Fungal Life-History Traits Vary Along a Resource Availability Gradient

Kylea Garces, PhD Candidate
KAS 2021

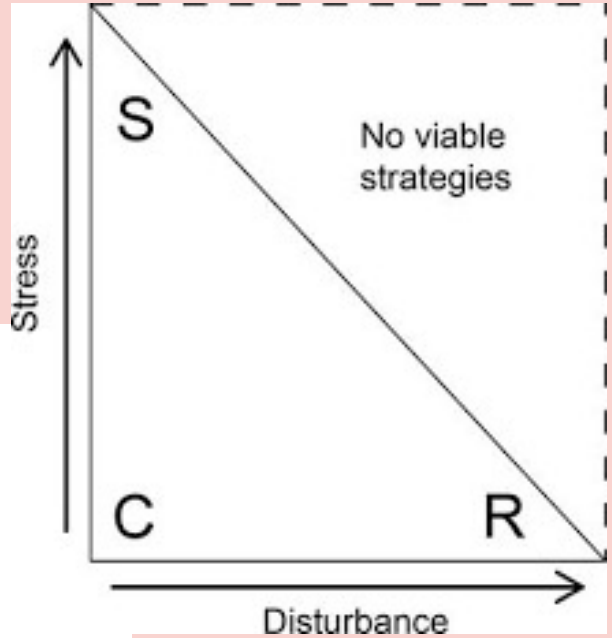
UNIVERSITY OF LOUISVILLE

How does a complex ecological community form? What allows for coexistence within a community?

Grimes (1977) CSR model – Plant Life History Traits

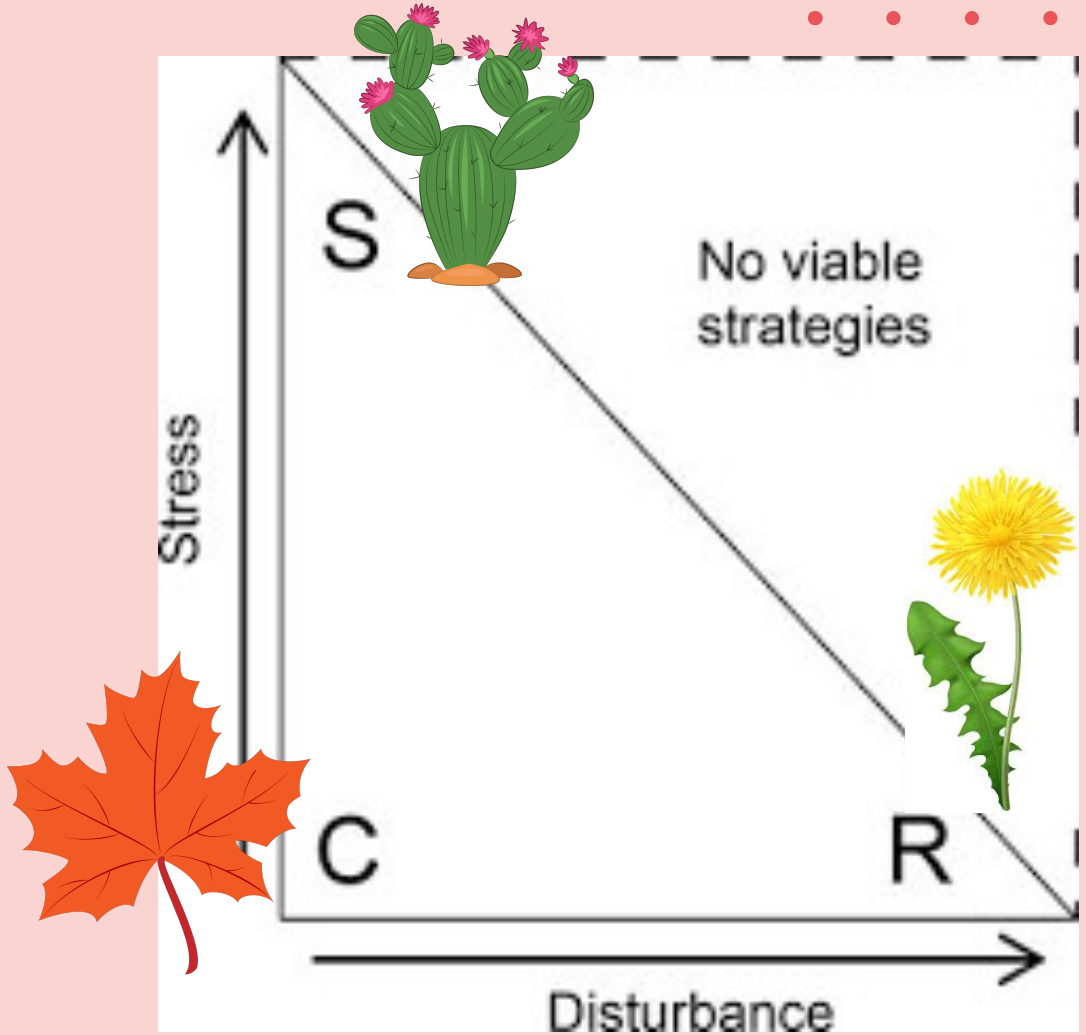
- Plants exhibit “trade-offs” when responding to their environment

- **Competitive (C)**
  - High growth rate
  - Efficient capture & utilization of resources
- **Stress-tolerant (S)**
  - Low growth rate
  - Tolerant of abiotic stressors
- **Ruderal (R)**
  - High growth rate
  - Short lived
  - High reproductive output



Grimes (1977) CSR model – Plant Life History Traits

- Plants develop strategies that demonstrate resource trade-offs between growth, reproduction, and maintenance
- Broadly categorized as disturbance and stress, which limit plant biomass
- Disturbance: herbivory, pathogens, anthropogenic interactions, fire, wind, etc.
- Stresses: water availability, nutrients, light, temperature and toxins

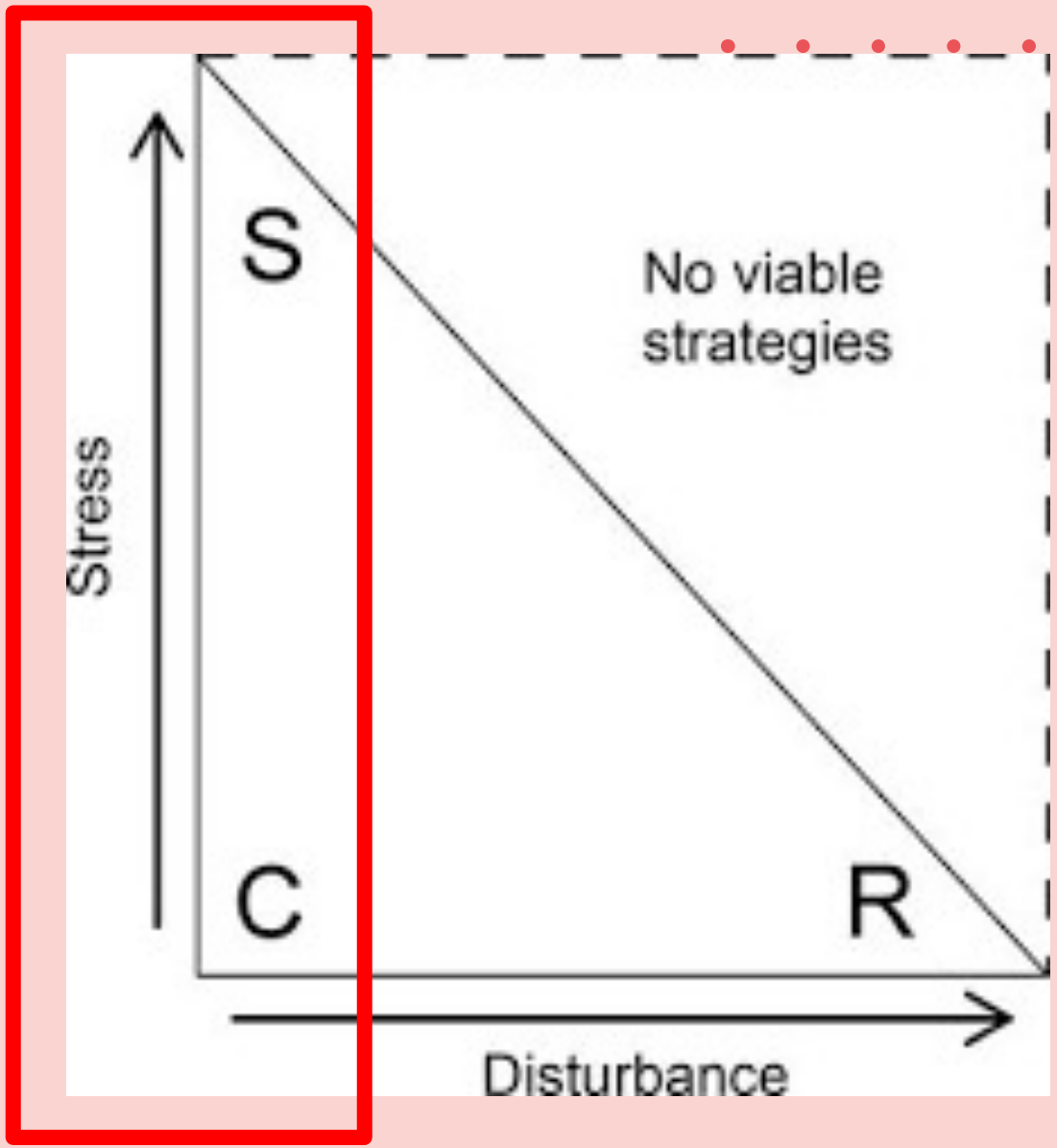


Life History Traits for Microbes

Do microbes follow similar patterns as explained for plants?

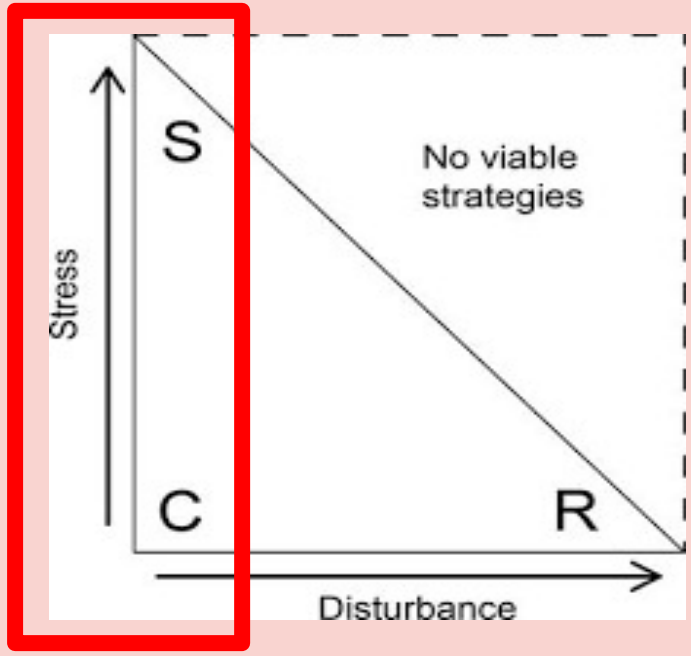
What are the trade offs between these strategies?

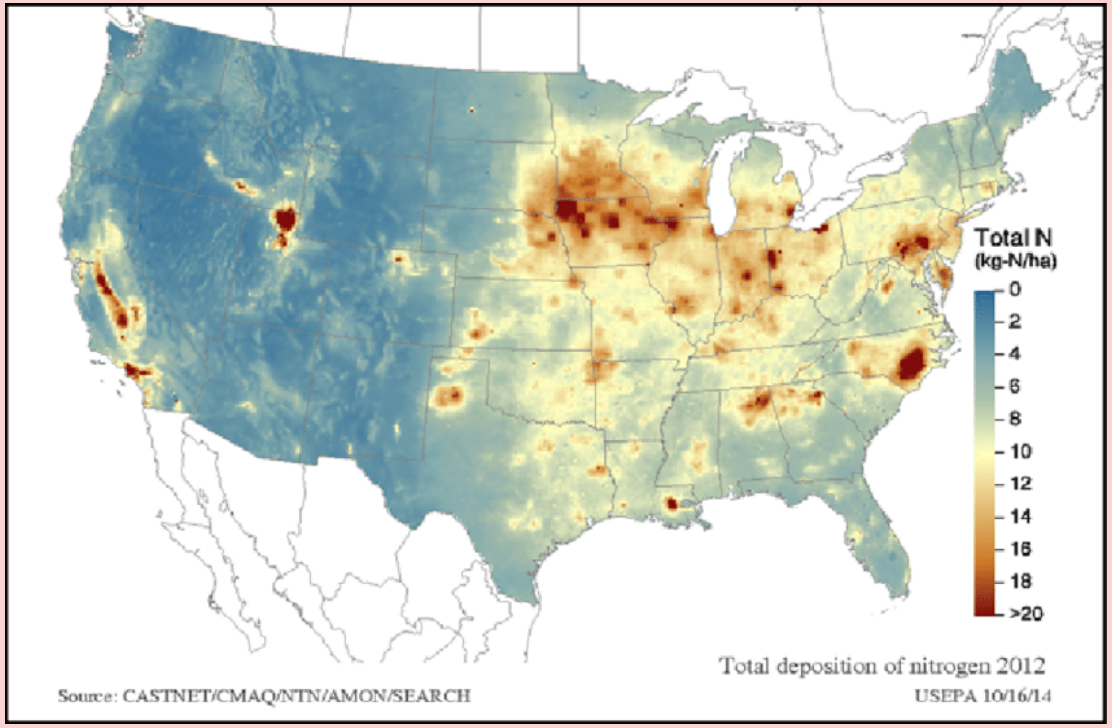
How do the abundance of taxa change as the environment shifts on a stress gradient?



Global Change: Nitrogen deposition

- Nitrogen deposition projected to increase 3-fold over the next century
- Changes in nitrogen = changes in carbon, two anthropogenic resources stresses are linked & can vary along gradient depending on nutrients available in system
- Directly changes plant stress & success -> changes microbial abundancies that rely on host



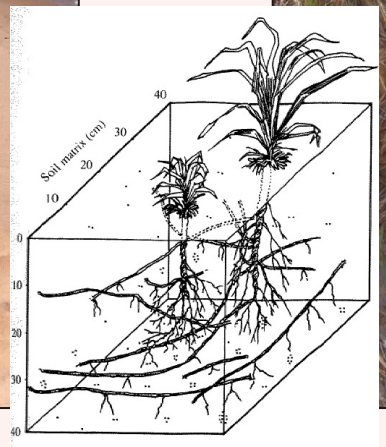


Global Change in the Great Lakes Dunes

- Field experiment; Leelanau State Park, MI
- Planted Spring 2010
- In 2016, added a Nitrogen manipulation to low nutrient system:
  - **control** (no N added)
  - **low** (0.5 g NH_4^+/m^2, corresponding to deposition rates for Chicago-area dunes)
  - **high** (10g NH_4^+/m^2, for nutrient stress release)

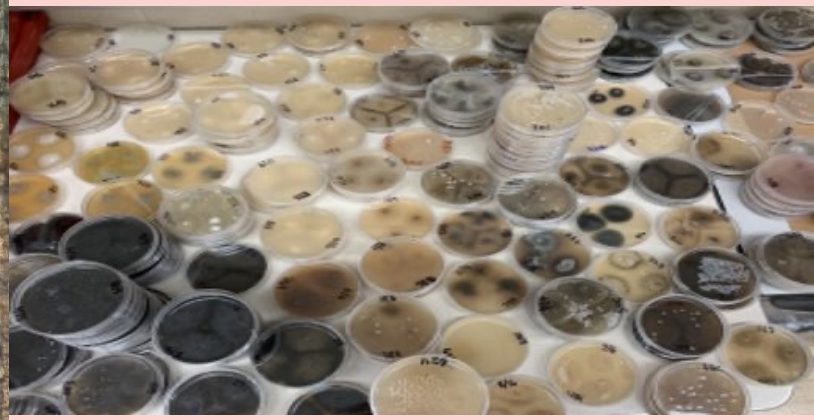
Fungal Root Endophytes in symbiosis with *Ammophila breviligulata* (American beachgrass)

- *Ammophila* is first species to colonize the beach
- Acts as an ecosystem engineer by stabilizing sand, allowing other species to continue to colonize



- Root endophytes hypothesized mutualists, but little is known!
- Found ubiquitously among plants
- Live intercellularly within roots

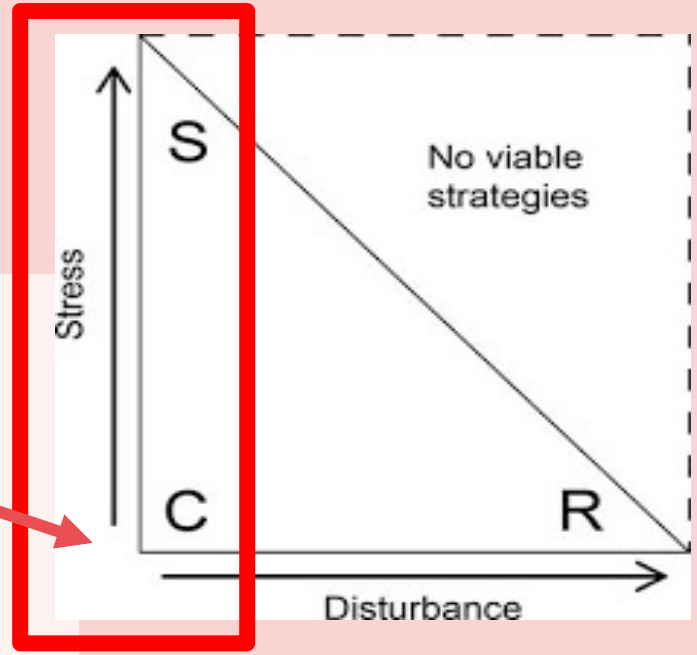
- Culture collection of 130+ morphospecies from long-term field experiment



Questions & Hypothesis

Q1.

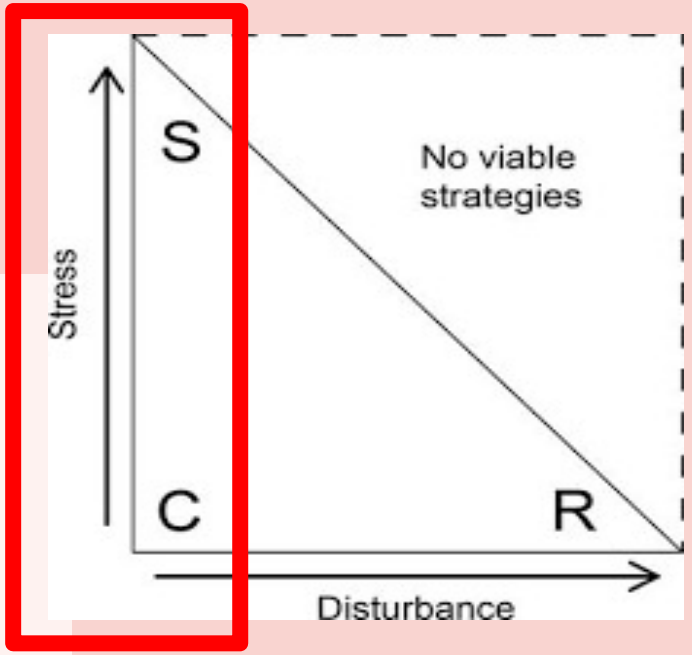
Do growth rates differ for **rare** vs **common** fungal taxa?



H1.

Fungi that are more common within a community will be better competitors than rare species, thus will have higher growth rates in ambient nutrient conditions.

Questions & Hypothesis



Q2.

Does resource availability differentially alter growth rates of common and rare species?

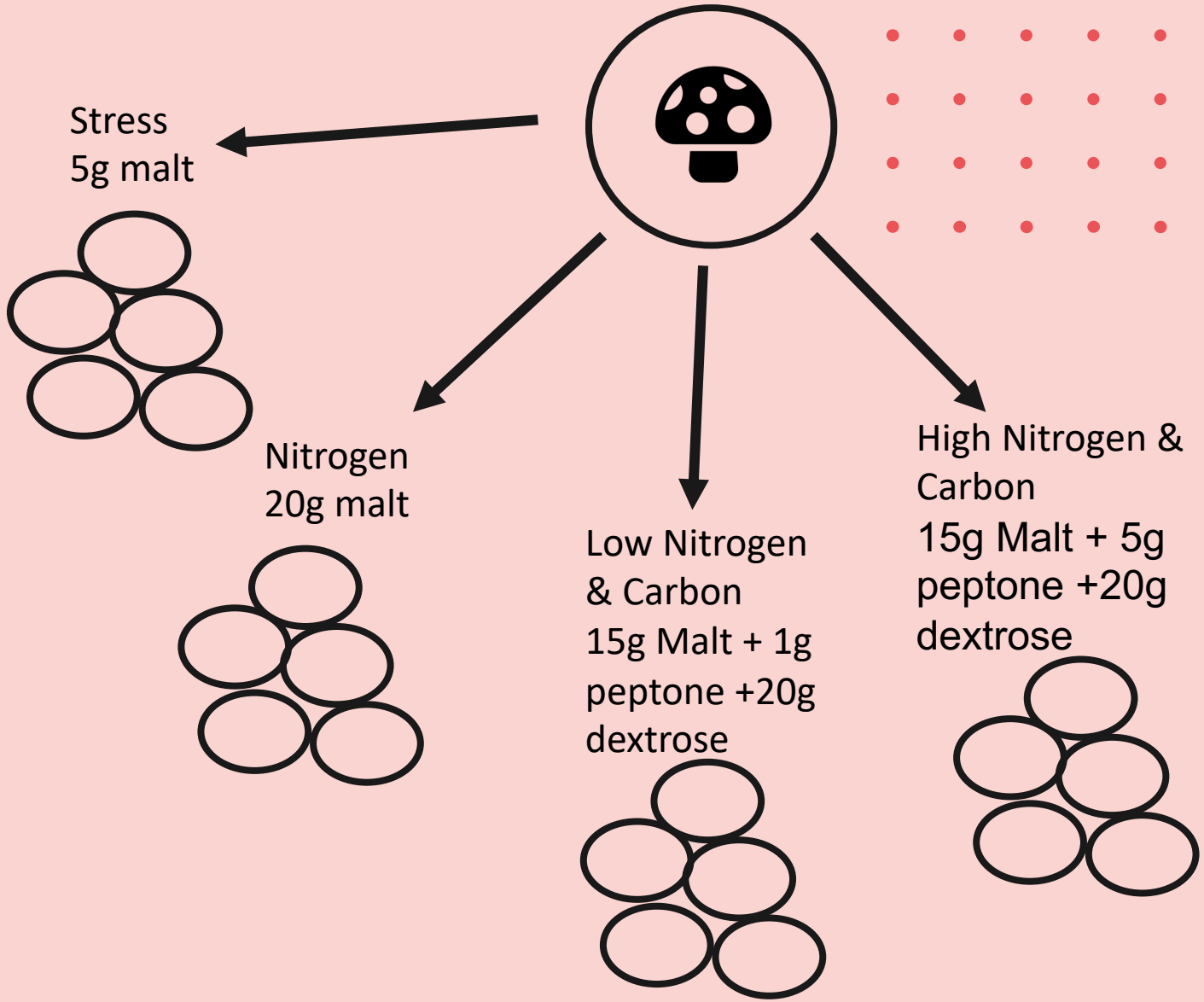
H2.

Rare taxa will display a stress-tolerant life history strategy and will not increase growth rates in high resource conditions. Common taxa will display a competitive life history strategy and increase growth rates with increased resource availability.

Experimental Design

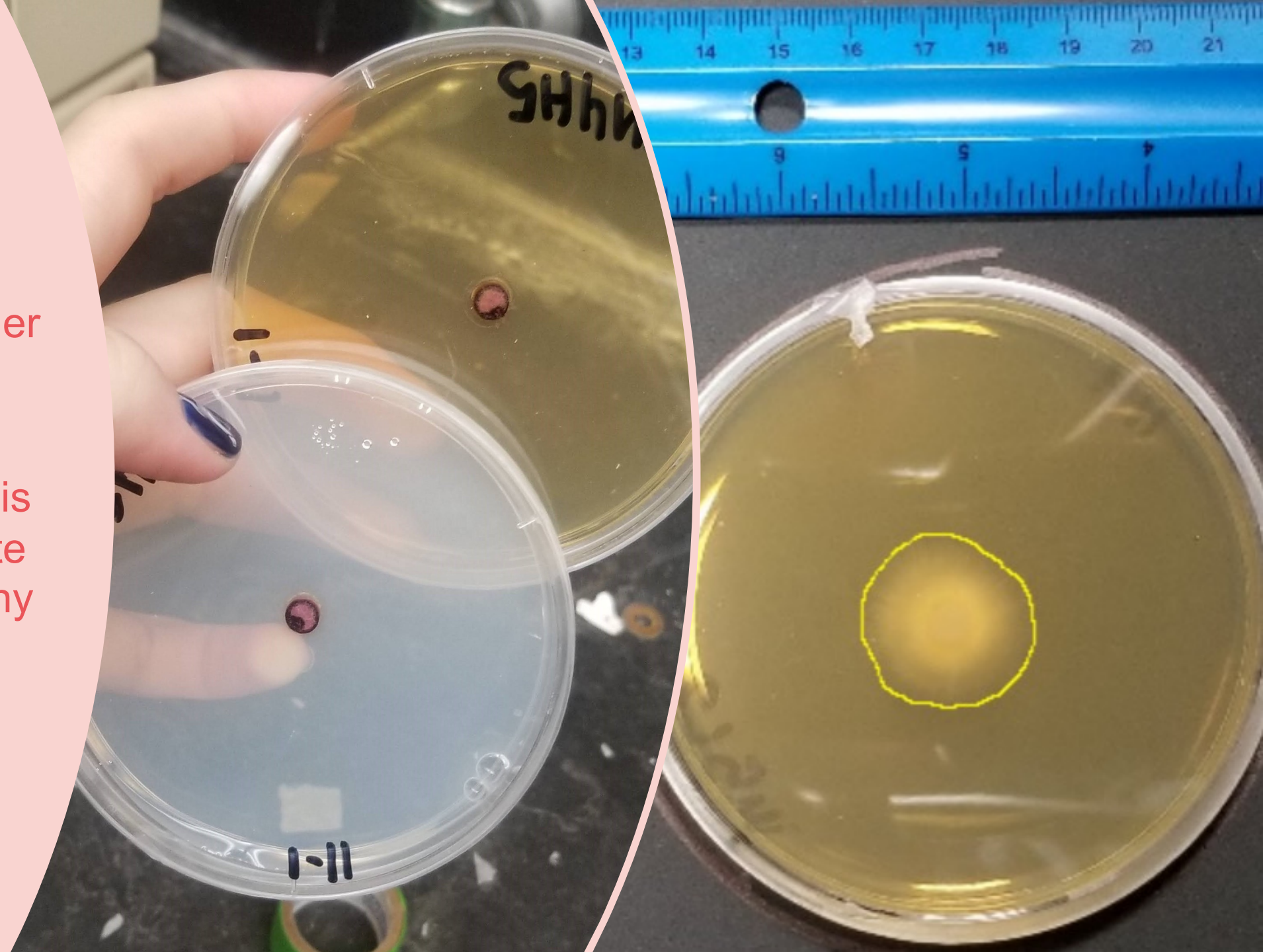
- In vitro culture-based experiment
- Each morphospecies subject to gradient of nutrient stress conditions

Marissa Huber,
Undergraduate Researcher



Methods

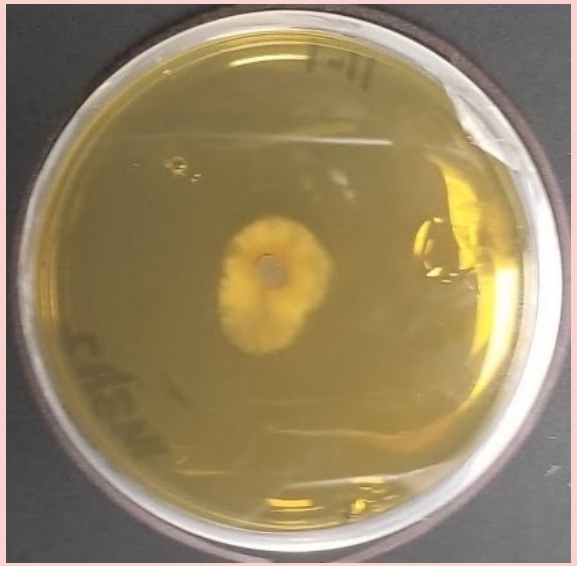
- Took pics every other day
- Used image analysis software to calculate area of fungal colony over time for two weeks
- Completed for 40+ morphospecies!



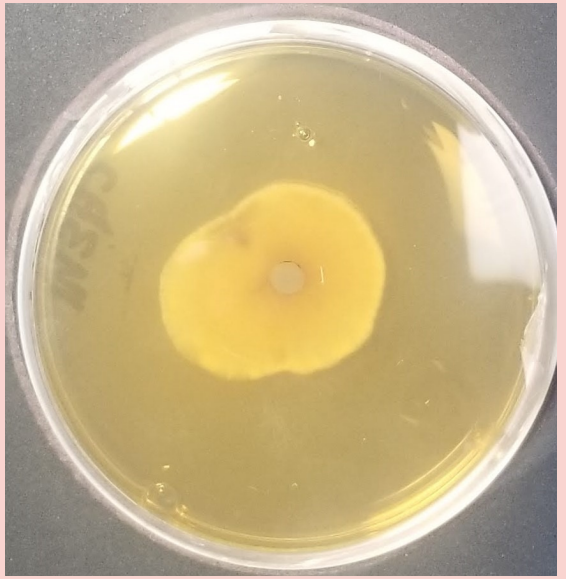
Fungal Growth

Day 1

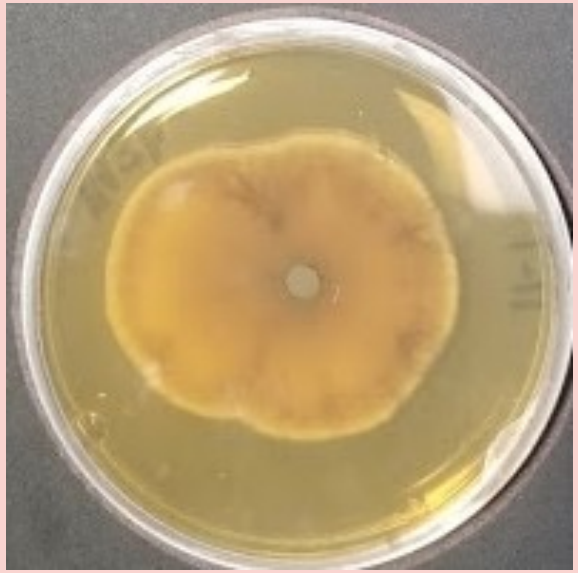
Day 3



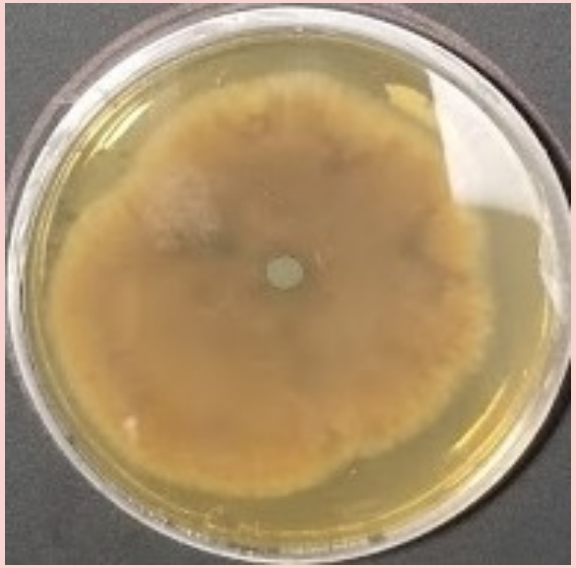
Day 5



Day 8

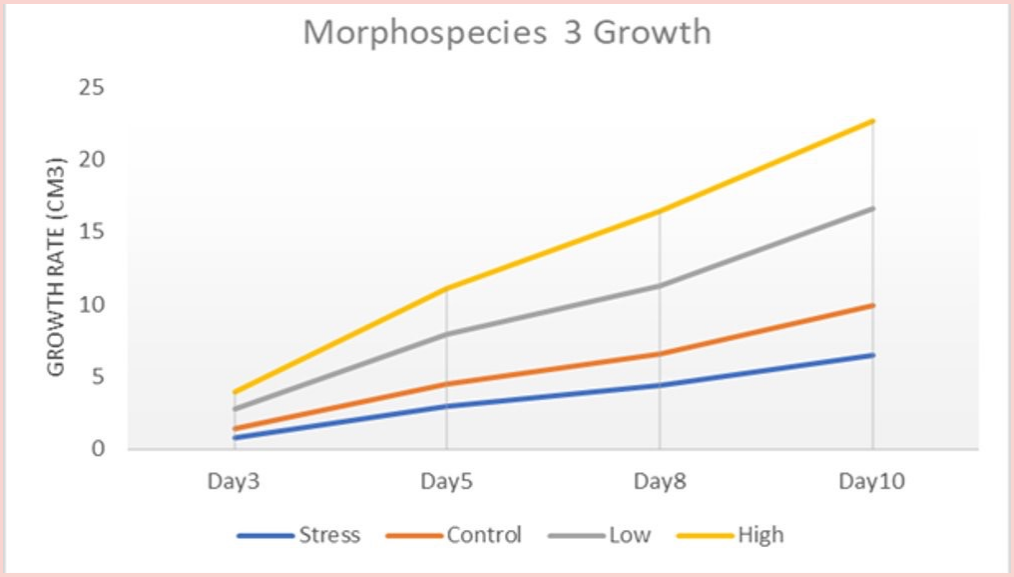


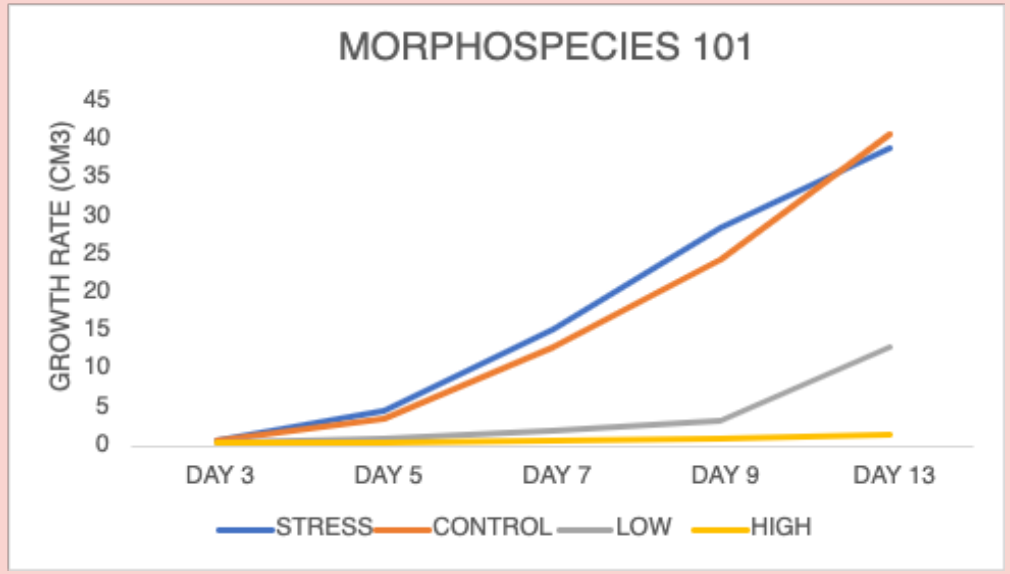
Day 10

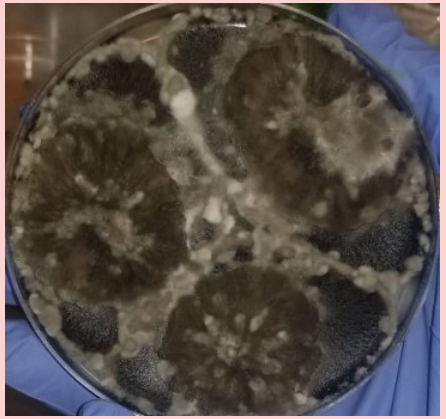


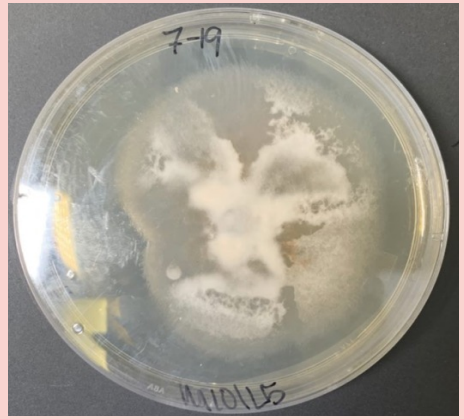
Day 14

Do growth rates differ for rare vs common fungal taxa?
Does resource availability alter growth rates?

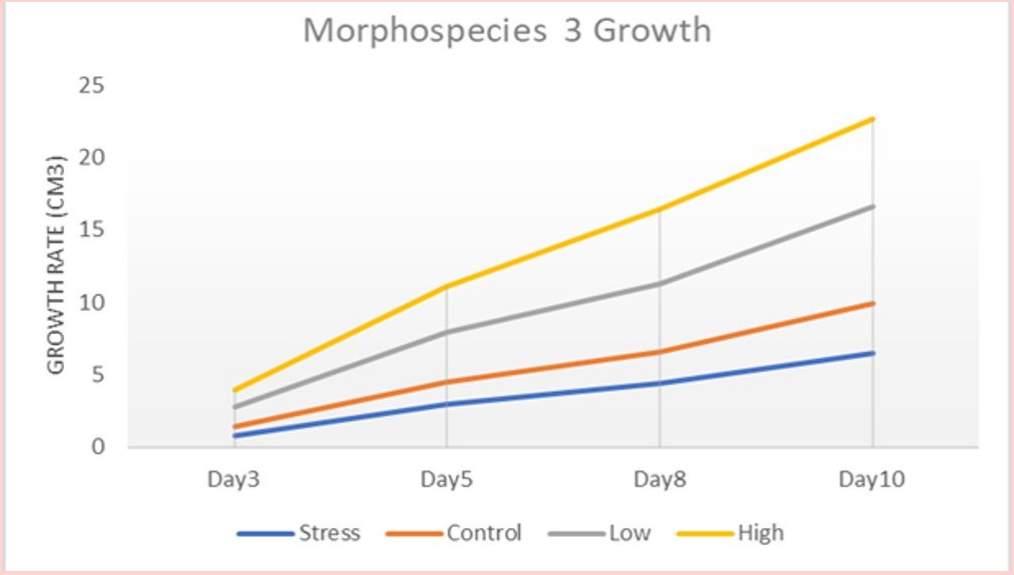


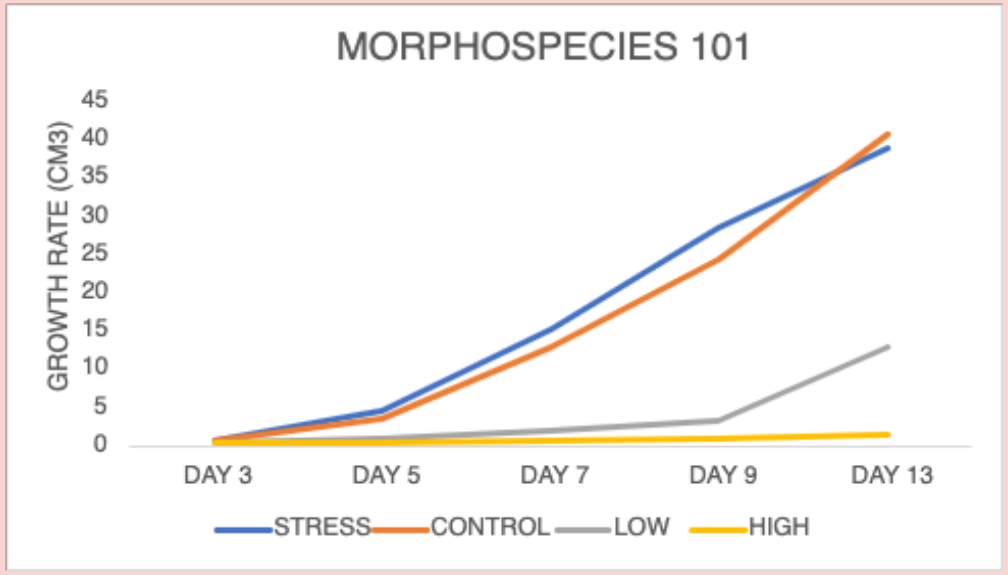


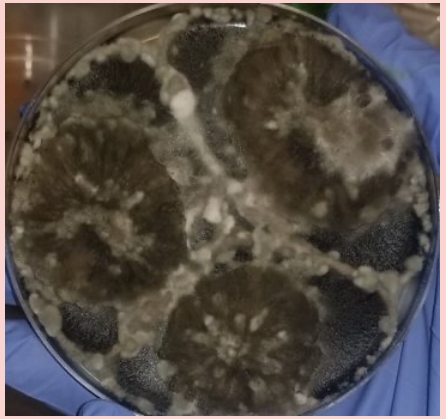


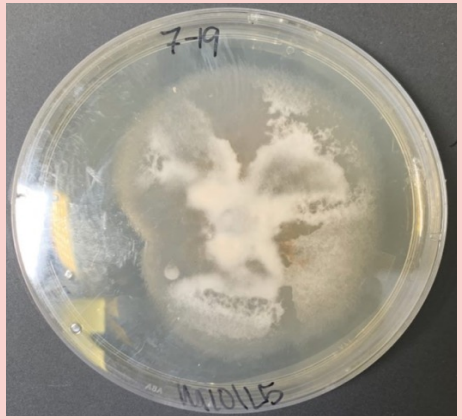


Do growth rates differ for rare vs common fungal taxa? YES!
Does resource availability alter growth rates? YES!









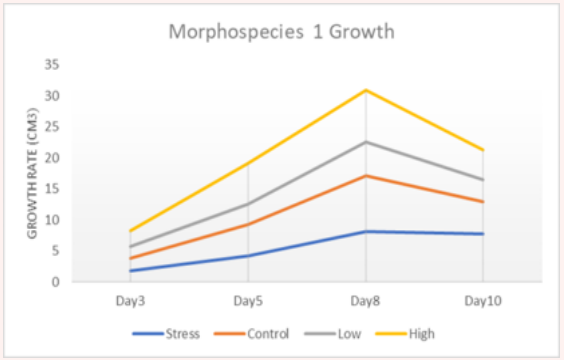
Common Vs Rare Species Growth Trends

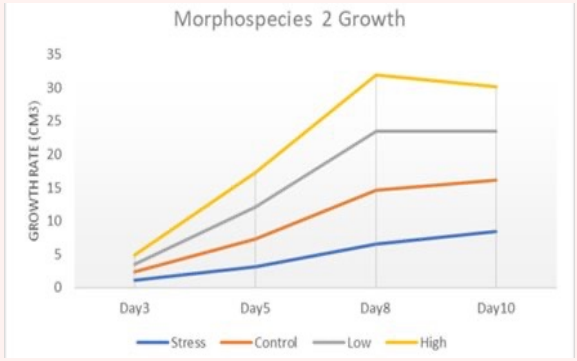
Alexa Comissiong,
Undergraduate Researcher

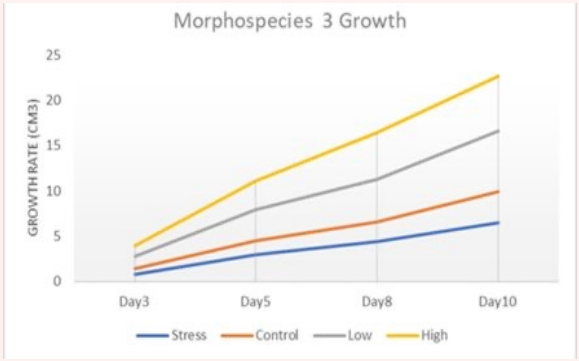
Common species use high nutrients most efficiently

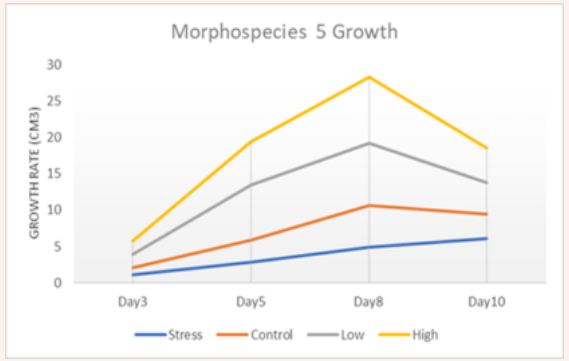
Rare species grow similarly on all resources, & even sometimes better on stress

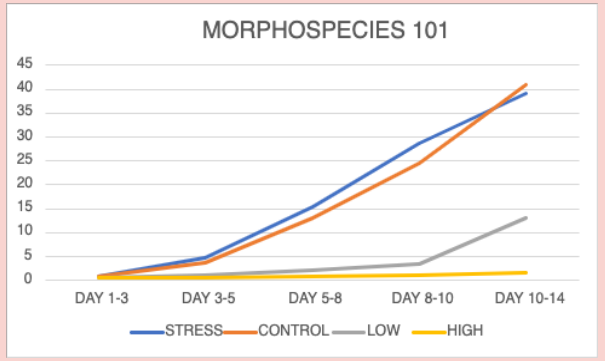
Ally Michaels,
Undergraduate Researcher

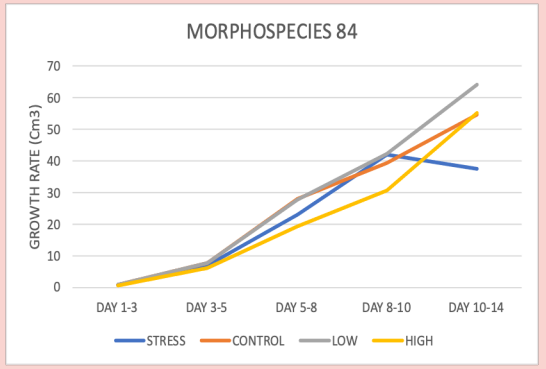


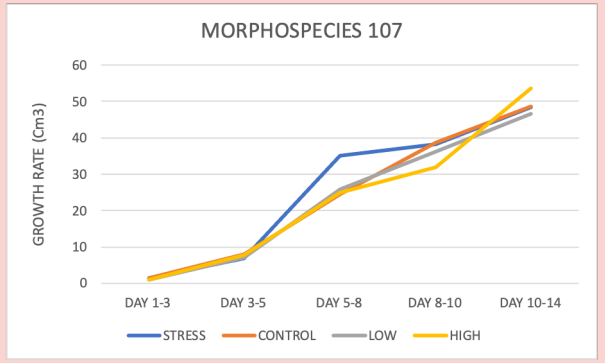


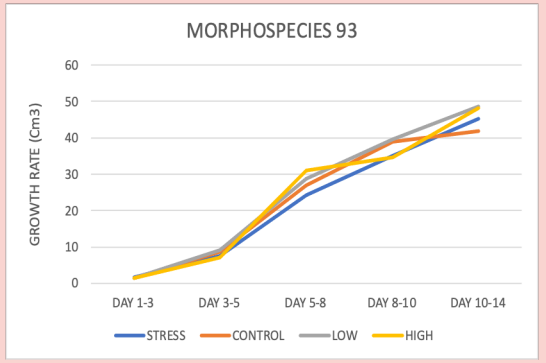








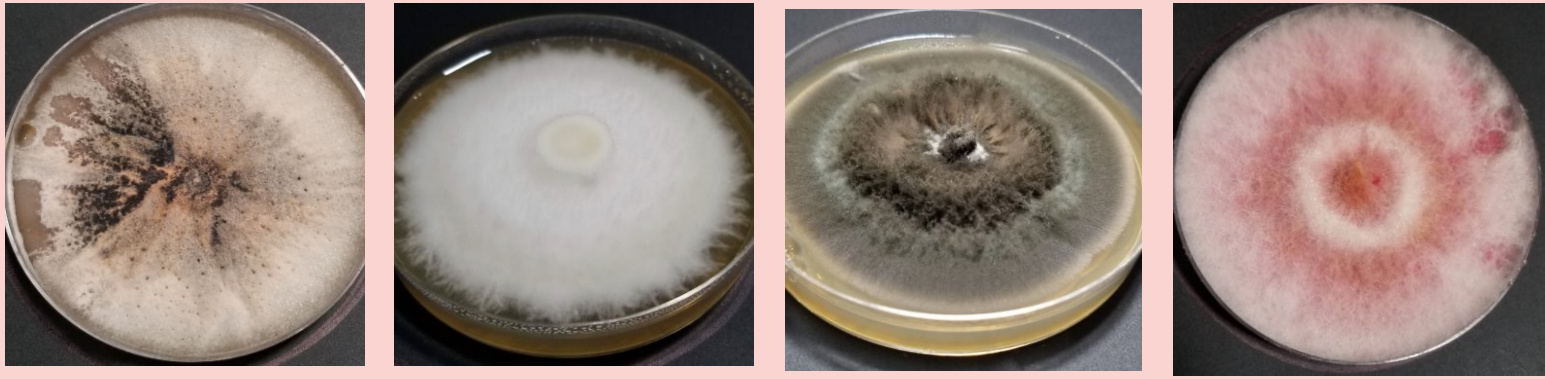




Overall take homes

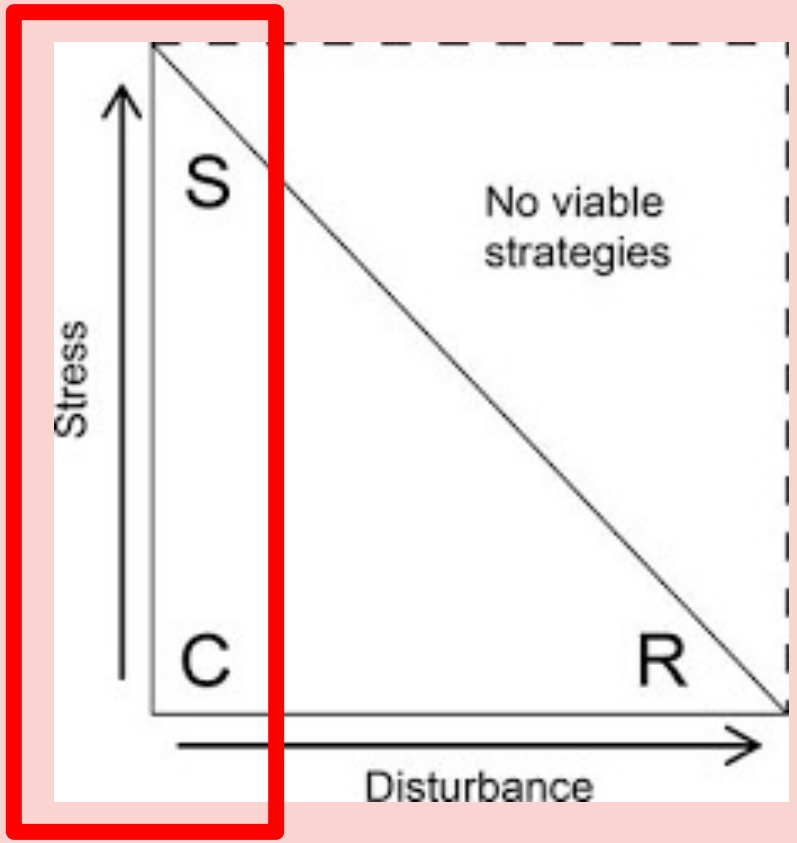
- Abundancies of different species tell us about their environmental tolerance & life history strategies

- In agreement with our hypothesis:
  - **Rare** taxa display stress-tolerance among the different resource treatments
  - **Common** taxa are more efficient competitors



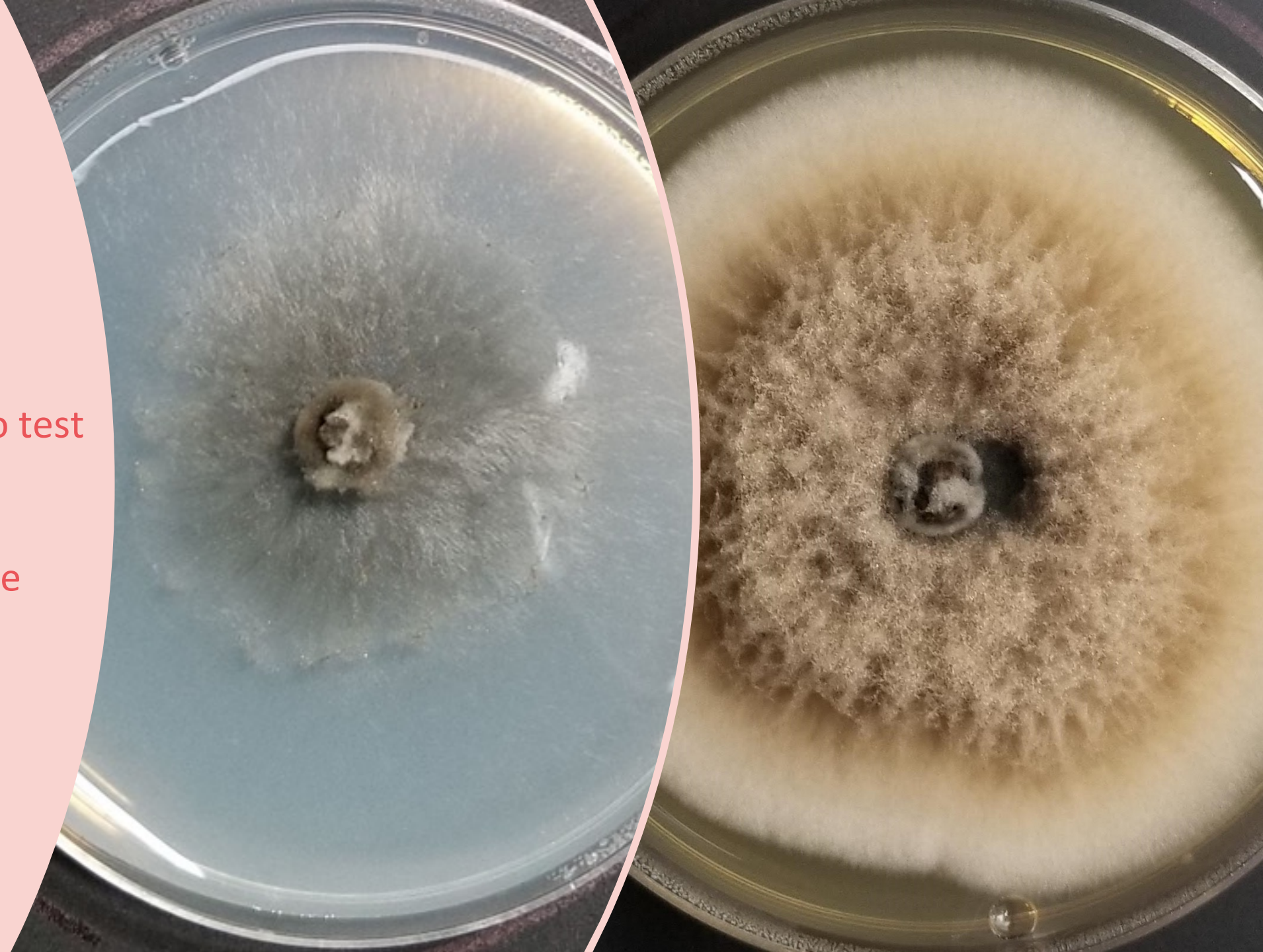
Rare Morphospecies

Common Morphospecies



Next steps

- Fungal Biomass!
- Genetic sequence identities
- Use collected data to test head-to-head competition to form microbial competitive hierarchies



Thanks! ☺

- Dr. Sarah Emery & Lab members
- Dr. Natalie Christian & Lab members

NSF

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