Exploring Phytobiome Systems: From Microbiomes to Next Generation Precision Agriculture

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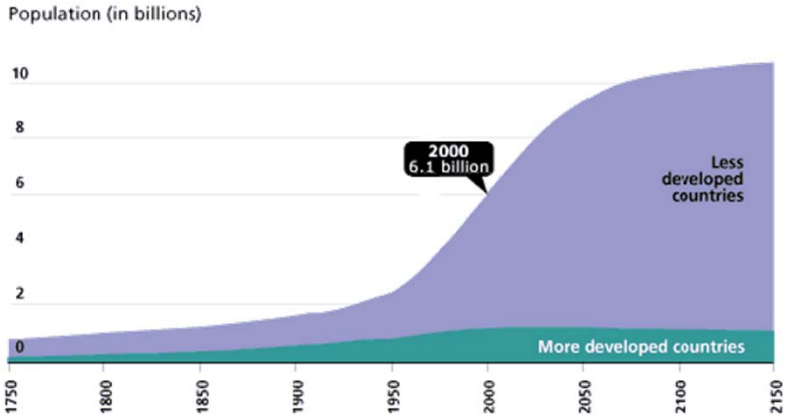
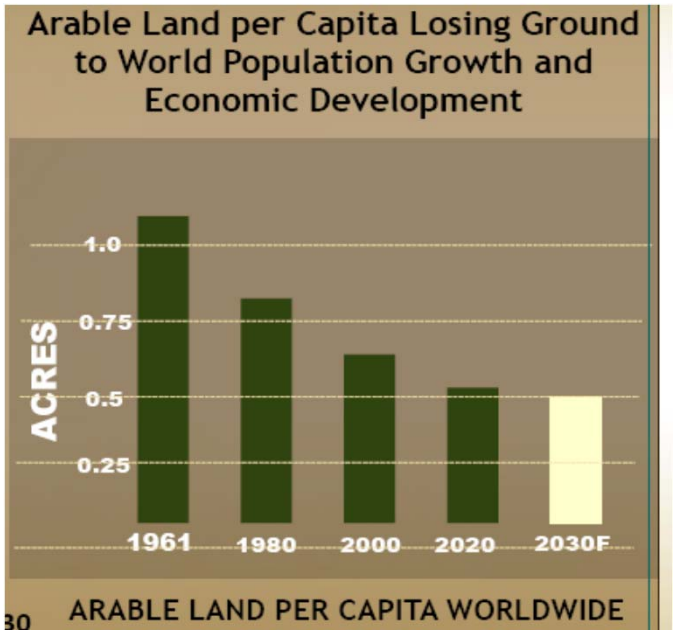
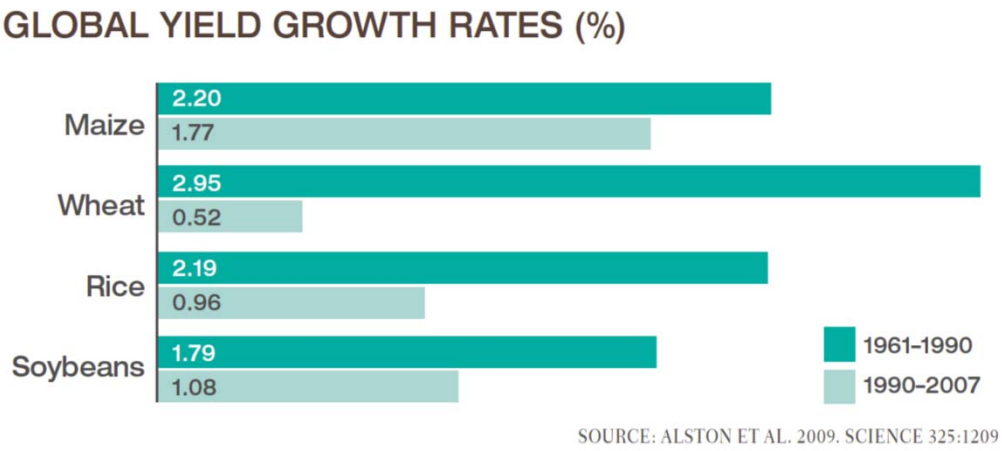
A New Paradigm is Needed

Sustainably provide sufficient quantity of high quality food, feed, and fiber





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



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

Another Approach is Needed

- Reductionist approach to biology and agricultural science
- World is linear – understanding parts individually
- Reliance on partial knowledge -genetics or environmental factors, soil or plant, plant or microbe, microbe or community
- Reality - Complex, non-linear organization and regulation of biological systems
- New Paradigm - Phytobiomes

What Are Phytobiomes?

Climate

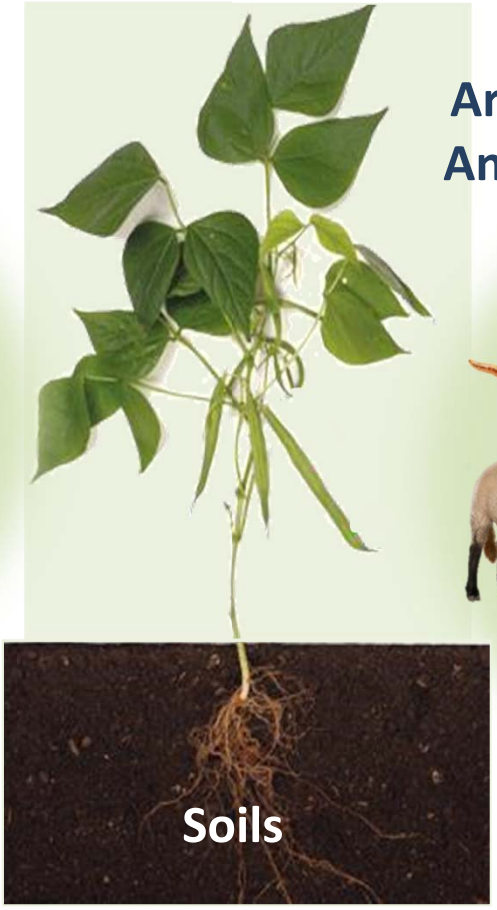
Plants

Micro- and Macroorganisms

Viruses
Archaea
Bacteria
Amoeba
Oomycetes
Algae
Fungi
Nematodes

Arthropods, Other Animals and Plants

Insects
Arachnids
Myriapods
Worms
Birds
Rodents
Ruminants
Weeds



Their environment

All of their associated organisms

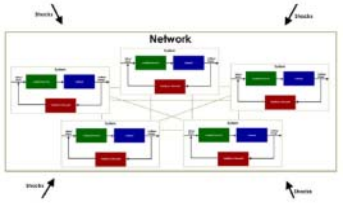
Phytobiomes vs Plant Systems

- **Plant systems** focus on a specific, defined plant (e.g., maize) and interactions of that plant with other components

- **Phytobiomes** focus on a plant ecosystem that may involve any number of different types of plants, organisms, and physical components.
  - Interactions of all these components will be used to identify the best crop/variety/management practices… for a given site and a given period

Why Now?

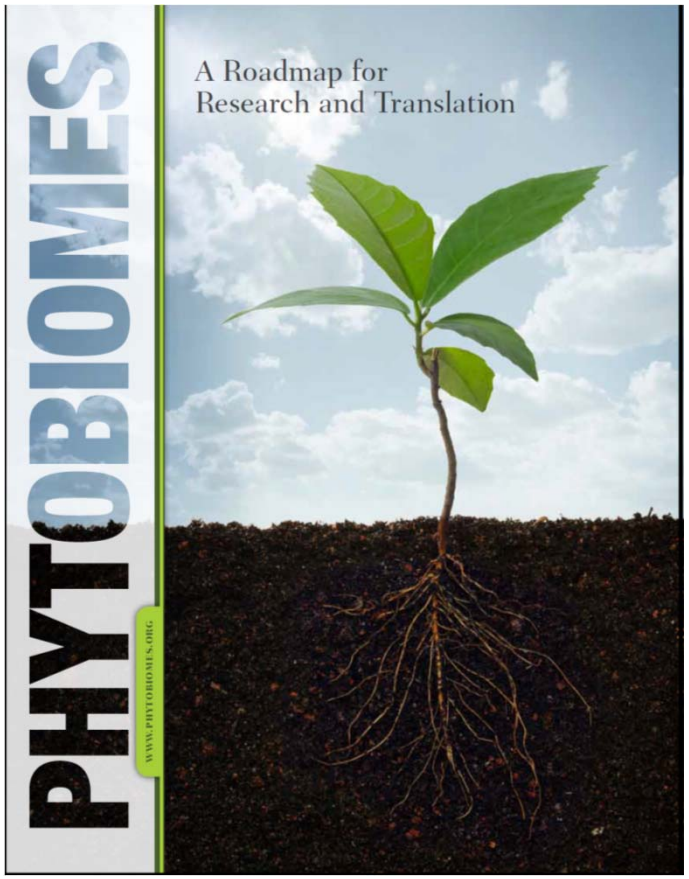
- ‘Omics-enabling technologies
  - high-throughput sequencing
  - computational biology & modeling
- Systems-level approaches



- Advances in computational science
  - Quantum computing
  - Machine learning
  - Analytics
  - Predictive analytics

- Precision Agriculture
  - Variable rate seeding & input
  - UAVs
  - Soil & weather sensors

How Do We Get There: Phytobiomes Roadmap for Research and Translation



A new vision for agriculture:

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

www.phytobiomes.org

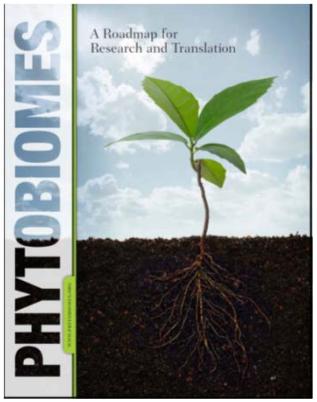
Roadmap: Interdisciplinary, systems-level approaches

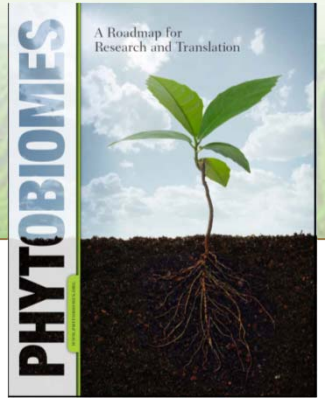
Developing a foundation of knowledge for:

- **how phytobiome components influence or are influenced by plants or the plant environment – *in context!***

- **how that information can be used to improve crop productivity, quality, nutrition, safety, and security**

- **Includes knowledge and technology gaps**





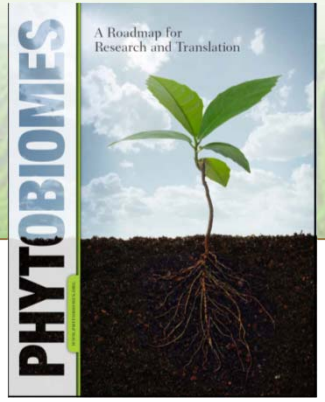
Key questions

What genetic linkages connect phytobiome components?

→ *Can we breed plants that select for beneficial communities?*

What constitutes a "healthy phytobiome"?

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



Key questions

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?

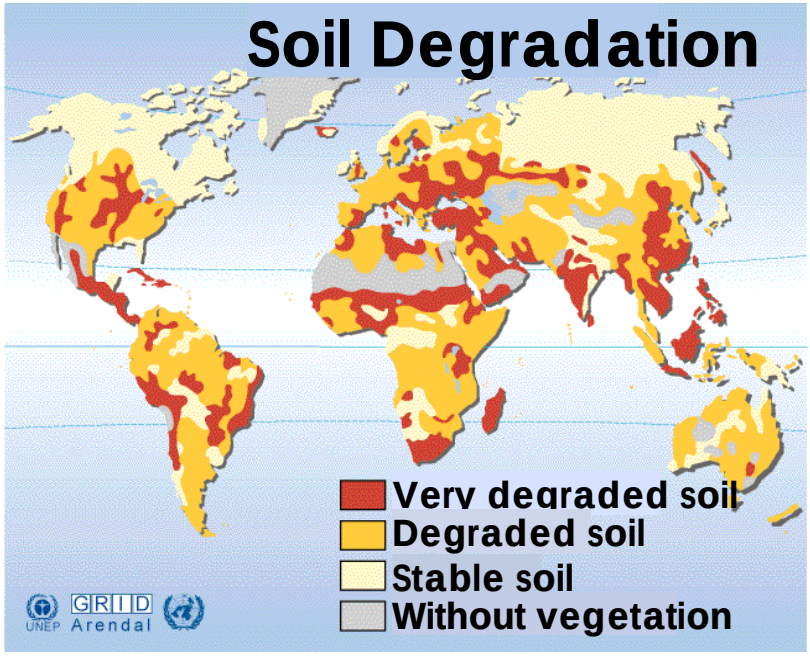
→ *Can we incorporate biological information into precision agriculture technologies?*

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

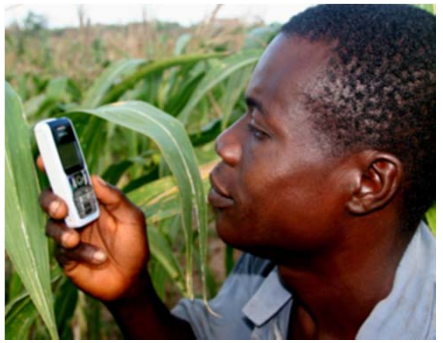
Outcomes of this new vision for agriculture

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 (precision agriculture)**

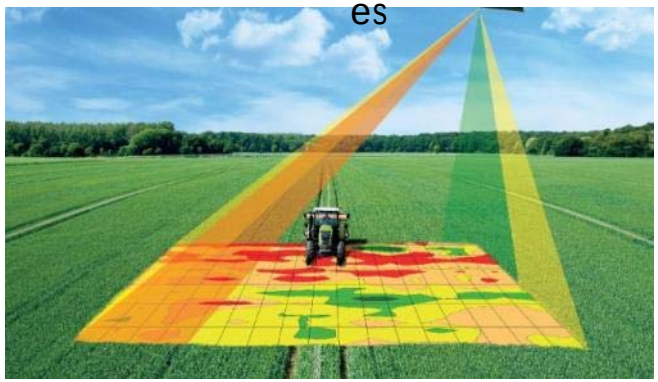
Outcomes of this new vision for agriculture

- 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

International Alliance for Phytobiomes Research, Inc.

- A nonprofit, public-private organization
- Mission -- to establish a science and technology foundation for phytobiome-based, site-specific enhancement of the sustainable production of food, feed, and fiber

www.phytobiomesalliance.org

PHYTOBIOMES ALLIANCE

Phytobiomes Alliance Sponsors

Science For A Better Life

BioConsortia

Phytobiomes Alliance: Activities

- Identify research & technology gaps and coordinate projects to address those gaps
- Establish national, international, and multi-national public-private projects and networks
- Coordinate and collaborate with existing initiatives internationally, e.g., soil health
- Establish standard protocols, reference collections, and reporting standards

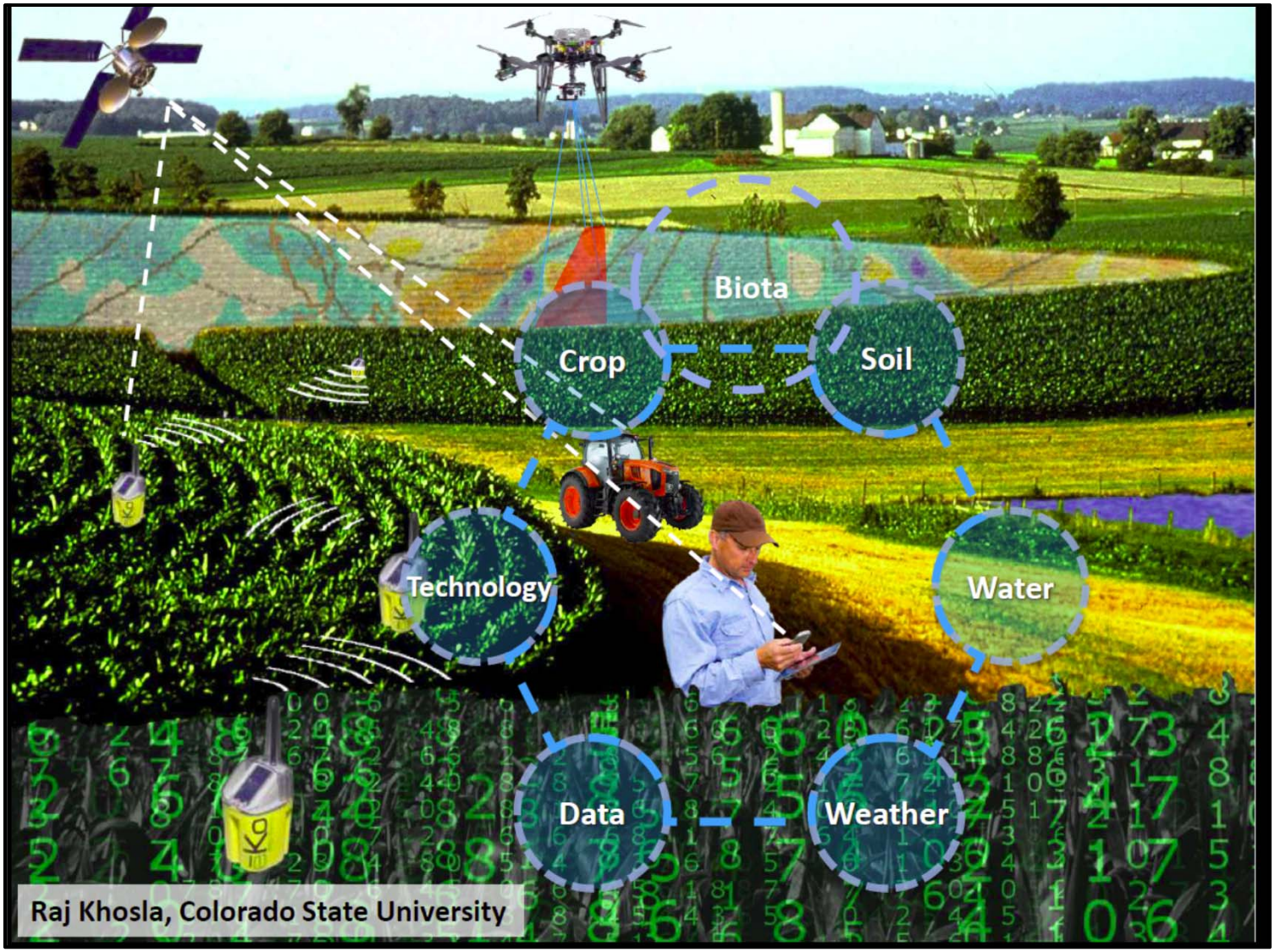
Scientific Coordinating Committee (project leaders and financial sponsors): Establish scientific strategy, coordinate projects, establish working groups, …

General Members: anyone with an interest in phytobiomes research

Standards

- Alliance-NIST (National Institute for Standards & Technology) Workshop on Standards for Phytobiomes, 12 August 2016
  - sample collection (how to avoid under- and over-sampling in the field)
  - sample storage
  - development of reference communities
  - minimizing plant macromolecule interference in microbiome/mycobiome/virome characterization
  - reference datasets for analytical tool development

Result: Phytobiome Enabled-Next Generation Precision Agriculture



Join Us!

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