United States Department of Agriculture

National Institute of Food and Agriculture

USDA NIFA

NATIONAL INSTITUTE OF FOOD AND AGRICULTURE

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Crowdsourcing to Address Wicked Problems

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Global Challenges

- Population
- Food
- Water
- Environment
- Climate Change
- Energy
- Health
- Poverty

- **Convergence**: Merging of technologies, processing disciplines, or devices into a unified whole that creates a host of new pathways and opportunities. It involves the coming together of different fields of study—particularly engineering, physical sciences, and life sciences—through collaboration among research groups and the integration of approaches that were originally viewed as distinct and potentially contradictory."

Sharp et al. 2011. The Third Revolution: Convergence of the Life Sciences, Physical Sciences, and Engineering. MIT

- **Transdisciplinary:** Engaging with different ways of knowing the world, generating new knowledge, and helping stakeholders understand and incorporate the results or lessons learned by the research.

Wickson et al. 2006. Transdisciplinary research: characteristics, quandaries and quality', Futures, vol. 38, no. 9, pp. 1046–1059.

Convergence: The Third Revolution in Action?

Crop Science Markets & Trade Economics Seed Technology

Soil Chemistry Plant Pathology Information Technology Hydrology

Weed Science Microbiology Soil Science Agric Engineering

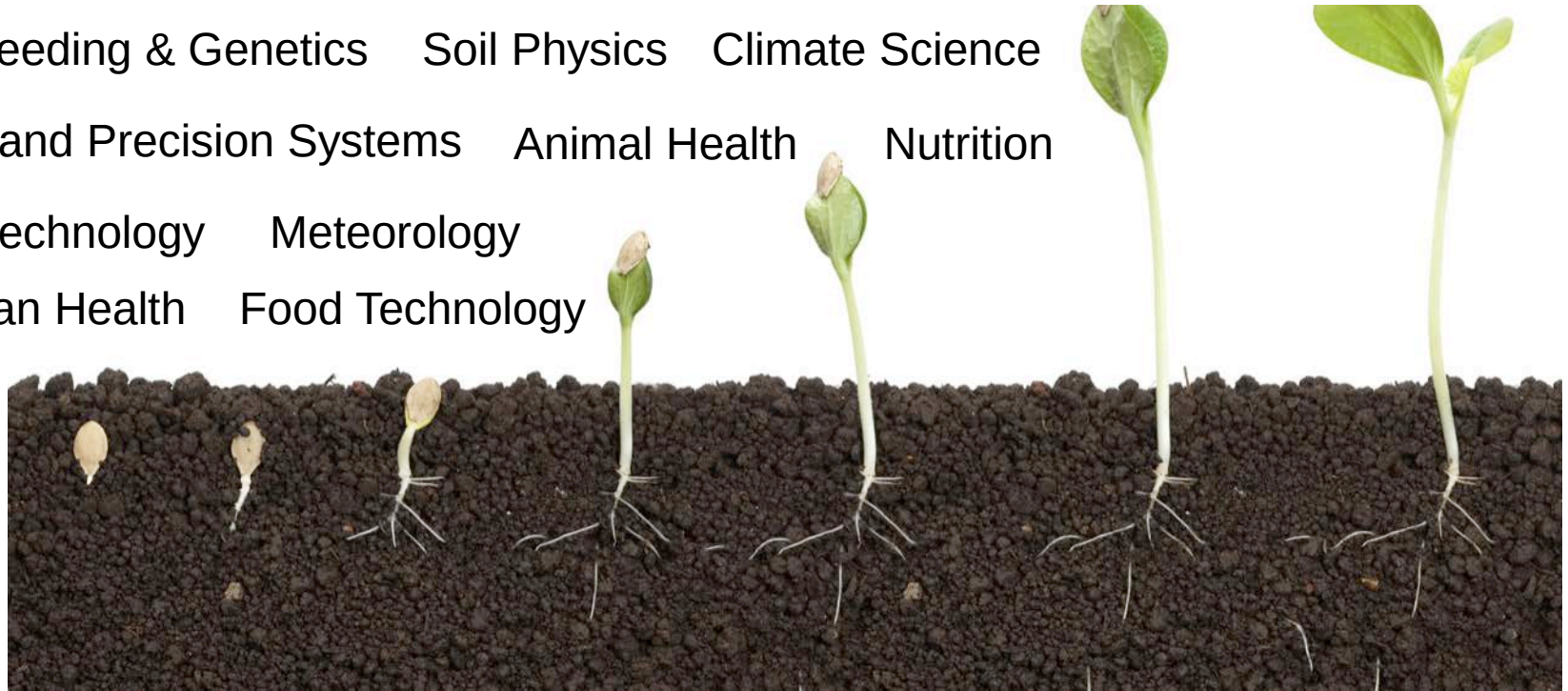
Entomology Water Engineering Agric Systems

Breeding & Genetics Soil Physics Climate Science

GPS and Precision Systems Animal Health Nutrition

Biotechnology Meteorology

Human Health Food Technology



Convergence of Nano-Bio-Info-Cognitive Technologies

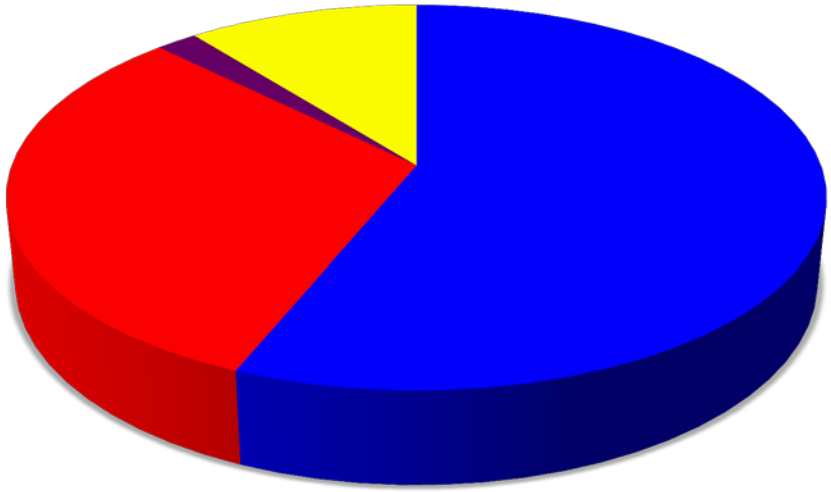
- The synergistic advances in NBIC knowledge and tools have stimulated new solutions to the challenges in agriculture, food and nutrition, value added products, and the environment.
  - Biotechnology has transformed agricultural production.
  - Nanotechnology has allowed new tools such as rapid gene sequencing.
  - Satellite imaging provides meg-data and trends of crops, animals, land, water, weather, etc. for precision agricultural production.
  - Service robots perform sophisticated and precise tasks in the difficult environment for agriculture field workers.
- Future programs and policies to encourage the convergence-divergence evolution process to enhance creativity, invention, and innovation.

NIFA's Role

- Support transdisciplinary approaches – User Inspired
- Fund innovations in the realm of convergence
  - Disciplines of biology, chemistry, nanotechnology, robotics, engineering, computational science, social sciences, others
- Identify opportunities for convergence
  - Science to address societal challenges
  - Structures to facilitate transdisciplinary interactions
- Evaluate if convergence is occurring
  - Supporting culture, environment, structures, opportunities

Innovation Ecosystem

NIFA Budget

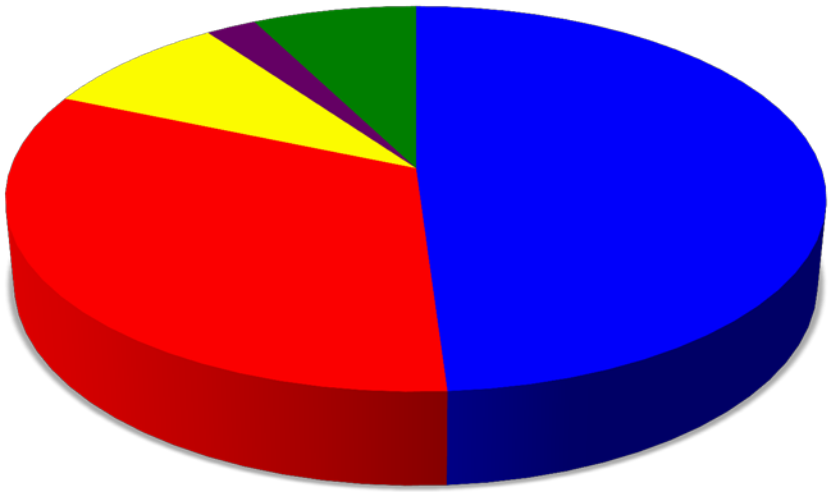


Proposed FY2015: $1.5 B

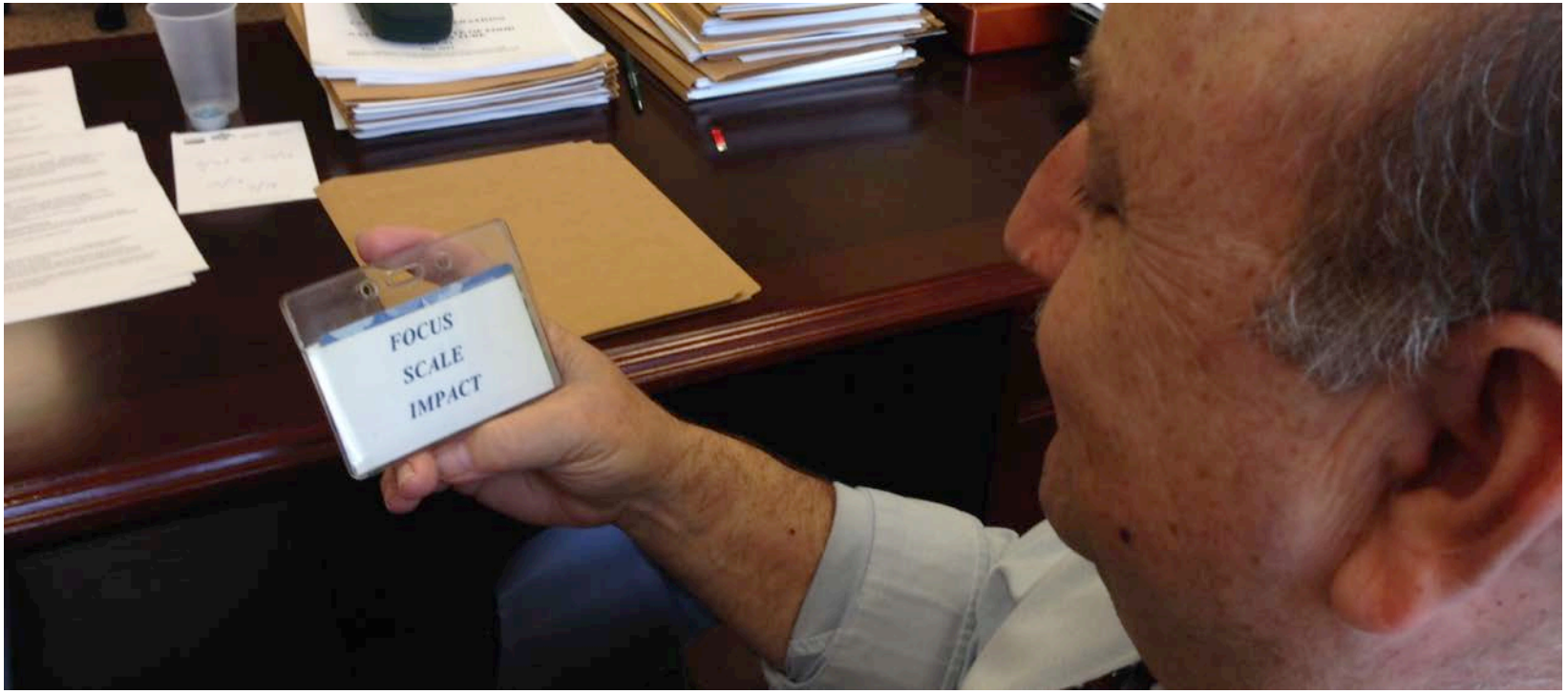
Research & Education: $842,773,000
Extension: $468,968,000
Integrated: $28,821.000
Mandatory & Endowment: $159,880,000

FY2014 AFRI: $316,000,000

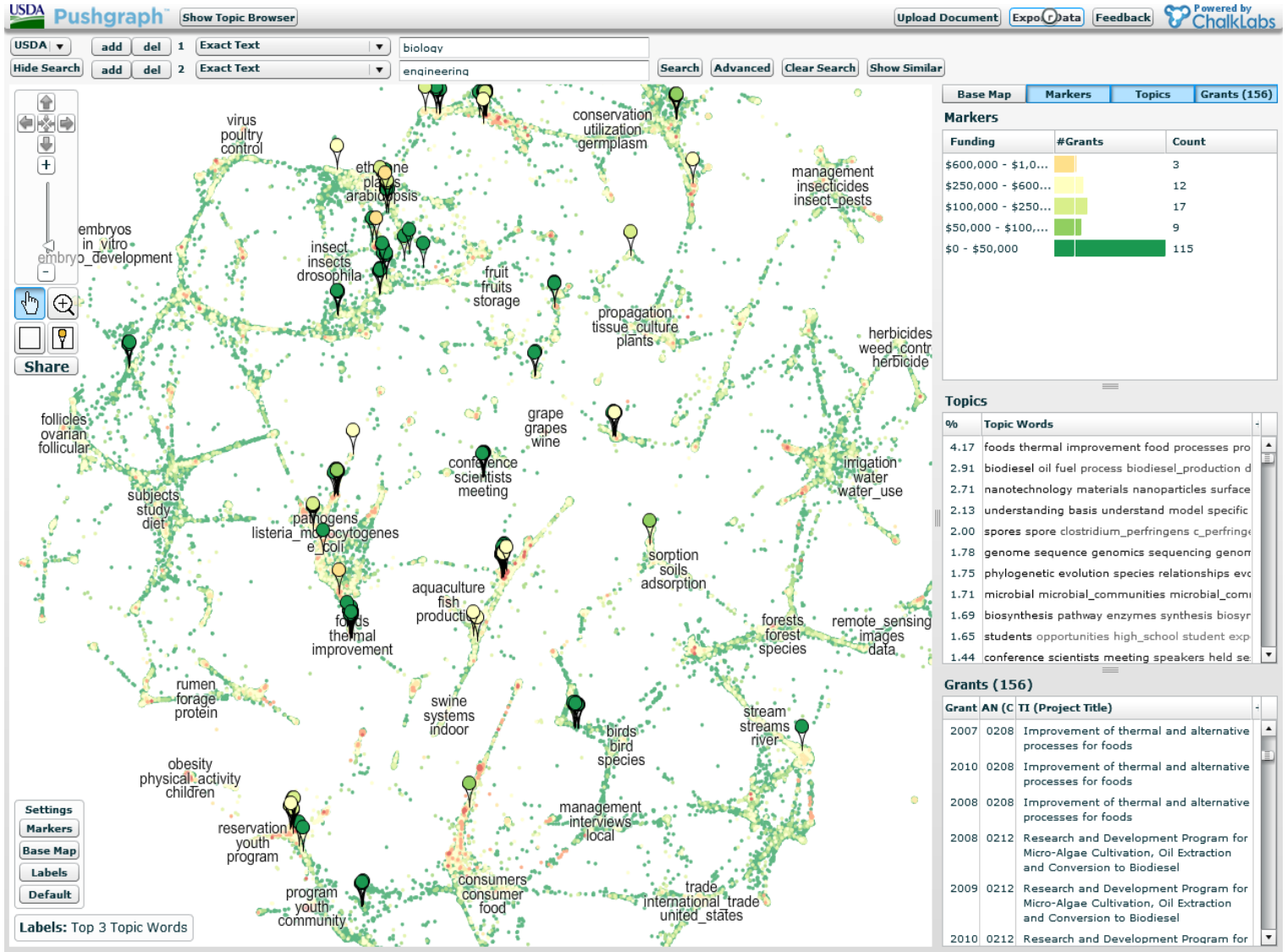
Challenge Areas: $154,437,748
Foundational Areas: $102,436,928
Interagency Collaborations: $27,500,000
Education: $7,316,923
Admin & Other: $23,732,062



Approach: Focus, Scale, Impact



Knowledge-Discovery Data Mining: Coupling Biology & Engineering



Convergence: Plant Production

- Use of Unmanned Aerial Vehicles (UAVs) to understand movement of high-risk plant pathogens in the lower atmosphere (Virginia Polytechnic)
  - Engineering coupled with population genetics techniques to test hypotheses concerning the origin, distribution, and spread of populations of fungal plant pathogen, *Gibberella zeae*, in the planetary boundary layer

Convergence: Climate Change

- Useful to Usable (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers (Purdue University)
  - To enhance usability and up-take of climate-based information and resources that will lead to more profitable agricultural systems
  - Includes social scientists, sociologists, economists, climatologists, atmospheric scientist, crop and climate modelers, and information technology specialists; team members also include evaluation, extension, and communication specialists

Convergence: Water/Watershed Conservation

- Cropland Watershed CEAP Synthesis: Transforming Knowledge for Evaluating Impacts of Conservation Practices on Water Quality, Improving Management of Ag Landscapes (NC State and 15 other institutions):
  - Over 150 years of watershed and water quality (WQ) experience, with specialties in WQ monitoring, agronomy, soil science, biological and ag engineering, rural sociology, economics, statistics, and modeling.
  - Assess and plan conservation practices at the watershed scale for better WQ outcomes; identify pollutants of concern and sources before selecting practices; prioritize practices in critical areas; select and apply practices effective for pollutants of concern; adoptable and maintained; keep track of practices for assessment, treatment needs; and establish monitoring protocols specifically for WQ changes from practices.

Convergence: Animal Health

- Nanowire switch and nanoelectrode/nanochannel based impedance biosensor for rapid screening of avian influenza virus (University of Arkansas)
  - Transdisciplinary efforts (chemistry, virology, mechanical and biological engineering) integrate nanotechnologies with microanalytical devices to develop an innovative nano-biosensor for in-field rapid screening of avian influenza virus infection in poultry
- Ecology and Evolution of Infectious Diseases (US-UK collaboration)
  - Convergence of biologic/life sciences and computational science to develop models to predict disease transmission

Convergence: Food Safety

- Engineering methods to improve safety of commercially produced food products (Michigan State University)
  - Work at the transdisciplinary interface between predictive food microbiology and food process engineering to optimize data/tools and improve integration of microbial models into engineering models for food handling, storage, processing, distribution and into risk models.

Convergence: Food Technology

- Novel microwave-assisted pasteurization system (MAPS) that can semi-continuously process pre-packaged chilled meals (Washington State University)
  - Transdisciplinary approach involving engineering, microbiology, virology, chemistry, sensory science, mathematic modeling and computer simulation, regulatory risk assessment, and social science (performance evaluation) makes the technology readily available for commercial uses in three years.
  - Collaborative team of academia, government laboratories (USDA/ARS, US Army Natick) and regulatory agencies (FDA, USDA/FSIS) and industrial partners.

Convergence: Plant Pathology

- Developing new methods of sustainable management of soybean root and stem rot
  - Work at the transdisciplinary interface incorporating field-based molecular diagnostics, plant and microbial molecular biology, genomics, bioinformatics, plant breeding, economics and market analysis to optimize durability of novel disease management methods, increase the probability of market acceptance and improve the long-term sustainability of soybean production.

Convergence: Farm(er) Safety

- AgrAbility: Assistive Technology Program for Farmers with Disabilities
  - To increases the likelihood that farmers, ranchers, and farm family members with disabilities will remain engaged in and succeed in agricultural production.
  - Convergence of human health, social work, and agricultural engineering to enhance quality of life. Teams also include family life specialists, farm safety extension educators, communications specialists and evaluation experts.

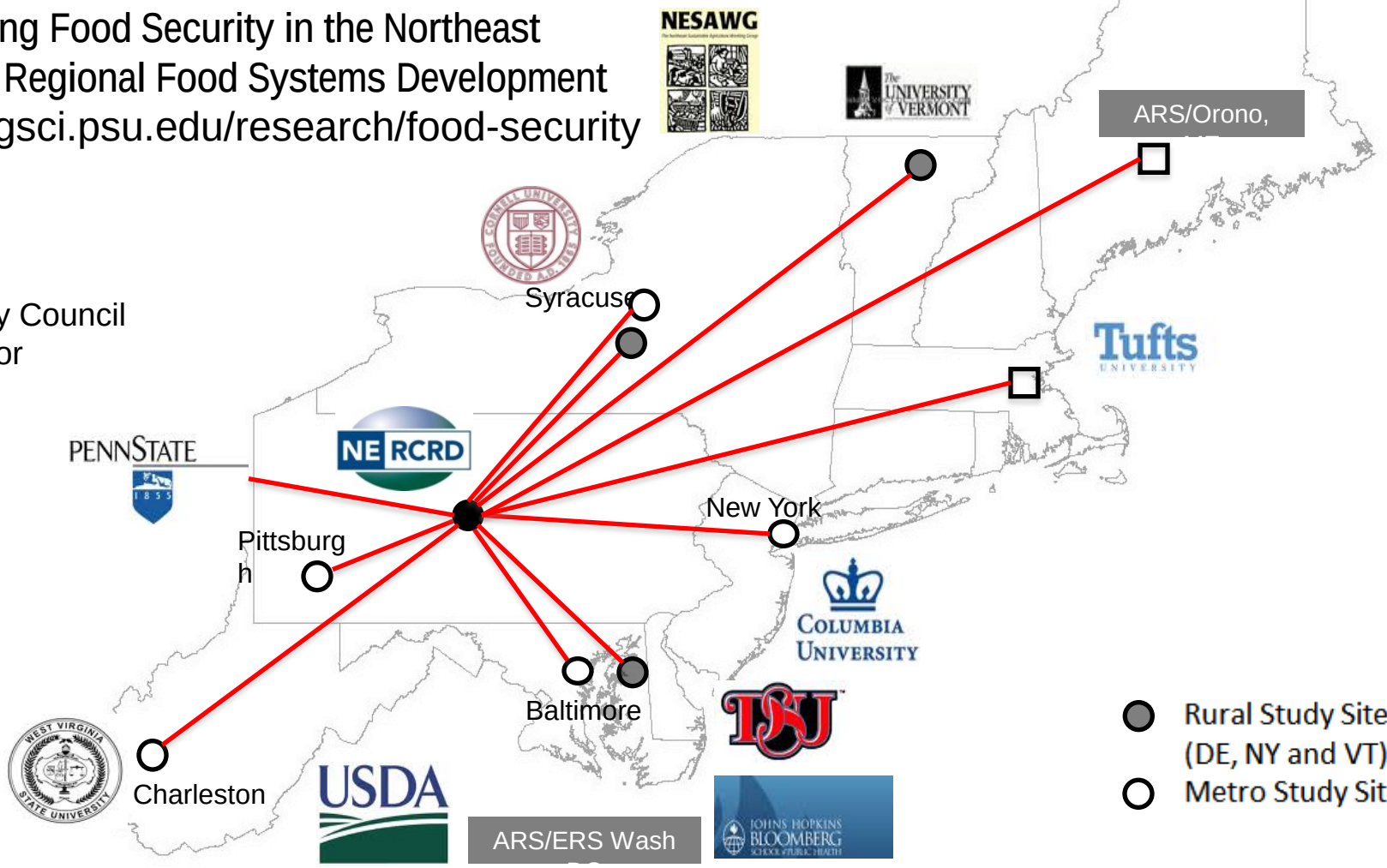
Convergence: Agricultural Systems

- Neuroeconomics of controversial food technologies (Oklahoma State University)
  - Medical imaging techniques coupled with social science: functional magnetic resonance imaging (fMRI) brain scanning while consumers engage in the perception, appraisal, evaluation, and choice of food products
- Computational Agriculture Initiative (Cornell University)
  - Collaborative effort between the Cornell Theory Center (CTC), a high-performance computing (HPC) and interdisciplinary research center, and the College of Agriculture and Life Sciences (CALS) to develop and coordinate a program on the application of high-performance computing (HPC) to agricultural problems

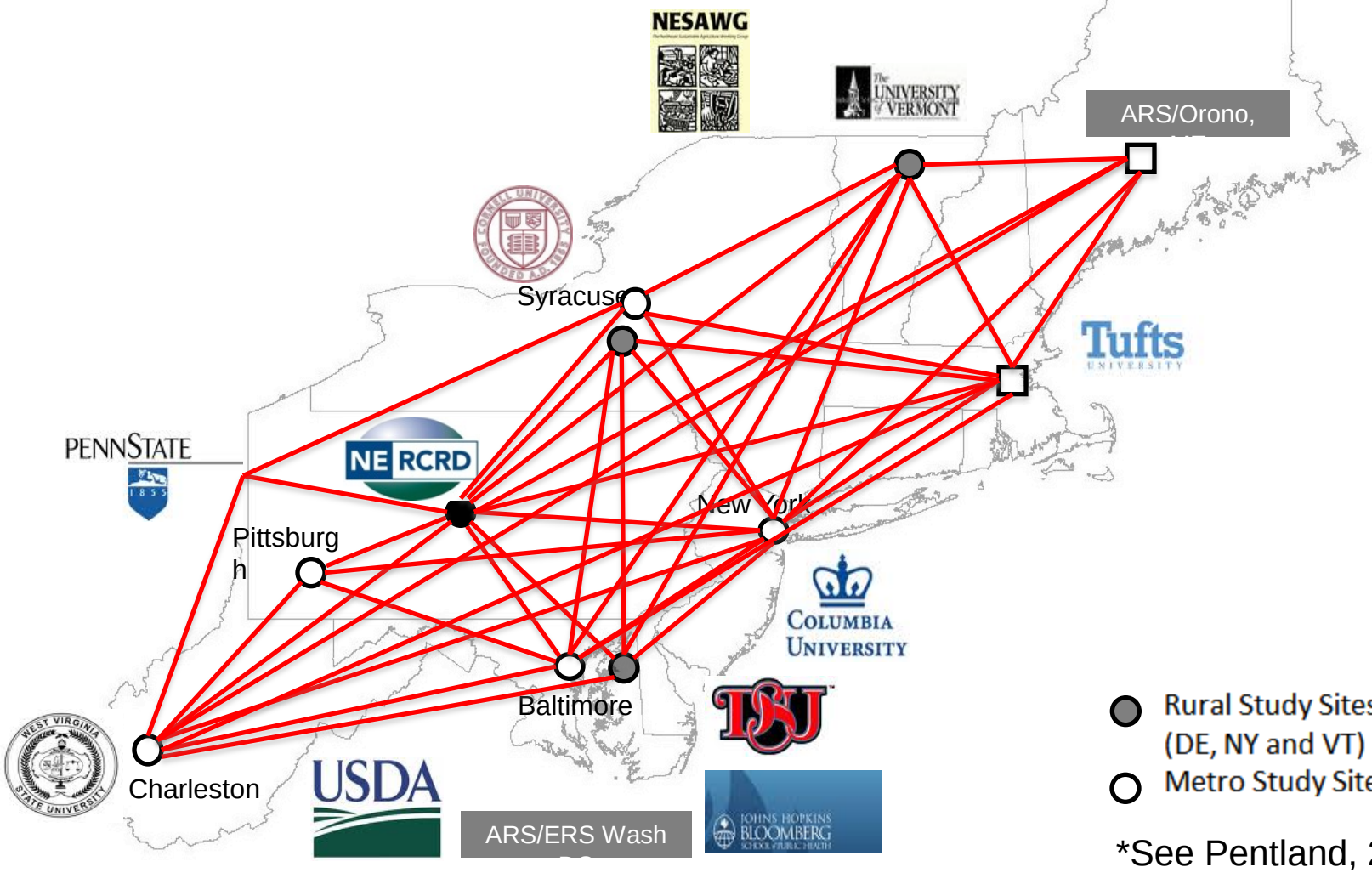
Convergence: Rural Development

Enhancing Food Security in the Northeast through Regional Food Systems Development
http://agsci.psu.edu/research/food-security

Advisory Council
Evaluator



Convergence: Connecting Hubs and Nodes

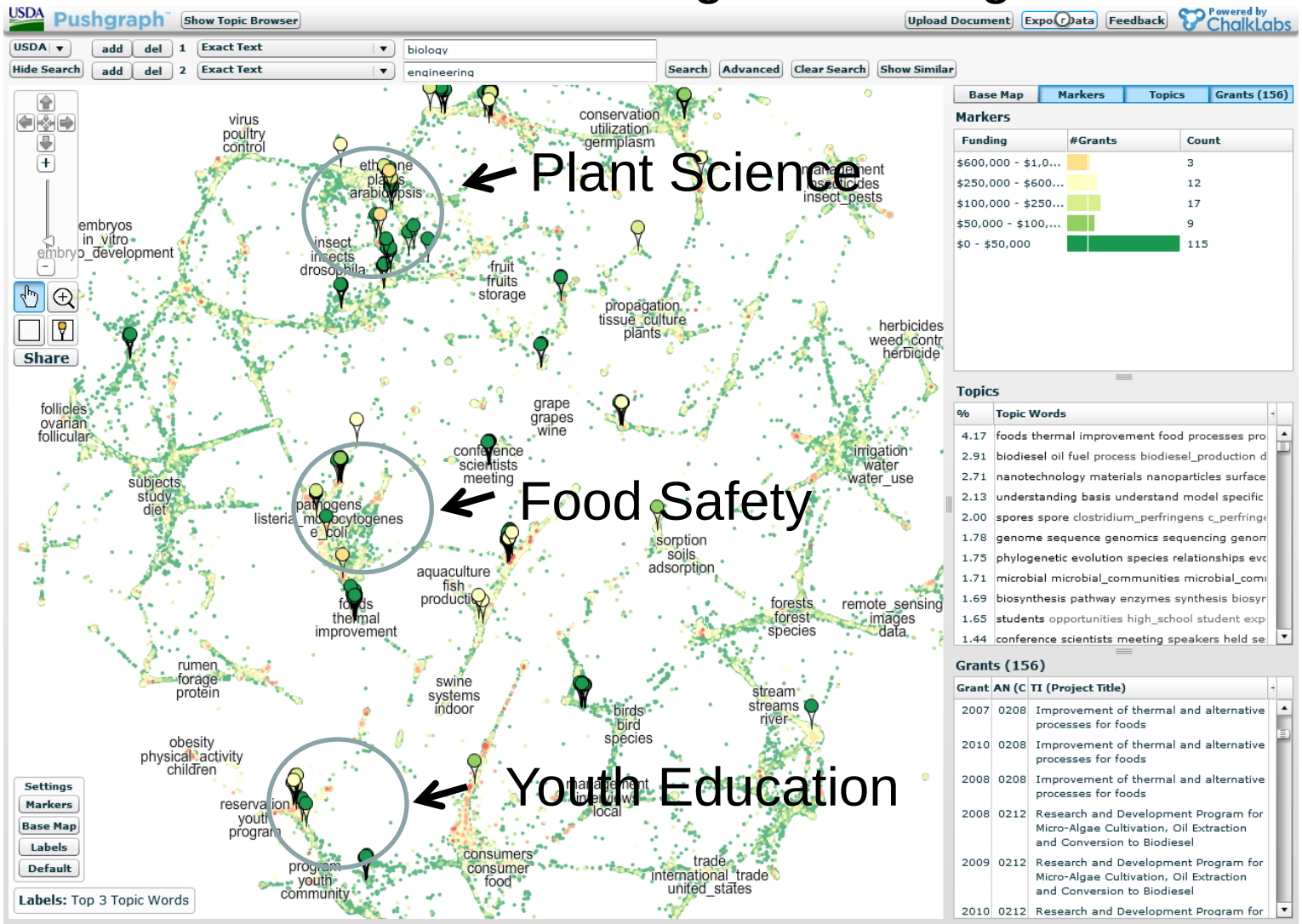


*See Pentland, 2014

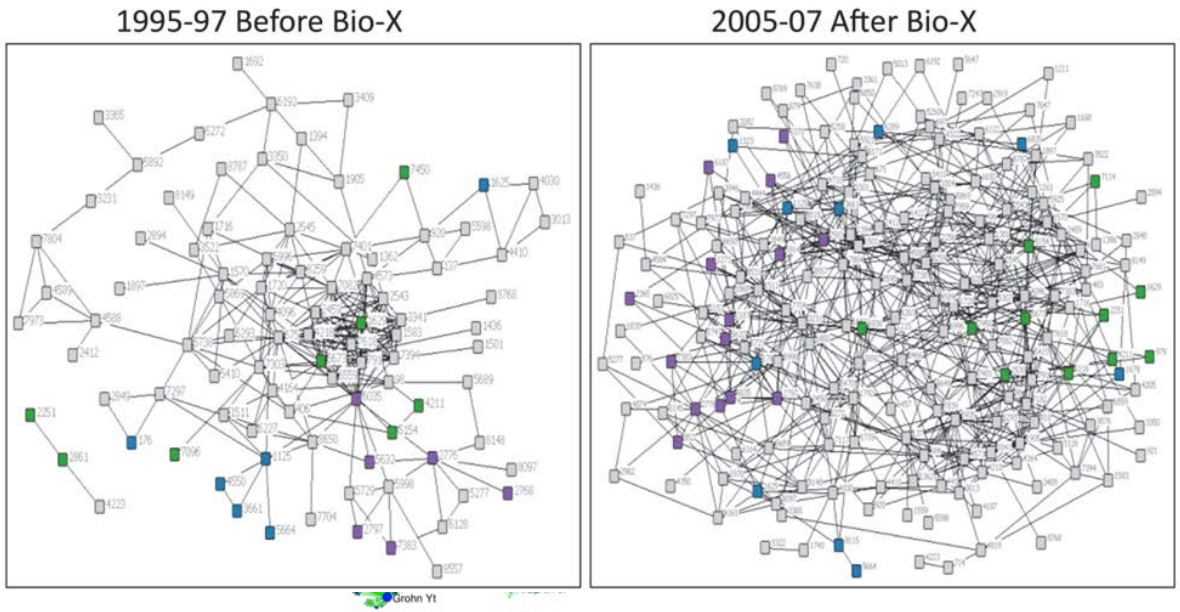
Convergence: Education

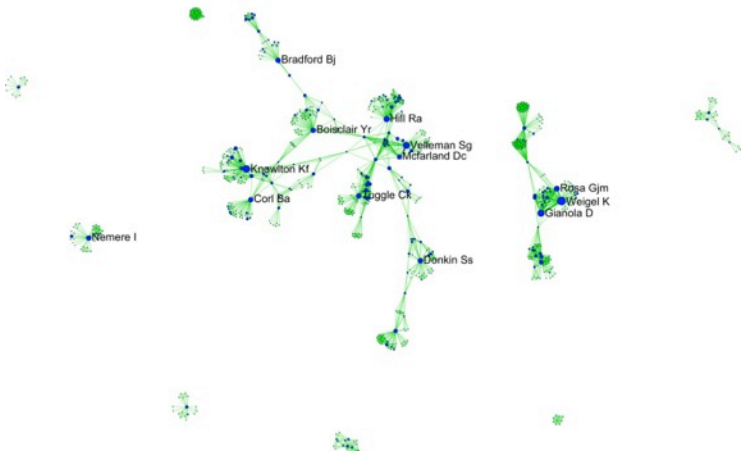
- Multidisciplinary Doctoral Education Program in Lignocellulosic Biofuels Science and Engineering (North Carolina State University)
  - Education program for a new generation of researchers who understand the entire spectrum of biofuels science and engineering: biochemistry and genetics (to understand feedstock modification), chemistry and chemical engineering (to design pretreatment processes), molecular biology (to understand enzymatic hydrolysis and fermentation), and life-cycle analysis (to understand effects on the environment).
  - To address disciplinary disconnects that are obstacles to this rapidly growing area.

Identifying Fertile Ground: Convergence of Computational Science and NIFA Program Management



How Will We Know It's Working?





- Network of faculty interactions at Stanford's Bio-X before and after the interdisciplinary convergence institute
- Network of NIFA-funded animal science researchers today and ?????

Challenges and Opportunities for NIFA

- Challenge: Maintain balance between fostering transdisciplinary research and maintaining robust disciplinary research
  - Opportunity: Include a convergence option in AFRI Foundational Research Program
  - Develop a “prize” program for convergence approaches
- Challenge: Provide opportunities to interact formally and informally
  - Opportunity: Focus annual project director meetings on convergence, encourage teams of researchers
- Challenge: Identify potential areas for convergence cultivation and evaluation
  - Opportunity: Fully develop computational science management tools to help elucidate where convergence could have greatest impacts to resolve societal challenges

Demise of Disciplinary Science?

- "*Convergence may spell the end of the existing organization of scientific fields. It, in fact, challenges the traditional disciplinary structure we are so comfortable with …and convergence will "threaten the hell" out of this structure, and its attendant funding mechanisms and departmental divisions. (Convergence) marks "the demise of disciplinary science.*"

Alan Leshner, chief executive officer of the AAAS, in: http://www.insidehighered.com/news/2011/01/05/is_convergence_the_new_big_idea_for_health_sciences#ixzz32wT6Bz3R

No!

Need deep disciplinary knowledge, along with transdisciplinary skills to enable convergence