Potential Vegetation and Carbon Redistribution in North America from Climate Change

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Objectives:

- This study uses an advanced mechanistic, individually based ecosystem model to predict the potential equilibrium response of terrestrial vegetation and carbon to future climate change in northern North America.
- The model used was the Ecosystem Demography (ED) model, modified to overcome limitations seen in previous studies, such as improvement of downregulation of carboxylation rates as light decreases on each plant functional type (PFT).
- The model was first run for 500 years with current climatology at a half-degree resolution and compared to remote sensing data on dominant PFT for northern North America for validation.
- Future climate data were then used as inputs to predict the equilibrium response of vegetation in terms of dominant plant functional type and carbon redistribution.
- Two climate datasets were used: CRUNCEP (a combination of Climate Research Unit and National Centers for Environmental Prediction data) for contemporary data and North American Climate Change Assessment Program (NARRCAP) for the future data.
- The NARRCAP climatology was converted to half-degree resolution with a WGS84 projection to match the CRUNCEP climatology.

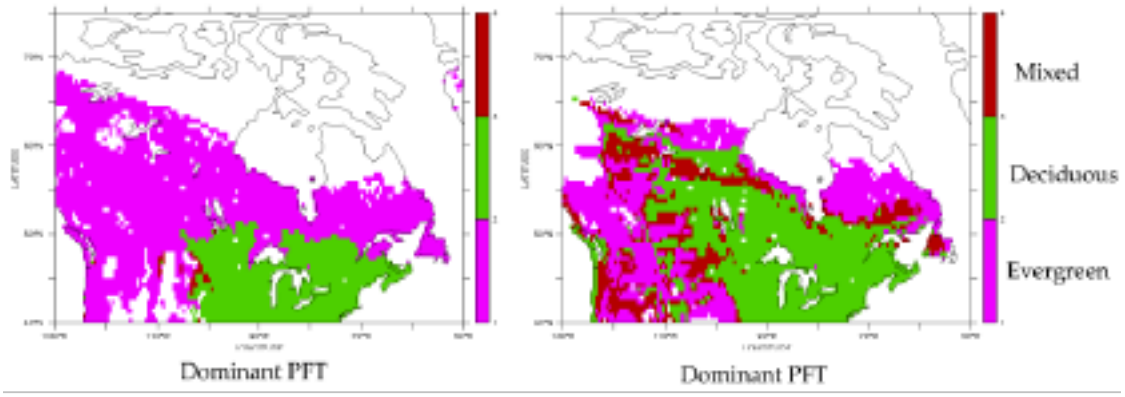
New Science:

- Results of this study suggest large potential changes to the distribution of PFTs and the distribution of terrestrial carbon stocks in response to future climate change.
- The study also suggests relatively modest net domain level change in both forest cover and carbon, with much larger underlying gridded changes in both the distribution of vegetation and in carbon stocks.
- Total regional forest cover increased by about 2% and total carbon storage increased by about 8% in response to climate change.
- Underlying these net changes, deciduous cover expanded by 77% and gained 107% carbon, while evergreen cover was reduced by 48% and lost 31% carbon.
- The percent of terrestrial carbon from deciduous and evergreen PFTs changed from 28%/72% under current climate conditions, to 54%/46% under future climate conditions, or approximately form 1:3 to 1:1.
- Overall, 58% of the domain changed dominant PFT, with evergreen expansion and withdrawal accounting for about 90% of the predicted change.

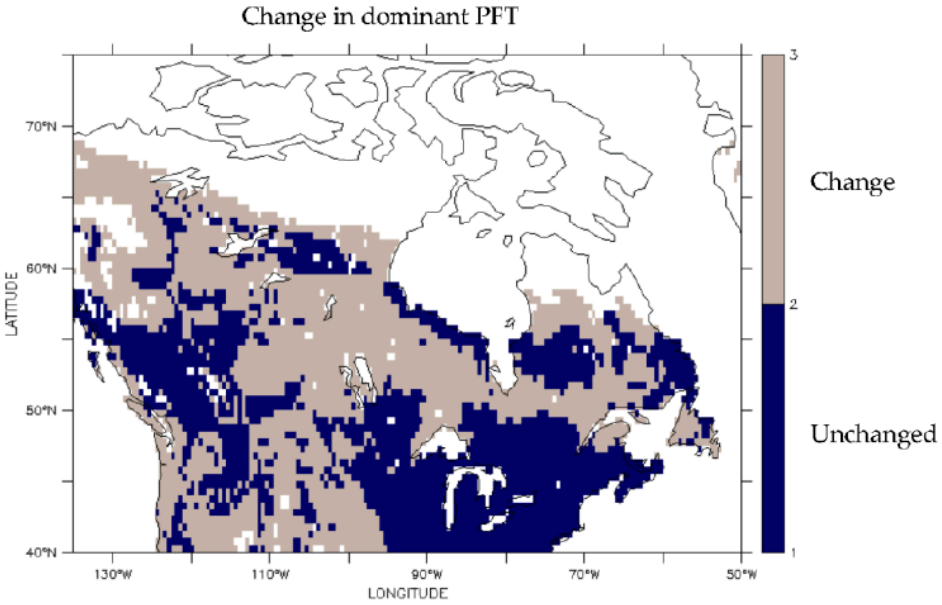
Significance:

- Previous research has demonstrated a strong relationship between climate and the distribution of terrestrial ecosystems, and anthropogenic forcing is expected to change future climate at its greatest rate in the next century.
- Forests contain roughly 80% of above ground carbon and sequester about 30% of annual fossil fuel emissions, thus forest response to future climate and the carbon consequences associated with these responses are important topics for research.

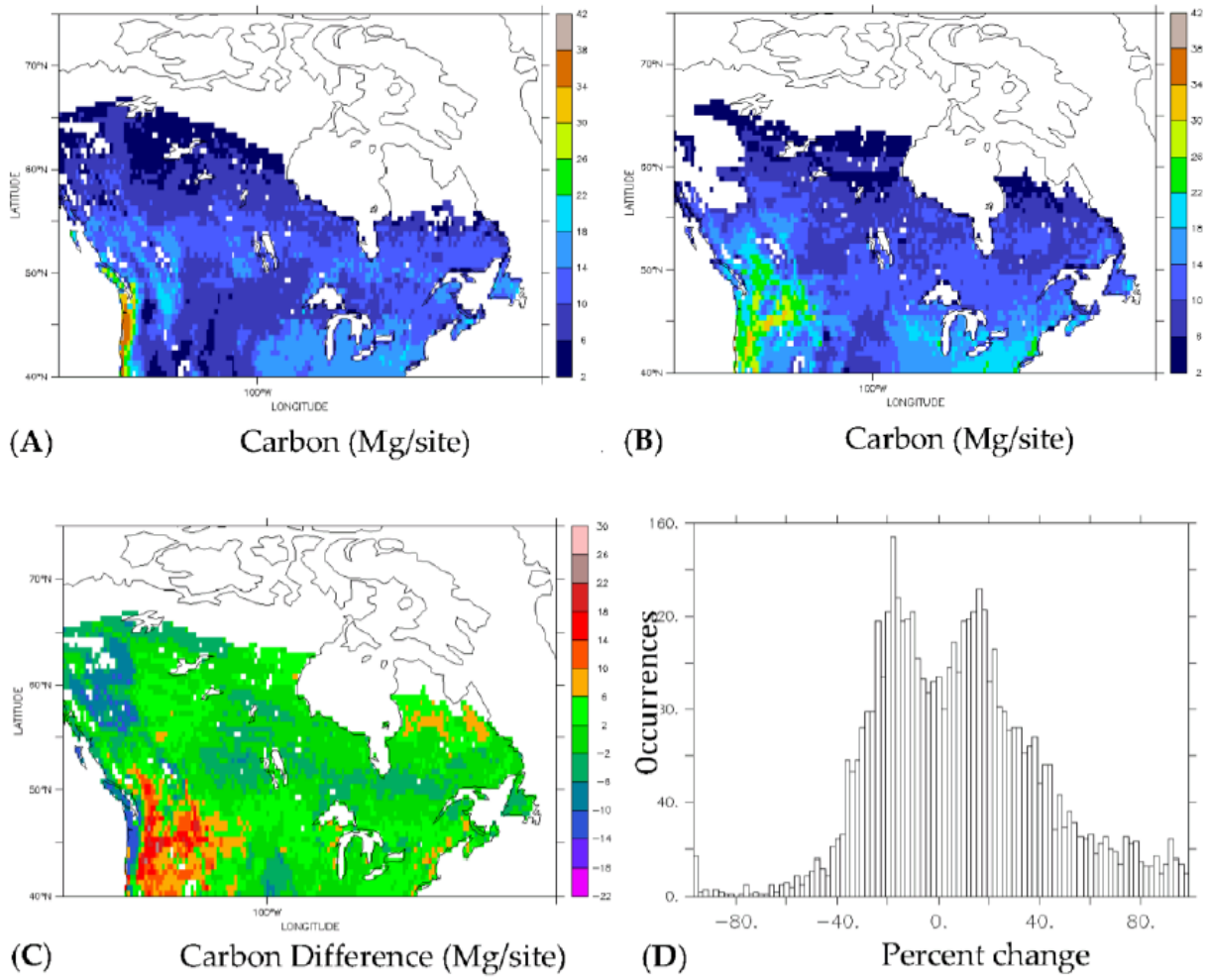
- For the northern hemisphere, the predicted changes are deciduous forest replacing evergreen forest at the southern boundary and evergreen forest expanding into areas previously in tundra at the northern boundary.
- The changes predicted at the PFT level likely mask more complex underlying changes at the species level.
- The individually based ecosystem model approach used here permitted the use of remote sensing data to validate current conditions and the same approach could be used to simulate the transient response of vegetation to climate change.
- The transient response of vegetation to climate change may introduce a time-lag to long-term equilibria due to factors such as landscape characteristics, disturbance rates, dispersal properties, and how these factors might be altered with climate change.
- The large potential changes indicated by these results suggest additional work is needed on the transient responses of these forests to climate change including assessments of sensitivity to alternative climate scenarios.



Contemporary and future predictions for mixed, deciduous, evergreen, and non-forest PFTs.



Sites that switch dominant PFT (gray) and remain unchanged (blue).



Predicted total carbon under (A) current climate and (B) future climate; (C) the carbon difference between the current and future; and (D) the percent change in carbon distribution.