Linking landuse to patterns in coastal stream discharge and loading of nutrients and suspended solids

Michael Piehler, Rebecca Schwartz, Suzanne Thompson and Mark Brush

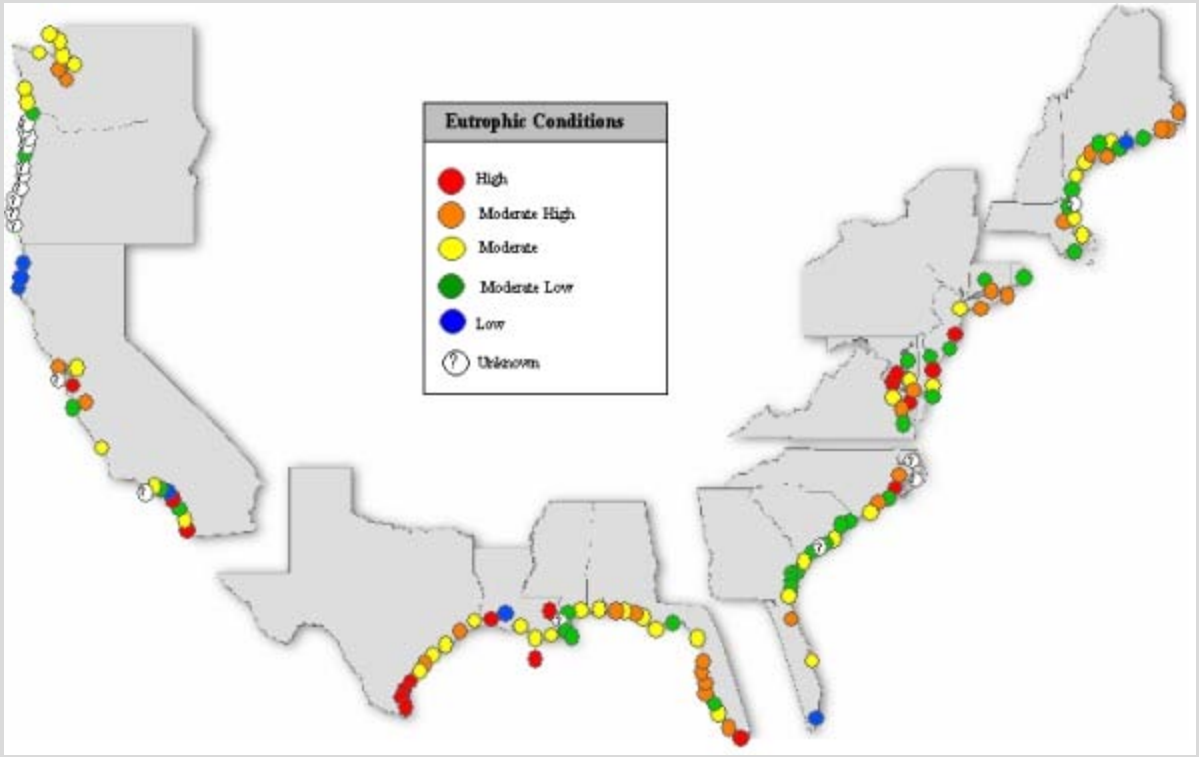
Why is stormwater a concern in estuaries?

- Nutrients
- Sediments
- Fresh water
- Pathogens
- Toxins

Not just pollution

Nutrients

- Fuel excessive primary productivity which leads to unsustainable levels of carbon loading



Excessive nutrient loading can also cause shifts in primary producer communities

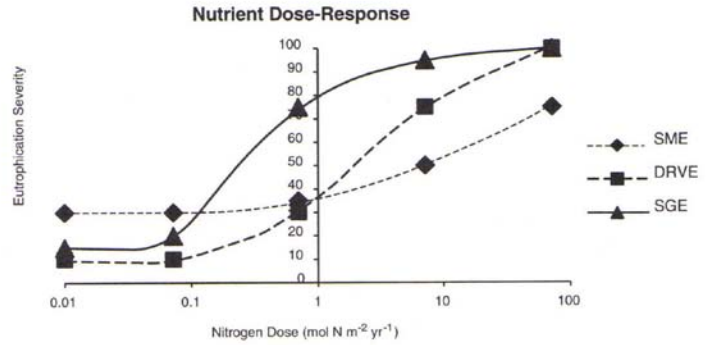


FIGURE 6-1 As nutrient loading is increased over the range of globally observed levels, it is hypothesized that different types of estuaries differ in their susceptibility to eutrophication. (A) This figure shows hypothetical Dose-Response Curves for three major types of coastal systems: Salt Marsh Dominated Estuary (SME), Plankton Dominated Drowned River Valley Estuary (DRVE), Seagrass Dominated Estuary (SGE). At the lowest levels of nitrogen loading (0.01 to 0.01 moles N m^{-2} yr^{-1}), each of the systems is likely to be oligotrophic (low level of productivity). Salt marsh estuaries are naturally more productive than seagrass dominated and plankton dominated drowned river valley estuaries. Seagrass dominated estuaries are likely to be the most sensitive to nutrient enrichment, shown by the rapid rise in eutrophication severity as nitrogen loading is increased from 0.1 to 1.0 moles N m^{-2} yr^{-1}. Salt marsh estuaries are expected to be the least sensitive to nutrient enrichment, which is illustrated by the slow rise in eutrophication severity only after nitrogen loading exceeds 1.0 moles N m^{-2} yr^{-1} (unpublished figure by C. Hopkinson).

Ecology, 82(4), 2001, pp. 1007–1022

MACROALGAL CANOPIES CONTRIBUTE TO EELGRASS (*ZOSTERA MARINA*) DECLINE IN TEMPERATE ESTUARINE ECOSYSTEMS

JENNIFER HAUXWELL,[1] JUST CEBRIAN,[2] CHRISTOPHER FURLONG, AND IVAN VALIELA

Boston University Marine Program, Marine Biological Laboratory, Woods Hole, Massachusetts 02543 USA

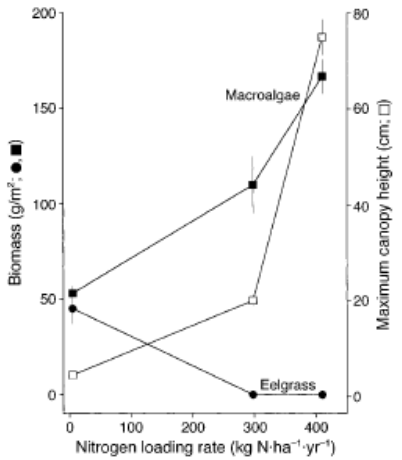
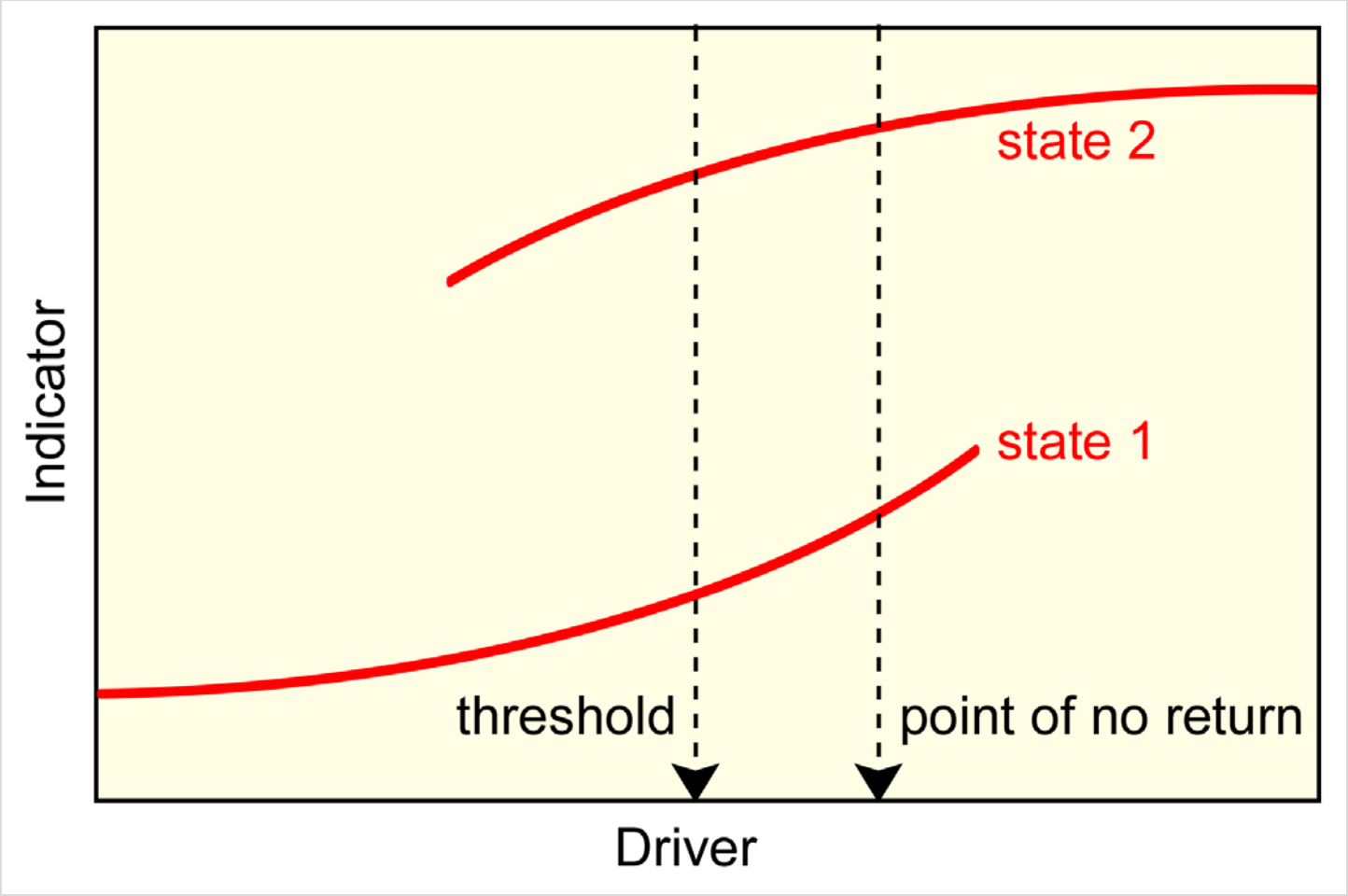


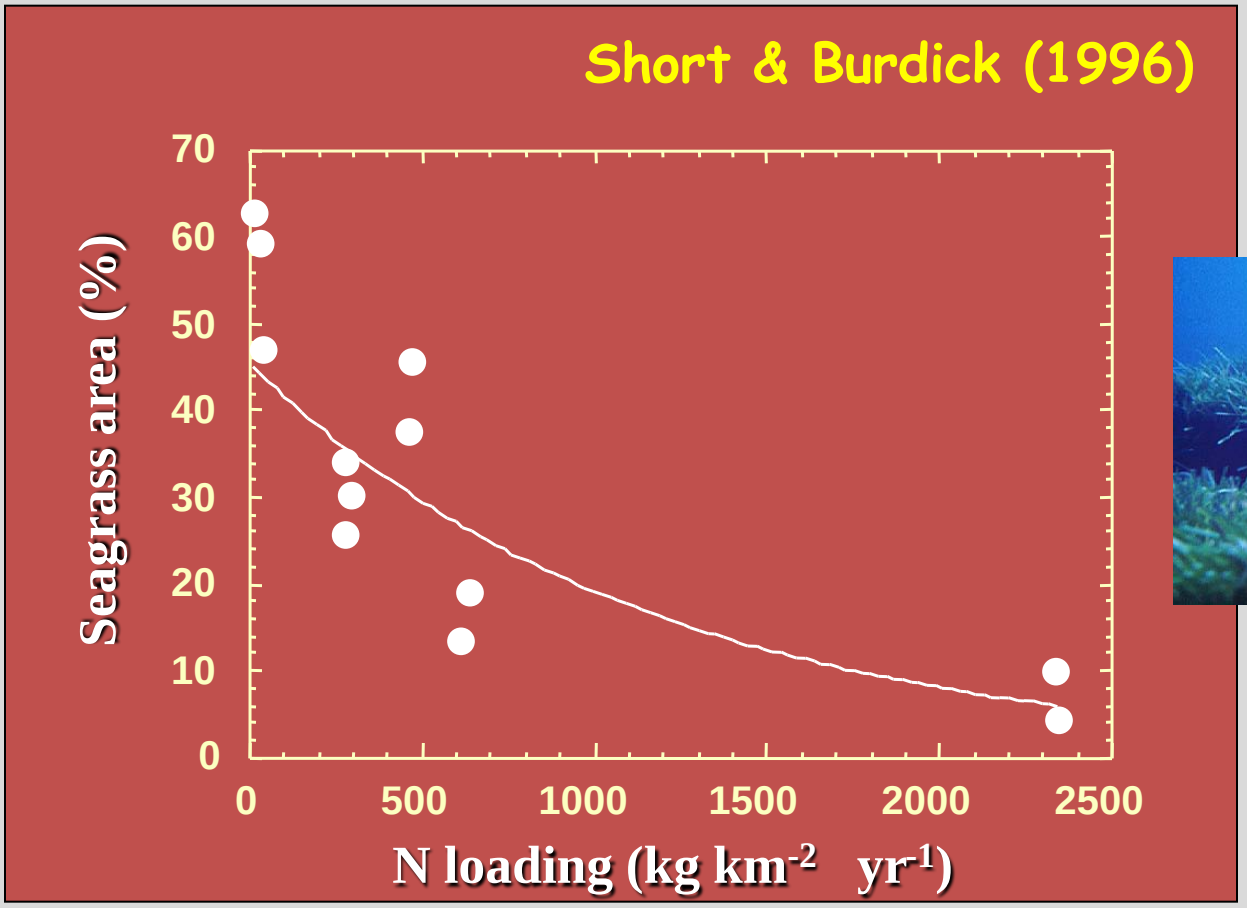
FIG. 1. Biomass of macroalgae and eelgrass (*Zostera marina*) and maximum macroalgal canopy heights in three estuaries of Waquoit Bay, Massachusetts, USA, that differ in their land-derived nitrogen loading rates. Biomass and canopy-height data were collected monthly for three years (1995–1997) at 10 sites per estuary (J. Hauxwell and J. McClelland, *unpublished data*); values are means ± 1 SE. The estuary with the lowest nitrogen loading rate is Sage Lot Pond (5 kg·ha^{-1}·yr^{-1}), the estuary with the intermediate N loading rate is Quashnet River (300 kg·ha^{-1}·yr^{-1}), and the estuary with the highest N loading rate is Childs River (410 kg·ha^{-1}·yr^{-1}) (Valiela et al. 1997*a*).

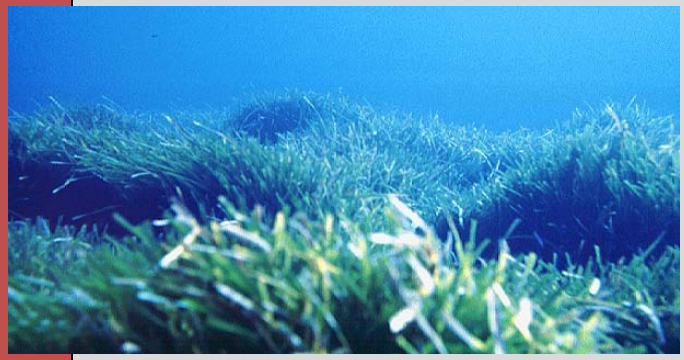
Catastropic shifts…



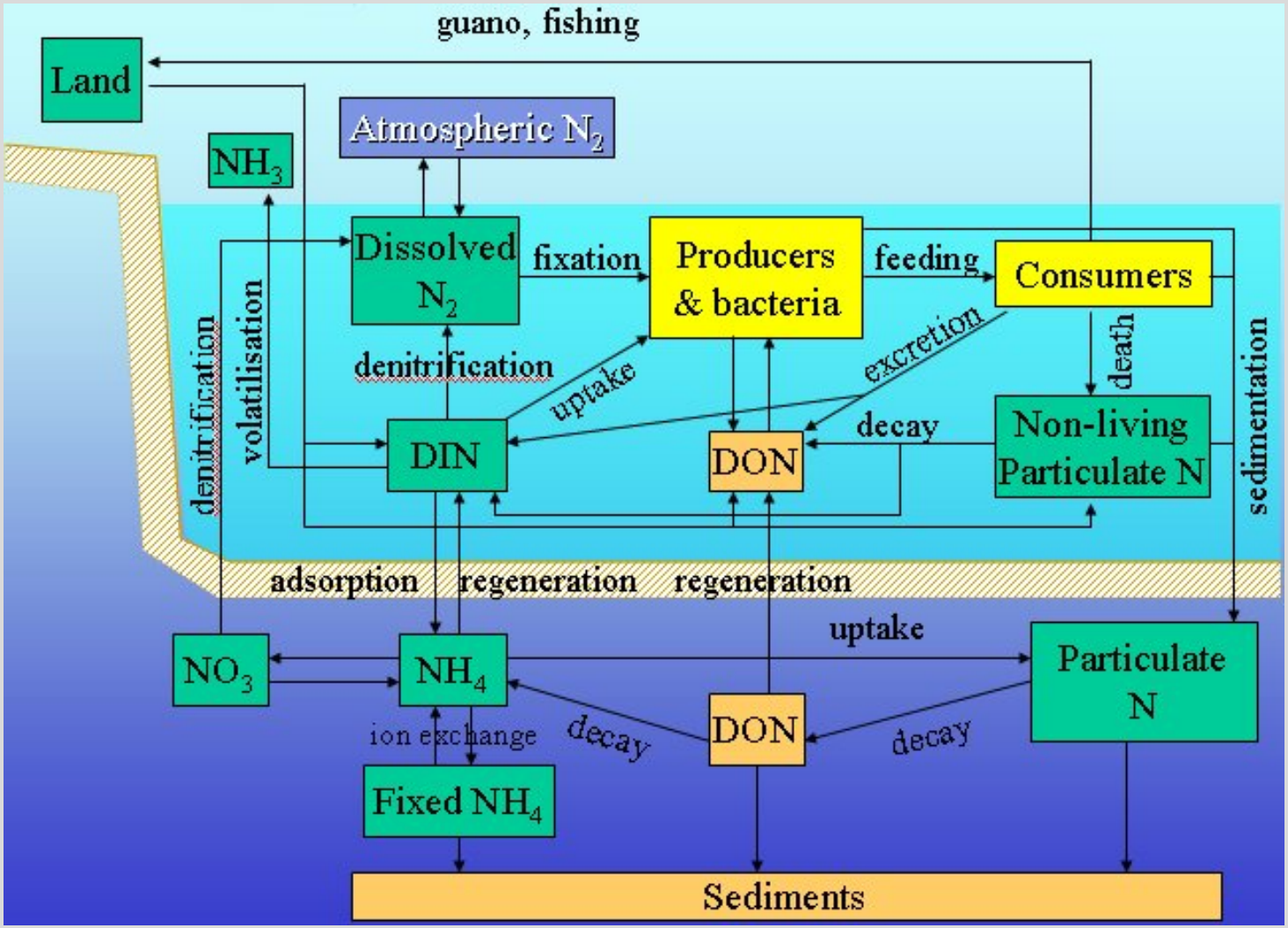
Scheffer et al., 2001

Potential for unpredictable losses of estuarine habitat

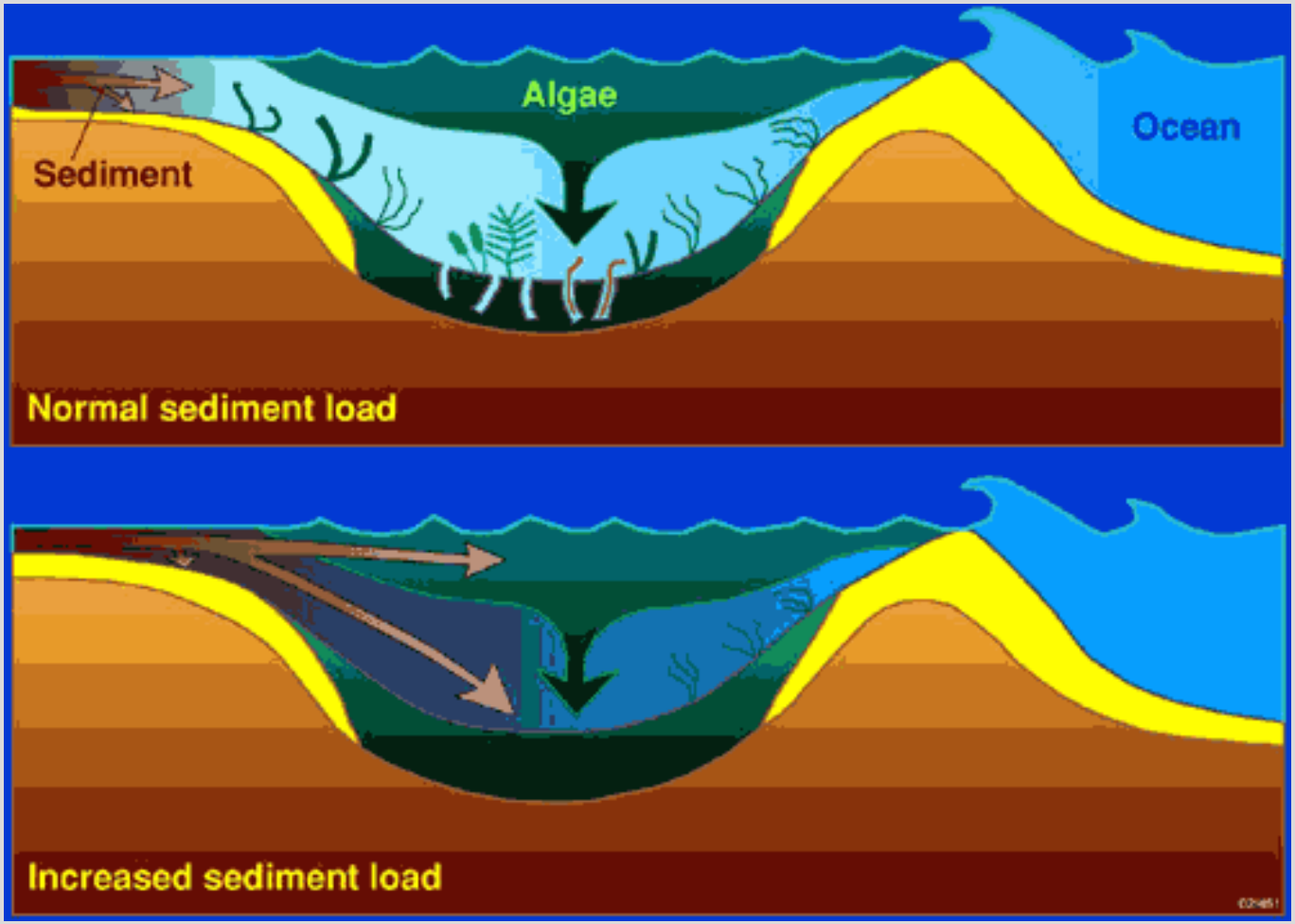




But estuaries require some nutrients…

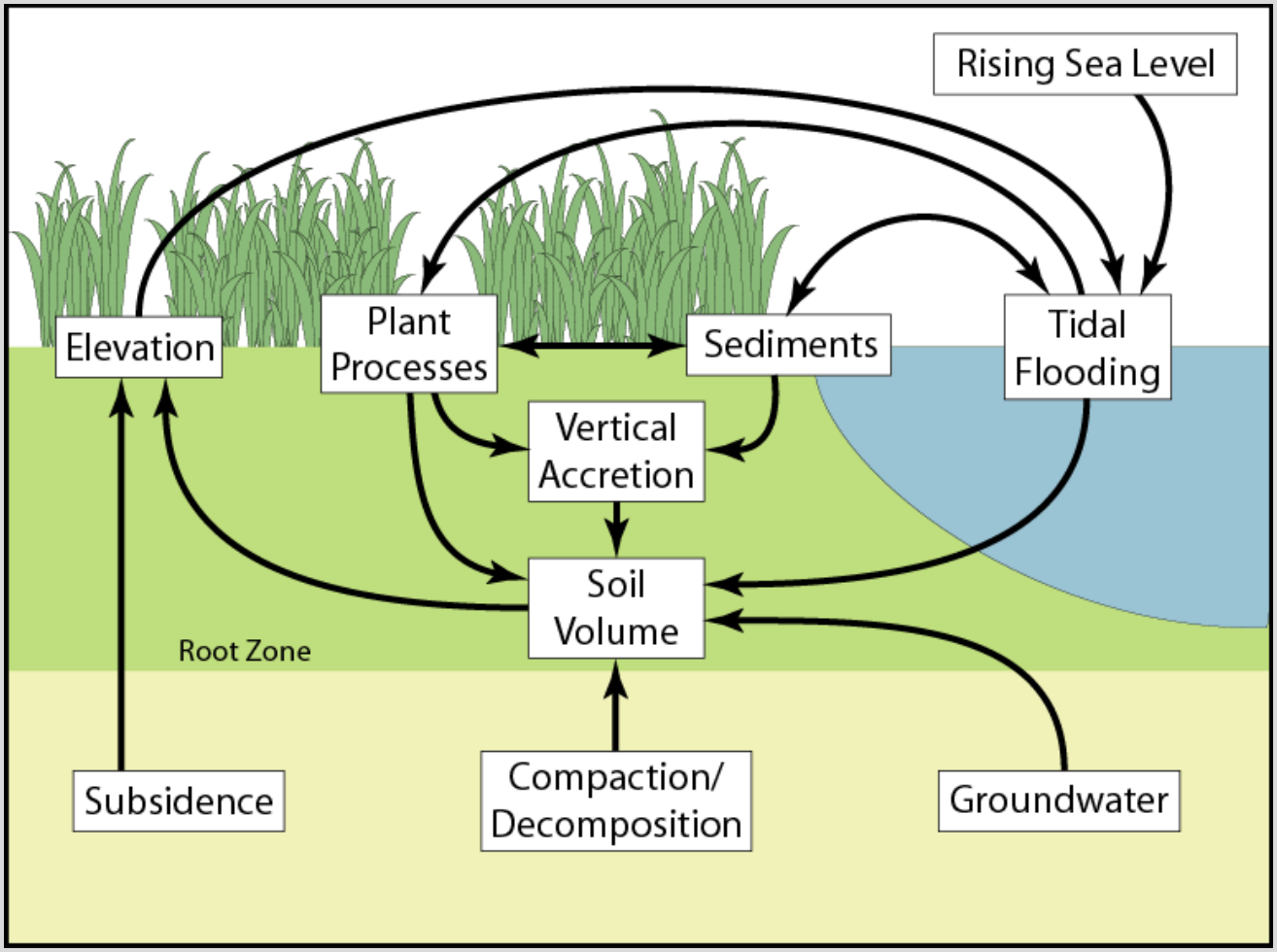


Sediments can impair coastal ecosystem function



http://www.ozestuaries.org

But don't forget the marshes…

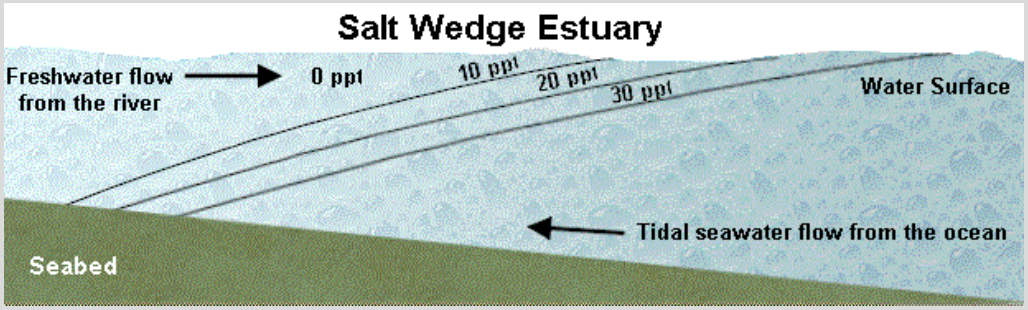


Modified from: Cahoon, DR., J.W. Day, Jr., and D. J. Reed. 1999. The influence of surface and shallow subsurface soil processes on wetland elevation: a synthesis. In, Current Topics in Wetland Biogeochemistry, Vol. 3. pp. 72-88, Wetland Biogeochemistry Institute, Louisiana State University, USA.

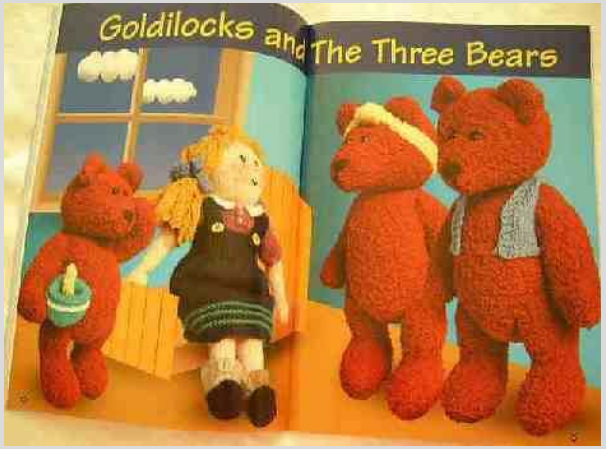
Too much freshwater?

- Freshening of tidal creeks
- Selection for freshwater species

Or just enough?



www.narrabay.com



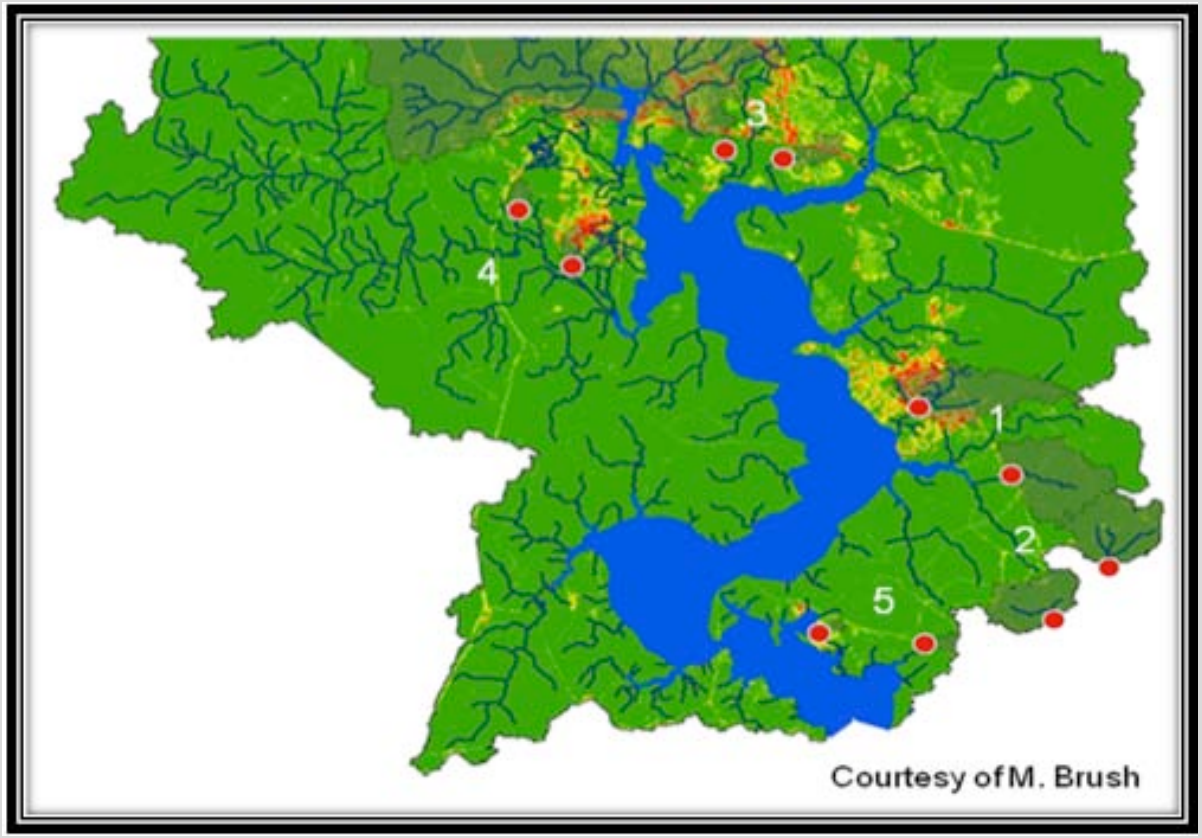
Why coastal streams?

Not much data on coastal stream material loading

Receiving waters are valuable and sensitive

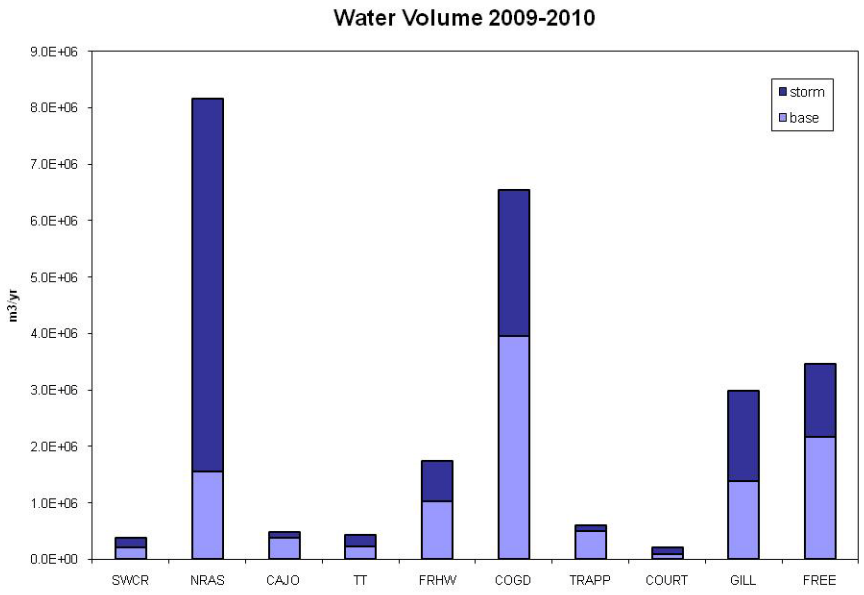
Materials being delivered have diverse effects

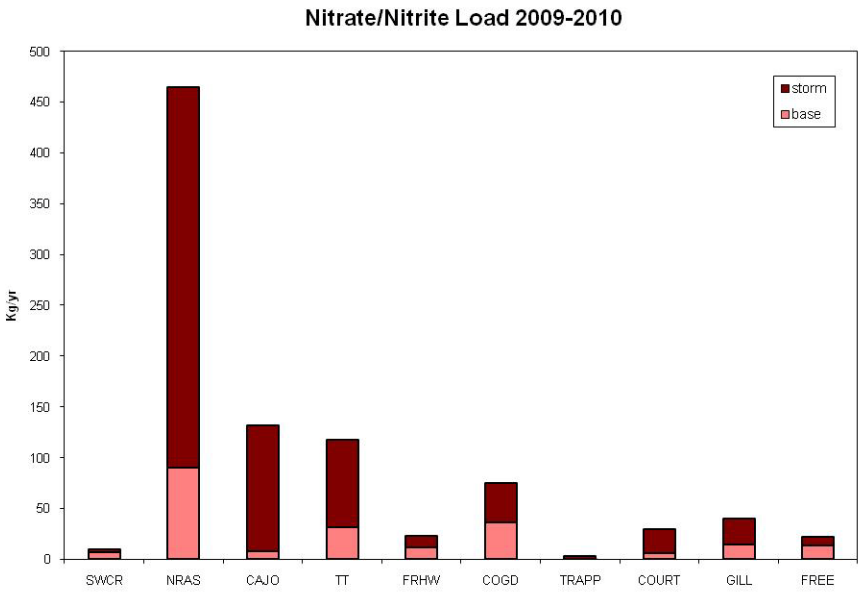
Regulations focused on coastal watersheds would benefit from additional data

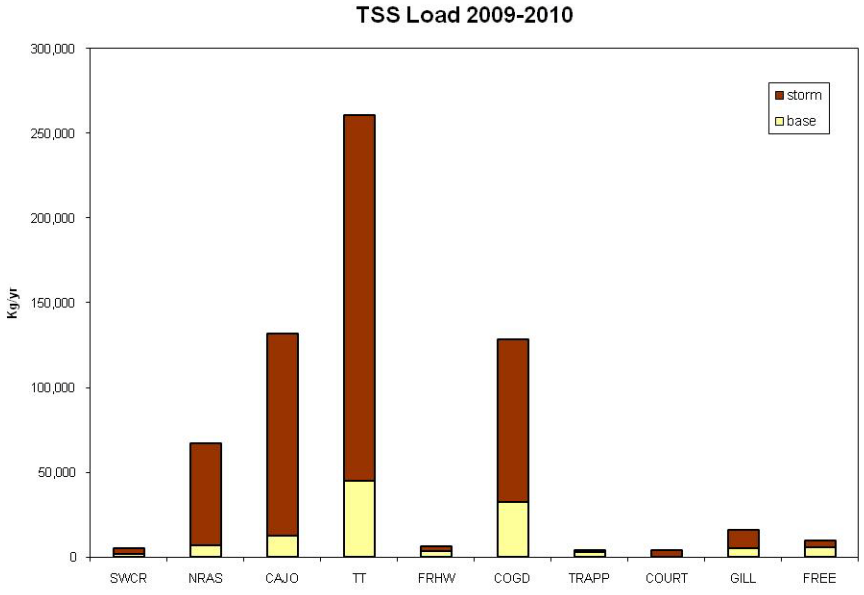


Site	Developed Land (%)
Cogdel	25.02
French	3.43
Freeman	3.69
Gillets	7.79
Tarawa	45.92
Camp Johnson	0
Air Station	49.94
Southwest Creek	8.60
Courthouse Bay	62.64
Traps	12.52

Does land use affect base- and storm-flow loading of nutrients and total suspended solids from coastal streams?

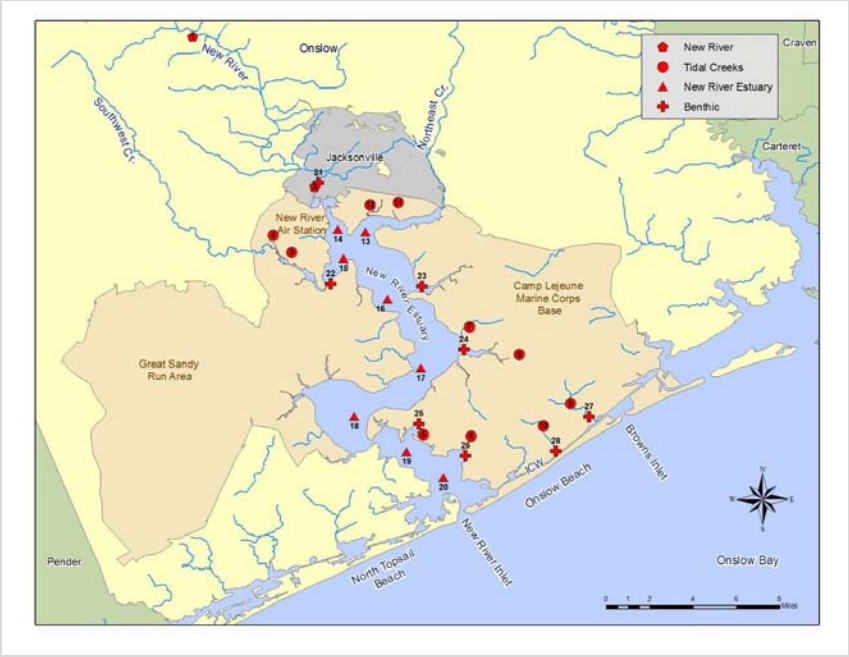




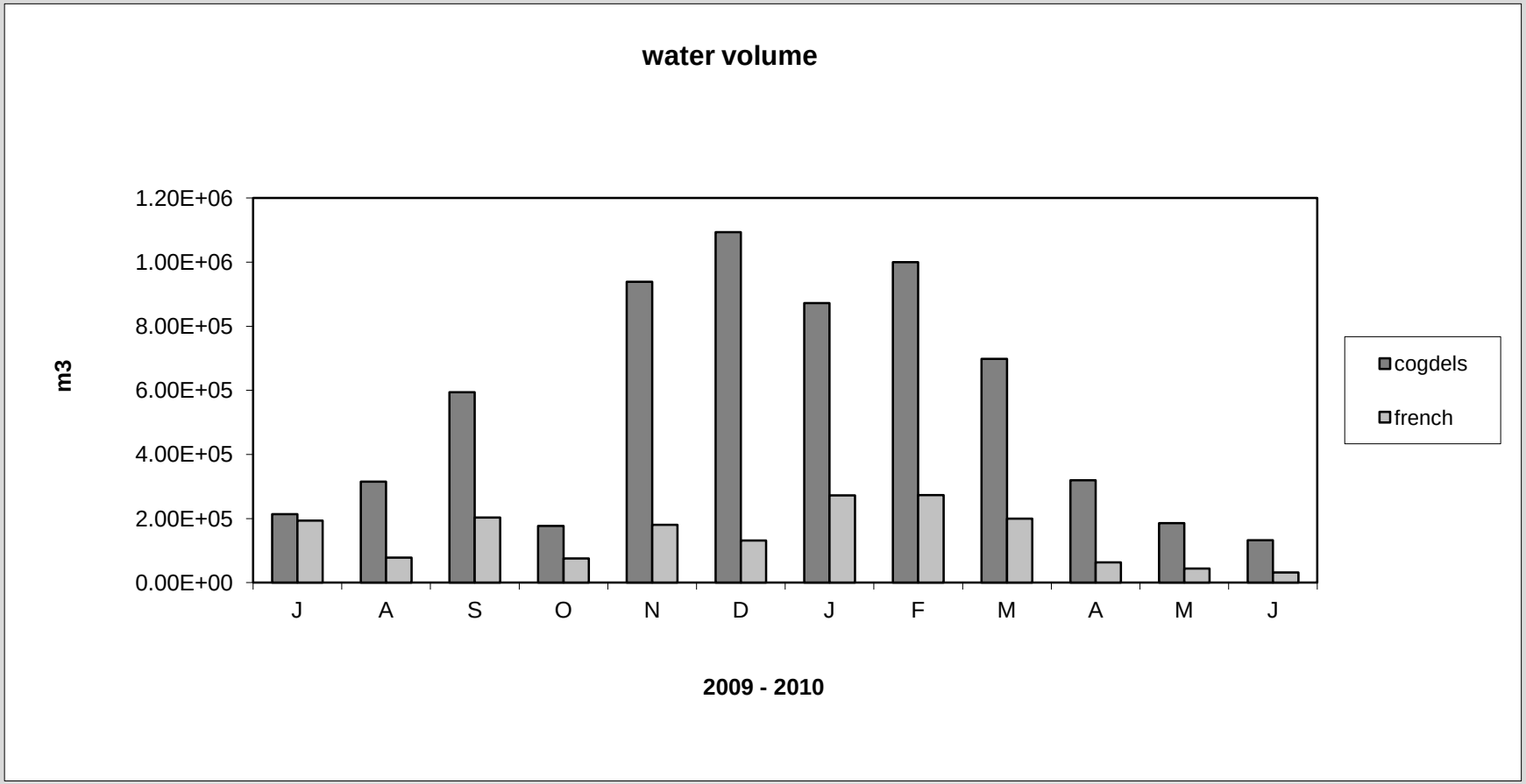


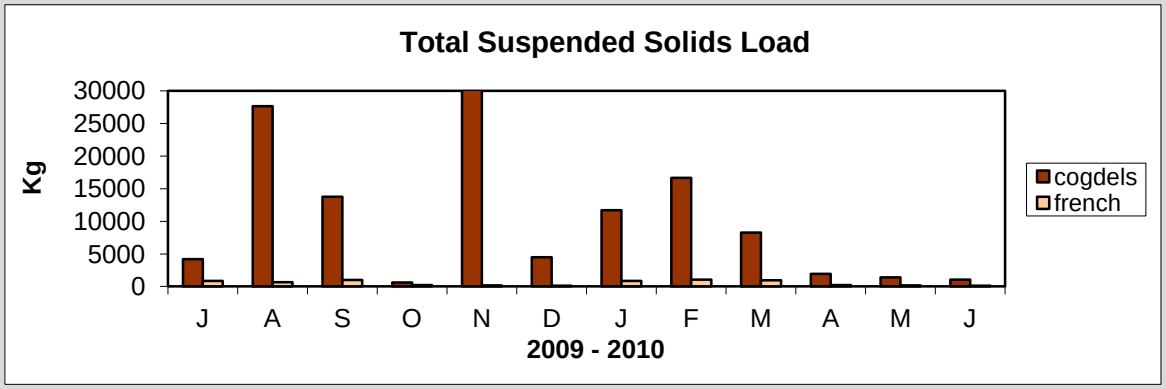
Percentage of each constituent delivered in storm-flow

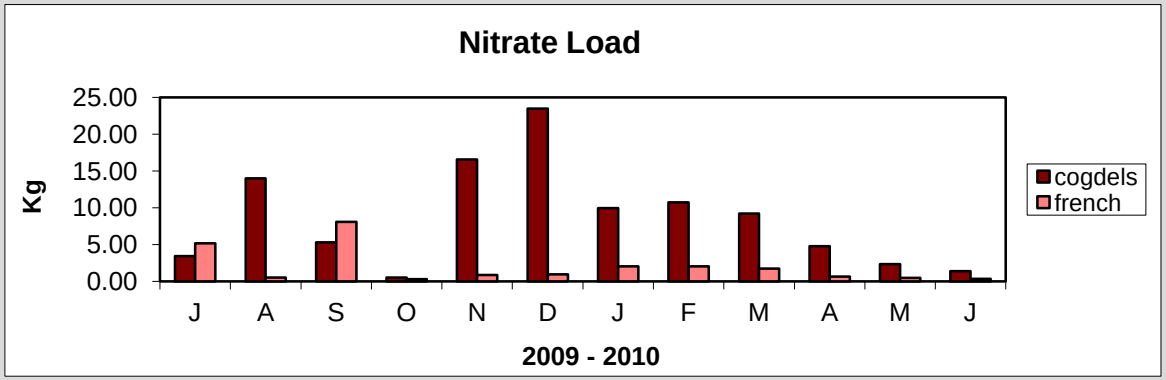
	Water	TSS	NO3	NH4	PO3	TDN	DON
Reference	35	59	51	45	35	52	51
Affected	**51**	69	63	49	**61**	58	57

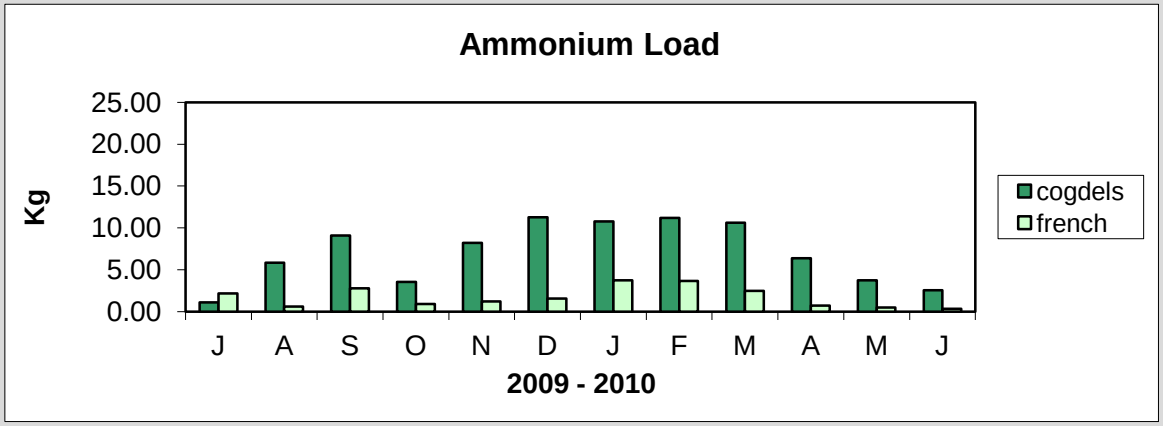


Are there seasonal patterns in material loading from coastal streams?

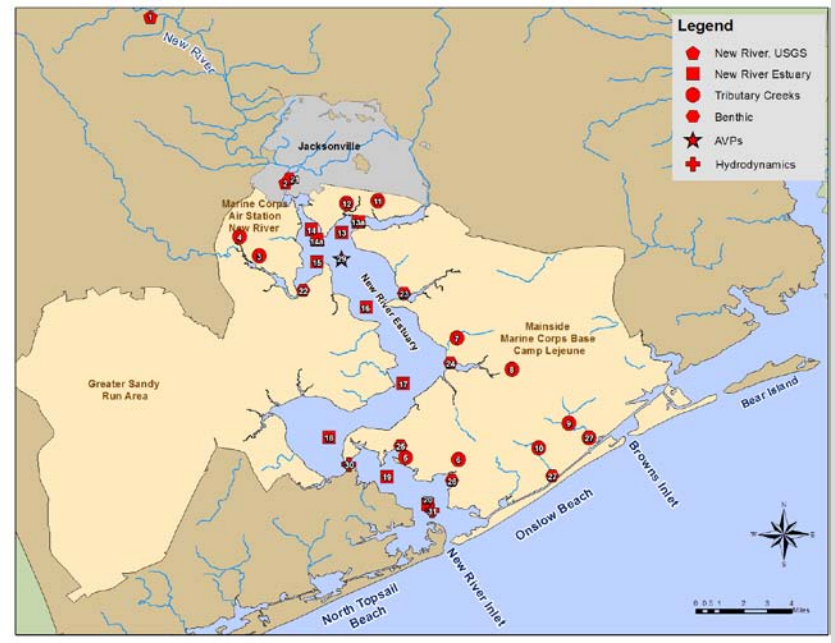

water volume
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
m3
J
A
S
O
N
D
J
F
M
A
M
J
2009 - 2010
cogdels
french


Total Suspended Solids Load
Kg
30000
25000
20000
15000
10000
5000
0
J A S O N D J F M A M J
2009 - 2010
cogdels
french


Nitrate Load
Kg
25.00
20.00
15.00
10.00
5.00
0.00
J A S O N D J F M A M J
2009 - 2010
cogdels
french


Ammonium Load
Kg
25.00
20.00
15.00
10.00
5.00
0.00
J A S O N D J F M A M J
2009 - 2010
cogdels
french

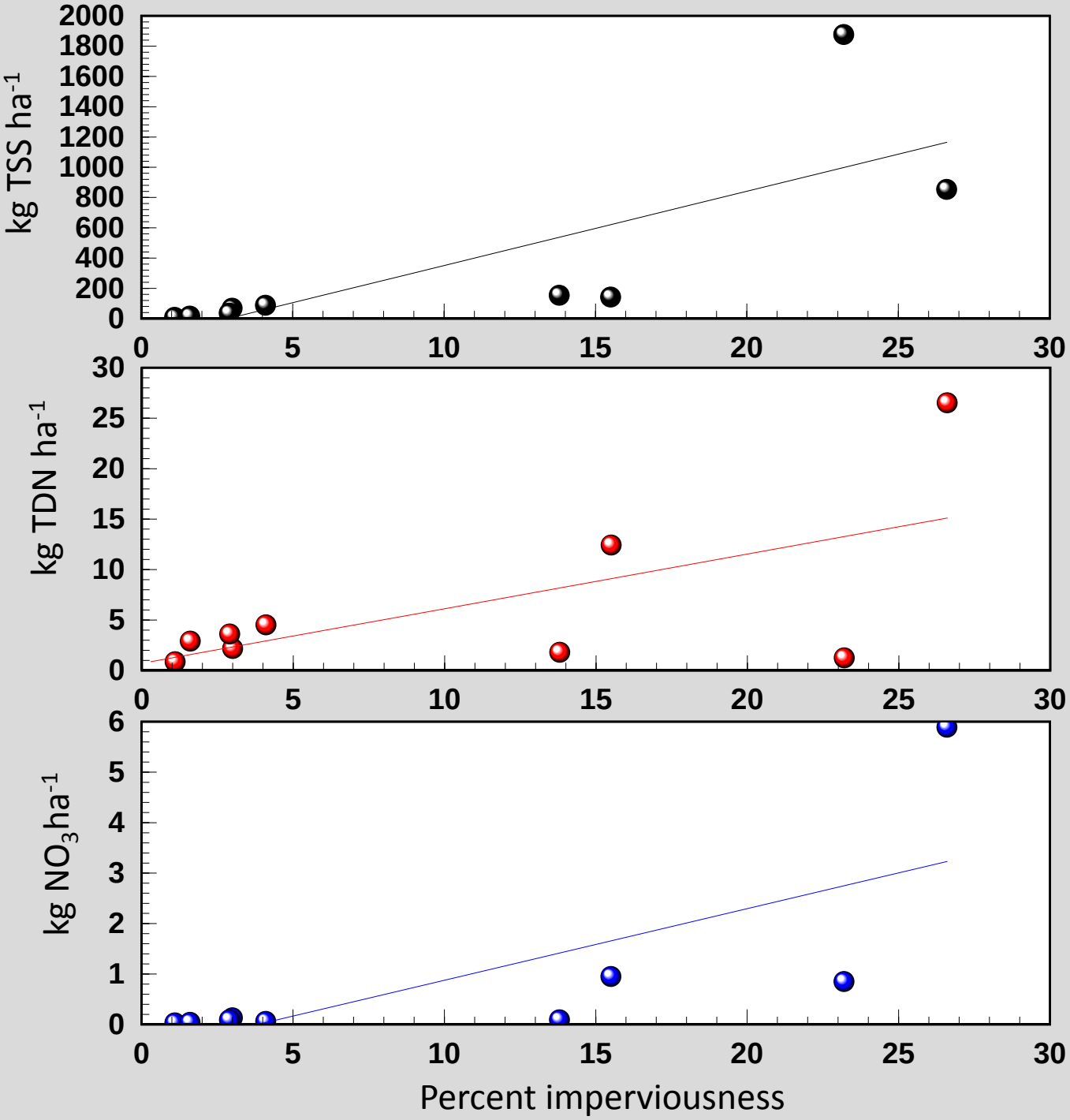
How NRE stream loads compare to other coastal systems?



	NO x kg/ha
Southwest	0.13
NR Air	5.89
Camp Johnson	5.92
Tarawa	0.85
French	0.03
Cogdel	0.09
Traps	0.06
Courthouse	0.95
Gillets	0.09
Freeman	0.04

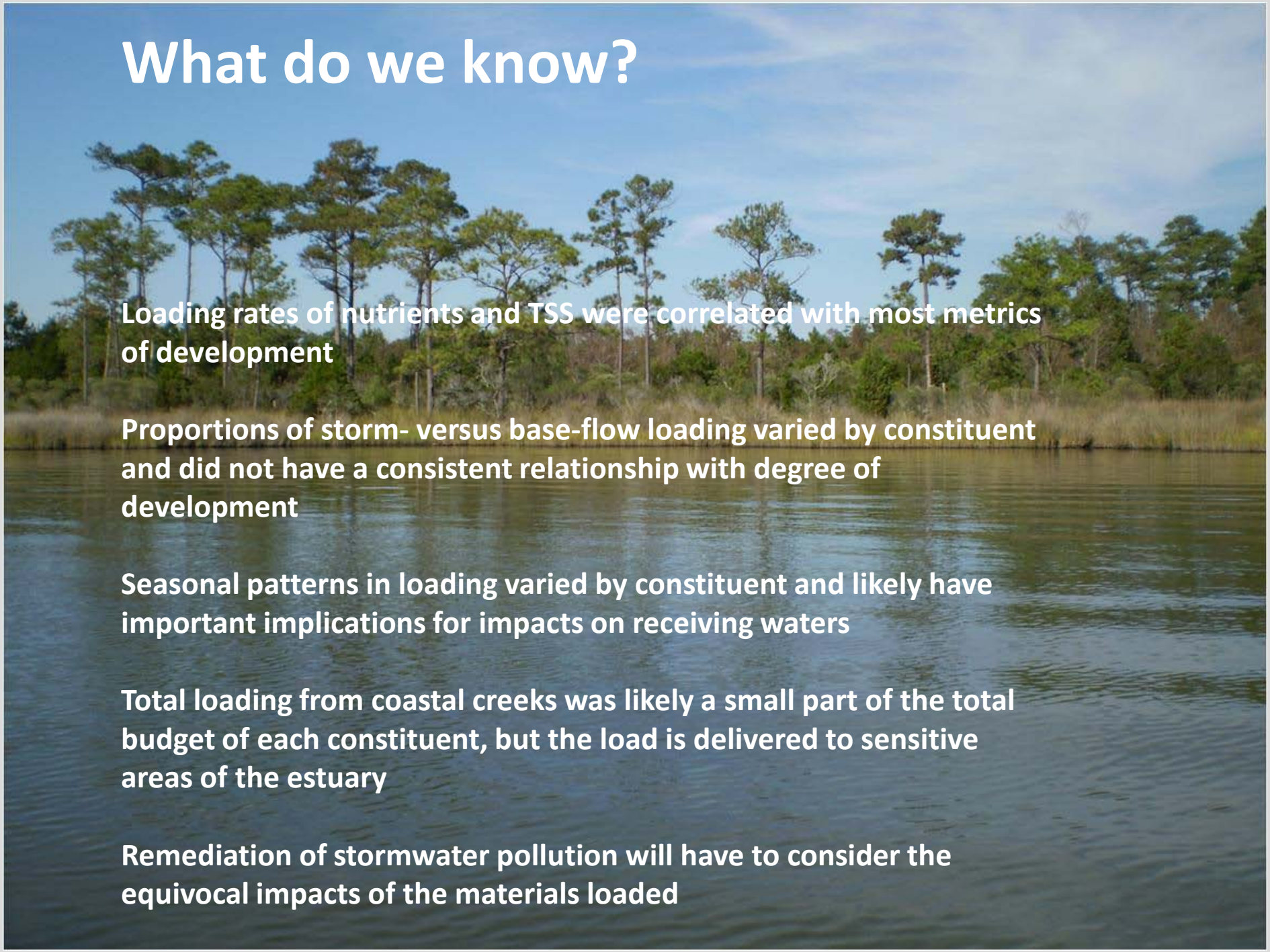
Chesapeake Bay tributaries	0.36-6.35 kg/ha (Correll et al 1992)	
Baltimore LTER	Forested	0.03-0.2 kg/ha (Kaushal et al 2008)
	Urban/sub	2.9-15.3 kg/ha (Kaushal et al 2008)

Are changes in loading of nutrients and TSS correlated with changes in land use?



Nutrient and TSS loading summary		Management implications
Mean values of all loads were higher at affected sites compared to reference sites	→	Increased development will likely lead to larger loads
Storm-flow did not always deliver larger proportions of load at affected sites compared to reference sites	→	Coastal stormwater management approaches may need to be revisited to ensure they are targeting the majority of the loading
Loads from streams were on the low end of ranges from other studies	→	Current land management appears sound
Imperviousness was correlated with loading	→	More evidence that increased development will increase loading

What do we know?



Loading rates of nutrients and TSS were correlated with most metrics of development

Proportions of storm- versus base-flow loading varied by constituent and did not have a consistent relationship with degree of development

Seasonal patterns in loading varied by constituent and likely have important implications for impacts on receiving waters

Total loading from coastal creeks was likely a small part of the total budget of each constituent, but the load is delivered to sensitive areas of the estuary

Remediation of stormwater pollution will have to consider the equivocal impacts of the materials loaded

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

MARINE CORPS BASE CAMP LEJEUNE

DCERP DEFENSE COASTAL/ESTUARINE RESEARCH PROGRAM

SERDP DOD • EPA • DOE

WILLIAM & MARY VIMS VIRGINIA INSTITUTE OF MARINE SCIENCE SCHOOL OF MARINE SCIENCE