Including Land Management in Landscape-scale Simulation Of Climate Change Impacts on Forests

Turner, D.P.[1], Conklin, D.[2], Vache, K.[2], and Bolte, J.[2]

[1]Oregon State University – Department of Forest Ecosystems and Society, [2]Oregon State University – Department of Biological and Ecological Engineering

Background

Forest resource managers increasingly rely on spatially-explicit scenarios of vegetation dynamics for landscape to regional scale planning exercises. Notable impacts of climate change on forests will include alteration of the disturbance regime and shifts in the geographic distribution of potential vegetation types. In this study, we integrated an agent-based landscape simulation model (Envision) that accounts for harvesting, fire, and land use change, with results from a Dynamic Global Vegetation Model (MC2), driven by climate scenarios developed for the 5th IPCC report. Our domain was the Willamette River Basin in western Oregon.

Approach

The Dynamic Global Vegetation Model. We ran the MC2 DGVM (Figure 1) over our spatial domain using three alternative climate scenarios. The MC2 biogeography module projects the potential vegetation cover type based on climate factors, including minimum temperature and number of growing degree days. The MC2 fire model initiates fires based on fuel dryness and current weather.

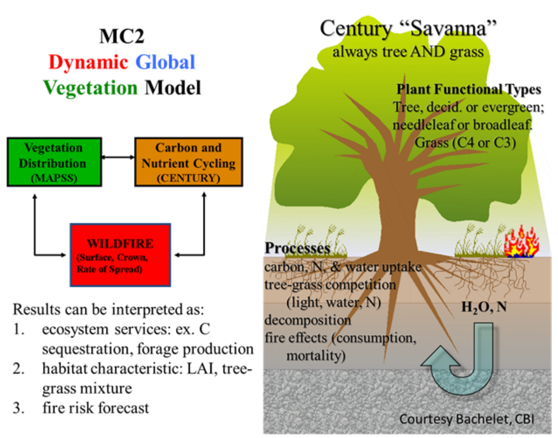

Figure 1. MC2 Dynamic Global Vegetation Model.

The Landscape Simulator. We used the Envision modeling framework to annually update vegetation cover type and to impose disturbances (harvest and fire) for the 2010 to 2100 interval. The initial condition of the landscape was mapped in the form of polygons (i.e. Integrated Decision Units) and their distribution was based on Landsat remote sensing data and forest inventory data. The initial set of state and transition models for the study area were developed by the Integrated Landscape Assessment Project. Future probabilities of fire depended on output from the fire model in MC2. Future rates of harvest depended on availability of stands in older age classes. Future vegetation type after a disturbance was prescribed based on the MC2 vegetation type.

The Climate Scenarios. We used GFDL-ESM2M 4.5 (+1.5°C in mean annual temperature by the end of the 21st century), MIROC5 RCP 8.5 (+5.0°C), HadGEM2-ES RCP 8.5 (+6.5°C). The GCM outputs were downscaled to the 4 km resolution using the Multivariate Adapted Constructed Analog (MACA) approach.

Results and Discussion

The contemporary vegetation of the Willamette River Basin is dominated by grassland/cropland or urban in the valley floor and coniferous forest in the uplands (Figure 2).

There was little change in potential vegetation type with the low climate change GFDL scenario, but most of the original forest area changed potential forest type by the 2090s in the other two scenarios (Figure 3). The change in the actual vegetation type lagged the change in potential vegetation type (Figure 4).

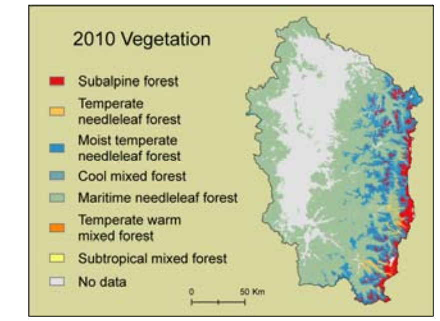

Figure 2. Vegetation State in 2010 (by IDU).

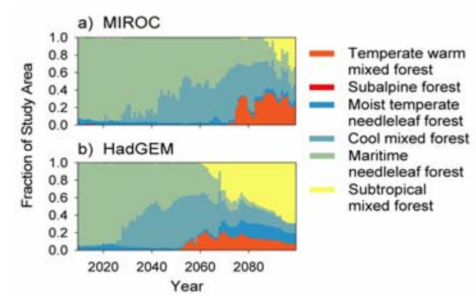

Figure 3. Changes in potential vegetation cover type 2010-2100: a) MIROC5, b) HadGEM.

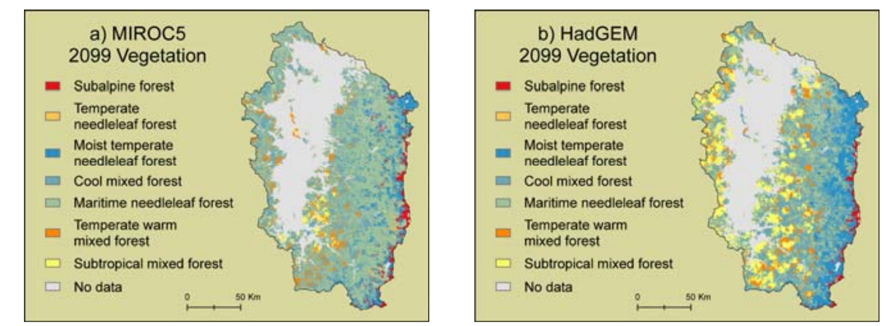

Figure 4. Simulated vegetation state in 2100. A) MIROC5, b) HadGEM.

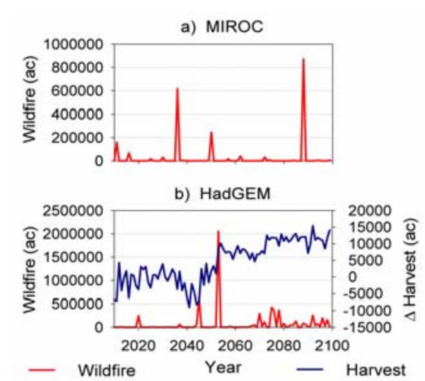

Figure 5. Area burned per year 2010-2100 (all lands). a) MIRCO5, b) HadGEM. Δharvest in b) refers to harvest area in MIROC minus harvest area in HadGEM

The simulated forest area burned per decade in the 2000s was on the order of 0.2 %/year and it remained at that level in the GFDL scenario. In the MIROC scenario, the area burned per year averaged over 2010-2099 was 0.6%/year, and in the HadGEM scenario rose to 2%/year (Figure 5).

By midcentury, the harvest rate was lower in the HadGEM scenario than in the MIROC scenario because of the higher incidence of fire in HadGEM (Figure 5b).

In the HadGEM scenario, the annual precipitation showed no trend but the actual evapotranspiration decreased during some periods because of disturbance-induced changes in forest leaf area (Figure 6).

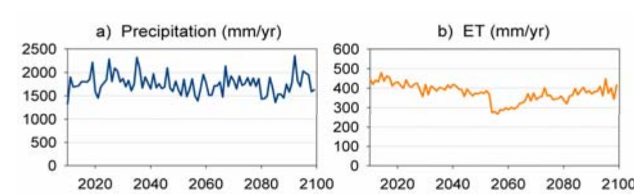

Figure 6. Basin-wide annual precipitation and annual forest evapotranspiration in the HadGEM scenario.

Conclusions

1. There will likely be widespread disequilibrium between the climate and the vegetation cover type over the course of the 21st century.
2. The area burned per year is expected to increase by up to an order of magnitude over the historical rate.
3. The area of forest available for harvest (≥ 60 years of age) on private land, and hence the area harvested each year, may decrease towards the end of the century because of limited availability of rotation age stands.
4. The changing disturbance regime will cause a shift to a younger and more open forest landscape, which will tend to reduce actual evapotranspiration.

Presenter Contact Information: David Turner (david.turner@oregonstate.edu)

Acknowledgement and Disclaimer:
This project is supported by the National Science Foundation under Grants No. 1039192, 1038925 and 1038899. Any opinions, findings, and conclusions or recommendations expressed in this document are those of the authors and do not necessarily reflect the views of the National Science Foundation. Thanks to David Ritts (OSU) for poster production.