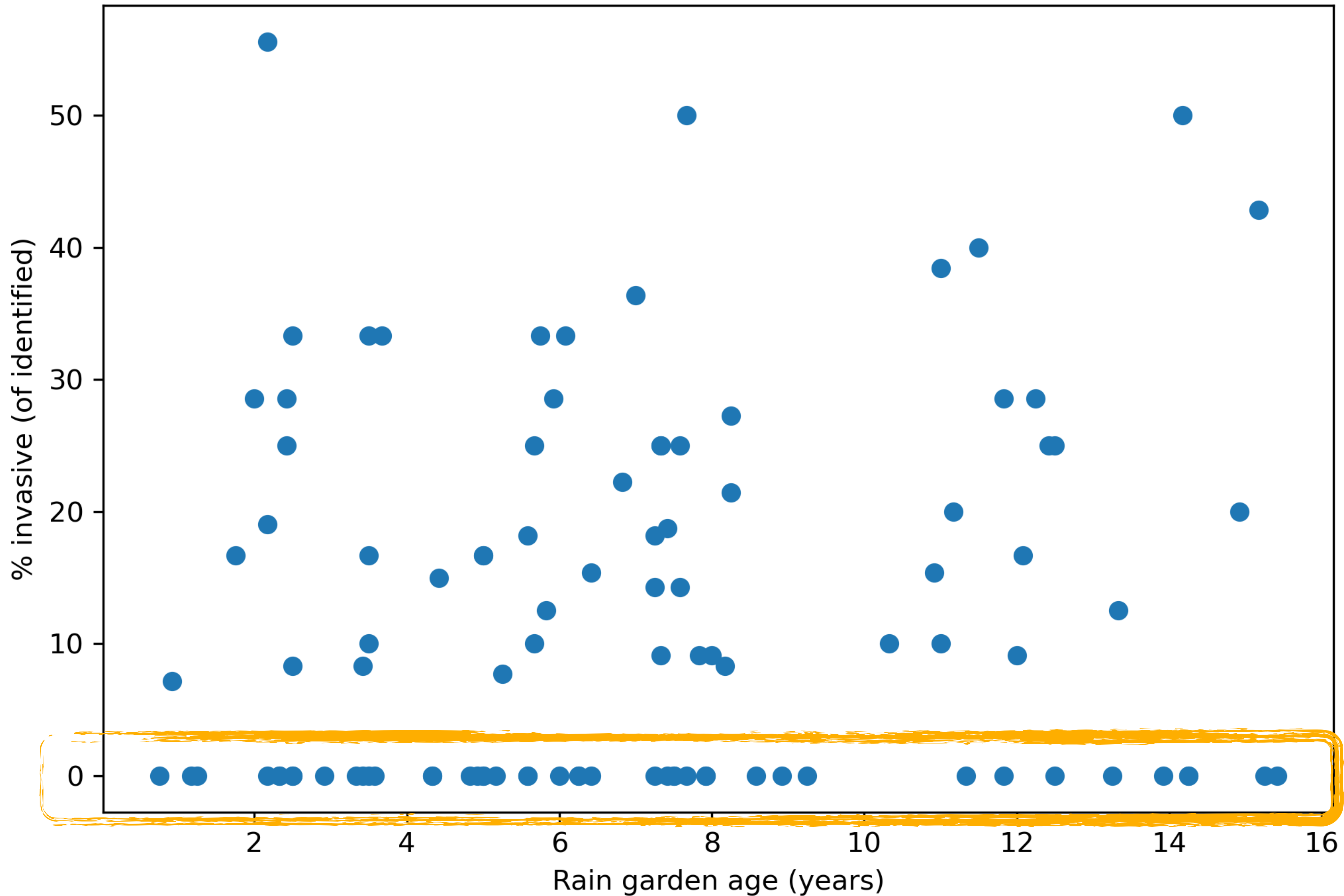


Increase in ornamental species richness from the mid-term to the long-term.

Potential drivers:

ornamentals not planted in design but added by residents; change in ownership, replacement for loss of other species or decline in quality of established plants? Knowledge mainly of, preference for, or nursery availability of ornamentals

Age vs. % Invasive taxa (of identified taxa)

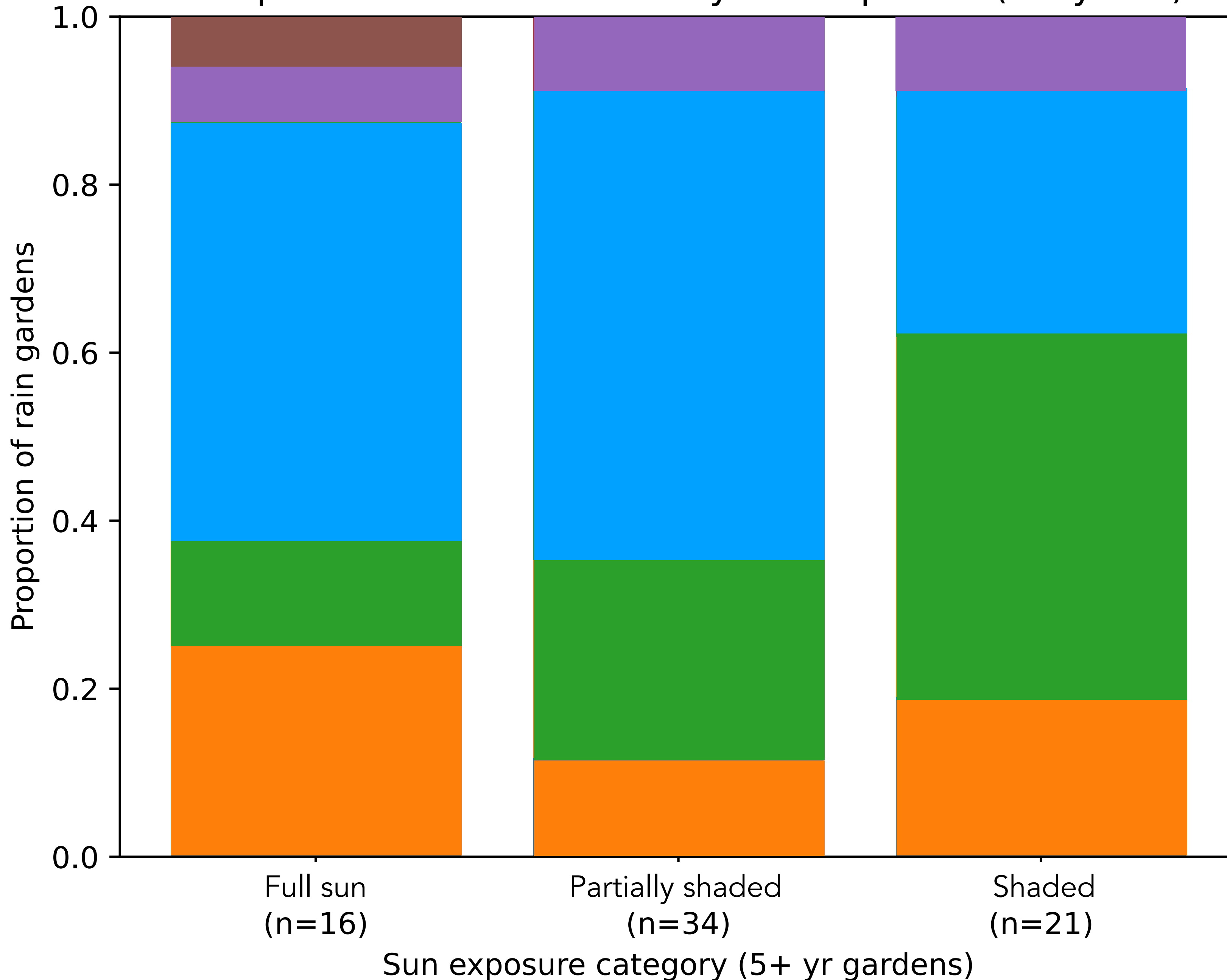


- % invasive taxa = (# invasive taxa / # identified taxa)
- Highly variable across ages; some higher values occur in older gardens, but many gardens across all ages have 0 invasives

Preliminary Results:

How does vegetation performance vary by sun exposure (for 5+ year old rain gardens)?

Live plant cover distribution by sun exposure (5+ years)



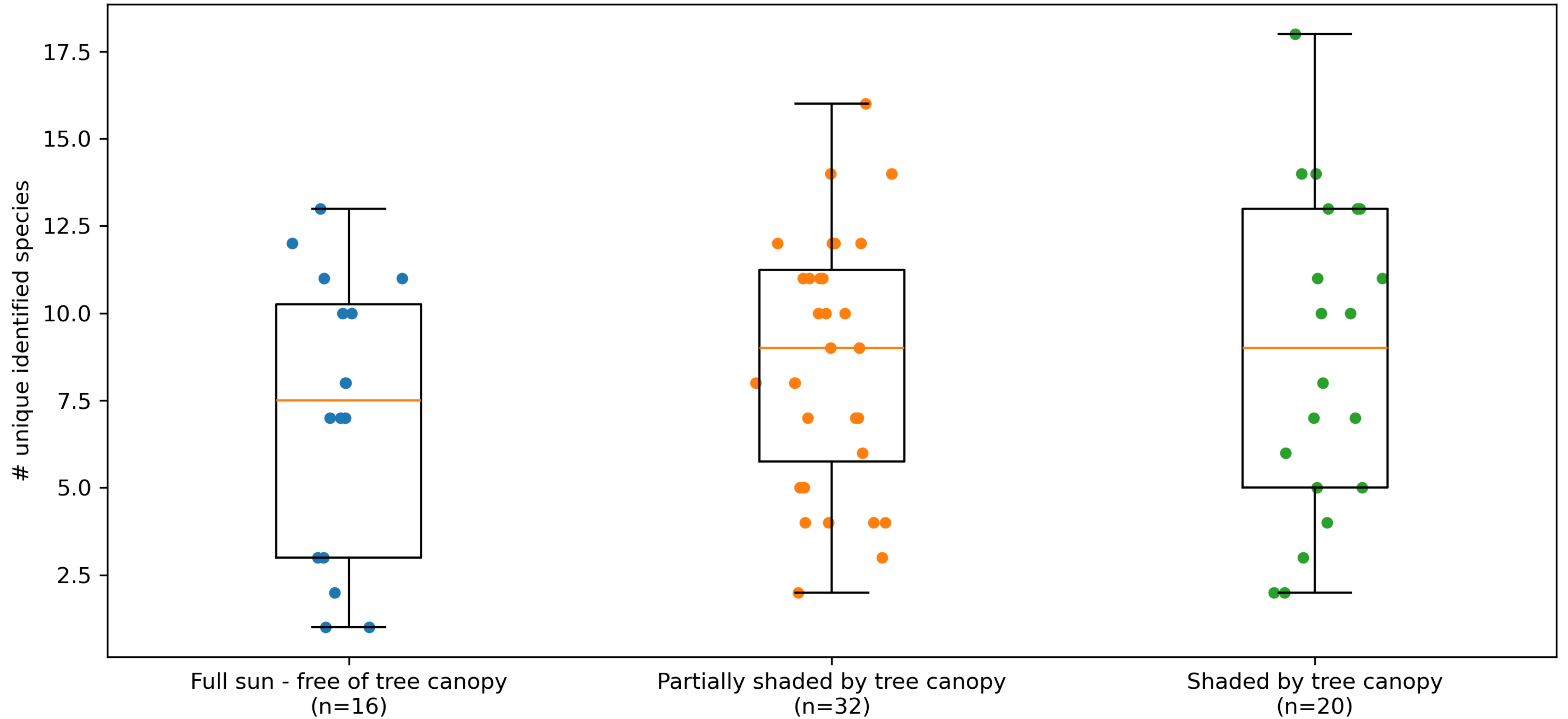
- Sparse
- Medium
- Healthy
- Overgrown
- other

5+ year old rain gardens
n= 71

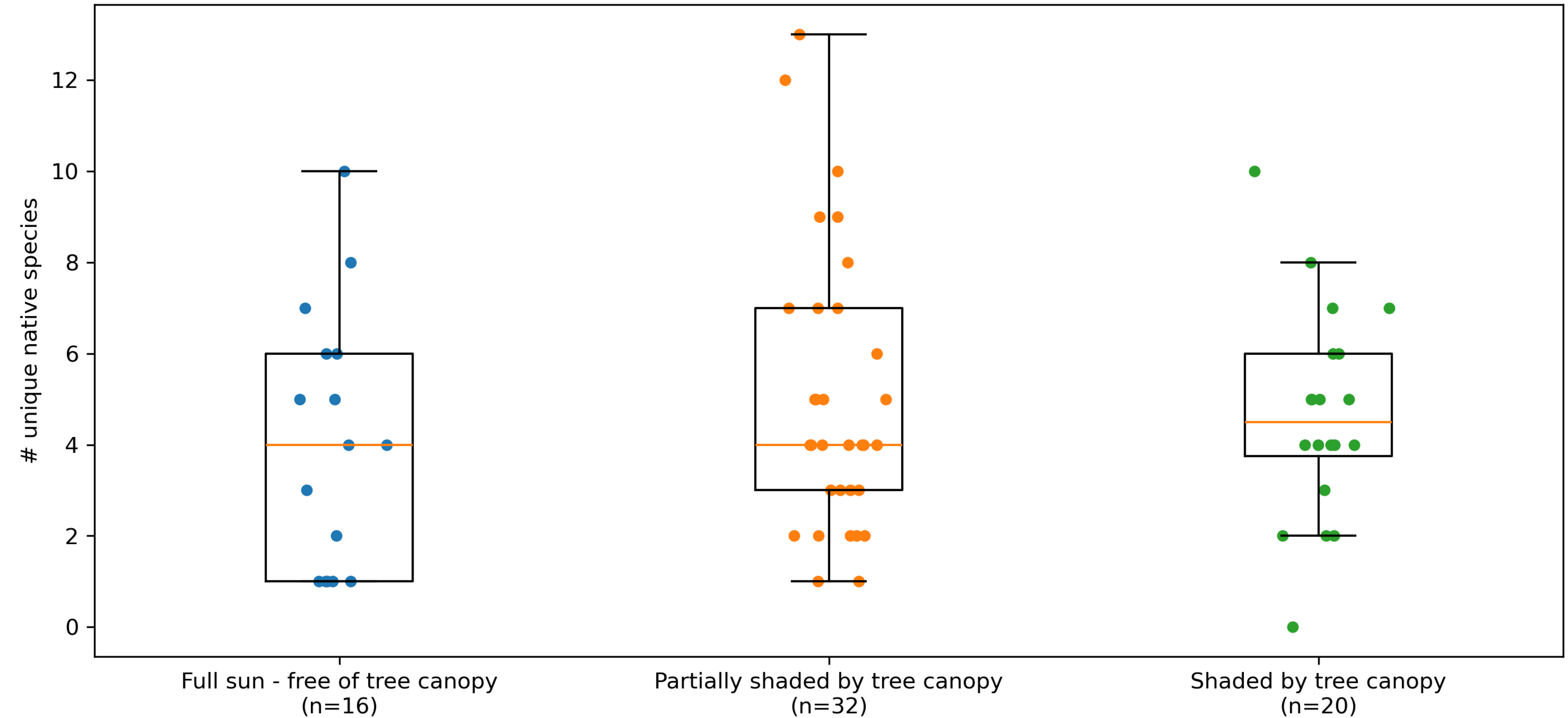
Fully shaded gardens have more overall sparse/medium growth than healthy fullness.

Potential drivers: plants receiving more light grow well (expected); species planted are not equipped for shade conditions.

Unique species richness by sun exposure (5+ years)



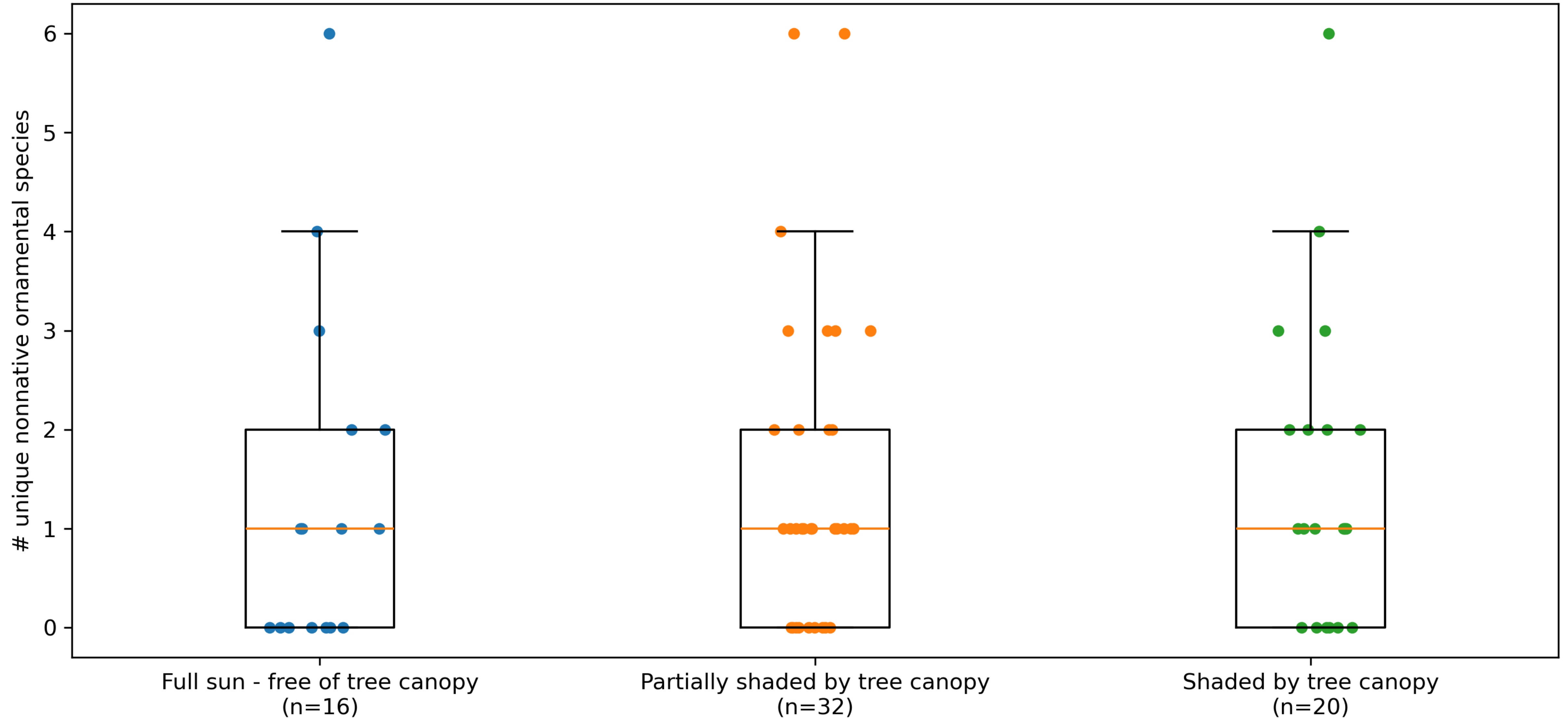
Native species richness by sun exposure (5+ years)



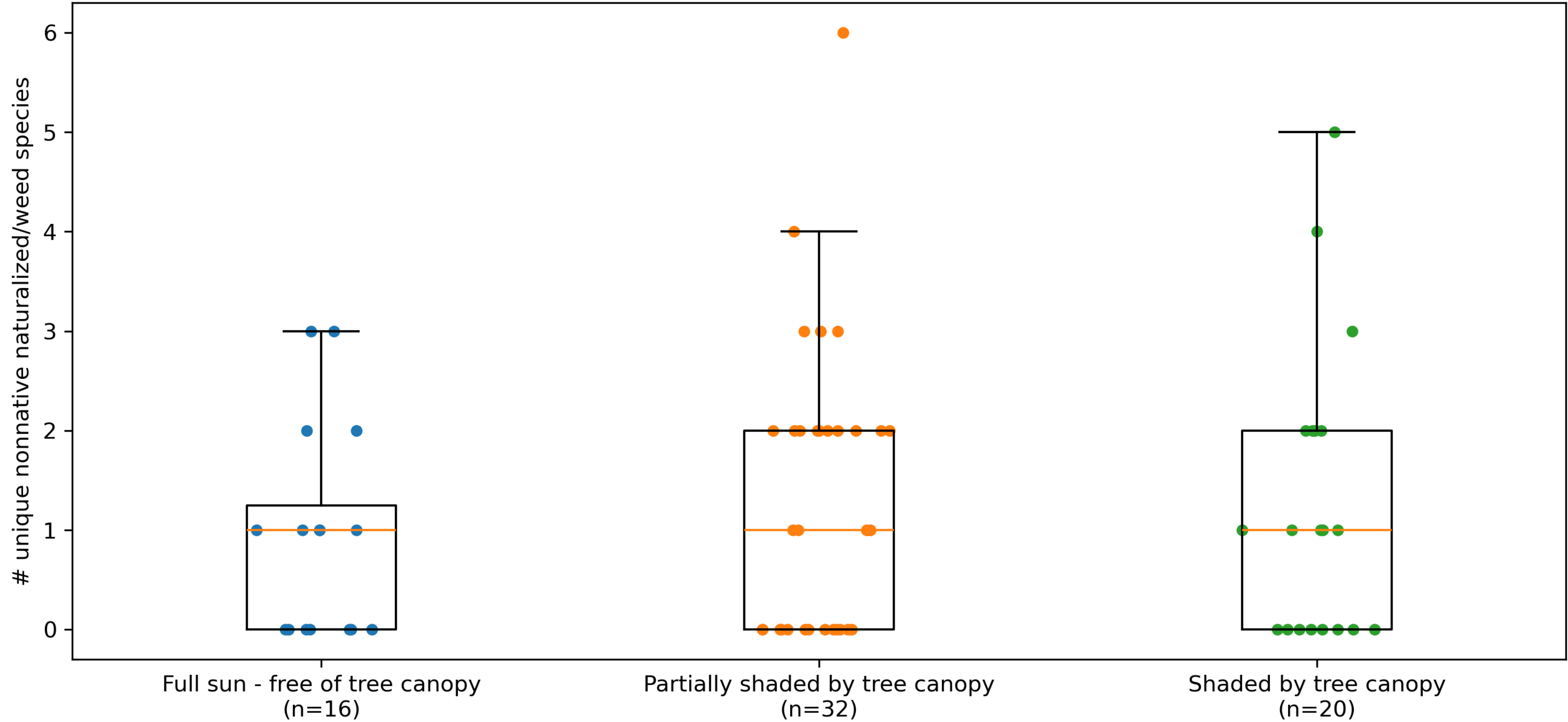
Invasive species richness by sun exposure (5+ years)



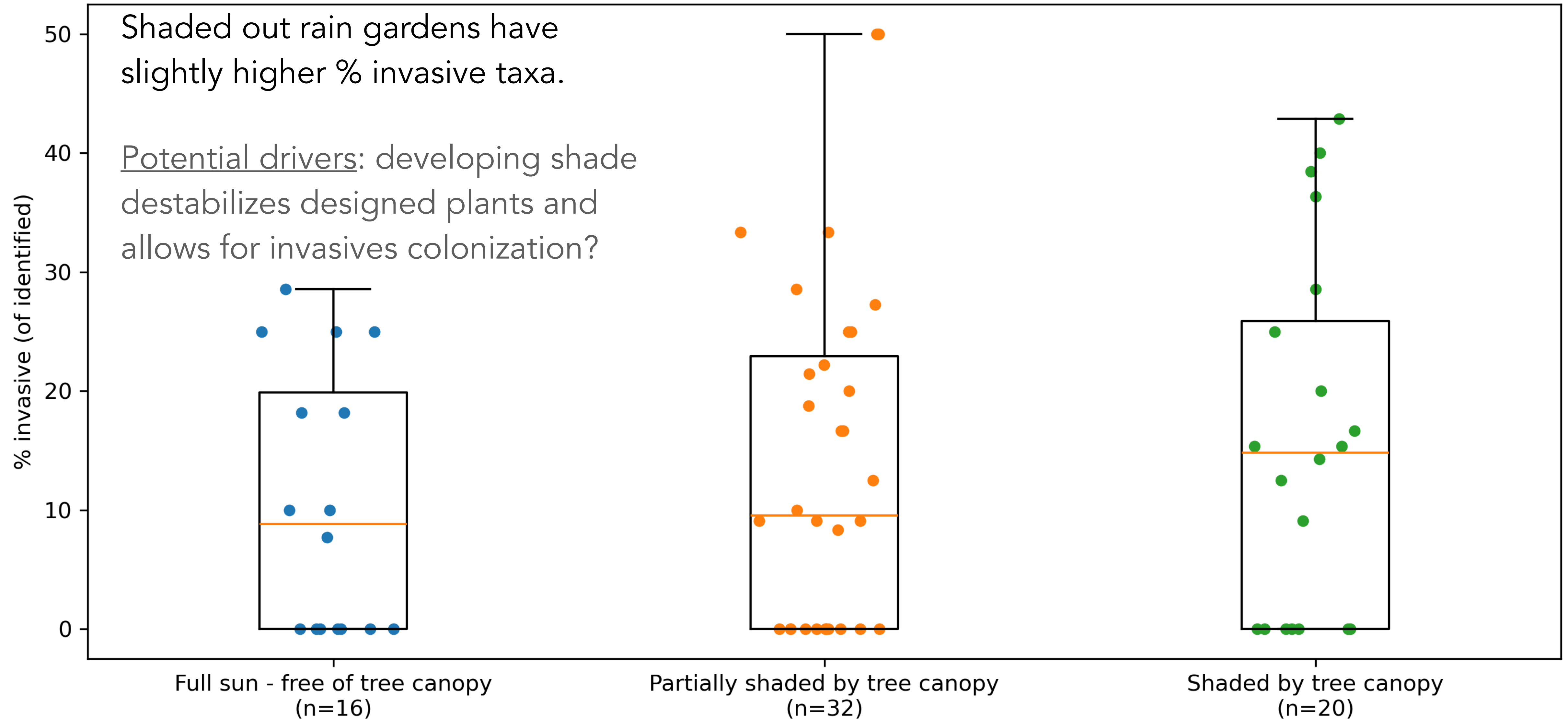
Non-native ornamental richness by sun exposure (5+ years)



Non-native naturalized/weed richness by sun exposure (5+ years)



% invasive taxa (of identified taxa) by sun exposure (5+ years)



What this suggests for long-term success

- **Plant Density** — long-term rain gardens maintain healthy coverage; coverage decreases somewhat in shade conditions
- **Species richness** — native richness declines somewhat in long-term rain gardens possibly due to replacement with non-native ornamentals; shade/sun conditions do not appear to impact richness
- **Invasive pressure** — increases with age; increases somewhat with shade exposure; invasives are common but usually low-richness / low share of taxa

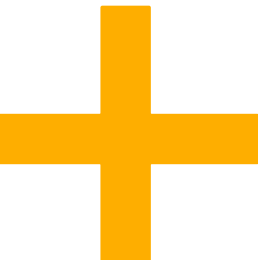
ECOLOGICAL SUCCESS

	Category	Indicator	Next Steps
	Plant health	Vegetation coverage	<ul style="list-style-type: none"> • Statistical analysis; score and weight for success
		Establishment and condition	<ul style="list-style-type: none"> • Photo-based plant condition categorization (well-established, weak plants, unhealthy plants, etc.) • Compare designed vs existing plant lists (for a sub-set of sites)
	Plant community diversity	Structural layer diversity (ground cover, perennials, shrubs, trees)	<ul style="list-style-type: none"> • Pollinator proxy for native species
		Root structure diversity	<ul style="list-style-type: none"> • Genus-level root categorization (for relationship to hydrology)
	Species diversity	Species richness	<ul style="list-style-type: none"> • Statistical analysis; score and weight for success
		Invasive pressure	<ul style="list-style-type: none"> • Photo-based % invasive cover estimates • Statistical analysis; score and weight for success

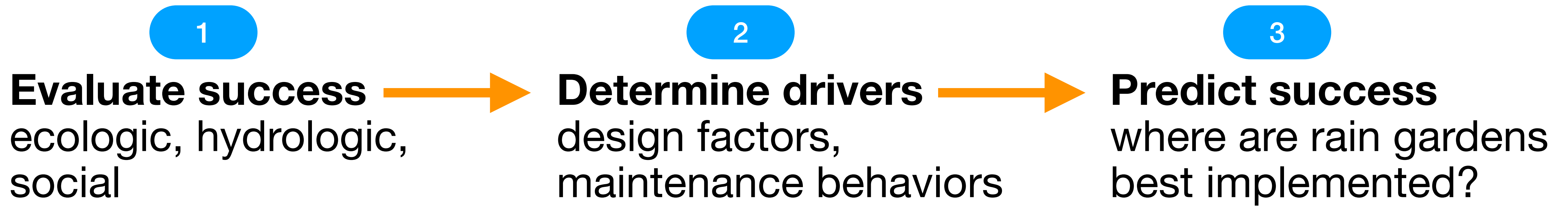
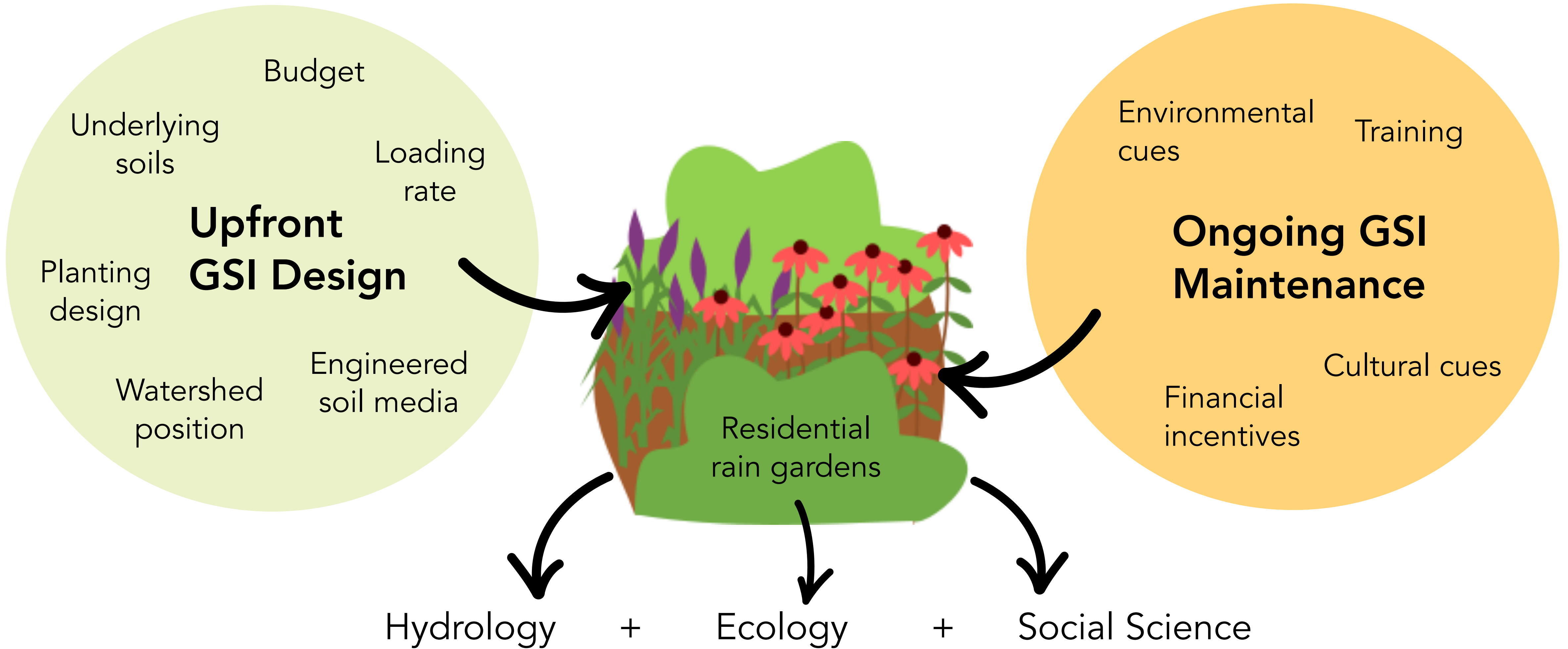
	Category	Indicator
ECOLOGICAL SUCCESS	Plant health	Vegetation coverage
		Establishment and condition
	Plant community diversity	Structural layer diversity (ground cover, perennials, shrubs, trees)
		Root structure diversity
	Species diversity	Species richness
		Invasive pressure



	Category	Indicator
HYDROLOGICAL SUCCESS	Infiltration Capacity / Drainage	Drainage performance
		Infiltration rate
	Flow Routing / Capture	Flow path
		Clogging
	Water Quality	Water bypass / overflow
		Water holding capacity*
	Water Quality	Sorption of pollutants*



SOCIAL SUCCESS



Thank you!

Project team:

Dr. Carolyn Voter
Dr. Yao Hu
Dr. Becca Nixon
Dr. Paul Imhoff

Jan Philip Ylanan De Leon
Shihao Xi

Brayden Rochester
Catherine Hunt
Ryan Knott
Emily Berger

Field work volunteers:

Austin Farnum
Dannielle Pratt
John Mosel
Kimani Kamau
Nicole Coviello
Savannah McMullen
Danial Golbaz
Kiersten Schmitt
Omowumi Erukubami
Christopher Rochester
Patricia Devine

RiverSmart Homes staff:

Arielle Conti
Jacqueline Moss



*NSF Strengthening
American Infrastructure
Award #2425112*

Contact: emmarugg@udel.edu