Consequences of Vegetation Changes for Energy/Water Feedbacks

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Background:

-Vegetation shifts in boreal Alaska: due to fire, natural successional processes, treeline migration (altitudunal and elevational), shrubification

-Change reflectance and energy balance (sensible and latent heat)

-Which one of these vegetation shifts may influence energy balance the most?

- The lower albedo and greater sensible heat flux of spruce compared to deciduous forests suggest that northward forest expansion could be a positive feedback to regional warming

-Loss forests to the south or net conversion from conifer to deciduous forests resulting from fire could have a net cooling effect

-Shrubification = lower albedo and positive feedback to warming



Biogeochemical Feedbacks $(CO_2 \text{ and } CH_4)$

Biogeophysical Feedbacks (Albedo: vegetation, snow) Black Spruce
Deciduous trees
Graminoid Tundra
Shrub tundra
White Spruce

Mean across three climate scenarios (A1, A2, B1) for the Echam GCM



Methodology for Computing Changes in Atmospheric Heating Due to Changes in Snow and Vegetation Shifts

Incoming solar radiation (R_{Sin}) from the TEM (seasonal)

Compute outgoing solar radiation (R_{Sout}) $R_{Sout} = R_{Sin} * a$, for each set of a, and then, $R_N = R_{Sin} - R_{Sout}$

Seasonal atmospheric heating is computed by multiplying R_{Sin} by the proportion of incoming R_{Sin} that is absorbed by the land surface (R_N/R_{Sin}) times the proportion of R_N that is transferred to the atmosphere ({H + LE}/ R_N) *Chapin et al. (2005) and Euskirchen et al. (2007)*.

Changes in snow cover obtained from a water balance model (Euskirchen et al., 2007)

Boreal Alaska

Year

All of Alaska

Year

Succession Following Fire in the Boreal Forest Underlain by Permafrost

Change in the Snow Season The data represent the mean (standard deviation) across the four climate scenarios.

Euskirchen et al., 2009

Biogeochemical Feedbacks $(CO_2 \text{ and } CH_4)$

Biogeophysical Feedbacks (Albedo: vegetation, snow)

Pathways of change

Percent change in Energy Flux

Summer Albedo

Boreal fen
Heath tundra
Shrub tundra
Black spruce forest
Treeline ecotone

Tussock tundra
Wet sedge tundra
Disturbed forest
Thermokarst bog

Snow Season Albedo

Heath tundra
 Boreal fen
 Shrub tundra
 Thermokarst bog
 Treeline ecotone

Wet sedge tundra
Tussock tundra
Disturbed forest
Black spruce forest

Variation in NEE across sites and years

Euskirchen et al., Ecosphere, 2012; Euskirchen et al., J. Geophys. Res., 2014, Euskirchen et al., in prep.

Regional Comparisons Based on Model Simulations in Boreal Alaska

Regional comparisons based on model simulations in boreal Alaska Can compare boreal Alaska feedbacks to those statewide

