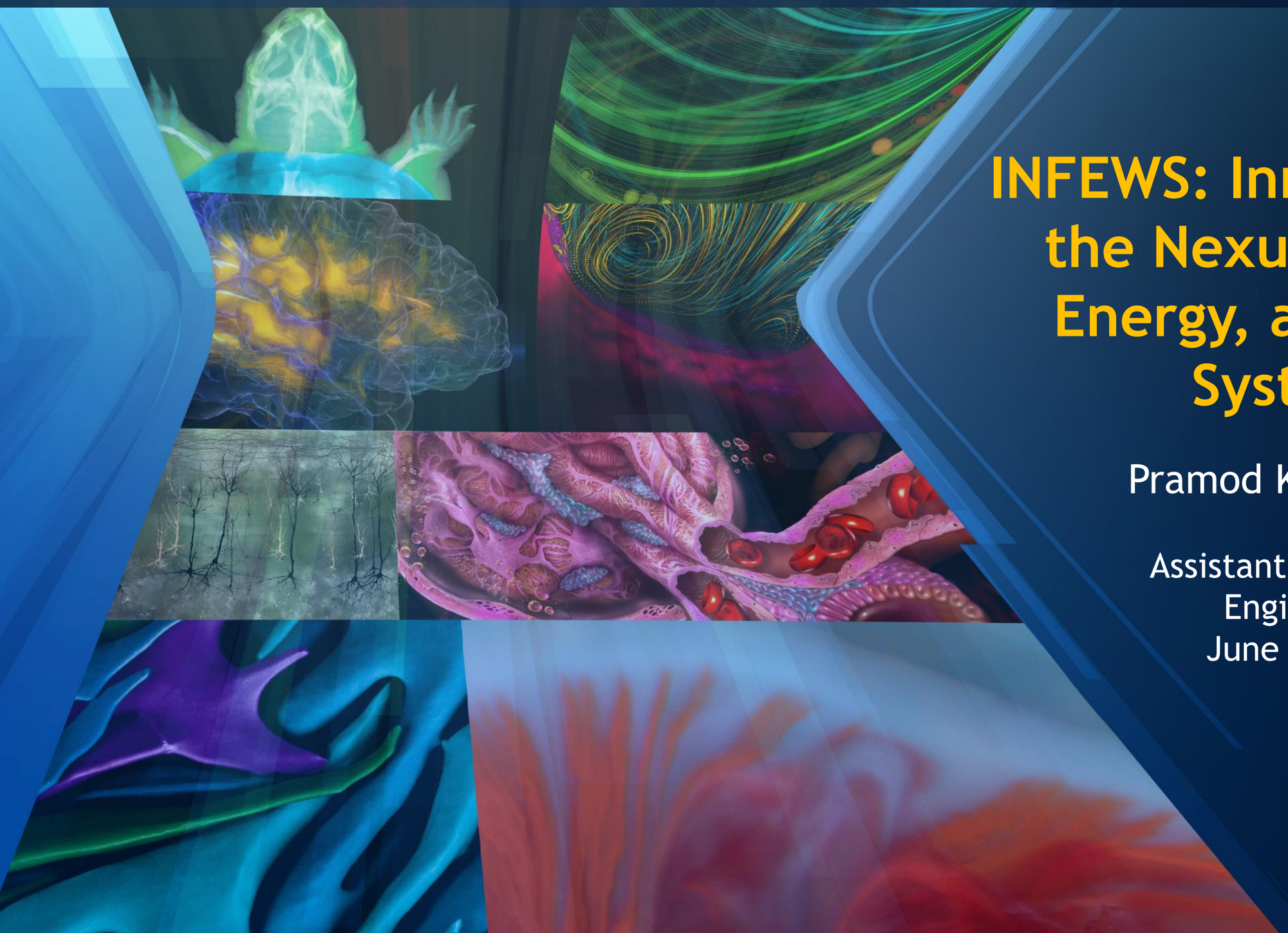


INFEWS: Innovations at the Nexus of Food, Energy, and Water Systems

Pramod Khargonekar

Assistant Director for Engineering

June 20, 2016

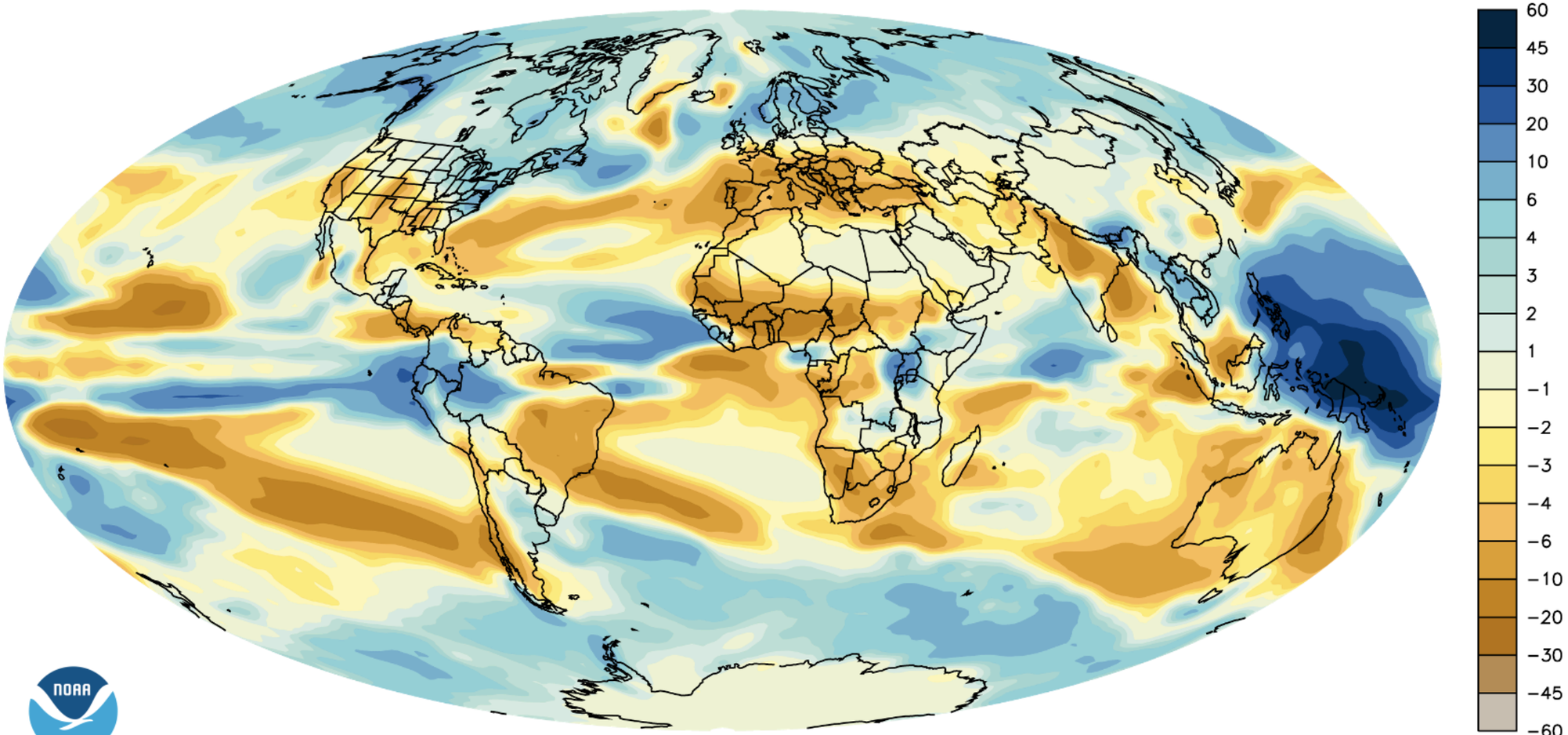
Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS)

- World population projected to reach 9 billion by 2050; corresponding US population 400 million.
- Population growth and economic growth leading major increases in demand for 3 critical resources: energy, water, and food.
- Increased variability in precipitation and temperatures will add to the coupling and stress on these resources.

More Food, Water, and Energy will be Needed

- 60% more food will be needed by 2050
- 80% more energy consumption by 2050
- 50% more water withdrawls in the developing nations by 2025
- 18% more water water withdrawls in the developed nations by 2025

CHANGE IN PRECIPITATION BY END OF 21st CENTURY
inches of liquid water per year



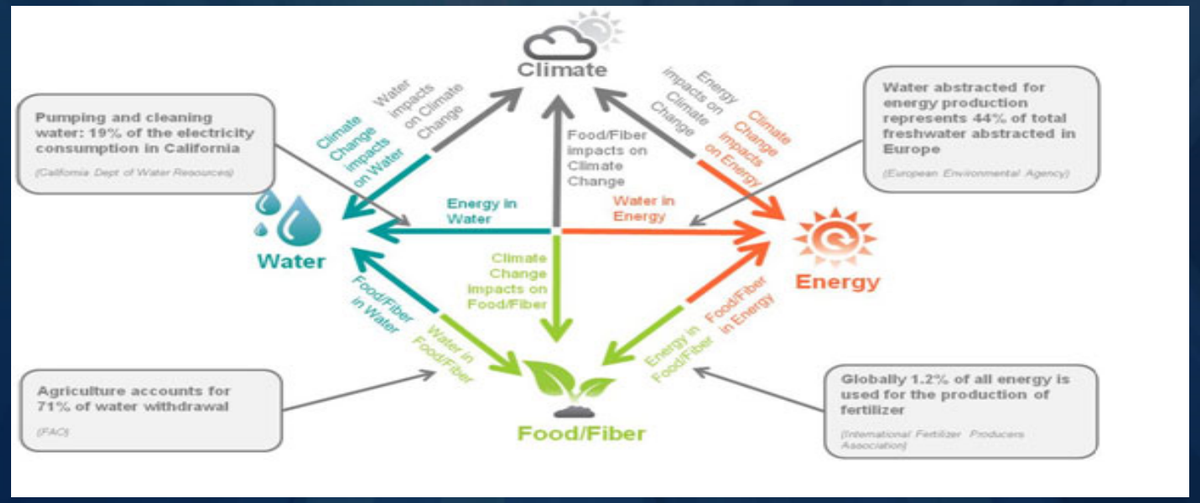
as projected by NOAA/GFDL CM2.1

Source: NOAA

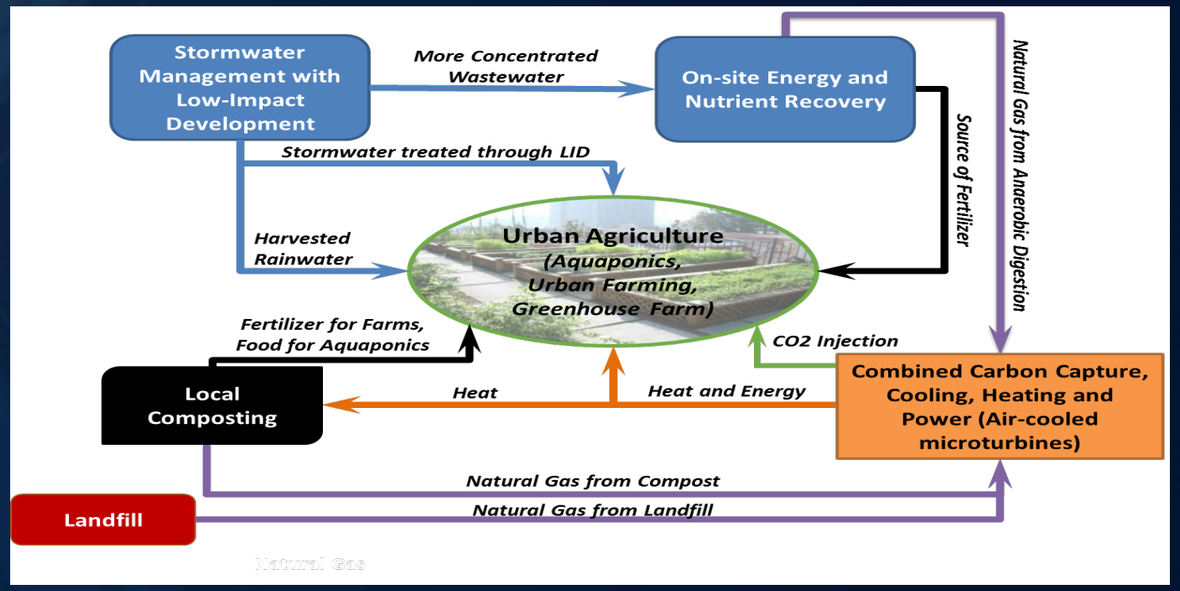
Nexus Thinking

- Globally, 70% of all fresh water withdrawls for agriculture
- 30% of energy used for food production and supply chains
- Bioenergy concepts couple food to energy production

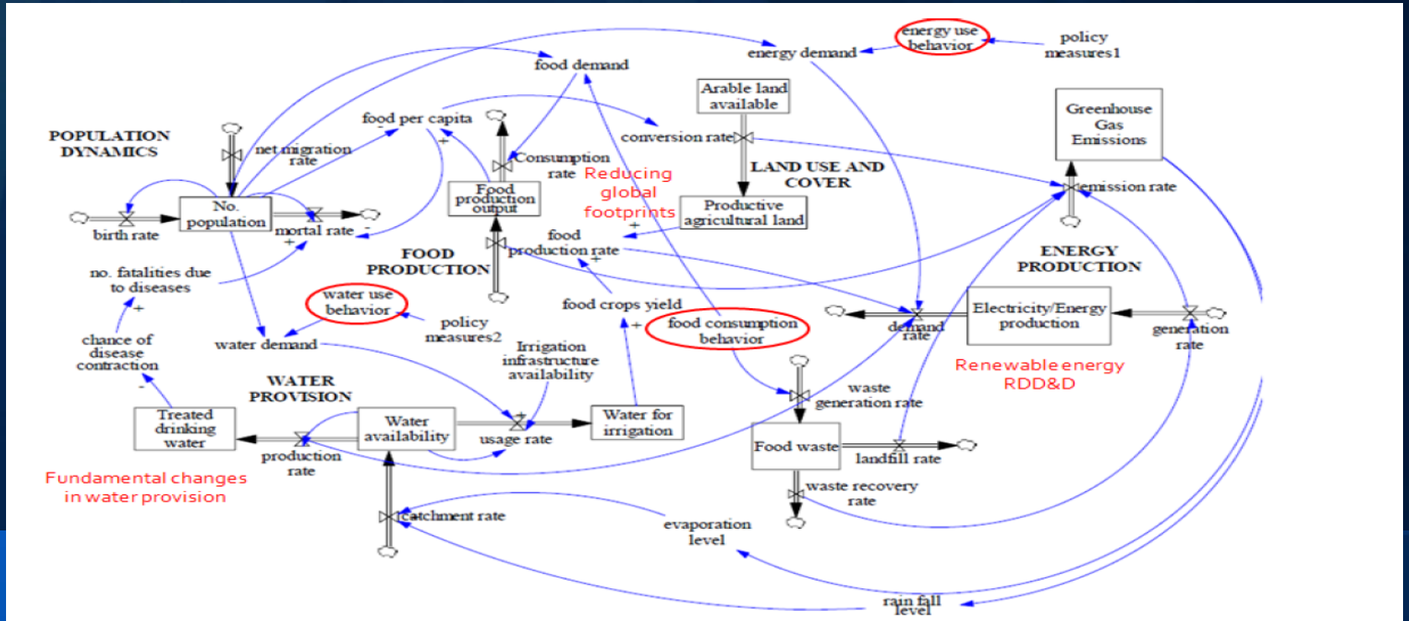
Nexus: System of Systems



K. Carlson, Colorado State Univ.



J. Crittenden, et al., Georgia Tech



D. Aguscinata, Northern Illinois Univ.

Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS)

- Advance understanding of the FEW system through quantitative and computational modeling
- Develop real-time, cyber-enabled interfaces that improve understanding of the behavior of FEW systems and increase decision support capability
- Enable research that will lead to innovative solutions to critical FEW problems
- Grow the scientific workforce capable of studying and managing the FEW systems

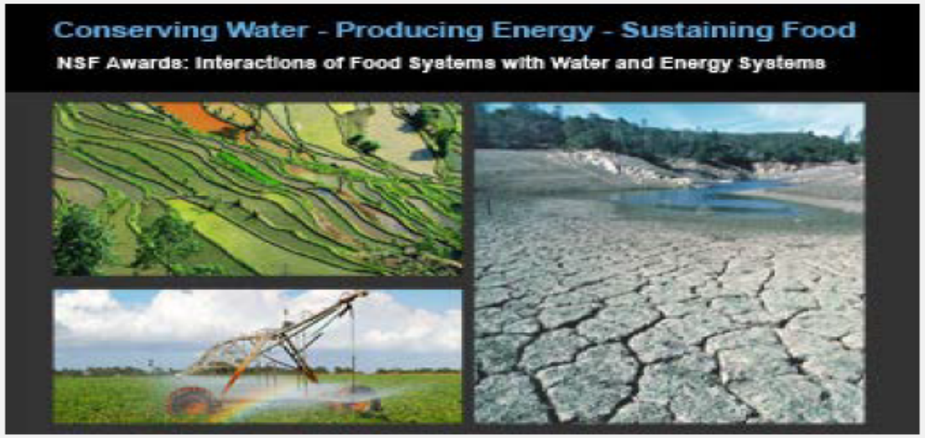
Food-Energy-Water in FY15

- 17 workshop grants
  - Designed to facilitate partnerships among researchers
  - Integrate Scientific Communities, including those at other federal agencies; enhance communication
  - Define fundamental science and engineering research needs/questions in FEW Systems

Press Release 15-090

New grants foster research on food, energy and water: a linked system

Amid population growth, drought and increased urbanization, understanding food, energy and water availability is increasingly important



How food, water and energy systems interact: a photo gallery.
Credit and Larger Version

August 14, 2015

In a world where a growing number of people lack food, water and sources of energy, providing these resources has become a challenge.

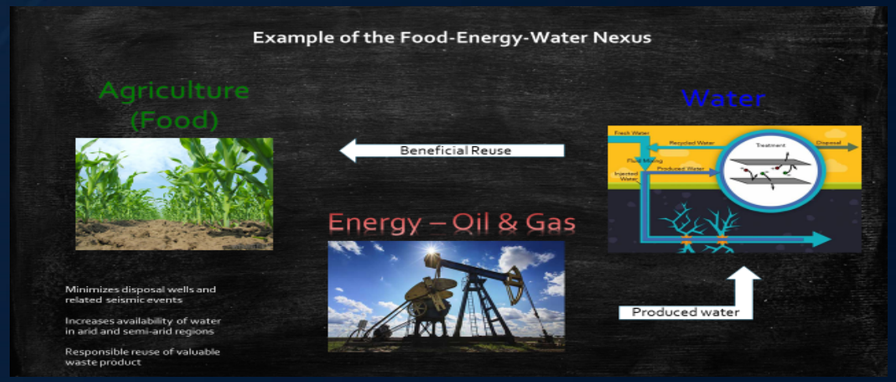
To find new answers, the National Science Foundation (NSF) has funded 17 grants, totaling $1.2 million, to support workshops on the interactions of food, energy and water, or FEW. Additionally,

Workshops

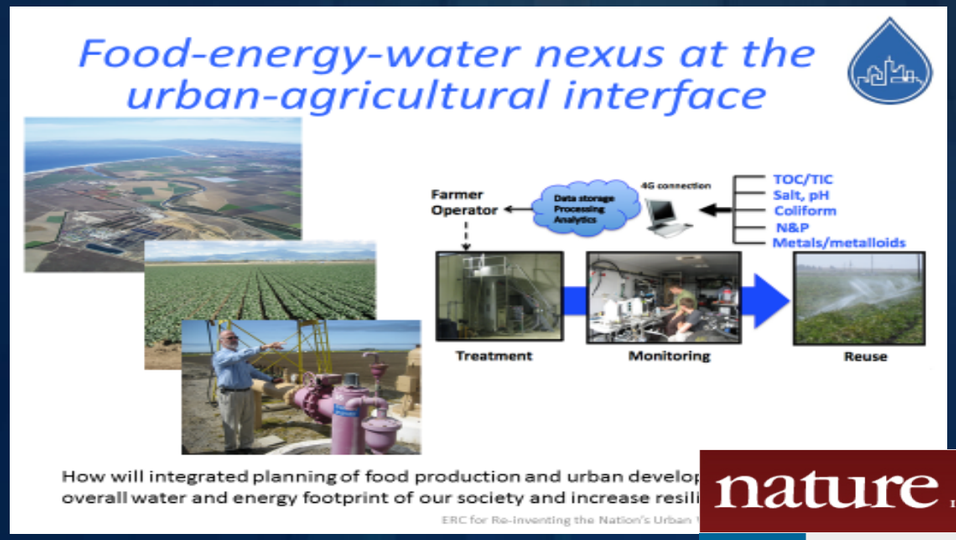
Proposal	Title	PI	PI institution	Amount	Confirmed Dates	Workshop Location
1542770	FEW NSF Workshop: Closing the Human Phosphorus Cycle	Platz	U Hawaii Hilo	$ 87,873	Jun 8 - 9, 2015	Arlington
1541880	FEW: Developing Intelligent Food, Energy,and Water Systems (DIFEWS)	Potts, Matthew D.	University of California-Berkeley	$ 49,863	Sept 28-29, 2015	UC Berkeley
1541838	FEW Workshop: "Scaling Up" Urban Agriculture to Mitigate Food-Energy-Water Impacts	Newell, Joshua	University of Michigan Ann Arbor	$ 69,242	Oct 5-7, 2015	Univeristy of Michigan, Michigan League
1541876	FEW: A Workshop to Identify Interdisciplinary Data Science Approaches and Challenges to Enhance Understanding of Interactions of Food Systems and Water Systems	Shekhar, Shashi	UMN	$ 50,000	Oct. 5-6, 2015	Washington DC or MN
1541883	FEW: Food-Energy-Water Nexus Workshop to Develop System Approaches and Sustainability Metrics for Evaluation	Schuster, Darlene S	American Institute of Chemical Engineers	$ 94,929	Oct. 7-9, 2015	Washington, DC
1541790	FEW: Coupling Economic Models with Agronomic, Hydrologic, and Bioenergy Models for Sustainable Food, Energy, and Water Systems	Catherine Kling	Iowa State University	$ 45,922	Oct 11-12, 2015	Iowa State University; Ames, Iowa
1541771	FEW: Food-Energy-Water infrastructure systems, engineering solutions and institutions	John L Sabo	Arizona State University	$ 94,905	Oct 13 - 15, 2015	ASU Campus
1541807	FEW: Workshop to Identify Opportunities and Challenges for Nanotechnology to Optimize and Unify Food, Energy and Water Systems	Lowry, Gregory V.	Carnegie-Mellon University	$ 58,358	Oct 19-20, 2015	Pittsburgh, PA
1541736	FEW: A sustainable rural framework workshop for the upper Great Plains.	Stone, James J	South Dakota School of Mines and Technology	$ 50,000	Oct 19 - 20, 2015	SDSM&T in Rapid City, SD
1541799	FEW Workshop - Planned Migration as a Strategy to Sustain Agricultural Production	McNider, Richard (1049050 NIFA)	University of Alabama in Huntsville	$ 56,335	Oct 21-23, 2015	NCAR, Boulder
1541866	Few Workshop: Food, Energy, and Water Nexus in Sustainable Cities	Assaf-Anid, Nada M	New York Institute of Technology	$ 98,877	Oct 20-21, 2015	Beijing, China
1541844	FEW: Conference on Environmental Change, Migration, and the Resilience of Regional Food, Water, and Energy Systems	Elena Irwin	Ohio State U	$ 97,496	Nov 4-5, 2015	Ohio State Univ.
1541868	FEW Workshop: Water- and Energy-efficient Food Production: Solutions for America's Bread Basket	Rezac, Mary E	Kansas State University (EPSCoR)	$ 50,000	Nov 19-20, 2015	Manhattan, Kansas; Governor's Conference Nov. 18 - 19
1541642	FEW: Development and Application of Analytical Tools in Support of Food-Energy-Water Nexus Planning	Miralles-Wilhelm, Fernando R	University of Maryland College Park	$ 99,980	Oct. 27-28, 2015	Washington DC
1541890	FEW: Towards Food, Energy and Water Security in California under Changing Conditions: the Nexus Perspective	Gebremichael, Mekonnen	University of California-Los Angeles	$ 49,680	Dec 2-4, 2015	UCLA, Los Angeles, California
1541863	FEW: Technology and Information Fusion Needs to Address the Food, Energy, Water Systems (FEWS) Nexus Challenges	Ebert, David	Purdue	$ 60,105	Nov. 5-6	Napa Valley Marriott Hotel and Spa
1541694	FEW: River FEWs: Workshop to explore the nexus between food, energy and water in a large international river system	Holtgrieve, G.W.	University of Washington	$ 98,367	Dec. 10-12, 2015	U. Washington, Seattle

Food-Energy-Water in FY15

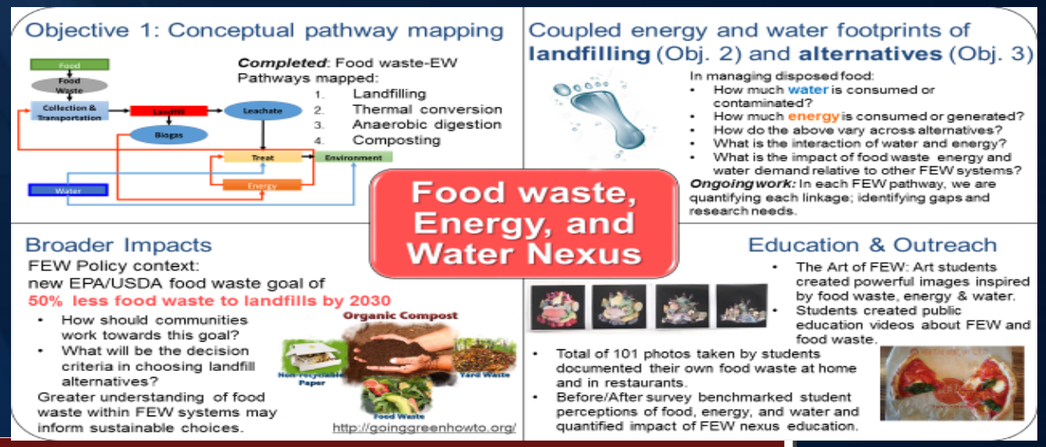
Supplements to existing grants to incorporate food components



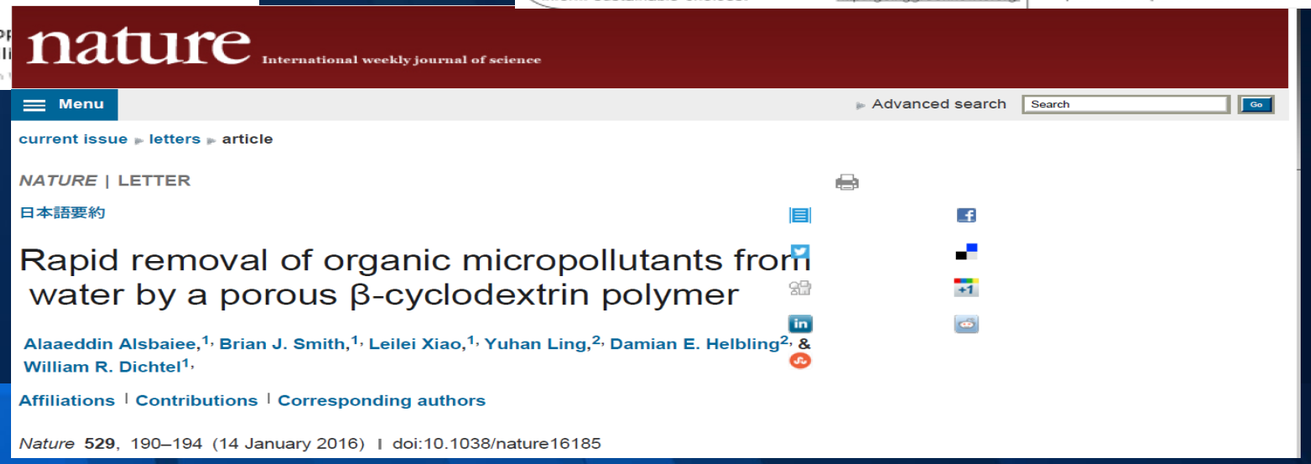
Ken Carlson, Colorado State Univ.



R. Luthy et al., Stanford Univ.



D. Reinhart, Univ. of Central Florida



INFEWS in FY16

- Interdisciplinary
- Investigation of the coupled system
- Partnership with USDA NIFA
- Education and workforce
  - Preparing the next generation of scientists and engineers
  - Community outreach

Innovations at the Nexus of Food, Energy and Water Systems (INFEWS)

PROGRAM SOLICITATION
NSF 16-524

National Science Foundation
Directorate for Geosciences
Directorate for Engineering
Directorate for Computer & Information Science & Engineering
Directorate for Mathematical & Physical Sciences
Directorate for Social, Behavioral & Economic Sciences
Directorate for Education & Human Resources
Office of International Science and Engineering
Office of Integrative Activities

National Institute of Food and Agriculture

Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

March 22, 2016

IMPORTANT INFORMATION AND REVISION NOTES

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised NSF Proposal & Award Policies & Procedures Guide (PAPPG) (NSF 16-1), which is effective for proposals submitted, or due, on or after January 25, 2016. Please be advised that proposers who opt to submit prior to January 25, 2016, must also follow the guidelines contained in NSF 16-1.

INFEWS in FY16

National Science Foundation
WHERE DISCOVERIES BEGIN

QUICK LINKS

SEARCH

HOME | FUNDING | AWARDS | DISCOVERIES | NEWS | PUBLICATIONS | STATISTICS | ABOUT NSF | FASTLANE

NSF 15-108

Dear Colleague Letter: FY 2016 Innovations at the Nexus of Food, Energy and Water Systems (INFEWS) Funding Opportunity on Nitrogen, Phosphorus, and Water

August 12, 2015

Dear Colleagues:

In 2010, NSF established the Science, Engineering, and Education for Sustainability (SEES)[1] investment area to lay the research foundation for decision capabilities and technologies aimed at mitigating and adapting to environmental changes that threaten sustainability. Some SEES investments advanced a systems-based approach to understanding, predicting, and

"The availability of **nitrogen**, **phosphorus**, and **water** are the three main factors that limit our ability to produce enough food to feed the growing population of the planet"

INFEWS in FY16

National Science Foundation Research Traineeship (NRT) Program

PROGRAM SOLICITATION
NSF 16-503

REPLACES DOCUMENT(S):
NSF 15-542

National Science Foundation

Directorate for Education & Human Resources
Division of Graduate Education

Directorate for Biological Sciences

Directorate for Computer & Information Science & Engineering

Directorate for Engineering

Directorate for Geosciences

Directorate for Mathematical & Physical Sciences

Directorate for Social, Behavioral & Economic Sciences

Office of Integrative Activities

Letter of Intent Due Date(s) ***(required)*** (due by 5 p.m. proposer's local time):

December 09, 2015

Applies to both tracks

December 09, 2016

Applies to both tracks

Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

February 09, 2016

Applies to both tracks

February 07, 2017

Applies to both tracks

Priority Area in Traineeship Track

- Development of innovative and potentially transformative approaches tograduate education
- Dissemination of outcomes and gained insights from NRT training approaches.
- Comprehensive training of STEM graduate students, including the development of technical and professional skills for both research and research-related careers within and outside academia.
- Evidence -based strategies to broaden participation of students from diverse backgrounds.
- Robust formative assessment that is central to the traineeship and routinely informs and improves practice.

INFEWS in FY16 - EPSCoR

EPSCoR Research Infrastructure Improvement Program: Track-2 Focused EPSCoR Collaborations (RII Track-2 FEC)

PROGRAM SOLICITATION
NSF 16-511

REPLACES DOCUMENT(S):
NSF 15-517

National Science Foundation

Office of Integrative Activities

Letter of Intent Due Date(s) ***(required)*** (due by 5 p.m. proposer's local time)*:*

January 11, 2016

Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

February 04, 2016

IMPORTANT INFORMATION AND REVISION NOTES

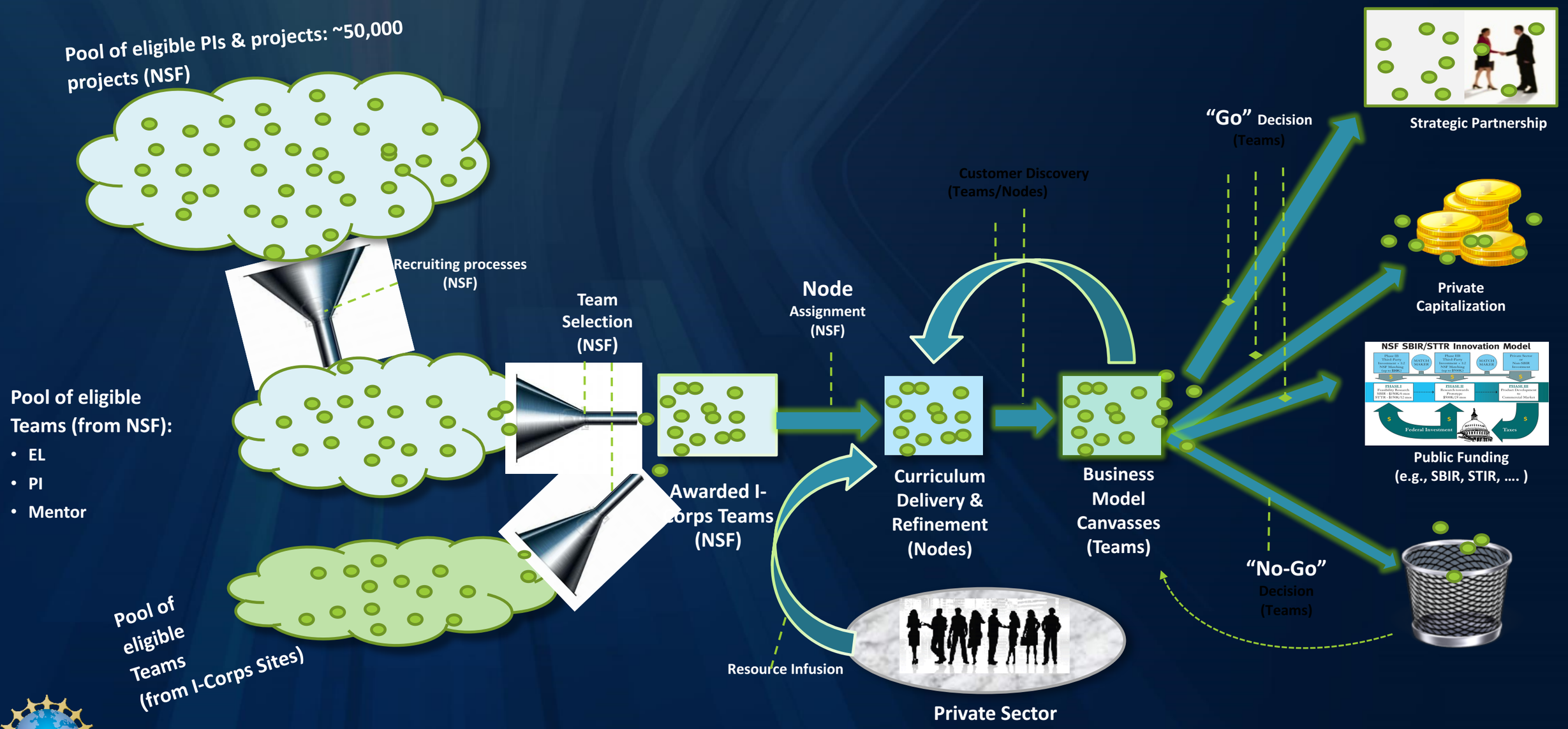
The following EPSCoR jurisdictions are RII-eligible for the FY 2016 RII Track-2 FEC competition: Alabama, Alaska, Arkansas, Delaware, Guam, Hawaii, Idaho, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Puerto Rico, Rhode Island, South Carolina, South Dakota, Vermont, US Virgin Islands, West Virginia, and Wyoming.

- There is a limit of a single proposal from each submitting organization.
- Each proposal must have at least one collaborator from an academic institution or organization in a different RII-eligible EPSCoR jurisdiction as a co-Principal Investigator (co-PI). Proposals with a PI and all co-PIs from the same jurisdiction will be returned without review.
- For FY 2016, RII Track-2 FEC proposals promote collaborations among researchers in EPSCoR jurisdictions on these topics: 1) Understanding the Brain; or 2) Sustainable Food, Energy, and Water Systems.
- The recruitment and/or development of diverse early-career faculty is a critical component of successful proposals.
- The extent and quality of the interjurisdictional collaborations must be clearly articulated.
- A letter of Intent (LOI) is required for the FY 2016 RII Track-2 FEC competition. LOIs must be submitted by the Sponsored Projects Office (SPO) of the submitting institution via FastLane on or before the LOI due date.
- PIs and co-PIs on current NSF EPSCoR RII awards with end dates later than October 31, 2016 are not eligible to submit proposals as a PI or co-PI in this competition.
- Support for non-lead collaborating institutions should be requested as subawards. Separately submitted collaborative proposals are not allowed.
- The project title must begin with "RII Track-2 FEC:" and follow with an informative title in the topic area.
- Allowable RII Track-2 FEC award amounts depend on the size of the collaboration. If two RII-eligible EPSCoR jurisdictions collaborate on a proposal, the award amount may not exceed $1 million per year. If three or more RII-eligible EPSCoR jurisdictions collaborate on a proposal, the award amount may not exceed $1.5 million per year. In either case, awards are for a maximum of four years.
- Awardees will be expected to participate in a joint project data collection effort. See Section V.B for corresponding budget requirements.
- Page limits apply. See Section V.
- No letters of commitment should be included in the Supplementary Documents. See Section V.A.10.
- A maximum of five letters of support may be included. See Section V.A.10.
- Collaborators and Other Affiliations Information is now required to be submitted with the proposal as a Single Copy Document. This replaces the List of Conflicts required as Supplemental Documentation in prior solicitations. See GPG Chapter II Section C.1.e.

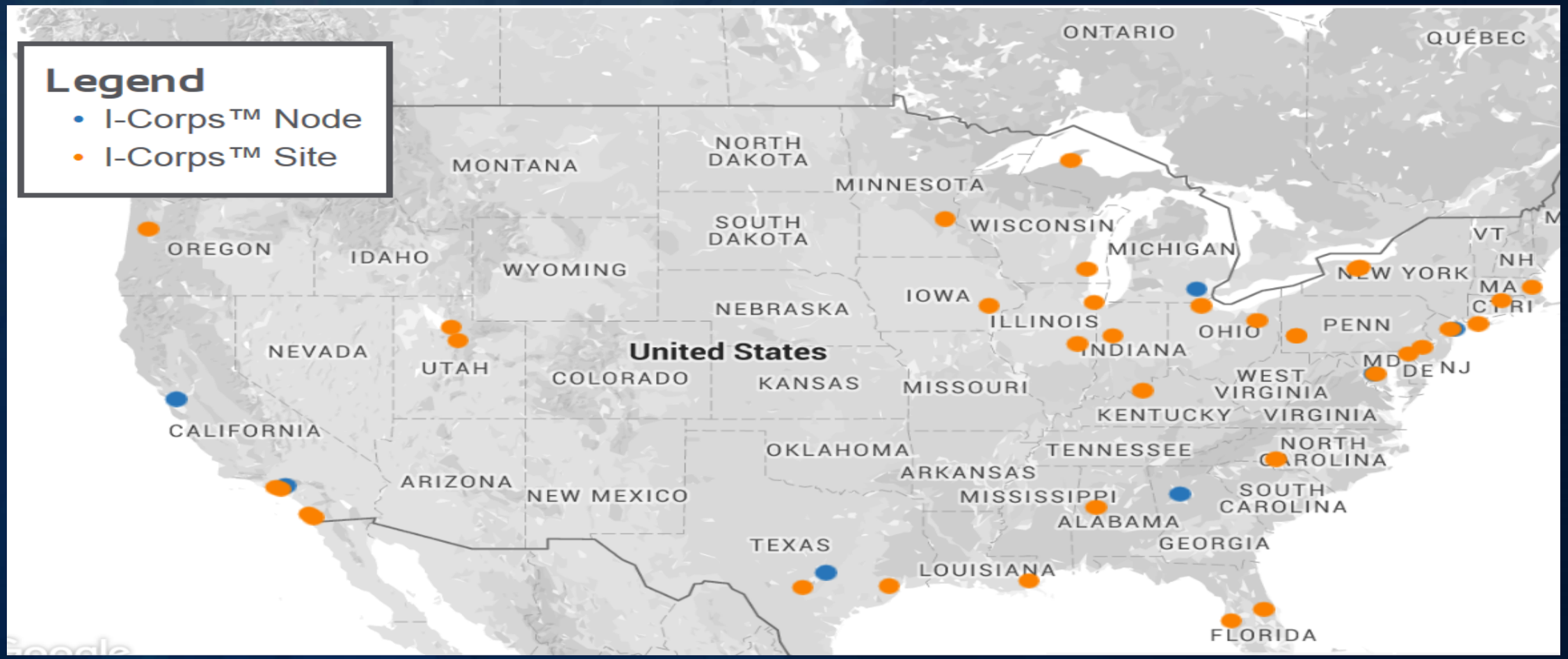
Innovation Corps (I-Corps)

- Designed to foster entrepreneurship that will lead to the commercialization of NSF-funded research
  - Uses customer discovery and business model development to validate commercialization opportunities
  - Successful I-Corps projects will be prepared for business formation
- Distinct components of I-Corps program
  - Teams – Composed of Principal Investigator (PI), Entrepreneurial Lead (EL), and Mentor (M)
  - Nodes – Hubs for education, infrastructure, and research that engage academic scientists and engineers in innovation
  - Sites – Academic institutions that catalyze the engagement of local teams in technology transition and strengthen local innovation

I-Corps process



I-Corps Nodes and Sites



7 Nodes 51 Sites

645 Teams trained to date

220 startups created