

Phytobiomes: A whole-system approach to advancing plant agriculture

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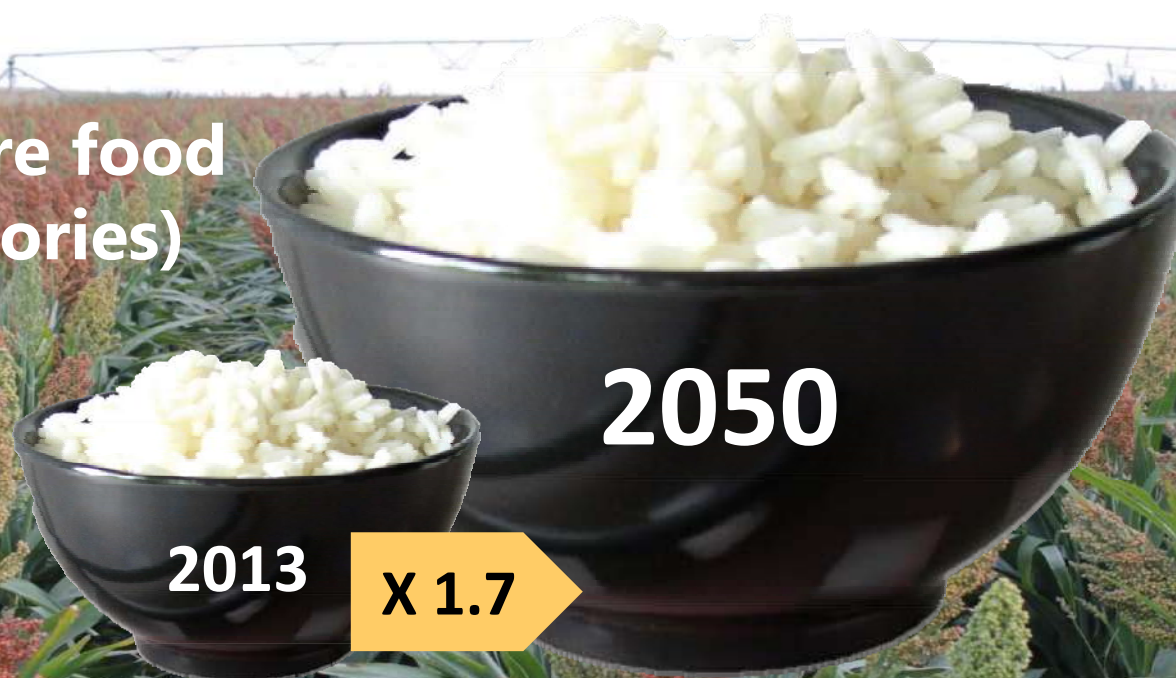


***Global Grand Challenge
To sustainably feed the world***



To feed a global population of 9.6 billion in 2050

Need 70% more food
(based on calories)

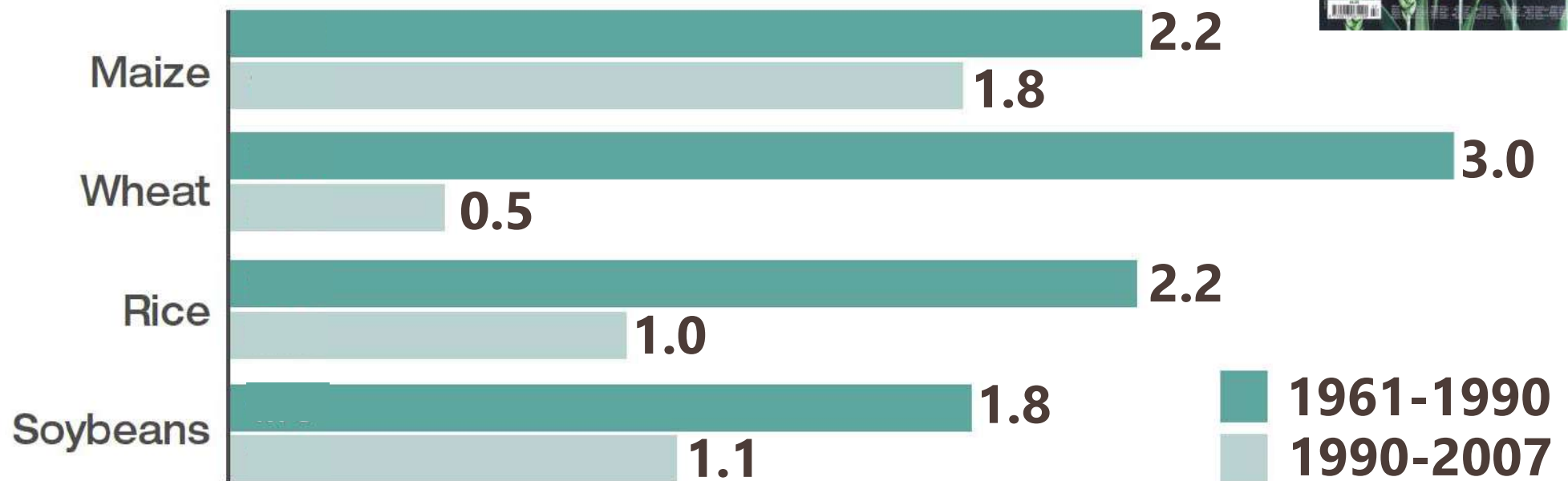


World Summit on Food Security (2013)

Doubling global crop production by 2050 will require ~2.4% increase per year in yields



GLOBAL YIELD GROWTH RATES (%)



SOURCE: ALSTON ET AL, 2009, SCIENCE 325:1209



American Phytopathological Society 2013
Directive to an international group of
“thought leaders”:

Develop concepts that can
contribute to doubling the
amount of safe and nutritious
food by 2050

→ **Time is right for a systems approach**



In the year **2050**,
the world population will require **70%** more food.

Phytobiomes: Systems in Context

Biological and Environmental Context



Micro- and Macroorganisms

- Viruses
- Archaea
- Bacteria
- Amoeba
- Oomycetes
- Fungi
- Algae
- Nematodes



Plants



Arthropods, Other Animals and Plants



- Insects
- Arachnids
- Myriapods
- Worms
- Birds
- Rodents
- Ruminants
- Weeds

Their environment

Soils

All of the associated organisms

Phytobiomes: Systems in Context

Management Context



Crop choices

Species Cultivar
GMO/Non-GMO

Monoculture
Cover crops
Crop rotations



Inputs

Application methods
Timing



Herbicides
Insecticides
Organic/Inorganic
fertilizers
Fungicides



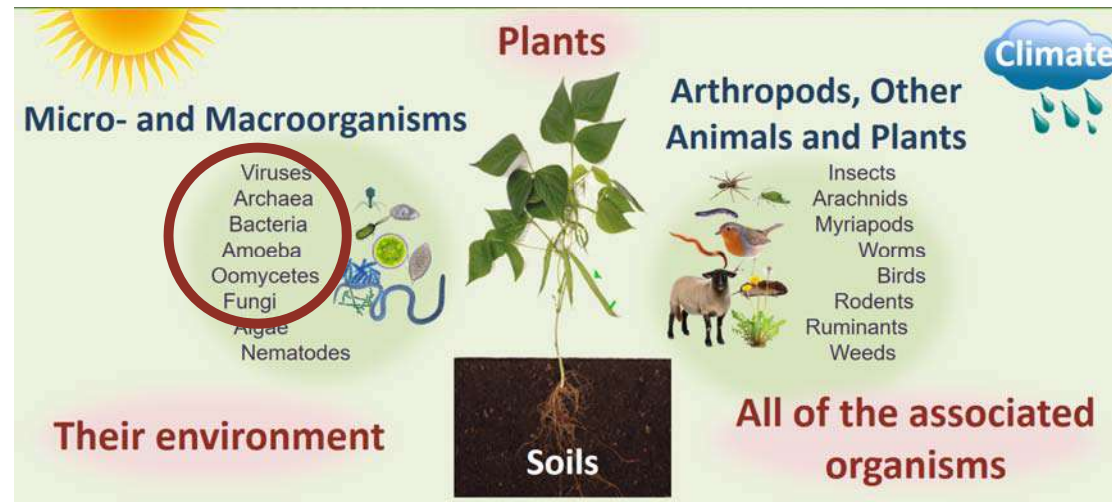
Site choices

Irrigation Tile drainage
Livestock Mgt

Till/No-till
Planting time
Harvest time

Conceptual development of “Phytobiomes”

Phytobiome vs. plant microbiome



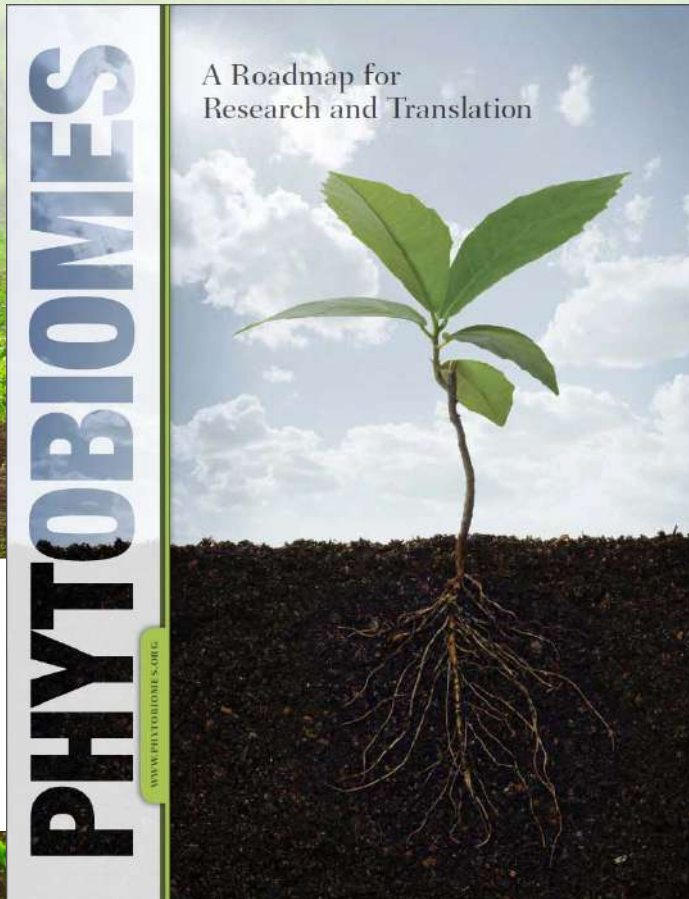
Phytobiomes - plants, their associated organisms, and their environment

Conceptual development of “Phytobiomes”

Plant systems vs. Phytobiomes

- **Plant systems** focus on a plant and then determine the interactions of that plant with all other components
- **Phytobiomes** focus on a plant ecosystem that may involve any number of different types of plants, organisms, and environmental components.
 - use information on all components and their interactions to identify the best plant(s) to grow at a given site in a given period

The Phytobiomes Roadmap Offers a New Vision for Agriculture...



**Achieve sustainable crop productivity
through a systems-level understanding
of diverse interacting components**

Origin of the Phytobiomes Roadmap

- **American Phytopathological Society meetings (2014-15)**
- **Interdisciplinary participants from academia, industry and government in**
 - **Workshop: *Phytobiomes 2015 - Designing a new paradigm for crop improvement* (>200 participants)**
 - **Interdisciplinary writing team**
- **Comments from the public and organizations endorsing the Roadmap**

The Phytobiomes Roadmap has been endorsed by:

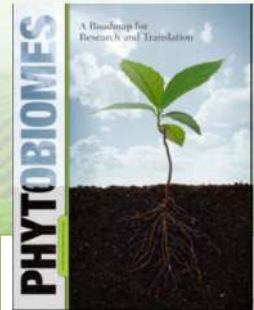


Science For A Better Life



Dow AgroSciences





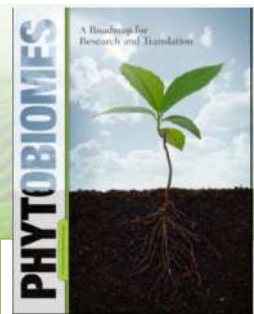
Embracing Complexity

Roadmap Theme



Reductionist approach to biology and agricultural science: Understand each component individually

Reality: biological systems are complex and non-linear in their organization and regulation



Roadmap Theme

Interdisciplinary, systems-level approaches are critical

Develop a foundation of knowledge

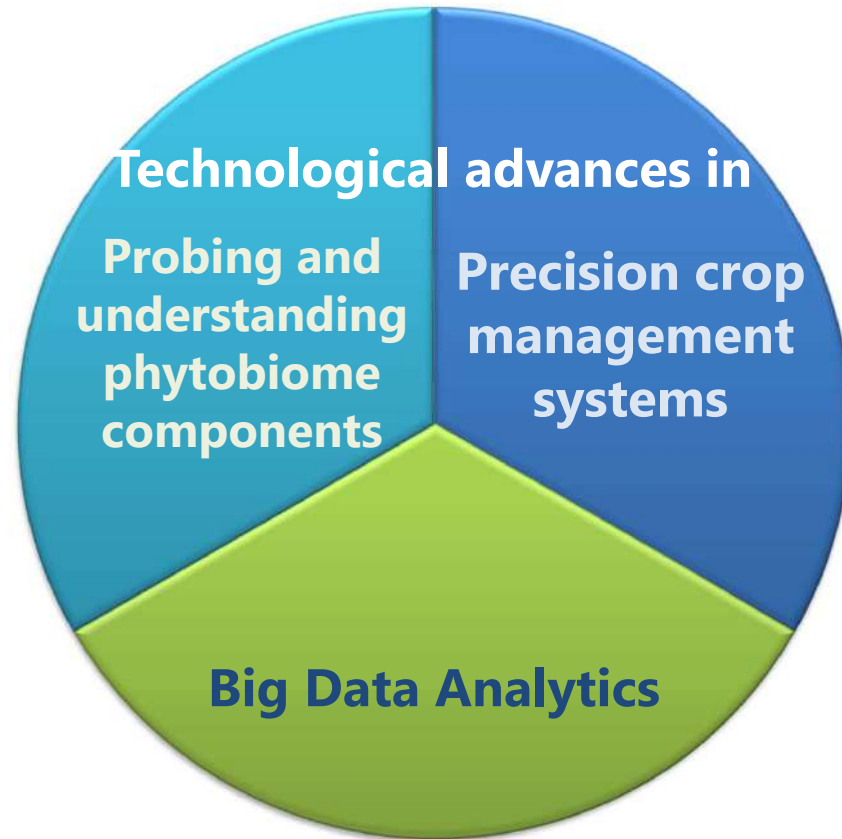
Public & Private sector scientists

Molecular biologists Soil scientists Growers
Organismal biologists Extension Crop consultants
Chemists Ecologists Agronomists Statisticians
Computational scientists Plant breeders Agribusiness
Atmospheric scientists Engineers Consumers

Translate that knowledge into application

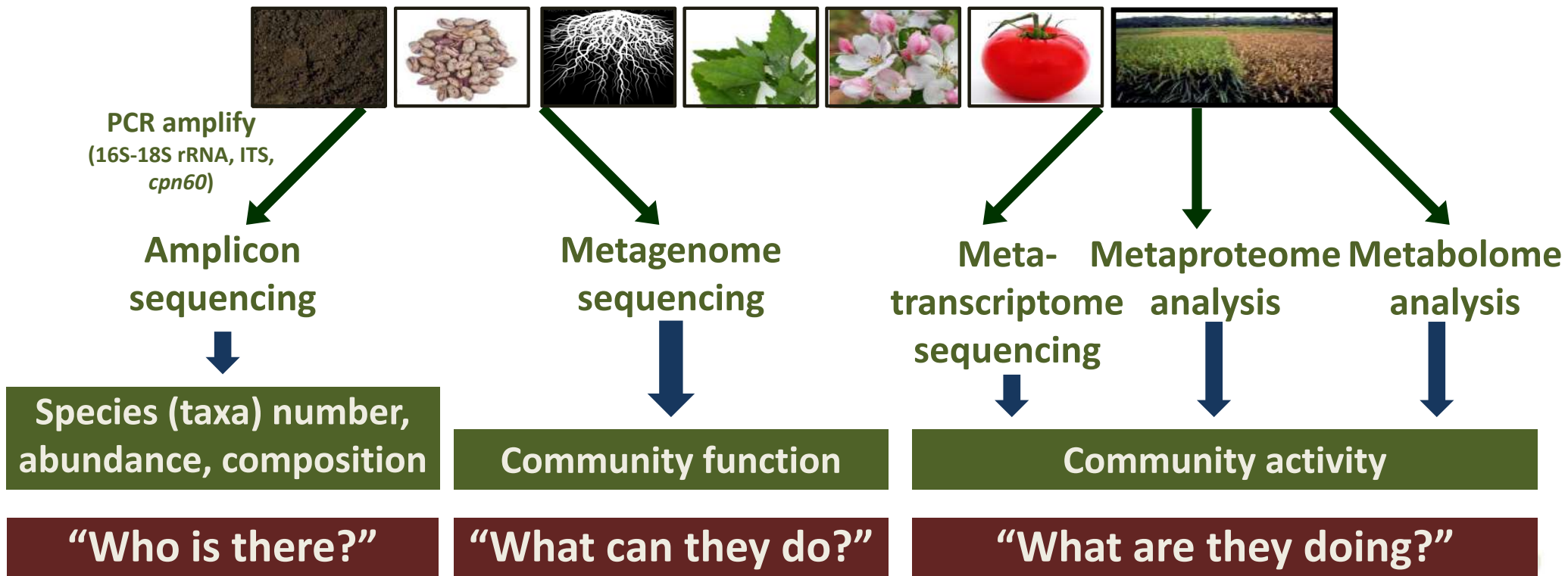
Why now?

Convergence of need & opportunities



Advances in assessing phytobiome components

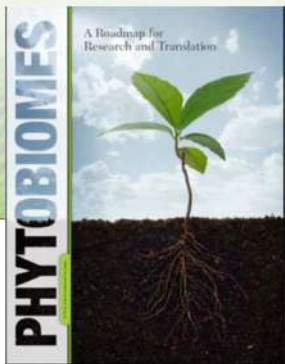
Genome-enabled technologies Computational biology and modeling



Advances in precision management strategies in agriculture



Mid-1990's: global positioning systems



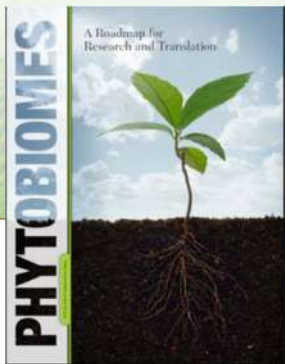
Vision

What genetic linkages connect phytobiome components?

→ *Breed plants that select for beneficial communities*

What constitutes a “healthy phytobiome”?

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



Vision

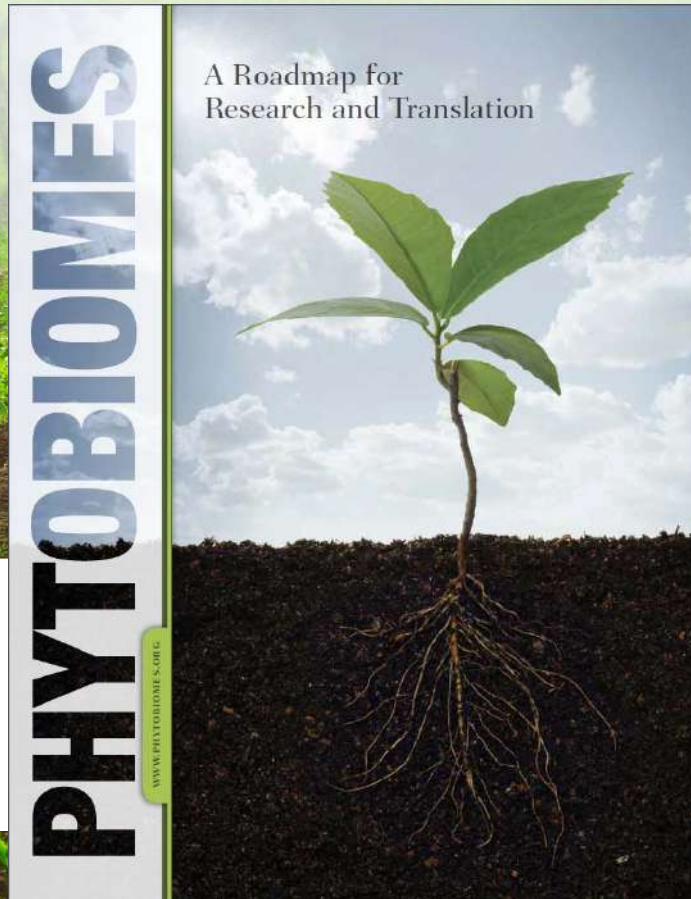
What are the **mechanisms** by which specific management practices promote ecosystem health?

→ *Design novel or improved management practices*

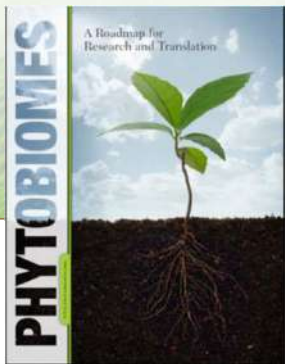
Can we exploit **predictive and prescriptive analytics** to design site-specific solutions to environmental challenges?

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

The Phytobiomes Roadmap Offers ...



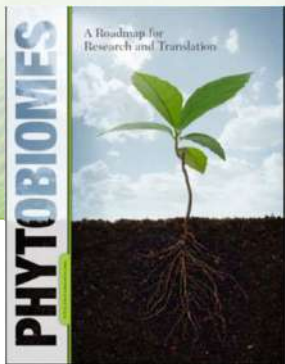
A strategic plan



Phytobiomes Roadmap identifies:

- Major gaps in
 - Knowledge
 - Technology
 - Infrastructure
- Challenges in educating and training a future workforce
- Short-, mid- and long-term actions and goals for the future

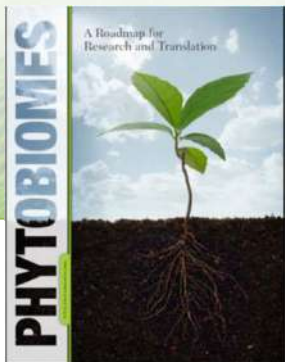




Actions

- Forming linkages among disciplines to recruit a broad base of expertise to the field of phytobiomes
- APS is launching a new, open-access journal
- Advocating for *new* support for phytobiome research





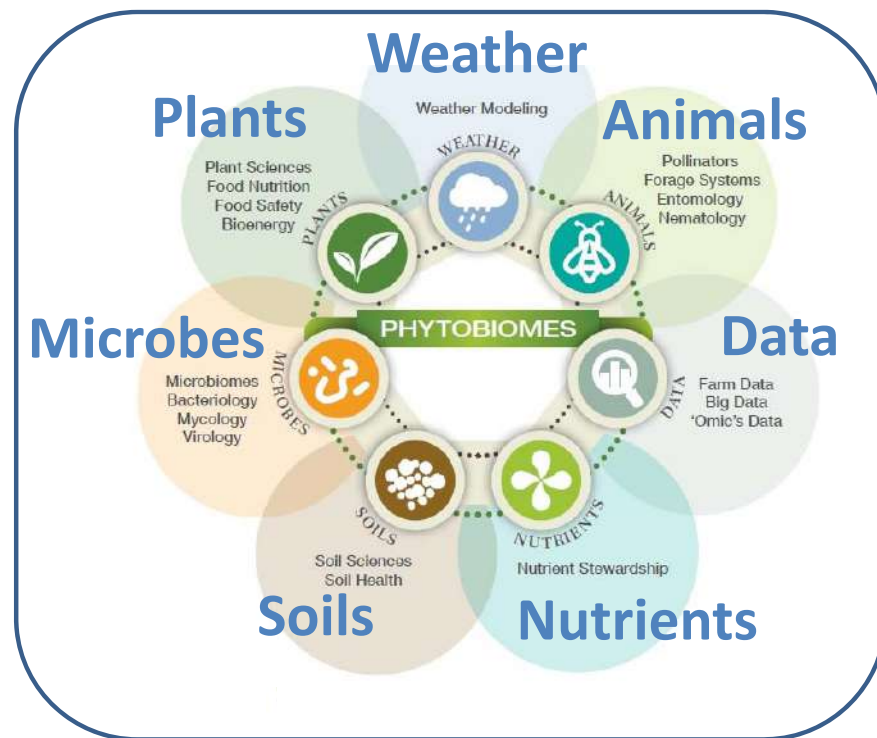
Actions

- Establishing the International Alliance for Phytobiomes Research, a public-private alliance to enhance interdisciplinary networks



**Executive Director:
Kellye Eversole**

- Working to attract and strengthen a cross-trained workforce

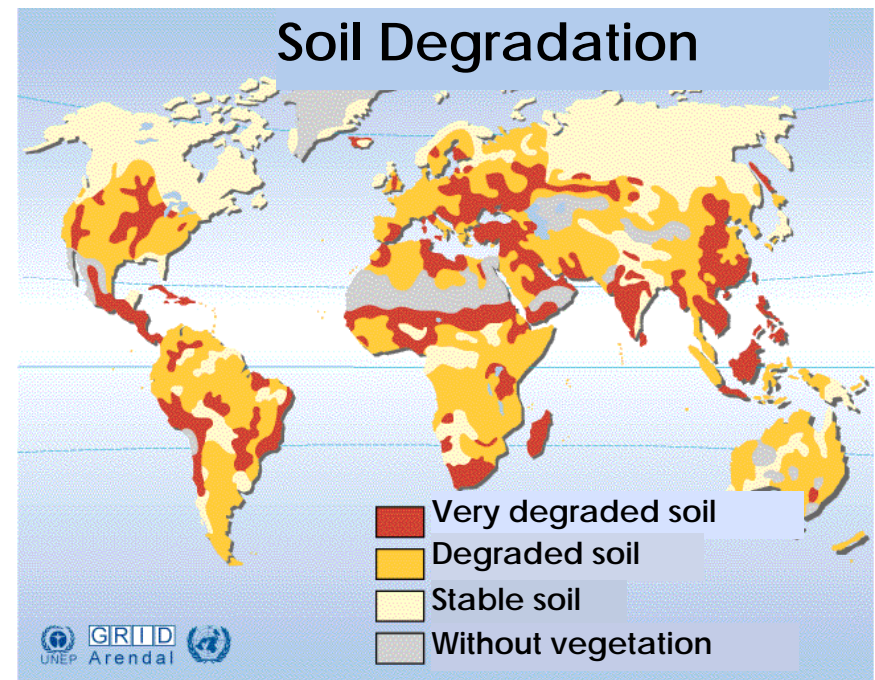


Outcomes of this new vision for agriculture

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

Managed or engineered phytobiomes that promote:

- Increased resilience of our cropping systems to pests, pathogens, water and nutrient limitation
- 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



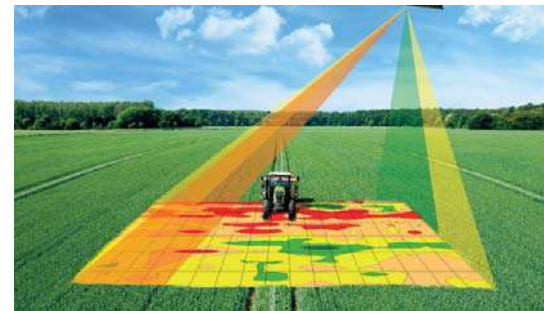
Outcomes of this new vision for agriculture

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



Audiencescapes

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



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

Future Events

KEYSTONE SYMPOSIA™
on Molecular and Cellular Biology
Accelerating Life Science Discovery

Join Us for the Conference on
Phytobiomes: From Microbes to Plant Ecosystems
November 8–12, 2016 | Santa Fe, New Mexico | USA
Organizers: Jan Leach | Kellye Eversole | Jonathan Eisen | Gwyn Beattie | Marcos Machado



<http://www.keystonesymposia.org/17S2>



www.phytobiomes.org