ATLAS: Winter Carbon Flux in Arctic Ecosystems

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Winter of 1999-2000

To estimate wintertime $CO_2$ respiratory losses from a variety of tundra communities, we placed NaOH base traps at nine sites along the Dalton Highway, at four sites at Toolik Lake, at two sites at Barrow, and at one site in the high arctic at Alexandra Fiord, Ellesmere Island, Canada. The sites along the Dalton Highway are near the following locations Livengood, Yukon, Kanuti River, Grayling Lake, Gold Creek, Chandalar Shelf, Galbraith, Happy Valley, Pump Station 2, and Deadhorse. HOBO temperature loggers were also placed at each of the sites to quantify overwinter soil surface temperatures. Base traps were set out in late-August 1999 and picked up in mid-June 2000.

Base trap data, while rather a coarse estimate of $CO_2$ efflux, provide a fairly easy way to estimate wintertime $CO_2$ losses in logistically remote sites that are difficult to attend to in the winter. To increase the accuracy of our base trap data, we are using two approaches. First, one set of base traps at Barrow was situated concentrically around the eddy covariance tower of Oechel's group. Since this tower ran for much of the non-growing season, we are able to compare eddy covariance estimates of carbon loss with the base trap estimates. Second, we made an intense field campaign in March 2000 during which all of the Dalton Highway sites as well as 10 different sites (i.e., vegetation communities) at Toolik Lake were visited. During this campaign, $CO_2$ concentrations beneath the snow and through the snow pack were measured with an infrared gas analyzer and respiratory carbon losses were calculated. Based on our experience from three previous winters, we used these instantaneous measurements of $CO_2$ efflux to calculate season-long estimates of carbon loss which can then be compared to the base trap data. As part of this data set, we collected soil temperatures beneath the snow, snow temperatures and snow densities at regular intervals through the snowpack, and snow depths. We also measured $CO_2$ efflux from the long-term LTER moist tussock tundra manipulation plots to follow up the intriguing flux results we had seen at these sites the previous winter.

Winter of 2000-2001

We have once again put out base traps and HOBO temperature loggers at 11 sites along the Dalton Highway to quantify over winter $CO_2$ respiratory losses. These were installed in mid-September 2000 and will be retrieved

~late-May 2001. Sets of base traps and associated controls and temperature dataloggers were installed at sites in Fairbanks (clearing, spruce), Livengood (deciduous, spruce), Yukon (clearing, mixed forest), Kanuti River (tundra, spruce), Grayling Lake (clearing, spruce), Gold Creek (clearing, mixed forest), Chandalar Shelf (tundra), Galbraith (tundra), Happy Valley (tundra), Pump Station 2 (tundra), and Deadhorse (tundra). Additional sites at Toolik included dry heath tundra and moist tussock tundra under ambient and deep snow. In addition we have installed base traps and soil and air temperature loggers at five sites in Council. These sites included mature spruce forest, low shrub, high shrub, woodland, and tundra and are meant to complement the summertime work of Chapin's group. Two wintertime trips are planned, one in November 2000 and one in March 2001, to the Dalton Highway sites and to Toolik Lake. During these trips we will also me monitoring instantaneous rates of carbon efflux using the concentration/diffusion method.

To further refine our estimates of wintertime CO2 losses, to substantiate our base trap estimates, and to move toward autonomous electronic systems, we have installed a system at Toolik Lake that is continuously monitoring CO2 fluxes throughout the 2000-2001 winter. Briefly, the system consists of an infrared gas analyzer, CR10 data logger, sample ports that extend under the snow pack to a sampling chamber, and a battery power supply. The system is set to briefly measure CO2 concentrations beneath the snow once a minute. The 60 measurements during each hour are then averaged and sent to the datalogger. This will allow us to estimate hourly CO2 losses throughout the winter. Although this is the first time we have used this system in the field, we feel confident that it will produce some of the best estimates of wintertime carbon losses from tundra ecosystems. We eventually intend to have several of these automated systems operating in a variety of tundra ecosystems and ecotones and in sites that have been experimentally altered (e.g., warmed, burned, increased snow).

Some of our earlier studies have pointed to the potential importance of fall and spring (i.e., the "shoulder seasons") for setting the stage for many ecosystem processes and plant growth dynamics during the subsequent growing season. Additionally, our research has indicated that there appears to be active uptake of N by plants during the winter season. What is not well documented is the potential importance of late fall and early spring environmental conditions and whether plants are actively taking up and using available N and water availability during these time periods. To this end, we have expanded some our experiments at Toolik Lake in moist tussock tundra to examine the potential uptake and use of nitrogen and/or water by plants and microbes in late fall and early spring. The fall experiment was installed in mid-September 2000. We applied labeled water (H218O) and three forms of labeled nitrogen (14NH4+15NO3-, 15NH4+14NO3-, H215NCH2CO2H) to selected plots. Pre-application and several post-application harvests of soil and various plant and moss species will allow us to determine the potential use of water, inorganic and organic N by plants and microbes in late fall and during winter. This experiment will be replicated in the spring to allow us to address the importance of the early spring time period as well. By collecting various plant species and examining specific plant parts, we should be able to determine (1) which species are most active at these times of the year, (2) the forms of N that are assimilated, and (3) the extent to which fall rain is stored over winter and used by plants in spring and summer.