A VISION of SUCCESS

How nutrient management will enhance and sustain ecosystem services

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“Sustainability is about stabilizing the currently disruptive relationship between earth’s two most complex systems – human culture and the living world.”

(Hawken 2007)

Humans need food, energy, transportation; all are sources of excess nitrogen

Humans need services produced by the living world, some of which are enhanced, and some degraded by excess nitrogen
URBAN ENVIRONMENTS

Traditional
* Import water, food, energy – export wastes
* Impervious surfaces
* Air pollution
* Heat islands
* Traffic jams

Environmental injustice

Sustainable
* Water and materials recycled
* Stormwater captured for beneficial uses
* Clean transportation & industry
* Trees, green spaces, energy efficiency

Public transportation, integral development
Environmental justice

*Affects the nitrogen cascade*
Can we feed 9 billion people sustainably?
**ENERGY & TRANSPORTATION**

**Traditional**

Energy production and transportation heavily dependent on fossil fuels – coal, oil, gas

Inefficient systems: legacy of old technology and cheap fuels

High temperature combustion creates nitrogen oxides

**Sustainable**

Renewable fuels (Nr increase or decrease?)

Renewable energy (non-combustion)

Efficient transportation systems

Reduced impervious surfaces for roads and parking areas
**SUSTAINABLE NITROGEN MANAGEMENT**

<table>
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<th>Reduce leakage of Nr to the environment</th>
<th>Sequester, remove, and reuse Nr</th>
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<td>Agriculture</td>
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Can we do enough while maintaining economic efficiency and food security?
TRADE-OFFS & UNINTENDED CONSEQUENCES of “SUSTAINABLE SOLUTIONS”

Renewable (bio) fuels may increase fertilizer use and Nr emissions

Waste to energy may increase N emissions

Feeding a hungry world will require more fertilizer and land conversion = more N leakage

Increasing mobility is good for people, but growing demand for private vehicles and air travel has costs, including increased N emissions
ON THE POSITIVE SIDE

Green infrastructure generates “bonus” ecosystem services, i.e. over and above water quality improvements (Messer et al. 2012)

Wetlands generally remove Nr in direct proportion to loading besides providing other services (Jordan et al. 2011)

Growth of non-combustion energy sources (wind, solar, hydro, etc.) will foster lower N emissions

Nr is a valuable resource! Can we reuse much of it instead of wasting it?
SOME ELEMENTS of a SUSTAINABLE SOLUTION

ENVIRONMENT

Reduce coastal eutrophication

Protect sensitive ecosystems & biodiversity

Increase N uptake and removal capacity
  wetlands
  forests
  grasslands

ECONOMY

Maintain productivity
  farms
  forests
  fisheries

Minimize costs; allocate equitably
  taxes
  subsidies
  markets
  regulation

SOCIETY

Protect human health & well-being

Maximize N-related ecosystem services
The CORE of a VISION

A future where the benefits of Nr use are not outweighed by its negative consequences for the environment & human health

The REQUISITE CHALLENGE

Apply an adaptive mix of technological, policy, regulatory, market-based and voluntary initiatives
Some of the considerations for sustainable solutions
Significant, sustainable reductions in Nr must be economically efficient, socially acceptable, environmentally sound, adaptable to changing climate, land-use and demographics; and permanent. These requirements can be met only through comprehensive, adaptive management of air, land, and water.
Replace waste with the natural cycle.
Sustainable nitrogen management will:

- protect, restore and sustain ecosystem services;
- reverse or prevent disastrous eutrophication of coastal seas and oceans;
- conserveNr as a valuable resource;
- sustain the health of people and ecosystems
THE BAD NEWS

The path to sustainable N will be long and hard

If you think CO$_2$ control is a tough sell . . .
the nitrogen problem may be even tougher

It won’t be easy to gain public awareness and understanding of such a complex problem

Excess Nr already in the environment will continue to cascade for . . . ?

The problem is likely to get worse before it gets better
THE GOOD NEWS

Federal agencies, some states, and the environmental science community are aware and working together on solutions

Society is in a transition from a “take all you can get and waste what you don’t use” ethic, to a “take only what you need and recycle the residuals” ethic

Sustainability is a path, not a destination; the gate is open
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