# ENERGY FLOW IN AN ARCTIC AQUATIC ECOSYSTEM

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PROJECT OVERVIEW

This project has been using natural isotope abundances to trace major pathways of energy flow to consumers in Imnavait Creek and the tundra ecosystem of the R4D watershed with comparative work in the coastal tundra. We have now accumulated and are processing samples collected at the R4D intensive site over the past three years and are comparing these data with similar samples collected from the coastal plain. Our overall goals are to a) determine if carbon is accumulating in upland and coastal tundra; b) determine the role of eroded peat carbon in the aquatic ecosystem; and c) determine the distribution of carbon and nitrogen isotopes in the tundra-pond ecosystem to establish the feasibility of using natural differences as tracers.

Our past work on fishes, birds, and the prey species of insects and aquatic crustaceans has shown that peat carbon is very important in the energy supply supporting the food webs over the course of the year. Obligate freshwater fishes from the coastal lakes and Colville River have been shown to contain up to 60 percent peat carbon at the end of the winter season. In contrast, migratory shorebirds and passerines contained much smaller radiocarbon abundances in summer, indicating a major shift to 'recent' in situ primary production in pond and stream ecosystems in summer months. For the past two years, we have narrowed our focus to the processes supplying carbon to the beaded stream system at MS-117 and have concentrated on determining the transfer and accumulation rates of carbon in the watershed.



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We have also assisted in the design and implementation of an initial tritium-labeled snow-melt study with the hydrology group. Unfortunately the initial experiment was interrupted by overflow water flushing out the runoff plot under study, but the experience gained will allow more effective design in 1988.

In cooperation with Mark Oswood, we have been monitoring the movement of carbon from the tundra into the pond system through runoff transport of dissolved organic carbon and erosion of peat. We are also considering the movement of organic nitrogen and have analyzed a detailed suite of samples from the summer-87 hydrologic season. Work-up of these data is in progress.

This proposal seeks funding to conclude this phase of data collection and analysis of collected samples. The remainder of the year will be spent synthesizing the collected data and writing manuscripts. The synthesis process will enable the identification of data gaps and will show the most productive directions for future studies. If the focus shifts from the current intensive study site to the coastal plain of the Arctic National Wildlife Refuge, we will be able to incorporate the information gained into the extensive site studies with minimum start-up time.

## PROGRESS TO DATE

The data obtained in this work has continued to provide a fascinating insight into the workings of the aquatic ecosystem. By far the largest energy source available to aquatic fauna of Imnavait Creek is the dissolved organic matter transported from the slopes to the streams by runoff, whereas in the larger rivers, eroded particulate organic matter predominates. To date, however, we do not know the temporal origin of the dissolved organic matter, i.e. is it derived from organic carbon fixed in the past season, past few years or is it derived from vegetative debris produced over many years. Radiocarbon analysis of the organic matter may yield the answer but the samples require tandem accelerator analysis and to date we are still awaiting

results from submitted samples. This information is critical toward interpretation of our findings that soil profiles indicate cessation of carbon accumulation approximately 2700 years B.P. We have collected additional profiles from the coastal plain which are currently being processed and have several addtional samples from MS-117 to confirm our findings there.

For the past two field seasons we have maintained a sampling program that has given us a nearly complete record of the amounts f organic carbon entering (and leaving) the Imnavait Creek system. Since past data indicate that by far the bulk of the organic carbon is transported as dissolved matter, conversion to biomass must proceed through accumulation by bacteria.

To test the lability of the organic matter to assimilation by consumers and determine if the primary source is peat, insects were collected from Imnavait Creek for radiocarbon activity determination. After sorting to general taxa, these have be sent off for tandem accelerator analysis of $^{14}C$ abundance. This will provide information as to whether the peat carbon is supplied to top consumers via a meiofaunal - insect - fish linkage.

During the snowmelt of Spring 1987, we attempted to measure the relative rates of melting in deep snow versus the snow surface by labelling the deep snowpack with tritiated ice and then sampling the tritium activity in meltwater over the course of the melt. Unfortunately, uphill melt breached the barrier surrounding the runoff plot and flushed the labeled water out of the plot. The labeled water was so diluted that tritium activity has below the, threshold of detectability. The plot boundary barriers have been repaired and the experiment is to be repeated in Spring 1988.

Our work is also continuing on the use of stable isotope abundances as tools for determining carbon accumulation and movement in the tundra. Samples of Sphagnum spp. have been carefully sectioned over growth corresponding to several years and analyzed for $^{13}C/^{12}C$ ratios to see if early spring subniveal growth is discernible by a zone of $^{13}C$-depleted tissue. This zone was hypothesized to have formed during periods when high $CO_2$ concentrations resulting from fungal respirations were present.

The initial samples tested yielded ambiguous results and a new sample collection is now being tested.

As part of a continuing survey of isotopic distributions within the environment, carbon and nitrogen isotope ratios were determined on two caribou killed in the vicinity of MS-117. Keratin in the hooves showed a sinusoidal cycle in isotope abundances of about 3 parts per thousand in both carbon and nitrogen over the length of the hoof. It is unknown at this time if the cause of this shift arises from internal metabolic fractionation or from dietary changes over the annual cycle. We have since collected hooves from three additional animals of known kill date in order to establish accurately the temporal rate of change in the isotopic abundances along the hooves. The analyses on these samples is still in progress. Isotopic variation due to dietary variability has been tested by collecting similar taxa over altitudinal gradients and from differing microclimates near the R4D site. Processing of these samples and mass spectrometry will require several more months of work.

Information obtained to date has been published as a contribution to the DOE-sponsored symposium "Stable Isotopes in Ecological Research" and as manuscript jointly produced with Mark Oswood and Kaye Everett. Further publications are anticipated as more data become available and are analyzed.

## OBJECTIVES - 1988

This proposal seeks funding for concluding the current analytical backlog accumulated over past field seasons and to analyze the data for publication. We will use our findings to provide direction for future work.

Specific objectives include:

Complete analyses of total organic carbon and organic

nitrogen in Imnavait Creek samples collected over the 1987 hydrologic season (in conjunction with Mark Oswood).

Complete mass spectrometry of vegetation, stream organic matter, insects and higher consumers.

Complete radiocarbon and total organic carbon analyses on soil sections obtained from Imnavait Creek, Ugnuravak Creek, and coastal bluffs (in cooperation with K. Everett).

Conduct a tritium-labeled snowmelt experiment to determine the relative melting rates of surficial versus deep snowpack (in cooperation with D. Kane).

Prepare and analyze data for publication.

Accomplishment of these objectives will require most of the next year. The snowmelt experiment will require a short trip to the R4D site in late spring 1988. We also request funds for a final field trip to collect samples to fill data gaps which may arise during the analysis of current samples. Since many of the samples have yet to be analyzed --especially $^{14}C$ -- this opportunity to complete required sampling would be very desirable.

## PROPOSED RESEARCH PLAN -- 1988

### Laboratory Studies

Imnavait Creek Carbon Flux. The collection of water samples from the 1987 hydrologic season has now been completed and the determination of organic nitrogen and carbon is underway. Almost 400 samples have been collected and the determination of both organic nitrogen and carbon will require several months of

analyses. The comprehensive data set acquired, however, will allow good correlation of hydrologic events and seasonal inputs with other climatological variables. When coupled with flow data, these data will allow estimation of carbon and nitrogen transport rates out of the system by stream flow.

Mass Spectrometry. Vegetation samples have been collected from differing microenvironments at the R4D site from ridgetops to the riparian zone of Imnavait Creek. Where possible, similar taxa have been collected at each site and these subdivided to roots, stems, leaves etc when possible. The goal of this work is to identify the sources of the large isotopic variations observed in consumers and to establish the presence or absence of environmental conditions leading to pronounced changes in isotope ratios within small geographical regions. Both carbon and nitrogen isotope ratios will be determined. Comparative samples have been collected from the Oliktok Point and Ugnuravak Creek area for comparison with the R4D site.

Radiocarbon Analyses. The role of peat in the nutrition of aquatic macroinvertebrates can only be assessed by determination of the radiocarbon content of the consumers. This measure in itself can only yield an approximation since the bomb $^{14}C$ tends to displace the 'normal' radiocarbon content of organic matter of relatively recent origin (pre-1960) upwards. Nevertheless, by combining knowledge of the average $^{14}C$ activity in soil profiles with the activities observed in runoff dissolved organic matter and stream dissoved organic matter, an estimate of the peat fraction can be obtained. We have collected soil profiles at the R4D site and have found from radiocarbon analyses that carbon accumulation has been very slow or nonexistent since approximately 2000 years BP. This implies that all fixed carbon is either consumed in place or transported from the system. Radiocarbon analysis of the transported fraction should provide good indication of the mean residence time within the ecosystem. Preparation and analysis of collected samples will continue over the next year.

## Field Studies

The only field work anticipated in 1988 will be to obtain runoff dissolved organic carbon and nitrogen with Mark Oswood and to conduct a tritium-labeled snowmelt experiment with D. Kane in May. This work will be combined with other tasks such as obtaining verification specimens that have been identified as necessary during this winter's mass spectrometry and lab work. These trips will be of minimum duration and cost.

## ANTICIPATED RESULTS

The completion of the the stream chemistry sampling and the final collections of samples for mass spectrometry will provide us with a good overview of the processes supplying energy to the Imnavait Creek ecosystem and the roles of the various energy inputs to the macroinvertebrate consumers.

Stable isotope investigations will provide us with a broad spectrum of data with which it may be possible to identify processes that govern isotope fractionation in the ecosystem. Since fractionation occurs only in those steps which do not go to completion, these data should offer insight into the rate limiting processes and points of potential energy or nutrient loss to the slope and stream system.

## CURRENT AND PENDING SUPPORT

### Current Support

Dept. of Energy -- this project
Principal Investigator -- 3.2 mos.

US Geological Survey

Determination of groundwater nitrate sources using $^{15}N/^{14}N$ isotope ratios.

Principal Investigator -- 1.0 mo.

NOAA

The Kotzebue Sound Marine Ecosystem

Principal Investigator --1.7 mos.

NSF - LTER

Principal Investigator -- 1.0 mo.

Pending Support

Dept. of Energy -- This project

Principal Investigator -- 3.2 mo.


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