Developing regional-scale stressor models for managing eutrophication in coastal marine ecosystems:

Interactions of nutrients, sediments, land-use change, and climate variability and change.

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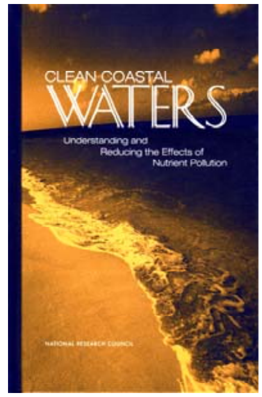
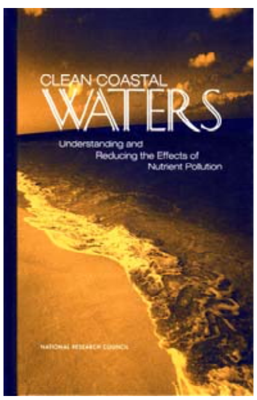
EPA/STAR grant: 1 year review
June 2004



NRC 2000:

Nitrogen is now the largest pollution problem in the coastal waters of the United States.

Two thirds of coastal rivers and bays are moderately to severely degraded from nitrogen pollution.



NRC 2000:

Priority recommendations:

- **Improve models for determining how management actions may affect nitrogen fluxes from watersheds, and how these may be affected by climate variability and change**
- **Develop a classification scheme for the sensitivity of estuaries to nitrogen inputs, as an aid for management decisions**

Principal Investigator:

Robert Howarth, Cornell (biogeochemistry, ecosystem science)

Key Personnel and consultants:

Roxanne Marino, Cornell (coastal marine biogeochemistry, ecosystem science)

Dennis Swaney, Cornell (watershed modeling)

Elizabeth Boyer, SUNY/Syracuse (watershed hydrology)

Merryl Alber, Univ. of Georgia (ecology of southeastern rivers and estuaries)

Don Scavia, Univ. of Michigan (water quality modeling)

David Jay, Oregon State (physical oceanography)

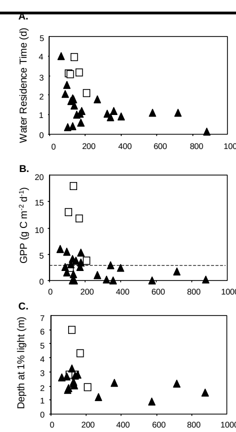
Estuaries vary in sensitivity to nitrogen inputs.

Examples: Chesapeake vs. Delaware & San Francisco Bays, Hudson River estuary.

For management, target nitrogen reductions for ecosystems that are most sensitive.

Will climate change increase or decrease sensitivity?

Residence time has other Influences on Sensitivity to eutrophication



Mesohaline Hudson River Estuary

(Howarth et al. 2000)

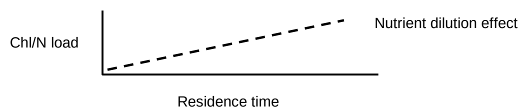
Water residence time as master variable controlling sensitivity?

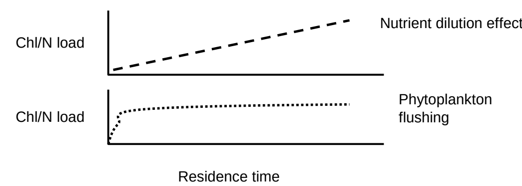
If so, highly responsive to climate variability and change, through change in freshwater runoff.

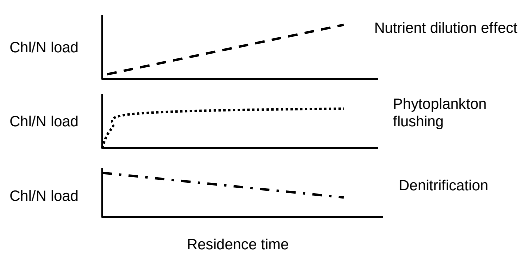
Water residence time as master variable controlling sensitivity?

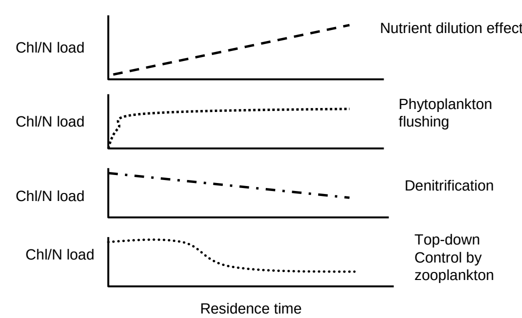
Residence time has numerous influences on sensitivity, mediated through:

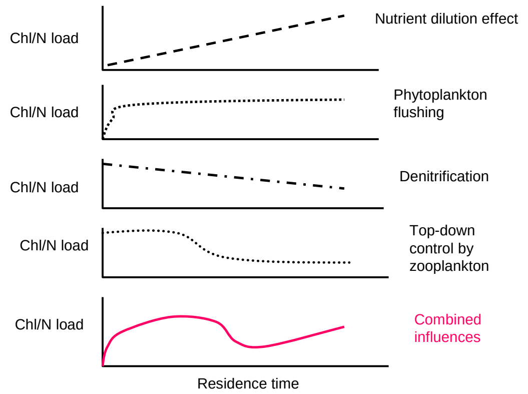
- -- flushing of phytoplankton relative to growth
- -- flushing and dilution of nutrients
- -- influence on denitrification
- -- flushing of zooplankton populations relative to growth

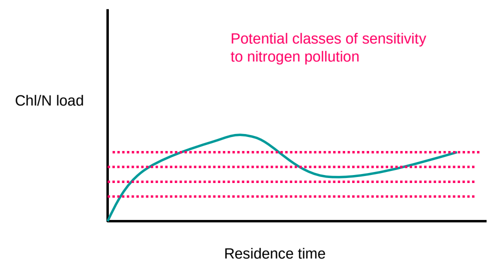












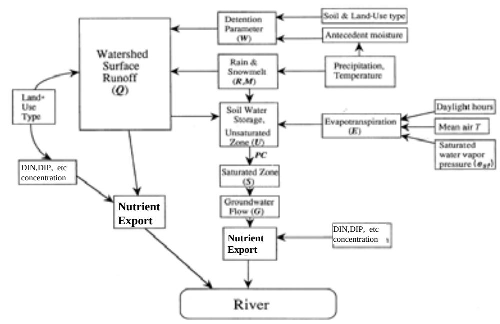
What next?

Use a simple simulation model of phytoplankton growth at different N loadings to evaluate potential interacting effects of residence time on sensitivity to eutrophication.

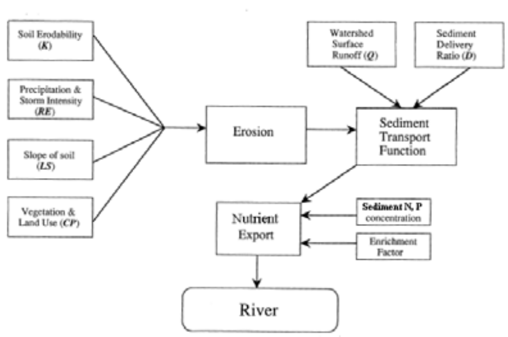
Develop data set on chlorophyll, N loading, and water residence times in estuaries, using consistent approaches. Use this data set for statistical analysis of response pattern.

Eventually, begin to consider factors other than water residence time (turbidity, stratification and depth of mixing, benthic grazing).

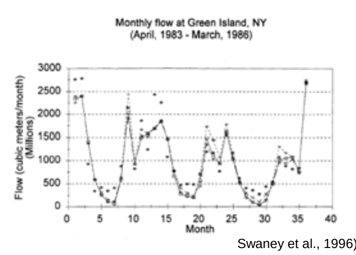
ReNuMa: Regional Nutrient Management model



Flowchart of ReNuMa hydrology and dissolved nutrient transport



Flowchart of ReNuMa erosion, sediment, and adsorbed nutrient transport



Swaney et al., 1996)

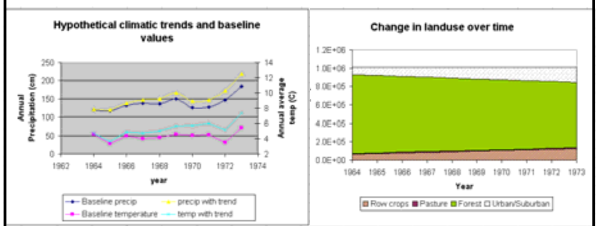
The parent model (GWLF) does well with hydrology… It also predicts erosion well, and so does well with phosphorus fluxes.

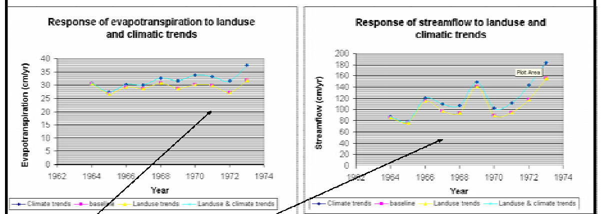
GWLF lacks some essential processes for nitrogen, particularly atmospheric deposition and denitrification. We are adding these, plus more on agricultural management options, for ReNuMa.

Preliminary model runs to evaluate the response of a watershed to hypothetical scenarios of landuse or climate change…

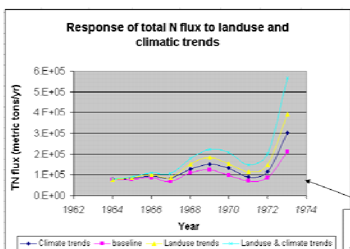
In this case, climate changes (an increase of 2 degrees C and 20% increase in precipitation over 10 years) are considered,

together with a doubling of area of urban and agricultural landuses…



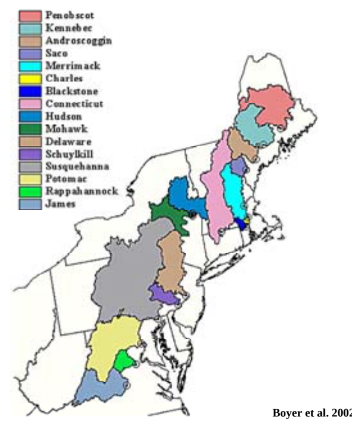


Climatic change appeared to be more important than landuse change to ET and streamflow in this simulation…



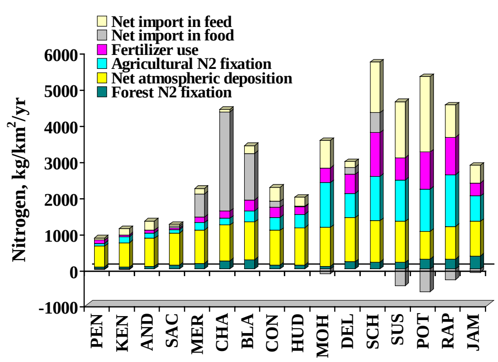
…But both landuse and climatic change affected nitrogen flux…

Anthropogenic nitrogen sources and relationships to riverine nitrogen export in the northeastern USA



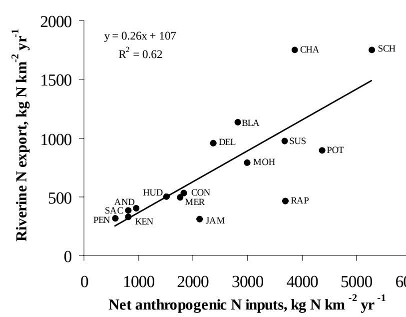
Boyer et al. 2002

NE region: watershed nitrogen inputs

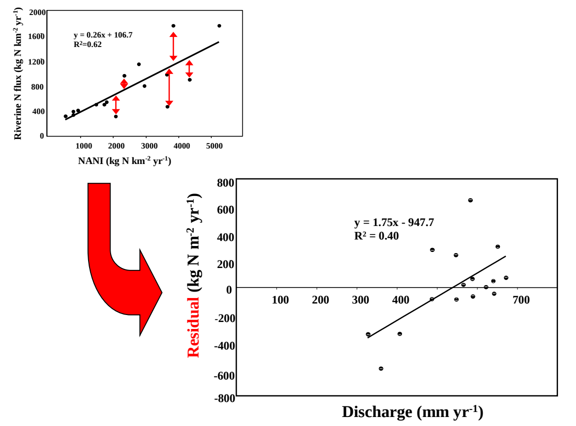


Boyer et al. 2002

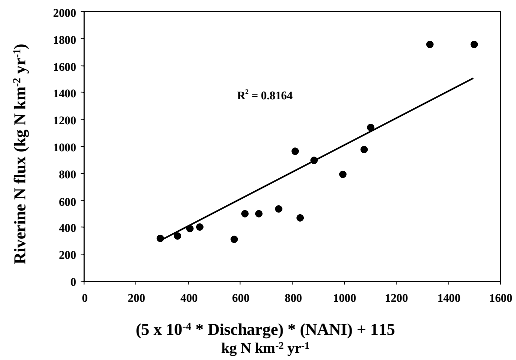
Moderate-sized Watersheds, Northeastern US (Boyer et al)



Note slope = 0.26 and intercept = 107 kg km^{-2} yr^{-1}



Riverine N fluxes very well predicted from net anthropogenic N inputs, attenuated by discharge-predicted fractional delivery.



Next steps with ReNuMa watershed model:

- add a module for atmospheric deposition of nitrogen onto the landscape
- add denitrification sink terms, as a function of climate
- improve modules for agricultural management options, with emphasis on nitrogen exports
- work with stakeholders in Susquehanna drainage basin within New York State to make model more useful for decision makers

Thanks to EPA STAR Program!