EPA Tools and Resources Webinar: Nutrient Management in Coastal Communities

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Excess nitrogen impairs estuaries and other aquatic systems

The Problem

Communities struggle to implement nitrogen (N) remediation programs:

- Nitrogen-reduction efficiencies of many interventions remain uncertain
- Costs of the interventions are difficult to identify and compare
- Additional social barriers to acceptance are unrecognized
- Benefits of remediating N are not being highlighted

Problem & Context

- **Coastal nitrogen pollution**
  - Leads to eutrophication
  - Affects ecosystem service delivery & local economies
  - Sources are human & natural
- **34 watersheds on Cape Cod have Total Maximum Daily Loads (TMDL) for nitrogen**
  - Driven by nonpoint sources (e.g., septic systems)
  - Sewering a prohibitively expensive ($6-8B) & lagged solution
  - Towns responsible for developing plans (w/state approval) to meet TMDLs
- **Other regions face similar problems**

Presentation Outline

- Septic Sensor Challenge
- Nitrogen research on Cape Cod

Septic Sensor Challenge 2016

- Goal: To incentivize the development and marketing of a low-cost N sensor for septic systems.

- Suffolk County Long Island
  - 360,000 conventional septic systems and cesspools
  - >200,000 of these systems are in nitrogen sensitive areas & need replacement

- Current cost of monitoring in MA for permitting
  - $300 to sample one On-Site Wastewater Treatment System (OWTS) & run lab tests
  - $4,500 to monitor one OWTS for 4.5 years, for the 50 systems = $155,250

Benefits of Sensor Development

State & County Regulators

- Assurance of long-term system functionality (improved evidence to recommend them)
- Reduce cost of data collection
- Minimization of human errors & time delays
- Improved standardization of methods & limits of detection

Industry

- Brand new market segment for the sensor, sensor maintenance, and data collection/analysis
- Important Innovative and Alternative (I/A) OWTS verification device, which could streamline the permitting process & thereby reduce field testing costs for manufacturers

Homeowners

- Assurance that I/A OWTS investment performs as advertised
- Facilitates routine maintenance to protect system longevity

United States Environmental Protection Agency

Partners

CT, MA, ME, NH, VT, RI, NJ, NY & Suffolk County OWTS Regulators

The Nature Conservancy

Cape Cod Commission

MassDEP

United States Environmental Protection Agency

NEOWTP
The University of Rhode Island

The Challenge

MASSTC
The Massachusetts Alternative Septic System Test Center

United States Environmental Protection Agency

Suffolk County Seal, New York

Stony Brook University
Center for Clean Water Technology

United States Environmental Protection Agency

SORA
State Onsite Regulators Alliance

Bill & Melinda Gates foundation

KOHLER.

Caltech

CAMBRIAN INNOVATION

SCO
Standards Coordination Office
National Institute of Standards and Technology

Proposed Sensor Design Specifications

Attribute	Attribute Description	Performance Goals		
		Minimum	Almost Ideal	Ideal
Parameter	What is being measured	NO_3^-, NH_4^+	NO_3^-, NH_4^+, TOC	Total nitrogen (TN)
Installation Price	Price to the homeowner to install	$1,500	$1,250	$1,000
Data Management	Ability to record and transmit data (i.e., telemetry) for real-time access by practitioners, regulators, and interested stakeholders	Record and automatically transmit data to designated server or cloud	Record and automatically transmit data to designated server or cloud	Record and automatically transmit data to designated server or cloud
Applicability & Accessibility	Applicability of sensor(s) to various innovative/alternative system designs and ease of access to OWTS for installation and maintenance	Located in-situ to provide performance information on the OWTS; must be accessible for maintenance	Located in-situ to provide performance information on the OWTS; must be accessible for maintenance	Located in-situ to provide performance information on the OWTS; must be accessible for maintenance
Frequency of Sensor System Maintenance	How often the sensor(s) need to be maintained	No more than quarterly	No more than semi-annually	No more than annually
Accuracy	Accuracy of sensor measurements to the true measurement	Within 20% of true value	Within 20% of true value	Within 20% of true value
Precision	Repeatability of sensor measurements	≤30% RSD	≤20-30% RSD	≤20% RSD
Range	Range of the detection	2-60 mg N/L	2-60 mg N/L 2-60 mg/L TOC	2-60 mg N/L
Sensor Operating Temperature Range	Temperature range in which the sensor can operate	4° C to 35° C	4° C to 35° C	4° C to 35° C
Deployment	Period of deployment	Continuous	Continuous	Continuous
System Lifetime	Expected life of sensor	5 years	5 to 10 years	10 years

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Advanced Septic System Nitrogen Sensor Challenge Phase I: 2017

- Partners: United States Geological Society (USGS) & The Nature Conservancy
- Challenge
  - Submitters encouraged to propose creative solutions toward meeting sensor design specifications
  - Written submissions
- Expert panel selected winners
  - 1st place: \$20K – Dr. Baikun Li & Dr. Yu Lei, UConn
  - 2nd place: \$15K – Jason Khoo, Stanford University
  - 3rd place: \$10K – William Powers, PixController, Inc.
  - 4 honorable mentions: \$2,500 each
- Winners were announced at Sensor Showcase Day on 6/29/17

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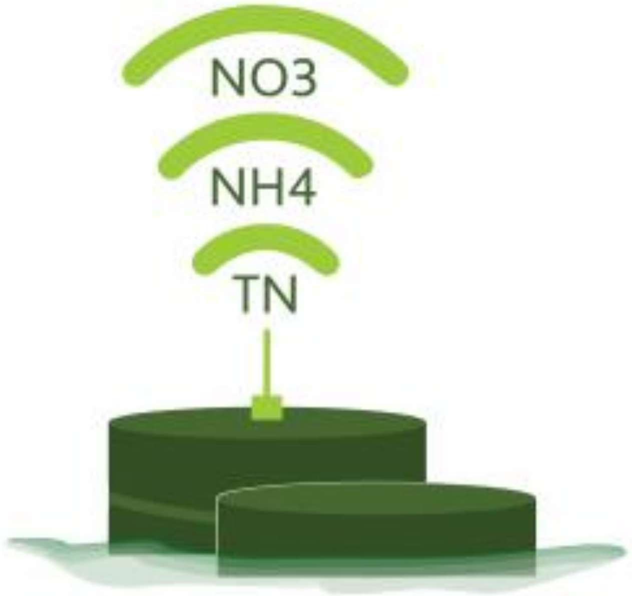
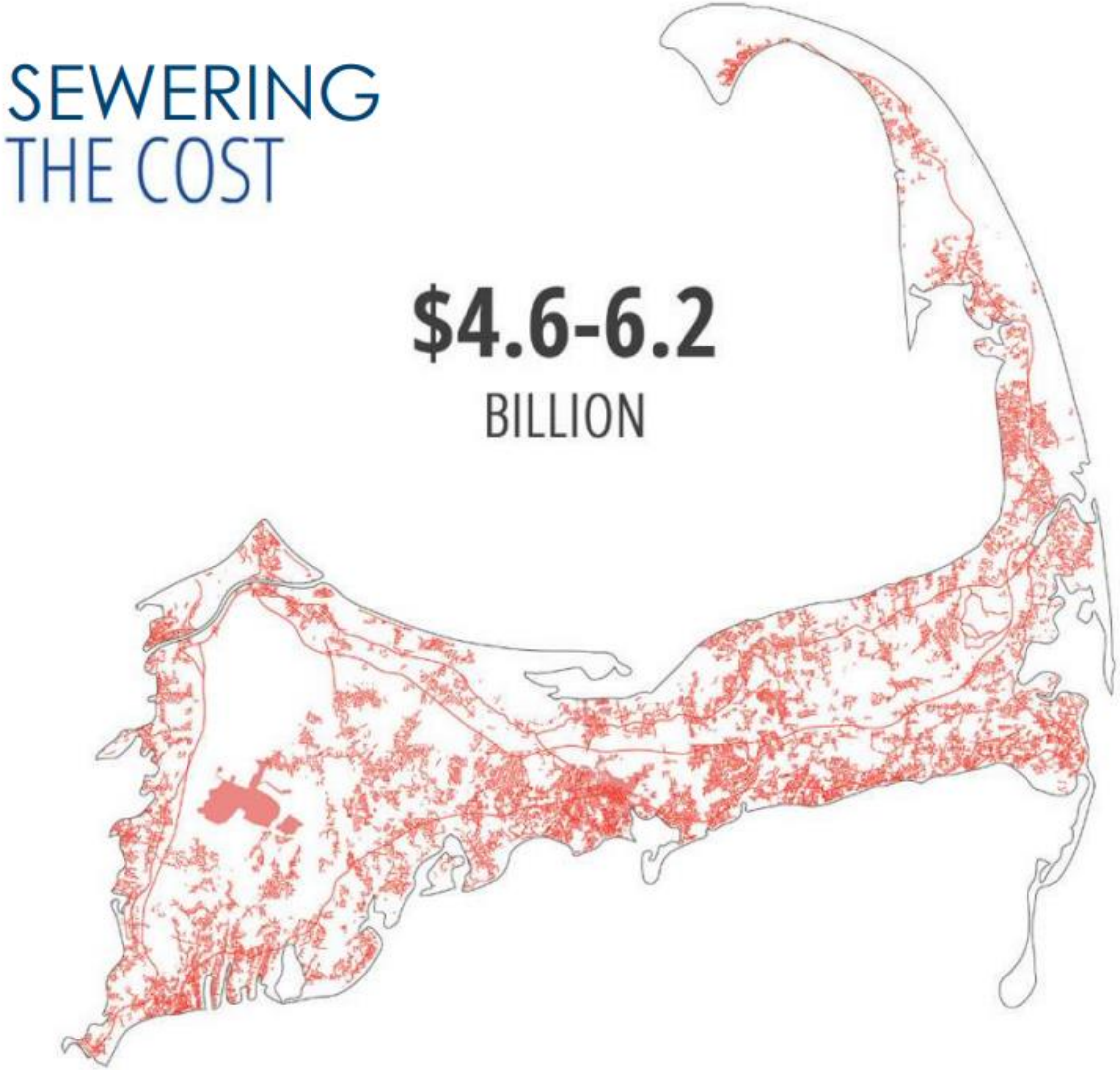
Phase II, 2019-21 Testing Schedule



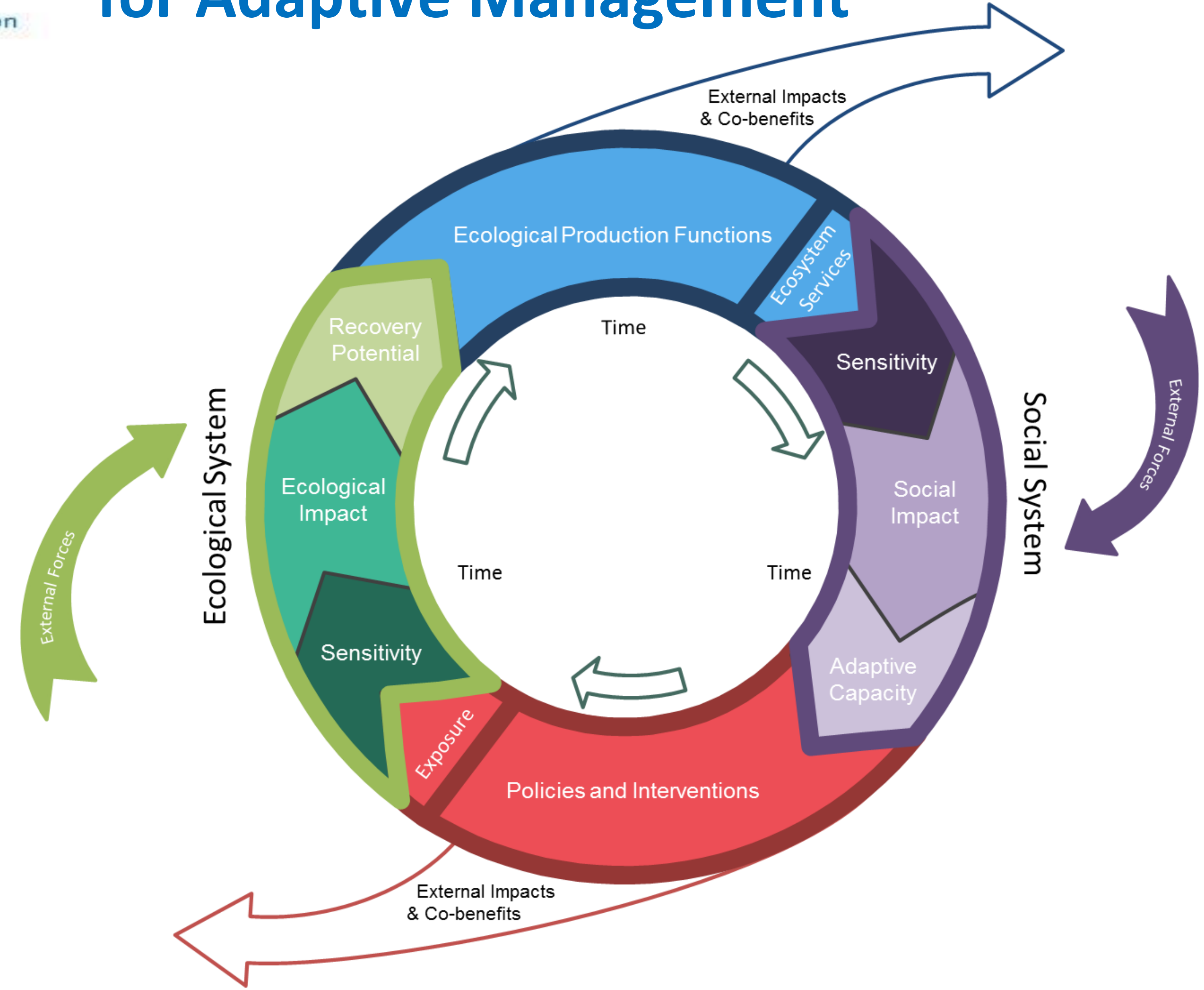
- 1 week screening test: 8/21-28/19
- By invitation only, one month test: December 2019
- By invitation only, 6 month field verification test: May 2019 –November 2020*
- Awards: **ISO ETV 14034 verification reports**, 2/2021**
- Proposed The Nature Conservancy order for 200 sensors: Spring 2021

http://www.verifiglobal.com/en/

Nitrogen Research on Cape Cod



Evaluating Social-Ecological Systems (SES) for Adaptive Management



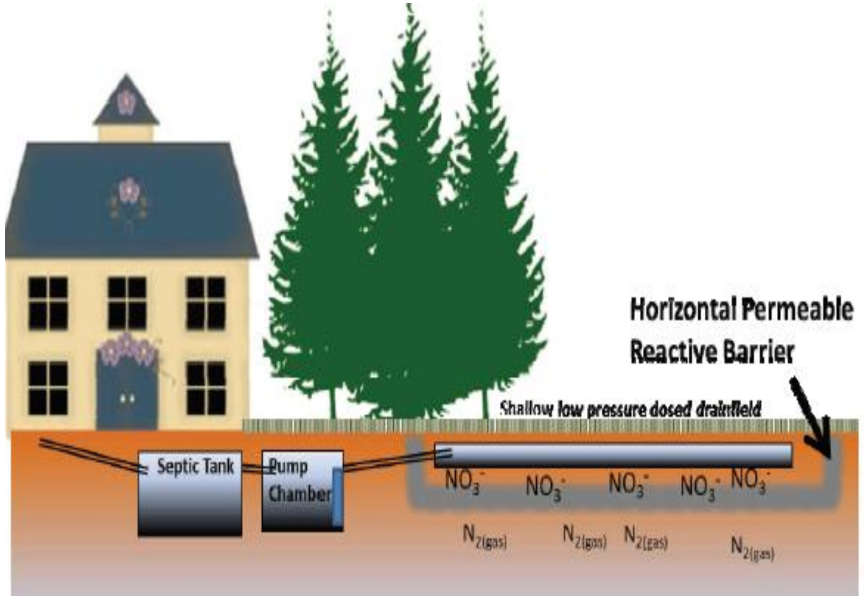
Elements of SES Research

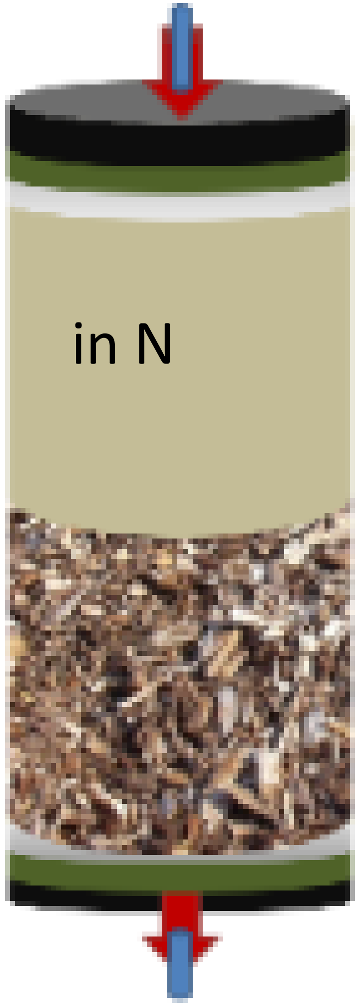
ORD's Atlantic Ecology Division

- Stakeholder engagement
- Experimentation: Impact of seawater intrusion on performance of alternative septic system designs
- Evaluate living shorelines as mechanism to increase wetlands and remove nitrogen
- Evaluate barriers and opportunities to using alternative technologies for nitrogen removal
- Develop dynamic optimization of alternative technologies
- Conduct structured decision making to evaluate tradeoffs
- Support restoration of wetland systems to improve water quality and coastal resilience
- Explore recreation demand in total maximum daily load (TMDL)-regulated waters

Seawater Intrusion Experiment

- Significant reductions in Nitrogen (N)
- Seawater addition did not appear to greatly impact the N removal efficiency





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Living Shorelines

Goals

- Examine the potential for improving water quality and facilitating nitrogen removal
- Stabilize the shoreline- prevent further erosion
- Encourage the regrowth of salt marsh

Co-Benefits

- Promote healthier salt marsh habitat for native plants and wildlife
- Assess the use of biodegradable materials for this particular restoration design

Findings

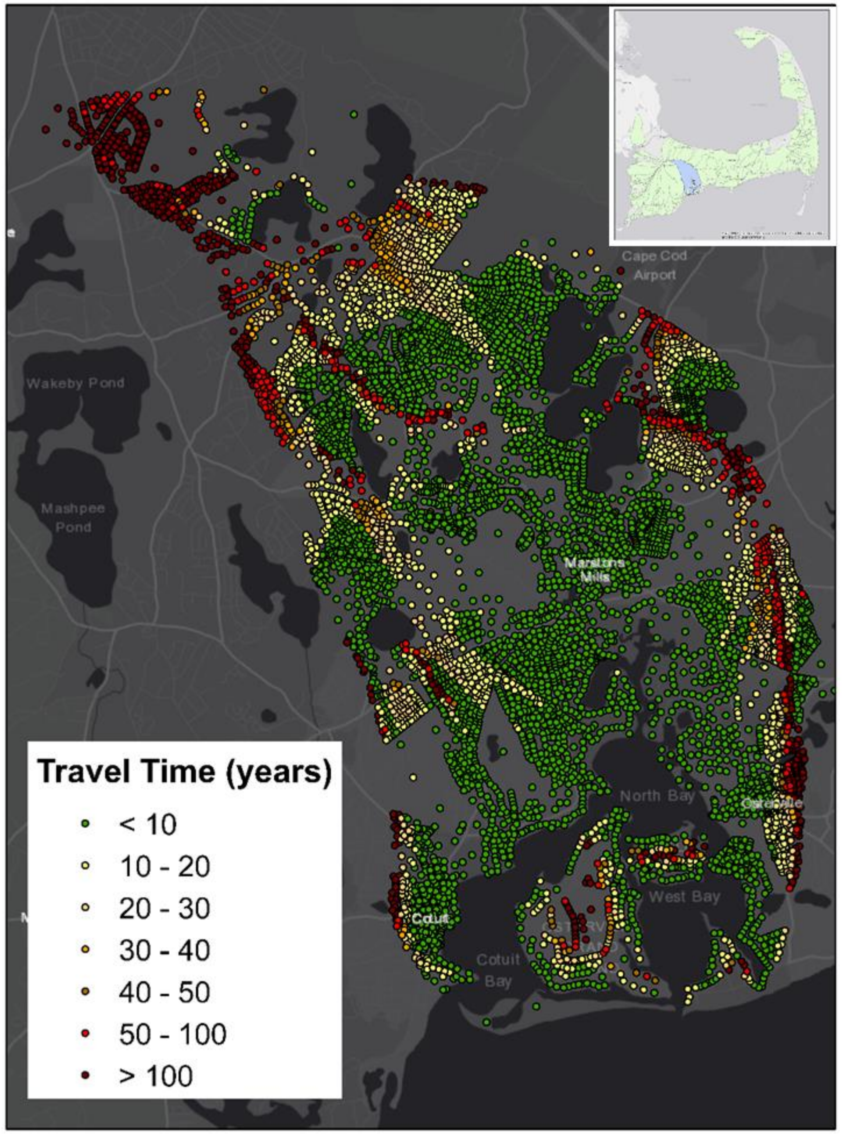
- Some evidence of N removal (Denitrifying Enzyme Activity)
- Slows marsh erosion
- Coir log restoration would be more successful with oyster castles or oyster reef balls in the foreground

Evaluating barriers and opportunities to use alternative technologies for nitrogen removal

- Semi-structured interviews and focus groups
- Acceptance > nitrogen reduction efficiency + engineering costs
- Big (additional) concerns:
  - Monitoring
  - Permitting
  - Maintenance
  - Siting
- Uncertainty
- Pilots: More trust if on Cape
- Shellfish, permeable reactive barriers (PRBs), and alternative septic systems

Dynamic optimization of alternative technologies

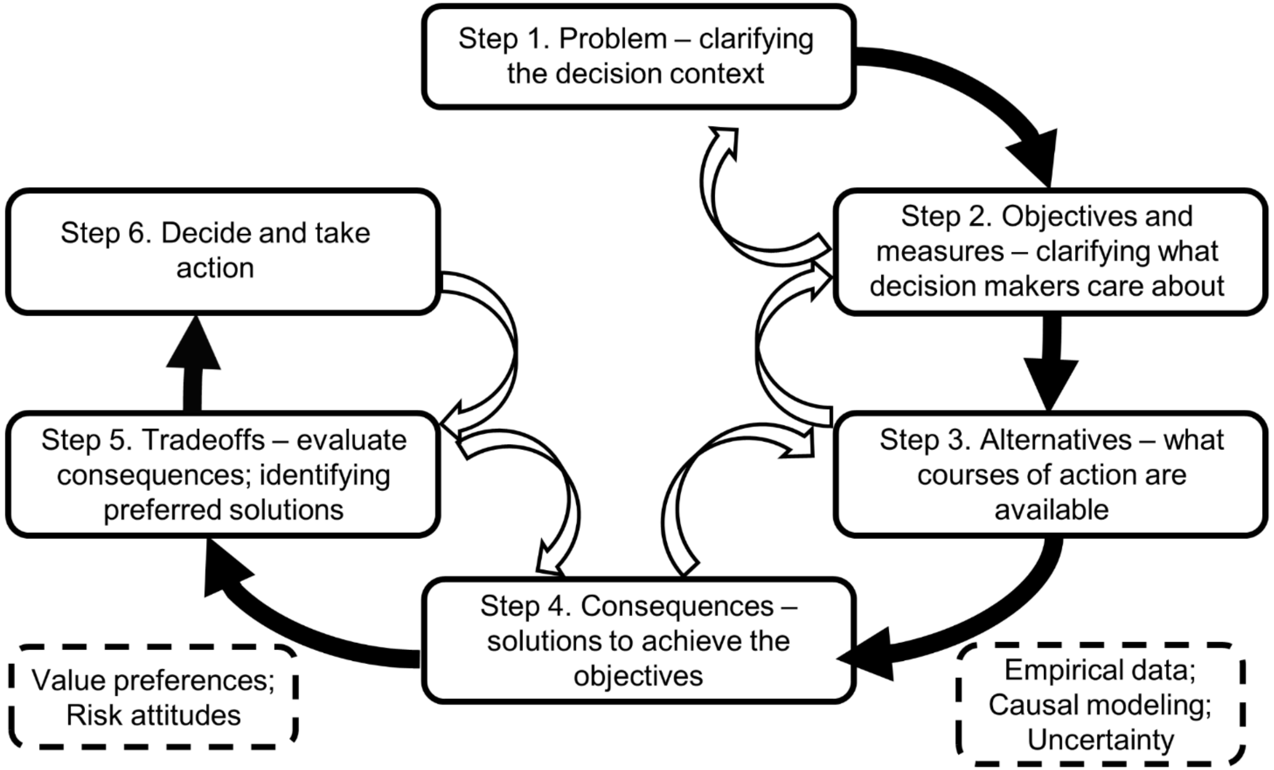
- 6K individual septic systems
- Constrained space for aquaculture, but more immediate impact on the bay
- Use multi-objective optimization to estimate dynamically efficient solutions
  - Min cost, max time meeting TMDL
- Aquaculture saves significant money and/or time when cleanup problem is considered in a dynamic framework



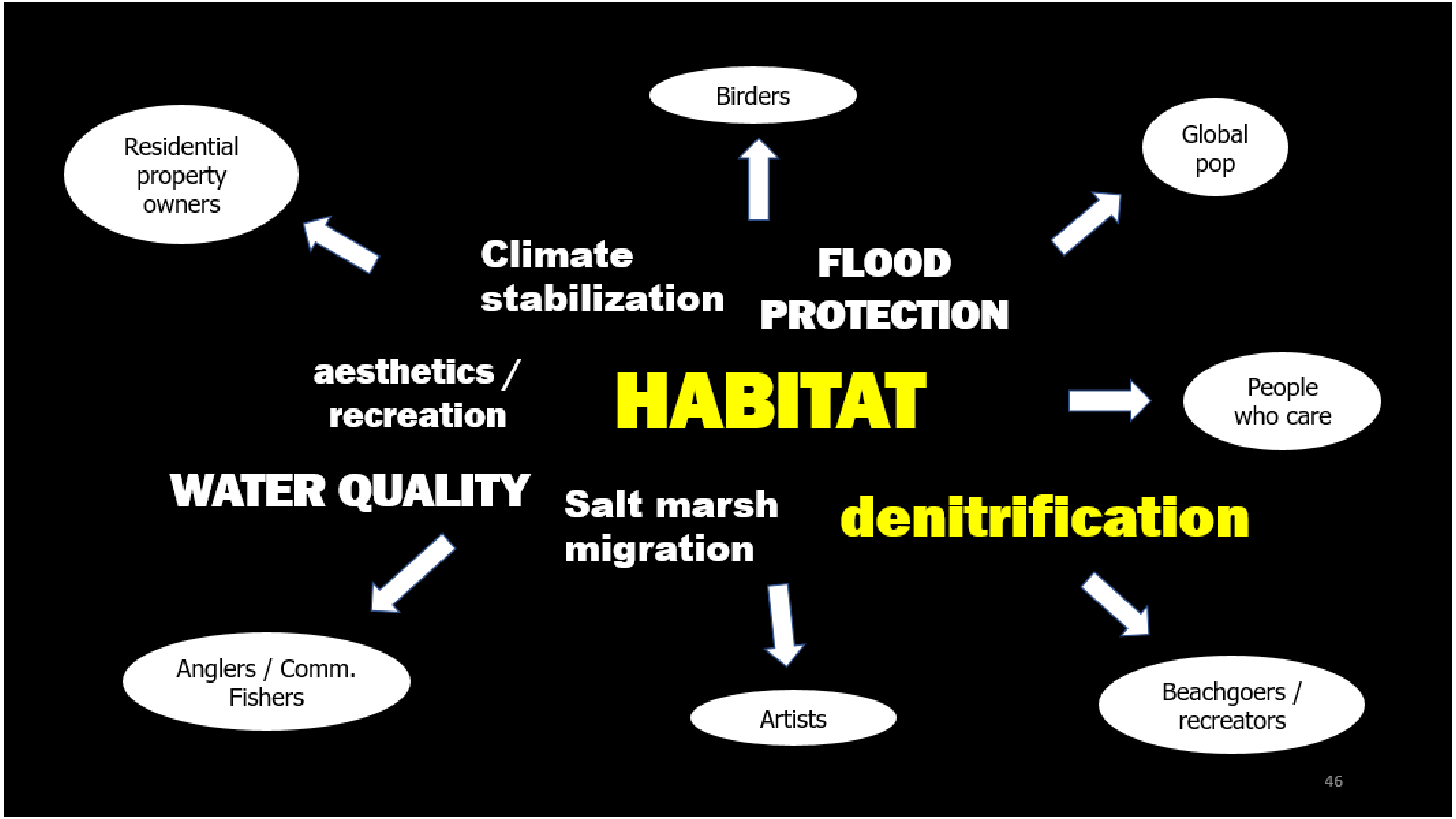
Decision Science on Cape Cod

Projects include:

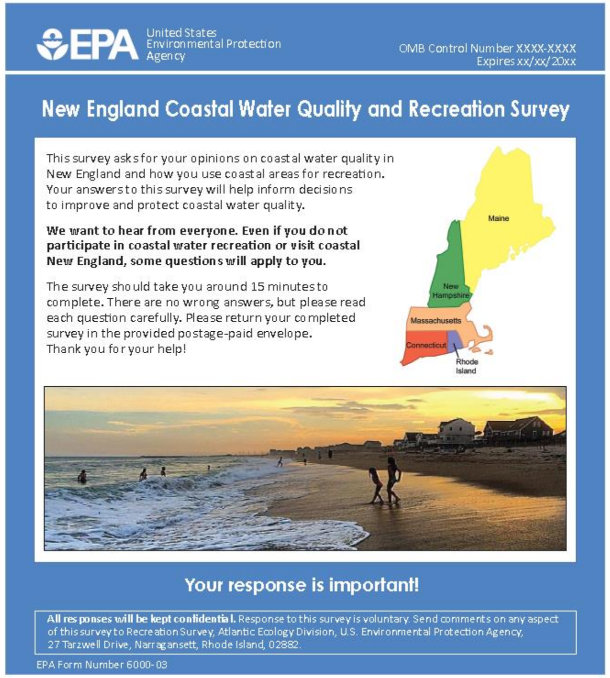
- Structured decision making to meet TMDLs
- Value of information and risk analysis to reduce uncertainty in I/A septic systems
- Adaptive management plan for I/A septic systems
- Monitoring the social benefits of ecological restoration of cranberry bogs



Support for restoration of wetland systems to improve water quality

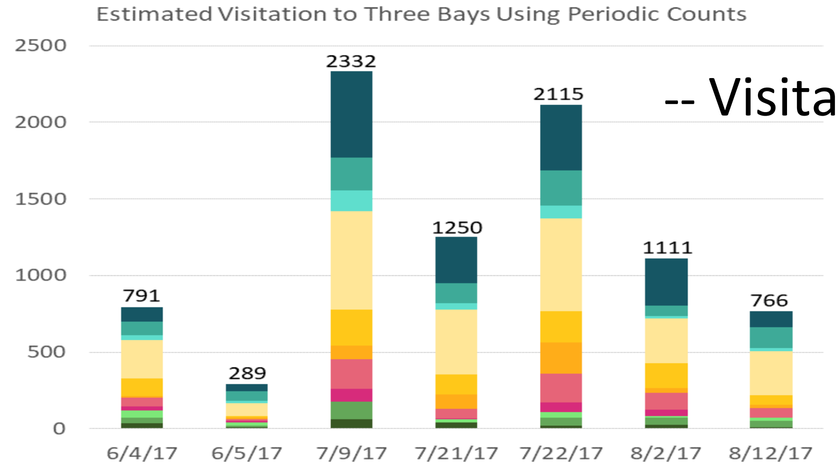


Exploring recreation demand in TMDL-regulated waters



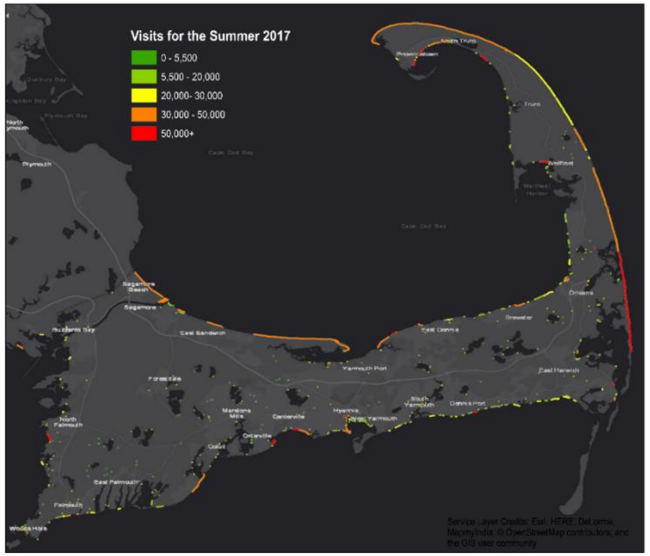
Recreation & Water Quality -- Survey

-- Lost $ for Beach Closures



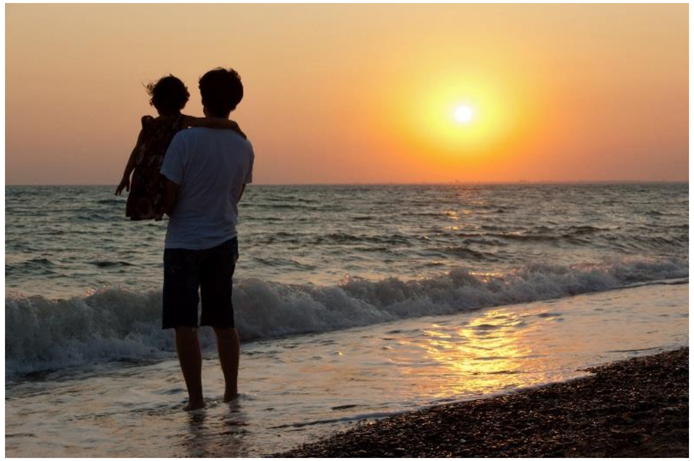
-- Visitation Estimation

Cell data --



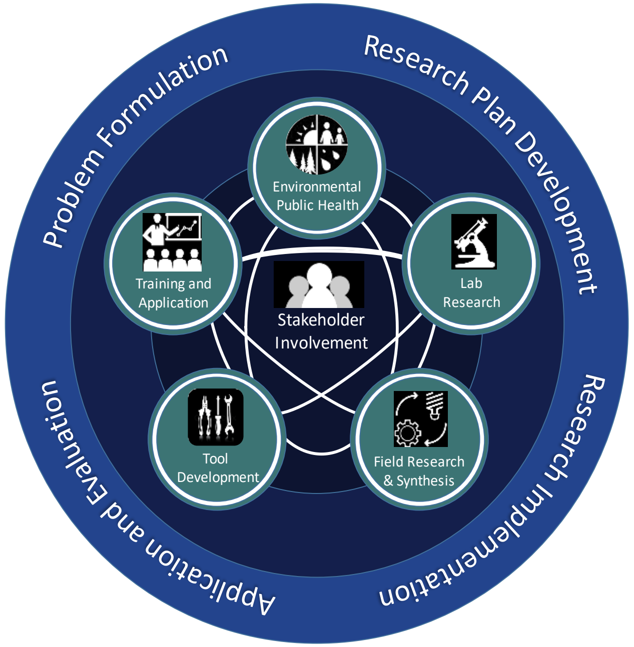
How will this information be used?

- Enable communities to:
  - Understand water resource vulnerability
  - Identify options that balance social and economic costs with environmental benefits
- Facilitate adaptive management of resources to improve resilience
- Transferability of approach to other locations
- Foundation for ORD Translational Science Pilot



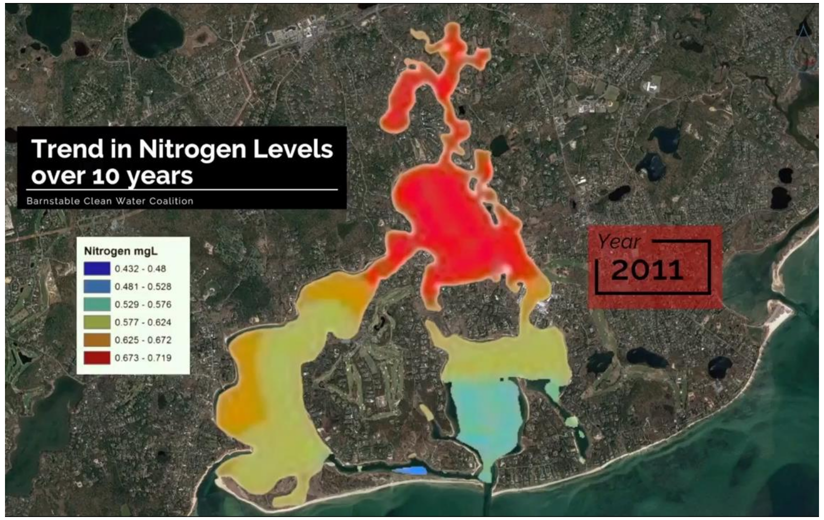
Focusing Research to Develop Science-based Solutions

- **Translational science**
  - –Genesis in public health (R&D to clinical outcomes)
  - –Study of how to move from bench research to real solutions
  - –Necessarily interdisciplinary
- **Solutions-driven research**
  - –Emphasizes stakeholder engagement
  - –Integrates activities to ensure science-based solutions
  - –Coordination, communication & collaboration are integral components
  - –Applies results of translational science to achieve better outcomes



Solution-Driven Research
Translational Science Pilot: Nutrients

- Inform watershed-based solutions for non-point source nutrient loading using non-traditional interventions
- Pilot solution-driven research approaches:
  - Actively engage stakeholders throughout the research cycle
  - Target research outputs that are most important to stakeholders
  - Assist partners' goal to solve their nutrient problem
  - Develop an approach to transfer solutions
- Evaluate effectiveness
  - Approaches to stakeholder engagement
  - Effectiveness of problem identification and formulation
  - Effectiveness of science-based solutions
  - Extent stakeholder needs are met



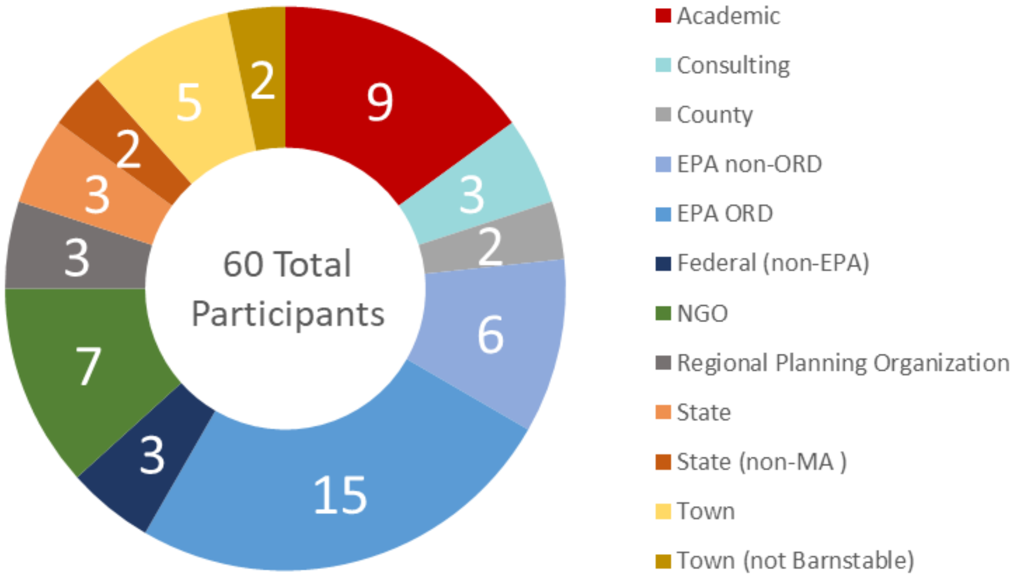
Specific Case: Three Bays Watershed

- Key stakeholder: Barnstable Clean Water Coalition
  - Promote watershed-based solutions to TMDL
  - Seek non-traditional solutions to N loading reduction
  - Committed to be a national model
  - Need cost-effective science-based solutions
- Multiple federal, state and local partners engaged

Current Loads: 46,221 kg/year
Reduction Target: 46% or 21,261 kg/yr

Problem Formulation Workshop

- Problem Formulation Workshop conducted to identify key needs
  - Conversation among stakeholders & scientists
  - Ensure clear & comprehensively understanding of problem
  - Elicit questions, concerns, interests of stakeholders
  - Inform development of research to address problem
- Outcomes
  - Clarified key knowledge gaps & research needs
  - Identified potential research contributions of partners
  - Build foundation of relationships & trust
  - Identified opportunities for transferability
  - Lessons learned for Translational Science

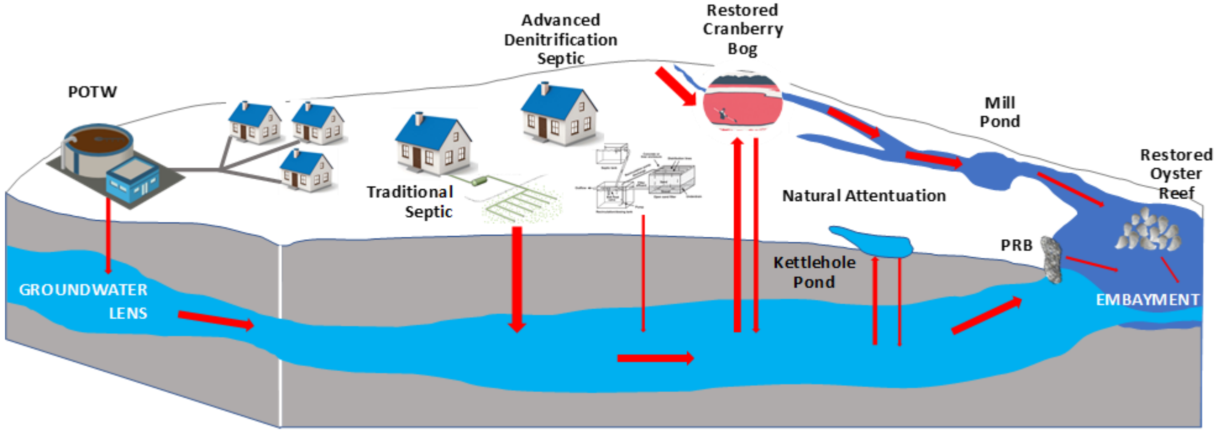


Moving from Problem Formulation to Research Planning

- **Goal:** Develop a comprehensive approach to reduce nitrogen loading to meet the TMDL in Three Bays and identify best practices suitable for use across Cape Cod and throughout the country.
- **Objectives**
  - **Phase 1:** Pilot a suite of Interventions and evaluate their performance and utility at localized scales (effectiveness, cost and cost effectiveness ($/Kg-N))
    - Actively engage with stakeholders and strategic partners throughout research planning
    - Integrate social science with intervention evaluation
    - Focus of near term research
  - **Phase 2:** Implement an integrated suite of interventions at a scale sufficient to achieve N-reduction goals in a sub-watershed (Marston's Mill)

Phase 1: Baseline Monitoring and Pilot Interventions

- Baseline monitoring
  - Groundwater, surface water, benthic condition
- Pilot Interventions – integrate social science
  - Innovative Alternative Septic Systems
  - Permeable Reactive Barriers
  - Shellfish
  - Cranberry bog restoration
  - Mill pond restoration
  - Dredging
- Social Science
  - Economics of water quality
  - Social acceptance of interventions
  - Decision support



Summary

Multifaceted approach to addressing coastal nutrient problem

Support the ***development of sensors*** to lower costs and improve performance data for ***innovative septic systems***

Social-Ecological System research

Solutions-Driven Science: ***Nutrients Translational Science Pilot***

- Continuous engagement of stakeholders throughout the research process
- Identify research outputs that are most important to stakeholders
- Assist partners' goal to solve their nutrient problems
- Evaluate how effective the translational science process is working
- Transferability

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