Final Technical Report
A Multiscale Approach to Modeling Carbon and Nitrogen Cycling within a High Elevation Watershed
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Abstract. This funding represents a small sub-award related the larger project titled: **A Multiscale Approach to Modeling Carbon and Nitrogen Cycling within a High Elevation Watershed.** The goal of the sub-award was to facilitate the characterization of carbon and radiocarbon data collected from the East River watershed outside Gothic, Colorado USA. During the period of funding from 8/1/15 until 7/31/17, we sampled 40 soil profiles and collected ~325 soil samples. This funding supported the collection, processing, and elemental analysis of each of these samples. In addition, the funding allowed for the further density separation of a subset of soil resulting in 60 measurements of ^{13}C and ^{14}C of bulk soil and density separates. Funding also supported installation of temperature and moisture data sensors arrays, soil gas wells, and soil water lysimeters. From this infrastructure, a steady stream data including soil gas, water, and physical information have been generated to support the larger research project.

Introduction. This research grant is a sub-award to the US Geological Survey in support of the full research grant titled: **A Multiscale Approach to Modeling Carbon and Nitrogen Cycling within a High Elevation Watershed.** The purpose of the sub-award was to facilitate the collection and processing of soil, soil water, stream water, and soil gas samples from the East River watershed outside Gothic, Colorado, USA. The overall goal of the larger project was to develop datasets and model infrastructure required in order to apply reactive transport modeling of soil carbon and nitrogen at the watershed scale. Reactive transport modeling is a more data-intensive tool compared with more tradition soil organic matter models and application to the watershed scale presents several technical and logistical challenges. To address limitations in our ability to sample the entire watershed, we focused on hotspots and hot moments of sampling corresponding to areas within the watershed where or periods of time when organic matter concentrations or fluxes were highest. The hotspots of SOM cycling were identified by semi-randomized sampling distributed over distinct regions within the watershed characterized by unique topography, vegetation, and or landscape position. Hot moments were identified by periodic resampling during periods of high climate variability. The efforts of sampling facilitated by this sub-award, in combination with the other efforts described in the full project report, were intended to improve our ability to map carbon and nitrogen across a watershed and to improve our ability to simulate changes to these ecosystem properties in response to changing climate regimes, such as more pronounced drought conditions, reduced snowpack, and/or shifting monsoon timing and intensity.

Methods. The methods used for this sub-award were focused on four main areas including (1) sample collection, (2) sample processing, and (3) basic biogeochemical analyses including elemental composition and carbon isotopic ratios. In combination with these 3 main tasks, this funding also supported the installation of soil gas, water and physical data sampling infrastructure at the East River upland study sites.

Soil Sample Collection. Soils were collected throughout the East River watershed using a combination of soil augering and soil pit excavation. Soils were sampled to the depth of the saprolite interface, which was typically around 1m or greater. In total, we collected approximately 325 distinct soil samples from 40 different soil profiles. Of these 40 profiles, only 4 were samples as soil pits, which create a greater environmental disturbance but allow for the installation of soil temperature and moisture dataloggers (more details below).

Soil Sample Processing. The soil samples collected were transported to US Geological Survey Laboratories in Denver, Colorado where they were air dried, sieved to 2mm, and then ground to pass a 80 µm sieve. A subset of soil samples, those collected from the 4 soil pits, were subjected to sequential density fractionation procedure whereby ground samples were suspended in a sodium poly tungstate solution with a density of 1.65 g cm^{-3} and centrifuged. The organic material that is less dense than this solution, which floats, was aspirated from the suspension and filtered. Then the remaining solution was sonicated for 5 minutes prior to repeating the centrifugation, aspiration, and filtering steps. The remaining heavy material, with a density greater than 1.65, was then rinsed and filtered.

Soil Sample Analyses: All 325 ground samples were weighed into tins and combusted in order to measure total C and N concentrations using an Elementar Vario Select with a solid phase sample adapter kit. Then all samples were reanalyzed following acidification with 10 HCL to remove inorganic C. The difference between these two measurements was used to calculate the total organic C content of each sample. Each of these 3 soil fractions collected from the density separation procedure in addition to the bulk soil sample were submitted for measurement of ^{13}C and ^{14}C at the UC Irvine KECK Accelerator Mass Spectrometry Laboratory.

Additional Sample and Data Collection. In combination with the soil collection, processing, and analyses described above additional soil sampling or data collection infrastructure was installed and sampled. Soil moisture and temperature monitoring stations, purchased through funds associated with the primary award to Stanford University, were constructed and installed during soil pit excavation at 4 primary study areas. These data collection stations have been continuously maintained by the sub-award PI, C. Lawrence. Additionally, 5 soil gas well sampling nests and 4 soil water sampling lysimeters were installed into auger holes generated during soil sampling. This infrastructure was regularly sampled during the study period and several additional samples were analyzed at the US Geological Laboratory in Denver including soil water samples for total C and N and soil gas for CO_2 concentrations. Finally, seasonally collected soil CO_2 was also submitted to the UCI KECK AMS for measurement of ^{13}C and ^{14}C of soil CO^2.

Results. The results of these efforts provide the data required to generate a landscape scale map of soil C and N across the East River watershed. The production of such a map requires generation and compilation of geospatial data and is currently in progress. The radiocarbon measurements described above facilitated the calculation of soil organic matter turnover times for the 4 focus soils and will be used to constrain ongoing reactive transport modeling of the soils in the East River Watershed.

Conclusions. The work supported by this sub-award forms the foundational datasets used to drive the ongoing East River Upland Carbon project. Data is still being collected from the sampling infrastructure described above and progress toward the overarching goals continues to be made. Future products leveraging these data will include a soil C and N map for the East River Watershed and complete dataset for model testing and validation. Those interested in the bigger picture results of this work should refer to the project report for the full proposal.