Rik Leemans: Relationship Between Land-Use and Climate Change
Summary from 19 September 2005 by David Zaks

Since the 1980's the study of land-use change has been key in understanding the dynamics of climate, and its potential impacts to Human well being. As described in the IMAGE2 model, the global population and world economy drives land use / land cover, and the demand for energy. Both of these lead to changes in atmospheric chemistry, and consequently act to change the climate through an enhanced greenhouse effect. Many numerical models, like IMAGE2 have been developed to incorporate land-surface processes, and recent iterations have explicitly integrated stakeholders and possible policy outcomes. Scenarios of possible futures have been developed in the Millennium Ecosystem Assessment, which synthesized the current state of scientific knowledge on the degradation of ecosystems, and the connection to human well being.

The carbon cycle links land use change to climate change through the sequestration or subsequent release of carbon dioxide. Before the anthropogenic burning of fossil fuels, levels of atmospheric carbon dioxide stayed relatively constant through the exchange of carbon between the land surface and the oceans. Since the start of the industrial era, the amount of fossil fuels burned is known, and the additional carbon was thought to be absorbed by both the oceans and land. While many scientists attempted to "close" the carbon budget, a significant amount of carbon could not be accounted for and was termed the "missing sink." It is now attributed to land use change and nitrogen deposition.

Much work has been done to gain understanding into the dynamics of land-use change. Pressures from population, economy and technology are the primary driving forces behind observed changes. Disciplines in the academic realm differ as to what the drivers behind land-use change are. For the case of deforestation, ecologists believe that roads are the primary driving factor, political scientists blame property rights and the failure to property assign these rights, and economists blame market failures. Varying combinations of these driving forces are incorporated into models and scenarios, such as the IPCC land cover scenarios for 2100.

While an increase in temperature is the direct result of increased concentrations of carbon dioxide in the atmosphere, there are biospheric feedbacks that act to either enhance or reduce the greenhouse effect. With an increase in carbon dioxide concentrations and temperatures, there is expected to be changes in the rate of photosynthesis. Increased temperatures stress a plant and reduce its ability to respire, therefore decreasing photosynthesis, while increased carbon dioxide concentrations act to increase photosynthetic production. In northern regions, where warming has already begun to occur, the boreal / tundra boundary is shifting north. As snow, which has a higher albedo then bare ground, melts, more solar radiation is absorbed by the ground and acts to raise the temperature further. As boreal species at the edge of the tundra zone are no longer impeded by cold temperatures, the boreal / tundra boundary is expected to continue its progression northward. Additionally, the carbon rich soils of the arctic are expected to thaw and breakdown the organic carbon they hold, further accelerating climate change.

Planting crops for use as biomass fuels, which simultaneously decreasing the area of land used for agriculture could reduce the atmospheric carbon dioxide concentrations by 70-80 ppm. Further sequestration could take place in plantations specifically for biomass storage. While the Kyoto protocol aims to reduce output of carbon dioxide from anthropogenic processes by 6%, a 50-60% reduction is needed to limit the projected warming. The only feasible way to accomplish this is the reduction of fossil fuels.