Projecting future distributions of ecosystem climate niches in British Columbia[1]

News

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Introduction

With accumulating evidence showing the ecological impacts of global climate change, scientists, land managers, and policymakers in British Columbia have become increasingly concerned about its impact on local ecosystems. One of the major concerns is the mismatch between the climate that an ecosystem is adapted to and the climate that the ecosystem will experience in the future. If such a mismatch occurs, the health and productivity of the ecosystem are likely to be compromised.

Niche-based bioclimate envelope models have been widely used to project future geographic distributions of ecosystem climate niches. However, challenges arising from model accuracy as well as the uncertainties of future climates make it difficult to apply the model projections with confidence in developing adaptive strategies in natural resource management. The bioclimate envelope models are built based on the relationships between the observed presence of an ecosystem type and the climatic conditions of a given ecosystem. However, such relationships are complicated and difficult to model.

For the future climates, there are over 140 climate change scenarios from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, and they vary substantially in magnitude as well as in spatial and temporal patterns. Using different climate change scenarios may lead to totally different adaptation strategies. Several individual scenarios can be averaged to create an "ensemble scenario," but specific details are lost in this process.

The Centre for Forest Conservation Genetics, Department of Forest Sciences, University of British Columbia (Tongli Wang and Sally Aitken), in collaboration with the Ministry of Forests, Lands, and Natural Resources Operations (Elizabeth Campbell and Greg O'Neill), have accurately modelled the Biogeoclimatic (BGC) ecosystem zones with climate variables. The model was built using Random Forest (a machine-learning classifier) with high-resolution climate variables generated by ClimateWNA (http://www.genetics.forestry.ubc.ca/cfcg/climate-models.html) and validated with an independent dataset. Consensus projections based on multiple climate change scenarios were used to cope with the uncertainty in future climate. The major results of this study are summarized below.

Predicted shifts in ecosystem climate niches have already occurred

Predictions based on weather instrument records from 2001–2009 indicated that 23% of the climate envelopes for BC ecosystems have already shifted to another ecosystem's cli-

Wang, T. 2012. Projecting Future Distributions of Ecosystem Climate Niches in British Columbia.
Journal of Ecosystems and Management 13(2):1–3.
Published by FORREX Forum for Research and Extension in Natural Resources.
http://jem.forrex.org/index.php/jem/article/viewFile/551/476

mate (i.e., a combination of 44 annual, seasonal, and monthly climate variables) since the 1970s. The magnitude of this change was surprising; it was essentially equal to changes projected for the 2020s, despite average temperature increases for 2001–2009 being smaller (0.71°C) than projected increases for the 2020s (1.17°C, averaged over the 20 climate scenarios). This is probably because increased temperature during 2001–2009 was not accompanied by increased precipitation (-0.5%) as projected for 2020s (3.3%), resulting in the expansion of grassland (Bunchgrass) and dry forest climates. However, we should be aware that decadal-term climate data can deviate from normal (30-year) data due to short-term climatic variability other than anthropogenic climate change.

Consensus projections for future periods

Based on projected changes in temperature and precipitation, 20 climate change scenarios were selected from the IPCC Fourth Assessment Report. Shifts in bioclimatic envelopes for BC ecosystem zones were projected based on each of the 20 climate change scenarios. A consensus projection for a future period was generated based on the most frequently projected ecosystem zone for each pixel among the 20 individual projections. We used the level of the model agreement among the 20 individual projections to represent the uncertainty of the ecosystem climate niche under climate change.

Projected changes varied among BGC zones. Climates suitable for Montane Spruce (MS), Sub-Boreal Pine - Spruce (SBPS), Spruce - Willow - Birch (SWB), and Alpine Tundra (AT) zones are projected to contract. Meanwhile, climates suitable for Interior Cedar-Hemlock (ICH), Ponderosa Pine (PP), Interior Douglas-fir (IDF), Bunchgrass (BG), and Coastal Western Hemlock (CWH) zones are projected to expand. Figure 1 shows the changes among the BGC zones based on the consensus projections for the 2050s.

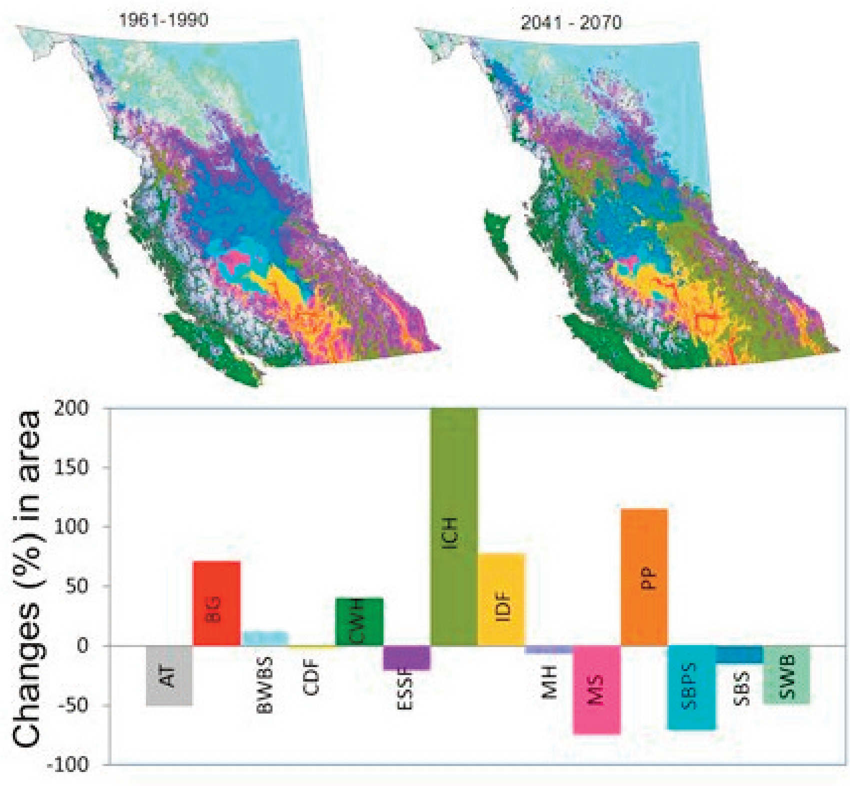

Figure 1: Projected shifts in ecosystem climate niches from the reference period (1961–1990) to the 2050s (2041–2070). The shades representing the BGC zones in the maps and in the bar chart are identical.

Conclusions

The bioclimatic envelope model built with Random Forest and high-resolution climate variables generated by ClimateBC/WNA accurately predicted the distribution of current ecosystems in BC. Climate envelopes of some BC ecosystems have already shifted to a different envelope. Projected shifts in BC ecosystem climates are substantial under climate change, which may compromise the health of the ecosystems and impose challenges to land managers and policymakers. However, expansions of climate niches for several productive ecosystems (ICH, IDF, and CWH) may provide an opportunity to increase forest productivity and carbon sequestration capacity in BC if appropriate species and populations are matched for future climates.

Spatial data visualization and access

Spatial data generated from this study can be visualized and accessed using a Google Map based web tool, "ClimateBC_Map," recently developed by the Centre for Forest Conservation Genetics (http://www.genetics.forestry.ubc.ca/cfcg/ClimateBC40/Default.aspx). This tool can be accessed through a web browser and no additional software installation is needed. This tool also allows users to 1) access a large number of climate variables by clicking at a location of their interest on the Google Map; 2) visualize climate variables, BGC units, and species distributions maps; and 3) download geographic information system (GIS) compatible data files.

Note

1. This article presents the highlights of a published scientific paper by Wang et al., 2012.

Websites

ClimateBC_Map. URL: http://www.genetics.forestry.ubc.ca/cfcg/ClimateBC40/Default.aspx

ClimateWNA. URL: http://www.genetics.forestry.ubc.ca/cfcg/climate-models.html

Reference

Wang, T, E.M Campbell, G.A. O'Neill, & S. Aitken. 2012. Projecting future distributions of ecosystem climate niches: Uncertainties and management implications. Forest Ecology and Management 279:128–140.

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