4R Nutrient Stewardship and the Phytobiome

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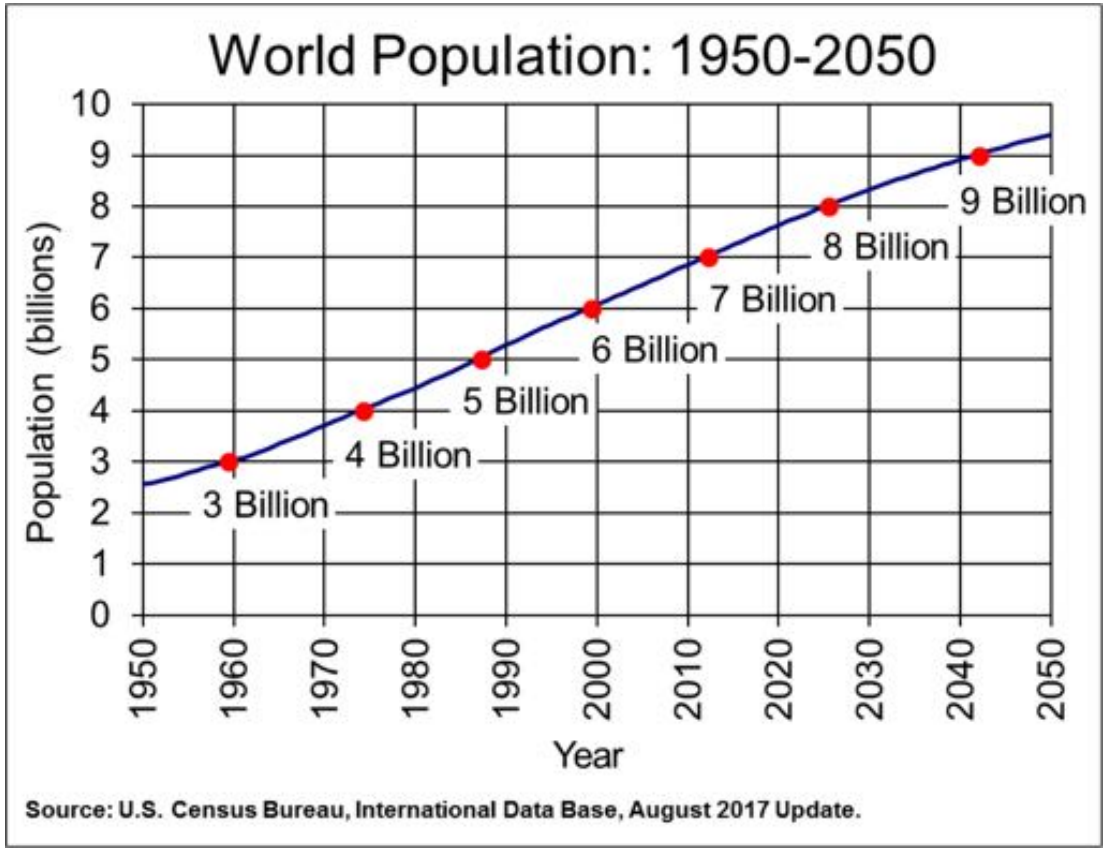
The Global Challenge



31 Growing Seasons

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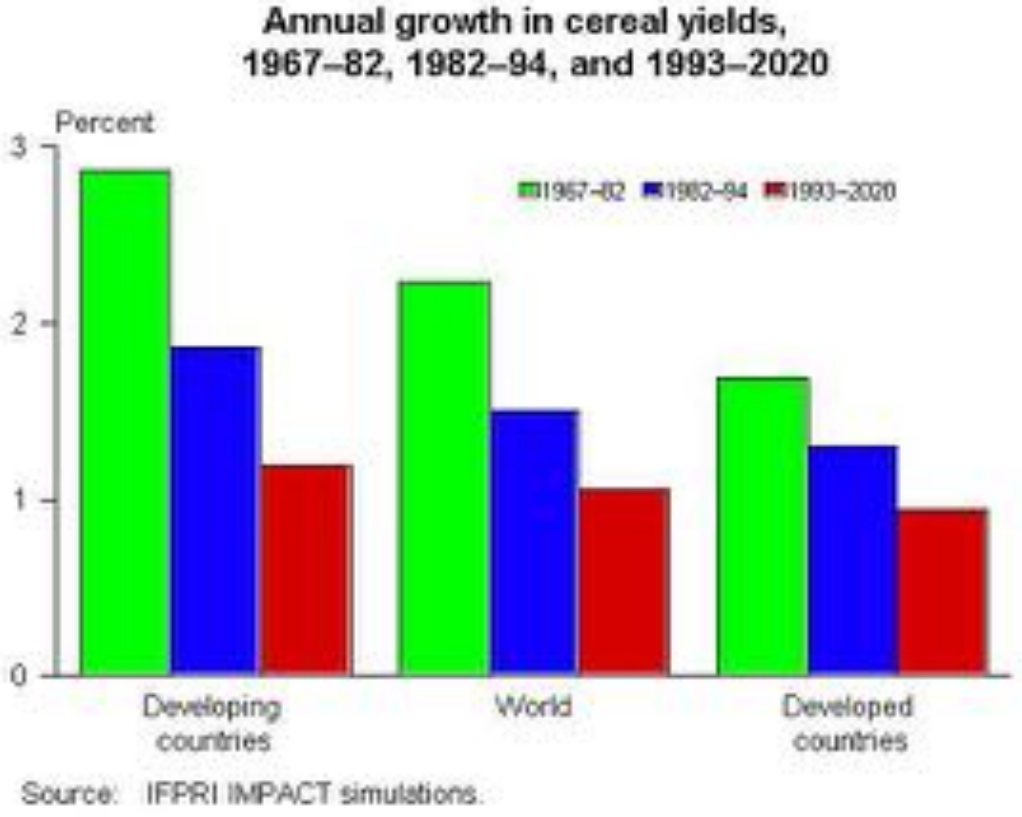
Declining Cereal Yield Growth



How do we reverse the trend and achieve sustainable production in 31 growing seasons?

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Move From Simple to Complex

Traditional science approach

- Reductionist
- World is linear and can be understood by focusing on individual components or within individual disciplines
  - Soils
  - Plant genetics
  - Weather
  - Microbes

Reality – agriculture is a **complex system**

- non-linear organization
- governed by multiple non-linear interactions and environmental variables

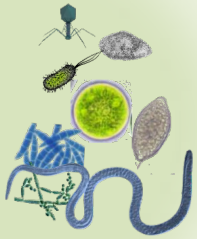
Plant-based Agriculture: A complex system

A "Phytobiome"

Climate

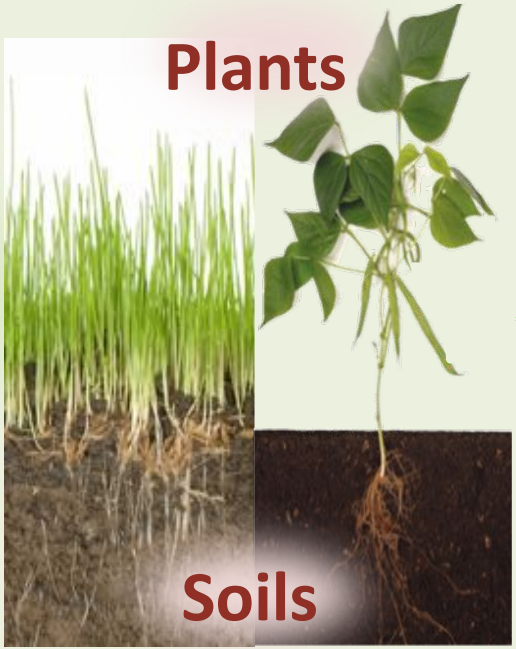
Micro- and Macroorganisms

Viruses
Archaea
Bacteria
Amoeba
Oomycetes
Fungi
Algae
Nematodes



Their environment

"Biome" – site-specific environment



Arthropods, Other Animals and Plants

Insects
Arachnids
Myriapods
Worms
Birds
Rodents
Ruminants
Weeds

Associated organisms

Plant-based Agriculture: A complex system

Management Context

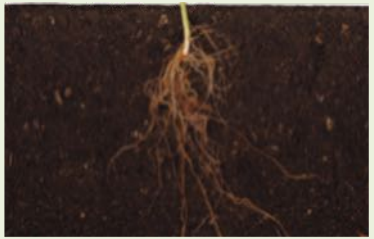
Crop choices
Species Cultivar
GMO/Non-GMO

Monoculture
Cover crops
Crop rotations

Inputs
Fertilizer type, rate
time & place

Herbicides
Insecticides
Fungicides

Site choices
Irrigation Tile drainage
Livestock Mgt



Till/No-till
Planting time
Harvest time

Holy Grail for Phytobiomics

To understand, predict and control emergent phenotypes* within specific phytobiomes for the sustainable production of food, feed, and fiber

*Properties (e.g., crop productivity or quality) that result from interactions among the many components of a phytobiome

How do we get there?

PHYTOBIOMES ALLIANCE

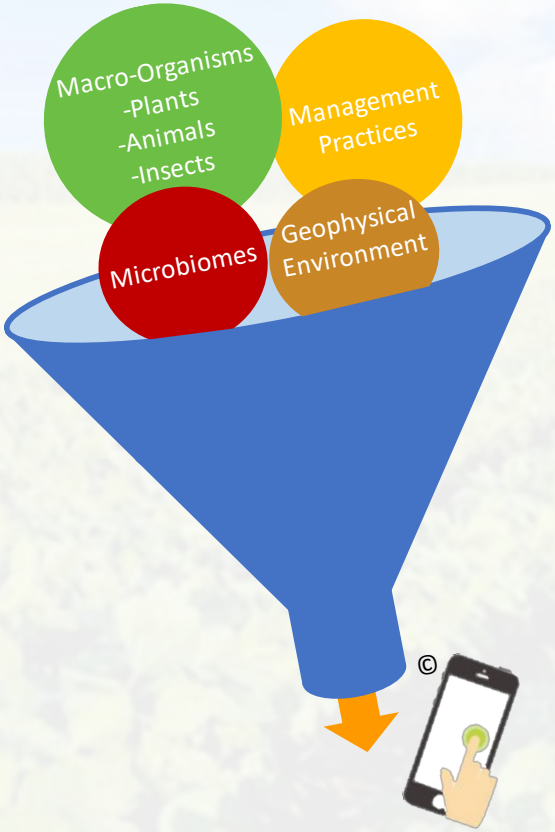
Phytobiomes Alliance

A nonprofit consortium of industry, academic, and governmental scientists

Mission

Establish a science and technology foundation for site-specific, phytobiome-based enhancement of sustainable food, feed, and fiber production

Phytobiomes Alliance Vision



By 2050, all farmers have the ability to use predictive and prescriptive analytics based on geophysical and biological conditions for determining the best combination of crops, management practices, and inputs for a specific field in a given year.

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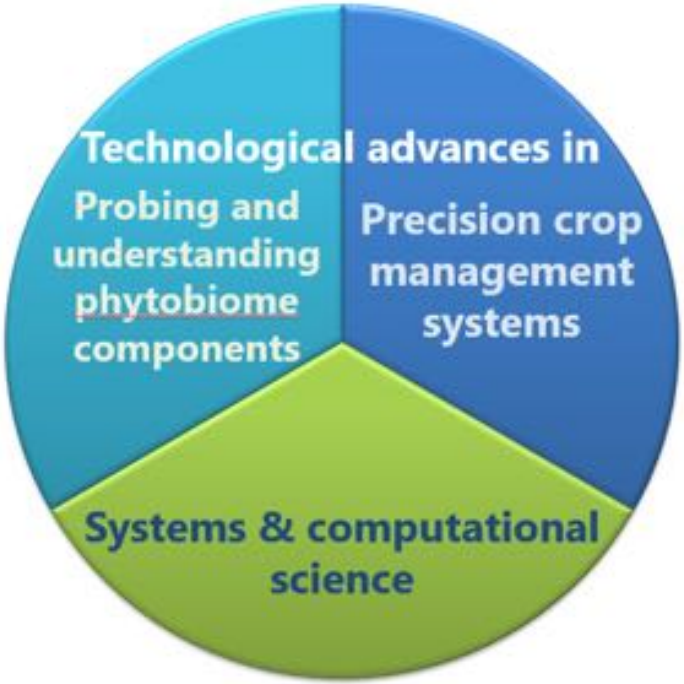
Why Now?

Convergence of need & opportunity



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Advances in assessing phytobiome components

Genome-enabled technologies

PCR amplify (16S-18S rRNA, ITS)

Amplicon sequencing

Metagenome sequencing

Meta-transcriptome sequencing

Meta-proteome analysis

Metabolome analysis

Species (taxa) number, abundance, composition

Community function

Community activity

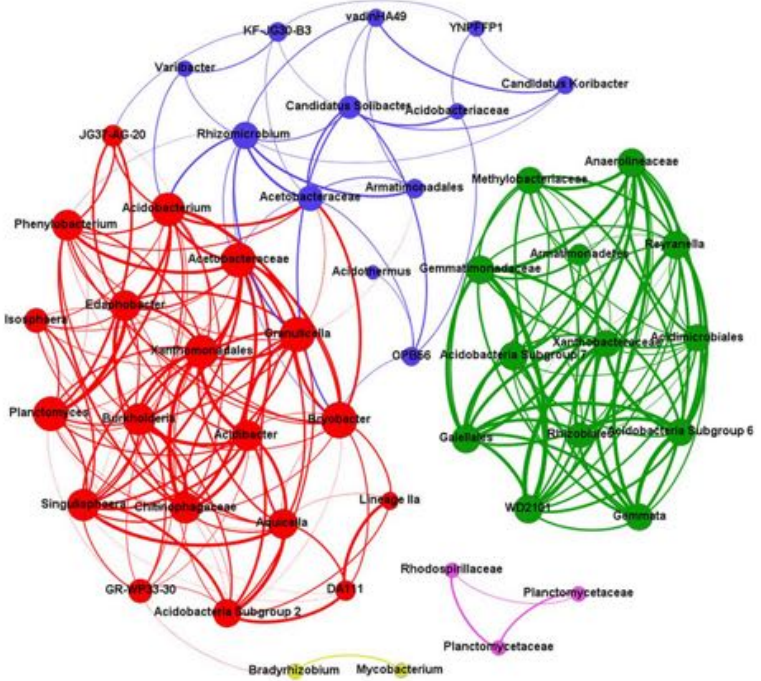
"Who is there?"

"What can they do?"

"What are they doing?"

Systems & Computational science

- Systems science

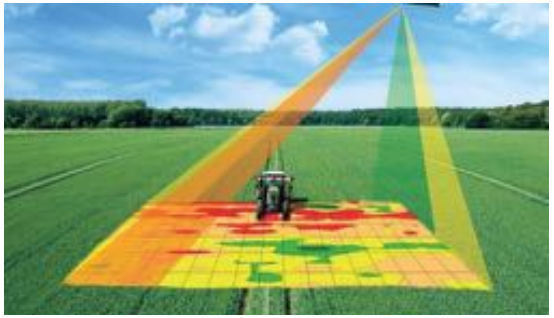


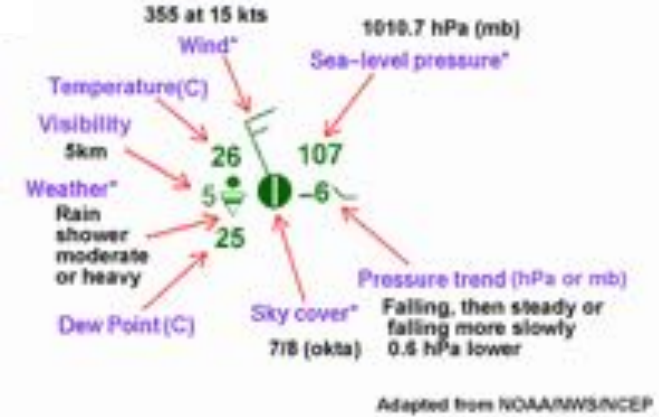
- Advances in computational science
  - Machine learning, deep learning
  - Predictive analytics
  - Quantum computing

Precision crop management systems

- Precision Agriculture

  - Variable rate technology…seeding & input
  - Unmanned Aerial Systems (UAS)
  - Soil, plant, & weather sensors
  - Robots





Vision

What genetic linkages connect phytobiome components?

→ *Breed plants that select for beneficial communities*

What constitutes a "healthy phytobiome"?

→ *Develop biologicals and indicators/predictors of crop and soil health*

Vision

What are the mechanisms by which specific management practices promote ecosystem health?

→ *Design novel or improved management practices*

Can we exploit predictive and prescriptive analytics to design site-specific solutions to environmental challenges?

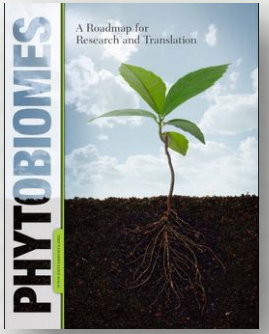
→ *Incorporate biological information into the next generation of precision agriculture technologies*

Strategies

- Develop an interdisciplinary community committed to advancing phytobiomes science

Strategies

- Develop an interdisciplinary community committed to advancing phytobiomes science
- Focus on pre-competitive science
- Determine research, resource, and technology gaps and develop roadmaps to fill them
- Coordinate and manage projects to address gaps
- Facilitate international and public-private collaborations
- Empower industry growth and profitability

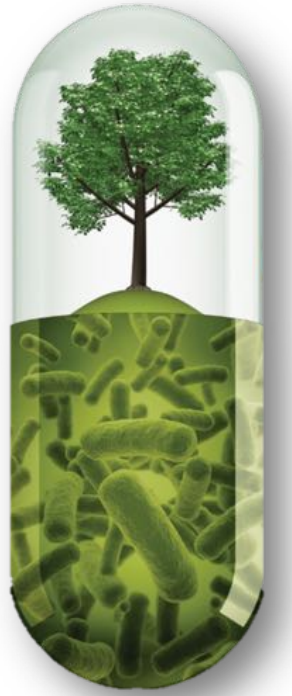


PHYTOBIOMES ALLIANCE

Outcomes of this new vision for agriculture

Managed or engineered phytobiomes that promote:

- Increased resilience of our cropping systems to pests, pathogens, water and nutrient limitation
- Nutrient stewardship and pest control practices that are best suited for sustainable productivity
- Full integration of biologicals into site-specific crop management – moving us to the next-generation precision agriculture

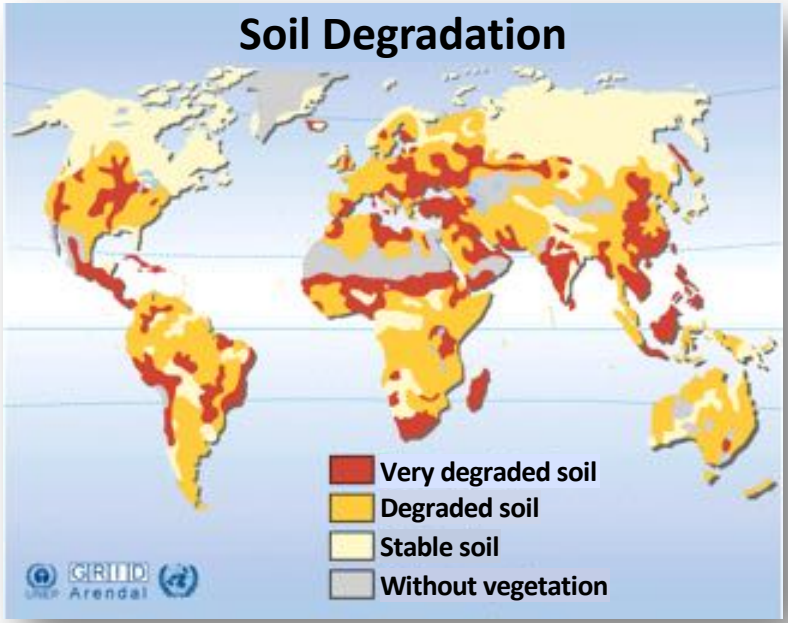


Outcomes of this new vision for agriculture

Managed or engineered phytobiomes that promote:

- Effective rehabilitation of degraded and depleted lands worldwide

*1.5 billion people depend on degraded lands for survival



Source: UNEP

Outcomes of this new vision for agriculture

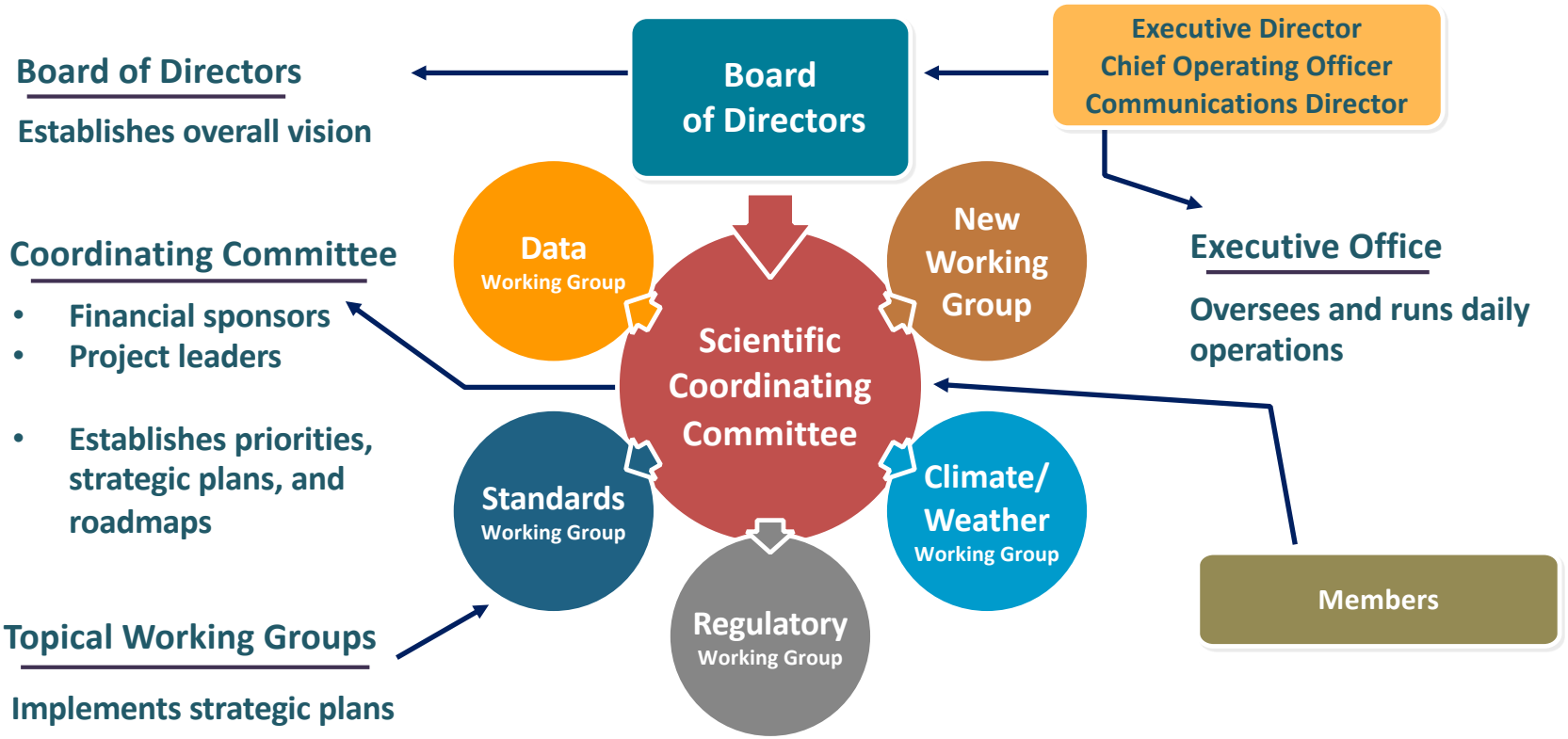
- Adaptive, data-driven, on-farm systems for managing phytobiomes for optimal productivity

- Increased profitability of sustainable food production to enable growers to meet demand

Audiencescapes

www.linkedin.com/pulse/foreign-affairs-precision-agriculture-revolution-ulrich-adam

Phytobiomes Alliance Organizational Structure



International Alliance for Phytobiomes Research Sponsors


www.phytobiomesalliance.org