From Simple to Complex – Phytobiomes and the 2050 Vision for Agriculture

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Plant and Animal Genome XXV
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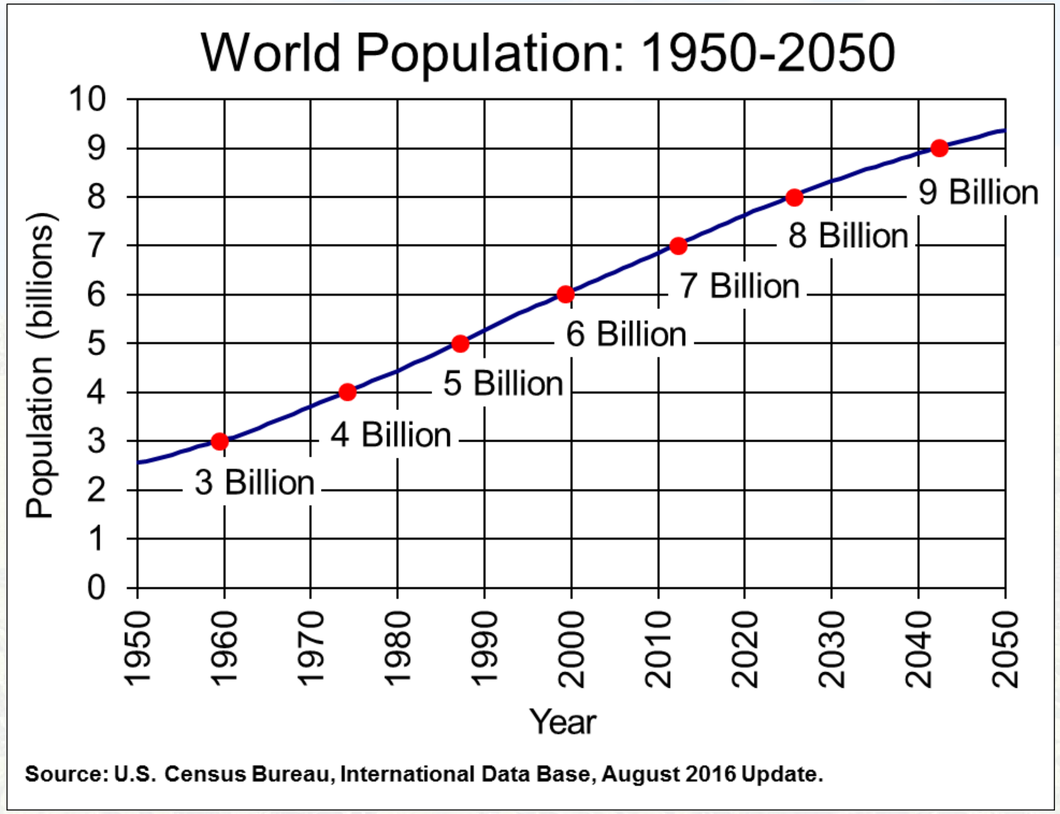
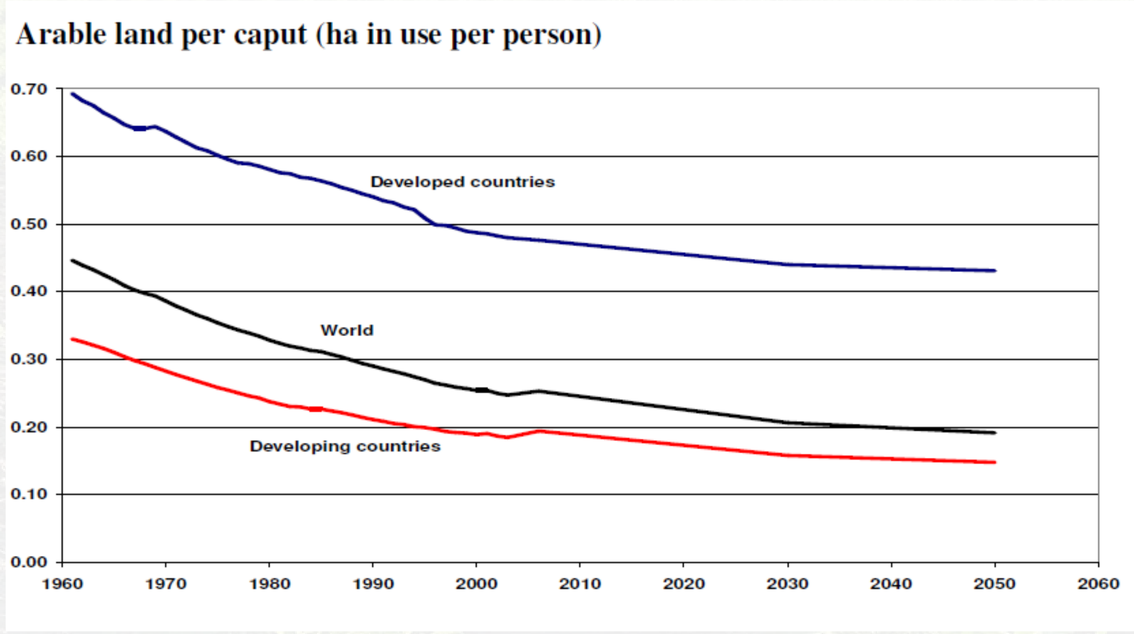
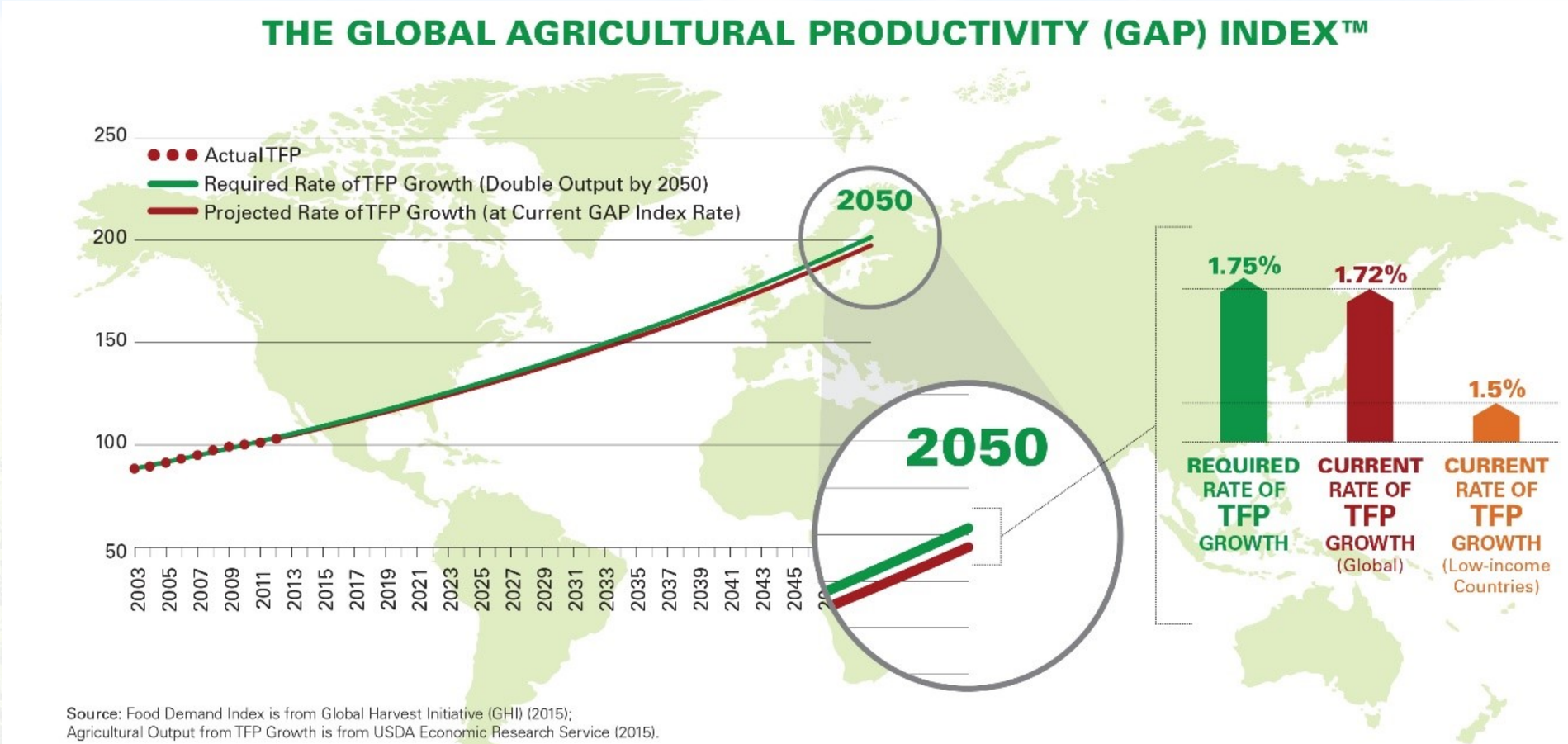
Global challenges



Source: U.S. Census Bureau, International Data Base, August 2016 Update.



Declining Productivity



Source: Food Demand Index is from Global Harvest Initiative (GHI) (2015);
Agricultural Output from TFP Growth is from USDA Economic Research Service (2015).

Global Harvest INITIATIVE

2015 GAP Report®

Crop Improvement Is Complex

- Increase yield
- Adapt to changing climate
- Achieve durable resistance to abiotic and biotic stresses
- Maintain consistent quality & yield
- Ensure sustainability
- Meet contextual situation

Simplicity to Complexity

Traditional Agricultural Sciences

- Isaac Newton - nature is exceedingly simple
- Reductionism
- World is linear – understanding parts individually
- Rely on partial knowledge – genetics, soils, microbiomes, animals, environment
- Linear, deterministic assumption that genes are causes and organismic fitness is effect

Real World Situation

- Complex system, non-linear organization
- Governed by multiple nonlinear interactions and multiple environmental variables

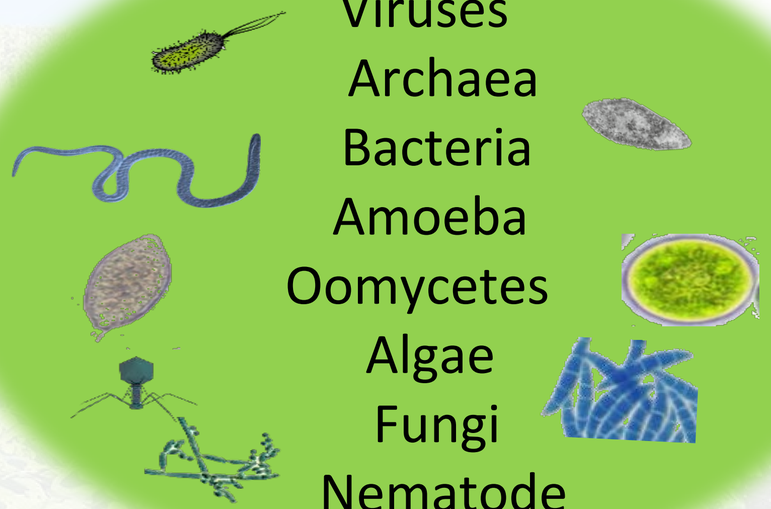
We need a global approach to elucidate, quantify, model, and potentially reverse engineer biological processes & mechanisms for their geophysical context

Decipher Phytobiomes

Phytobiomes

Climate

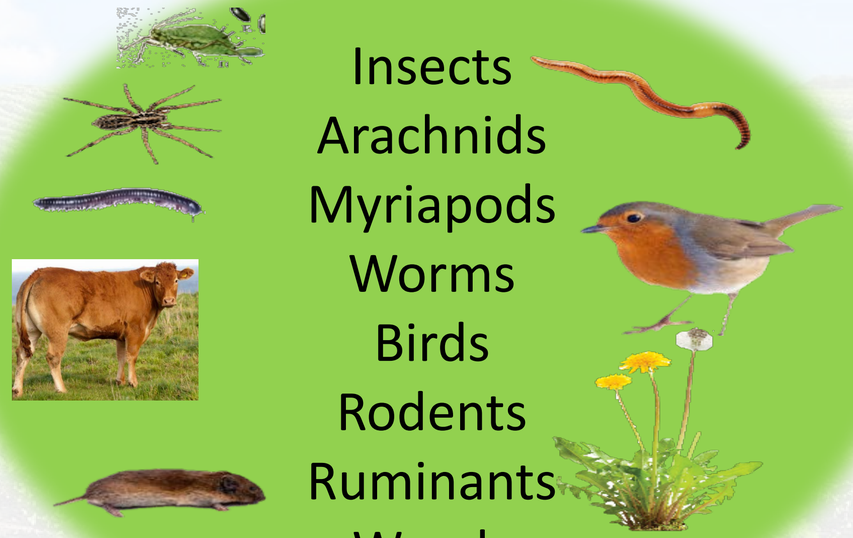
Micro- and Macroorganisms



Viruses
Archaea
Bacteria
Amoeba
Oomycetes
Algae
Fungi
Nematode

Plants

Arthropods, Other Animals and Plants



Insects
Arachnids
Myriapods
Worms
Birds
Rodents
Ruminants
Weeds

Site specific environment

Associated organisms

“Phytobiome”?

- “Phyto-” related to plants, crop plants
- “Biome” distinct geographical area, e.g., site specific, farm
- Phytobiome ≠ “plant microbiome”
- Phytobiomes ≠ “plant systems”

Holy Grail of Phytobiomics

To understand, predict, and control emergent phenotypes for sustainable production of food, feed, and fiber on a given farm.

How?

PHYTOBIOMES ALLIANCE

The International Alliance for Phytobiomes Research

Who We Are

An international, nonprofit Alliance of industry and academic partners

PHYTOBIOMES ALLIANCE

BAYER
Science For A Better Life

MONSANTO

THE CLIMATE CORPORATION

Eversole Associates
Enabling Science & Technology

indigo

THE SAMUEL ROBERTS NOBLE FOUNDATION

NewLeaf SYMBIOTICS

APS
Healthy Plants • Healthy World

BioConsortia

Vision

All farmers have the ability to use predictive and prescriptive analytics to choose the best combination of crop/variety, management practices, and inputs for a specific field in a given year taking into consideration all **physical** (climate, soil…) and **biological** conditions (microbes, pests, disease, weeds, animals….).

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Strategy

- Explore individual components and their interactions
- Integrate phytobiomes systems-based knowledge, resources and tools
- Optimize phytobiomes-based site-appropriate solutions
- Apply phytobiomes-based solutions in next-generation precision agriculture
- Sustain enhanced food, feed, and fiber production worldwide
- Educate and engage scientists and society

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Implementation

- Identify research gaps and coordinate projects to address such gaps, e.g., model development
- Translate big data into knowledge
- Establish national, international, and multi-national public-private projects and networks
- Foster the emergence of multidisciplinary teams

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Understanding and Predicting

- Develop, validate, and optimize accurate models that include all physical & biological components and their interactions
- Enable simple, simulation models that are functionally accurate to real world complex conditions – e.g., greenhouse studies that reflect field conditions
- Design systems level predictive and prescriptive analytics for on-farm implementation
- Create databases of near real-time environmental and biological data

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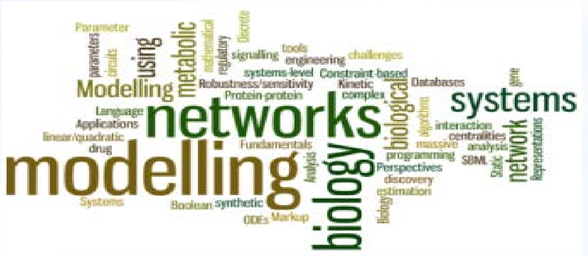
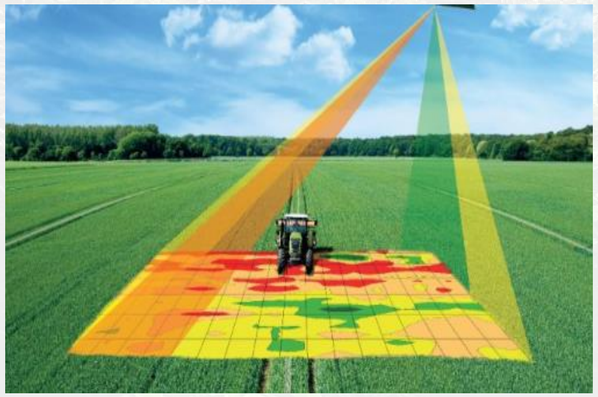
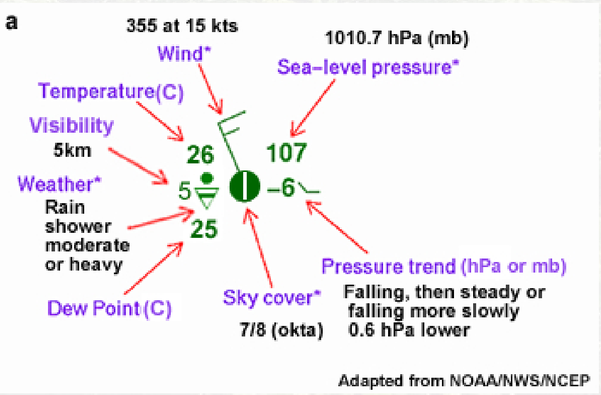
Why Now?

- Omics-enabling technologies
  - high-throughput sequencing
  - computational biology & modeling
- Systems-level methods
- Advances in computational science
  - Quantum computing
  - Machine learning
  - Analytics
  - Predictive analytics
- Precision Agriculture
  - Variable rate seeding & input
  - UAVs
  - Soil & weather sensors





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



Initial Draft Priorities

- Pre-competitive whole genome sequence database for microbes and a curated pathogen sequence database that includes geospatial data
- Website clearing house for microbiome data that captures best practices, protocols, and kits from human microbiome
- Phytobiome Research network proposals (RCN, COST, linkage grants, etc.)
- Standards development – sampling, storage, reference communities, reference datasets for analytical tool development
- Linkages with data groups – weather, soil
- Regulatory science

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Working Groups

- Ag Data – physical & biological
- Standards
- Regulatory
- Climate/Weather

How to become involved

- Scientific Coordinating Committee
  - ✓ Alliance sponsors
  - ✓ Project leaders
- Alliance working groups
  - ✓ Overall topical leader
  - ✓ Involved in projects aimed at filling gaps in knowledge, resources, or tools

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Acknowledgements

Board of Directors:

- Gwyn Beattie, Iowa State University
- Kellye Eversole, Eversole Associates
- Magalie Guilhabert, Bayer CropScience
- Jan Leach, Colorado State University

Chief Operating Officer – Lori Leach

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Alliance Sponsors

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For More Information:

www.phytobiomesalliance.org

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