
Memo

To: Dr. Dean Urban
From: Dahl Winters
Date: 9/29/06
Re: Potential Changes in the Rocky Mountain Fire Regime Due to Climate Change - for Env 214 Exercise 2

I met with Amy McCleary, Katerina Savvas, and Julie Tuttle, *to discuss* the potential changes in the Rocky Mountain fire regime under two possible climate change scenarios. The first (Scenario A) involved climate change consisting of substantially warmer (nonfreezing) winter temperatures, a very small increase in summer temperatures, and no change in precipitation. The second (Scenario B) involved an increase in the frequency of convective storms, which produce lightning but negligible rain, and no change in summer temperatures.

Scenario A should result in generally increased fire frequencies due to the much warmer winters. Since the survival of parasite populations is highly dependent on minimum winter temperatures, warmer winters will lead to more parasites, which will lead to more weakened and dead trees. Dead trees have less moisture than live ones, and are thus more flammable. Parasite infestations tend to lead to stands of killed trees if tree diversity is low, since more suitable hosts are nearby to spread to. An ignition in a stand of dead trees can spread rapidly and become a large, intense fire, endangering nearby healthy forest and harming prospects for tree regeneration. Over a longer term, such burned stands would be a barrier to fire, but over the short term, warmer winter temperatures would result in more standing fuel due to the greater overwintering survival of parasites.

Although there would be more parasites, some species may be less susceptible to them. Higher-elevation species such as spruce would be more resistant because cold-adapted trees gain more of a growth advantage under warmer winter temperatures than warm-adapted trees, and would presumably be less stressed due to the more favorable conditions.

Given the small increase in summer temperatures and no change in precipitation, above average drought conditions would be produced. Trees that are less drought-tolerant will do less well under such conditions, and would be more susceptible to insects. The most drought-tolerant trees are often at low elevations where it is drier, so creating more water stress for these trees will not have as much of an effect as creating drought stress for higher-elevation trees that have a lower drought tolerance.

Concerning the temporal effects of warmer winter temperatures on the fire regime, the greater fuel availability due to parasite survival and subsequent tree death within 2-3 years would mean an intense fire if ignition occurred after tree death. This would be followed by several consecutive years of low fire frequency until fuels had a chance to reaccumulate. Parasites would migrate in from surrounding stands to re-infest the regenerated stand, which would result in tree kills once again. A greater number of parasites would result in more tree kills during any one outbreak, but the trees would not be killed any faster because it still takes a certain time for regeneration to occur. Therefore, fire frequency should not be increased under the warmer winter temperature scenario unless dealing with a species like spruce that will thrive in the warmer winters. Its regeneration might happen more quickly, in which case a new stand of trees can be infested by nearby parasites sooner, and the fire frequency would increase. Within the spruce ecosystem, there would be selection for more fire-tolerant or fire-dependent plants as a result of the increased fire frequency.

One last thing to consider is the impact of warmer temperatures on evaporation, which can affect storm formation. More lightning could result, which will increase the number of ignition points and thus allow more forest cover to be burned more frequently. This would be bad for high-elevation tree species, since these elevations already have a higher frequency of lightning strikes.

Higher elevation areas usually have long fire return intervals due to the wetter climate. Thus, a large quantity of fuel is often available, just waiting for several decades to pass until drought conditions ensue and ignition can take place. If winters are warmer, snow cover might be lower in amount and extent, decreasing the available soil moisture. This could increase flammability by making plants drier. The same would go for north-facing slopes. Winter warming could radically change species composition after a burn, since the large quantity of fuel could lead to an intense seed and root-killing fire. What regenerates afterward could likely be early successional species. We would advise that high-elevation areas in particular are highly sensitive to fire regime changes. Conditions are right for fire at these elevations, but only if the normal high level of wetness hindering ignition and fire spread were removed. Such would be the case under this climate change scenario.

Scenario B should result in elevation-dependent changes in fire frequencies because of how fuel and moisture availability vary inversely with each other. At higher elevations, it is presently already wet enough to lengthen fire return intervals to several decades in length. Storms that produce more lightning but little rain will simply offer more ignition points that don't ignite, since plants are already too wet to catch fire. Thus, it would seem an increased frequency of convective storms has no effect on the fire regime. At lower elevations, there is usually not a large quantity of fuel because more frequent ground fires occur under the drier conditions. Until fuels regenerate themselves, increased lightning there will not have an effect on the fire regime. Plants adapted to high fire frequencies generally grow here because of the dryness, while at high elevations, low fire frequency plants grow due to the wetness. It is at middle elevations where we feel an increased number of lightning strikes would have the greatest impact on fire frequency. Here, it may not be too moist to hinder ignition, and fuels have had longer times to accumulate, so forests will be more flammable compared to lower or higher elevation ones. The middle-elevation forests are also prone to increased fires by upslope spread from lower elevations. Fire can spread better upslope due to winds than downslope, so increased lightning within the middle-elevation region or lower elevations will increase the fire frequency within the middle elevation.

An increased frequency of lightning strikes to trees melts tree sap, which will attract more parasites even if the tree doesn't burn. This will weaken the tree and may eventually kill it. When the next ignition comes to that tree or a nearby tree in the parasite-killed stand, the tree will ignite and spread if dead trees or dry live trees are near. This would be a source of increased flammability at all elevations.

Ecotones are especially susceptible to fire frequency changes. Both ecotones and fire frequencies tend to be correlated with elevation, and fires can open up gaps for recruitment of other more fire-dependent or fire-tolerant species. To protect existing species range boundaries, we would advise that forests with large fuel accumulations be selectively thinned to remove bushy undergrowth that can propagate crown fires. During dry years, a high danger exists that areas that would normally not burn will burn, and with a greater intensity, because of the high fuel load. During a very wet year, there will be a temporal offset in fire events such that during the next dry year that additional growth could burn, boosting the intensity of the fire and potentially slowing regeneration times if the fire becomes something larger and hotter than a normal ground fire.