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NARRAGANSETT-3VS MODEL OVERVIEW

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In an effort to advance sustainability, EPA Region 1 (New England) and the EPA Office of Research and Development (ORD) are collaborating on a project to address the problem of nutrient impairment to ecological functions in sensitive waterways. The project is based on the Triple Value (3V) framework, an innovative approach that captures the dynamic interrelationships among economic, environmental, and social systems.
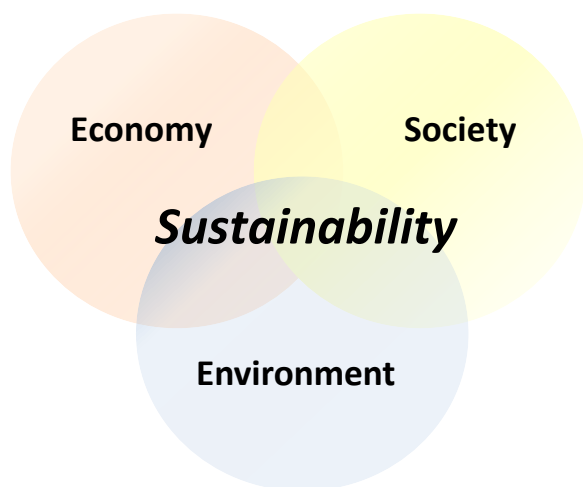
This approach is being piloted in the Narragansett Bay watershed with the development of a policy simulation tool that draws from watershed-specific data and stakeholder input. The model, entitled **Narragansett-3VS** (Triple Value Simulation) enables users to explore different scenarios, interpret results, and evaluate outcomes of selected policies or interventions aimed at reducing adverse impacts of nutrients on the watershed. The model is based on an integrated assessment methodology called *System Dynamics* and is intended to serve as a communication tool that can help build shared understanding of policy alternatives among diverse groups including technical experts, policy makers, and citizens. The model is not intended to support specific permitting decisions or individual site constraints; rather, the goal is to create scenarios that launch strategic dialogue about alternative water resource management policies. The 3V framework is transferable to other locations and to other issues.

Economy   Society

Sustainability

Environment

The model schematic on page 3 illustrates the 3V framework of economy, environment, and society, including the primary variables included in the Narragansett-3VS model, as well as key relationships among them. The schematic shows the indicators and relationships included in the model (solid lines), as well as additional ones that have been identified as important elements of the system that the model represents, but which could not be included quantitatively in the model (dashed lines). Black lines indicate amplifying causal relationships while red lines indicate diminishing causal relationships. Interventions are represented by green circles and are situated on the targeted causal relationships.

The main elements of the schematic can be grouped into loadings (boxes with arrows pointing toward the grey box labeled "Flows of water, nutrients, pathogens via land, groundwater, surface water"), environmental relationships (boxes and arrows in the "Environment" section of the schematic), and impacts on economy and society (all other boxes and arrows). The model currently focuses on nitrogen (N) as the key nutrient.
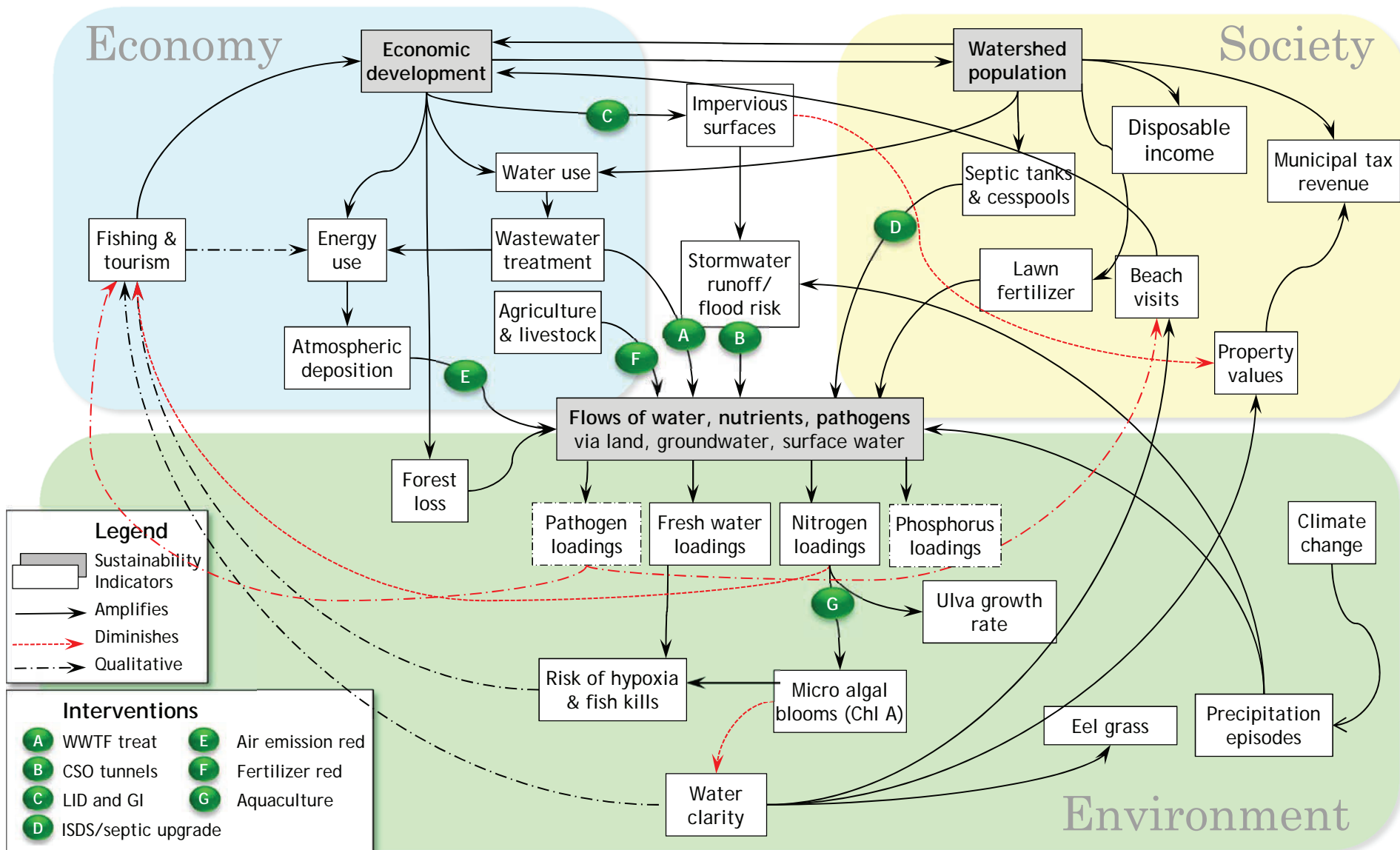
An outline of the scenario setting options and a list of the key output indicators available for the Narragansett-3VS model are provided below. Additionally, innovative interventions such as N recovery and reuse, and new employment sectors, can be considered in future scenarios.

OPTIONS AVAILABLE FOR SETTING SCENARIOS

1) **Specify the interventions:** Methods used to reduce nitrogen loadings or to increase nitrogen removal for Narragansett Bay include specified reductions from:
    - Upgrades to Wastewater Treatment Facilities (WWTFs).
    - Upgrades to Onsite Wastewater Treatment Systems (OWTSs).
    - Reductions in nitrogen loading from animal waste.
    - Reductions in nitrogen loading from agricultural fertilizer.
    - Reductions in nitrogen loading from residential lawn fertilizer.
    - Reductions in atmospheric deposition of nitrogen.
    - Nitrogen reduction in the water body through removal by aquaculture farms.
    - Reductions in nitrogen loadings from surface water runoff through use of Low Impact Development/Green Infrastructure (LID/GI) to reduce effective impervious area.

2) **Specify the magnitude of change for each intervention:** Magnitude of change expressed as a percent (e.g., 40% reduction in N loading, or 10 % reduction in impervious area).

3) **Specify the timing of impact for each intervention:** Year at which change is achieved, can include interim targets (e.g., 5% reduction by 2020 and 20% reduction by 2030).

4) **Specify the geographic location of impact for the interventions:**
    - WWTF reductions, LID/GI, and residential fertilizer reductions can be specified by region of the watershed.
    - The number of aquaculture farms can be specified by location within the Bay.
    - All other interventions affect the entire watershed.

5) **Specify cost of nitrogen reduction for each intervention:**
    - Capital costs, including the costs of financing capital investments.
    - Ongoing costs: dollars per kg of N reduced.

6) **Specify financing options for each intervention:**
    - Specify percent of cost publicly financed (as opposed to borne by citizens).
    - Specify interest rate and financing period for publicly financed interventions.

SCHEMATIC OF ECONOMIC, SOCIAL, AND ENVIRONMENTAL VARIABLES AND RELATIONSHIPS IN THE NARRAGANSETT - 3VS MODEL

March 2015

3

Economy

Society

Environment

Economic development

Watershed population

Impervious surfaces

Disposable income

Municipal tax revenue

Water use

Septic tanks & cesspools

Fishing & tourism

Energy use

Wastewater treatment

Stormwater runoff/ flood risk

Lawn fertilizer

Beach visits

Property values

Atmospheric deposition

Agriculture & livestock

Flows of water, nutrients, pathogens via land, groundwater, surface water

Forest loss

Pathogen loadings

Fresh water loadings

Nitrogen loadings

Phosphorus loadings

Ulva growth rate

Climate change

Risk of hypoxia & fish kills

Micro algal blooms (Chl A)

Eel grass

Precipitation episodes

Water clarity

Legend

- Sustainability Indicators
- → Amplifies
- → Diminishes
- → Qualitative

Interventions

- A WWTF treat
- B CSO tunnels
- C LID and GI
- D ISDS/septic upgrade
- E Air emission red
- F Fertilizer red
- G Aquaculture

KEY OUTPUT INDICATORS

INDICATOR	UNITS	Scale
Economic/Social Indicators		
Total and per capita cost of N reduction	dollars/year	Varies by Intervention
Total and per capita private N reduction costs	dollars/year	Varies by Intervention
Total public N reduction costs	dollars/year	Varies by Intervention
Total cost as percent of disposable income	%	Varies by Intervention
Commercial finfish landings	dollars	Whole Bay
Aquaculture revenue	dollars	Whole Watershed
Employment in aquaculture	jobs	Disaggregated
Beach visits	# of visits	Disaggregated
Value of beach visits	dollars	Disaggregated
Property value change	dollars	Disaggregated
Change in municipal tax revenue	dollars	Whole Watershed
Environmental Indicators		
Total Nitrogen loadings	kg/year	Disaggregated
Nitrogen loadings by source category	kg/year	Disaggregated
Nitrogen concentration	mg/L	Disaggregated
Chlorophyll *a*	ug/L	Disaggregated
Water turbidity / clarity (secchi depth)	meters	Disaggregated
Ulva Growth Rate	%/day	Disaggregated
Eelgrass Improvement Potential	Unitless	Disaggregated
Hypoxia Risk	Unitless	Disaggregated

Due to data limitations, the model does not currently include several indicators that are considered important elements of the system affected by nitrogen pollution in Narragansett Bay (or by policy alternatives aimed at reducing nitrogen loadings). These indicators include dissolved oxygen, loadings of other pollutants (e.g., pathogens, phosphorus, metals, and sediment), access to water, recreational fishing and boating, aesthetics, human health, and flood risk.

QUALITY ASSURANCE
The Narragansett-3VS model was developed using quality assurance practices mandated by the EPA and implemented by EPA ORD and our contractor. The model and documentation are currently undergoing peer review.

CONTACTS FOR INFORMATION
The pilot study involved EPA's Office of Research and Development, EPA Region 1, and contractual work with Industrial Economics, Inc. Inquiries may be directed to Dr. Marilyn ten Brink, (401-782-3078, tenbrink.marilyn@epa.gov), Dr. Hal Walker (401-782- 3134, walker.henry@epa.gov) or Dr. Gary Foley (919-541-0711, foley.gary@epa.gov) in the EPA Office of Research and Development, or to Johanna Hunter (617-918-1041, hunter.johanna@epa.gov) in the EPA Region 1 Office of Ecosystem Protection.