Future riverine nitrogen export to US coastal areas: Prospects for improving water quality amid population growth

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Coastal ecosystem services

- Protection from flooding and storm events
- Maintenance of fisheries
- Nutrient cycling
- Water purification
- Recreation
Excess N in coastal ecosystems

• Reduced biodiversity
• Degraded water quality
• Harmful algal blooms
• Hypoxia
Question

How will population growth affect future N loads to US coastal areas?
Future coastal TN loads

- Nutrient Export from WaterSheds (NEWS) model
- 2030 scenarios
  - Millennium Ecosystem Assessment
  - Two additional scenarios
    - “Business as usual”
    - “Ambitious”

Seitzinger 2010
Agricultural sources
Atmospheric deposition
Background N-fixation

Land-to-water delivery
Storage/removal on land

Sewage

In-stream retention

N delivered to basin mouth

NEWS model: N transport by rivers

Mayorga 2010
### MEA scenario storylines

<table>
<thead>
<tr>
<th>Reactive environmental management</th>
<th>Globalization</th>
<th>Proactive environmental management</th>
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<tr>
<td>Global Orchestration</td>
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<td>Order from Strength</td>
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**Regionalization**

- Millennium Ecosystem Assessment 2005; Seitzinger 2010
## Key scenario drivers

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2000, AM, GO: Seitzinger 2010
BAU, AMB: Agriculture: Smil 1999; Sewage: Van Drecht 2009
Scenario outcomes

Particulate
Natural
Sewage
Atmospheric deposition
Agriculture
Scenario assumptions in context

- Scenarios reflect interaction of
  - Socio-economic factors
  - Nutrient management practices
- Compared assumptions to
  - US agency publications
  - Scientific literature
Population growth

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- Population growth drives increases in
  - Crop production
  - Fossil fuel combustion
  - Sewage
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- Crop production
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US Census Bureau
- 2012: 312 million
- 2030 projection: 373 million people
**Fertilizer recovery efficiency**

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Since 2000, additional 28 m acres under some form of nutrient management

MARB Hypoxia Task Force 2011
### Fertilizer recovery efficiency

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- ~35% of US cropland meet BMPs for rate, timing, and method of fertilizer application
- Typical fertilizer recovery efficiencies ~50%
- Future improvements appear optimistic

Cassman and Doberman 2002; Ribaudo et al. 2011
## Dietary preferences

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- Strong, positive relationship between wealth and food consumption

Van Drecht 2009; Kearney 2010
Dietary preferences

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- **2000–2010 trends**
  - Meat consumption down 5%
  - Total food consumption flat

- **Effects of economic conditions or changes in dietary preferences?**
Sewage treatment effectiveness

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- States planning for 66% N-removal efficiency

Time lags

• NEWS model structure assumes N is in steady-state

• Evidence of N accumulation in managed landscapes
  – 30 y time lag between N input and export for River Thames
  – >20 y of N management in Europe, but no consistent reductions in coastal export

Howden 2011; Grizzetti 2012
Conclusions

• Substantial changes in nutrient management needed
  - Technologies and BPM’s exist today to reduce coastal N loads
  - Reducing agricultural N will have the greatest coastal benefit

• Policies must take decadalal perspectives

• Degradation of coastal ecosystems and services likely to continue
Questions
NO\textsubscript{x} emissions have declined

**Figure 8: NO\textsubscript{x} Emission Trends for All Acid Rain Program Units, 1990-2009**

Source: EPA, 2010