**ESS 162, Lab 8**

# Due Monday March 15 at 5PM

This lab is substituting for the final exam and you will need to work alone on all steps.

Your assignment is to: (1) complete the appended flow diagram by indicating whether the various relationships are positive or negative, and (2) use the flow diagram to predict how specific ecosystems would respond to four scenarios.

For each of the four scenarios: (1) clearly state your prediction, and (2) explain your reasoning.

The **rules** for the assignment are:

Take as much time as you need, provided the assignment is turned in by 5P March 15.

The assignment is open book - use your notes. You may ask me for clarification or a hint if you are stuck on a specific step.

This is a work alone project.

**General guidelines** are:

## The flow diagram is the key to answering the questions. Approach it methodically, taking one arrow at a time. Take the time to understand the flow diagram and make sure you get it as correct as possible. Then use it to answer the questions.

Refer to the flow diagram as you explain the reasoning behind your predictions.

In some cases there may not be a single correct answer. In these cases you should state that the answer would depend on the balance between competing processes, and explain the reasoning behind each process. Study the diagram closely for each question. There may be two (or more) plausible paths – one very short and the other much longer. Make sure you describe both.

1. Complete the appended flow diagram by indicating in each circle whether the relationship is positive or negative. Place a **+** next to a positive relationship and a **-** next to a negative one. A positive relationship indicates that an increase in the first aspect of the environment causes an increase in the second. A positive relationship also indicates that a decrease in the first aspect of the environment causes a decrease in the second. For example, an increase (or decrease) in light causes an increase (or decrease) in photosynthesis, and so light and photosynthesis are positively related. For the relationships between amount of soil water and decomposition, and also between temperature and photosynthetic rate, draw graphs in the adjacent rectangles and indicate in the circles how decomposition or photosynthesis changes with soil moisture or temperature.

Diagram

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(2) The increase in atmospheric CO2 concentration has a direct effect on ecosystems through stomatal opening that is independent of the projected changes in climate (increased atmospheric CO2 causes stomates to close). This effect is often ignored or downplayed in climate change assessments, even though it has the potential to significantly impact the future trajectory of California's ecosystems and hydrology. **How do you expect the increase in Atmospheric CO2 concentration independent of climate change will affect Riverflow and also the Amount of Live Biomass in California?** Assume the following do not change: Temperature, Decomposition, Canopy photosynthetic rate, LAI and the amount of wildfire.

A picture containing diagram

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Stomate opening will decrease as plants acclimate to increasing atmospheric CO2 concentrations, as the increased concentrations allow them to maintain the same concentration gradient in CO2 as they narrow their stomata while also reducing water loss. This decrease in stomate opening causes actual evapotranspiration to decrease, which would leave more water to flow into rivers. Thus, river flow would increase. Because it is assumed that the canopy photosynthetic rate stays constant, the amount of live biomass ultimately does not increase as atmospheric CO2 concentrations increase.

(3) California has some awesome forests in the Sierra Nevada Mountains, especially at middle elevations - this elevation zone experiences a year round growing season that is limited by neither winter cold nor summer drought, resulting in trees that are 200 feet tall and that include the Giant Sequoia. **How do you expect increasing Temperature will affect the health of these forests, and specifically the Amount of Live Biomass and the PFT composition (amount of trees)?** Assume the following do not change: Decomposition, Atmospheric CO2 concentration, Total Precipitation, Canopy Stomatal opening, Canopy Photosynthetic Rate, LAI.

Diagram, map

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The amount of live biomass is predicted to decrease, and this decrease stems from (1) increasing amount of wildfires and (2) decreasing the amount of soil water, which leads to increased tree death.

As temperatures increase, more severe fire weather will also increase, which would increase the amount of wildfires and burn and destroy more live biomass. Increasing temperatures will also increase evapotranspiration, which decreases fuel moisture and helps to increase the amount of wildfires. The increase amount of wildfires will also decrease PFT composition, and this reduced biodiversity can decrease tree growth which would then decrease the amount of live biomass.

Increasing temperatures have two effects that will both decrease soil water, which would lead to increasing tree death that will decrease the amount of live biomass. As temperatures increase, evapotranspiration will increase, reducing soil water content. In addition, the fraction of precipitation to fall as snow will decrease, which would lead to more runoff and so the soil returns less water from precipitation. This would then lead to increased tree death and decreasing live biomass.

(4) Vegetation at higher elevations in the Sierra Nevada Mountains is quite sparse, and the current climate in this alpine zone prevents photosynthesis from October to May, resulting in a brief 3-4 month growing season. This high elevation zone is especially important for California's hydrology, producing a disproportionate share of Riverflow. **How do you expect increasing Temperature will affect the vegetation and hydrology of the alpine zone, and specifically the PFT composition, amount of Live Biomass and the amount of Riverflow produced?** Assume the following do not change: Decomposition, Atmospheric CO2 composition, Total Precipitation, Fraction of Precip as snow, Amount of wildfire, Probability of Tree Death. Assume that the current temperature too cold for year round photosynthesis, and that any warming will push things to the middle of the graph.

Map

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Temperature increases will decrease river flow. As temperatures increase, evapotranspiration will increase, leaving less water available for river flow.

Temperature rise will also cause the amount of live biomass in alpine forests to rise. As temperatures rise, photosynthetic rates in the alpine forests will also rise, leading to increased NPP that will produce more wood and, therefore, more live biomass. The increased NPP also causes increased biodiversity of plant functional types, which would lead to increased growth of wood and increased live biomass.

(5) The deserts in California are very dry, which restricts plant growth to brief periods after rain. Some models indicate desert Precipitation will increase in the future, which would likely have an effect on these dry ecosystems. **How do you expect increasing Total Precipitation will affect the amount of necromass and also the occurrence of wildfire in California's deserts?** Assume the following do not change: Temperature, Riverflow, Atmospheric CO2 concentration, PFT composition, Probability of Tree Death, Fuel Moisture. Assume that the current soil water content is too dry to allow much decomposition, and that any added precipitation will push things to the middle of the graph.

Map

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Changes to necromass and wildfire occurrence is nuanced, but it appears that necromass and wildfire occurrence probably will not change. As annual precipitation in deserts increase, the amount of soil water will increase. Soil water content is in a negative feedback loop with stomate opening and actual ET. Thus, soil water content and stomate opening are somewhat stabilized. Stomate opening is positively coupled with canopy photosynthetic rate, which leads to positive couplings between NPP, leaf growth, fine litter production, and the amount of necromass. Therefore, increases in stomate opening will lead to increases in the amount of necromass. However, because stomate opening is part of a negative feedback loop, it is unlikely to change, meaning that any changes in necromass due to changes in stomate opening from soil water content and annual precipitation is likely to be negligible. In addition, while increasing soil water content will increase decomposition rates in deserts and decrease necromass as a result, soil water content is part of a negative feedback loop and will likely remain relatively constant. As a result, decomposition rates is unlikely to change significantly, and so the amount of necromass is unlikely to change due to decomposition.

If soil water content and stomate opening are not part of a negative feedback loop with actual evapotranspiration, then increasing precipitation will increase soil water content in deserts, leading to increases in stomate opening. As stomate opening is positively coupled with primary productivity, increases in stomate opening will cause an increase in fine litter production that will increase necromass. However, increasing soil water content causes increased decomposition rates, leading to decreasing necromass. Thus, if there no negative feedback loops between soil water content, stomate opening, and actual evapotranspiration, then there are conflicting feedbacks, with some feedbacks increasing necromass (through increasing primary productivity and fine litter production) and some feedbacks decreasing necromass (through increasing decomposition), making the change in necromass unclear. When a negative feedback loop is incorporated, then changes in necromass are likely to be mitigated. The factor in the negative feedback loop that increases necromass (stomate opening) and the factor in the negative feedback loop that decreases necromass (soil water content) remain relatively constant, meaning that changes in necromass are likely to be neglible.

While changes in necromass are relatively unclear, the direction in which wildfire occurrence changes is clearer: it is likely to remain unchanged. Wildfire occurrence is positively coupled with fine litter production, which is in turn positively coupled with primary productivity. Primary productivity is positively coupled with stomate opening. Thus, increases in stomate opening will increase primary productivity, increase fine litter production, and increase wildfire occurrence. However, stomate opening is part of a negative feedback loop, meaning that the size of stomata is likely to remain unchanged, and so the amount of fuels are likely to remain constant, leading to relatively constant wildfire occurrence.