Key to Quiz Questions—Week 8

Forests Through Time and Space, Fall 04

1. *Using the double-edged sword principle described by Bret to explain the latitudinal diversity gradient, explain why no organisms have evolved a stable strategy for long-term persistence in the temperate zone, and how that contributes to patterns of global diversity.*

The double-edged sword principle refers to an intrinsic trade-off between efficiency and robustness. In the temperate zone, organisms get it coming and going. Because the temperate zone has highly variable weather and climate over most temporal scales (between day and night, seasons, years, and glaciation events), organisms cannot adopt a single strategy to persist here. Good competitors may persist during interglacials, but due to intrinsic trade-offs, will not be robust enough to survive glaciations. Robust organisms may well survive glaciations, but soon after those end, will get outcompeted by invaders returning from the South, whose ancestors were not robust enough to survive the glaciation, but who are themselves efficient enough to outcompete those who can withstand climatic extremes. In general, temperate species are inefficient because they must retain the capacity to deal with unpredictable abiotic conditions if they are to survive a harsh winter. Competitive exclusion rules the day in the temperate zone, so overall diversity is low.

In the tropics, on the other hand, species are relatively specialized and efficient, due largely to more stable abiotic conditions. The forces dictating species diversity in the tropics are primarily biotic—that is, other species that are competing for food or space. Competitive exclusion is rarer because the climate is stable enough to allow specialists to evolve multiple equally fit strategies for survival; thus, several species can co-exist on an adaptive ridge (which is stable) in the tropics, so species richness is high. This is in contrast to the relatively few species that are struggling to persist on the adaptive dunes that are always moving out from under temperate species. Thus, the global pattern of biodiversity can be viewed not primarily as an increase in number of species as you approach the equator, but rather a decrease in species diversity as you move away from the equator.

2. *Forests are being used in the global warming discussion as a way of taking carbon dioxide out of the atmosphere. Different forest ecosystems hold onto the carbon in the trees for varying time periods.*

    a. *Which of the forest types listed below has the potential to store the most carbon Why?*

    (Four points) The ideal forest to store the most carbon would be the one with the most biomass per unit area and the highest NPP per unit area. Although you weren't specifically asked to calculate NPP/ m^2. you can't compare just NPP given in the table because the forest types occupy differing areas. The tropical wet and moist forest has the greatest potential for carbon storage since it has the most C/ m^2 stored in biomass. However, you could make an argument for the boreal forest, based on its larger area, longer MRT, and moderately high biomass per m^2. However, its low NPP/m^2 make it the slowest of the carbon storage options (three points for boreal answer)

    b. *Which of the forest types listed below stores their carbon for the longest time? Calculate the MRT for carbon in the various forests. Is this the same forest that you chose for "a"? Explain your results.*

    (Six points: 3 for calculations, 3 for answer) After calculating the MRT for carbon in each of these forests, it is apparent that the boreal forest has the longest MRT. The mean biomass per square meter and the NPP/m^2 are both lower than the wet tropical forest. Boreal forests grow slowly. Although there is a relatively high amount of biomass C/m^2, this is the accumulation of many years growth. The wet, moist tropical forest which has the highest biomass and NPP per unit area has a faster nutrient cycle and carbon turnover than the boreal forest.

Ecosystem	Area (10^{12} m^2)	Mean plant Biomass (kg C/m^2)	Total mass of carbon in vegetation (10^{15} g)	Net primary Production (10^{15} g/yr)	MRT (years)	NPP gC/m^2 yr
Tropical wet & Moist forest	10.4	15.0	156.0	8.3	18.80	798.1
Tropical dry forest	7.7	6.5	49.7	4.8	10.35	623.4
Temperate forest	9.2	8.0	73.3	6.0	12.22	652.2
Boreal forest	15.0	9.5	143.0	6.4	22.34	426.7