Trait variation and long-term population dynamics of the invasive *Alliaria petiolata* across three forest microhabitats

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Population Dynamics, Habitat Connectivity, & Invasion

- Understanding the connections between habitats – especially those of differing suitability – could be critical to predicting species' ability to adapt to and persist in new areas and habitats
- Source-sink dynamics and metapopulation structure as an invasion mechanism
- This can happen on macro spatial scales (landscape) to micro spatial scales (meters)

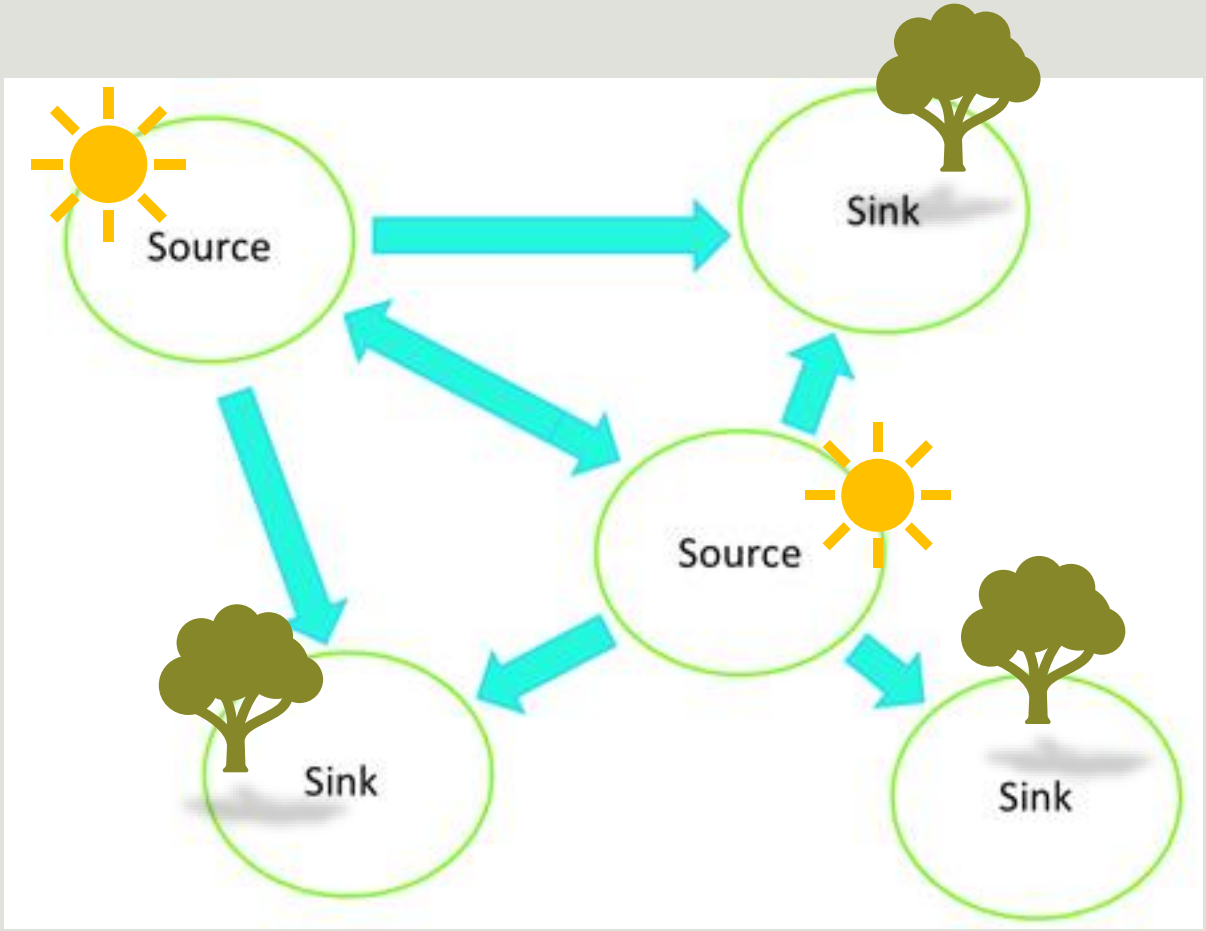
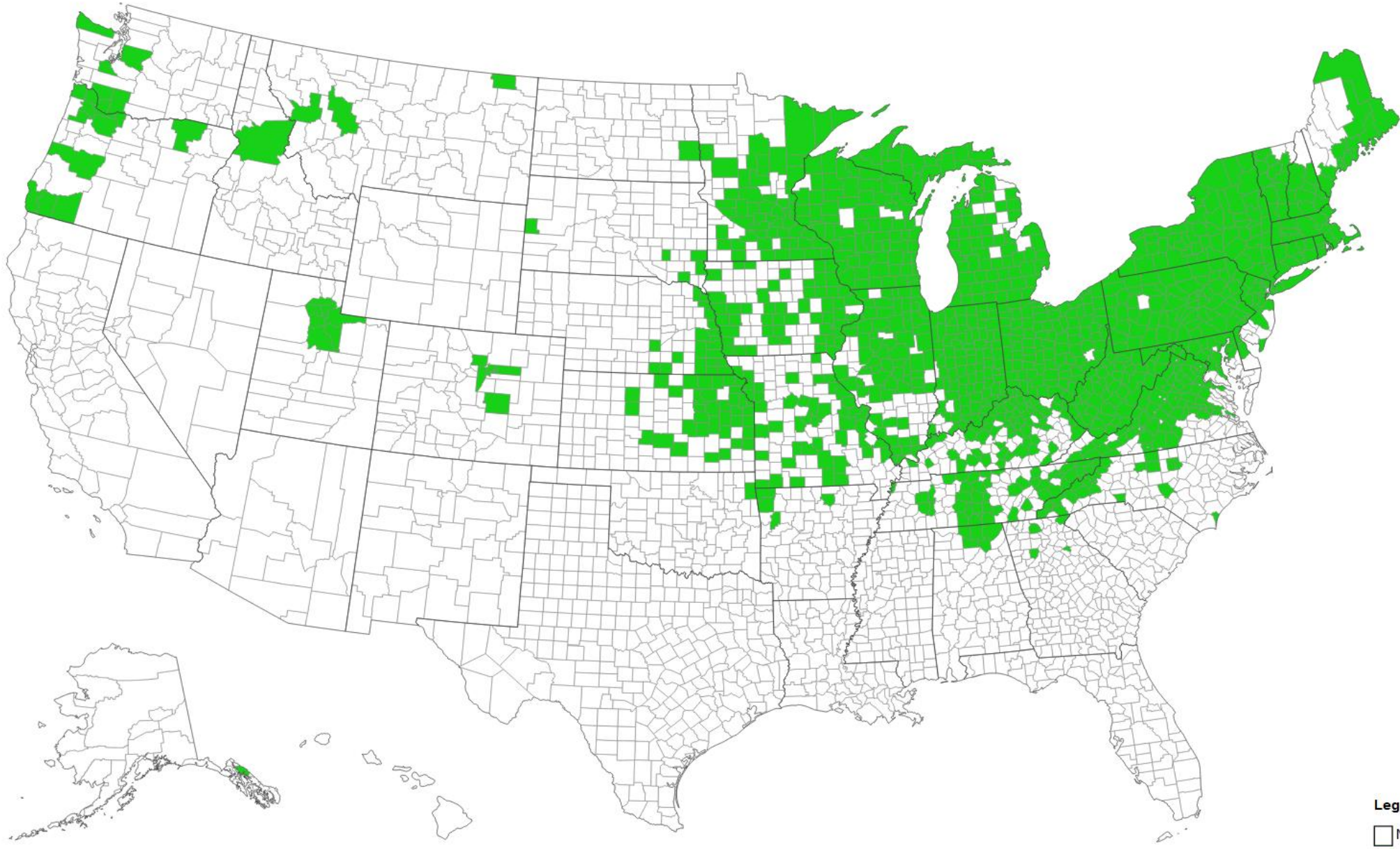


Photo by Rebecca Finneran, MSU Extension.
https://www.canr.msu.edu/news/garlic_mustard_may_be_michigans_worst_woodland_weed

Photo credit: Adam Davis, University of Illinois.
https://www.prweb.com/releases/2008/12/prweb1721474.htm

garlic mustard (Alliaria petiolata)

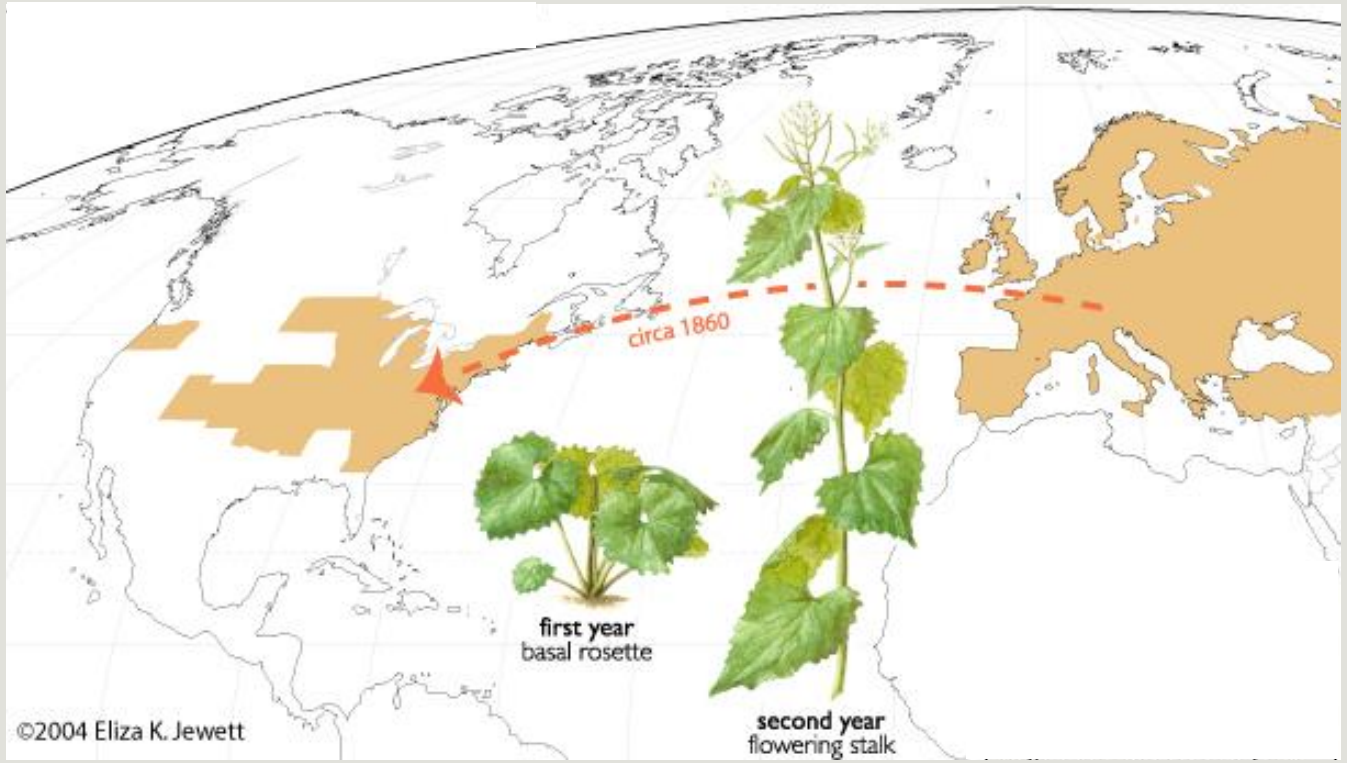
EDDMapS
find • map • track



Map created : 12/2/2020

Alliaria petiolata (garlic mustard)

- "Garlic mustard" or "jack by the hedge"
- Native to Eurasia
- In its native range, *A. petiolata* usually grows in "hedgy" areas
- First recorded in the U.S. circa 1868
- Disrupts above and below ground community composition
- Impacts could last for years after removal



Research Questions

1. Does *A. petiolata* performance, biomass allocation, growth, and reproductive capacity differ across forest growth microhabitats*?*
2. Are there demographic differences among populations of *A. petiolata* growing across microhabitats and over time (decadal scale)?

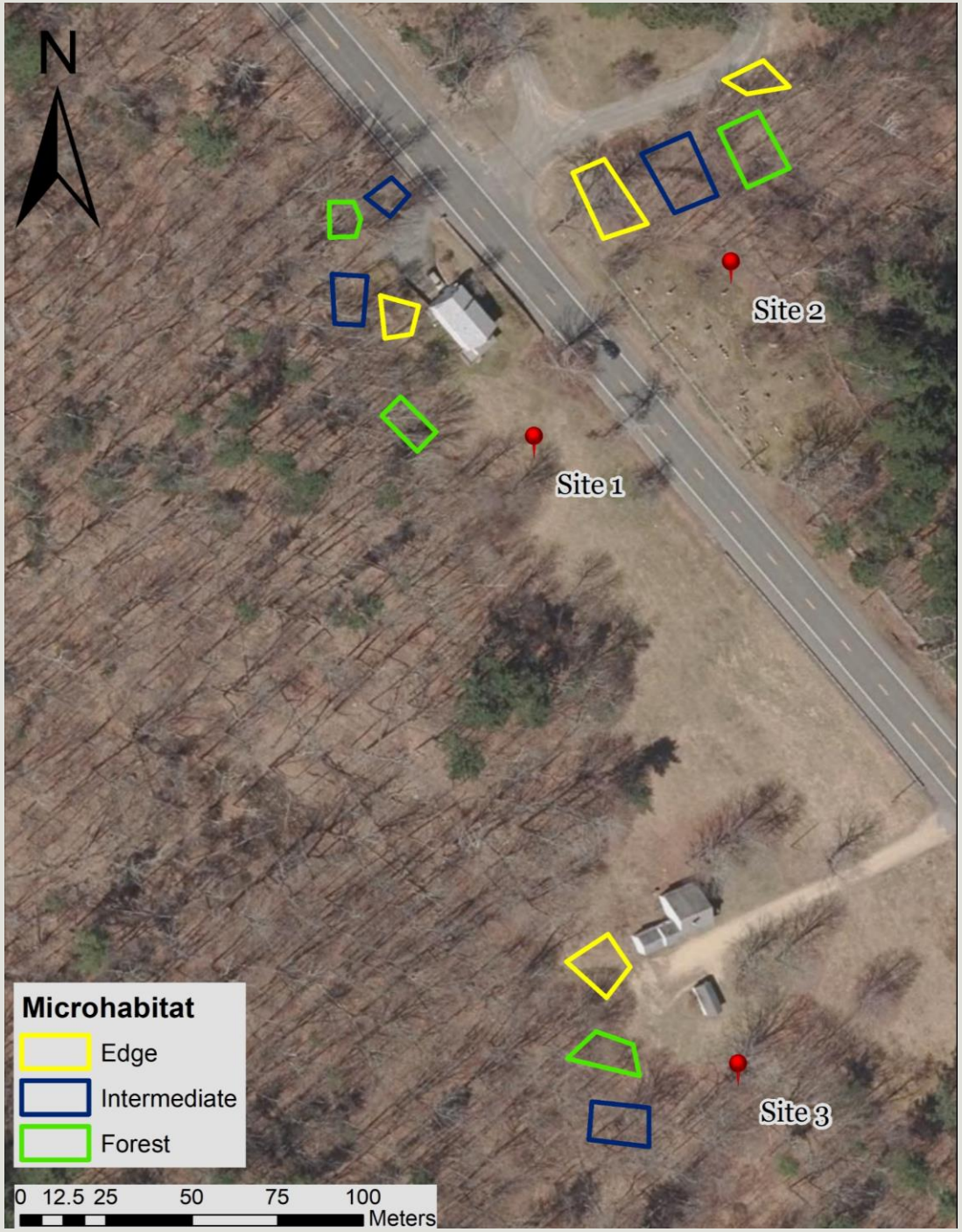

Forest Edge


Intermediate


Forest Understory

The Harvard Forest LTER

- Spatial sampling scheme
  - **Three replicate sites** which each contain three focal growth microhabitats
    - Forest edge (n=3)
    - Forest understory (n=4)
    - Intermediate transition zone (n=4)
- Temporal sampling scheme
  - Sampling period 1 (2003-2006)
  - Sampling period 2 (2015-2016)
- Used a stratified random sampling scheme to collect data on environmental variables, individual plant performance, and population demography



Year 1: Seedlings

Year 1 to Year 2: Rosettes

Year 2: Reproductive adults

Germination proportion

Seed bank

Fecundity (seeds/plant)

Garlic mustard life cycle

Survival proportion

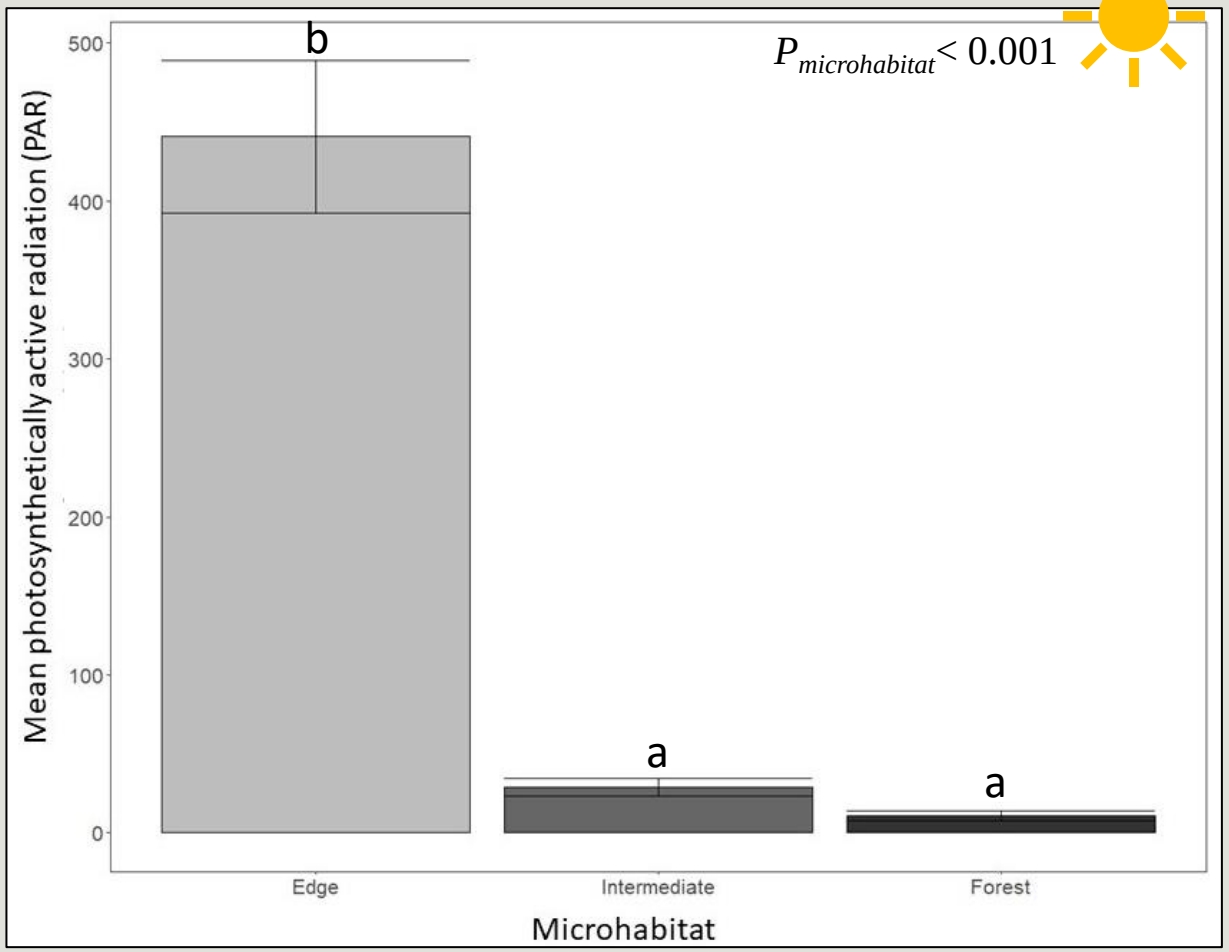
Survival proportion

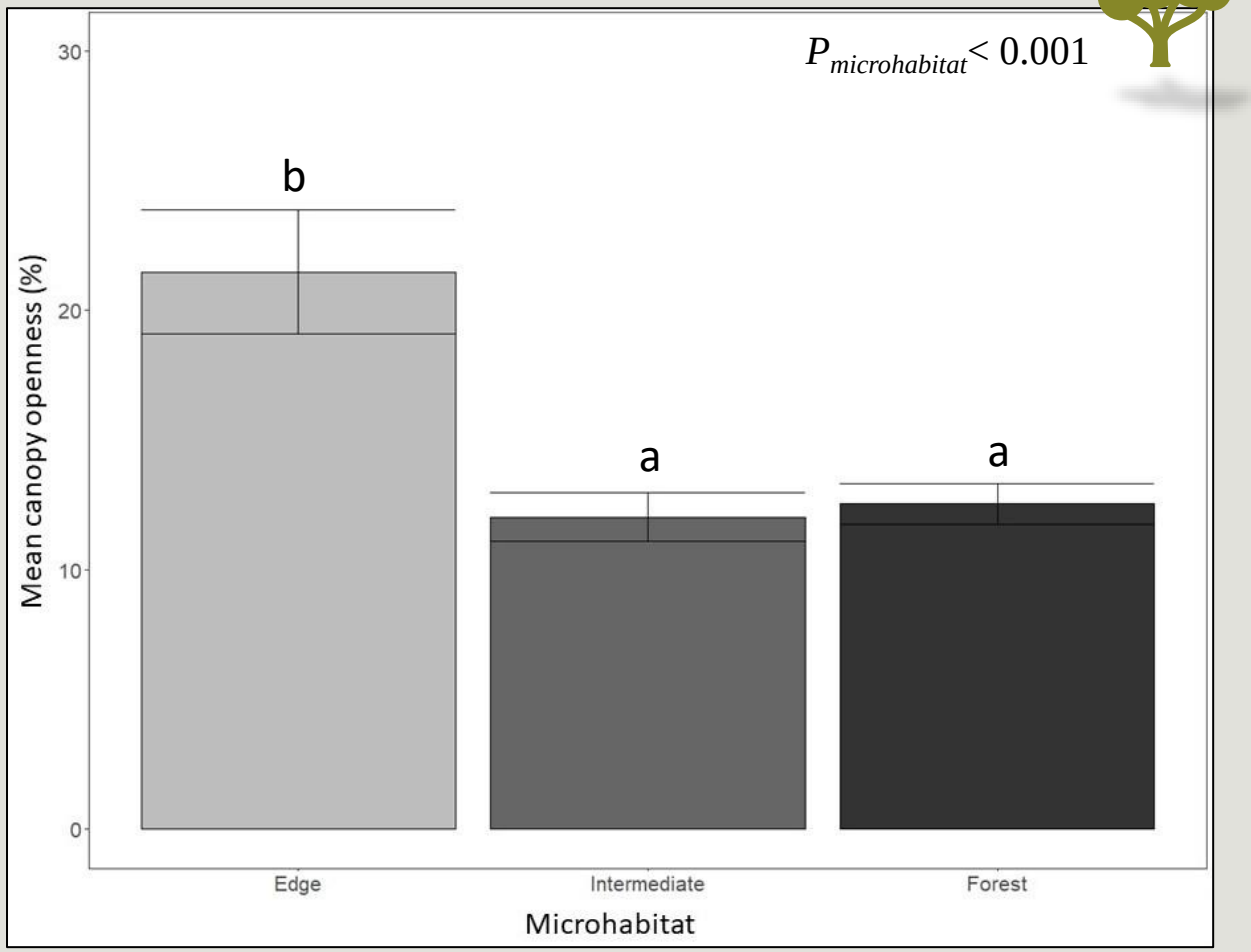
Results: Light Availability Across Microhabitats

Responses:

- Canopy Openness
- Photosynthetically Active Radiation (PAR)

Light availability is not a linear gradient from edge to understory

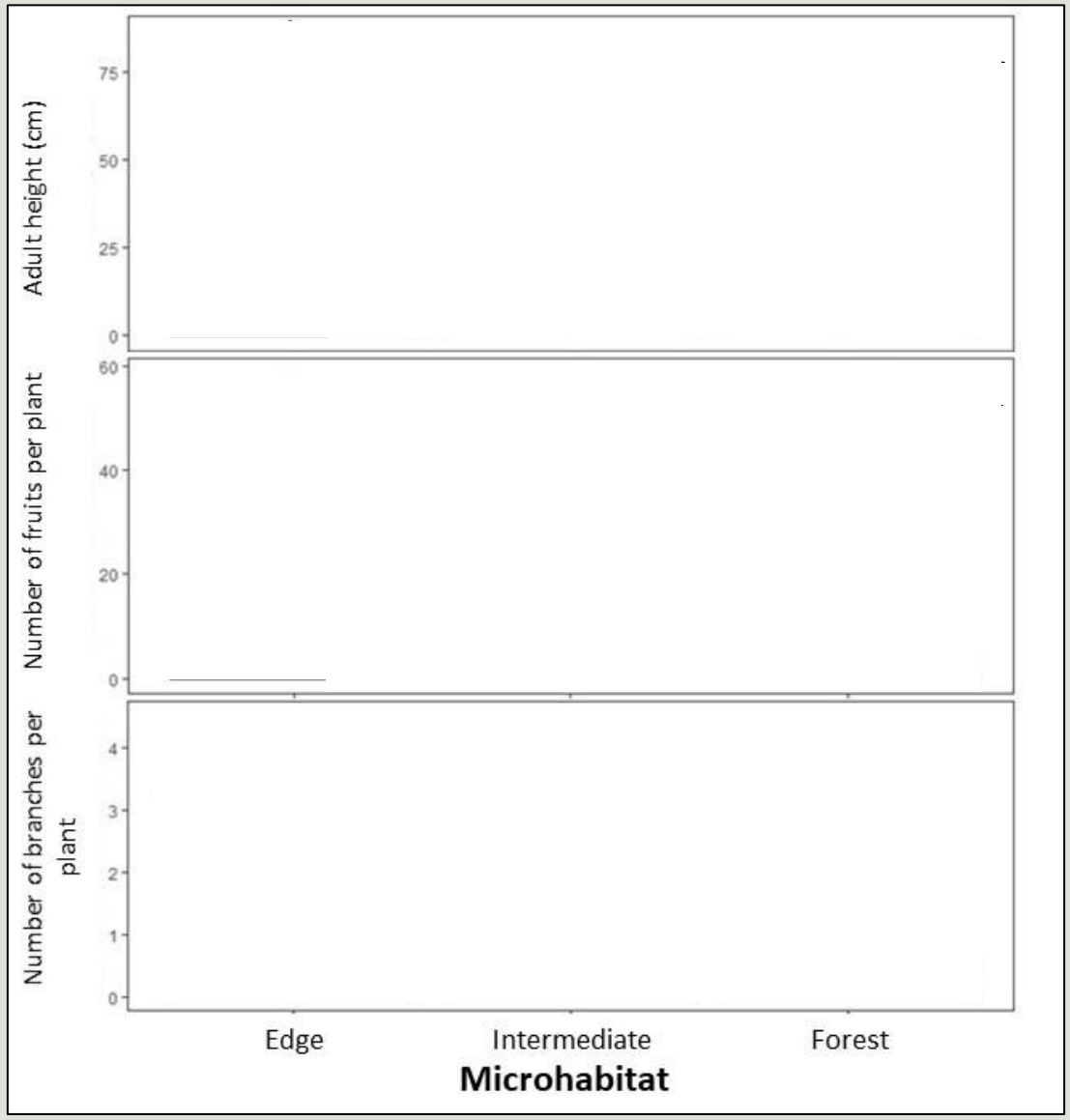


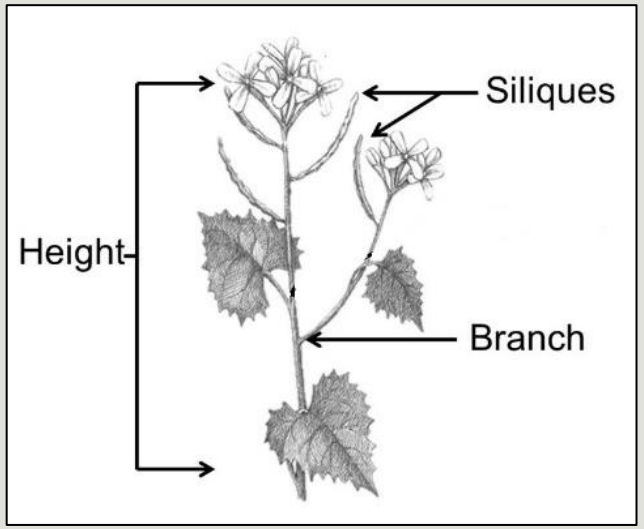


Results: Plant Performance & Trait Variation

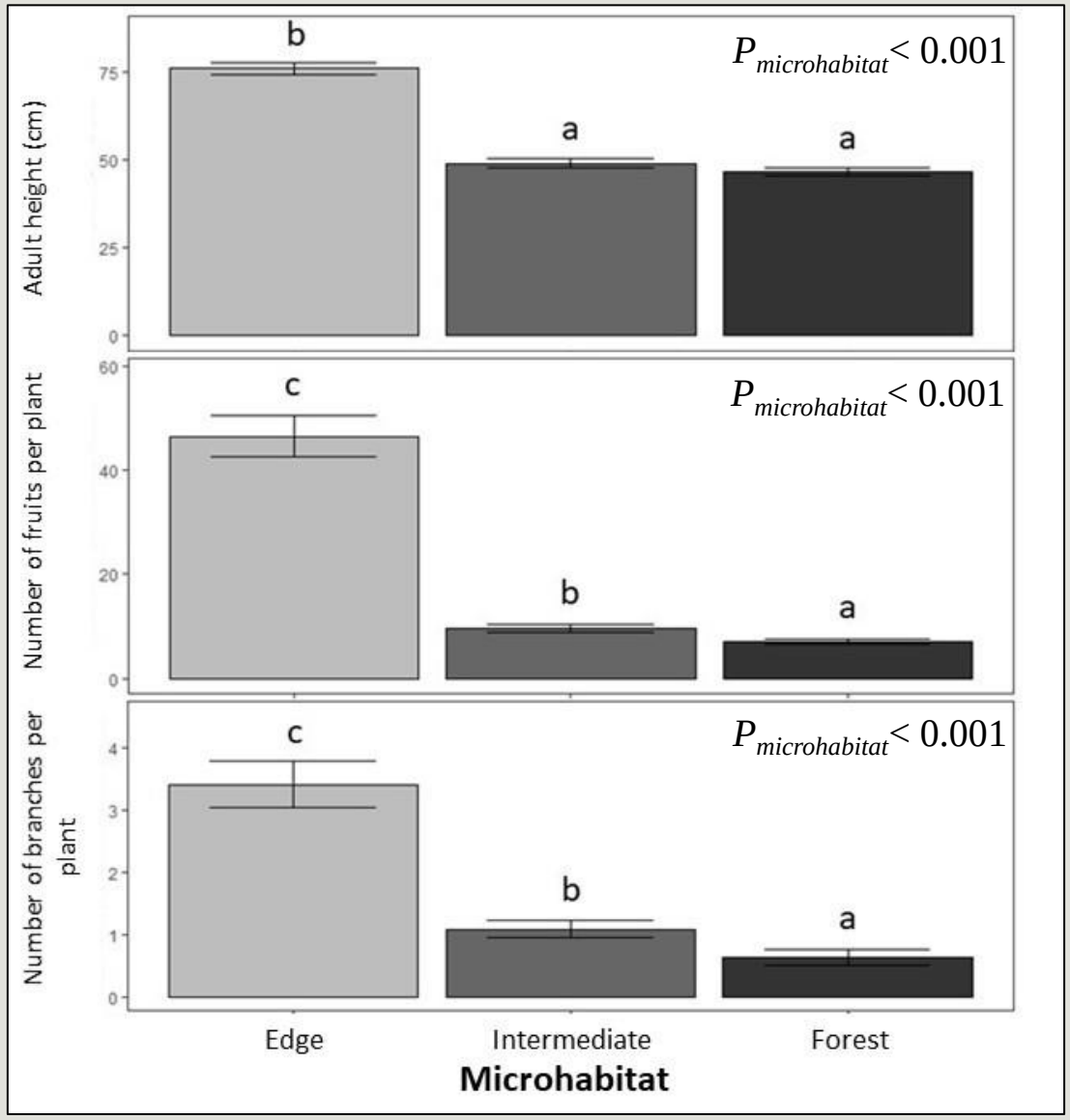
Responses:

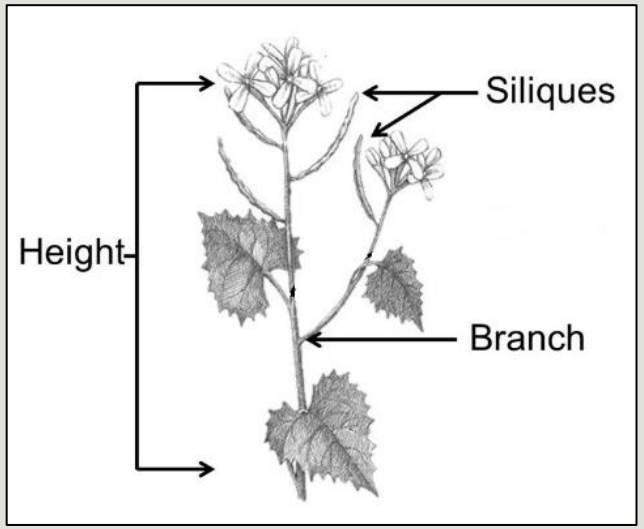
- Adult Growth
  - Height
  - Number of branches
  - Number of fruits
- Adult Biomass (dry)
  - Total
  - Reproductive
  - Reproductive:vegetative ratio
- Reproductive Capacity (Seed production)


Adult height (cm)
75
50
25
0
Number of fruits per plant
60
40
20
0
Number of branches per plant
4
3
2
1
0
Edge
Intermediate
Forest
Microhabitat

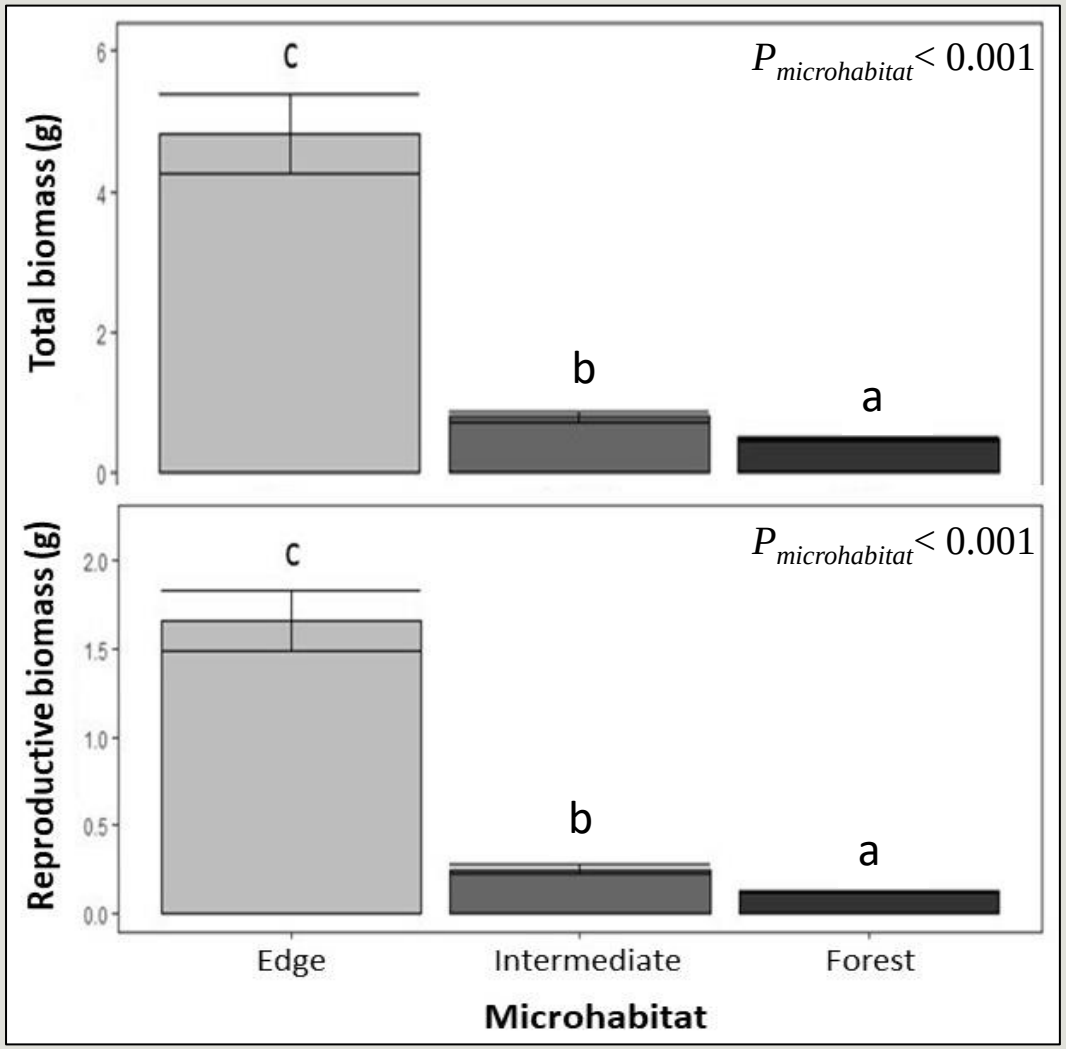

Siliques
Height
Branch

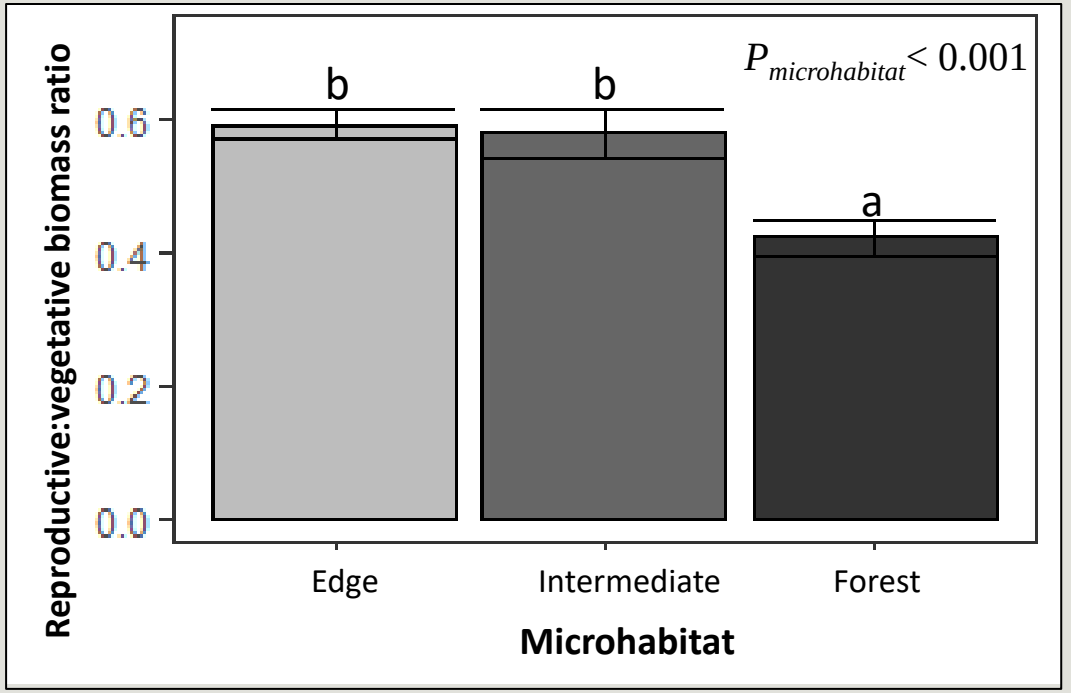
Plants in the edge are largest and perform the best across multiple growth metrics



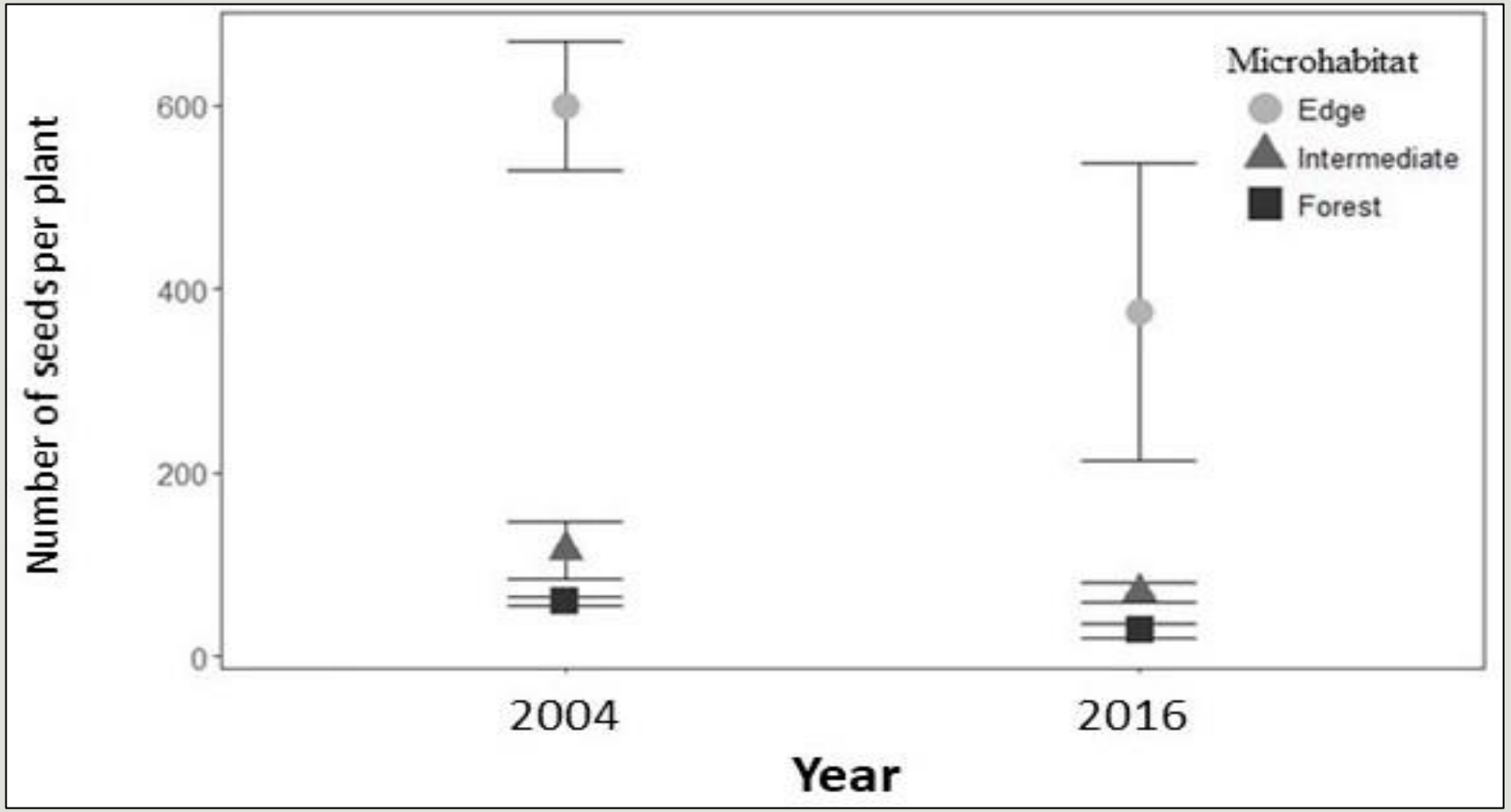


Per plant biomass is highest in the edge; reproductive allocation is lowest in the understory





Seed production is highest in the edge across time



$P_{\text{microhabitat}} < 0.001$

$P_{year} < 0.001$

$P_{\text{microhabitat X year}} = 0.205$

Results: Long-term population dynamics

Responses:

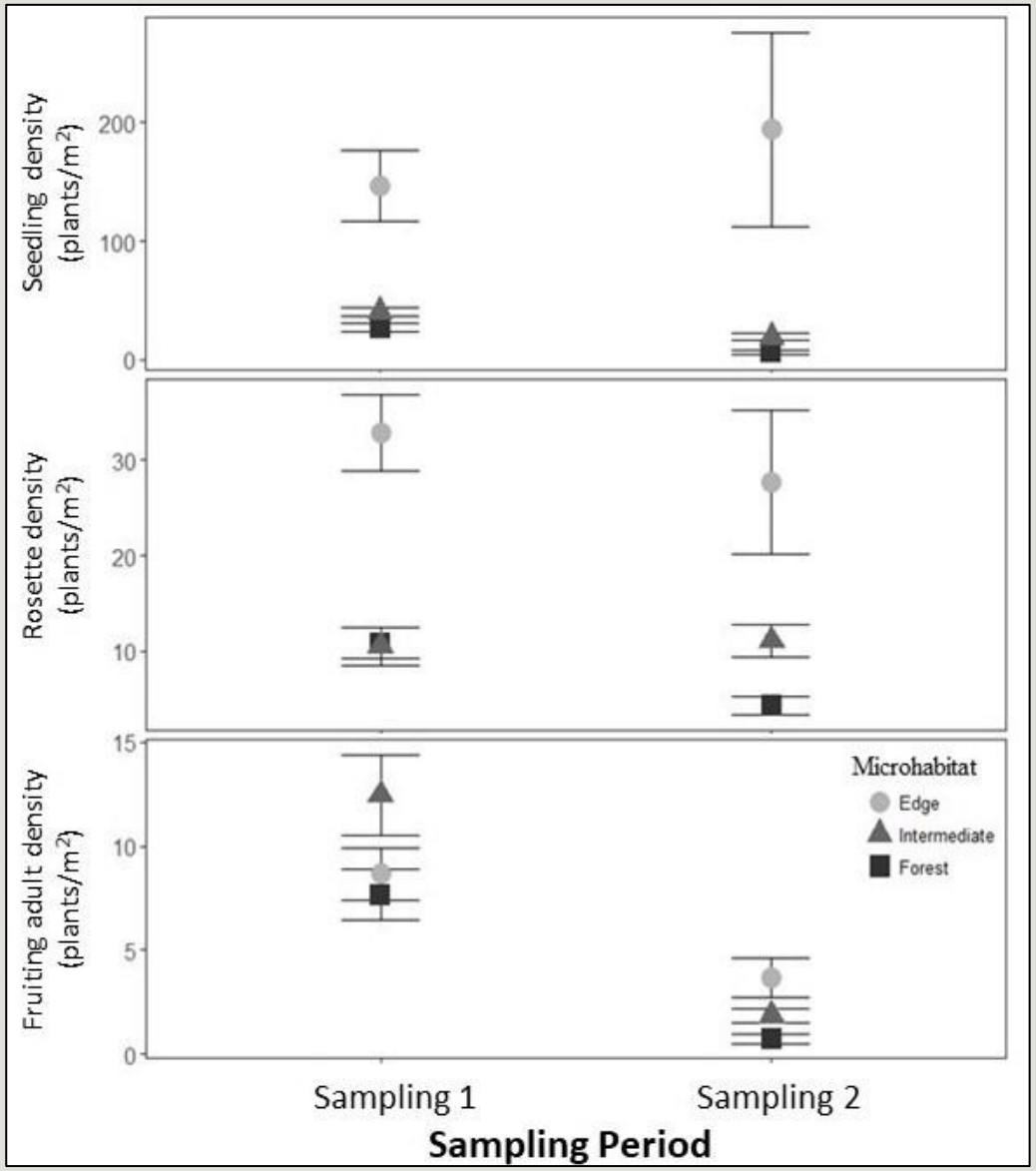
- Plant density (plants/m^2)
  - Seedlings
  - 1st year rosettes
  - Reproductive adults
- Population growth rate (lambda; λ)

Year 1: Seedlings

Year 1 to Year 2: Rosettes

Year 2: Reproductive adults

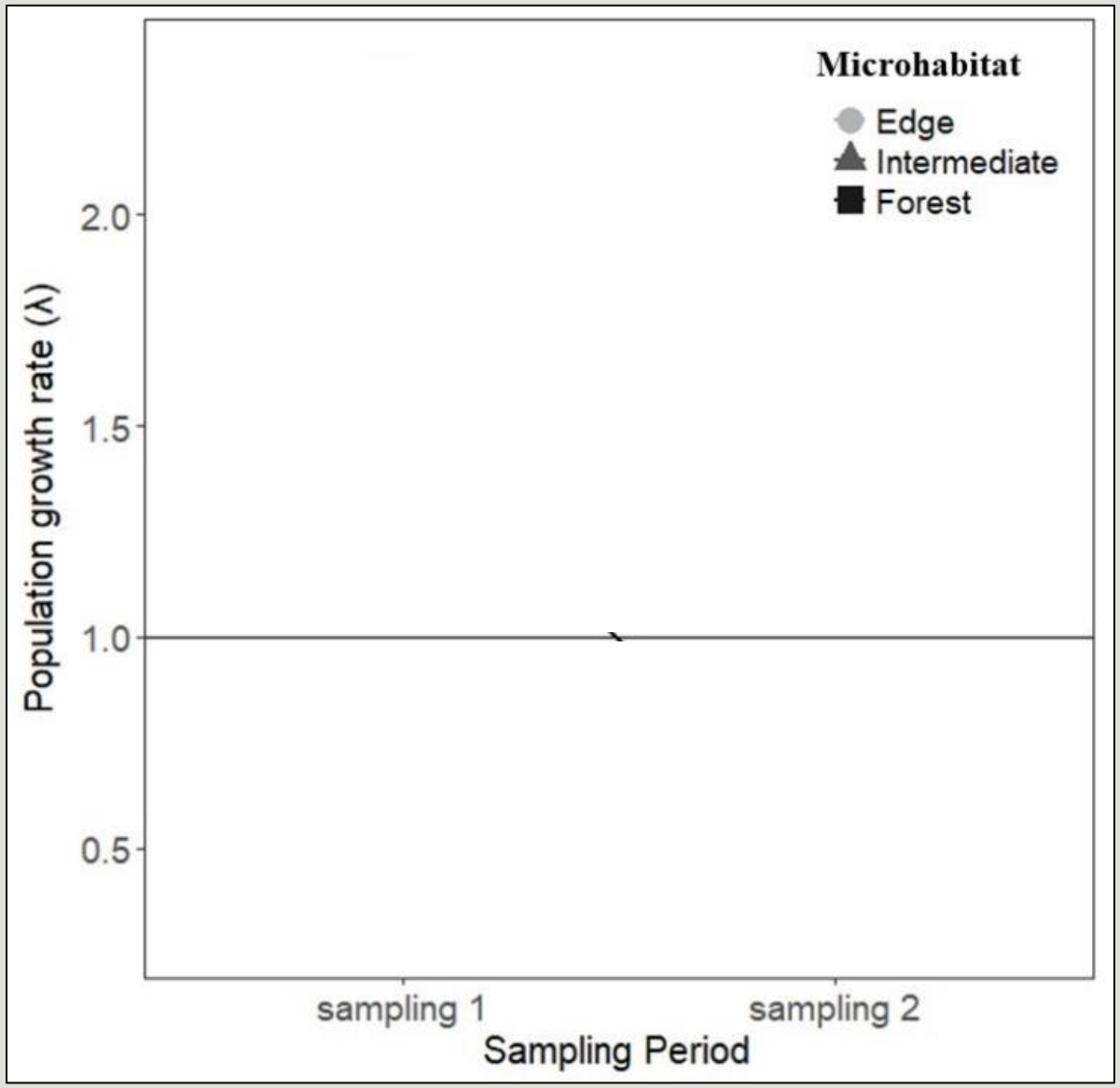
The edge supports the highest number of early life stage individuals across time



$P_{\text{microhabitat}}<0.001$
$P_{\textit{sampling period}}<0.001$
$P_{\text{microhabitat X sampling}}=0.003$

$P_{\text{microhabitat}}<0.001$
$P_{\textit{sampling period}}=0.007$
$P_{\text{microhabitat X sampling}}=0.023$

$P_{\text{microhabitat}}<0.001$
$P_{\textit{sampling period}}<0.001$
$P_{\text{microhabitat X sampling}}=0.001$

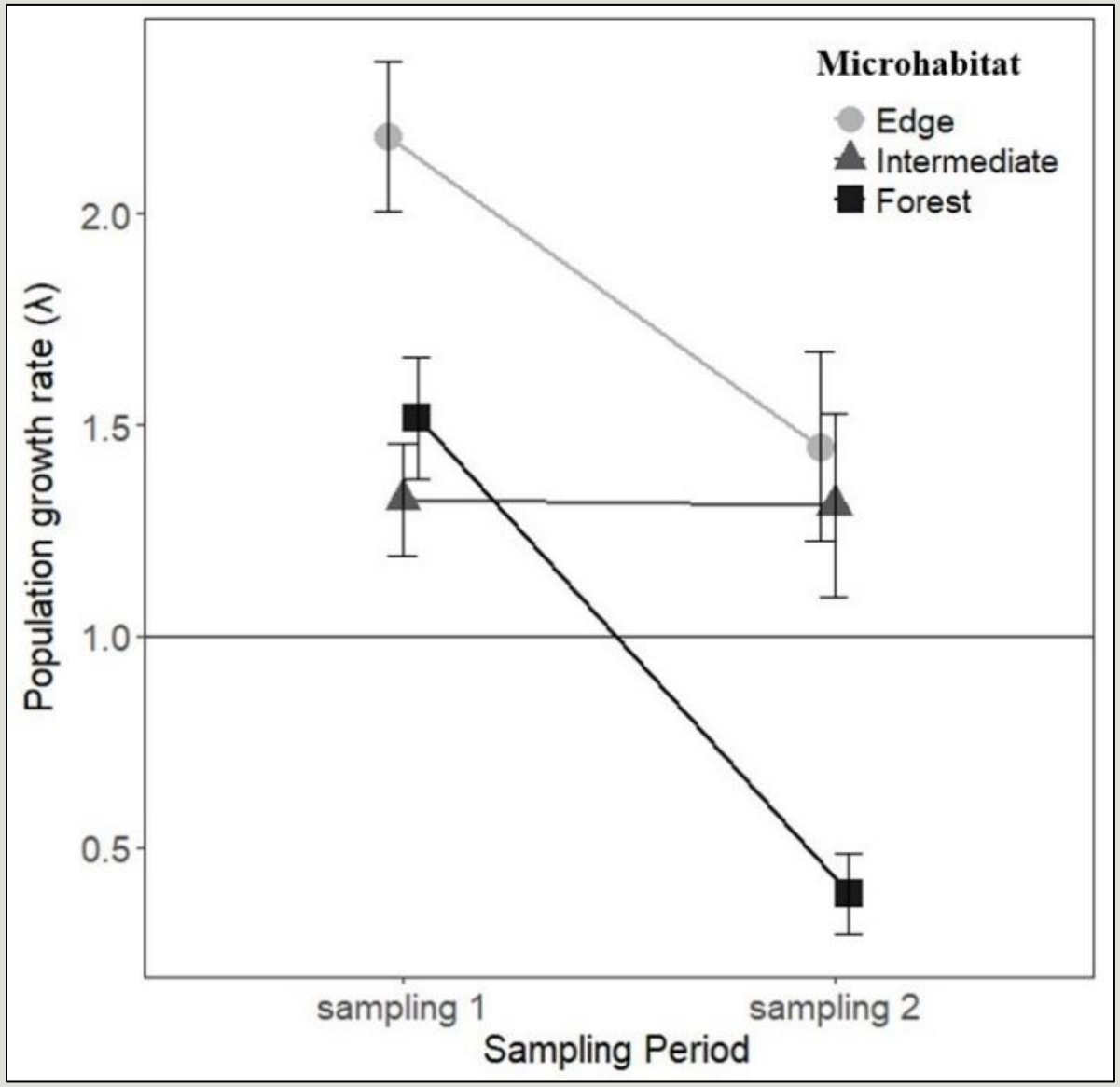


population size increasing

stable population size

population size decreasing

Edge & intermediate populations are growing; forest populations are declining



population size increasing

stable population size

population size decreasing

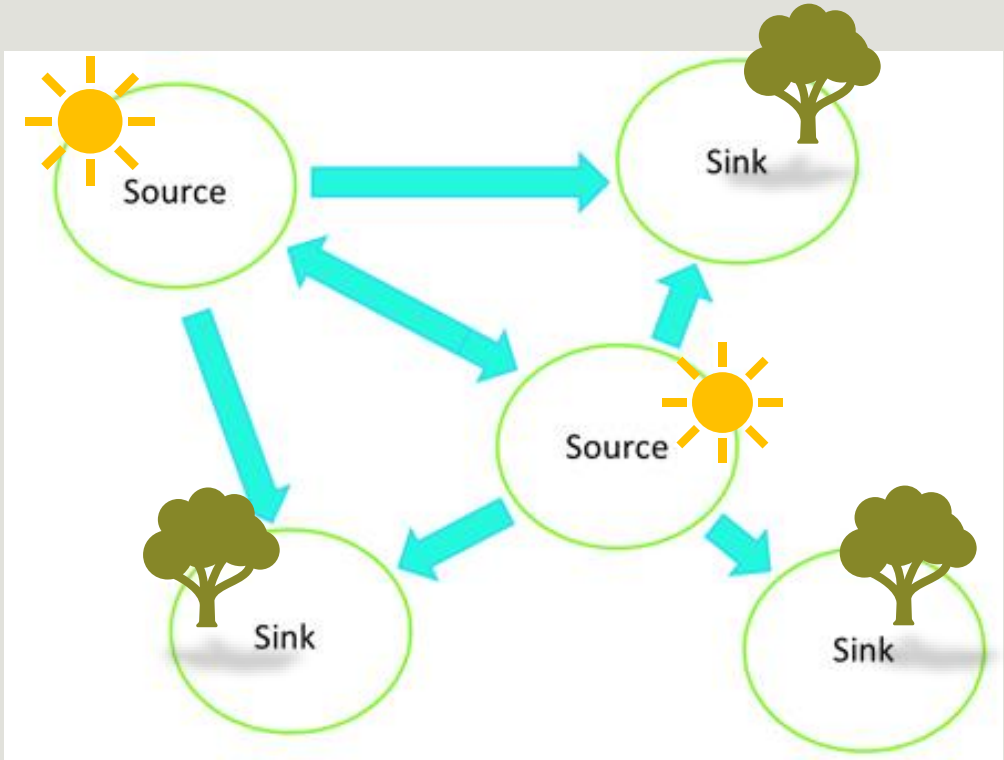
$P_{\text{microhabitat}} < 0.001$

$P_{\textit{sampling period}} < 0.001$

$P_{\text{microhabitat X sampling}} = 0.001$

Key Conclusions

- The edge microhabitat is most optimal for plant performance, growth, and fecundity
- Forest plants show depressed growth and performance, with less allocation to reproduction
- *A. petiolata* populations are still growing in the forest edge and intermediate microhabitats
- Source-sink population dynamics are likely playing a role in *A. petiolata*'s incursion into New England forests
- Management efforts should consider invasion across heterogeneous habitats



Brought to you by:

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