Report for 2005MT64B: STUDENT FELLOWSHIP: Watershed carbon distribution and flux across environmental gradients

Publications

- There are no reported publications resulting from this project.

Report Follows

May 23, 2006

Susan Higgins, Communications Director
Montana Water Center
101 Huffman Hall
Montana State University
Bozeman, MT 59717
Re: Montana Water Center Student Research Fellowship Final Report

Dear Ms. Higgins,

I am writing to give a final report on my research project "Watershed carbon distribution and flux across environmental gradients", which is supported in part by the Montana Water Center Student Research Fellowship Program. I am including my abstract with contact information, my research accomplishments, and conclusions.

Abstract:
The spatial and temporal controls on soil CO_2 production and efflux have been identified as an outstanding gap in our understanding of carbon cycling. We investigated the primary driving factors and their variability over space and time of soil CO_2 concentration and efflux across environmental gradients in the 550 ha Stringer Creek watershed, Little Belt Mountains, Montana. We collected measurements of soil temperature, soil moisture, C:N ratios, CO_2 efflux, and soil air CO_2 concentrations at two depths (20 cm and 50 cm) at 32 locations across riparian/hillslope transitions in a high elevation mountain watershed in the northern Rocky Mountains. We found that aspect exerted a large control on soil CO_2 concentrations and efflux as western aspects had larger CO_2 concentrations and efflux than eastern aspects. We also found that riparian landscape positions showed greater variability in soil CO_2 concentrations and efflux than hillslope landscape positions. In addition, we installed and collected hourly data from groundwater monitoring wells at over half of the sampling locations in order to determine the effect of groundwater fluctuations on soil CO_2 concentrations and efflux. We found a large increase in soil CO_2 concentrations and efflux as riparian landscape positions changed from saturated to unsaturated conditions. We also examined the diurnal variation in soil CO_2 concentrations and efflux and found that both CO_2 concentrations and efflux reached their maximum during the late afternoon. We conclude that environmental gradients related to catchment topography in soil moisture and soil temperature led to CO_2 concentration and efflux heterogeneity through space and time. We suggest that controlling variables such as riparian versus hillslope landscape position, aspect, differences in C:N ratios, and groundwater fluctuations are the primary controls on heterogeneity in CO_2 concentration and efflux across riparian/hillslope transitions.

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Collaborators that will be listed on poster and in pamphlet (in order of “importance”)

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Research Accomplishments:
For this project, I installed 120+ CO_2 monitoring wells, 60+ soil surface CO_2 efflux plots, and 60+ groundwater wells and piezometers. My experimental design was set up to determine differences in CO_2 production and efflux across different riparian/hillslope transitions throughout the Stringer Creek watershed in the Little Belt Mountains of central Montana.

Conclusions:
CO_2 concentrations and efflux were highly variable, both within and between dominant landscape elements. This heterogeneity was the result of a fluctuating groundwater table, differences in soil moisture, soil temperature, soil nutrient status, organic matter availability, CO_2 concentration gradients, and soil diffusional properties, all of which changed with landscape position. My most significant results are as follows:

1. **Excess soil moisture inhibited soil CO_2 production in riparian landscape positions**. Riparian zones showed greater variability in soil CO_2 concentrations than the hillslope zones along the same transect. Once the water table dropped in the riparian zone, soil saturation no longer inhibited respiration, and CO_2 concentrations quickly climbed up to two orders of magnitude.
2. **Soil CO_2 concentrations and efflux were controlled by soil temperature in hillslope landscape positions.** Soil CO_2 concentrations increased as soil temperatures increased and soil moisture levels remained nearly constant. There was also a small peak in hillslope soil CO_2 concentrations at the end of August, which was controlled by soil moisture as soil temperature remained nearly constant. Thus, **the relative control of soil temperature vs. soil moisture on soil respiration reversed on hillslopes during warm summer months when soil moisture limited respiration.**
3. **Soil CO_2 efflux diurnal fluctuation was controlled by variations in soil temperature**. Peak flux rates occurred late in the afternoon at levels 2-5 times as high as those measured late at night or early in the morning.
4. **Riparian zone soils showed much higher CO_2 concentrations than those soils located in hillslope landscape positions along the same transect.** This was attributed to the proximity of the water table in riparian landscape positions.
5. **The snowpack (1-2 m) exerted a strong influence on soil CO_2 concentrations and efflux as it insulated the ground and formed a poorly permeable layer.** This resulted in a large buildup of CO_2 underneath the snowpack and a decrease in CO_2 efflux.

These results were presented at the Montana Chapter of the American Water Resources Association meeting (October, 2005) in Bozeman, MT and the Fall Meeting of the American Geophysical Union (December, 2005) in San Francisco, CA. I acknowledged financial support from the Montana Water Center at both of these presentations.

Sincerely,

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