Prediction of N loads to Delmarva Coastal Bays:

Discussion of a management-focused, user-friendly model

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Acknowledgements

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- Ivan Valiela and colleagues

Sea Grant

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University of Maryland
Center for Environmental Science

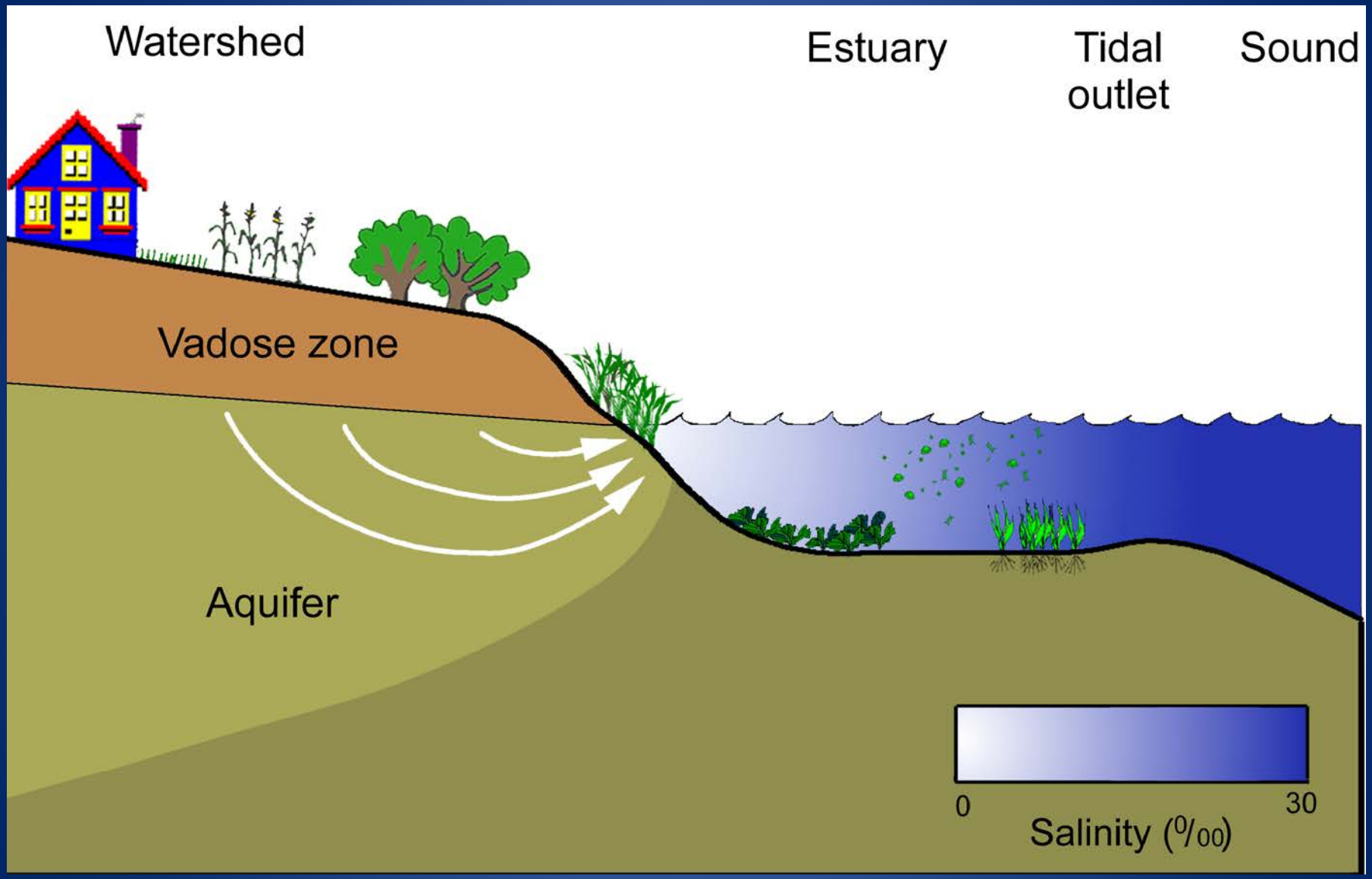
University of Delaware

Project Objectives

- Constrain and modify a Nitrogen Loading Model (NLM) to predict total nitrogen (TN) loads to Delmarva coastal bays
- Link N loading model to:
  - Lagoon Ecosystem Model
  - Submerged Aquatic Vegetation Model
- Make models available for direct use by stakeholders

Nitrogen Loading Model (NLM)

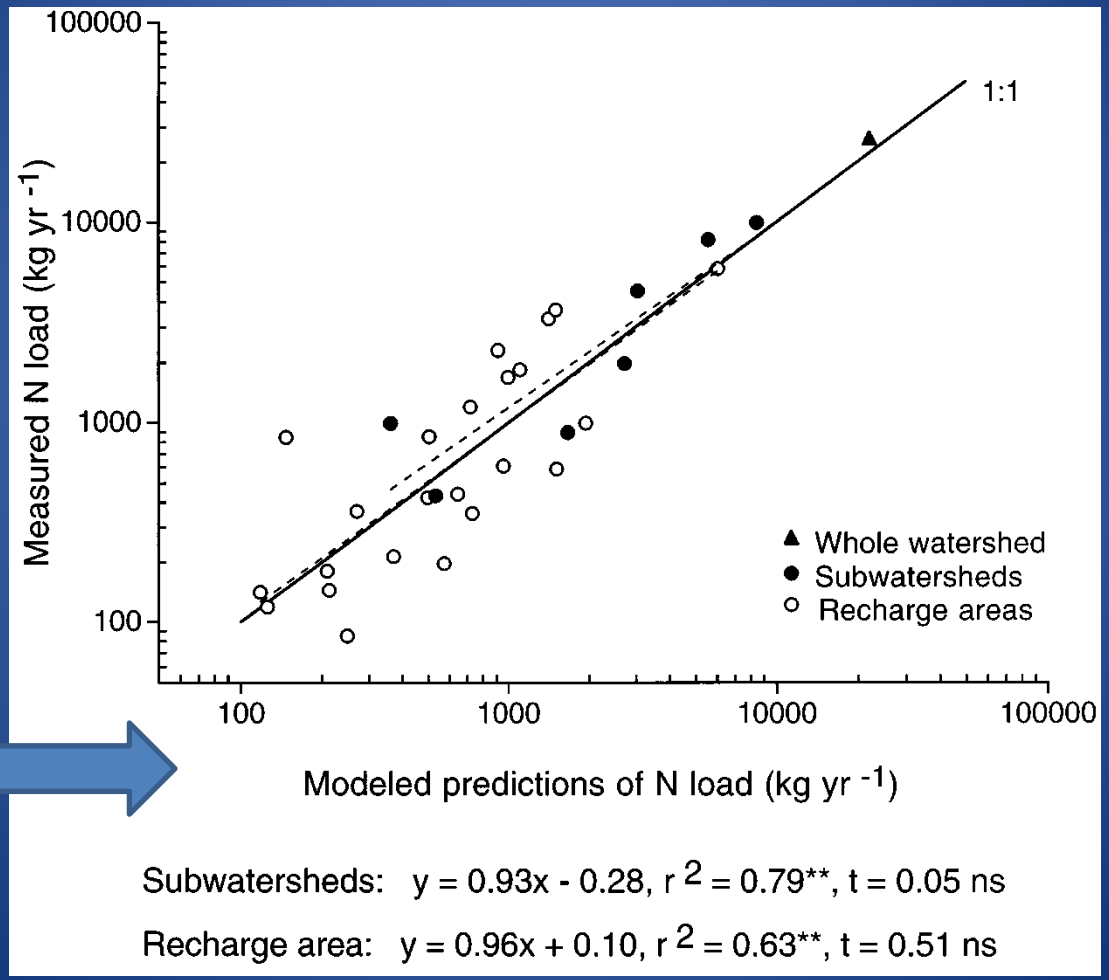
- Developed for watersheds underlain by unconsolidated sandy sediments
- Appropriate where groundwater is dominant source of freshwater
- Rural to suburban land-uses
- Original model relied on exhaustive search of literature for many default values; current version has updated and added to these


Watershed
Estuary
Tidal outlet
Sound
Vadose zone
Aquifer
0
30
Salinity (‰)

Original Calibration

Based on N concentrations in 100s of GW samples

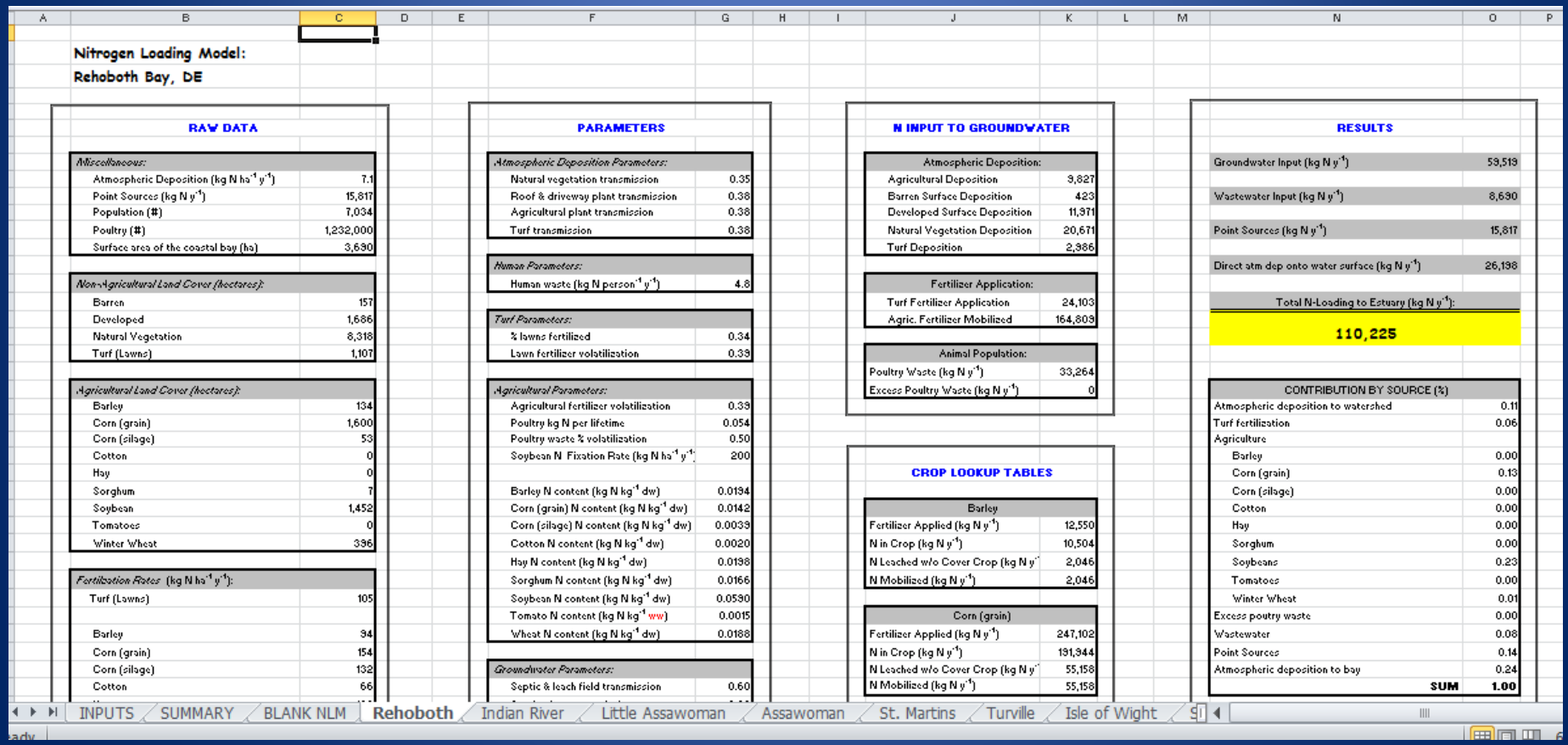
NLM model output



Valiela et al. (2000)

Model formats

- Online
- Excel spreadsheet



Nitrogen Loading Model:
Rehoboth Bay, DE

RAW DATA

Miscellaneous:	
Atmospheric Deposition (kg N ha^{-1} y^{-1})	7.1
Point Sources (kg N y^{-1})	15,817
Population (#)	7,034
Poultry (#)	1,232,000
Surface area of the coastal bay (ha)	3,630

Non-Agricultural Land Cover (hectares):	
Barren	157
Developed	1,686
Natural Vegetation	8,318
Turf (Lawns)	1,107

Agricultural Land Cover (hectares):	
Barley	134
Corn (grain)	1,600
Corn (silage)	53
Cotton	0
Hay	0
Sorghum	7
Soybean	1,452
Tomatoes	0
Winter Wheat	396

Fertilization Rates (kg N ha^{-1} y^{-1}):	
Turf (Lawns)	105
Barley	94
Corn (grain)	154
Corn (silage)	132
Cotton	66

PARAMETERS

Atmospheric Deposition Parameters:	
Natural vegetation transmission	0.35
Roof & driveway plant transmission	0.38
Agricultural plant transmission	0.38
Turf transmission	0.38

Human Parameters:	
Human waste (kg N $person^{-1}$ y^{-1})	4.8

Turf Parameters:	
% lawns fertilized	0.34
Lawn fertilizer volatilization	0.39

Agricultural Parameters:	
Agricultural fertilizer volatilization	0.39
Poultry kg N per lifetime	0.054
Poultry waste % volatilization	0.50
Soybean N Fixation Rate (kg N ha^{-1} y^{-1})	200
Barley N content (kg N kg^{-1} dw)	0.0194
Corn (grain) N content (kg N kg^{-1} dw)	0.0142
Corn (silage) N content (kg N kg^{-1} dw)	0.0039
Cotton N content (kg N kg^{-1} dw)	0.0020
Hay N content (kg N kg^{-1} dw)	0.0198
Sorghum N content (kg N kg^{-1} dw)	0.0166
Soybean N content (kg N kg^{-1} dw)	0.0590
Tomato N content (kg N kg^{-1} ww)	0.0015
Wheat N content (kg N kg^{-1} dw)	0.0188

Groundwater Parameters:	
Septic & leach field transmission	0.60

N INPUT TO GROUNDWATER

Atmospheric Deposition:	
Agricultural Deposition	3,827
Barren Surface Deposition	423
Developed Surface Deposition	11,371
Natural Vegetation Deposition	20,671
Turf Deposition	2,386

Fertilizer Application:	
Turf Fertilizer Application	24,103
Agric. Fertilizer Mobilized	164,803

Animal Population:	
Poultry Waste (kg N y^{-1})	33,264
Excess Poultry Waste (kg N y^{-1})	0

CROP LOOKUP TABLES

Barley	
Fertilizer Applied (kg N y^{-1})	12,550
N in Crop (kg N y^{-1})	10,504
N Leached w/o Cover Crop (kg N y^{-1})	2,046
N Mobilized (kg N y^{-1})	2,046

Corn (grain)	
Fertilizer Applied (kg N y^{-1})	247,102
N in Crop (kg N y^{-1})	191,944
N Leached w/o Cover Crop (kg N y^{-1})	55,158
N Mobilized (kg N y^{-1})	55,158

RESULTS

Groundwater Input (kg N y^{-1})	53,519
Wastewater Input (kg N y^{-1})	8,630
Point Sources (kg N y^{-1})	15,817
Direct atm dep onto water surface (kg N y^{-1})	26,198

Total N-Loading to Estuary (kg N y^{-1}):

110,225

CONTRIBUTION BY SOURCE (%)	
Atmospheric deposition to watershed	0.11
Turf fertilization	0.06
Agriculture	
Barley	0.00
Corn (grain)	0.13
Corn (silage)	0.00
Cotton	0.00
Hay	0.00
Sorghum	0.00
Soybeans	0.23
Tomatoes	0.00
Winter Wheat	0.01
Excess poutry waste	0.00
Wastewater	0.08
Point Sources	0.14
Atmospheric deposition to bay	0.24
SUM	1.00

INPUTS | SUMMARY | BLANK NLM | Rehoboth | Indian River | Little Assawoman | Assawoman | St. Martins | Turville | Isle of Wight

Delmarva NLM Inputs

Photos: ian.umces.edu, Chesapeake Bay Program, Virginian-Pilot

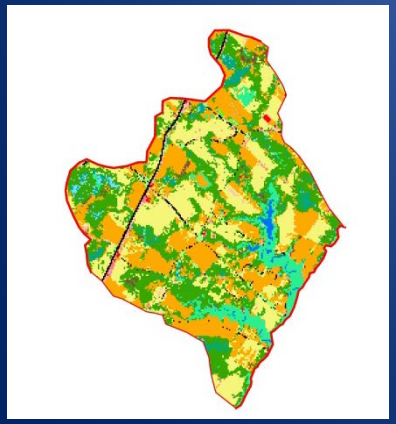
Atmospheric deposition

Crop distributions (county-level ag stats)

(from aerial photos)

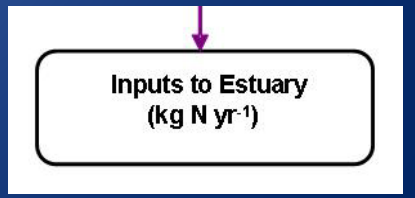
Residential development (septic tanks, lawns, impervious)

Land use distributions

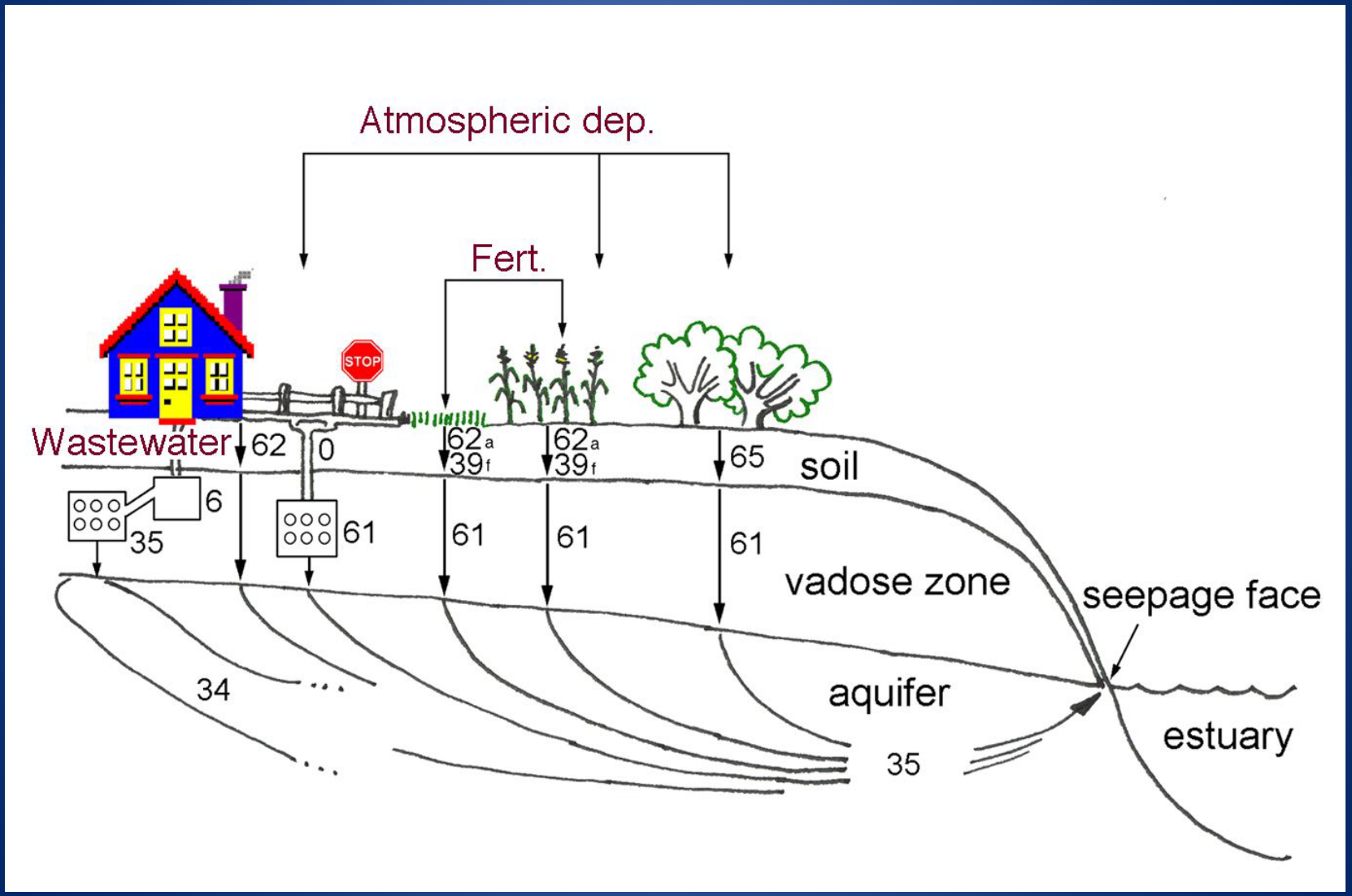


Poultry operations (average practices)

Model Output:

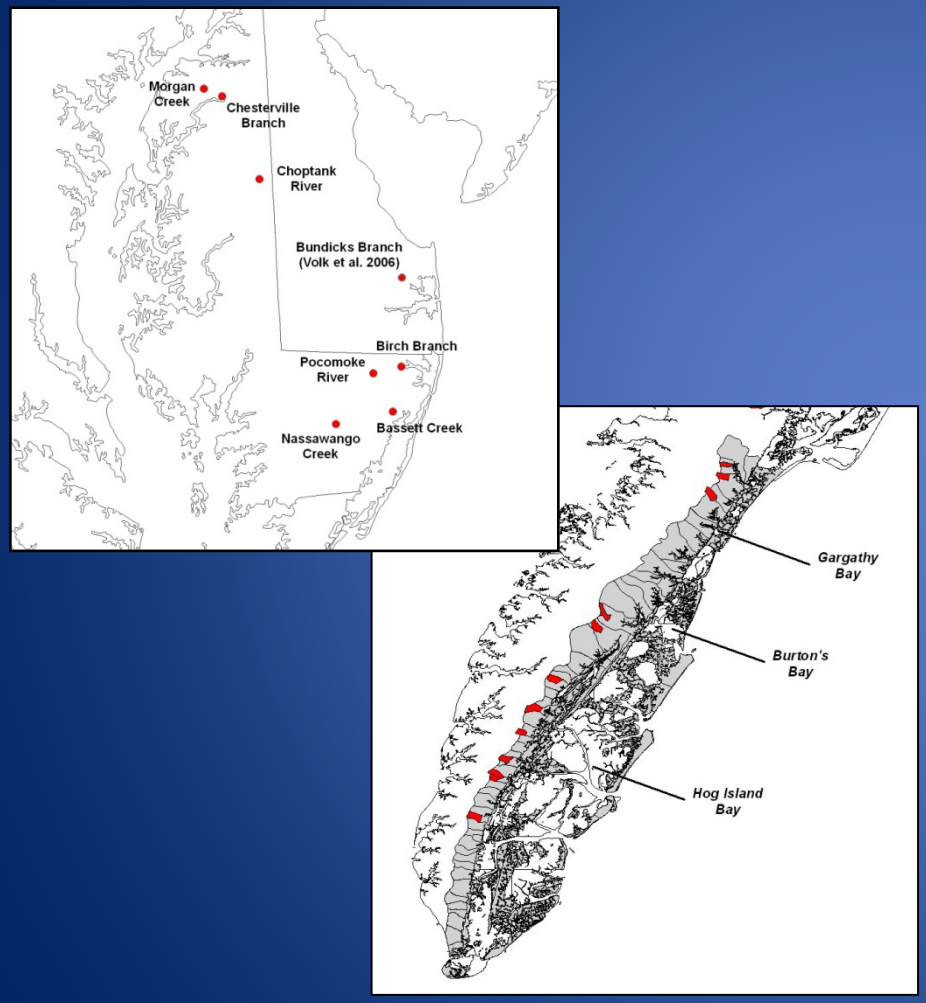


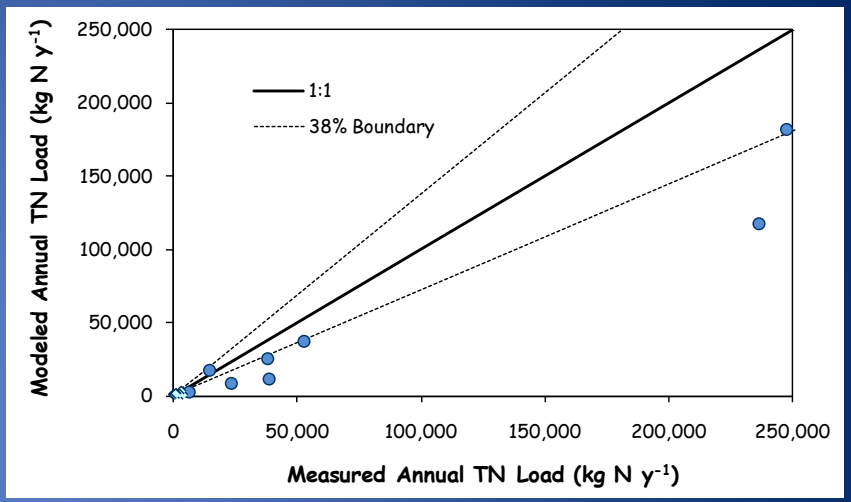
NLM Schematic

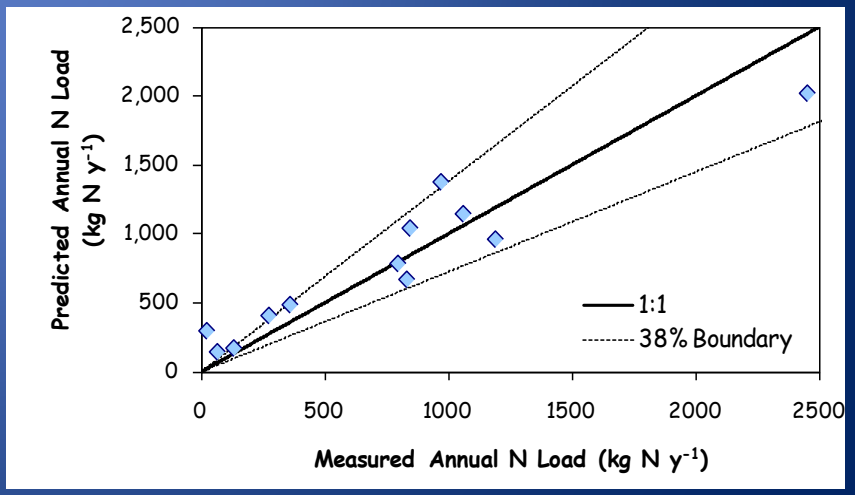


Valiela et al. (2000)

Model Calibration

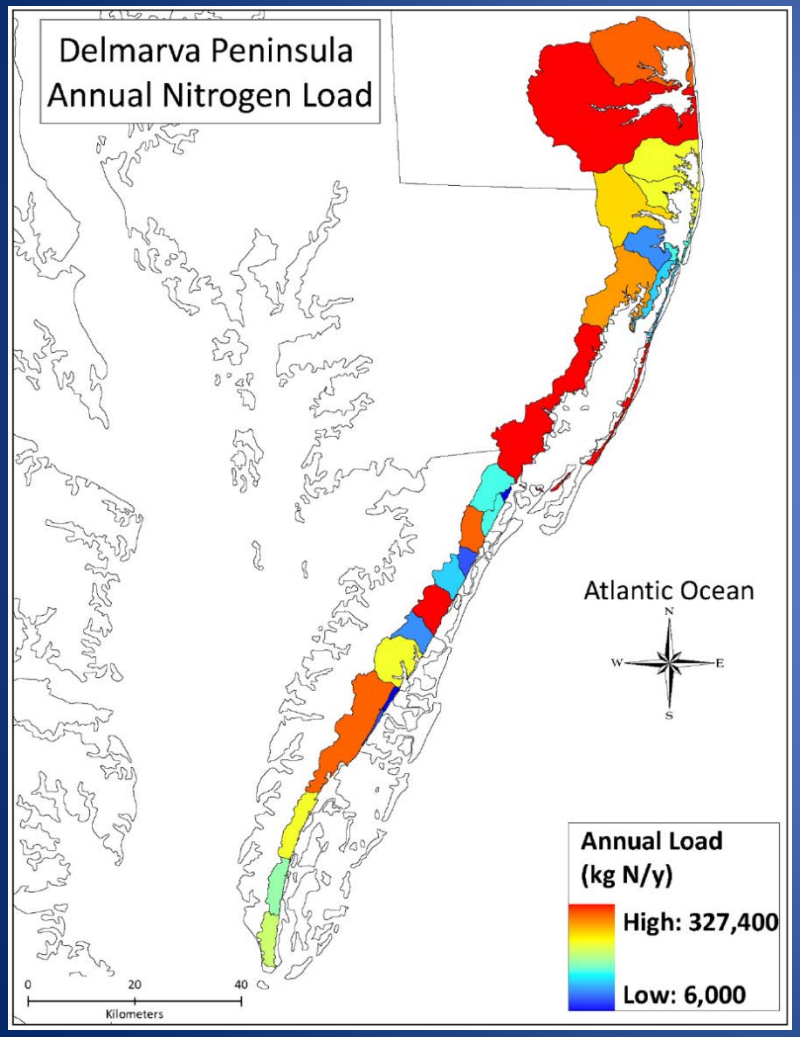


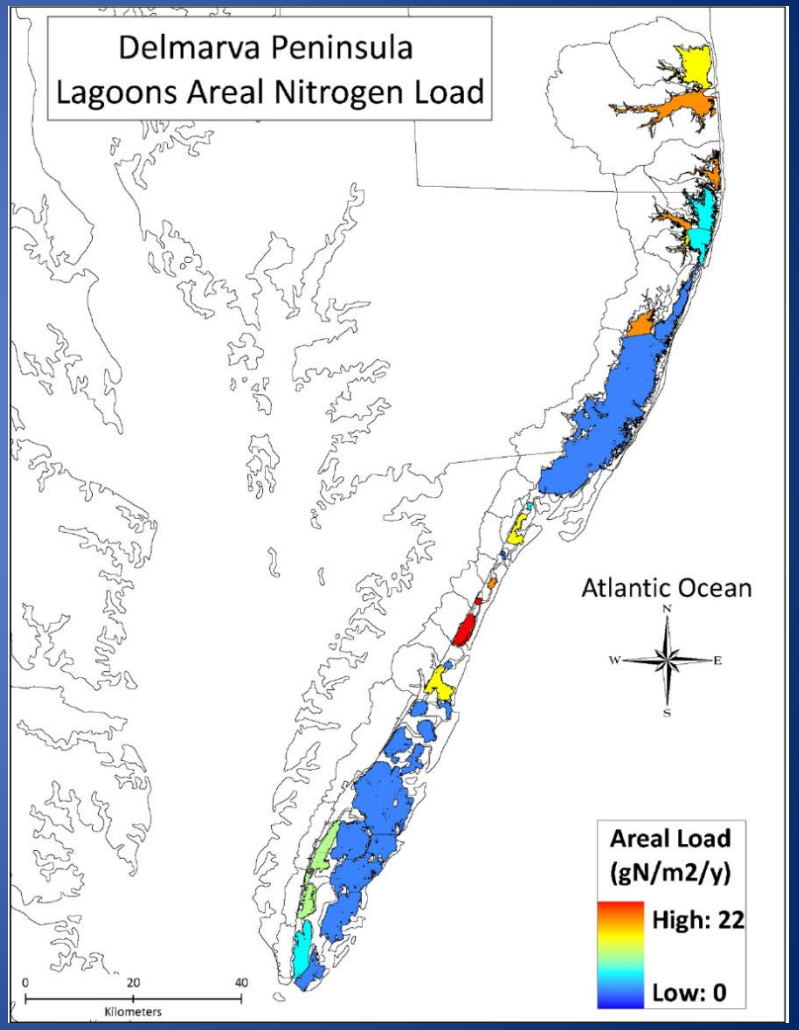




Brush et al. 2015; Giordano et al. 2011

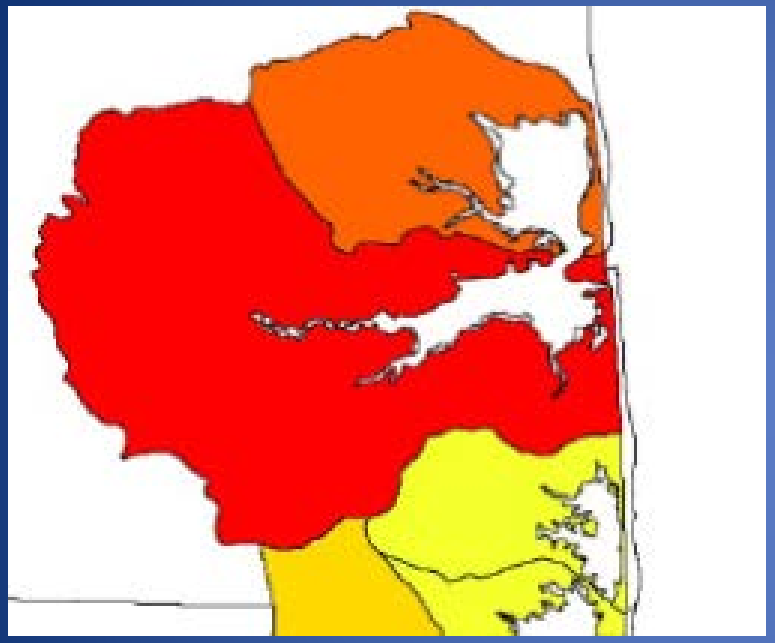
Model Results





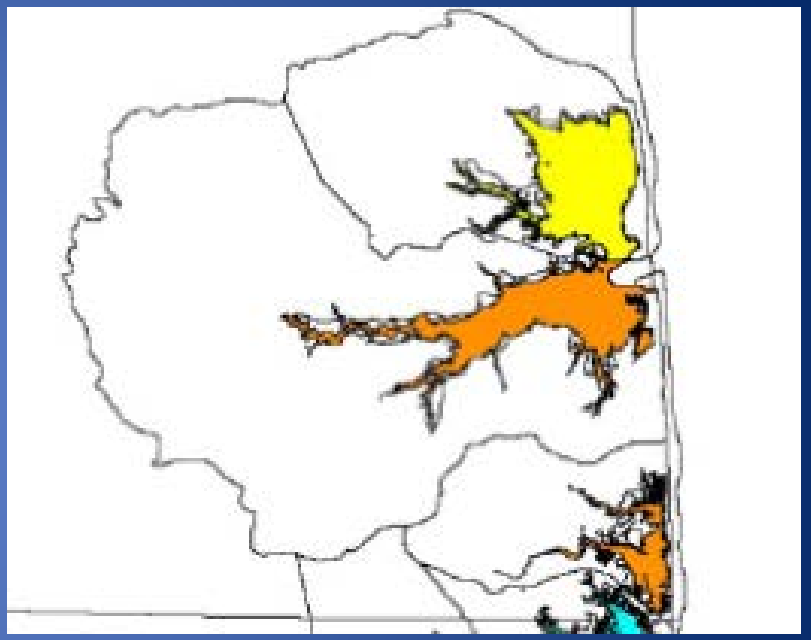
Courtesy of Mark Brush, VIMS

Model Results



Total N load (kg N/year)

Rehoboth Bay:	110, 193
Indian River Bay:	279,453
Little Assawoman Bay:	42,605

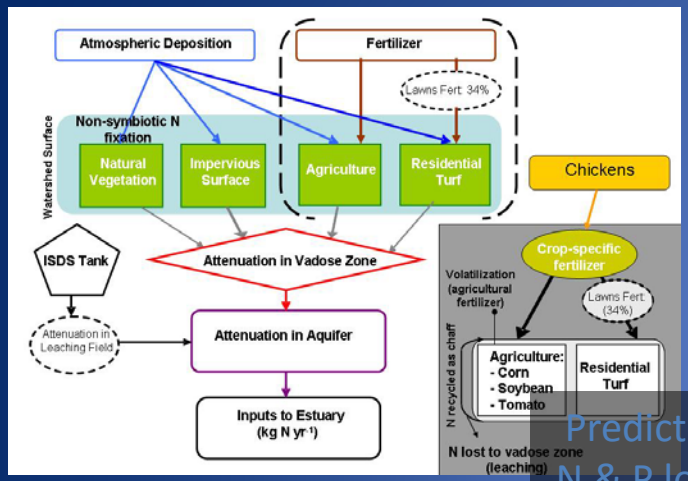


Load to waterbody surface (kg N/ha/year)

Rehoboth Bay:	30
Indian River Bay:	70
Little Assawoman Bay:	52

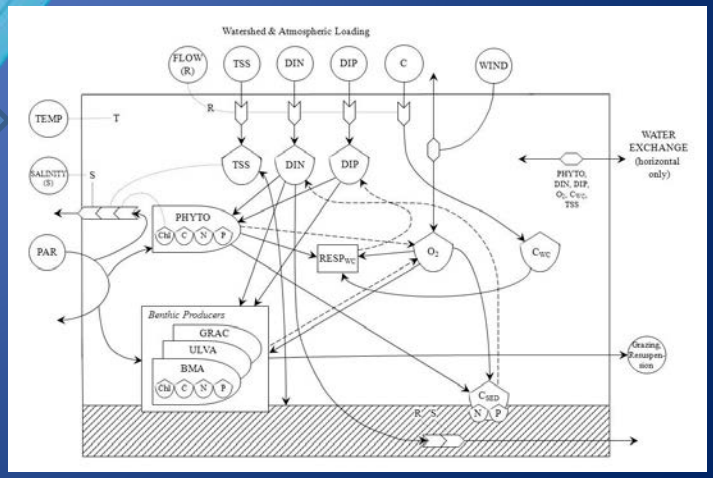
Courtesy of Mark Brush, VIMS

Lagoon Ecosystem Model



Predicted N & P load

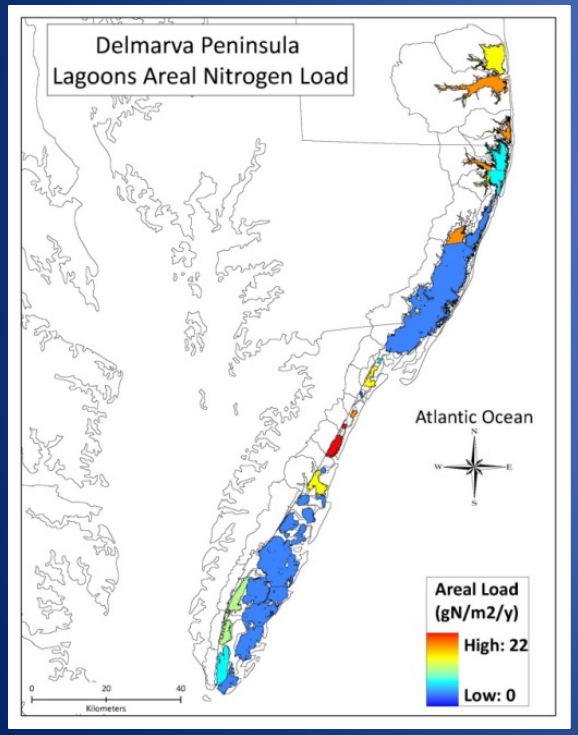
Lagoon response



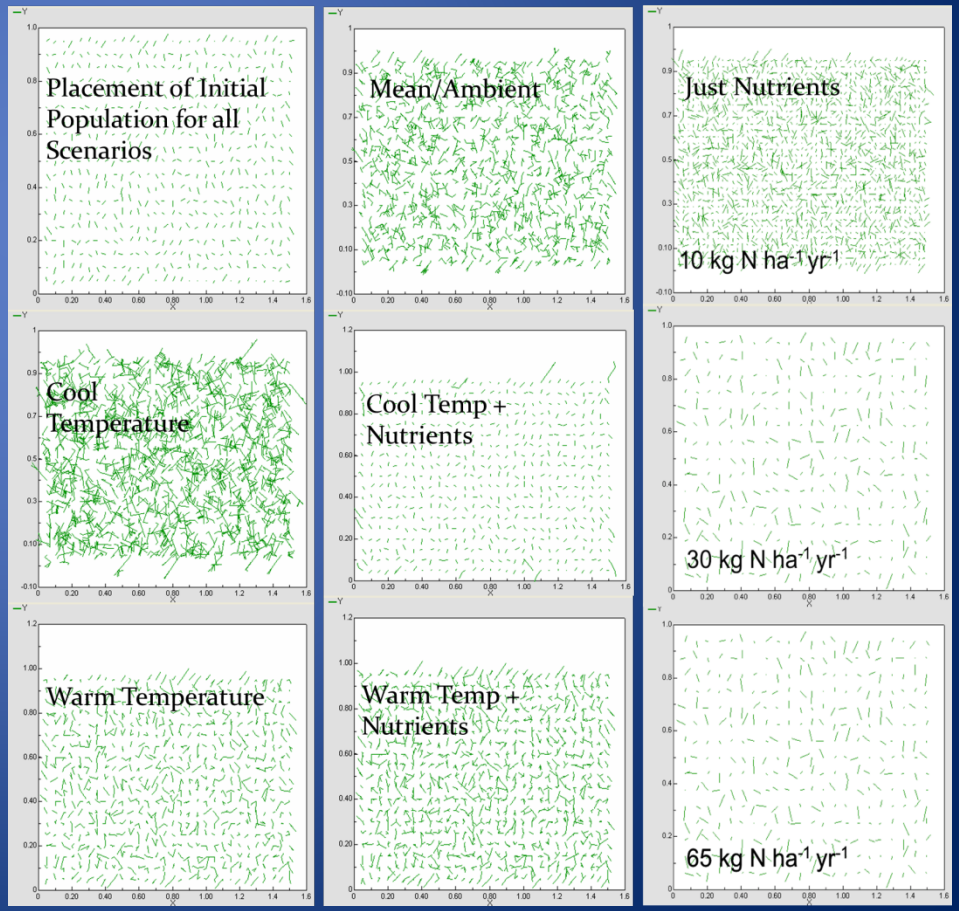
Courtesy Mark Brush

SAV Model

Virtual Eelgrass Meadow (VEM)



\+ *Light*
& *Temp*



Courtesy Lora Harris

Queries of the model

What is the major source of the N delivered to Rehoboth Bay?

Queries of the model

What is the major source of the N delivered to Rehoboth Bay?

Atmospheric deposition to watershed	12%
Turf fertilization	4%
Agriculture	
Barley	1%
Corn	**21%**
Soybeans	**39%**
Winter Wheat	2%
Excess poultry waste	0
Wastewater	8%
Point Sources	2%
Atmospheric deposition to bay	10%

Queries of the model

What will happen as the watershed becomes more “suburbanized”?

Queries of the model

What will happen as the watershed becomes more "suburbanized"? (halve area of corn/soybeans; population 7000-> 10,000)

Atmospheric deposition to watershed	12%	11%
Turf fertilization	4%	7%
Agriculture		
Barley	1%	1%
Corn	21%	7%
Soybeans	39%	14%
Winter Wheat	2%	2%
Excess poultry waste	0	0
Wastewater	8%	14%
Point Sources	2%	17%
Atmospheric deposition to bay	10%	29%

Model Utility

- Allows users to consider different scenarios impacting N loading
  - Where should N intensive land uses be located relative to the shoreline?
  - What happens if we make zoning decisions that change options for land use?
  - How much N load reduction bang would we get for the big bucks to hook up a neighborhood to a WWTP?

Now, your turn:

- What do we really want to know about water quality?
- Does N loading drive poor water quality in these systems?
- Given the legacy of N loading– which is already en route to estuaries via groundwater- what can we do now?