Global N and P cycles

I. Intro
   A. look at aspects of these cycles
   B. dominant processes and how man's activities are affecting them

II. Nitrogen cycle **Fig. 12.1**
   A. strongly coupled to the carbon cycle
      1. some key differences
   B. a larger variety of nitrogen species
      1. N_2 - large reservoir in the atmosphere but not easily available to biota
         a. other gaseous form - NO and N_2O
      2. biologically available N - ammonium, nitrite, nitrate
      3. nitrogen oxides such as N_2O
         a. N_2O not generally thought of as a reactive form of N but it is a greenhouse gas
         b. produced by both nitrification and denitrification
         c. other nitrogen oxides
      4. a large number of biogeochemical transformations possible

III. Global nitrogen cycle **Reeburg figure**
   A. atmospheric N_2 is the largest pool
      1. ~10^9 Tg N in atmos.vs. ~10^5 g in terr systems (terr. biomass and soil OM)
      2. oceans contain ~10^6 g of "bioactive" N (not N_2)
   B. contrasts other elements that have their largest pool in sed rocks (ie, C)
      1. instead of burying it away for long periods of time, N cycling "stores" most N in the atmos. in a form that is simply much less biologically available
      2. atmospheric residence time is over 20 million years
   C. Human activity has severely affected global N cycle
      1. first look at controls on pre-industrial N cycle
      2. then look at how human activity is affecting the cycle

IV. Long-term N cycle dominated by a balance between biological N-fixation and denitrification
   A. rapid internal cycling both in the oceans and on land **Fig. 12.1**
   B. these may not always be balanced **– show my cartoon**
   C. some studies suggest that the pre-industrial N budget was not in steady-state
      1. pre-industrial ocean may have been losing fixed nitrogen
      2. opposite may have been the case during glacial times
   D. evidence that combined N imbalance may change on glacial/interglacial time scales
      1. decrease in denitrification rates during glacial times
         a. possibly related to drop in sea level and decrease in the area of continental shelves (important sites of denitrification)
         b. could help explain the lower atmos CO_2 during glacial times **show my systems diagram**
      2. could also be related to an increase in N fixation **Fig. 14-13**

V. Man's impact on the nitrogen cycle
   A. human activities have severely affected the global N cycle

B. add fixed N in several ways **show N cascade figure**

1. energy production - fossil fuel burning
   a. converts N_2 and org N in fossil fuels to NO
   b. NO oxidized to NO_2 which then rains out at nitrate
      (i) leads to acid rain
      (ii) has a rel. short lifetime in atmosphere
      (iii) see atmos. Fixed N turnover times in **Fig. 3**
2. fertilizer production - Haber process
   a. converts N_2 to ammonium
3. crop cultivation
   a. human-induced increase in biological nitrogen fixation

VI. Anthropogenic cycles of reactive N **Fig. 3 Reeburg**

A. on continents, human activities are producing reactive N at comparable rates to natural processes
   1. ~140 vs. ~190 Tg N/yr
B. release of reactive N from continents to coastal oceans has doubled **Fig. 2**
   1. comparison of pre-ind. world to present day
      a. present day = pre-ind. + anthropogenic fluxes
C. net atm transfer of N from continents to oceans has gone from ~0 to 18 Tg N/yr
   1. absolute emission of reactive N to atmos have increased
      a. 29 Tg/yr (pre-ind) to 107 Tg/yr (currently)
D. allows more reactive N to be re-distributed to points far from the pt. of fixation **Fig. 12.3**

VII. human activity on land fixes ~ 140 Tg N/yr **Fig. 2 with animation**

A. where does it go
B. 41 Tg/yr transported to coastal ocean
C. 18 Tg/yr are deposited on oceans from atmos.
   1. primarily from atmos deposition
D. 3.4 Tg/yr are emitted to atmos as N_2O
   1. leads to an increase in atmos. N_2O increasing
   2. N_2O less reactive in atmos. longer turnover time
      a. another greenhouse gas
E. ~80 Tg/yr not accounted for
   1. retained on land in groundwater, soils or vegetation
   2. may be be denitrified on land
      a. estimate of this is 50 -110 Tg/yr
      b. based on N_2O prdn. rate and a N_2:N_2O denitrif. ratio of 14-32

VIII. Fate Anthro reactive N added to oceans

A. 41 Tg/yr transported to coastal ocean by rivers
B. 18 Tg/yr are deposited on oceans from atmos.
C. What is its fate **Fig. 6**
   1. buried in seds (some) or denitrified (most)
   2. in a local sense this plays a role in cultural eutrophication of coastal regions
   3. little of this apparently escapes coastal ocean

a. no enhanced C_{org} burial in open ocean, implies that N burial has not increased
b. DN on shelves may be greater than river input of reactive N

D. on land and in the ocean the ultimate fates or anthro reactive nitrogen is denitrification
1. the problem is what happens along the way

IX. Impacts of increasing anthrpogenic N fixation **go through Nr slides**
1. once an atom of Nr enters the system it can cause multiple effects
a. in the atmosphere, in terr. ecosystem and in marine and freshwater environments
2. effects become magnified over time

B. Cascade of reactive N **go thru N cascade figures**
1. Reactive nitrogen (Nr) is accumulating in the atmosphere.
2. Nr is accumulating in terrestrial systems
3. Once Nr enters water (streams, rivers, estuaries) most will eventually denitrify
a. generally far from point of entry.
4. Accumulation occurs on short- and long-time scales
a. different reservoirs have different residence times
b. leads to accumulation

X. Forecast for the future

A. anthro N fixation driven by energy and food production **EHP Fig.**
1. controlled by human pop. and standards of living
2. both will prob. incr. with time

B. the implications of this increase will depend on how and where this N accumulates

C. even if most is eventually denitrified there are still regional and global problems

XI. Phosphorus cycle

A. linked to N & C cycles
1. some distinct diffs in P cycle
2. P has no significant atmos component
3. phosphate and org. P are the predom. species

B. much more of a "geological" cycle **look at figures**
1. no significant atmospheric fluxes from continent to oceans
a. atmospheric inventory component minor
2. on long time scales, P is generally considered to be the major nutrient limiting primary prod.

C. internal recycling very important – particularly in the oceans

D. Increased P remobilization by human activity
1. mineable P in the budget
2. see it, for example, in incr. P loading by rivers **Fig. 10.16 Mackenzie**
3. again its effect will be more regional rather than global (like N)
a. no major atmos. P cycle
b. P cycling relies strongly on hydrologic transport
4. distribution from fertilizer run-off and sewage treatment is likely confined to freshwater and nearshore coastal ecosystems