Geophysical Research Abstracts
Vol. 12, EGU2010-4668, 2010
EGU General Assembly 2010

Eco-Geomorphology of vegetation boderline ecotones in mountain areas

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Early in the 20th century, a close spatial correlation between an annual average temperature of 5° to 6° Celsius and the extent of trees in mountain and polar regions has been identified in Biogeography and Geobotany. This spatial correlation is also backed by recent research on the physiology of trees. Therefore, an increase of the elevation and latitude of treelines in mountain and polar areas is postulated as a consequence of global warming in the 21st century. The newly forested areas are also considered to be potential sinks for atmospheric Carbon. However, the spatial relevance of the physiologic controls on treeline elevation has not been tested. Apart from temperature, soil development and surface processes, for example mass wasting and avalanches, exert a strong control over the ecologic conditions in vegetation borderline ecotones along treelines. These processes themselves are not independent of global warming and may balance or even dominate any positive effect of increasing temperatures on plant physiology and thus spatial distribution in mountain and polar regions. This study aims at distinguishing different warming effects on the extent and development of the treeline ecotone from an ecogeomorphologic perspective. Two study areas are compared: Grindelwald in Switzerland and the Kananaskis Valley in Alberta, Canada. Both areas have experienced a significant increase in temperatures (ca. 1°C since 1960). The two regions differ with regards to the disturbance regimes for the vegetation. In Grindelwald, logging, grazing, skiing, but also the protection of forests as avalanche buffers exert a strong control over the extend of the treeline ecotone. In the Kananaskis Valley, the forest is not used for logging and only sparsely populated. Disturbances by fire are well-documented. For both sites, aerial photographs are available and enable us to map changes in forest cover and treeline extent for the past 50 to 60 years. Our results show that neither forest cover or treeline ecotone extent have reacted to the climate signal in both areas. While not surprising for Grindelwald, the feedback between surface processes, especially mass wasting, appears to limit the increase of the treeline in Kananaskis. These results highlight the importance of an ecogeomorphologic perspective on vegetation changes as a consequence of global warming. Certainly, a simple coupling between physiologically-derived threshold temperatures and coarse scale simulations of future climate will not provide a realistic scenario of future tree cover in mountain areas. Further research, especially in polar regions, is required to properly assess the role of ecogeomorphologic feedback loops on vegetation cover and thus the global Carbon cycle.