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

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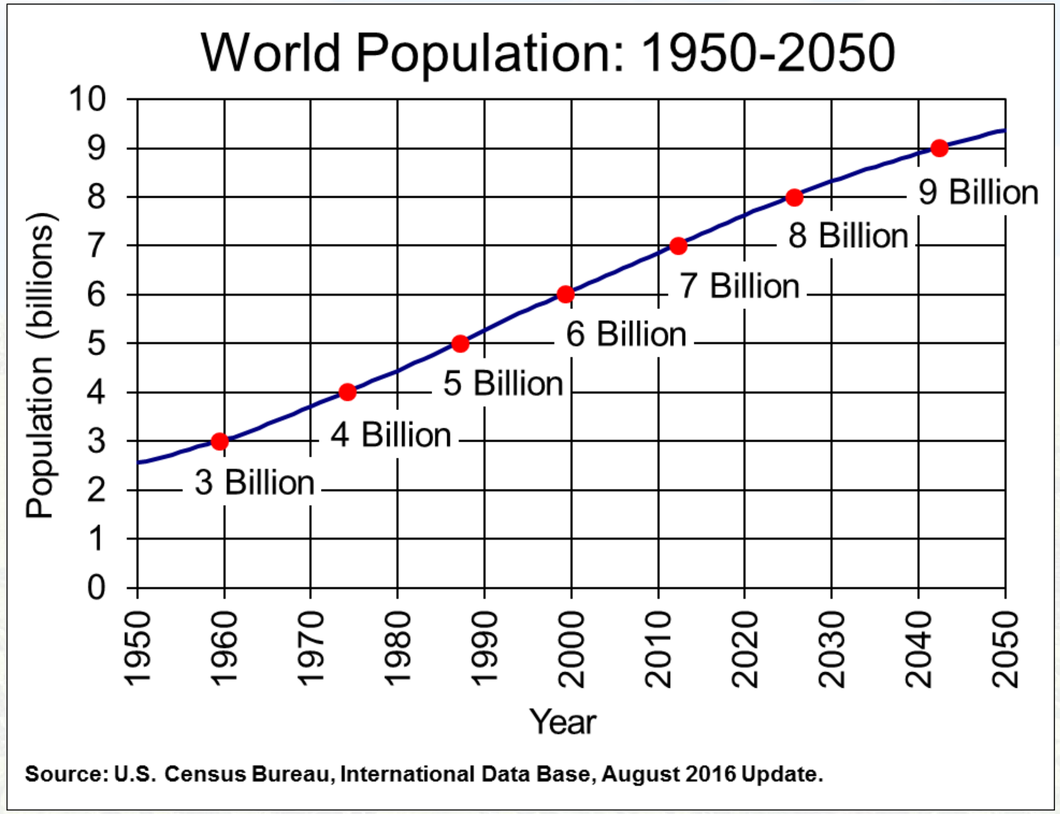
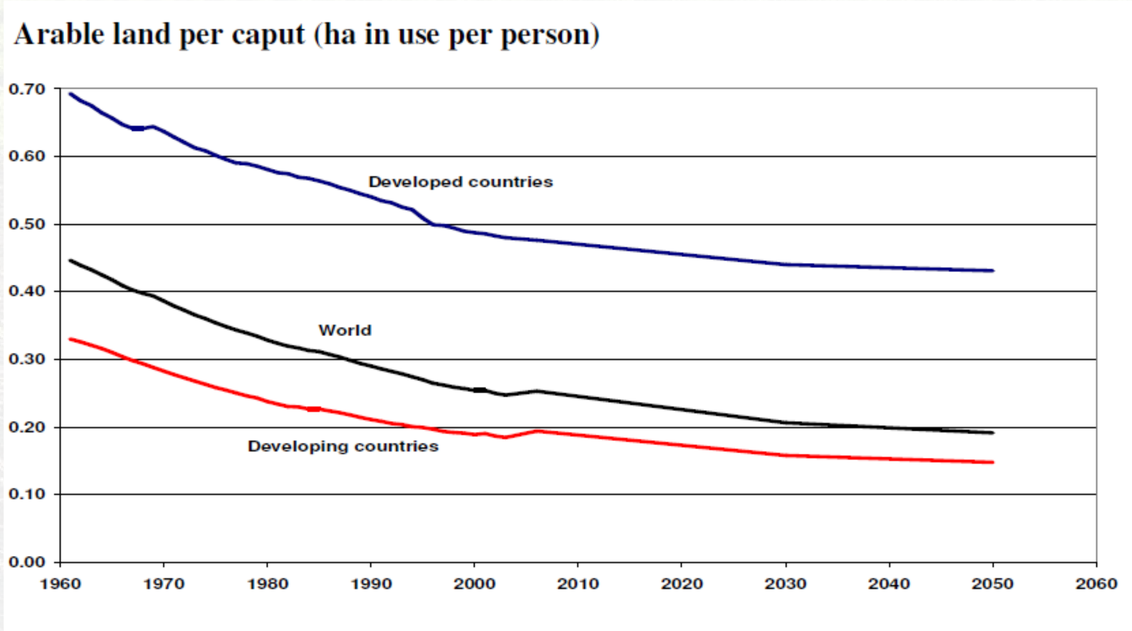
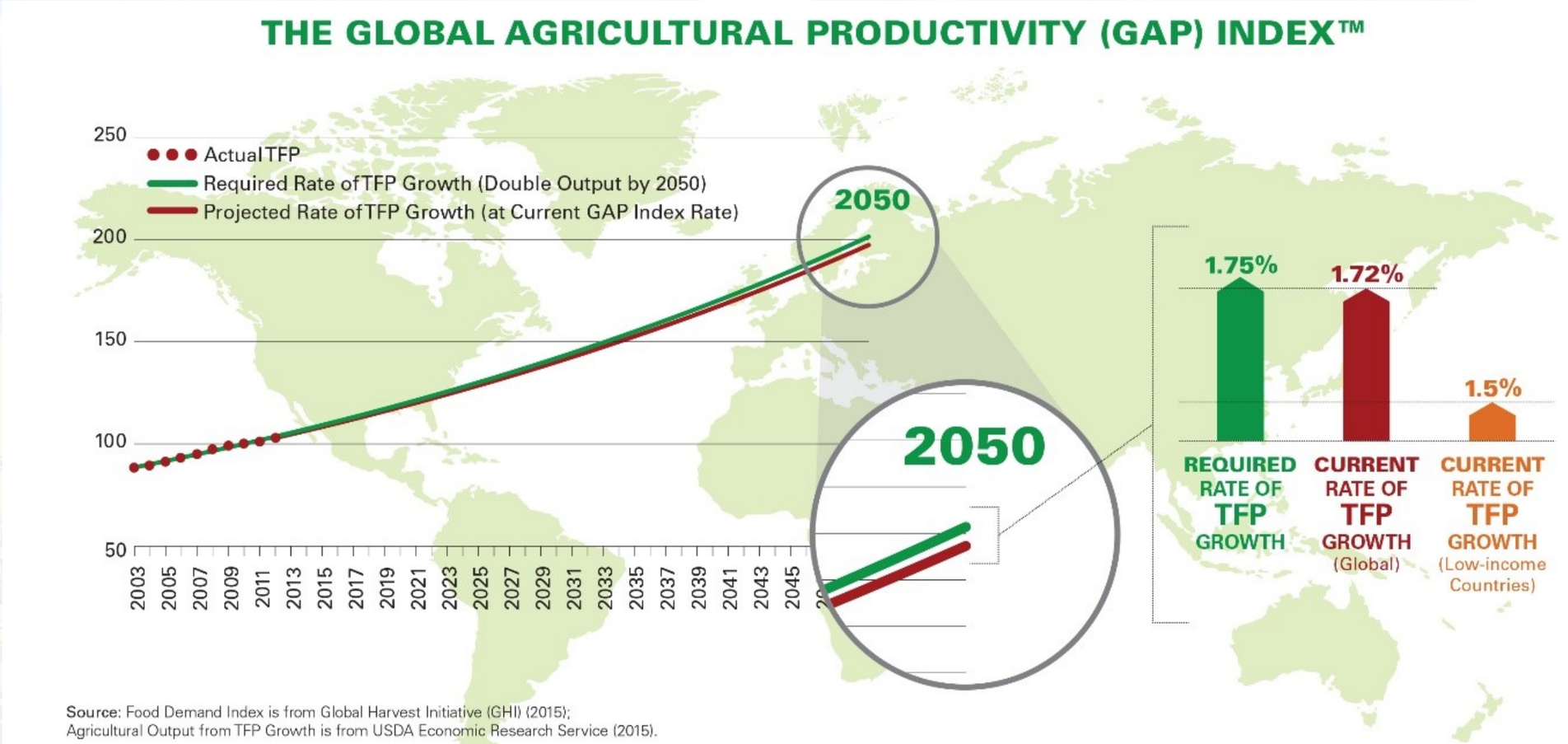
Global challenges



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

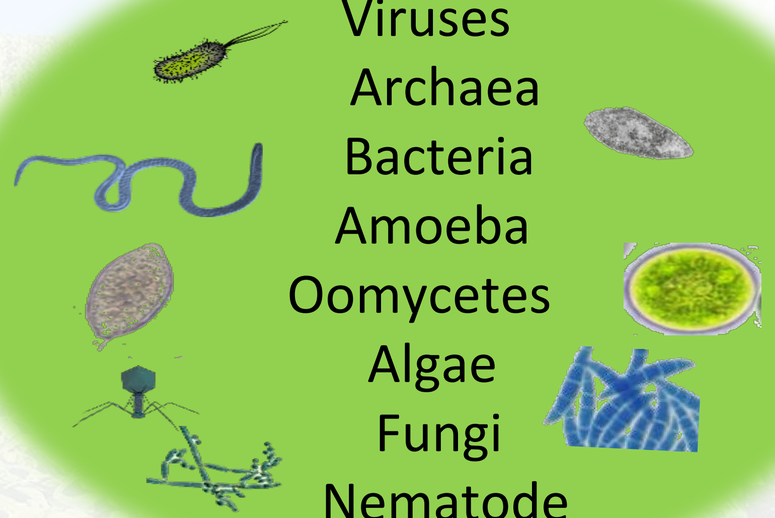
Decipher Phytobiomes

Phytobiomes

Climate

Crop plants, their environment, and their associated micro- and macro-organisms.

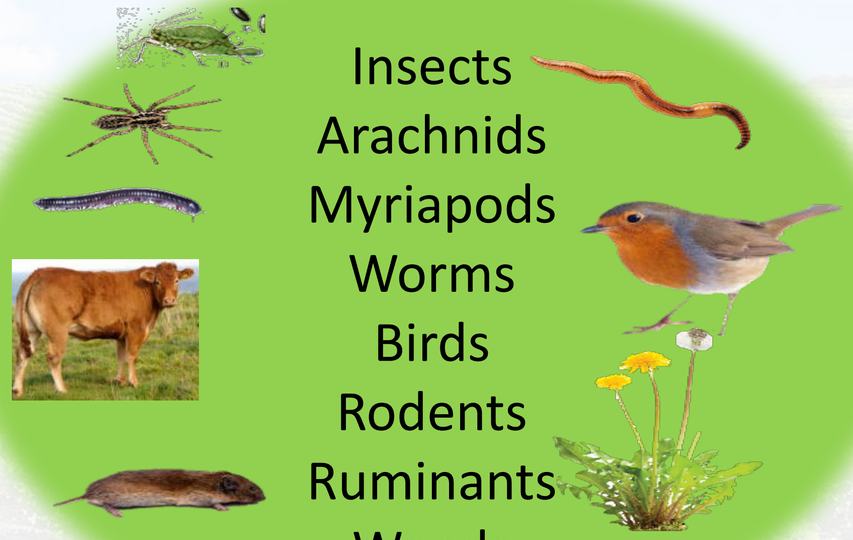
Micro- and Macroorganisms



Viruses
Archaea
Bacteria
Amoeba
Oomycetes
Algae
Fungi
Nematode

Plants

Arthropods, Other Animals and Plants



Insects
Arachnids
Myriapods
Worms
Birds
Rodents
Ruminants
Weeds

“Biome” - 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, academic, and governmental partners

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BAYER

Science For A Better Life

MONSANTO

THE CLIMATE CORPORATION

Eversole Associates
Enabling Science & Technology

indigo

INRA
SCIENCE & IMPACT

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….).

Strategy and implementation

- Industry leadership in identifying research, resource, and technology gaps (e.g., model development)
- Focus on pre-competitive science
- Facilitate linkages within and between industry and academia
- Coordinate projects to address gaps
- Empower industry growth and profitability in the phytobiomes space – connecting site specific biological and physical information for agriculture

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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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Alliance Priorities

- A whole genome sequence database for microbes that includes geospatial data
- Accessible, curated strain repository for all agriculturally relevant microbes with back-up at ARS genetic resources preservation labs
- Multidisciplinary phytobiomes research coordination networks
- Standards development – sampling, storage, reference communities, reference datasets for analytical tool development
- Research linking site-specific and temporal physical & biological data for crops, forests, and grasslands
- Science to support the regulations that may exist for agricultural biologicals, including biopesticides and permitting

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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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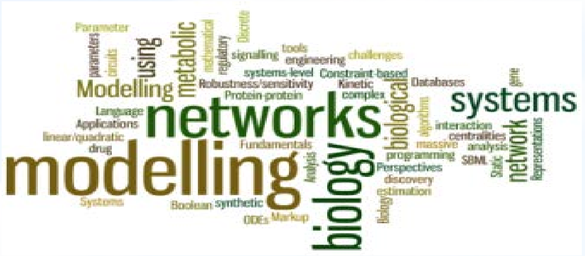
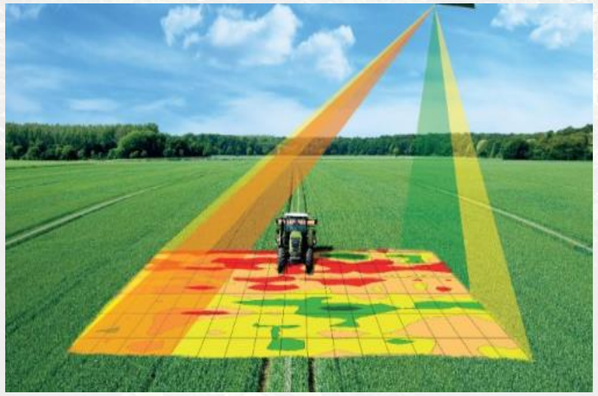
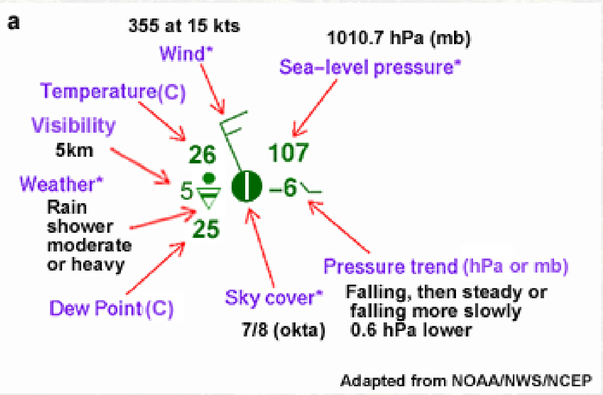
Why Now?

- 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
  - UASs
  - Soil & weather sensors

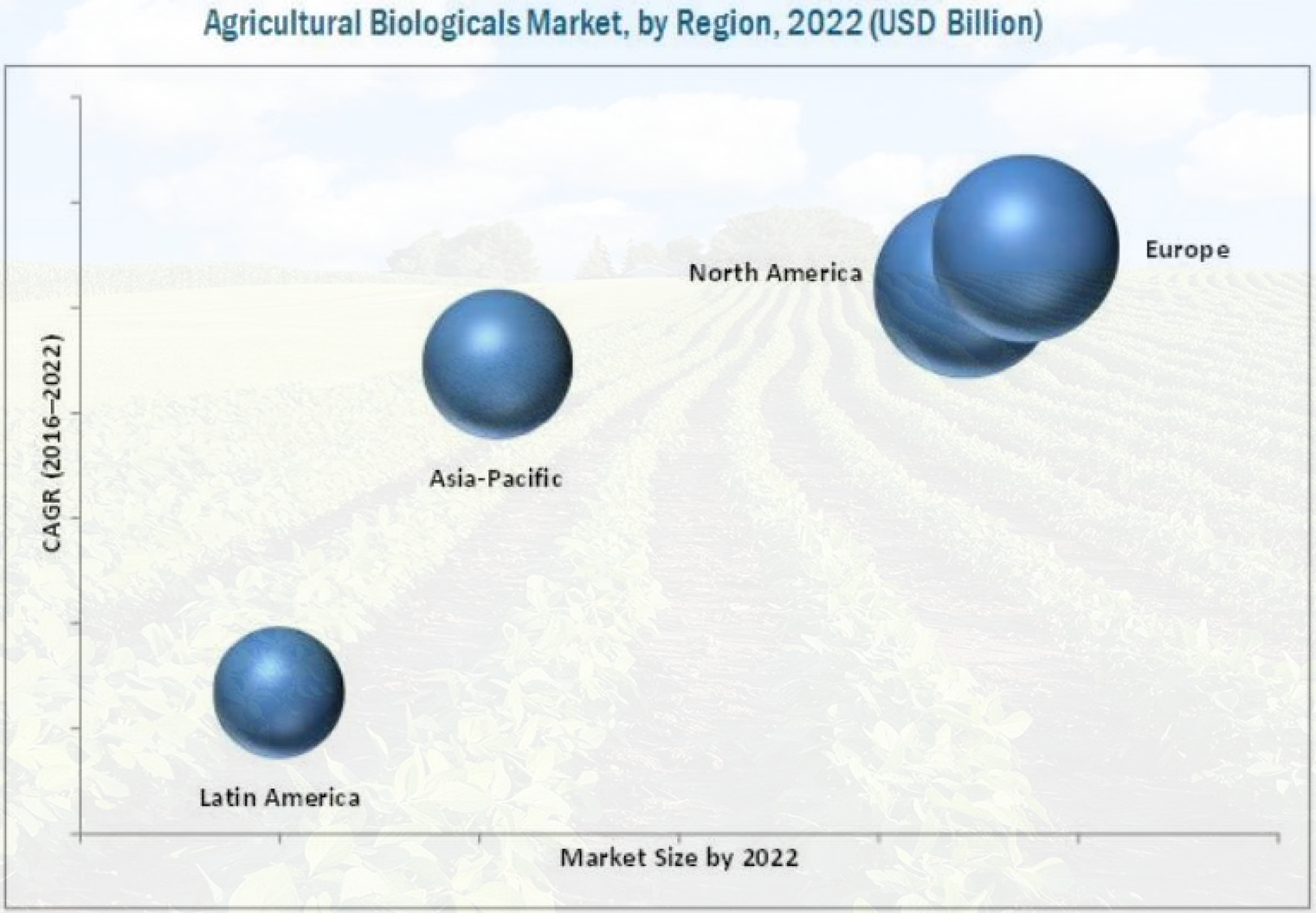




www.linkedin.com/pulse/foreign-affairs-precision-agriculture-revolution-ulrich-adam



Agricultural Biologicals



2016-2022
CAGR =
12.76%

Market equals
$11.35 Billion
in 2022

Source: Markets and Markets, 2017

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Growing Agricultural Investments

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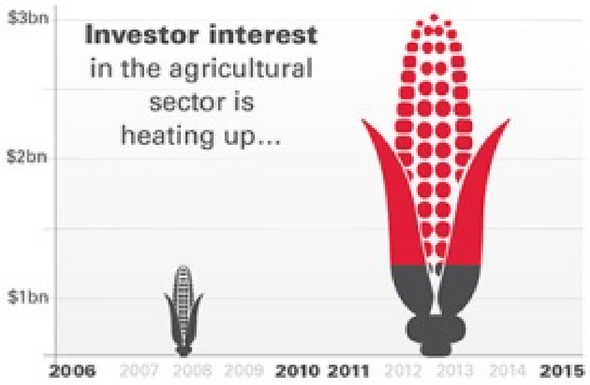
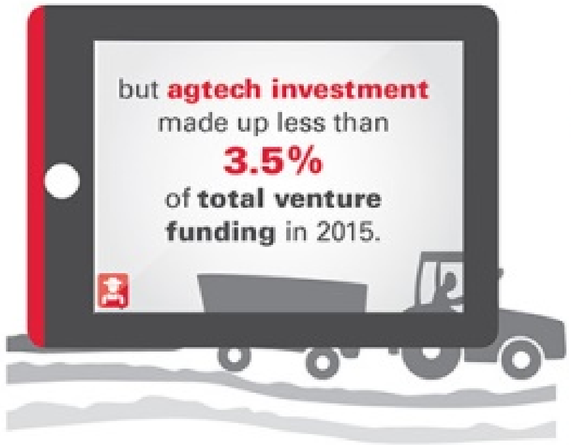
The Growing Pace of Global Investment in Agriculture



In **2006-2010**, new funds raised an average of **$1.24 billion** a year to invest in agriculture.
The same figure more than doubled for **2011-2015** to **$3.08 billion** a year.

And there's still room for investment to grow. **Agriculture** makes up nearly **7%** of **global GDP**,



Major agtech subsectors that received **funding** in 2015 include:

- **Irrigation & Water** ($673 million),
- **Drones & Robotics** ($383 million),
- **Soil & Crop Technology** ($168 million),
- **Sustainable Protein** ($160 million),
- and **Indoor Agriculture** ($77 million).

Sources: AgFunder, Preqin, CIA World Factbook, Gro

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Now is the time to

Join Us!

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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

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Phytobiomes Alliance

For More Information:

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