Period B
Environmental Science
12/7/11

The Effects of Climate Change on New England’s Forested Ecosystems

Abstract:

The purpose of this report is to uncover the possible effects that climate change may have on the forested ecosystems of New England. In order to make these predictions, various models were used to calculate how changes in temperature and precipitation will affect biomass years from now. After using models, specifically from the New England Climate Impacts Assessment, it was found that a rise in temperature combined with heightened precipitation amounts will cause biomass to increase drastically. Further research was conducted that identified some of the possible negative results of these changes.

Introduction:

Climate is determined by average temperature and precipitation levels in a given area. These levels can be affected by air circulation patterns, elevation, sun exposure, proximity to water and latitude. Climate change not only affects weather, but also the changes in seasons and global temperature over extensive periods of time. Climate change can be caused by a number of different factors. One factor that has a direct impact on climate is rising levels of CO^2 in the atmosphere, often due to human activity such as burning fossil fuels. There is much debate among scientists as to what will happen to both natural ecosystems and human communities regarding climate change.

For this study the focus was primarily on the impact of climate on New England's forests ecosystems. To judge these impacts several factors were considered including biomass and net primary productivity (NPP). Biomass is defined as the amount of living material in an area. Factors that influence biomass levels are precipitation and temperature. In order to calculate the biomass of a particular area, one must first determine the limiting factor, whether that be NPP-P (precipitation) or NPP-T (temperature). NPP stands for net primary production and is the creation of new organic matter through the process of photosynthesis. NPP, the input flux to the system, can be calculated by subtracting the losses occurring due to respiration from the increase in biomass. An example to explain this idea is the Oyster River High School forest plot. During preliminary model runs the ORHS plot was found to be limited by temperature, meaning NPP of plant matter could go no higher than that determined by temperature.

The ORHS plot, considered to be a sink, absorbs a greater amount of carbon each year than it releases through carbon sequestration. The amount of plant matter, which is solely responsible for this absorption of carbon, can affect the carbon cycle. For example, the more plant matter, the more carbon. However, the lower the biomass levels, the less carbon will be absorbed by plant matter, meaning that more would be left in the atmosphere. An increase of carbon in the atmosphere will lead to examples of positive feedback such as a rise in global temperatures, a rise in sea levels, and the greenhouse effect. These problems all could contribute to harming the ecosystems of the world.

New England, being located in the Northeast United States, has a temperate deciduous forested ecosystem. Temperate deciduous forests are known for their rapid changes in temperature and precipitation. Average temperatures can go from around 20˚C down to freezing. Deciduous forests are home to trees which lose their leaves each year. Dominant species include oak, elm, maple and beech. In order to determine the effects that global climate change would have on the New England ecosystem, the following modeling study was conducted and research was initiated regarding temperature and precipitation.

Methods/Materials:

This investigation began with the use of The Biomass Accumulation Model to determining the limiting factor to the growth of the ecosystem. The model included 3 variables, temperature, precipitation and turnover rate. These variables were used as inputs to the model and that affect the biomass and carbon storage. First, the turnover rates, temperature and precipitation variables were each changed individually. The changes were compared to the baseline run of data. Once the trends were confirmed from these results, data from the National Center for Atmospheric Research (NCAR) Climate Change Projections was used in the model. The NCAR data was specific to the New England area and was used to predict changes in the towns of Durham, Lee and Madbury. The variables predicted by the NCAR models were air temperature, precipitation, and surface runoff. The NCAR data was composed of four different model scenarios with different predictions of carbon dioxide in the atmosphere. The first model, Commit, predicted that carbon dioxide in the atmosphere would reach no higher than the levels measured in the year 2000. The second model, SRESB1, predicted that CO^2 levels would reach 550 ppm by 2100. The third model, SRESA1B, predicted levels to reach720 ppm by 2100 and the last model, SRESA2, predicted 850 ppm. The predictions based off of these models for temperature and precipitation change were put into the biomass accumulation model to see how these particular changes would impact biomass and carbon storage.

Results:

Some of the most telling data was found by taking the predicted temperature and precipitation changes from the NCAR models and using them in the biomass accumulation model to predict changes in biomass over the next 100 years, as well as NPP-P and NPP-T (Table 1).

Although both temperature and precipitation are expected to change under increased levels of CO2, the effect of increasing temperature changes on NPP never resulted in a greater NPPT than NPPP. This indicates that precipitation, even under the new climate conditions does not become a limiting factor to growth in the New England ecosystem. Based on this fact we can say that the increase in temperature correlates with an increase in maximum biomass after 100yrs as well as an increase in carbon storage.

Table 1: Biomass Calculation Model Results: NCAR and Baseline

	Δ Temperature (°C)	**Δ Precipitation (mm/yr)**	**NPP-T**	**NPP-P**	**Biomass after 100 years**	**Carbon Storage**
Baseline	0	0	1,134	1,555	22,527	11,264
Commit 393 ppm CO^2	.17	-20.05	1,149	1,555	22,527	11,264
SRESB1 550 ppm CO^2	1.24	86.48	1,228	1,635	22,912	11,456
SRESA1B 720 ppm CO^2	2.96	89.16	1,373	1,635	23,503	11,752
SRESA2 850 ppm CO^2	4.5	103.45	1,496	1,643	24,001	12,001

Graph 1: Biomass of NCAR Data

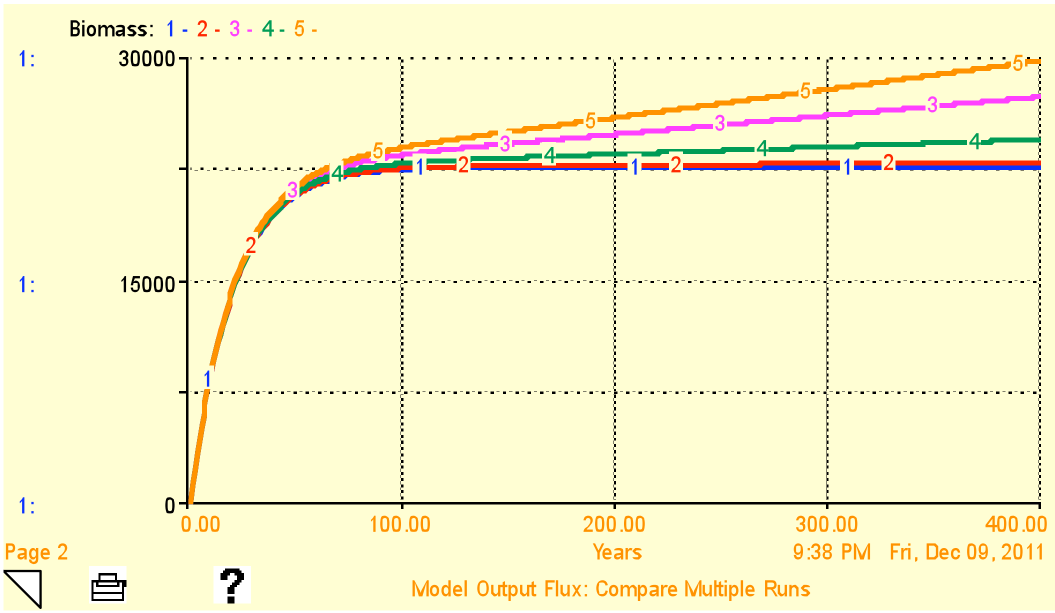

Figure 1: Biomass of NCAR Data. The blue line represents a baseline, where temperature, turnover rate and precipitation remain unchanged. The red line represents model Commit, the green line represents model SRESB1, the pink line represents model SRESA1B and the orange line represents model SRESA2.

Discussion:

Data Table 1 shows an increase in biomass as the ppms of CO^2 increase as well. Graph 1 displays this, with each line representing each of the different models, following consistent upward curves. The orange line, representing the model with 850 ppm of CO^2 has the steepest line meaning the biomass is increasing the most rapidly out of all the models. The levels of Net Primary Productivity appear to be limited by temperature, meaning that NPP cannot rise any higher than the NPP-T. Graph 1 shows this because NPP-T increases noticeably, while NPP-P remains relatively unchanged. One can conclude from this information that temperature has a far greater affect on NPP than precipitation.

The NCAR models showed an overall increase in biomass when generated in the biomass accumulation computer model. The model that resulted in the highest increase of biomass was the NCAR model, SRESA2, with 850 ppm of CO^2. The temperature increase for this particular model was 4.5°C from the baseline. The baseline biomass was 22,527 and the biomass for SRESA2 was 24,001. There was a nearly 2,000 (g/m^2) increase in biomass resulting from a temperature increase of 4.5°C in 100 years. The increase in biomass also means there is an increase in carbon storage because carbon storage is equal to 50% of biomass. This increase is plausible for New England's ecosystems and could have many detrimental effects in the long run.

A climate change such as temperature increase can alter the species of animals and trees that thrive in the New England forested ecosystems. Trees that are among the many species common to New England forests are maple, birch, beech, hemlock, and pine. These trees all have specific climate requirements that allow them to reach maximum growth. Without the right temperature, rainfall, soil nutrients, wind amount and other necessary requirements, some of these species will fail to thrive in New England forests. The variety of tree species is likely to change as a result of climate change.

Even though the data collected from the biomass accumulation models are merely predictions, there is fairly significant and substantial evidence that supports their validity. A continuation of this experiment over the next century is the only way to confirm these predictions. If we included more factors in our model or used a different model that allowed for the input of soil type, tree species, etc. our predictions would improve. Changes involving human behavior, natural disaster or other phenomena could alter these effects. Running more advanced models, performing local scale experiments and using past conditions might improve our knowledge of the forested ecosystems of New England and the changes that end up occurring.

Works Cited:

National Center for Atmospheric Research. "Climate Models and Predictions." *National Center for Atmospheric Research*: n. pag. Print.

(n.d.). *The Flow of Energy: Primary Production to Higher Trophic Levels* [Fact Sheet]. Retrieved December 7, 2011, from University of Michigan website: http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/energyflow/energyflow.html

Union of Concerned Scientists. "Confronting Climate Change in the US Northeast." *Northeast Climate Impacts Assessment*: n. pag. Print.