Modeling the Impacts of Tundra Fire on Shrub Expansion

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Observations show that the productivity and composition of high-latitude vegetation are changing in response to climate warming. Among these changes, the expansion of woody shrubs across the Arctic tundra has been widely reported. With rapid climate warming tundra fire is also reported to be more frequent and intense. The impact of these recent and predicted changes in fire regimes on shrub expansion is uncertain. Here, we applied a well-tested mechanistic ecosystem model, *ecosys*, to examine how tundra fire affects the productivity of shrubs. At site scale, the model was prescribed with known fire vs. non-fire (control) events across the selected sites in Kougarok watershed, Seward Peninsula, Alaska. At regional scale, we applied the model to examine the effects of the past and projected changes in fire regimes across the tundra ecosystems of Alaska. Our model result shows that tundra fire (1) alters surface vegetation, soil organic carbon stocks, seedbed quality, and thus seedling regeneration, (2) deepens the active layer, and (3) enhanced mineralization. We show that these processes control post-fire soil temperature, nutrient cycling, and competition among tundra plant functional types. We modeled a 21st century increase in shrub productivity in both simulations (with and without fire). Compared to control simulations, fire events were modeled to cause a decline in the spatial average NPP of shrubs (~11%) across Alaskan tundra. However, fire events were modeled to result in changes in the composition of the tundra plant functional types that particularly favors deciduous shrubs. We conclude that changes in vegetation composition, accelerated by fire events, have important implications to Arctic tundra ecosystem function through its effect on the carbon cycle and energy balance and thus on the climate system.