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Modeling the Feedback Effects of Lodgepole Pine Wildfire and Insect Outbreak Frequencies on Global Climate Models

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The carbon feedback effects on global climate from boreal forest wildfires and insect population eruptions have been investigated using a specialized adaptation of existing climate modelling schemes. Existing models and parameters and equations from the literature were combined in a model on the Vensim platform. It specifically reflects fire and mountain pine beetle effects on lodgepole pine trees, as described in the most recent literature. Only lodgepole pine forests were considered in order to be able to more accurately represent species specific carbon dynamics.

Lodgepole pine forest climate responses worldwide were modelled with temperature dependent wildfire and mountain pine beetle outbreak frequencies for different Representative Concentration Pathway (RCP) scenarios between 1990 and 2100. For each of the four RCP scenarios (RCP2.6, RCP4.5, RCP6.0, and RCP8.5), different temperature - insect outbreak, and temperature - wildfire frequency feedback relationships were tested. Placing these lodgepole pine climate response dynamics within a simple global carbon cycle model permits the quantification of the relative effects of these feedbacks on global climate models.

The differences between standard RCP scenario expectations and simulations including lodgepole pine wildfire and insect outbreaks were up to 0.6% of the final atmospheric carbon stock of the standard RCP scenarios. Within lower emission scenarios, negative feedbacks between wildfire, insect population eruptions, and temperature result in an increase in carbon accumulation in lodgepole pine trees. Within higher emissions scenarios (RCP6.0 and RCP8.5), increases in temperature and consequent wildfire frequency increases led to reduced carbon stocks in lodgepole pine trees, which corresponds to the positive feedback of increased atmospheric carbon. Since lodgepole pine forests make up only approximately 0.08% of the global terrestrial biosphere, even the relatively small positive climate feedbacks observed in this study suggest that global wildfire and insect outbreak frequencies could potentially change atmospheric carbon level forecasts of global climate models by up to 8 percent.