Quantification and modeling of patch-scale shrub expansion in the Alaskan Arctic

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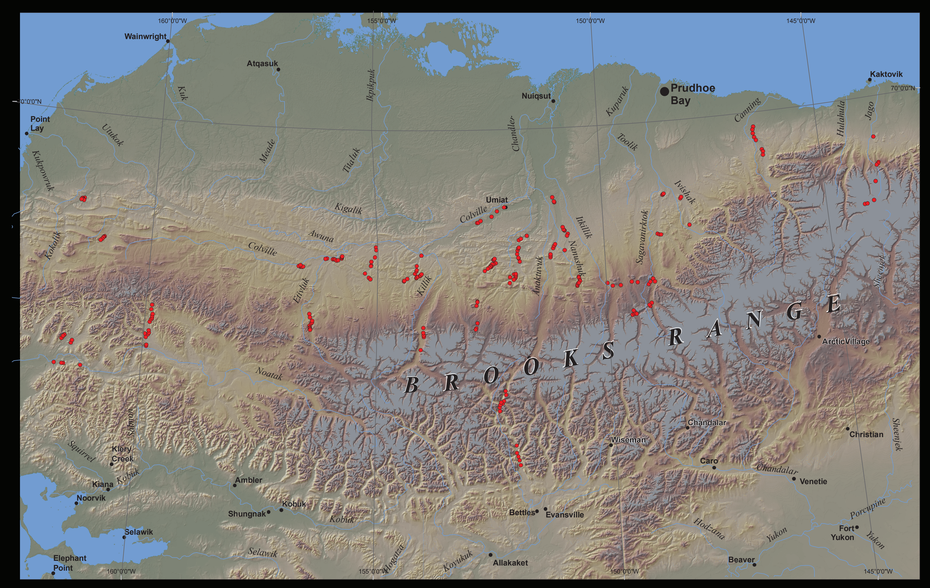
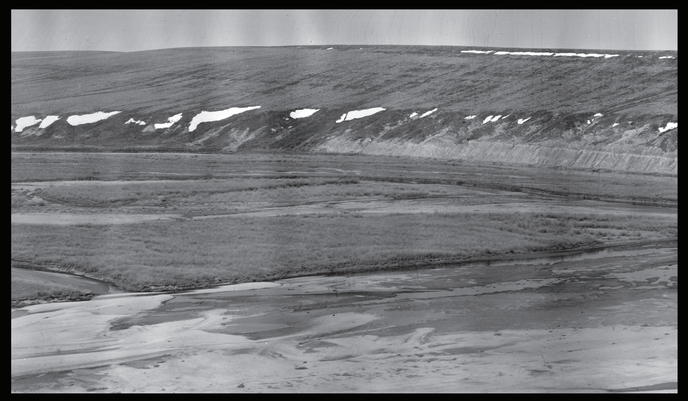
The expansion of shrubs (e.g., Alnus, Betula, and Salix spp.) into tussock tundra in the Alaskan Arctic is well-documented in the ecological literature (e.g., Liston et al. 2002; Jia et al. 2003, Myneni et al. 1997; Press et al. 1998; Stow et al. 2004; Sturm et al. 2001; Sturm et al. 2005). Many such studies utilize data from either fine-scale experimental plot data or broad-scale satellite remote sensing. There is, however, a critical gap in the scientific knowledge regarding expansion at the intermediate patch- or landscape-scale. Tape et al. (2006) analyzed 202 pairs of repeat oblique aerial photographs from two dates (late 1940s and late 1990s) in the Colville River basin and were able to identify significant expansion in all four geomorphic areas (interfluves, valley slopes, river terraces, and floodplains). This expansion ranged from 3 to 80%. Tape et al. (2006) proposed that this expansion could be explained using a simple logistic growth model. The precise nature of this expansion in the interim period is, however, largely unknown, and could alternately be explained by a different mathematical model. Building on this work, this research aims to more explicitly quantify and model the manner in which shrub expansion has occurred in the Colville basin and other sites throughout the North Slope. Specifically, we want to develop and refine hypotheses on the environmental controls of shrub expansion. In addition, through the use of a computer simulation model, we strive to test the validity of the logistic growth model and develop a means for predicting future shrub expansion.

Study Area

Our work is focused on shrub expansion primarily in the North Slope borough of Alaska. Our focus will be on the sites formerly established by Tape et al. (2006), but there are plans to expand study locations to Noatak National Park and Gates of the Arctic National Park, and surrounding wilderness areas.



Methods



Source: Tape et al. 2006

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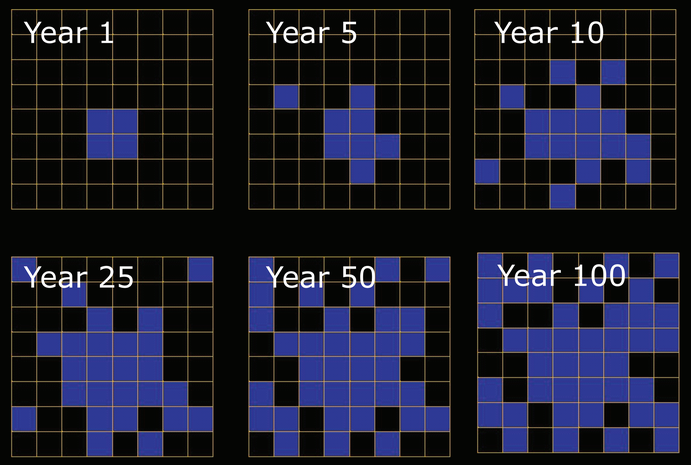

We have begun to acquire and georectify historic vertical aerial photos of these sites taken in the interim period. We will then map shrub patches shown on these photos using a GIS. From there,we will evaluate the quality of our interpretation using the original oblique aerial photographs from the Tape study and a limited set of QuickBird imagery. After the evaluation stage, we will calculate pattern metrics using FRAGSTATS to pinpoint potential variability in spatial patterns.

Finally, we will develop and implement a stochastic cellular model (left) that simulates shrub expansion and incorporates environmental heterogeneity and biological processes. Analysis of the model output using FRAGSTATS, MANOVA, and Principal Components Analysis (PCA) wil allow us to determine which environmental parameters best explain the observed pattern of expansion.

Significance

As a stipulation of NSF funding, we will regularly conduct outreach efforts in local Arctic communities and scientific organizations. This largely focuses on presentations to members of these communities. We also intend to share our data and results with other scientists and community members through the Barrow Area Information Database - Internet Map Server (BAID-IMS) and a web site.

In the future, shrub expansion may have significant impacts on the Arctic region in terms of environmental sustainability and economic development. This work will supplement other vegetation change studies currently underway by other agencies such as the National Park Service. Collectively, the research on shrub expansion will inform the development of future land management policies.

This project is generously funded by the National Science Foundation (Award #0806506) and maintained through the Texas A&M Research Foundaiton.

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