10/28/04

Key to Quiz Questions—Week 5
Forests Through Time and Space

1. *Fertilization of second-growth forests is increasingly common here in the PNW. This increased nitrogen input into the forest ecosystem can have a number of deleterious ecological effects, including destruction of ozone in the stratosphere. A common form of nitrogen fertilizer used is ammonium nitrate. When it dissolves in the soil solution, it forms both ammonium (NH_4^+) and nitrate (NO_3^-). Outline the forms of nitrogen, the organisms involved, locations in the ecosystem, and the names of the processes the nitrogen molecules go through until they end up in the ozone layer.*

This question gives you an opportunity to review the nitrogen cycle and the connections between it and the atmosphere. In order to receive full credit, you needed to restrain your discussion to the specific reactions involved with ammonium nitrate entering the soil as nitrate and ammonium. You also needed to make the specific connection between one of the products of denitrification (N_2O) and ozone destruction.

The nitrogen from ammonium nitrate entering the soil as nitrate and ammonium has a number of possible fates. Both forms of nitrogen can be taken up by plants or soil microorganisms (MOs) and converted into organic nitrogen. This organic nitrogen can go through repeated recycling within the ecosystem, decomposition (ammonification) and uptake. Ammonium gets converted to nitrate by chemoautotrophic bacteria (*Nitrosomonas, Nitrobacter*) living in the soil. Nitrate can go into intra ecosystem cycling, or go through denitrification which occurs in anaerobic zones in the soil. These zones can be in water-logged soils where oxygen diffusion is limited or inside soil aggregates with high organic content where high rates of respiration deplete the oxygen. The products of denitrification are nitrogen gas (N_2) and nitrous oxide (N_2O). Nitrous oxide is not chemically reactive in the lower atmosphere. It is a very effective greenhouse gas (200 times better than CO_2). N_2O diffuses to the upper atmosphere where it breaks down to form NO which destroys ozone molecules catalytically, thus linking fertilization of forests with ozone destruction and thinning.

2. *The chum salmon that are returning to Kennedy Creek this year represent several lineages; while some returning individuals are probably siblings, most are not related.*

    a. *Explain in as much detail as you can muster why "Bob," one of this years' returnees, would be better off if the pals he's swimming upstream with die before they get to the spawning grounds. (5 points)*

To get full credit, you need to have invoked group selection by name, and explained what it is. That is: natural selection favors individuals that are the best fit for their environment, as those individuals pass on the most copies of their genes. Unrelated individuals are competitors, so their disappearance aids the individual. There is no advantage to "group-think" in unrelated organisms, except possibly at extremely low population densities—that is, if your population is so small that you have nobody to mate with, you've got problems. Explanations of organisms doing what is best for the species, at cost to themselves individually, are "group selection" arguments, and make no sense evolutionarily. (Note that group living organisms with multi-generational family structures and overlap of generations—including elephants, many whales, and apes, including us—start to change the rules somewhat, especially once you add the ability to build scenarios—imagine the

future ramifications of current behaviors—which is arguably the most important thing that separates humans from other species.)

If you explained why group selection doesn't make sense—for instance, by pointing out that if other males reproduce, it reduces the chance that Bob will get to—but didn't call it group selection, you get 4 points.

Partial credit was given in some cases for other arguments that aren't as strong as the group selection argument, but still may apply in some circumstances—for instance, that if the population becomes extremely small, there may be nobody to mate with if everyone else dies off. But keep in mind that the population has to be reduced extremely severely for this to matter to Bob. Furthermore, at relatively low population density, Bob is at an advantage due to reduced intra-specific competition.

b. Give two real examples of how either intra- or inter-specific competition on chum salmon can affect their reproductive success (that is, their production of viable offspring). Be specific. (5 points)

The question asked for real examples, which were most easily pulled from the Essington (1999) article, a required reading from the website. If you provided theoretical examples (that is, examples that are possible but not proven), you may receive partial credit, but not full. Three points for the first example, 2 for the second.

Four examples (the question only asks for two), all from Essington 1999:

- Redd superimposition by later-spawning females (Essington, p 206)
- Reproductive success (RS) is density dependent (Essington, p 209, fig 2)
- Sockeye presence affected chum post-depositional RS, due to overlap in spawning times. (Essington p 210)
- Bonus information, that isn't an example unto itself, but adds detail: Magnitude of interspecific effects with sockeye will be mitigated by other factors, including relative body size, spawning date, and habitat use patterns within spawning sites. Microhabitat preferences such as for depth, velocity, substrate, and cover may segregate the species. (Essington p212, last two paragraphs before end.)