James Rennie Bequest Fund Report

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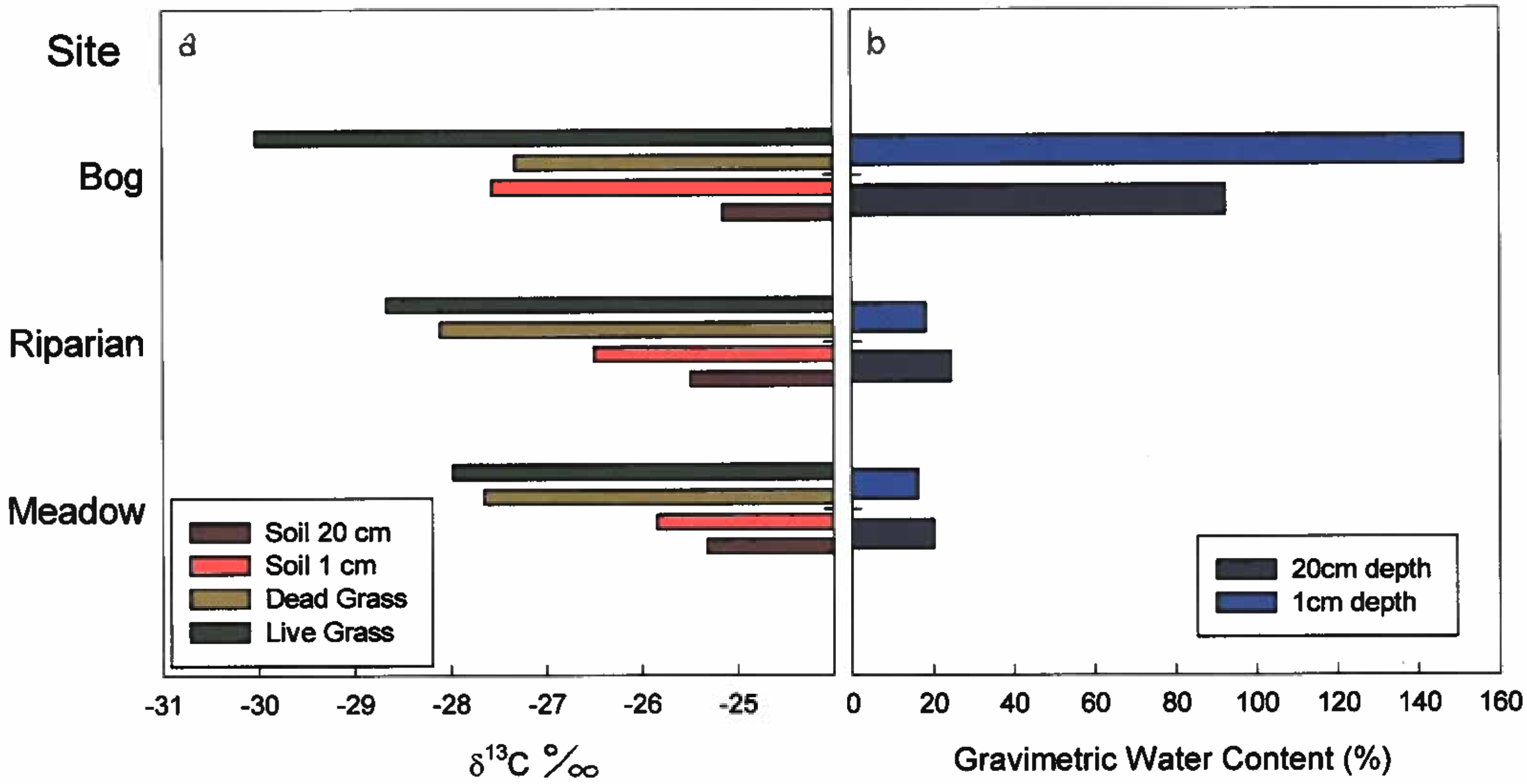
- **Purpose of funding** - to attend a short lecture and laboratory course on stable isotope ecology at the University of Utah.
- **Objectives of visit**
  - to obtain an intensive introduction to the application of stable isotopes in ecological studies
  - to gain practical experience in sampling, preparing and analysing materials for stable isotopes
  - to make international contacts with other scientists and students using stable isotope techniques in the biogeochemical sciences.
- **Skills obtained**
  - a thorough introduction to carbon, nitrogen, oxygen and hydrogen stable isotope abundance and discrimination pathways through lectures and seminars
  - insight into the different processes that explain the stable isotope abundance at a diverse range of scales and organisms
  - practical experience in sampling soils, water, animals, plants and gases for C, N, O and H stable isotopes within the framework of team projects run over two weeks. Typical projects and questions addressed are shown in the two project examples I completed and a list of other project titles covered overleaf.

Project undertaken in week one of course

Differences in decomposition with variations in moisture regime

- **Objective**
  - Decomposition rates vary with moisture content in riparian, meadow and bog environments.
- **Hypothesis**
  - Carbon isotope differences through the plant-soil continuum would be greatest in systems with higher rates of decomposition.
- **Methods**
  - The stable isotopes of carbon were analysed from grass leaf material, litter and soil in three locations. All samples were weighed before and after oven drying at 65°C and ground finely in a pestle and mortar. Carbonates were removed from duplicate soil samples using 1N HCl over 24 hours and subsequent washing with distilled water. 2 mg of the ground material were placed in tin cups and analysed using continuous flow-IRMS.
- **Results**
  - refer to Figure 1.
  - The data show differences in isotopic composition with depth in the soil profile. The tendency for the $\delta^{13}C$ to become heavier (less negative) with depth was observed in all three environments.

Figure 1a and 1b Showing the changes in $\delta^{13}C$ with respect to depth and site soil moisture conditions.



- The greatest gradient in the $\delta^{13}C$ signature between live grass and 20 cm soil occurred at the Bog site which was also the wettest at time of sampling.
- There was no apparent difference between the Riparian and Meadow site for both $\delta^{13}C$ signature and gravimetric water content.
- The $\delta^{13}C$ signature for live organic matter fell within the range expected for organic debris derived from C3 plants.

- **Discussion**
  - The pattern of isotopic enrichment in carbon moving down the soil profile is primarily the result of diagenetic processes within the soil. Some studies have attributed this to enhanced microbial contribution of ^{13}C-enriched (re-) synthesized compounds.
  - The differences in the $\delta^{13}C$ signature of the grass at the three sites caused the main difference between the gradients. This was most probably a consequence of isotopic fractionation during photosynthesis. During photosynthesis discrimination against the heavier isotope (^{13}C) occurs and results in fixation of the lighter carbon isotope. This is most pronounced in plants with a continual supply of CO_2, however any stomatal resistance to this supply causes the heavier isotope to be fixed, hence the foliage incorporates a heavier signature as in the Riparian and Meadow environments. As the plants in the Bog environment were less likely to endure long periods of water stress, stomatal conductance would be relatively larger than the plants under water stress and as a consequence be relatively lighter.

- Lastly, the relative speed of decomposition in soils between environments differed. Smaller ^{13}C enrichments with depth usually reflect faster decomposition of litter. For instance when decomposition is inhibited the ^{13}C signature of the original plant material would remain in the soil system with depth. Under conditions promoting rapid decomposition, the ^{13}C signature at the top of the soil profile would be very close to the value obtained further down the column and not that of the original plant material. The Bog environment seemed to show the fastest trend in decomposition. The difference in the $\delta^{13}C$ values between the live material and the litter were relatively larger than for the other two environments. The $\delta^{13}C$ values of the litter at the Bog environment were also similar to the values found further down the profile. This would imply that plant material decomposed quickly in environments with larger water contents.

Project undertaken in week two of course

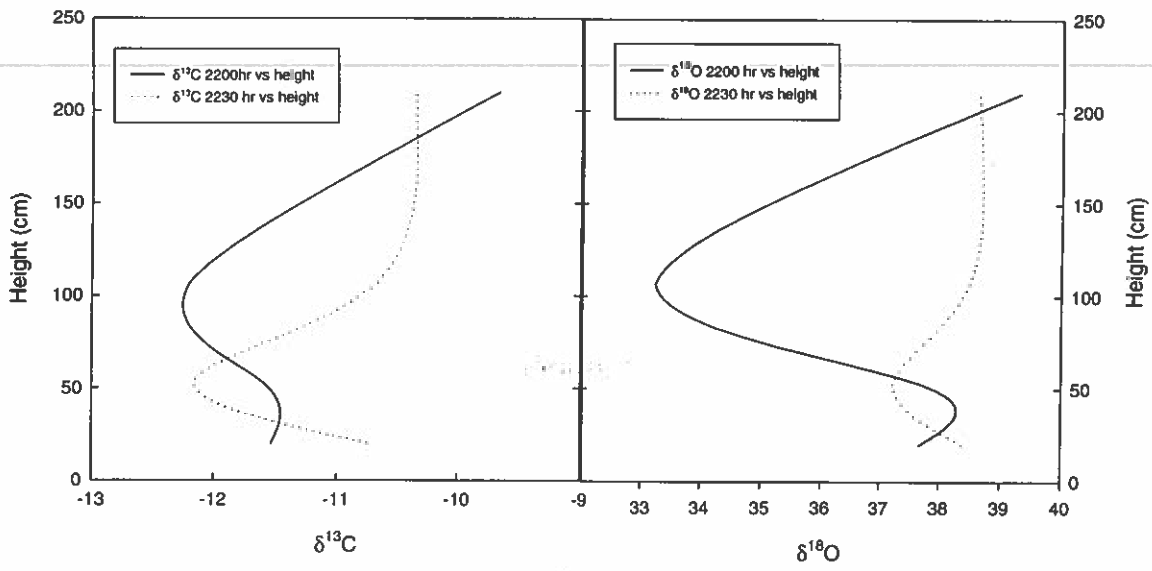
Investigation of the relative contribution of different respiratory sources to the total canopy atmosphere using $\delta^{13}C$ and $\delta^{18}O$

- **Objective**
  - Can the relative contribution of respiratory sources in a plant canopy be estimated using the atmospheric signal within the canopy of $\delta^{13}C$ and $\delta^{18}O$?
- **Methods**
  - Leaf material from the top of the canopy was collected to obtain the $\delta^{13}C$ value. Stream water and leaf material samples from the top of the canopy were collected to obtain the $\delta^{18}O$ values. During the nocturnal build up of respired CO_2 we obtained 100 ml flask samples at 4 heights in the Salix canopy over three 30 minute intervals to obtain CO_2 concentrations and isotopic composition. Unfortunately due to an error in the lab only four of the twelve flasks measured for isotopic composition were also measured for CO_2 concentration.

- **Results**
  - Figure 2 shows the gradient of $\delta^{13}C$ and $\delta^{18}O$ that is present with height in the canopy during the nocturnal build up. The isotopic signal of carbon is more depleted near the bottom of the canopy reflecting the lighter signal produced from respired organic matter, whereas at the top of the canopy the isotopic signature becomes more similar to the global atmospheric $\delta^{13}C$ value of –8‰. There was also a depletion in the $\delta^{18}O$ signal with depth in the canopy reflecting the gradient in values

Figure 2

Profile of $\delta^{13}C$ and $\delta^{18}O$ measured in a Salix canopy during the nocturnal build up

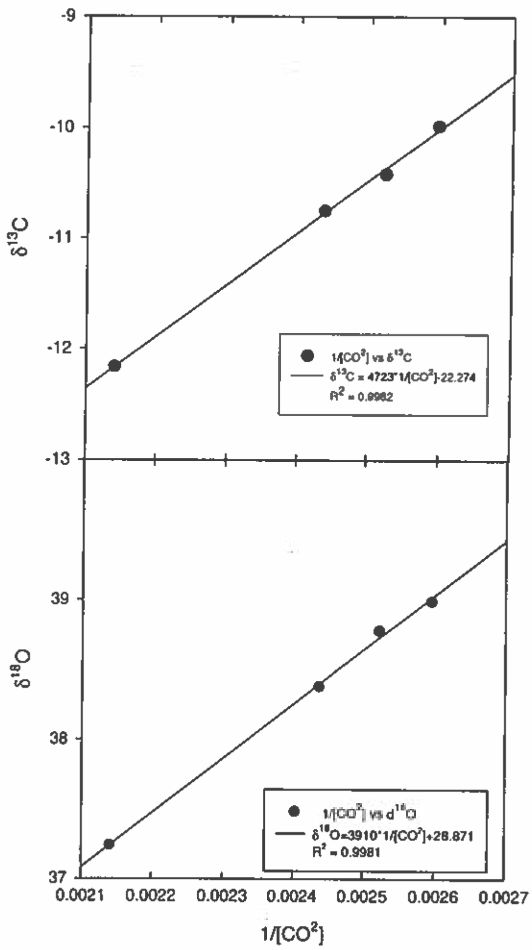


- between the stream water/soil water signal and the bulk leaf water signal.

- The isotope data was then correlated with the $1/CO_2$ concentration obtained for each flask sample, to make Keeling Plots for both isotopes shown in Figure 3. Inferred from a Keeling Plot is information regarding the prominent source of respiratory CO_2. The Keeling Plot for $\delta^{18}O$ indicates a source value of 28.871‰, when a correction of –41.42‰ for the equilibration fractionation constant for CO2 in water is applied the source value becomes –12.329‰. The $\delta^{18}O$ values for stream water and bulk leaf water were, -16.45‰ and –0.93‰, respectively. From this data the contribution of soil-respired CO_2 to the total CO_2 build up was estimated at ~ 79%. The remaining 21% of the flux was attributed to the foliage. From this calculation it was also possible to estimate the $\delta^{13}C$ soil value as ~-20.83‰ using the canopy and foliage $\delta^{13}C$ values.

Figure 3

The relationships between $1/[CO_2]$ concentration and the $\delta^{13}C$ and $\delta^{18}O$ of CO_2 in air samples collected from different heights above ground at night in a *Salix* canopy.



Other Projects

Would black caterpillars be more enriched in deuterium relative to green caterpillars, due to increased solar absorption and increased evaporative losses?

Does the carbon isotope ratio of respired CO_2 differ from that of structural carbon pools; are these differences more apparent in mature leaves than in young leaves?

Do carbon isotope ratios differ among tissues within plant species?

Are there diurnal patterns in leaf ^{13}C? Are patterns related to carbon accumulation within the leaf?

Do male and female *Acer negundo* both have access to ground water? Is leaf water enriched in deuterium relative to stem water? Are females less conservative in their water use?

What do fingernails reveal about their owners' eating habits?

Do the ^{15}N and ^{13}C isotope compositions of a scale from a very large Amazonian fish, the Pirarucu, vary with position along a transect from the edge to the middle of the scale?

Do wet soils emit N_2O relatively more enriched in ^{15}N than soils from dry sites, representing increased denitrification in the wet sites and nitrification at the dry sites?

- **Relevance of visit to my future research work**
  - my proposed PhD work was presented to the course and feedback from the group about my aims and the advantages of incorporating stable isotope techniques to my studies was obtained
  - individual feedback on techniques, equipment and advice was obtained from leading researchers in the specialist field of trace gas fluxes, the major area of my PhD
  - the course gave me a good understanding of stable isotopes, giving me the confidence to speak to specialists and make contacts at other institutes
  - follow up work since this course has resulted in the application for stable isotope analysis tied to my PhD to the Scottish Universities Research and Reactor Centre and the Institute of Terrestrial Ecology, Merlewood

- further stable isotope collaborations with the Max-Planck Institute, Jena and University of Newcastle are being planned in the future
- further stable isotope projects are being planned in the future with colleagues within I.E.R.M
- two further conferences in stable isotope ecology have been planned for the new year, in the UK and Germany, where I plan to present a poster
- I have also encouraged other international scientists to visit the University of Edinburgh and present their work and use of stable isotope techniques in special seminars at the institute