Memo

To: Dr. Dean Urban
From: Dahl Winters
Date: 9/22/06
Re: Potential Climate Change Impacts in the Sierra Nevada for Env 214 Exercise 1

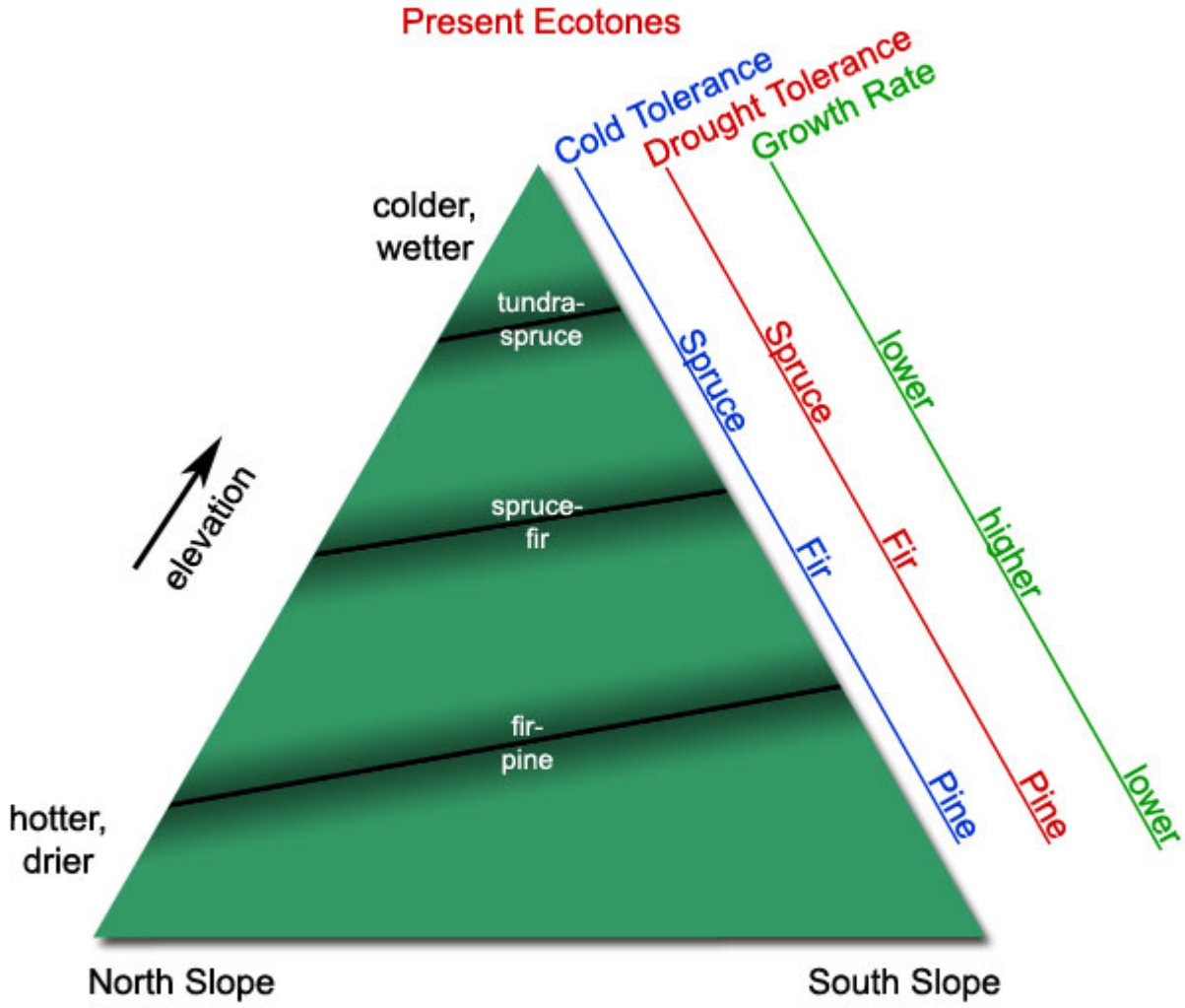
I met with Naoma LaValle, Jocelyn Tutak, and Julie Tuttle *to discuss* the potential climate change impacts in the Sierra Nevada given two climate scenarios and possible complicating factors. *The two scenarios we considered* were a +2 degree C increase in average temperature with no change in precipitation (Scenario A), and +20% more precipitation, but no change in seasonality or temperature (Scenario B). A summary diagram of our findings is on the second page of this memo.

We believe that for Scenario A, the warmer temperature combined with no change in precipitation would bring about drier conditions because evapotranspiration increases with temperature. This will result in a general upward range shift for all three tree species, which will be more obvious on the northern vs. southern slopes. Over time, fir would overtake spruce because fir's upper limit is driven by cold tolerance and it has a faster growth rate than spruce. Pine may or may not move up depending on fir's drought tolerance, which defines the lower range boundary of fir. Spruce will likely increase its density because it grows better at warmer temperatures, and if edaphic conditions are right in the higher tundra, its treeline should also shift upward. Fir is less cold-tolerant, so fir density would not increase as much as spruce density due to the warmer temperatures.

For Scenario B, *we believe that* with more precipitation, all tree species will grow better, but fir will increase its density and shift its lower range boundary downward. Since its lower limit is governed by drought tolerance and it has a faster growth rate than pine, more available soil moisture will allow fir to outcompete pine. Another factor allowing fir to win in competition is pine's greater drought tolerance (and thus, lower shade tolerance, due to a tradeoff between shade and drought tolerance). Fir will shade pine as it grows, allowing fir to take over. We expect more mixing of fir with pine over time, and a gradual thinning of pine stands at the pine-fir ecotone. For spruce, neither the upper or lower limit would shift, since spruce cannot outcompete the faster-growing fir at the spruce-fir ecotone.

One big *complicating factor* for both scenarios is that disturbances can open up gaps, which would speed establishment of species favored by the change in climate, or hinder establishment if species less adapted to the climate change are present. For example, fire might enhance the upward movement of pine in Scenario A if the fire occurs on the fir side of the pine-fir ecotone. There are likely to be an increase in insect outbreaks due to the increased susceptibility brought about by drought stress, as well as changes in insect phenology and life cycles due to warmer temperatures. Additionally, with greater moisture, more landslides might also be possible.

We recommend monitoring as part of an adaptive management regime for the Sierra Nevada, beginning with basic recording of the locations of all 3 ecotones (the transition zones between spruce-tundra, spruce-fir, and fir-pine). The edges of these ecotones as well as their adjacent areas where trees mix should be monitored for differences in species abundances wherever climate change has been observed. The appearance of disturbance events such as fires, insect outbreaks, and landslides should also be noted, and tree establishment monitored within gaps formed by disturbance events in or near ecotones.



Scenario 1: All ecotones shift upward, moreso on North vs. South slopes

Scenario 2: Fir increases density, shifts downward