A Changing Arctic: Ecological Consequences for Tundra, Streams, and Lakes

<1>Preface

This book in the Long Term Ecology Research (LTER) Synthesis Series, reports results from ecological studies at a site in northern Alaska, the region around Toolik Lake. When the study began in the mid-1970s, ecological research in northern Alaska had been restricted by the difficulty of access in a region with no roads. Accordingly, research was concentrated on the coastal ocean, shallow ponds and lakes, and the wet coastal tundra near the Barrow research laboratory where there was an airport. In addition to research at nearby sites, the ONR-funded Barrow laboratory supported a few temporary field camps in the mountains where small planes could land on lakes and snow fields. This era of limited access suddenly changed in 1975 when the construction of the oil pipeline and the adjacent Dalton Highway gave scientists easy access to a transect of the coastal plain, foothills, and mountains of the Brooks Range. A foothills site with tussock tundra, the deep Toolik Lake, and the Kuparuk River was chosen for detailed investigation.

The Toolik research began in 1975, the year the International Biological Programme study (IBP, NSF) ended its intensive research at Barrow. By coincidence, this was the same year as the opening of the Dalton Highway alongside the pipeline. This gravel road allowed sampling the organisms along the road in the coastal plain, the foothills, and the Brooks Range mountains. The road also allowed a base camp to be established at Toolik Lake so that observations could be made over time, meals and sanitation could be provided, and a small laboratory set up. During

the first two summers, power and an emergency phone was provided by a nearby pipeline construction camp. Today Toolik is a modern year-round research facility operated by the University of Alaska with dormitories, laboratories, electricity, and fiber-optic cable internet access.

The goal of the early NSF-funded research was to document the region's organisms and ecological processes as examples of ecology of the Low Arctic. Organisms and processes are identical or very similar throughout northern Alaska but only the wet sedge and coastal freshwaters had been studied in detail (e.g., in the IBP at Barrow). At the Toolik site to the south in the warmer foothills, tundra, deep lakes, and rivers could be investigated and the ecology compared with the well-known processes in the cooler coastal regions. After the initial documentation phase, the terrestrial and aquatic research asked questions about nutrient controls of primary productivity, temperature effects, and top-down and bottom-up control of populations. Both the aquatic and terrestrial researchers made use of large-scale experimental manipulations including nutrient additions to streams, lakes, and tundra, the heating of tundra plots, and the manipulation of food webs and plant communities. Mathematical models help to understand the integration of these processes and help to project the results to large areas of the Arctic and into the next century.

In 1987, the research became the Arctic LTER project, a part of the NSF Long Term Ecological Research program (LTER) that now includes 25 sites. The Arctic LTER project is responsible for the collection of environmental data and the measurement of samples of various types from the tundra and aquatic systems as well as for the archiving of environmental data in computer files accessible to all. In addition, the LTER maintains several large experiments on tundra and streams and facilitates research projects at Toolik by a large number of investigators

who cooperate closely and use the LTER data and experiments. Goals of the Arctic LTER include continued long-term measurements of biota and of ecological processes. In recent years the goals have included the ecological effects of environmental changes especially those linked to the long-term changes of the Arctic such as a possible increase in frequency of wildfire and to effects of warming permafrost. Another goal is to examine the movements of organisms and material across different parts of the landscape. New questions include the fate of carbon produced in photosynthesis each year or sequestered in permafrost thousands of years ago, the ecology of Toolik in the next century, and the changes in the extent of thermokarst, the physical change in the land surface caused by melting of ice inclusions in permafrost.

How typical of the Arctic is the Toolik Lake region? The short answer is that no single site can be completely typical of a vast circumarctic region where climate variability south to north produces annual average temperatures ranging from 0 to -18 ^{o}C, or of lakes with four months of open water and lakes with a year-round ice cover. The same latitudinal gradient leads to plant cover ranging from an unbroken blanket of tussock tundra to a polar desert of scattered individual plants. Despite this variability, the types of tundra, ecological processes, and relationships investigated in detail at Toolik occur arctic-wide and are very relevant to understanding the ecology of all arctic ecosystems. The Toolik region lies in the warmest of the arctic vegetation zones, and where productivity and diversity is higher than in the other zones. On the aquatic side, freshwaters across the Arctic all have low primary productivity but also the same species of algae and zooplankton tend to make up lake food webs while fish, such as arctic char and grayling, are also similar across the entire Arctic.

The research at Toolik Lake began as a follow-up to the IBP at Barrow, Alaska. The director of the IBP project, Dr. Jerry Brown, played a major role in contacting the pipeline and

oil companies so that researchers could take advantage of the newly-accessible pipeline road. Drs. George Llano and Polly Penhale at the Office of Polar Programs of NSF recognized the value of intensive investigations of streams and lakes and encouraged coordinated research at Toolik. Terrestrial research in the early days of the research was funded by NSF's Division of Ecological Programs. The Department of Energy supported a large ecological project at nearby Imnavait Creek.

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