



# Cross-EPA Nitrogen Research & Policy Integration

*Anne W. Rea, Ph.D.  
Office of Research & Development  
SAB/BOSC review  
July 10-11, 2012*

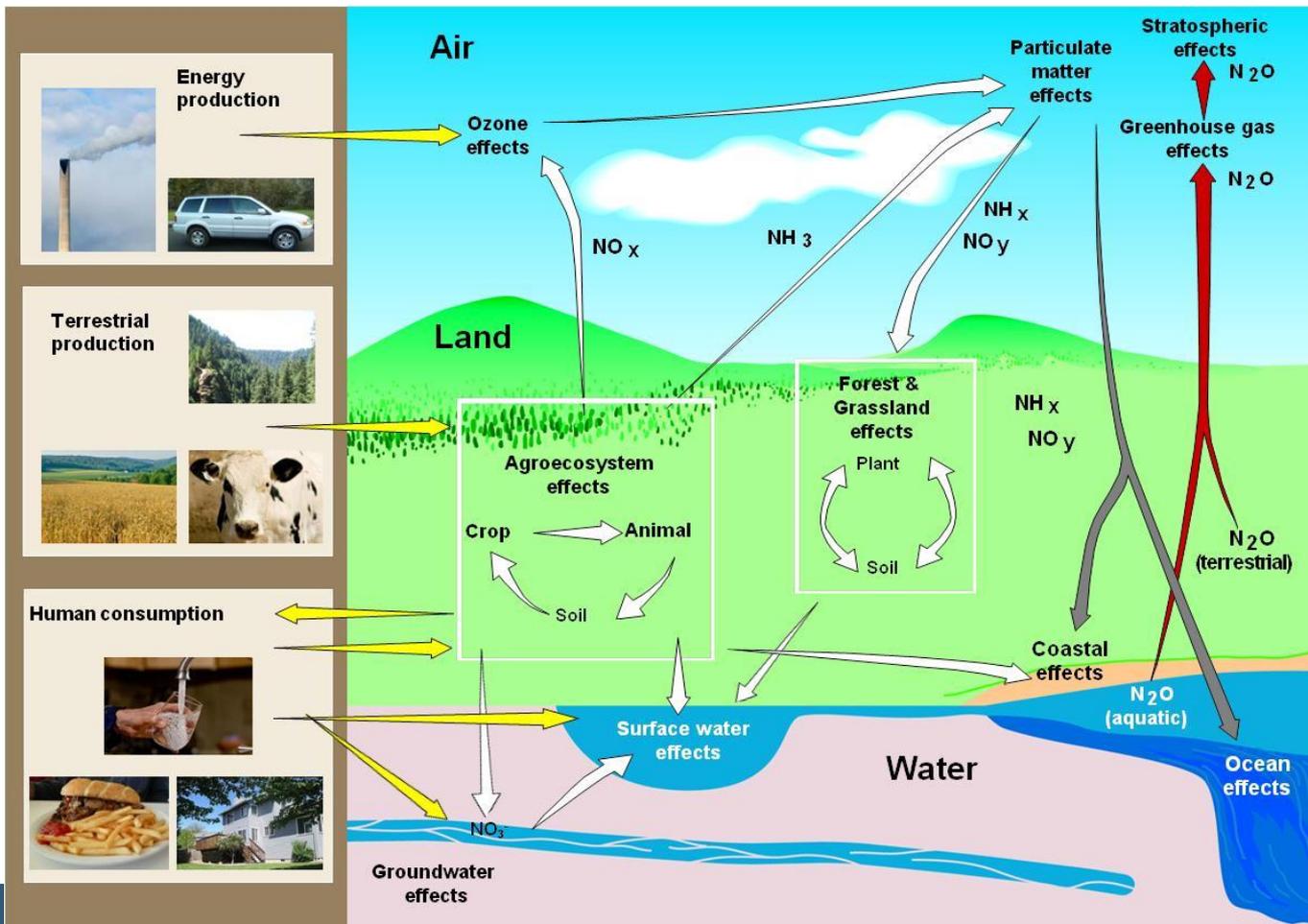


- SAB's recommendations to EPA for science-policy integration to achieve nitrogen loading reductions
- Cross-EPA Roadmap for Integrating Nitrogen & Co-Pollutant Research & Policy

**Problems cannot be solved at the  
same level of awareness that  
created them.  
– *Albert Einstein***

# The Nitrogen Cascade

## Community Level Decisions



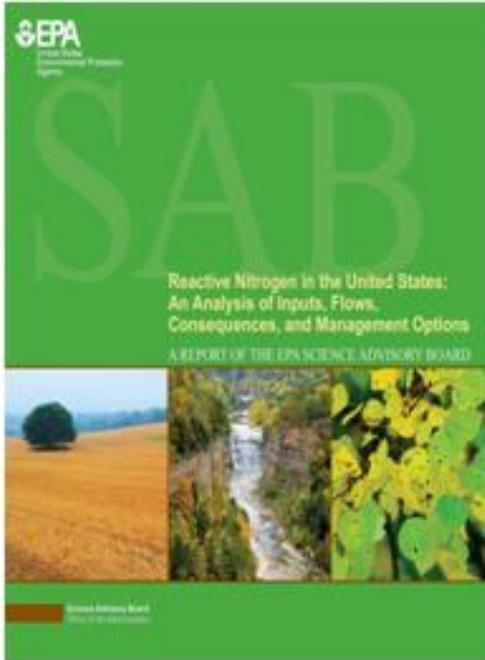
## Policy Levers

**OAR: NAAQS:**  
PM,  $\text{O}_3$ ,  $\text{NO}_x$ ,  
 $\text{SO}_x$ ; Title IV,  
mobile sources,  
Clean Air  
Interstate Rule

**OW:** Framework for  
State Nutrient  
Reduction,  
National Nutrient  
Management Strategy  
TMDLs,  
Nutrient Criteria,  
drinking water MCLs,  
DO, hypoxia

# SAB: Reactive Nitrogen ( $*N_r$ ) in the United States

## Four Overarching Recommendations for EPA



1. Employ an integrated approach to the management of  $N_r$
2. Utilize adaptive management & monitoring to improve cost effectiveness & lower implementation costs
3. Establish an intra-Agency  $N_r$  management task force
4. Convene an inter-agency  $N_r$  management task force

***\* $N_r$  includes all biologically active, chemically reactive and radiatively active nitrogen compounds***

[http://yosemite.epa.gov/sab/sabproduct.nsf/WebReportsLastMonthBOARD/67057225CC780623852578F10059533D/\\$File/EPA-SAB-11-013-unsigned.pdf](http://yosemite.epa.gov/sab/sabproduct.nsf/WebReportsLastMonthBOARD/67057225CC780623852578F10059533D/$File/EPA-SAB-11-013-unsigned.pdf)

# Initial Responses to SAB

- **Administrator's response (3/23/2012):**
  - *Commends the committee for its comprehensive overview...*
  - *Reviewing the committee's proposal...ask that the proposal be discussed in the context of future intra-agency and interagency efforts.*
- **Informal Intra-Agency EPA N<sub>r</sub> Task Force**
  - N team (ORD, OW, OAR, Regions)
    - Ongoing discussions, briefings for senior Agency officials, seminars multi-day workshops
  - Foundation for developing a path toward nitrogen research & ***policy integration***
- **Inter-Agency N<sub>r</sub> Task Force:**
  - USDA, USGS, etc.



# Current Research Program Outputs (examples)

## **Safe & Sustainable Water Resources**

- Support for development of numeric nutrient criteria for inland & coastal waters

## **Sustainable & Healthy Communities**

- Synthesis of information on N impacts on ecosystem services for air & water regulatory needs (terrestrial & aquatic)

## **Air, Climate & Energy**

- Linked modeling system that connects key elements of the N cascade across air, land & water

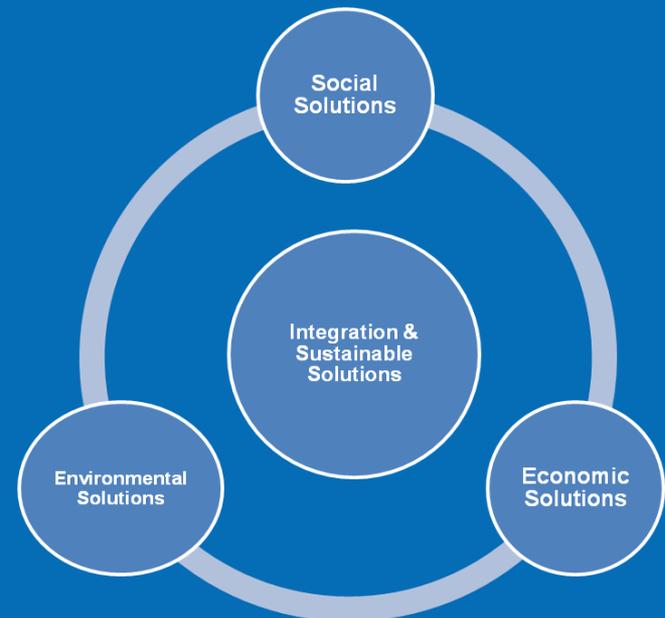
## **Human Health Risk Assessment**

- ISA for NO<sub>x</sub>SO<sub>x</sub> secondary NAAQS

## **STAR Grants**

- Model simulations predicting a shift in hydrology, resulting in acidification of soil and stream water and deterioration of water quality in forested watersheds

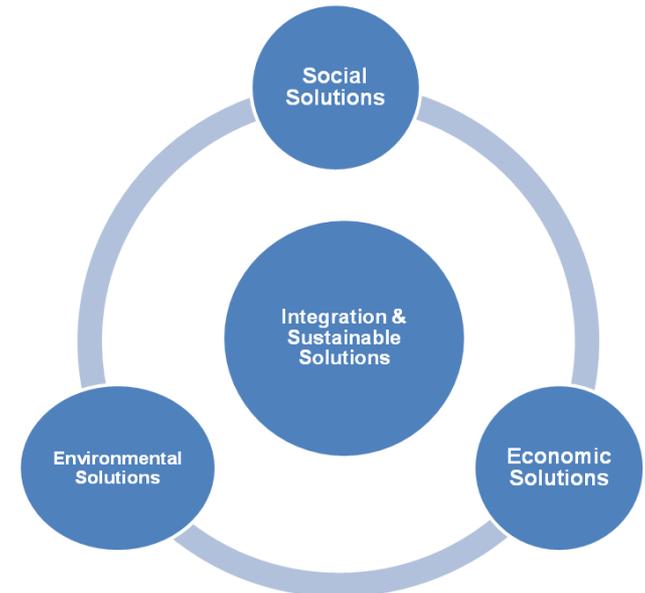
# EPA N Roadmap: Integrating Research & Policy to Achieve Sustainable Nitrogen & Co-Pollutant Management



# Cross-EPA Nitrogen Research & Policy Integration

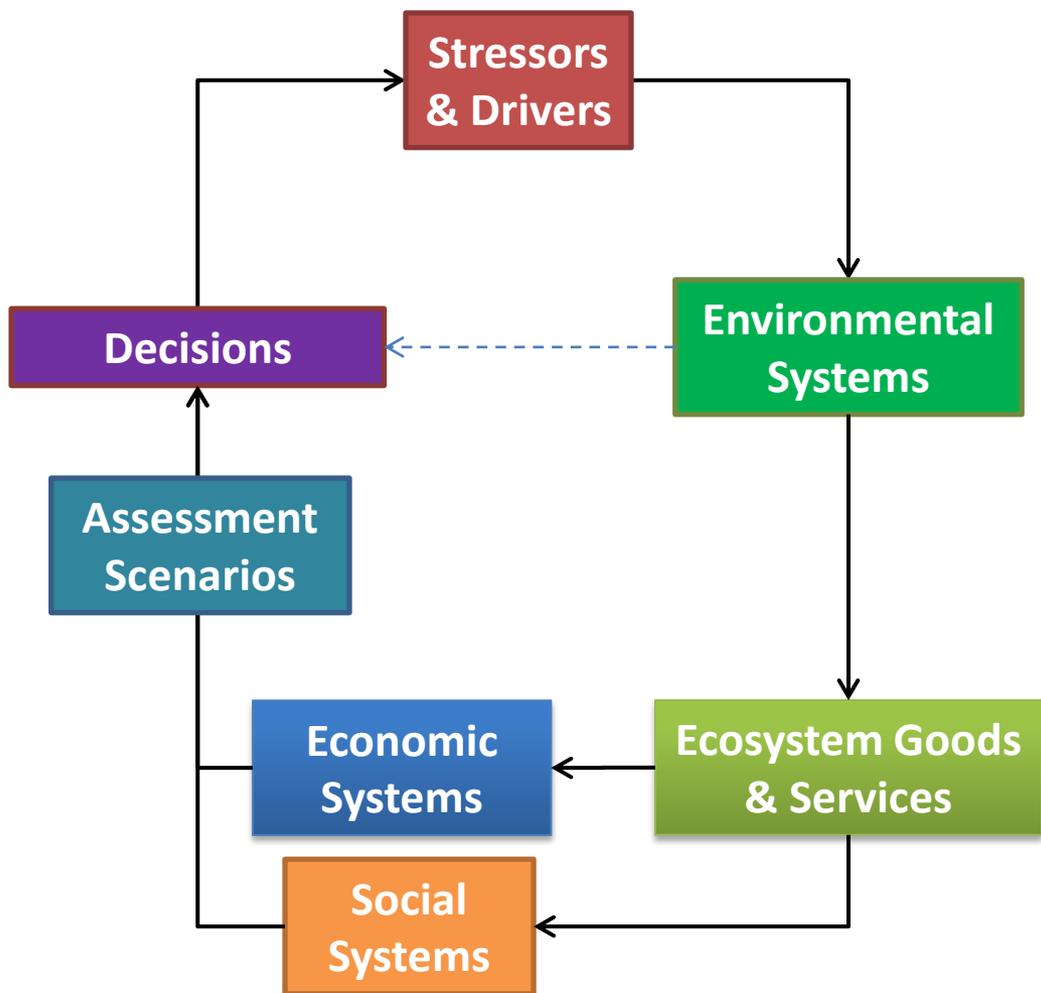
Significant reductions in  $N_r$  loadings are necessary to meet air & water quality goals.

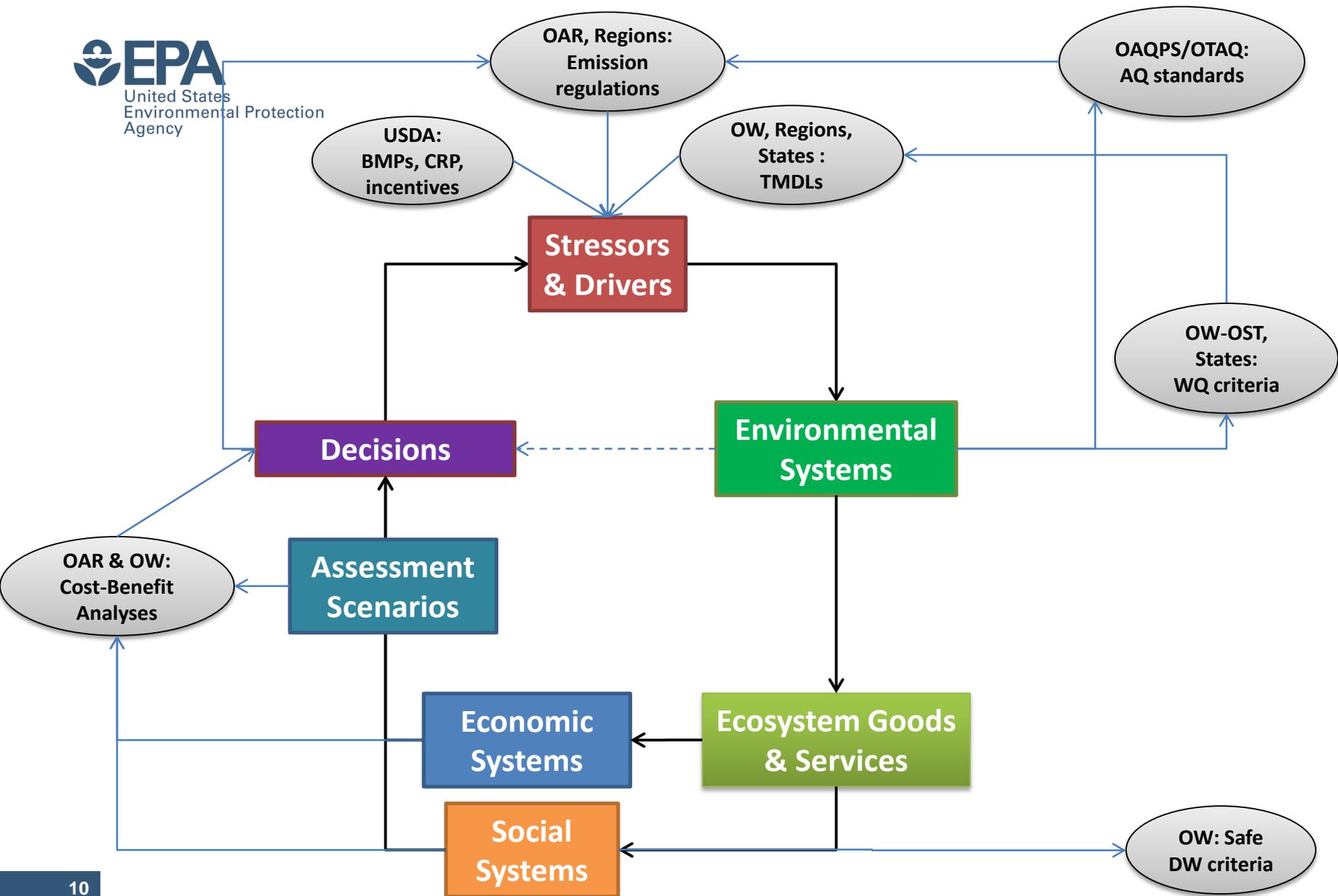
- **Key Question:** What would be the most economically efficient, socially acceptable & environmentally sound way to do this?
- **Vision:** A one-EPA perspective on sustainable nitrogen & co-pollutant management
  - Optimizes uses of nitrogen
  - Reduces environmental & health impacts
  - Maximizes benefits to society
- **Needs:** Variety of tools, range of scales, cost effective & practical



# Sustainability: Triple Bottom-Line

## Environmental, Economic & Social Systems

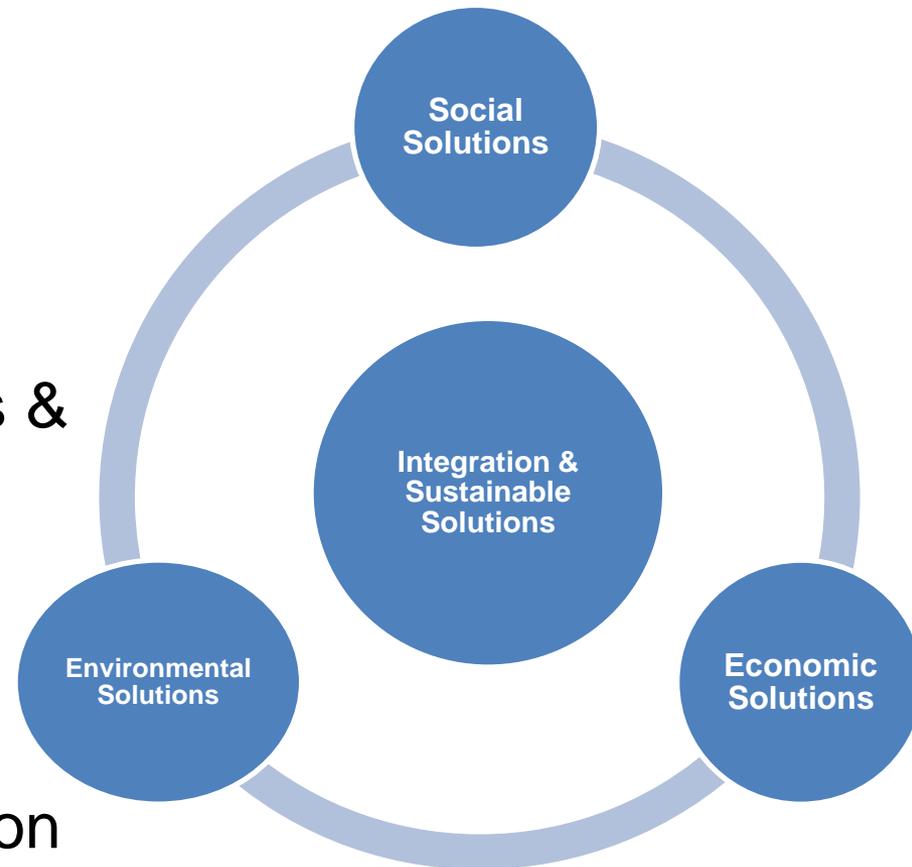






# Roadmap Outline

- Roadmap Goals
- Background & rationale
- Vision for integration
- Approach
- Inventory of Air/Water policies & ORD research
- Sustainable solutions for managing Nr
- Hypoxia & Mississippi River Basin: focus area for integration
- Synthesis: value to research programs and Program Offices



- Recognized need for integration across EPA & beyond
- Several ongoing projects w/in current research programs address nitrogen & co-pollutant issues
- Cross-EPA effort to develop N Roadmap
- External communications/collaborations needed

# Appendix:

## *Examples of Current N-related ORD Research*

**SSWR**

**Safe & Sustainable Water Resources**

**SHC**

**Sustainable & Healthy Communities**

**ACE**

**Air, Climate & Energy**

**HHRA**

**Human Health Risk Assessment**

*Note: A more extensive project list is found in the  
Table of ORD nitrogen & co-pollutant research projects (provided)*



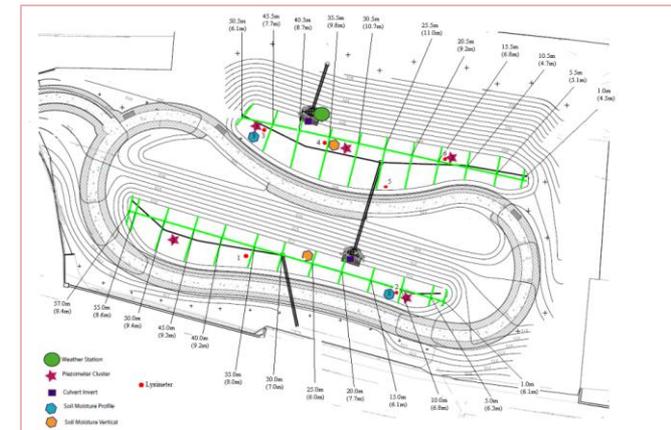
# Determine Integration of Green Infrastructure in Communities

- CSO mitigation through multi-scale implementation of GI in communities

Develop effective integrated green & gray approaches at sewershed scale to reduce Combined Sewer Overflows (CSOs)

- Place based & experimental monitoring of green & grey infrastructure best management practices (BMPs)

Identify key data gaps regarding BMP performance



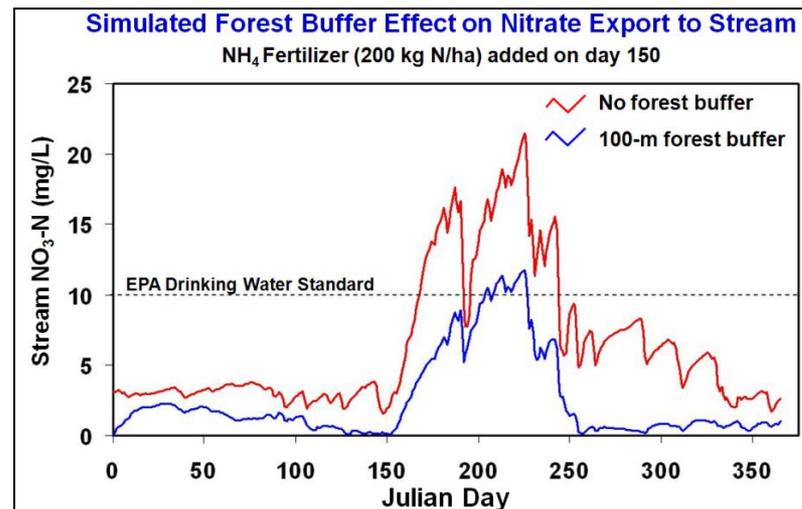
# Determine Integration of Green Infrastructure in Communities

- Incorporate stormwater management practices into watershed modeling tools

Reliably predict natural infrastructure & engineered green infrastructure water quality impacts at watershed scale.

- Develop statistical & process models of natural green infrastructure

Reliably predict natural infrastructure & engineered green infrastructure water quality

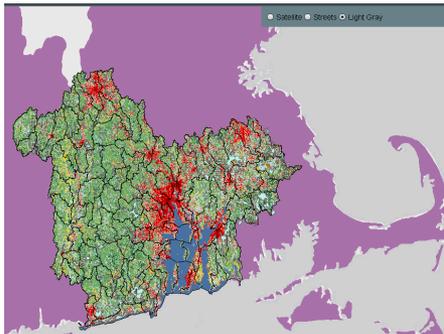
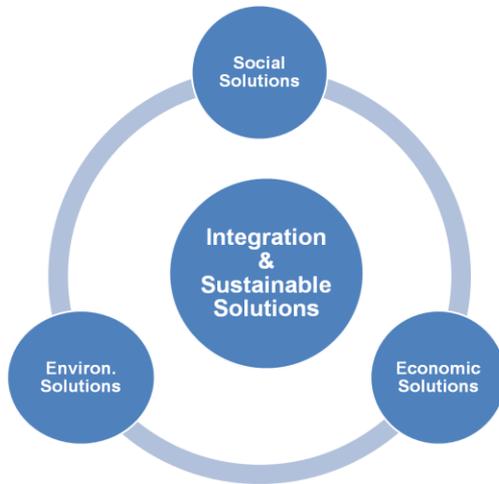


# Narragansett Bay and Watershed Sustainability - Demonstration Project

SHC

ACE

**Goal:** Informing more holistic & integrated nutrient management decisions to maintain/improve human well-being & ecosystems

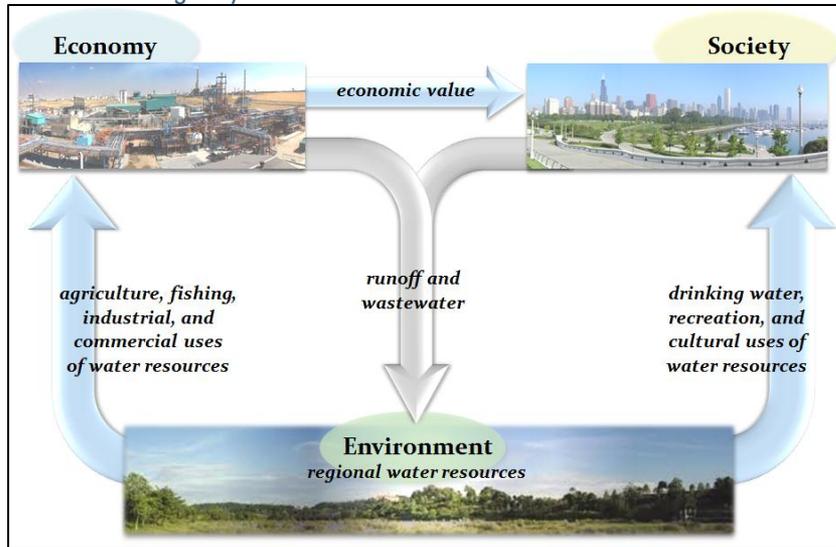


- **Retrospective:** A systems analysis of Narragansett Bay, its watershed, and its stressors: the cumulative effects of previous management decisions on current ecosystem integrity.
- **Contemporary:** Determine how drivers of change & disturbances/enhancements specifically related to nutrients affect ecosystem structure & function.
- **Prospective:** A comprehensive systems management approach to achieve a sustainable Narragansett Bay & its resources (includes MA & RI components of the watershed).
- R&D designed to inform key governance decisions
- Approach & decision support tools that can be adapted for use elsewhere

## Other SSWR Nutrient-Related Projects

- **Southern New England Technology/Policy Innovation Hub – title TBD**
  - Public-private forum to develop sustainable solutions to nutrient pollution & estuarine restoration
  - Promote innovative technologies for nutrient control & management
- **Region 1/ORD Sustainability Pilot:**
  - Policy “triple value” simulation tool drawing from available models, databases & stakeholder input (available autumn 2012)
  - Systems analysis of scenarios assessing how combinations of interventions (e.g., green infrastructure/low impact development, wastewater treatment facilities, and bio-harvesting) affect economic, social & environmental indicators over time

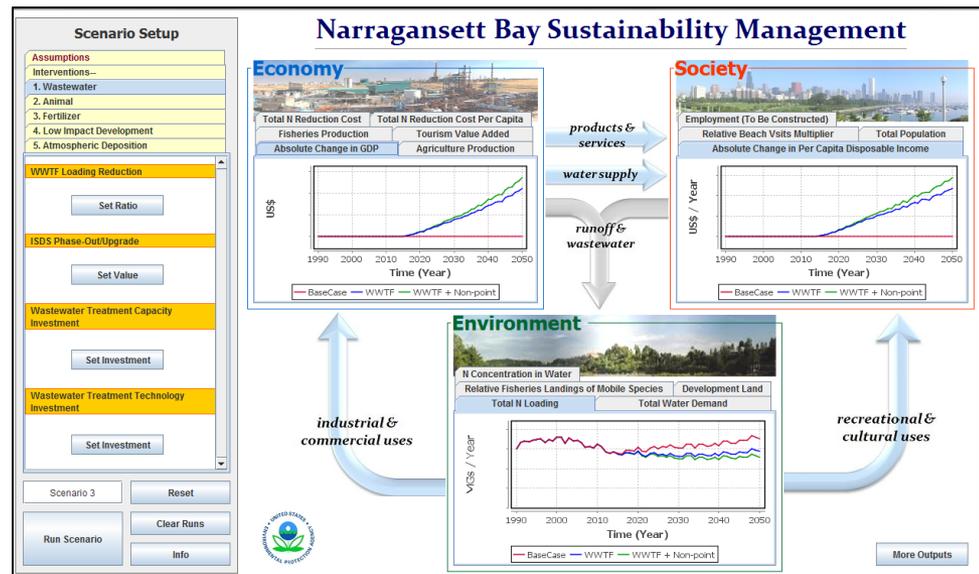
# ORD/R1 Narragansett Bay Sustainability Pilot



The triple value framework shown on the left examines relationships among economic, social & environmental systems helping users to consider holistic sets of interventions

- Reducing both nitrogen loadings & stormwater runoff
- Exploring increased uptake of nitrogen through bio-harvesting of shellfish
- Managing future impacts of climate change & population growth

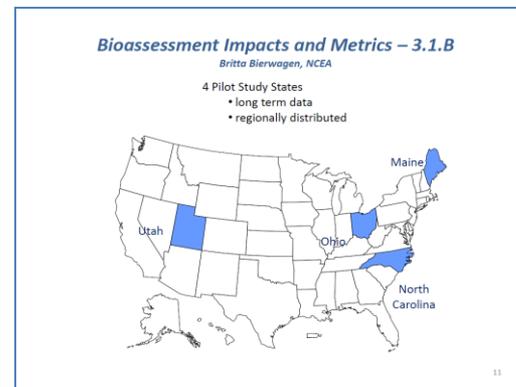
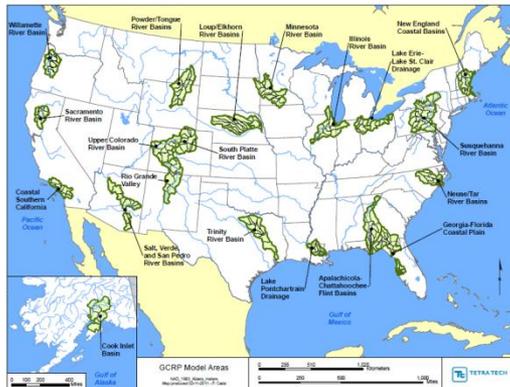
The tool includes a user friendly interface shown on the right that allow users to test a variety of “what-if” scenarios & trace directional impacts on indicators over time



- Indicators include economic, social, & environmental outcomes, for example:
  - Employment, shellfish production
  - Beach visits, property values
  - Phytoplankton, eel grass levels

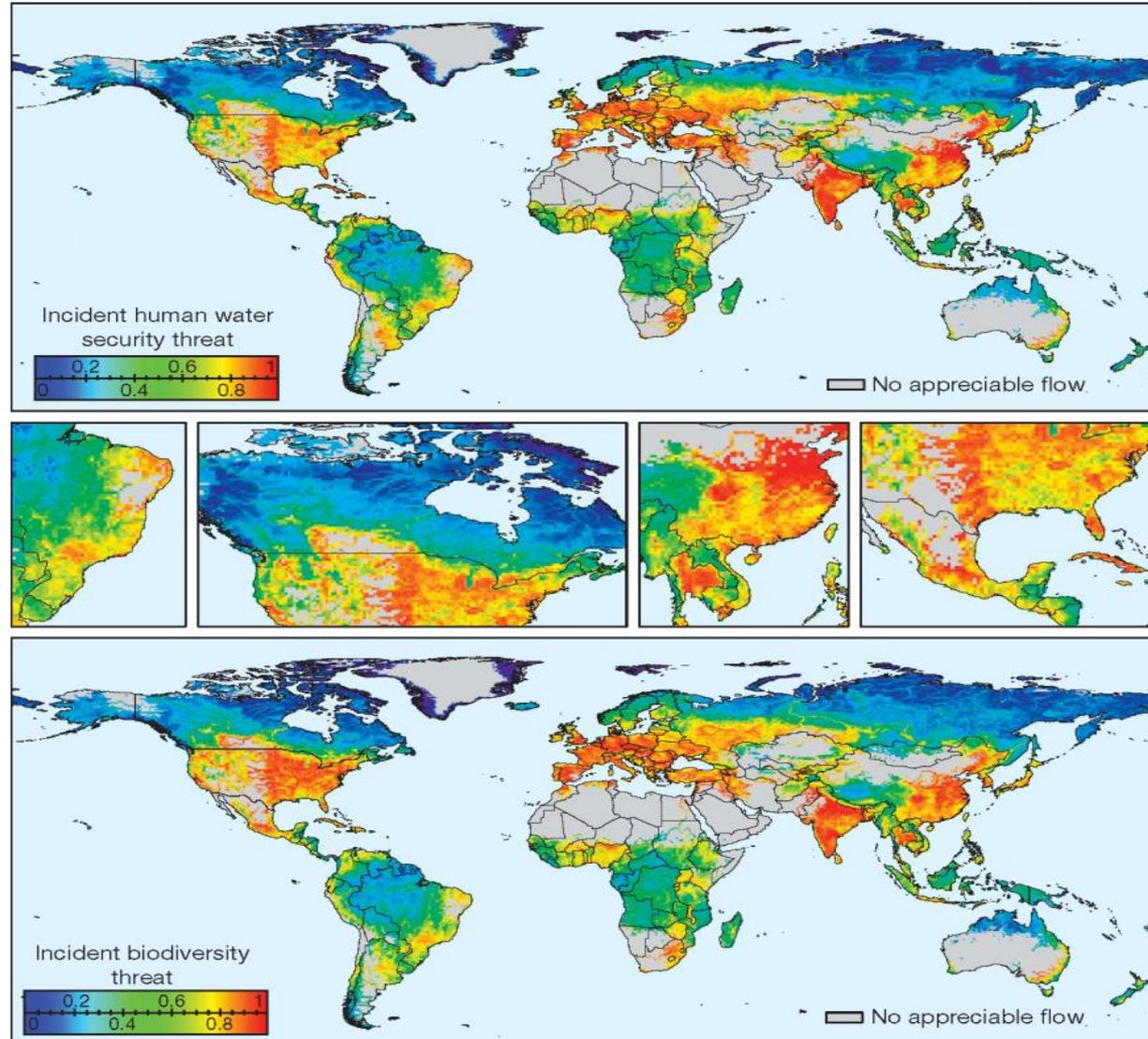
## Also SHC

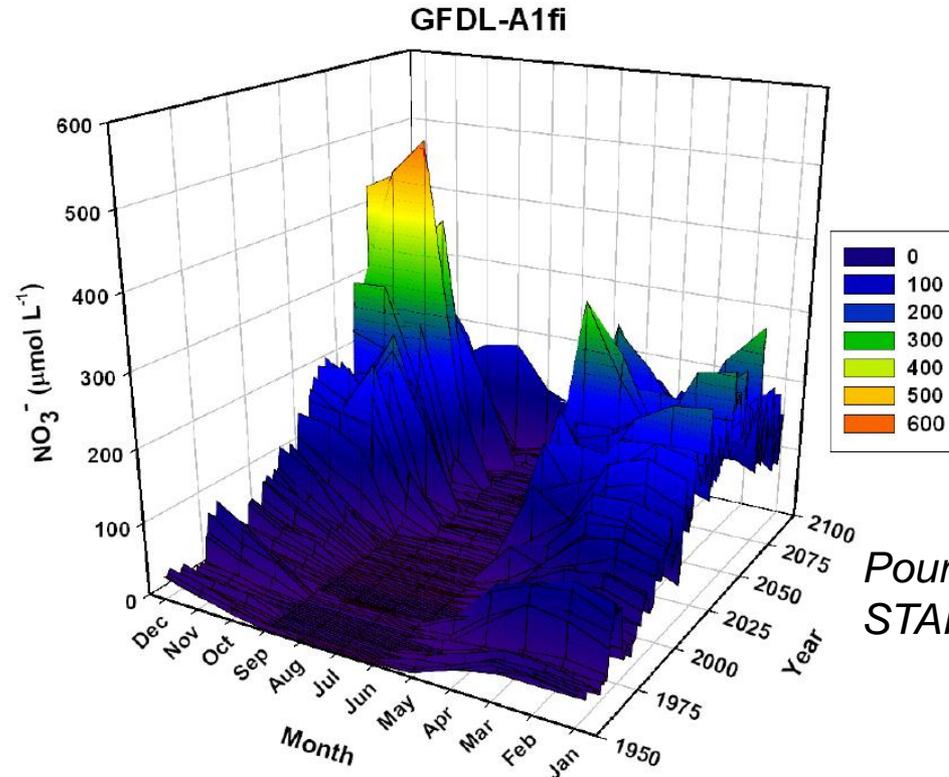
- Watershed Modeling to Assess Hydrologic & Biogeochemical Sensitivity to Climate & Land Use Change  
 Assess sensitivity of U.S. streamflow, nutrient (N & P), & sediment loading to climate change across a range of plausible mid-21st Century climate futures
- Vulnerability of Water Quality Regulatory Programs to Climate Change  
 Identify climate change threats to water quality standards & bioassessment programs



23 environmental stress factors used to identify water security threats to both human society and biodiversity.

- Uncovered a pandemic syndrome of risk to rivers.





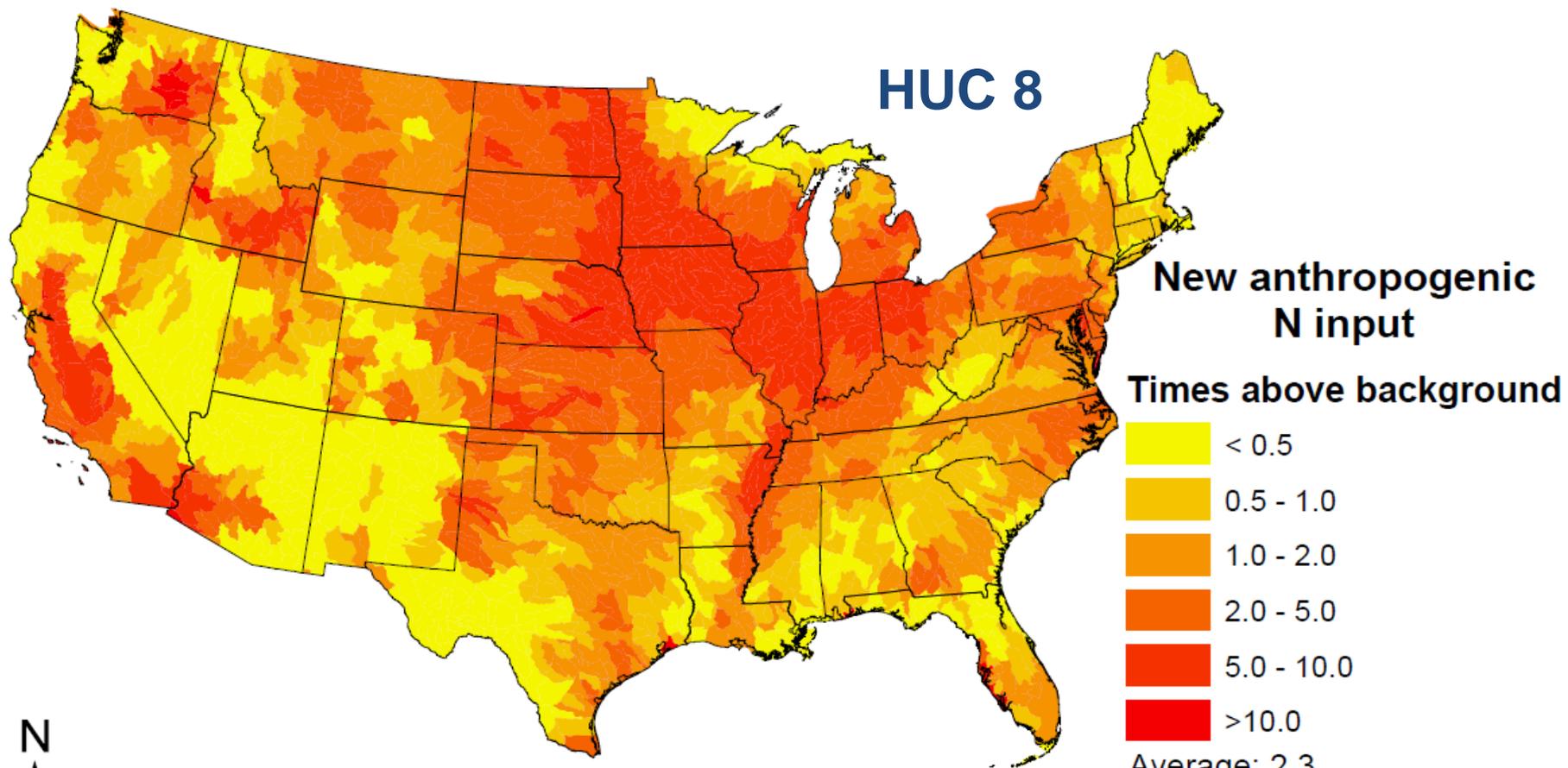
*Pourmokhtarian et al., 2012*  
STAR Grant: 834188

## Concentrations of Nitrate in Stream Water

NOAA Geophysical Fluid Dynamics Laboratory model CM2.1, A1fi (fossil fuel-intensive)

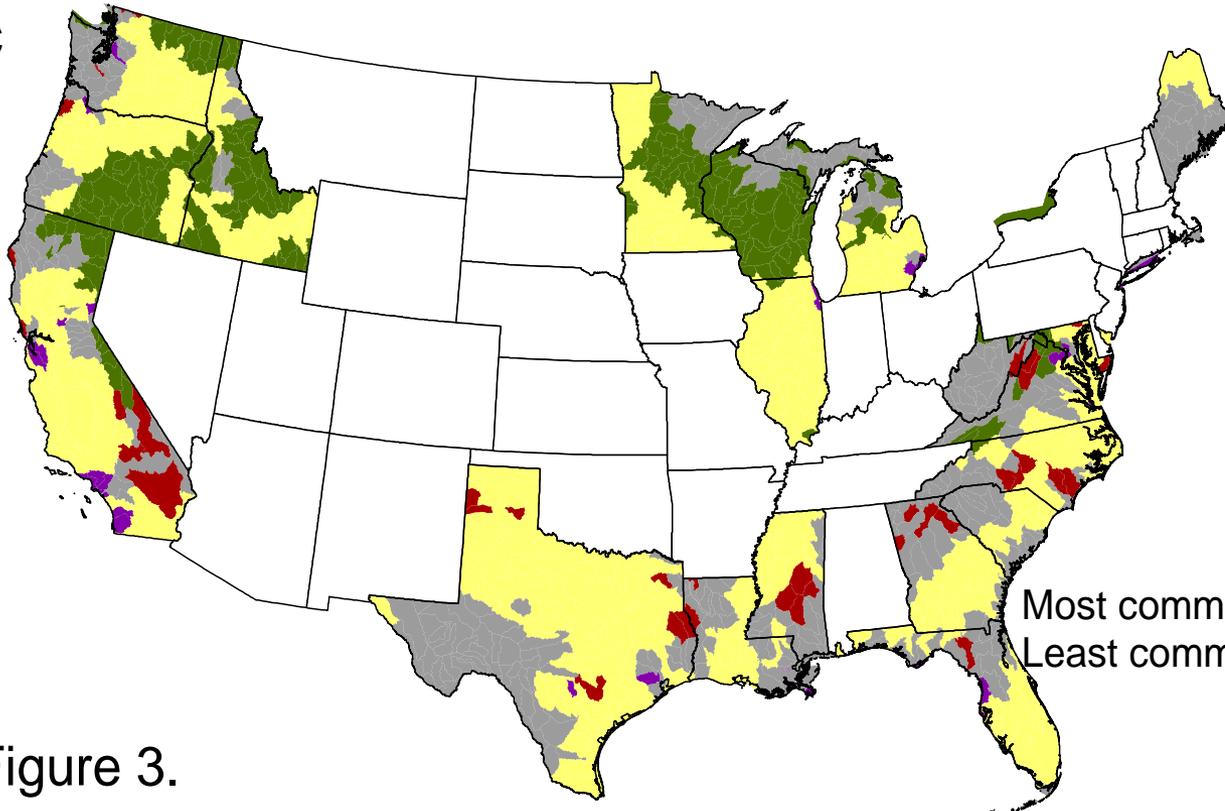
Model simulations under climate change displayed a shift in hydrology characterized by later snowpack development, earlier spring snowmelt, greater evapotranspiration, and a slight increase in annual water yield. Under elevated temperature, net soil nitrogen mineralization and nitrification was simulated to increase markedly, resulting in acidification of soil and stream water and altering the quality of water draining from forested watersheds.

# Human-driven Increases in $N_r$ : Spatial Pattern



# N<sub>r</sub> Sources to HUC 8 Watersheds

**C**



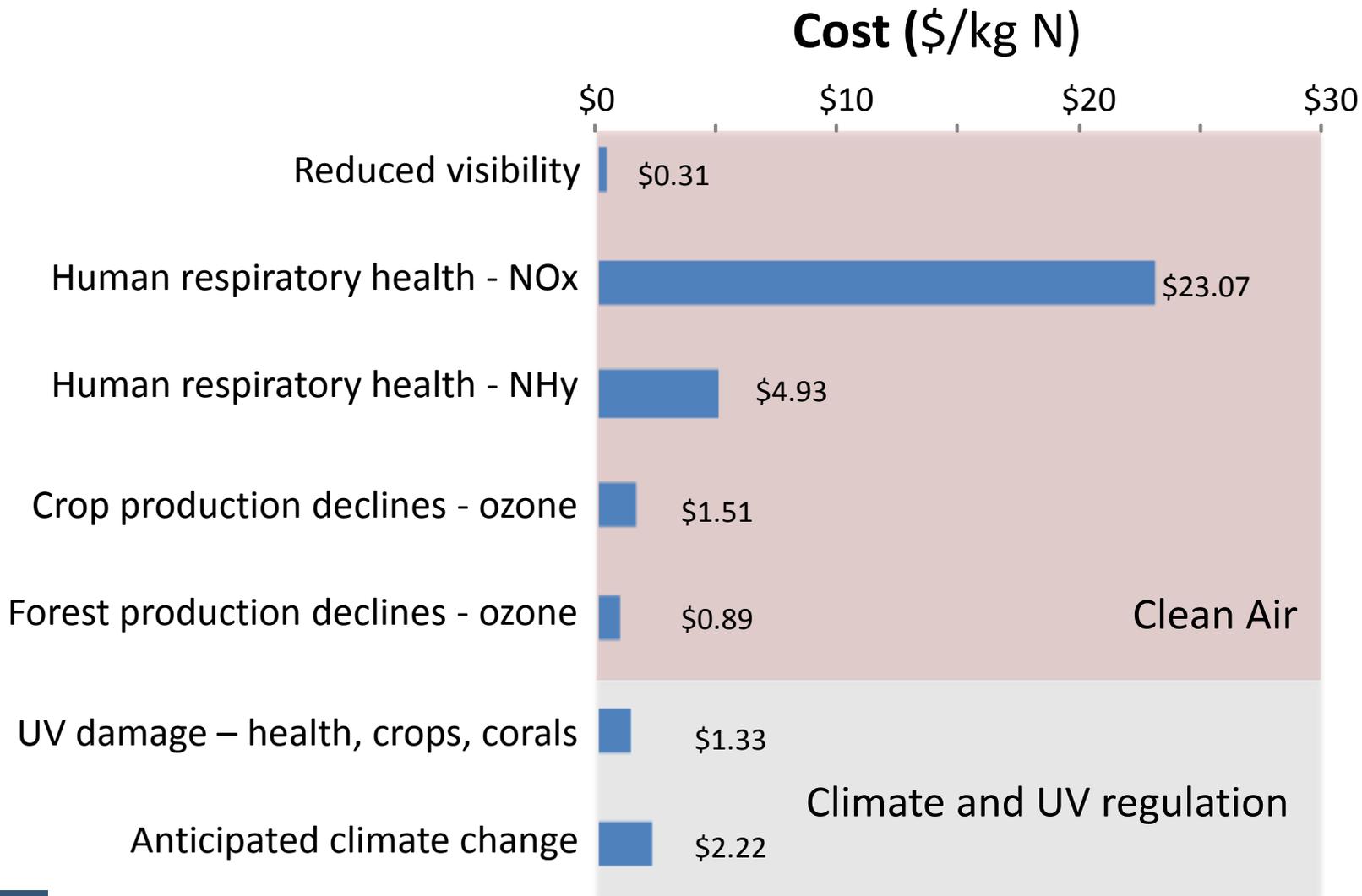
## Largest anthropogenic N source

-  Synthetic fertilizer
-  Agricultural BNF
-  Atmospheric deposition
-  Confined feedlot manure
-  Centralized sewage

Most common: Synthetic fertilizer (890 HUCs)  
Least common: Centralized sewage (35 HUCs)

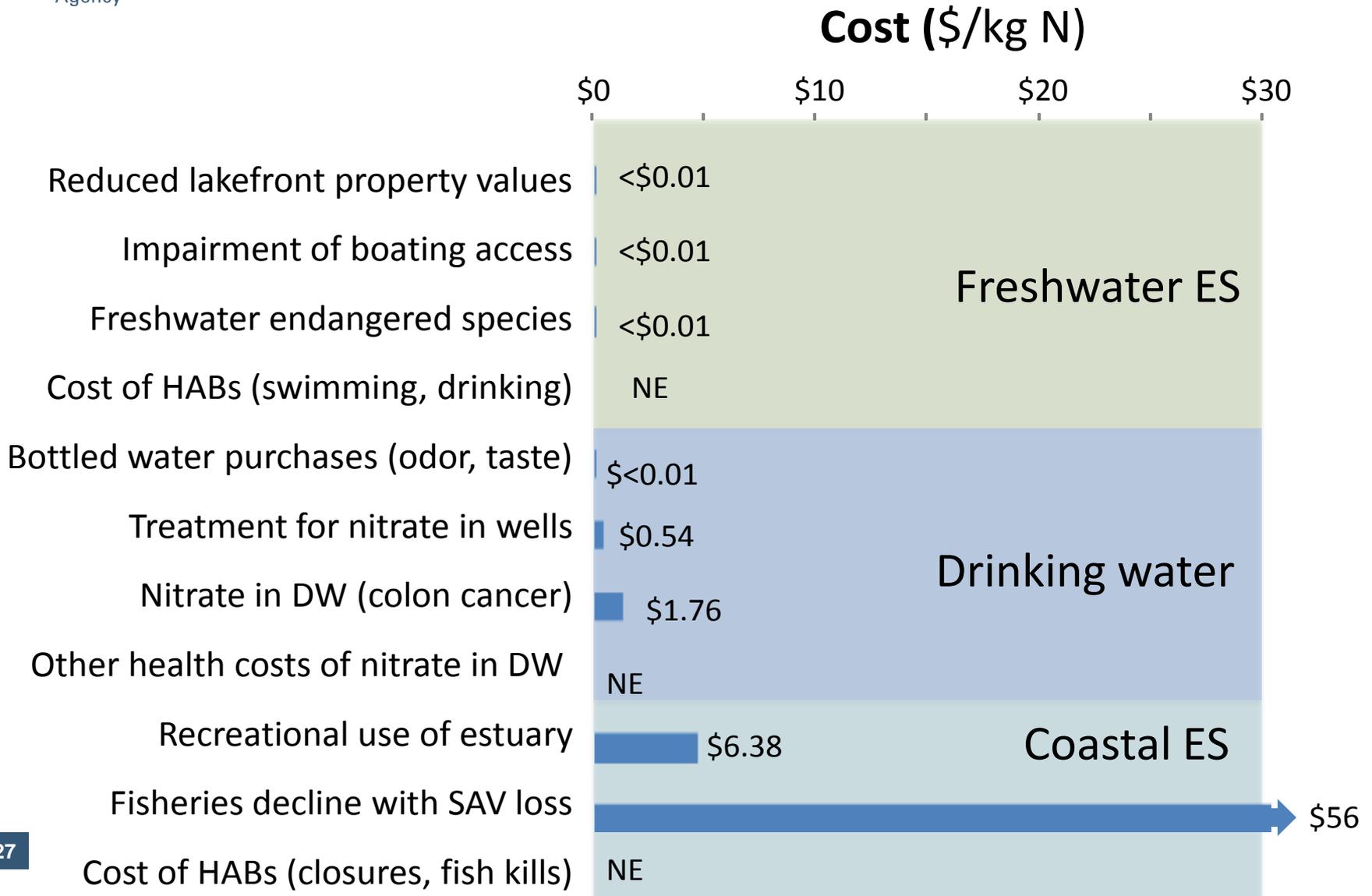
Figure 3.

# Damage to Air Ecosystem Services



*Compton et al. 2011 Ecology letters*

# Damage to Water Ecosystem Services

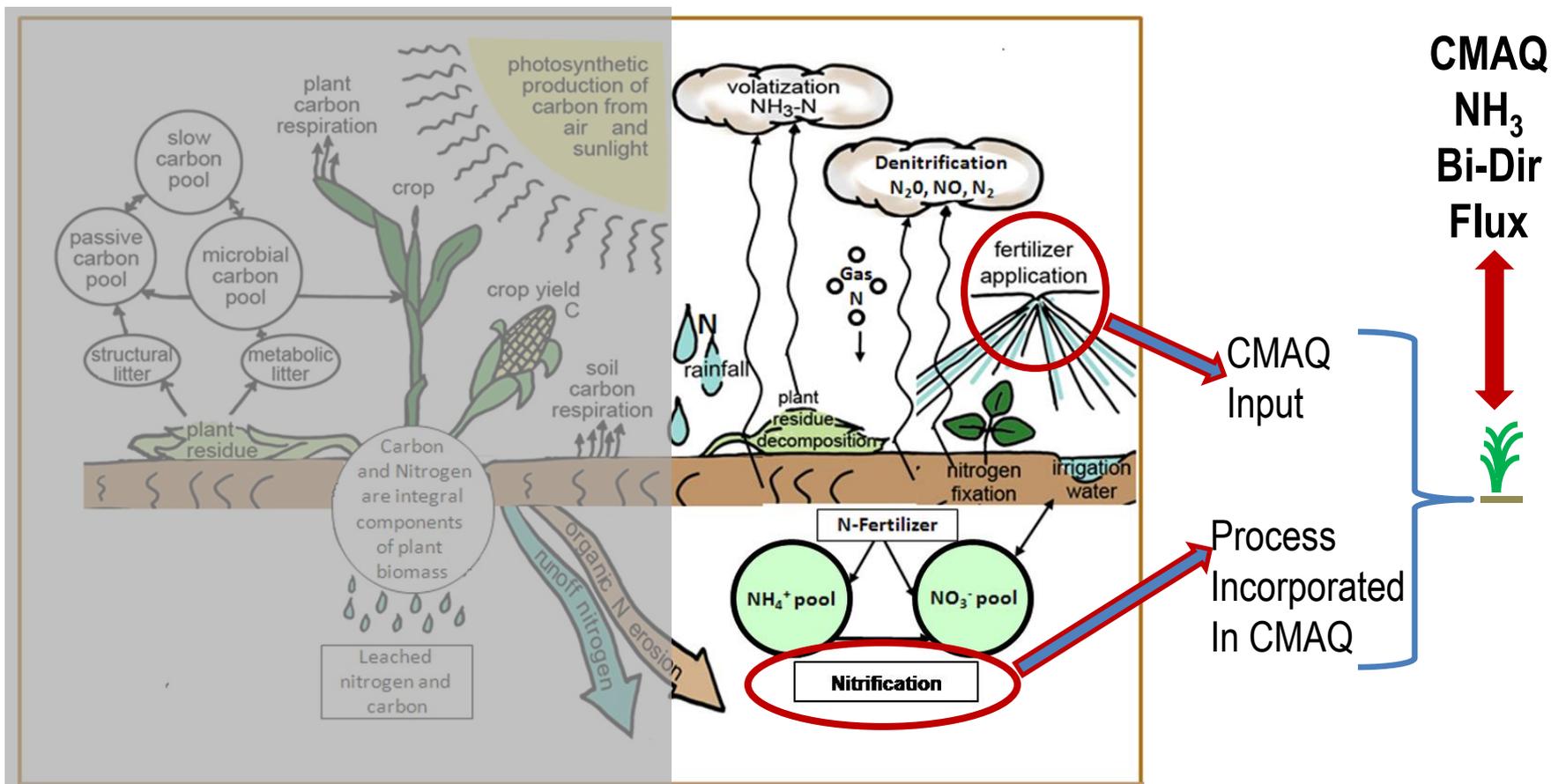


# Nitrogen Removal by Major Classes of Wetlands in the Contiguous US

Class	Area (km <sup>2</sup> )	Mean Nr load (g/m <sup>2</sup> /yr)	Mean efficiency	Total Nr removal (mT/yr)
Estuarine	18,501	17.75	0.333	133,550
Fresh marsh	105,813	98.65	0.493	4,746,098
Swamp	210,564	8.62	0.627	923,493
<b>Total</b>	<b>406,270</b>			<b>5,803,140</b>

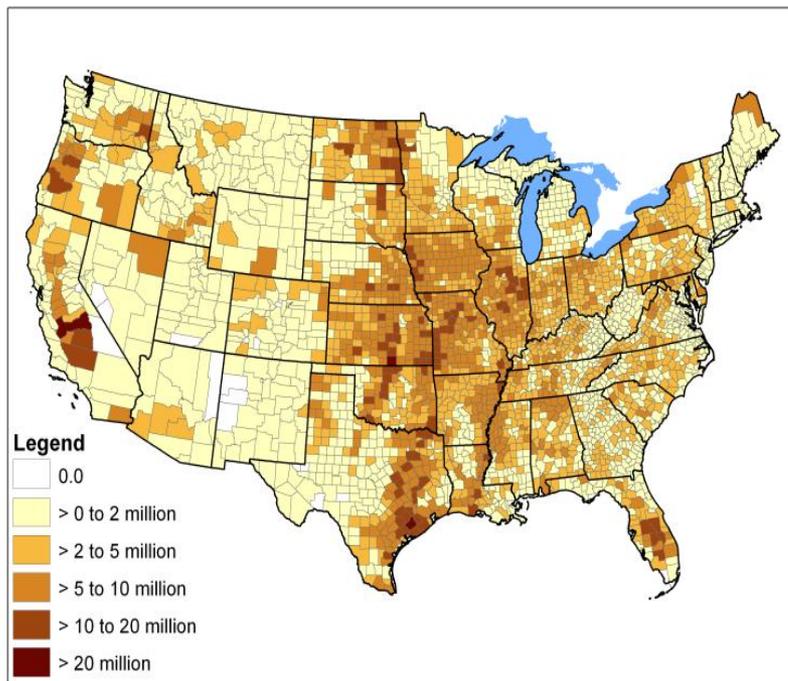
*Total removal is ~20% of total anthropogenic load*

# National Scale Fertilizer Application (USDA EPIC) Coupled to NH<sub>3</sub> Bi-directional Air-Surface Exchange



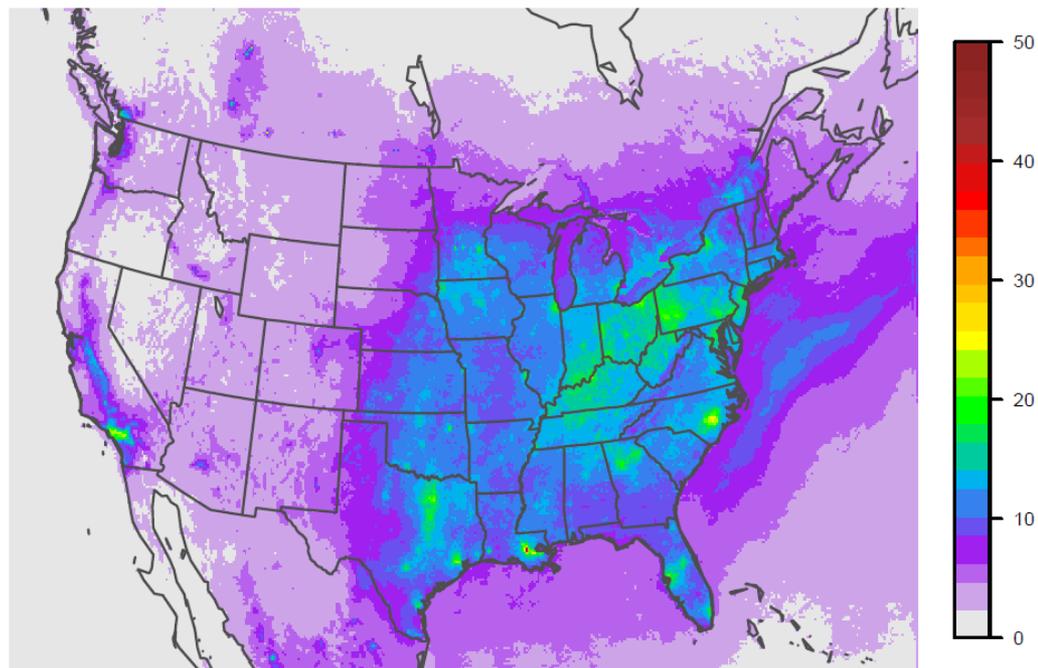
# Parameterizations Are Developed and Implemented at the Continental Scale

Preliminary EPIC Fertilizer Demand (kg)



Based on County Ag Crop Plant Demand

Research Version  
CMAQ with Bi-Directional  $\text{NH}_3$   
2002 Total N Deposition (kg-N/ha)



EPIC = Environmental Policy Integrated Climate Model

# Atmospheric Deposition Tools To Inform the Secondary NAAQS

Field measurements of air surface exchange processes  
& speciated deposition budgets of N & sulfur  
compounds & ozone in key ecosystems



Models of air-surface exchange based  
on field measurements generalized for  
incorporation into regional air quality  
models



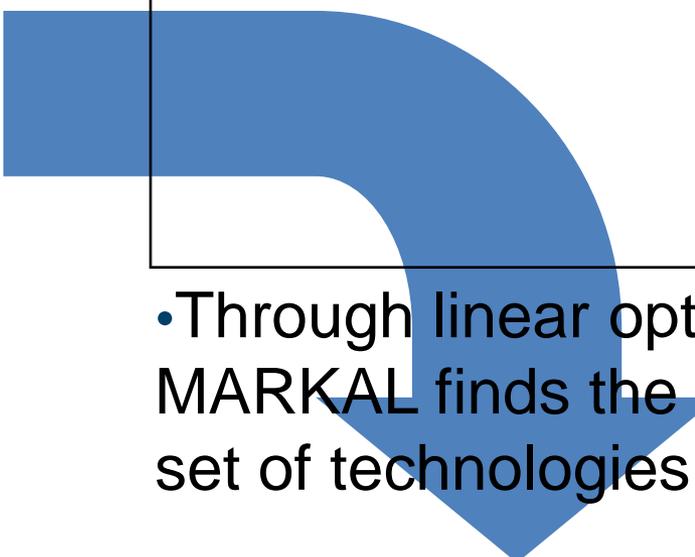
CMAQ refined air-surface flux  
& evaluation data sets  
New step:  $\text{NH}_3$  bi-directional exchange

NAAQS: Empirical air concentration  
to deposition transfer functions

# Impacts of Energy Technology Change With MARKet ALlocation (MARKAL)

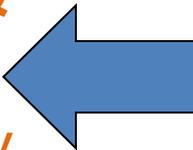
## MARKAL Inputs:

- Future-year energy service demands
- Primary energy resource supplies
- Current & future technology characteristics
- Emissions and energy policies



• Through linear optimization  
MARKAL finds the least cost  
set of technologies

**CMAQ**  
Air  
Quality,  
Deposition



## MARKAL Outputs:

- Technology penetrations for meeting industrial, residential, commercial, and transportation demands
- Fuel use by type & region
- Sectoral & system-wide emissions
- Marginal fuel & emissions reduction prices

- Development of Integrated Science Assessments (ISA) for ecological and human health effects of NO<sub>x</sub>.
  - The ecological assessment includes review and synthesis of published peer-reviewed literature of the effects of N deposition on all US ecosystems.
  - These assessments provide scientific support for the review of the primary (health effects) and secondary (welfare effects) National Ambient Air Quality Standards for NO<sub>x</sub>
- Integrated Risk Information System (IRIS) assessment of the human health effects of Ammonia

