The role of land-cover change in high latitude ecosystems: Implications for the global carbon cycle

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Objectives:
- To conduct change-detection studies of land-cover change in the Alaska region.
- To develop a prototype spatially explicit modeling framework capable of using satellite-derived data to estimate how changes in land cover cause changes in ecosystem carbon storage at high latitudes.

Progress in Change-Detection Studies:

- Bias in estimates of land-cover change caused by positional error (Verbyla and Boles, 2000; ***http://www.lter.alaska.edu/~dverbyla/change_detection/index.html***)
- Land cover change on the Seward Peninsula: The use of remote sensing to evaluate potential influences of climate change on historical vegetation dynamics (Silapaswan, et al, 2001; see Figure 1)
- Development of an algorithm for estimating burn severity of wildfires (Macander et al., in preparation)
- Change vector analysis of increased shrubbiness on the North Slope of Alaska
- Decrease in number of ponds/lakes in discontinuous permafrost region – Copper River Basin, AK

Progress in Development and Application of Modeling Framework:

- Modeling the physical properties of high latitude ecosystems (Zhuang, et al., in press; see Figure 2)
- Modeling the interactions between physical properties and ecosystem function (see Figure 3, Zhuang, et al, in review; Zhuang et al., in preparation)
- Modeling the effects of disturbance on ecosystem function at the regional scale (McGuire, et al., in preparation; see Figures 4 and 5)
- Modeling the effects of disturbance on ecosystem function at the global scale (McGuire, et al., 2001; see Figure 6)

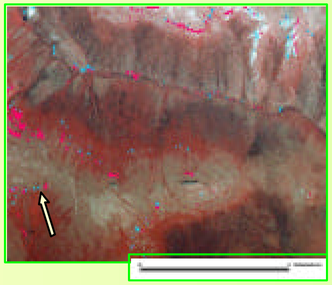

Figure 1. The change detection analysis for the Seward Peninsula identified a general pattern of increased shrubbiness, as illustrated in the valleys north of the Bendeleben Mountains (pink and blue regions are 1986-1992 CVA results overlaid on an infrared aerial photograph, showing areas of detected increases in TM Band 4/TM Band 3 and TM Band 5 (pink), and increases in TM Band 4/TM Band 3 and decreases in TM Band 5 (blue), suggesting an increase in shrub advance). This result agrees with visual interpretation of aerial photography between 1985 and 1999, which indicates that shrubs have advanced approximately 100 m in valleys north of the Bendeleben Mountains.

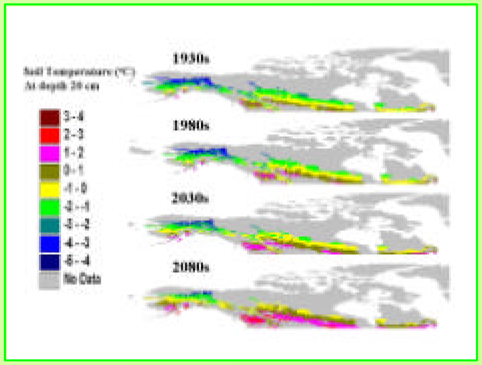

Figure 2. Spatial distribution of mean annual soil temperature for the upper soil organic layer simulated by the application of the STM-TEM across the range of black spruce ecosystems in North America north of 50° N during four decades separated by 50 years during the simulation period (1900-2100): 1930-1939, 1980-1989, 2030-2039, and 2080-2089.

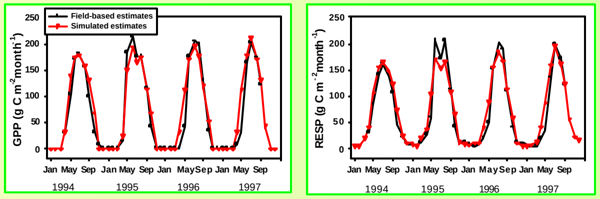

Fig. 3. Field-based and simulated estimates of (a) monthly gross primary production (GPP) and (b) ecosystem respiration (RESP) for an old black spruce ecosystem in northern Manitoba, Canada from 1994 to 1997. Simulated soil temperatures were used to drive some of the biogeochemical processes in the coupled STM-TEM. Field-based estimates are from Clein et al. In press. The role of nitrogen dynamics in modeling historical and projected carbon balance of mature black spruce ecosystems across North America: Comparisons with CO_2 fluxes measured in the Boreal Ecosystem Atmosphere Study (BOREAS), *Plant and Soil*.

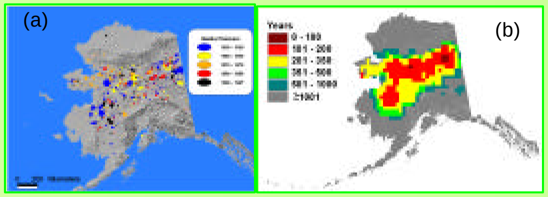

Figure 4. (a) The fire scar data set of Alaska. In the sensitivity analyses (see Figure 5), PFRI was set to 50%, 100%, and 150% of the historical fire return interval (FRI) since 1950, which was defined spatially for Alaska with an interpolation algorithm that spatially smoothed FRI at 100-km resolution (b).

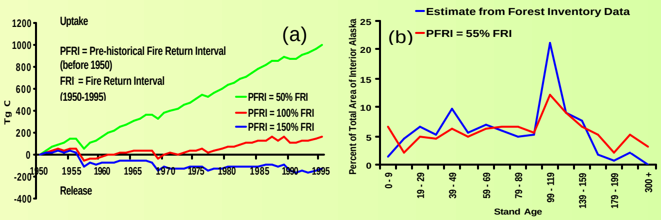

Figure 5. (a) Sensitivity of cumulative changes in carbon storage for Alaska to assumptions about the fire return interval prior to 1950 (PFRI) as simulated by the Terrestrial Ecosystem Model (TEM) in the modeling framework. (b) The stand-age distribution of Alaska is best reproduced when PFRI equals 55% FRI.

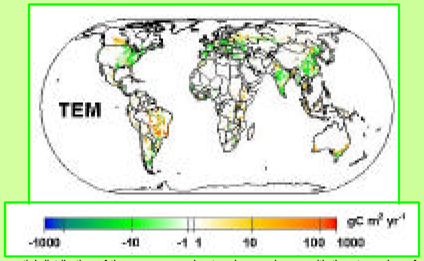

Figure 6. The spatial distribution of the mean annual net carbon exchange with the atmosphere from 1980 through 1989 associated with cropland establishment and abandonment as estimated by each of four terrestrial biosphere models. The change in net carbon storage associated with cropland establishment and abandonment was estimated by subtracting the cumulative change of a simulation that considered increasing atmospheric CO_2 and climate from that of a simulation that considered both increasing atmospheric CO_2, climate variability, and cropland establishment and abandonment. Positive values indicate net releases to the atmosphere and negative values indicate net storage in terrestrial ecosystems.

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