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Title:	LANL-USDA Program Lead Meet and Greet
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Intended for:	LANL virtual meeting with USDA Program Leads
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LANL-USDA Program Lead Meet and Greet

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January 17, 2023

Microbial and Biome Sciences Group (B-IOME)

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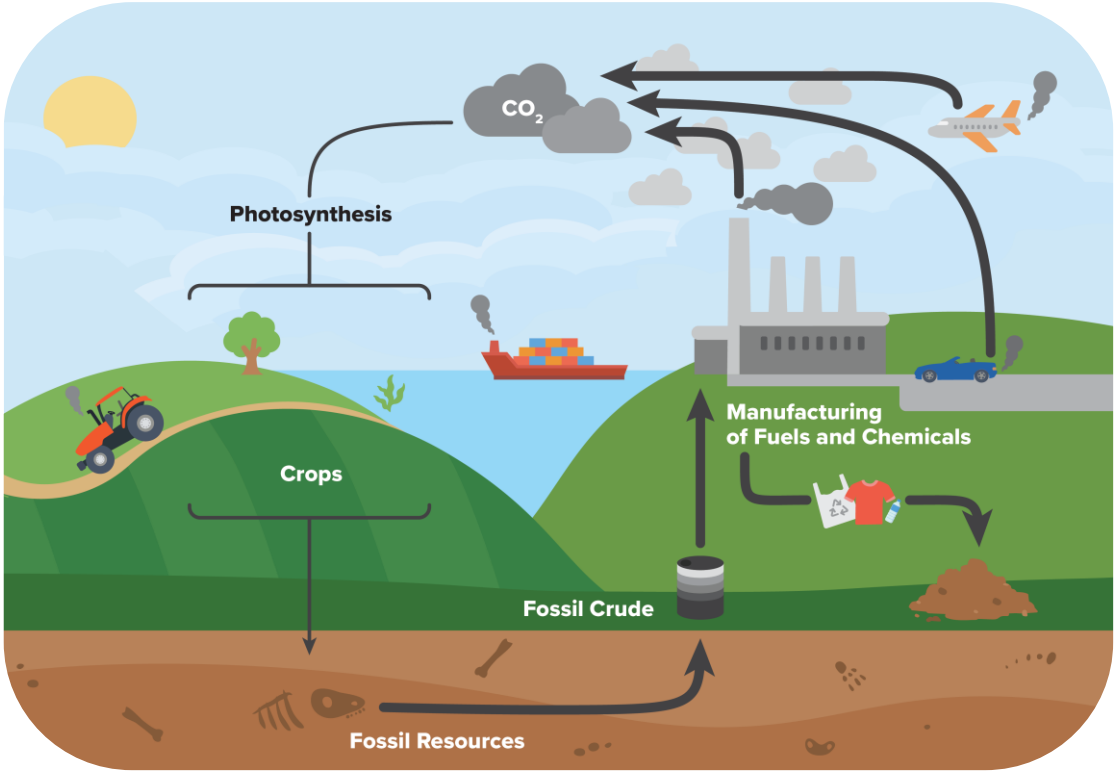
January 17, 2023

Carbon is intricately tied to national and global security



- Carbon as a resource is connected to global events
  - Geopolitical
  - Climate

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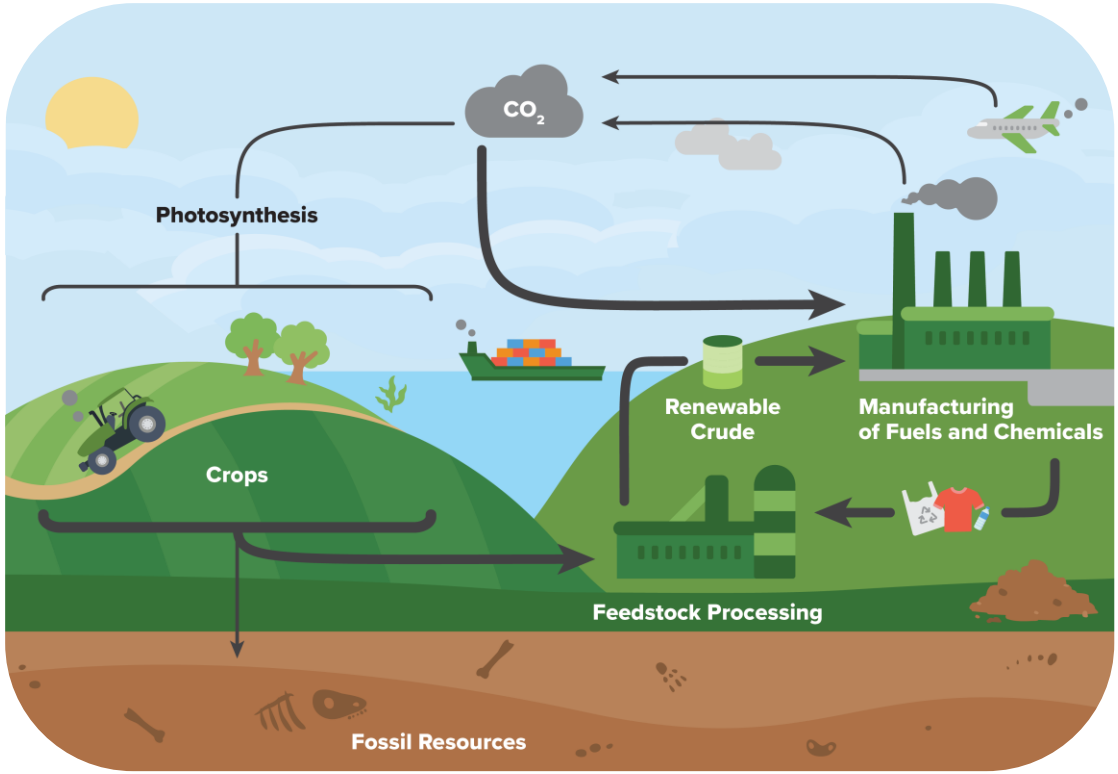
Rebalancing and increasing our domestic carbon supply



Enable our energy, environmental, and economic security by developing a scientific understanding of, and approaches for manipulating, how carbon moves through natural and engineered biological systems

Sustainable carbon cycling is an important underpinning of the bioeconomy

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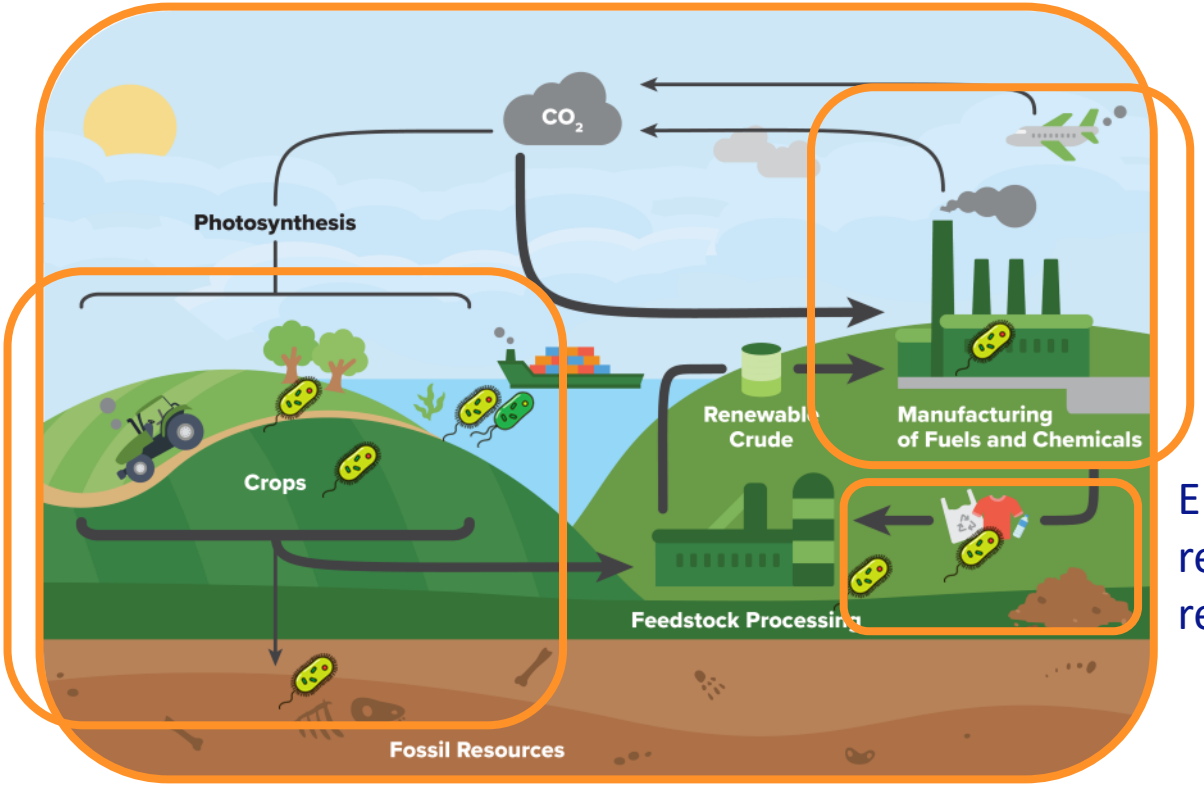
Four primary research areas

Plant, soil, algae productivity & resilience



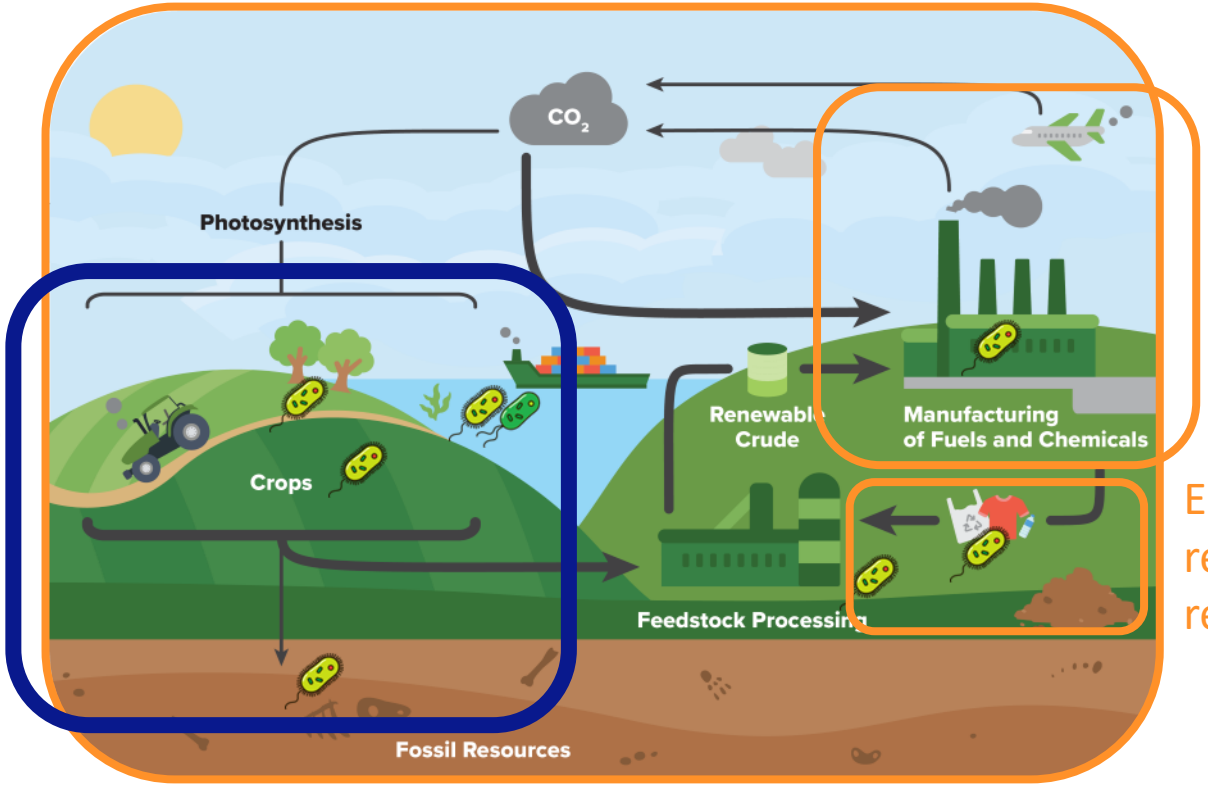
Biomanufacturing

Environmental restoration and recovery

Modeling, analysis, and place-based solutions

Four primary research areas

Plant, soil, algae productivity & resilience



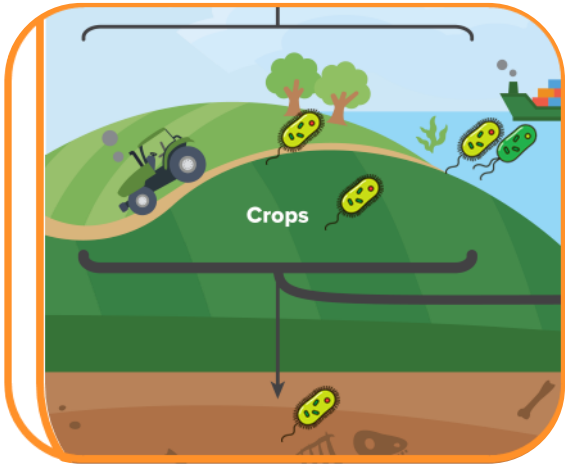
Biomanufacturing

Environmental restoration and recovery

Modeling, analysis, and place-based solutions

Why biological (and specifically microbial) systems?

- Microbes are nearly everywhere
  - Land, air, and “sea”
- Significant influence on our lives and the environment
  - Critical roles in elemental flux in the atmosphere and on Earth (C, N, P, etc)
    - Agriculture, ecosystems, climate
  - Pests/pathogens
    - Crop, animal, and human health
- Not your standard *E. coli* or yeast
- Relatively simple in structure, but complex in diverse metabolism and communities
- Potential to use far beyond beer, cheese, and pharma
  - Crop solutions, biomanufacturing



Relevant LANL Capabilities

Microbial & fungal sciences

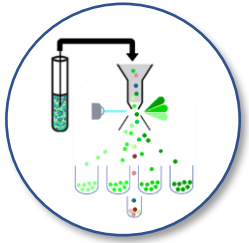
Single cells to biomes, natural & engineered systems

Plant & soil sciences

Carbon management, nutrient & stress tolerance

Environmental simulation

Aquatic & terrestrial, outdoor harmonization approaches



High throughput screening

Assay development & application

‘Omics data & analysis

Meta-’omics, sequencing & analysis tools

Modeling & decision support

Machine learning, epidemiology, sustainability

Plus: Testbed & field partnerships, marginal land emphasis

LANL plant science capabilities and plant:microbe evolution

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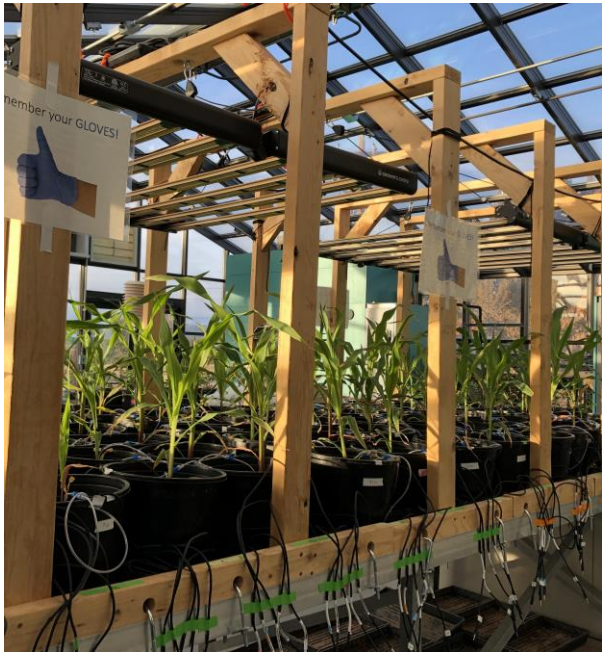
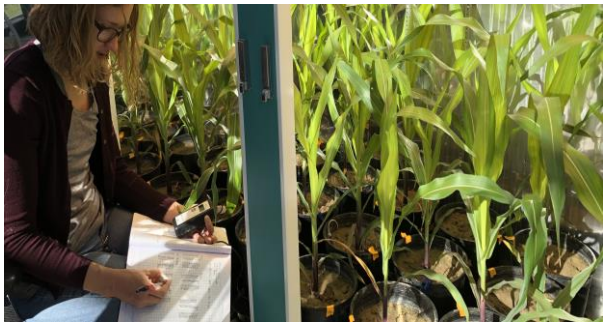
LANL Greenhouse capability





Temperature, light, CO_2 and humidity control

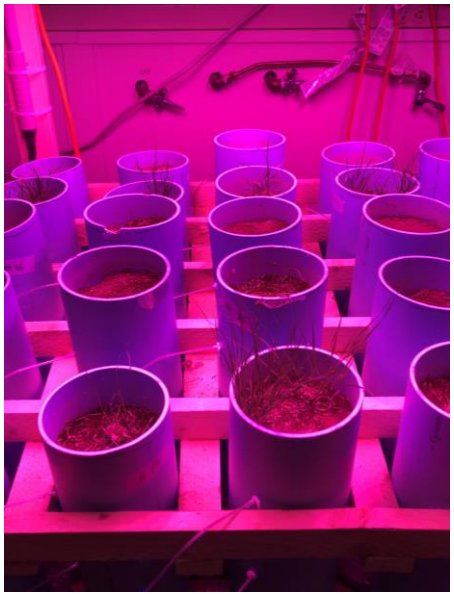
Experimental Capabilities

Microbial inoculations

Isotopic labeling

Natural soil hydrology

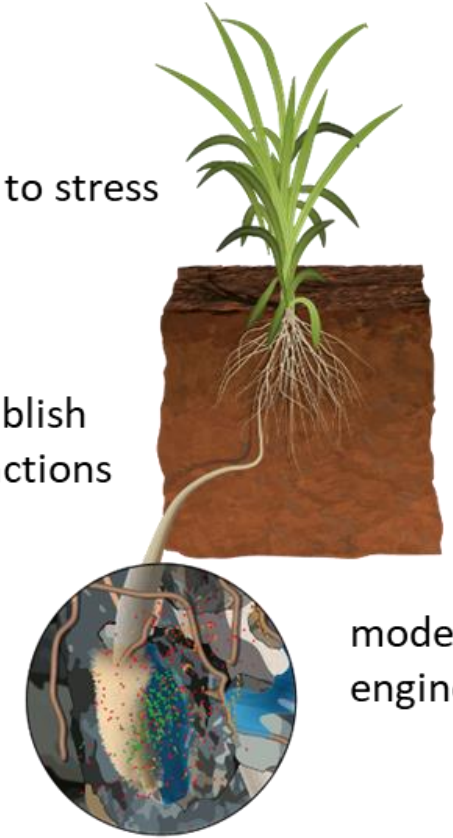
Natural soil stratification



Plant:microbe interactions: Towards improving and engineering plant resilience productivity

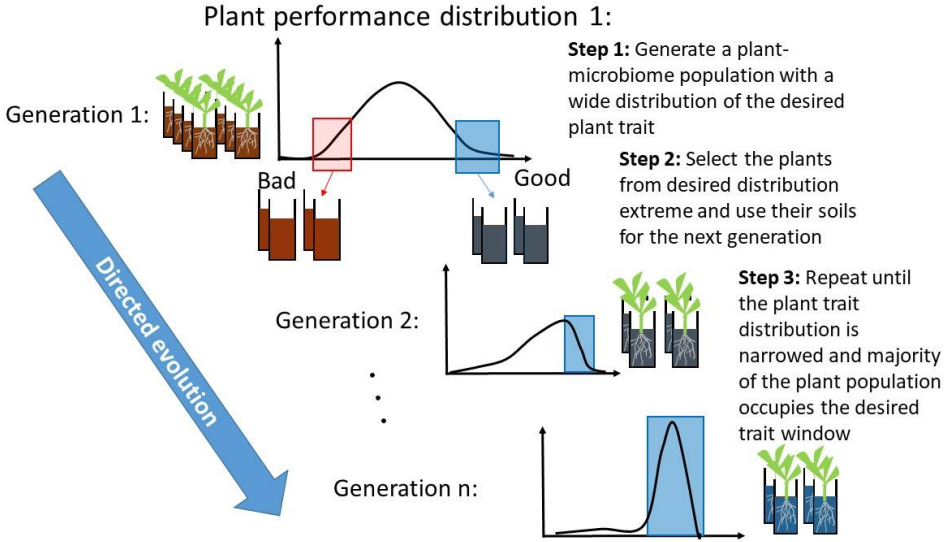
provide resilience to stress

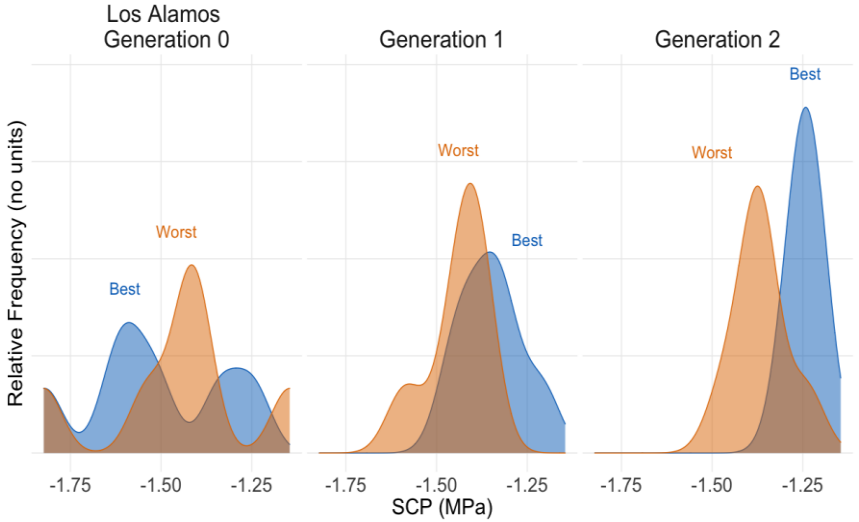
signals that establish beneficial interactions



modeling interactions with engineered microbiomes

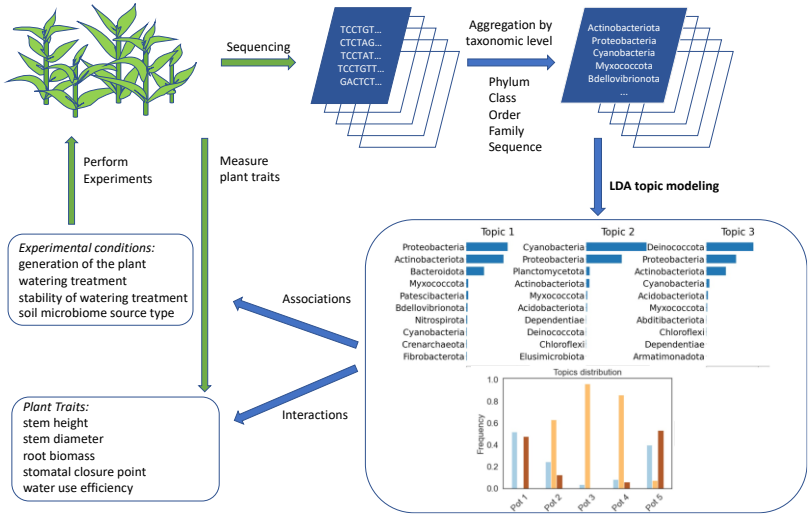
Directed plant:microbiome evolution to control plant function



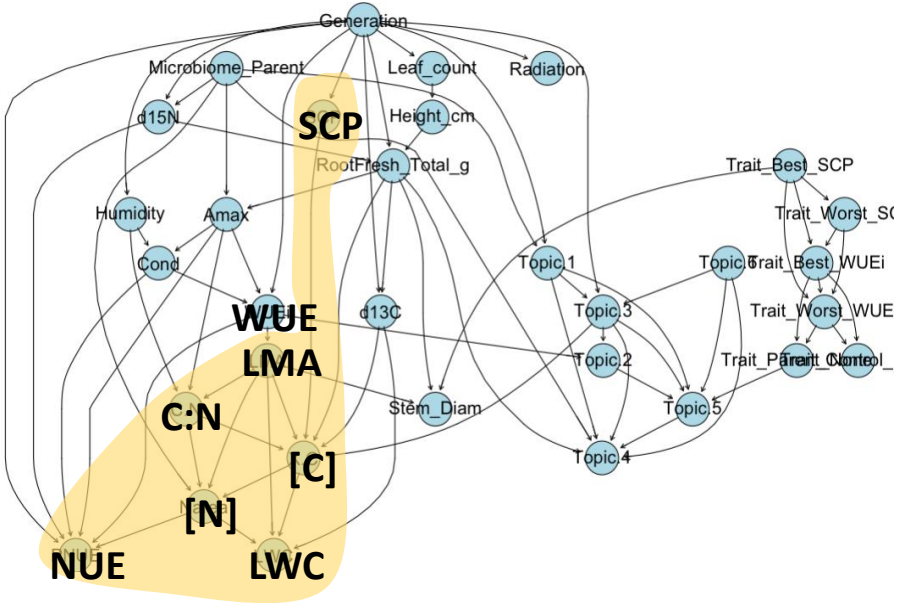


Machine learning to understand complex systems

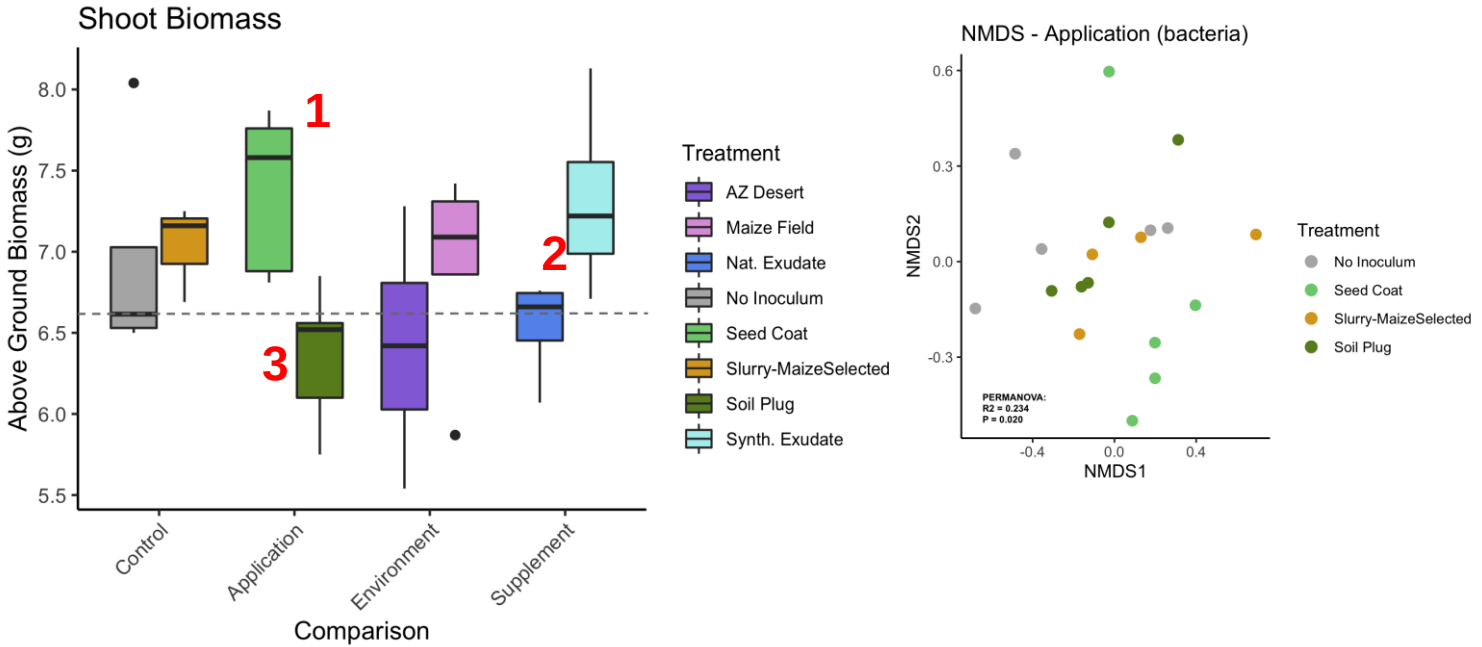
Dimensional reduction using Latent Dirichlet Allocation



Non-linear interactions with Probabilistic Graphical Modeling

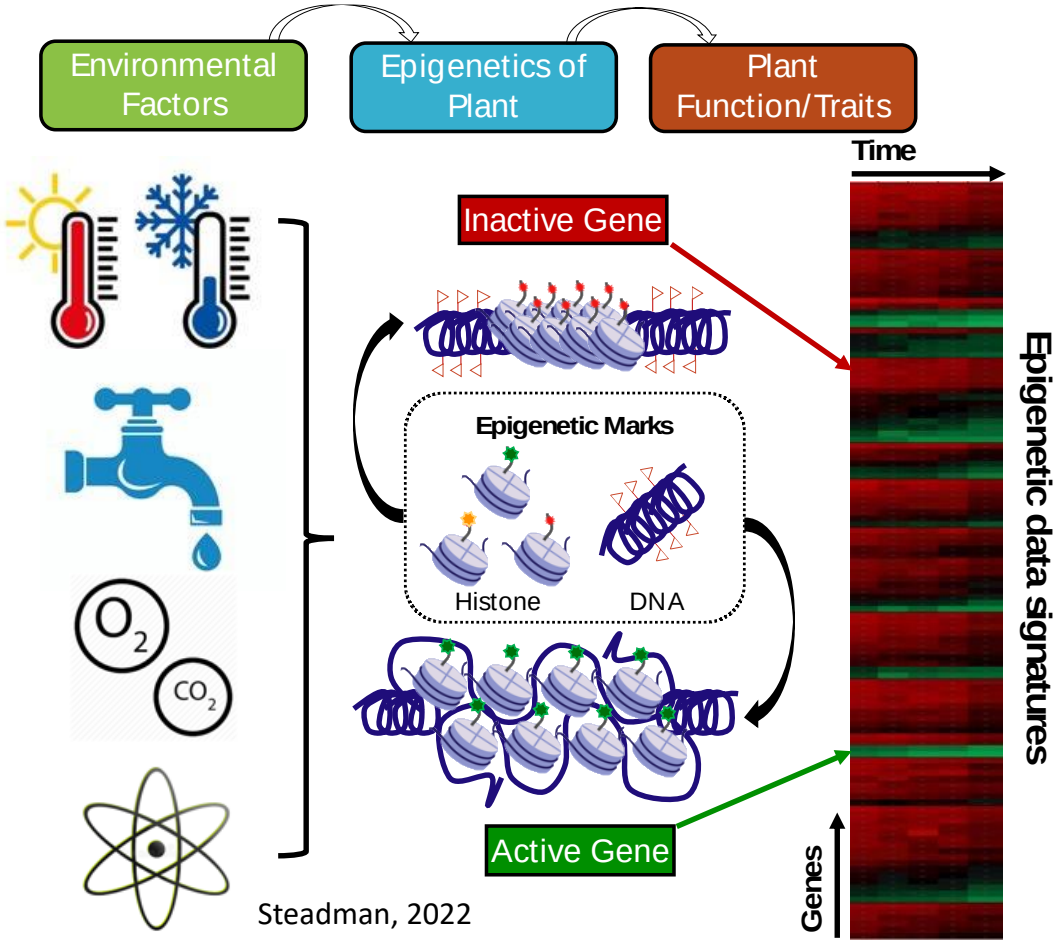


Microbial inoculations in natural soil from USDA-ARS Fort Collins



- Test conduced in the greenhouse in natural soil, with wick systems providing natural hydrology & in the field at USDA ARS Fort Collins, CO field site
- Inoculum application method matters: Seed coating or soil plug perform best
- Results pending from the field

Epigenetic control of plant response to climate change

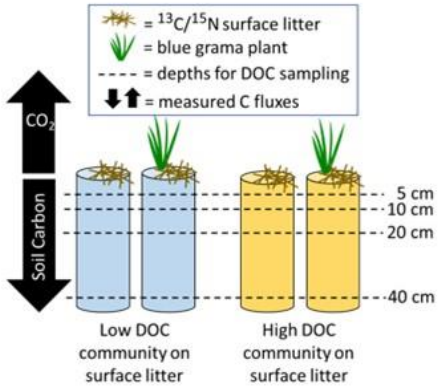


Steadman, 2022

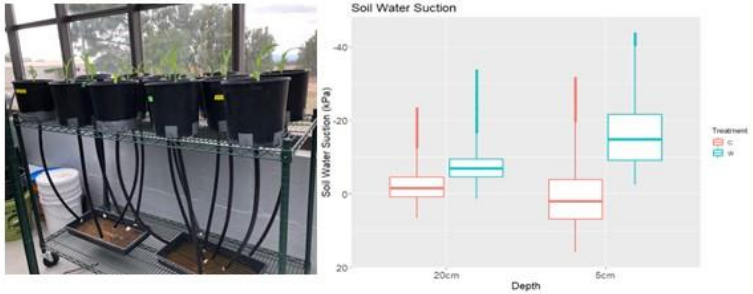
Christina Steadman
EES-14

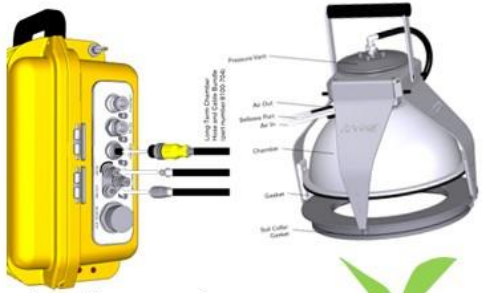
Greenhouse gas emission testbed

SFA



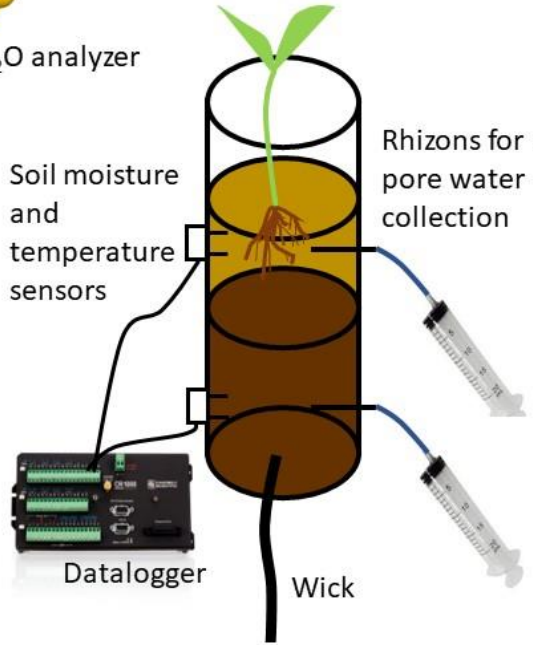
LDRD DR project





GHG measurement chamber

$CO_2/CH_4/N_2O$ analyzer



Plant growth promoting microbes

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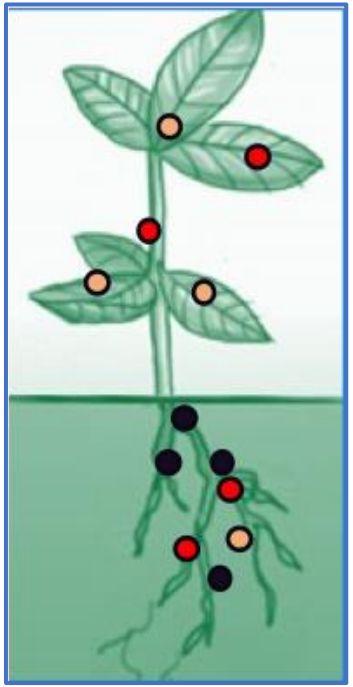
LANL/USDA Program Lead Meet and Greet, January 17, 2023

Why Plant Growth Promoting Microbes (PGPMs)?

Factors affecting plant growth

1. Biotic: Bacteria, fungus, and insects
2. **Abiotic: Salinity, drought, temperature, and pH,**

Camelina sativa



How can beneficial endophytes help?

Biofertilizers/biostimulants/ biopesticides

- **Growth promotion**
- **Yield enhancement**
- **Stress tolerance**
- **Nutrient availability**
- **Biocontrol**
- **Eco-friendly**

- Multipurpose oilseed crop (jet fuel and edible oil)
- Cash cover crop
- Collaboration with USDA-ARS Maricopa

Development of high throughput root phenotyping method

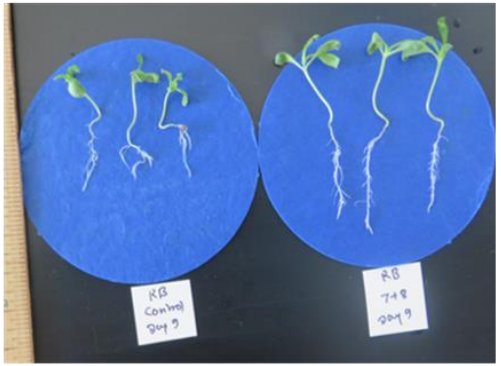
20 bacterial endophytes screened, 5 best performing endophytes selected, 4 combinations tested (1000 seedlings screened)

Control

Treated

Auxin overproduction

Individual and combined endophyte effect on root phenotype

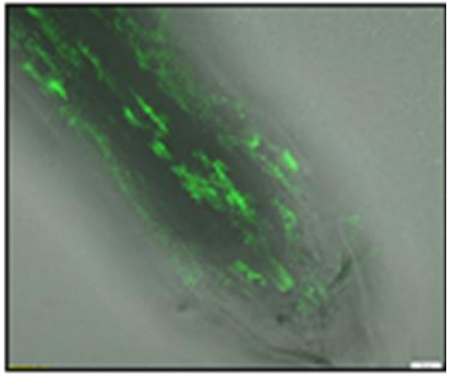


Effect of a consortium (5 endophytes) on root phenotype

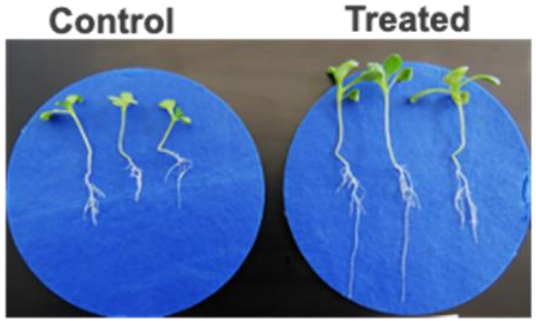
- Endophytes with ability to modulate plant hormones can significantly alter root phenotype
- Selected endophytes were effective in two different Camelina cultivars

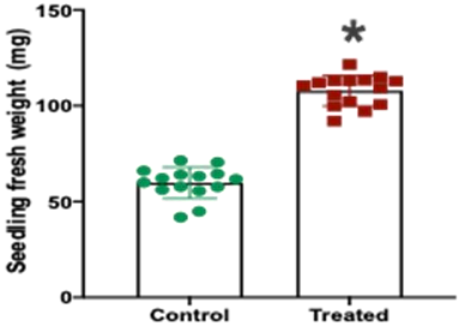
Proof of concept: Improvement in growth

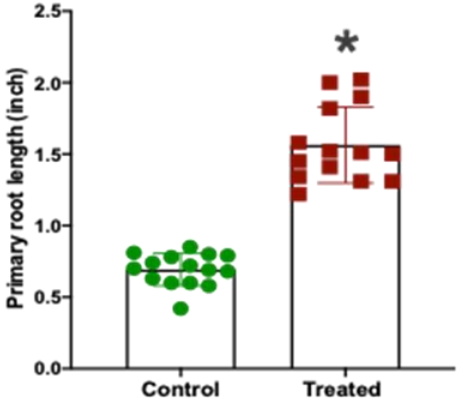
Beneficial endophyte consortium improved root phenotype and overall seedling growth in Camelina

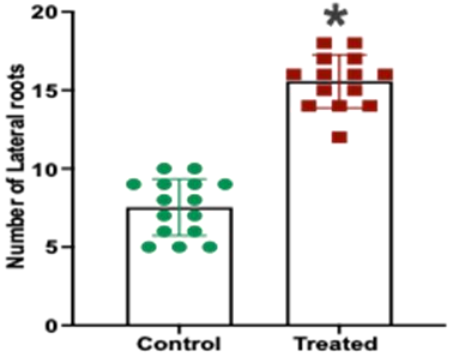


Root Colonization









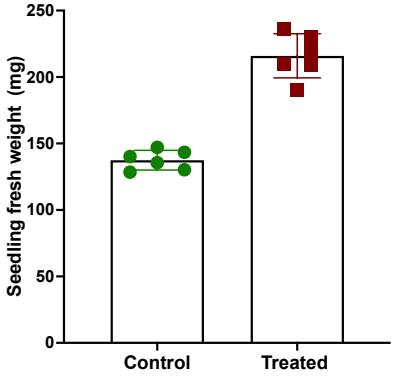
The average and SD of 15 seedlings are reported, and significant differences (a Student's t-test determined *) between Control and treated, P < 0.0001. Seedlings were grown on agar plates after seed treatment with endophytes

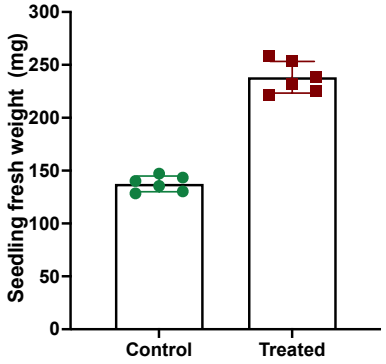
https://discovr.labworks.org/

Proof of concept: Improvement in growth (Sorghum)

Beneficial endophytes improved root phenotype and overall seedling growth in Sorghum

The average and SD of 6 seedlings are reported, and significant differences (a Student's t-test determined *) between Control and treated, P < 0.0001. Seedlings were grown on agar plates after seed treatment with endophytes





High throughput, imaging, and ‘omics tools

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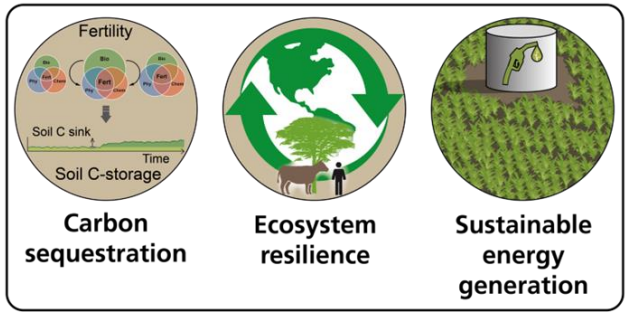
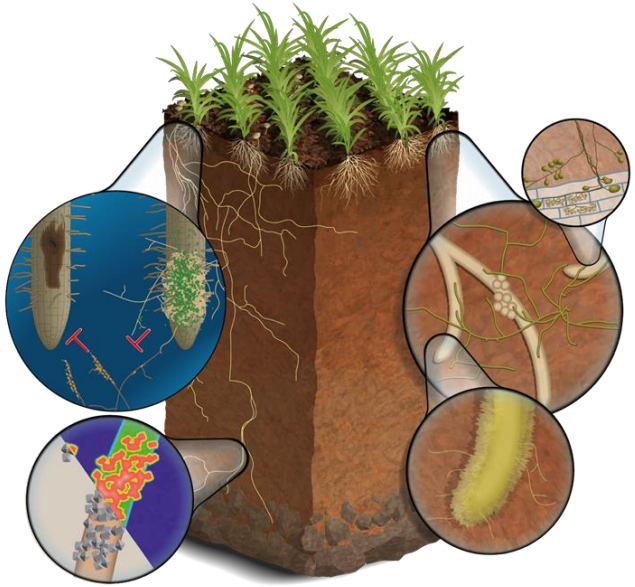
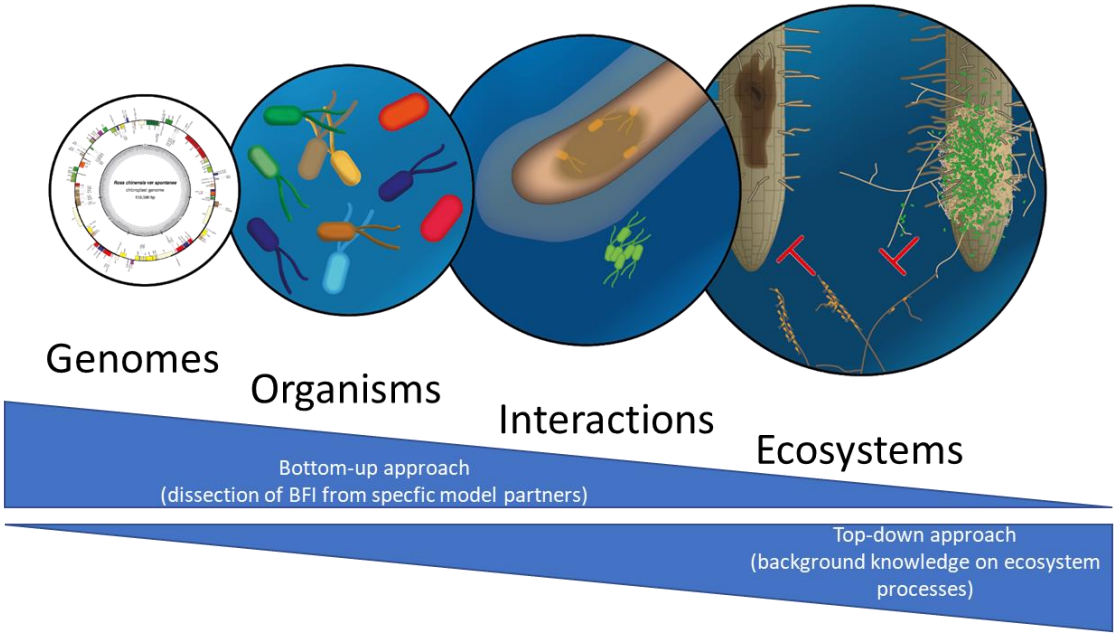
Addressing DOE priorities studying bacterial-fungal interactions (BFI) – DOE Science Focus Area

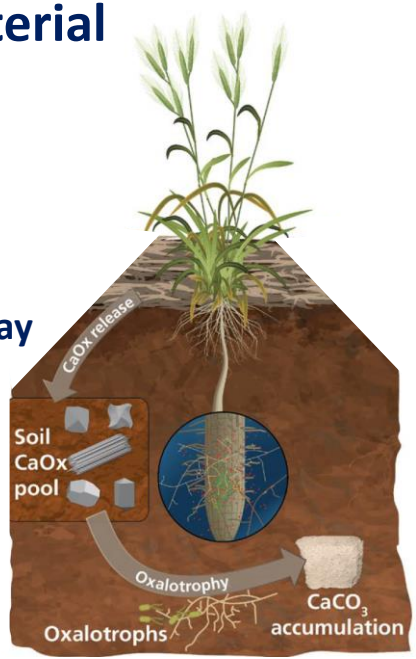






Rhizosphere fungal-bacterial interactions driving soil C-sequestration

Oxalate-Carbonate pathway



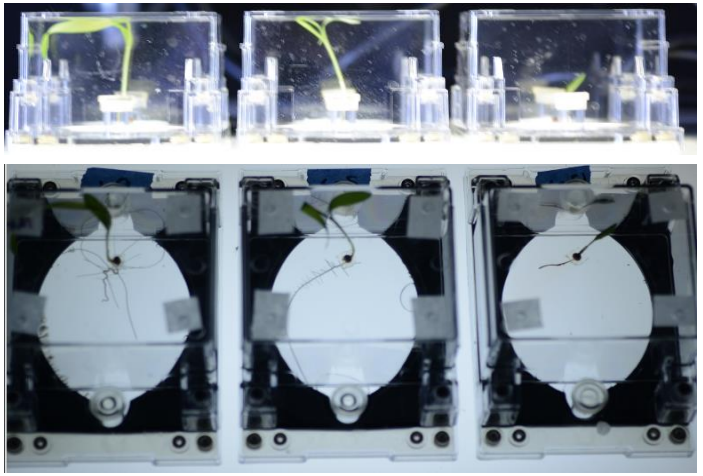
Sevilleta LTER
lternet.edu/site/sevilleta-lter/

Experimental system for arid and marginal lands.

Blue grama as model grass for heat and drought tolerance.

High throughput tools for phenotyping and imaging

Quantifiable plant phenotypes under stress conditions in EcoFABs



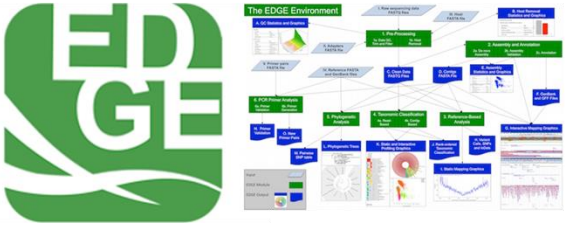
Visualizing spatiotemporal plant-microbe interactions using isolates and defined consortia

Bioinformatics tools with standardized workflows

User-friendly and publicly accessible

nmdc
National Microbiome Data Collaborative

microbemetadata.org



edgebioinformatics.org

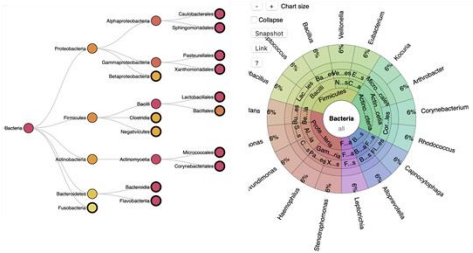
sfa-bfi.edgebioinformatics.org

Establishing and promoting standardized methods for microbiome research

- developing best practice algorithms for microbiome data analytics
- bridges with national facilities (e.g., JGI, EMSL), harmonize workflows, metadata, and -omics data management
- working with a broad array of partners such as funding agencies and societies (NSF, NASA, ASM) and institutions (NCBI, ICTV, SeqCode, GSC, IMMSA, etc.) to establish concrete metadata and analysis standards

EDGE: Empowering the Development of Genomics Expertise

- fully integrated web-based bioinformatics platform
- user-friendly and interactive interface accessible to the larger scientific community
- established pipelines and spearheading quality control in COVID-19 genome analyses, transitioning and poised for biosurveillance of future pandemics



- publicly available repository of known fungal-bacterial associations
- input sourced from fungal genome SRA data
- interactive, publication-linked

Emerging efforts

- Moving GPGMs into EcoFabs and greenhouse
- Coupling EcoFabs to downstream HT screening tools
- Use of hyperspectral data to track microbial applications and nutrient use
- Biochar, alone and coupled to microbial applications, with an emphasis on arid and semi-arid soils
- Application of epidemiological models and decision support tools to plant disease spread