UW Board of Trustees Research and Economic Development Committee
Agenda
January 24, 2024, at 1:00 pm – 1:30 pm

Public Session:

Agenda #	Description	Page #
1.	**Research Excellence Presentation:** Trustee Research Excellence Fund Seed Grant recipients: *"ENERGYE: Ecologicial networks and Ecosystem Resilience in the Greater Yellowstone Ecosystem"*—Dr. Corey Tarwater, Associate Professor, Zoology & Physiology – presented by Anna Chalfoun/Patrick Kelley "*Integrating Evapotranspiration, Crop Growth, and Energy Models For Predicting Vertical Indoor Farming Performance"*—Dr. Liping Wang, Associate Professor, Civil & Architectural Engineering presented by –Dr. JJ Chen, Assistant Professor, Plant Sciences and Sujit Dahal PhD Candidate *"Characterizing the biogeography and potential management of beneficial microbes in controlled environment agriculture settings"*—Dr. Cynthia Weinig, Professor, Botany	5 12 16

AGENDA ITEM TITLE: **Research Excellence Fund Seed grant Presentation: ENERGYE-**
Tarwater et. Al – presented by Patrick Kelley and Anna Chalfoun

SESSION TYPE:
☐ Work Session
☒ Information Session
☐ Other
☐ [Committee of the Whole – Items for Approval]

APPLIES TO STRATEGIC GOALS:
☒ Yes (select below):
- ☒ Institutional Excellence
- ☒ Student Success
- ☒ Service to the State
- ☒ Financial Growth and Stability

☐ No [Regular Business]

☒ *Attachments are provided with the narrative.*

EXECUTIVE SUMMARY:
Our planned NSF proposal has three primary objectives, the first two of which form the basis for the UWNPS Seed Grant: (1) Characterize spatially and temporally dynamic pollination and seed dispersal networks. (2) Examine mechanisms altering species roles and network structure. (3) Experimentally alter the system to examine resilience and robustness to change.

We intend: (1) To address variation in networks across space and time, work will span elevational and habitat gradients and flowering and fruiting seasons. To build networks, we will measure interactions between plants and animals using game cameras and determine species diet. (2) We will evaluate multiple mechanisms that may alter species roles in the networks, including phenology, range, abundance, functional traits (e.g., size, shape), and behavioral traits (e.g., locomotion, foraging) of plants and animals. Mechanisms that may alter network structure include abiotic conditions (e.g., temperature and humidity; both extreme events and average conditions at different scales), habitat type, and percent of invasive species. (3) Increased robustness (i.e., smaller changes in a community in response to a disturbance) and resilience (the community rebounds to its original, pre-disturbance state) facilitate ecosystem stability. We will conduct experiments that exclude species with differing roles (both plants and animals) from interactions to evaluate how a reduction or loss of particular species impacts ecosystem resilience and robustness.

PRIOR RELATED BOARD DISCUSSIONS/ACTIONS:
N/A

WHY THIS ITEM IS BEFORE THE BOARD:
Informational item

ACTION REQUIRED AT THIS BOARD MEETING:
N/A.

PROPOSED MOTION:
N/A

PRESIDENT’S RECOMMENDATION:
N/A

AGENDA ITEM TITLE: Research Excellence Fund Seed grant Presentation: Integrating Evapotranspiration, Crop Growth, and Energy Models for Predicting Vertical Indoor Farming Performance- Liping Wang– presented by JJ Chen, Sujit Dahal

SESSION TYPE:
☐ Work Session
☒ Information Session
☐ Other
☐ [Committee of the Whole – Items for Approval]

APPLIES TO STRATEGIC GOALS:
☒ Yes (select below):
- ☒ Institutional Excellence
- ☒ Student Success
- ☒ Service to the State
- ☒ Financial Growth and Stability

☐ No [Regular Business]

☒ *Attachments are provided with the narrative.*

EXECUTIVE SUMMARY:
Vertical farming, referring to a method of hydroponically growing crops in indoor stacked layers, provides a possible solution to the grand challenge of food shortage and water scarcity around the globe. The PIs propose to simulate the performance of complex vertical farming systems integrating evapotranspiration (ET), crop growth, and energy component models. Such an approach will enhance the theoretical understanding of mechanisms affecting vertical farming systems while facilitating efficient and sustainable operations. ET provides essential information regarding water use and heat transfer for accurate prediction of thermal performance in vertical farming. However, there are currently no generalized ET models for leaf vegetable species growing in indoor hydroponic systems. Additionally, existing energy simulation models do not address the complex interaction between ET and environmental controls unique to vertical indoor farming systems. Environmental controls are critical not only for crop growth and development, but also to optimize efficiency and energy budgets in the farms. Finally, no crop growth models simulate the effect of light quality on crop growth, which is essential for vertical farming systems utilizing sole-source lighting (i.e., production under solely electric fixtures with no sunlight). Therefore, for the development of meaningful simulation tools for vertical farming, a new integrated modeling approach must be used which accounts for the components of ET, crop growth, and energy.

PRIOR RELATED BOARD DISCUSSIONS/ACTIONS:
N/A

WHY THIS ITEM IS BEFORE THE BOARD:
Informational item

ACTION REQUIRED AT THIS BOARD MEETING:
N/A.

PROPOSED MOTION:
N/A

PRESIDENT’S RECOMMENDATION:
N/A

AGENDA ITEM TITLE: **Research Excellence Fund Seed grant Presentation: Characterizing the biogeography and potential management of beneficial microbes in controlled environment agriculture settings-** Weinig

SESSION TYPE:
☐ Work Session
☒ Information Session
☐ Other
☐ [Committee of the Whole – Items for Approval]

APPLIES TO STRATEGIC GOALS:
☒ Yes (select below):
☒ Institutional Excellence
☒ Student Success
☒ Service to the State
☒ Financial Growth and Stability
☐ No [Regular Business]

☒ *Attachments are provided with the narrative.*

EXECUTIVE SUMMARY:
Innovations in Controlled Environment Agriculture (CEA) provide a possible avenue to meet domestic food demand while minimizing detrimental environmental impacts associated with conventional agriculture. CEA includes indoor farming styles from single-level greenhouses to more compact vertical farming, and creates environments for plant growth that are often insulated from external environmental fluctuations. CEA can dramatically increase both total crop yield and yield predictability per square meter relative to conventional field agriculture. Through recycling systems, CEA may use up to 90% less water than conventional field agriculture and much lower levels of other agricultural inputs such as pesticides, herbicides, and fertilizers. Advances in and widespread adoption of CEA are limited by a lack of foundational and use-inspired research in CEA. Of particular note, little is known about the distribution or function of microbes in CEA settings, despite the pervasive effects of microbes on plant performance and the potential to manage CEA microbiomes to improve plant yield.

PRIOR RELATED BOARD DISCUSSIONS/ACTIONS:
N/A

WHY THIS ITEM IS BEFORE THE BOARD:
Informational item

ACTION REQUIRED AT THIS BOARD MEETING:
N/A.

PROPOSED MOTION:
N/A

PRESIDENT'S RECOMMENDATION:
N/A

ENERGYE

Ecological Networks and Ecosystem Resilience in the Greater Yellowstone Ecosystem

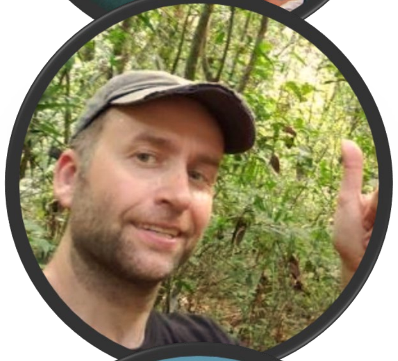
Funded by a UW Research Excellence Fund Seed Grant

Problem: Pollination and seed dispersal are critical for maintaining terrestrial biodiversity, yet their response to multiple environmental stressors is unknown.

Our goal: To understand and predict the impacts of environmental stressors on communities and ecosystem resilience by studying pollination and seed dispersal networks using network theory, ecology, behavior, and physiology

Anna Chalfoun
Dept. of Zoology and Physiology
USGS

Corey E. Tarwater
Dept. of Zoology and Physiology

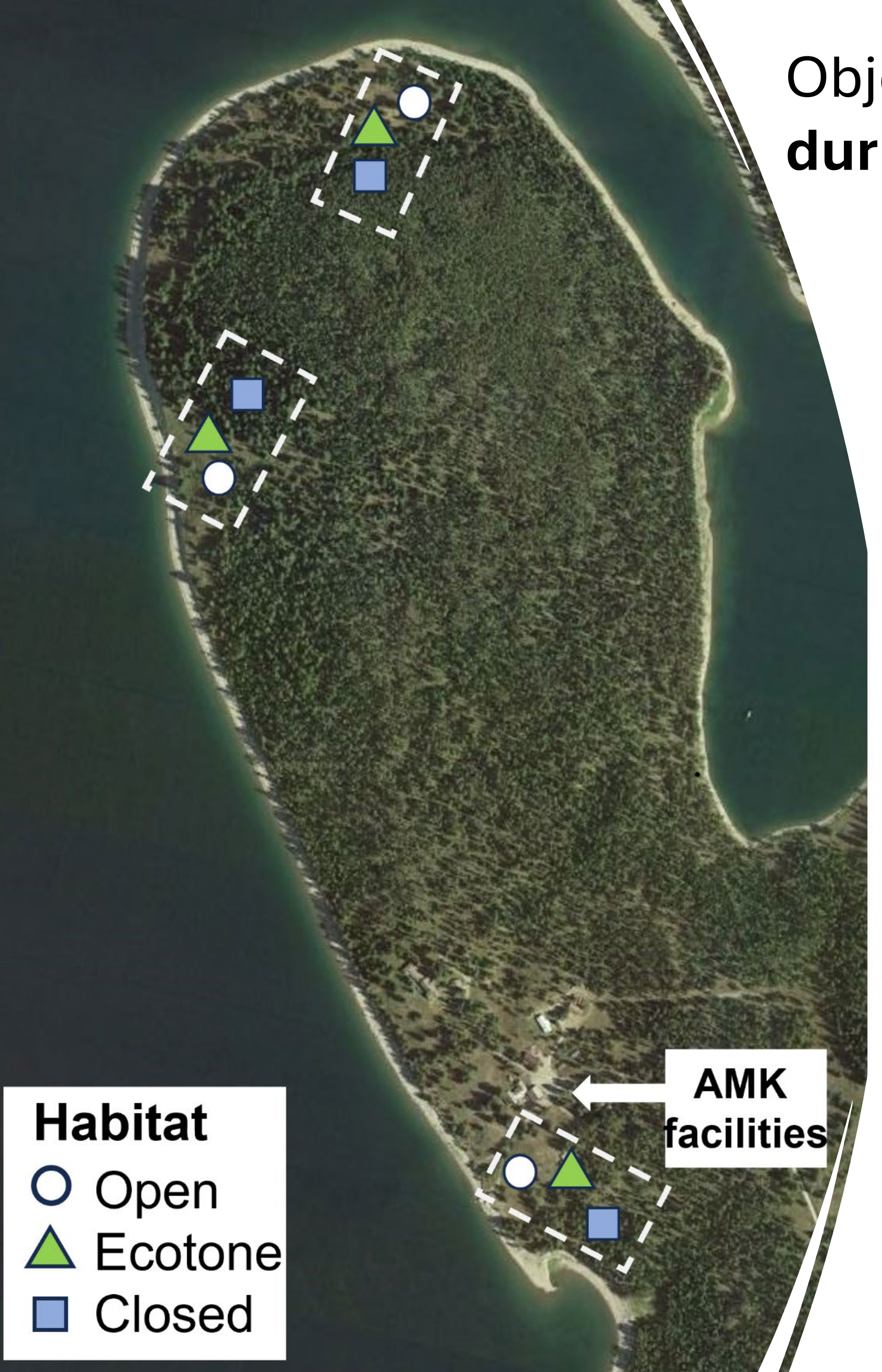


Patrick Kelley
Dept. of Zoology and Physiology

Hilary Rollins
Station Manager / Science Coordinator
UW-NPS Field Station

Daniel Laughlin
Dept. of Botany

Michael Dillon
Dept. of Zoology and Physiology
Interim Directory, UW-NPS Research Station

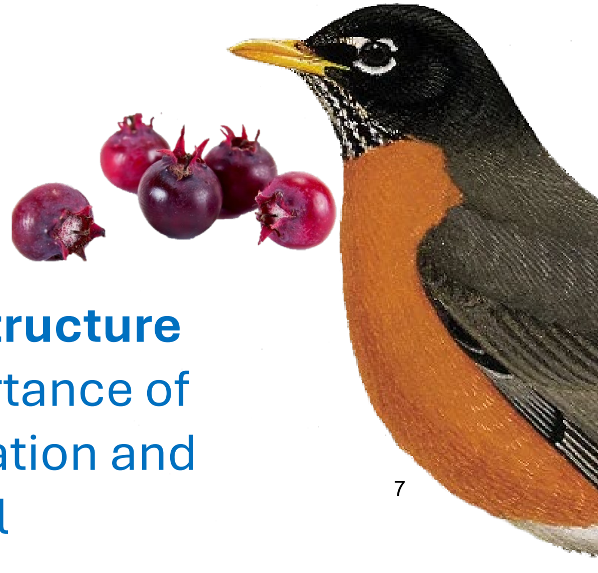


Objective 1: **Characterize the species that are interacting in during pollination and seed dispersal**

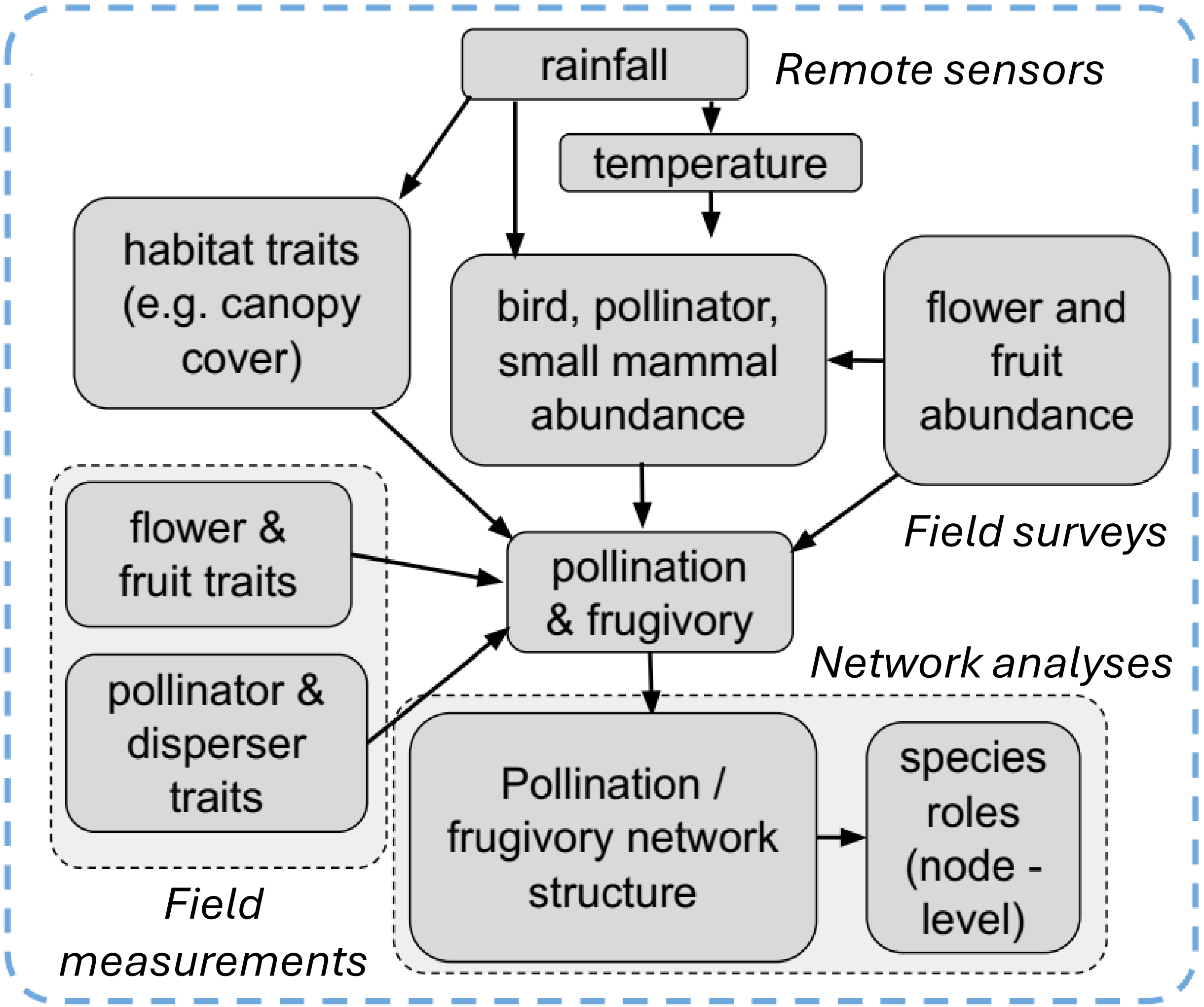
Quantify species interactions using motion-activated camera systems
(80 cameras deployed/day; >87k hours coverage during this pilot study)

Manual and AI-assisted processing of camera data

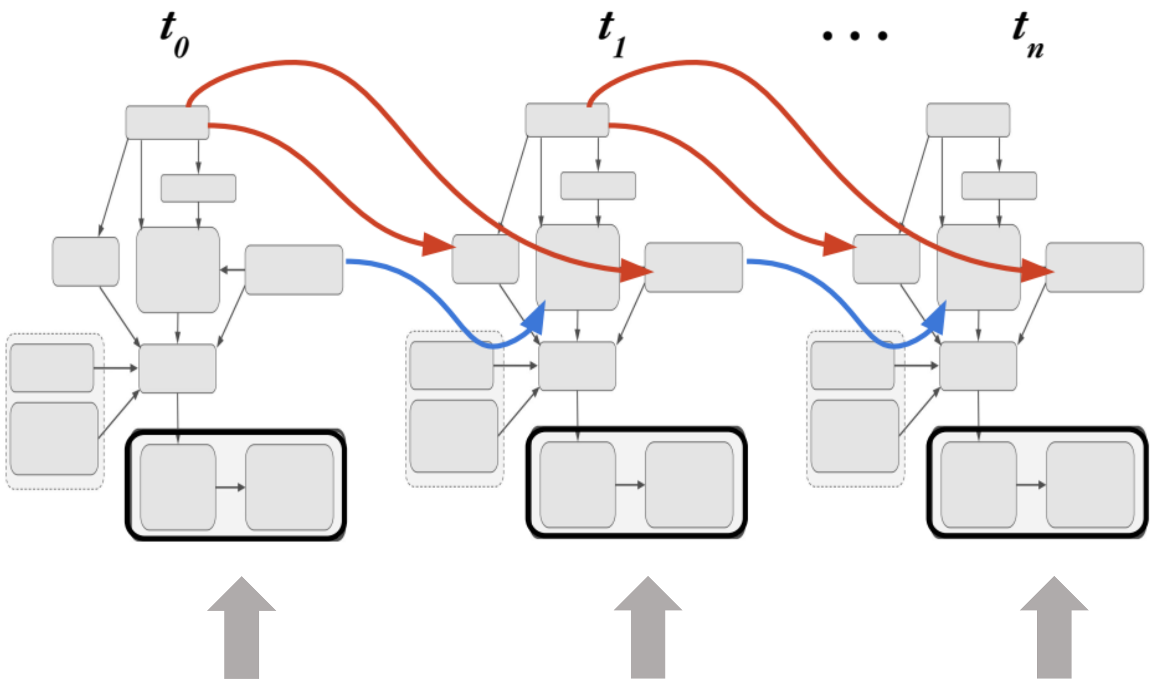
Calculate network structure and metrics for importance of each species in pollination and seed dispersal



Objective 2: **Examine mechanisms altering species roles and network structure over time and determine optimal sampling scale**



Causal links between time points (dynamic causal modeling)



Changes in network structure and species role over time (to assess resilience)

Benefits to Wyoming

- contributes to maintaining and restoring biodiversity (important for promoting ecotourism and recreation in WY)
- promotes synergy with ongoing activities at the UW-NPS Station (facilitating/expanding the station's grant-funded research with additional research infrastructure)
- sparks productive and interdisciplinary research collaborations
- provides training for multiple UW undergraduate and graduate students
- expands the UW-NPS Station existing Harlow seminar series to include outreach days

National Science Foundation: Biodiversity on a Changing Planet (BoCP)

Deadline: 05-September-2024

The data from this work will:

- inform us of which species are involved in interactions
- help identify optimal sampling method required for project upscaling
- help identify the scale of proposed network manipulation experiments to detect ecologically relevant network changes

UW Research Excellence Fund

Integrating Evapotranspiration, Crop Growth, and Energy Models For Predicting Vertical Indoor Farming Performance

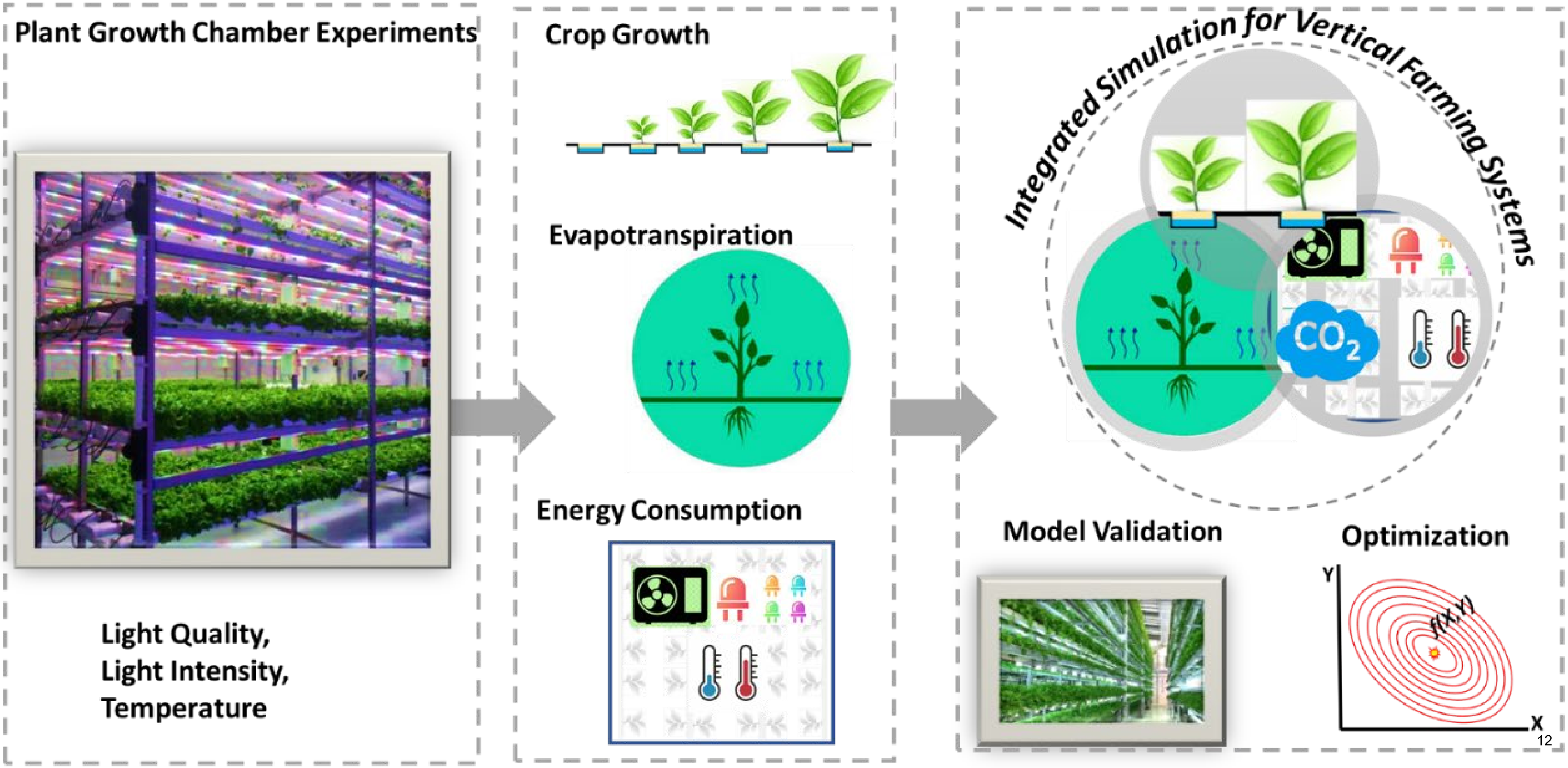
Liping Wang, Ph.D., P.E.
Associate Professor
Interim Director, CEA

JJ Chen, Ph.D.
Assistant Professor
Plant Sciences

Sujit Dahal
Ph.D. Candidate
Civil Engineering

Emmanuel Iddio
Ph.D. Candidate
Civil Engineering

An integrated model for controlled environment agriculture (CEA) is essential and leads to resource efficiency and maximizing crop growth for future agriculture.



An integrated simulation tool for CEA, connecting with an existing CEA facility, to support prediction, training, and education, along with improving the design and operation of CEA.

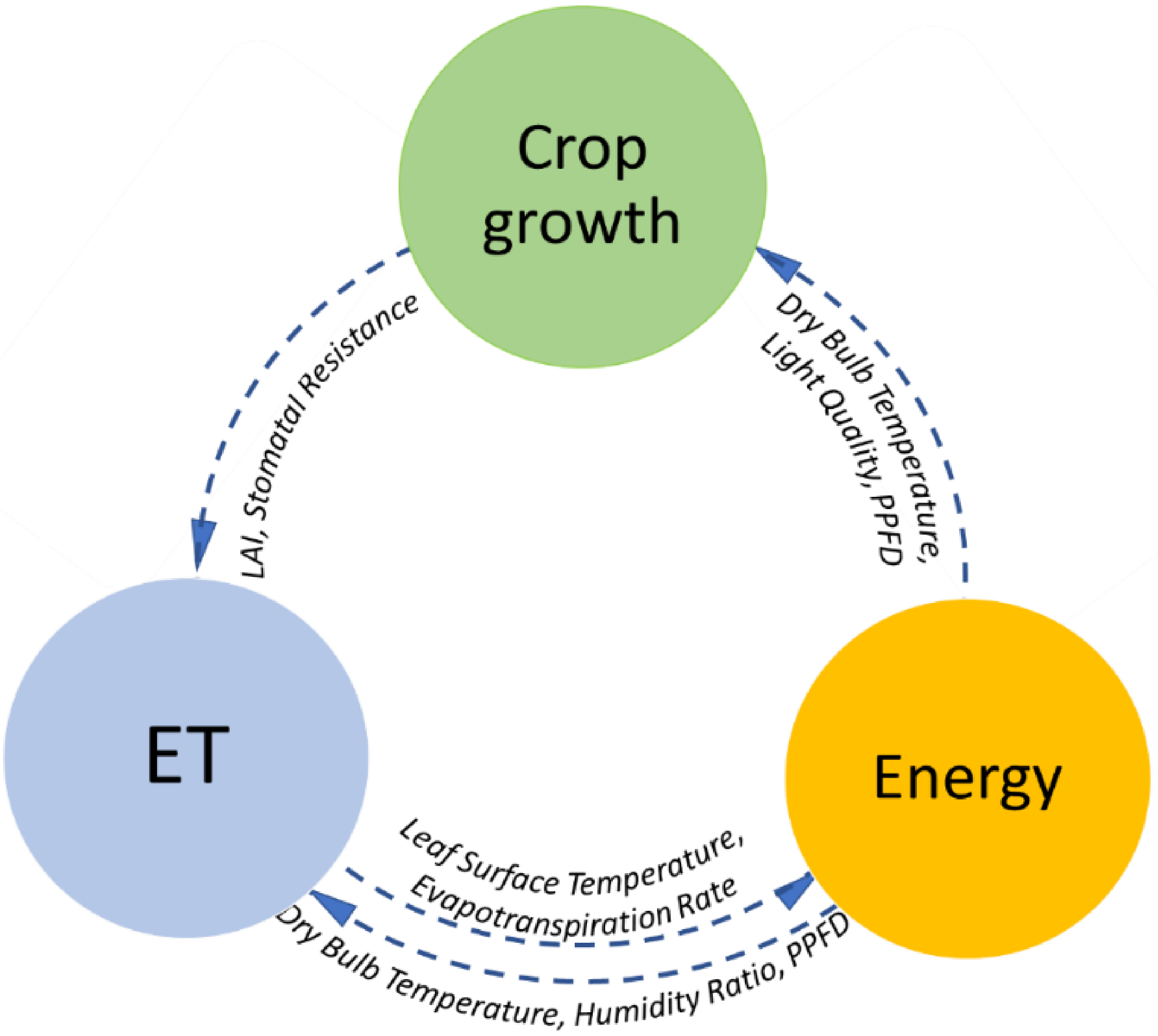


Fig. 3-1. The dynamic coupling scheme among energy, ET and crop growth models. (LAI: leaf area index; PPFD: photosynthetic photon flux density)

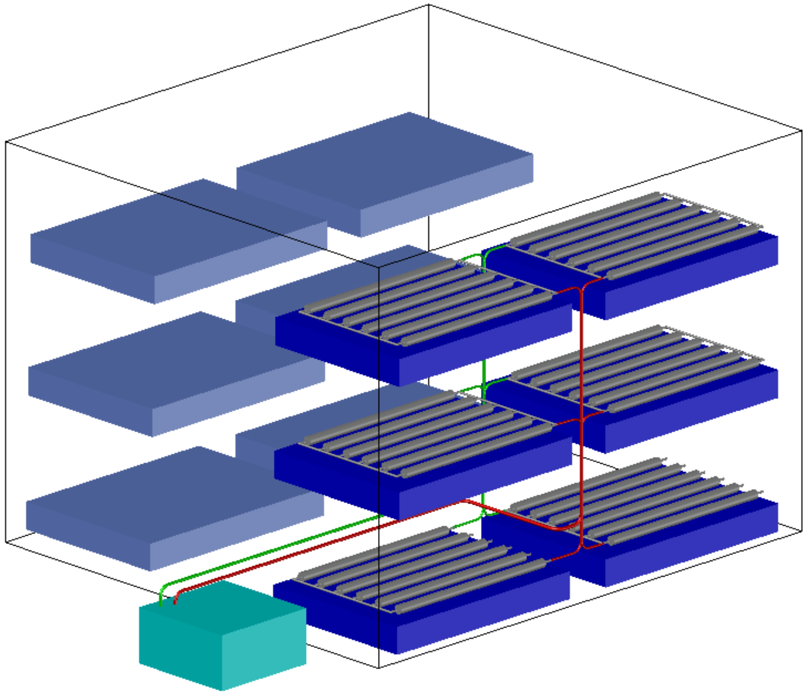


Fig. 4-1. The design of growth chamber experiments

Fig 4-2. Walk-in growth chamber in UW

Research Plan:

Plant materials: Lettuce (*Lactuca sativa*) and spinach (*Spinacia oleracea*).

Growing conditions: temperature, vapor pressure deficit, lighting intensity, CO_2

Plants will be grown in a 3-week cycle.

Data collection: Plant growth data and transpiration rate will be recorded weekly, and water use will be collected using lysimeters.

Research Schedule:

2023	***November***	*Tested the walk-in growth chamber at UW SI building.*
	December	*Designed hydroponic systems for the growth chamber.*
2024	***January***	*Purchase and assemble hydroponic system.*
	February	*Calibrate hydroponic system.*
	March	*Conduct 1^{st} trial (252 plants/trial).*
	April	*Conduct 2^{nd} trial (252 plants/trial).*
	May	*Conduct 3^{rd} trial (252 plants/trial).*
	June	*Data analysis*

Model Validation

Simulated plant water use via Penman–Monteith equation will be compared with the actual plant water use.

Total leaf area and fresh weight at the end of each growing cycle will be used to validate plant growth model.

Other team members

Brent Ewers

Department of Botany

Cynthia Weinig

Department of Botany

Jianting Zhu

Civil Engineering

Carmela Rosaria Guadagno

UW Center for CEA

Thank you for your great support!

Funding opportunity : NSF, NASA, USDA, and DOE

Characterizing the biogeography and potential management of beneficial microbes in controlled environment agriculture settings

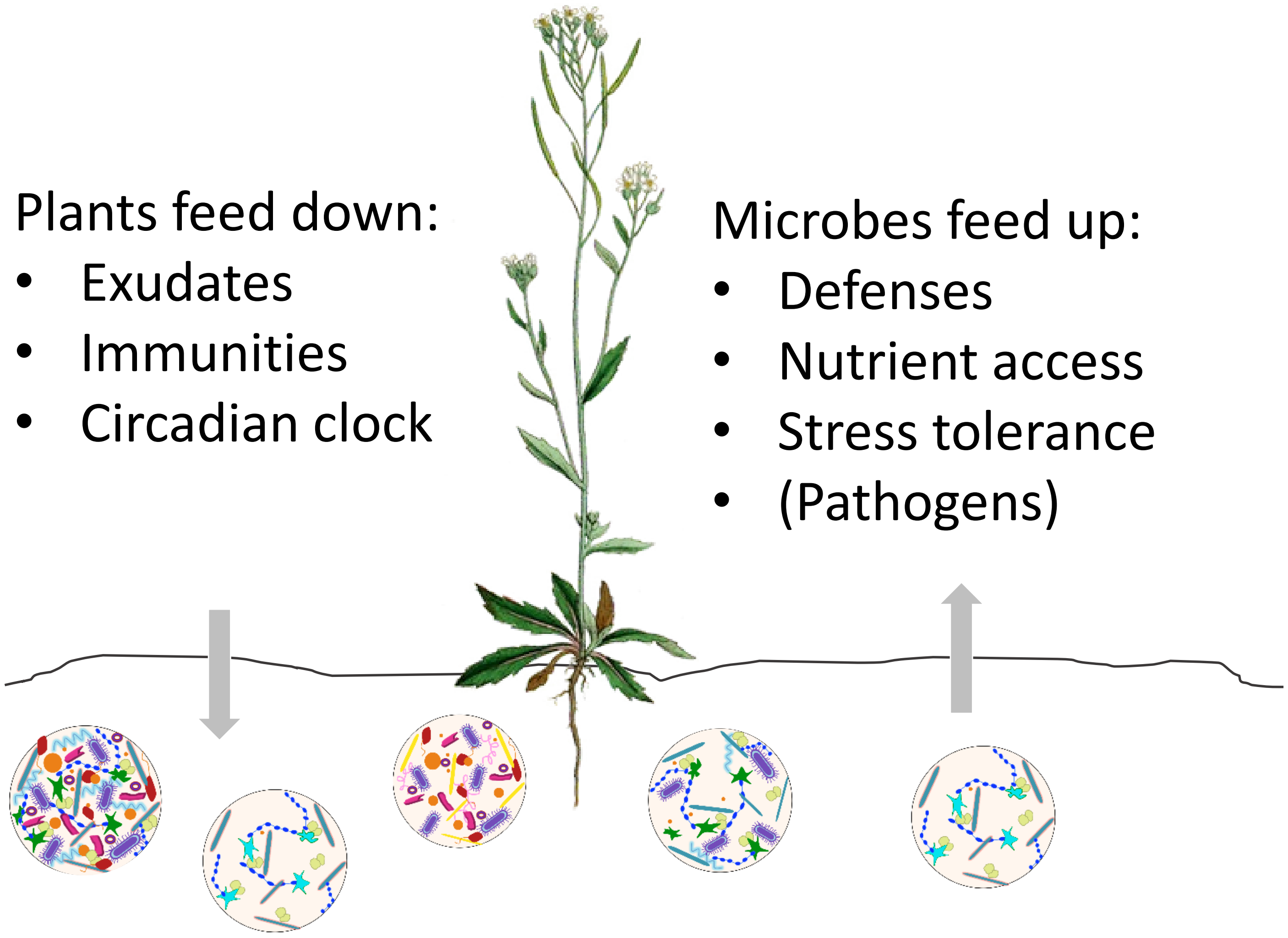
Microbes are living organisms too small be seen with the naked eye

A gram of soil has ~10,000 species of microbe, and hundreds of millions of living cells

Each microbe has ~4,000 genes, encoding (producing) proteins that may affect plant growth

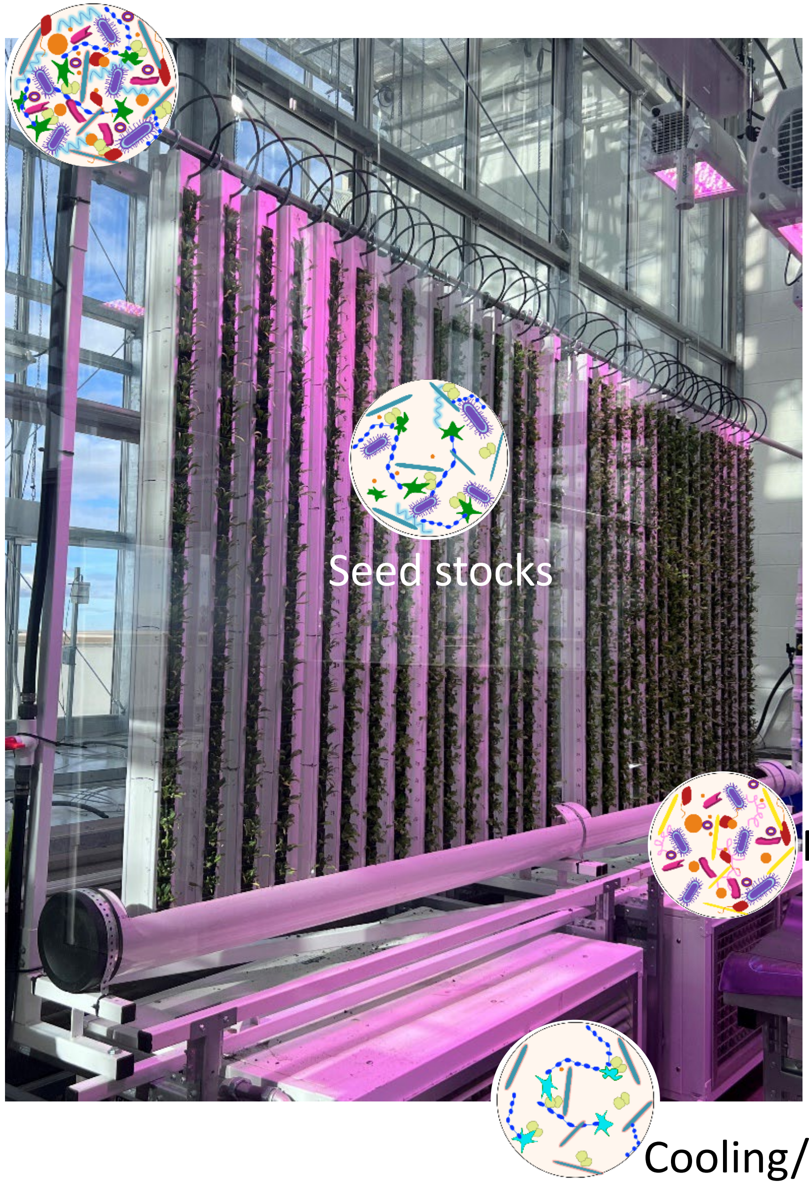
Microbes be detrimental to plants (pathogens) or favorably affect growth (biofertilizers)

1. How are microbes distributed in CEA settings, and 2. can we “drive” the community to a beneficial composition?



1. How are microbes distributed in CEA settings?

Air exchange to outside



Nutrient solutions

Cooling/heating

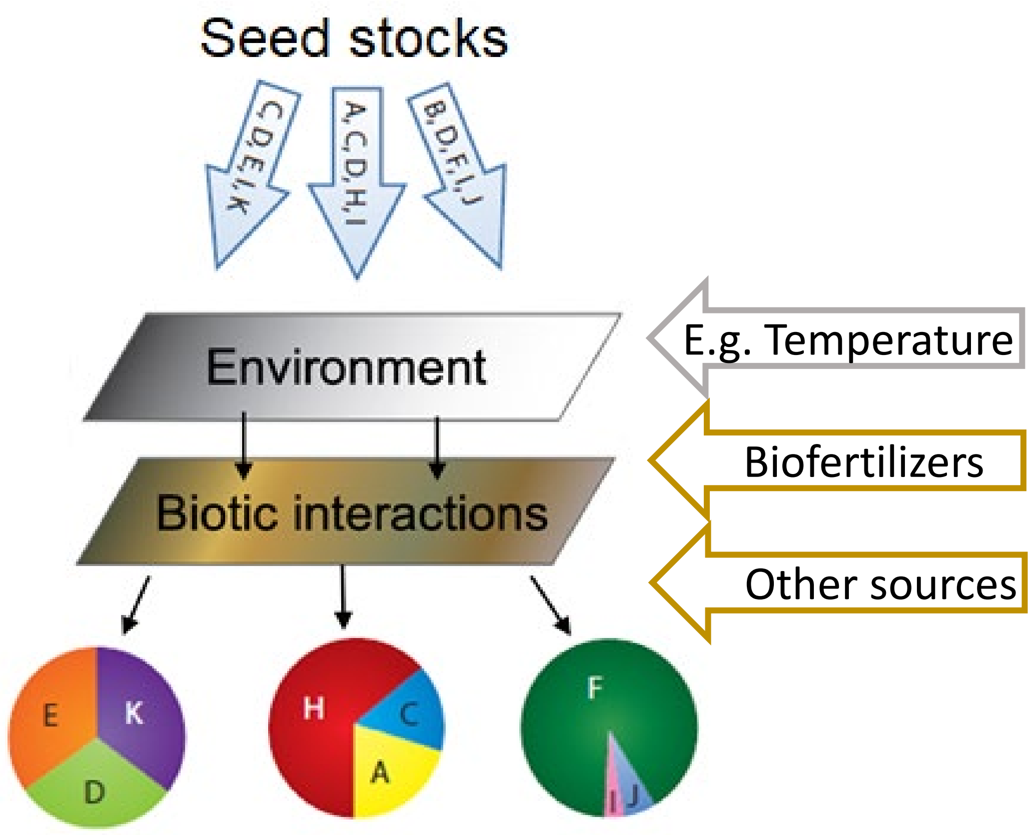
Controlled Environment Agriculture includes indoor farming styles, and creates environments for plant growth that are insulated from external environmental fluctuations. All requirements for plant growth are met through automated or semi-automated processes.

Microbes are found throughout CEA production systems.

They may enter the system within the seeds, in growth media, through air exchanges, in the circulating water and nutrient solutions, via HVAC systems etc.

Microbial community composition is a uncharacterized in CEA. And, which of the preceding leads to the plant microbiome is unknown!

1. How are microbes distributed in CEA settings?



Final communities of microbes

Letters in the above model denote microbial species.

We will sample different seed stocks, surfaces, solutions, and mature plants to ascertain where microbes are coming from that are ultimately found in association with plants.

Seed stocks have a “starting’ community of microbes.

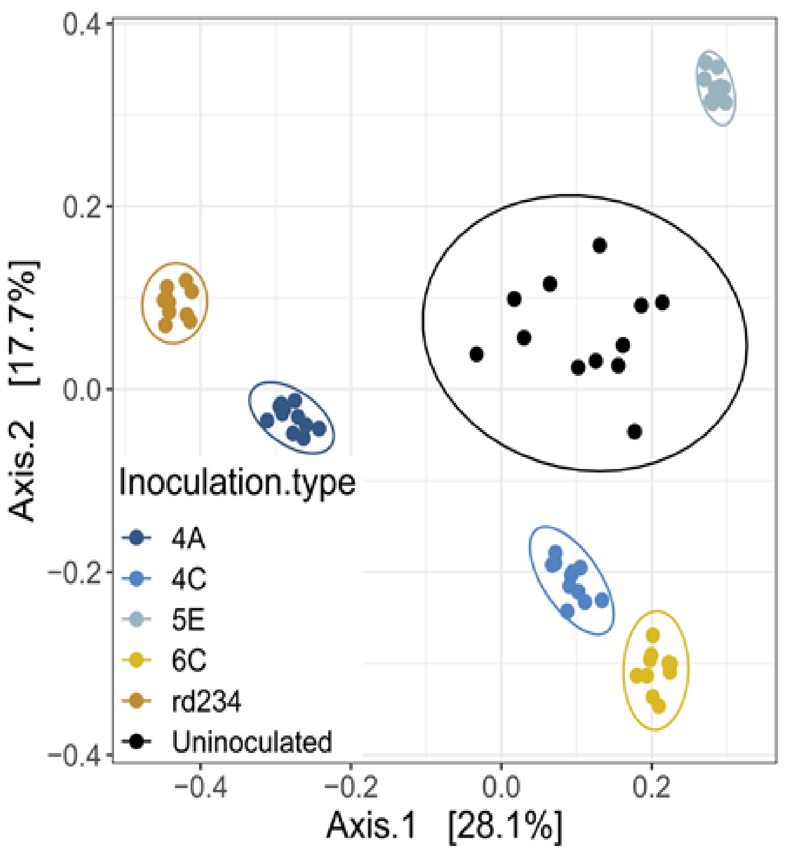
These microbes may be sensitive to abiotic environmental factors, like temperature.

Microbial communities may be influenced by “migrants” entering as biofertilizers or in solutions etc.

The final communities will reflect the sum total of environmental and biotic effects.

Ideally, we drive the system toward a beneficial community.

2. Can we drive the microbial community toward one favorable for plant growth?



The early arrival of some microbial taxa to the growth media and plant host influences the establishment and succession of other microbes.

Our preliminary data in a greenhouse setting indicate that among seeds growing in sterile media inoculated with soil-derived microbes from one of five sites (4A, 4C, 5E, 6C, and rd234), five predictably different and stable microbial communities become established.

Further, the microbial communities do not overlap in composition between the inoculated and uninoculated replicates, suggesting that early seed inoculation can lead to distinct communities that are resistant to secondary introduction of microbes.

If early arrival (aka priority effects) contribute to CEA microbiome assembly, then CEA agronomists may be able to manage the assembly of desirable, plant-growth promoting communities.

Conclusions

- We will characterize the distribution of microbes in CEA settings
- We will work to discover methods to drive the community toward a favorable composition.
- Seed grants reflect a critical investment by UW into new research that increases the likelihood of outside funding.
- We have proposals planned for submission to the Plant-Biotic Interactions panel, and we submitted a CEA-related proposal today (January 24th) to the NSF EPSCoR Track II program.
- Total funding of awards on which I am PI or co-PI from NSF and USDA is $44.8 million to date.

Accessible format for telling stories across all ages