The role of land-cover change in high latitude ecosystems: Implications for carbon budgets in northern North America

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Objectives:

To take the next step towards our overall goal, we propose

- To evaluate one key question that emerged from our previous studies, and
- To extend the application of our modeling framework to the entire Alaska-Canada region.

Evaluation of Regional Lake/Wetland Drying (Verbyla):

Issue

In one of the change detection studies we conducted as part of the previous studies, we found a dramatic decrease in the number of ponds and lakes in the Copper River Basin from 1985 to 1995 using Landsat Thematic Mapper data (see Figure 1). This decrease is surprising since the precipitation regime was similar during both time periods and there was no change in lake area or pond numbers observed at higher elevations. An important question raised by this research is: Is this phenomenon restricted to the Copper River Basin or is this a consequence of regional climate warming across Alaska and extending into north-west Canada (see Figure 2)?

Proposed Research

We hypothesize that there has been a significant decrease in the number of lakes and ponds in regions of discontinuous permafrost. We will test this hypothesis by comparing Landsat TM imagery from the 1980s with Landsat-7 ETM+ imagery from 2000. We will use scenes from an east-west climate gradient of Alaska. The areas range from maritime to continental climate regimes: Seward Peninsula, Innoko Flats, Tanana Flats, Forty Mile Flats, and the Yukon Flats (see Figure 3). In addition, we will also study an area of continuous permafrost North Slope where we expect no significant loss of water bodies over the past 20 years.

Extension of Modeling Framework to the Alaska-Canada Region (McGuire, Melillo, Kicklighter):

- Fire: Stocks, CFS (see Figure 4); Kasischke, UMD
- Nitrogen deposition: Melillo and Kicklighter (see Figure 5)
- Agriculture: Melillo and Kicklighter
- Timber Harvest and Insects: App/Kurz, CFS
- Application of Modeling Framework (see Figure 6a)

Evaluation of Alaska-Canada Simulation in Context of Regional Estimates (McGuire):

- Bayesian Inversion Analysis: Darvgaville, NCAR (see Figure 6b)

Evaluation of Alaska-Canada Simulation in Context of Satellite-Derived Data (Myneni):

- AVHRR and MODIS
- LAI/FPAR Algorithms

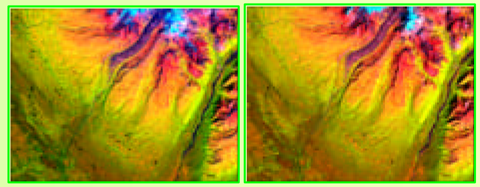

Figure 1. Change in number of lakes and ponds in a discontinuous permafrost region (source: Landsat Thematic Mapper band 5 images from mid summer 1985, 1995).

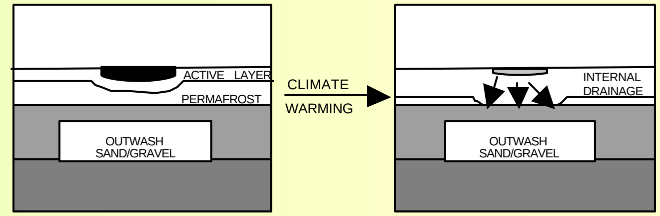

Figure 2 . Change in drainage associated with climate warming in a discontinuous permafrost area

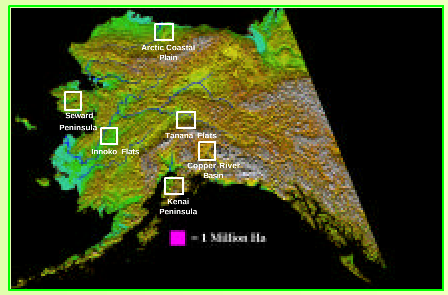

Figure 3. Proposed areas to examine for change in water bodies over the past 20 years.

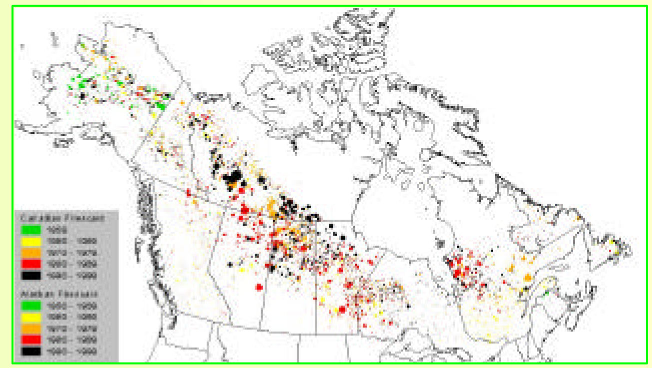

Figure 4. Location and area of historical fires in Alaska (1950-1999) and Canada (1960-1999).

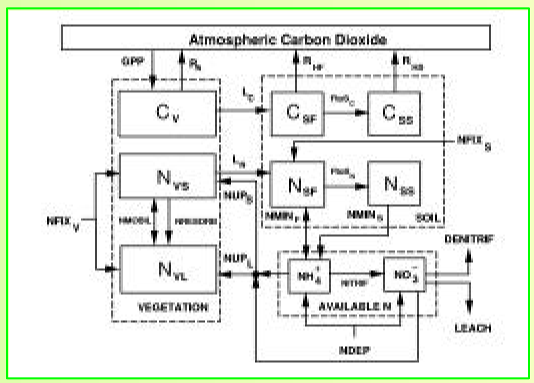

Figure 5. The structure of the version of the Terrestrial Ecosystem Model (TEM) that represents nitrogen inputs (nitrogen deposition, NDEP, and nitrogen fixation, $NFIX_V$ and $NFIX_S$) and losses (denitrification, DENTRIF, and leaching , LEACH). State variables include: carbon in the vegetation (C_V); structural N in the vegetation (N_{VS}); labile N in the vegetation (N_{VL}); organic carbon in soils and detritus (C_{SF} and C_{SS}); organic N in soils and detritus (N_{SF} and N_{SS}); and available soil inorganic N as ammonium (NH_4^+) and nitrate (NO_3^-). Arrows show C and N fluxes; GPP, gross primary production; R_A, autotrophic respiration; R_H, heterotrophic respiration; L_C, litterfall carbon; L_N, litterfall N; $NUPTAKE_S$ and $NUPTAKE_L$, N uptake by the vegetation; NRESORB, N resorption from dying tissue into the labile N pool of the vegetation; NMOBIL, N mobilized between the structural and labile N pools of the vegetation; and NETNMIN, net N mineralization of soil organic N.

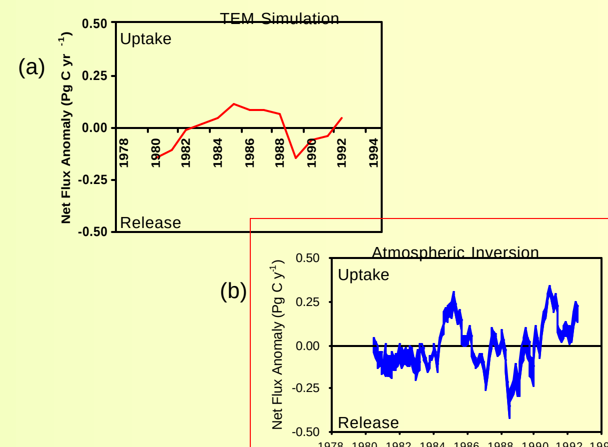

Figure 6. Anomalous carbon fluxes for the Alaska-Canada region between 1980 and 1992 as estimated by (a) TEM, and by (b) a Bayesian time-dependent synthesis inversion (Dargaville et al., In press, Estimates of large-scale fluxes in high latitudes from terrestrial biosphere models and an inversion of atmospheric CO_2 measurements). The shaded area represents the range of results from applications of the inversion using the fluxes simulated by four terrestrial ecosystem models to define initial conditions.