Nitrogen Pollution: an economic assessment

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Great cycle disruption

- Although nitrogen is a major component of the atmosphere biologically available nitrogen is limiting in most ecosystems
- Human activity (fossil fuel burning, N-fixing plants, fertilizer) have thrown the natural nitrogen cycle severely out of balance.
- Like carbon dioxide the nitrous oxide level in the atmosphere been rising steadily
- In addition dry and wet deposition has increased dramatically

Where does this nitrogen come from?

Emission of nitrogen gases U.S.

- Industry, utilities burning fuel 57%
- Cars, trucks, buses burning fuel 38%
- Other industrial processes 3%
- Solid waste and miscellaneous 2%

How does this nitrogen affect ecosystems?

- The primary problem is the changes added nitrogen encourages in ecosystem organization and function
- The nitrogen also contributes to acid rain and acidification (compounding problems caused by sulfur emissions)

This addition of nitrogen can be catastrophic

- Although farmers sometimes benefit from this N deposition it is very damaging to both aquatic and terrestrial ecosystems
- Nitrogen changes the balance of power between various organisms favoring weedy, high response species

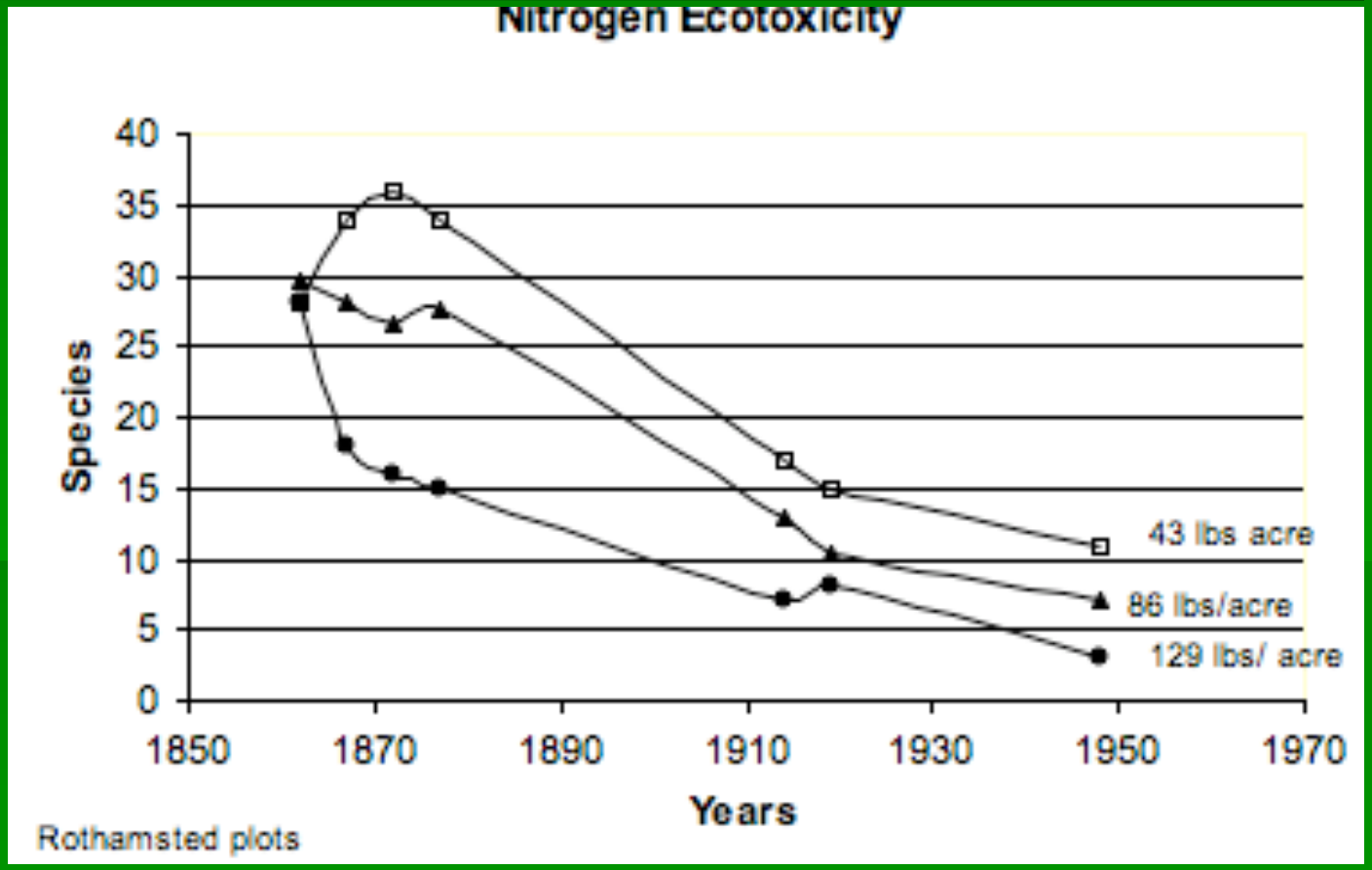
Impact = capacity /rate * time

- Very sensitive areas in high mountains with limited buffering capacity are disrupted by N deposition rates of only 1-2 kg/ha
- The high deposition rates now found in many areas are very damaging to even robust ecosystems

Two examples

- At the Rothamsted plots in England we have data for a 100 year long experiment with added N. At first the diversity rose, but then it collapsed. The higher N rates led to the lowest diversity
- In a study of grasslands in the Midwestern U.S. added N reduced diversity 50% in just twelve years and native bunchgrasses were replaced by exotic grasses

Nitrogen pollution is toxic



What can be done about it?

- There are three basic approaches:
  - Limit emissions
  - Treat ecosystems
  - Provide economic incentives to limit emission and treat ecosystems

Limiting emissions -- the technical solution?

- The major sources of N pollution in most developed countries are automobiles and power plants
- New standards cut auto emissions from 2 gm/km to less than 0.25, but mileage driven is up and more light trucks and SUVs have offset auto gains
- True gains will require changes in urban design, more bicycling and walking

Power plant N emissions can be reduced but not eliminated

- **The** use of high chimney stacks moved England's N problem to Norway and Sweden
- Reducing power plant emissions will require reducing power demand
- And use of fossil fuels

Reducing demand is helpful

- A test house in Davis was redesigned for solar optimization, it cost less to build than the conventional design and reduced peak summer cooling demand from 3.6 to 2 kw.
- The cost per kwh saved was $-2.33, contrast this with up to $+3.80 paid in the California energy crisis on the spot market and typical costs approaching 20¢kwh expected in the future

What might a technical solution cost?

- The U.S. has made little effort to combat this problem or to calculate control costs
- The European Commission has drafted several plans for control, encouraged by counties already combating N pollution, estimated at 50 billion Euros per year (IIASA)

Could a technical solution work?

- The key for success with this technical approach is education, users and regulators need to know there is a problem
- It will require a much expanded research program to understand allowable levels of N pollution in different areas

Even with a technical solution lifestyle changes are needed

- Lifestyle changes across societies will be needed- these are unlikely in the near term
- For San Diego County with estimated deposition rates of 20 kg/ha in some areas and an unwillingness to consider alternatives to the auto or the very large unsolar tract home and unsustainable office building the prognosis is grim

What is the treatment option?

- The treatment option would treat ecosystems with materials that tie up the excess nitrogen
- Recalcitrant soil amendments with high lignin content have been used with some success on environmental restoration sites
- In addition aggressive control of exotic species would be needed

What impacts would aerial treatment cause?

- We don’t know - but theoretically N absorbing amendments would help
- Are there any similar treatment programs?
- Yes, the treatment of acidified lakes with lime in Norway and Sweden has now been extended to ecosystems with some promise--but many unknowns
- Adding calcium to acidified systems has also helped

What would treatment cost?

- We don’t really know
- Treating ecosystems with lime has cost about $450 ha in Norway, but this appears likely to help for 20 years or more
- The cost of applying recalcitrant amendment should be less, the application rates are lower, but it will be very expensive to spread thousands of kg a year
- Treatment does not appear to be a good option except for limited areas

What would an integrated approach look like?

- The obvious approach is to adopt both the polluter pays principle and the precautionary principle
- Most emissions can be related to fuel or energy consumption so use fees would be relatively straightforward (fees per liter, kwh, etc.)

Market solutions work best

- An annual fee based on pollution levels would also be desirable - this would increase the cost of operating diesels which are major NOx generators
- The fees collected could be used for both ecosystem treatment and research

At what level should N control be adopted?

- Nitrogen pollution is a regional, national and international problem
- In Europe the Copenhagen Protocol proposes such a community-wide solution
- In North America it should be binational or trinational
- In the western U.S. it must be strong at the regional and state level

What would the program look like in California's deserts?

- The California deserts are rich in biodiversity
- Dramatic changes are appearing as invasive species increase and wildfire spread kills stable historic plant communities

Costly to manage on the land

- Full treatment costs might exceed $100 million dollars a year for San Diego county
- An adequate monitoring and research program would cost about $20 million a year
- An education program would cost $5 million per year

Where would the $ come from?

- Current gasoline use in San Diego county is 1+ billion gallons a year, so a N offset fee of only 7-8¢ gallon would pay for most of the program, if it was all charged to transportation
- Housing and commercial buildings could contribute with a fee of 2-5¢ kwh

Nitrogen pollution is

- A perfect example of an ecological economics problem
- It involves incomplete information and understanding
- Complex science with multiple feedbacks and interactions
- And very large costs and transfer of costs to Society and future generations

Ignorance is not bliss

- Limited awareness in public and policy making arenas
- Profound impacts on the natural environment
- Solutions that will require reimagining and reengineering our lifestyles

Why an economic approach?

- It is the best way to influence consumer behavior
- It will allow architects, engineers, planners and designers more flexibility as they redefine **Best Management Practices**
- It will help minimize parasitic costs of bureaucracy and legal actions

Where do we go from here?

- Market solutions
- Education to increase Awareness
- Research - a series of local Long Term Ecological Research projects is urgently needed to track changes in ecosystem structure and function
- Action

The first step is acknowledging the problem

- We are fossil fuel addicts
- Our addiction is costly and damaging

- ***We can kick the habit!***