The gaping hole at the edge of the tundra lake was the size of a football field and impossible to miss. As our helicopter circled into position to land, we could see two men standing on the edge of the crater. They were dwarfed by the enormity of this slumped land stripped of vegetation.

Muck, methane and the carbon sink

THERMOKARSTS

Story and photos by Marie Gilbert

During the past 50 years arctic temperatures have risen progressively. As the Arctic's once permanently frozen ground, called permafrost, thaws, the ice within melts. The soil on top collapses, leaving pits and sunken landscapes called thermokarsts.

These landscape failures can swallow buildings and buckle roads, which make them a serious issue for planners. But it's what thermokarsts "exhale" that interests UAF biogeochemist Jay Jones, a researcher for the Institute of Arctic Biology. He studies the interactions between the biological, geological and chemical parts of an ecosystem.

"The big deal with thermokarsts is that their formation can trigger the sudden release of large amounts of carbon and methane from permafrost into the atmosphere," said Jones, one of several scientists and students working on the thermokarst that day.

Permafrost soils in boreal and arctic ecosystems store almost twice as much carbon as is currently present in the atmosphere. The bulk of this carbon comes from thousands of years of accumulated plants and animals. If it's released, it could have significant climate-altering effects.

"Instead of small amounts of carbon being gradually released from permafrost over long timescales, say, hundreds of years," said Jones, " … huge amounts of carbon are being released into the atmosphere over just a couple of decades."

Ancient ice

The day I flew in to join Jones and Ben Abbott, a UAF graduate student, at the NE-14 thermokarst, the distant clouds were dark with rain, and the occasional bolt of lightning gave everyone something to ponder other than the merciless mosquitoes. Namely, would the weather permit the helicopter to pick us up or would we be walking back to camp?

Once I got used to the whine of mosquitoes I noticed faintly audible drips and plops as I walked along the upper edge, or headwall, of the thermokarst. I climbed over the edge and down into the oozing muck to take a look. Jones explained I was hearing ice formed in the Pleistocene-era — melting. Imagine: floating into the air all around us was carbon dioxide released from 10,000- to 20,000-year-old decomposing plants and animals.

NE-14 is a slump thermokarst. It formed on a slope, and as the vegetation sloughs off down the hillside, it pushes oxygen into the ground, where carbon is stored. Microbes in the soil use the oxygen to convert the stored carbon into carbon dioxide, which then goes into the atmosphere. Where the Arctic was once considered a storehouse or sink for global atmospheric carbon dioxide, thermokarsts are now thought to be contributing toward making the Arctic a source of this greenhouse gas.

By 2100 temperatures could increase as much as 12 degrees Fahrenheit, and scientists expect to see more thermokarsts develop.

Jones and Abbott want to know how much carbon NE-14 and other thermokarsts store, how much carbon dioxide and methane they release, and under what conditions. The goal is to produce a computer model of fluctuating levels of these gases in the Arctic. The research is part of a multi-institutional, $5 million, four-year National Science Foundation project studying the environmental and human aspects of thermokarsts in Alaska.

Sampling sites

Jones and Abbott spent summer 2009 walking for miles on ankle-busting tundra, helicoptering to thermokarsts between thunderstorms (once an arctic oddity), and braving swarms of mosquitoes to map, measure and sample several dramatic landscape failures around the UAF Institute of Arctic Biology's Toolik Field Station on Alaska's North Slope.

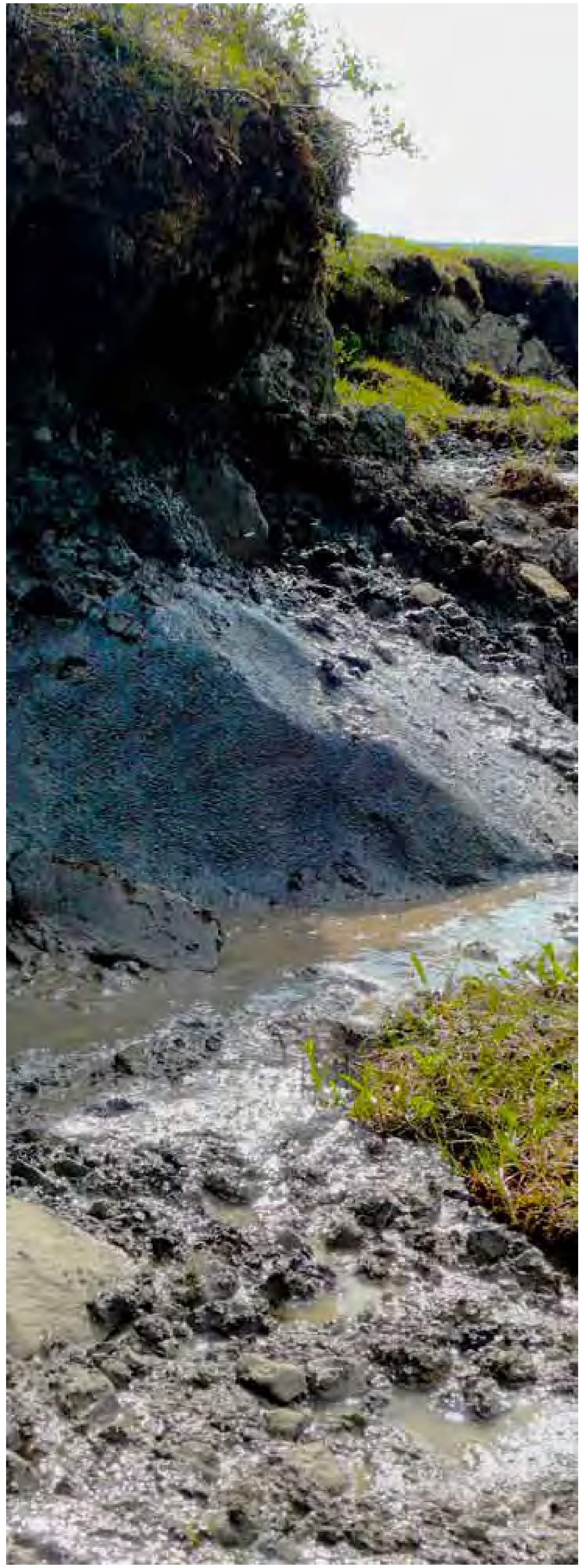
Looking like Johnny Appleseed, Abbott toted a bag filled with dozens of plastic pipe collars. He also carried a small mallet and a bright yellow briefcase full of gas-analyzing equipment. As he walked back and forth across the length and breadth of the NE-14 thermokarst, he pounded the collars in a grid pattern into muck and remnants of vegetation to mark sample sites.

On each collar Jones tightly attached a device about the size of a small food processor, called a gas flux chamber. The chamber measures the concentration of carbon dioxide and methane in the air above the ground; it also measures ground moisture and temperature. A quick glance at the collective data stored on a hand-held device connected wirelessly to the chamber can tell him whether the outgassing is increasing over time or remaining relatively stable.

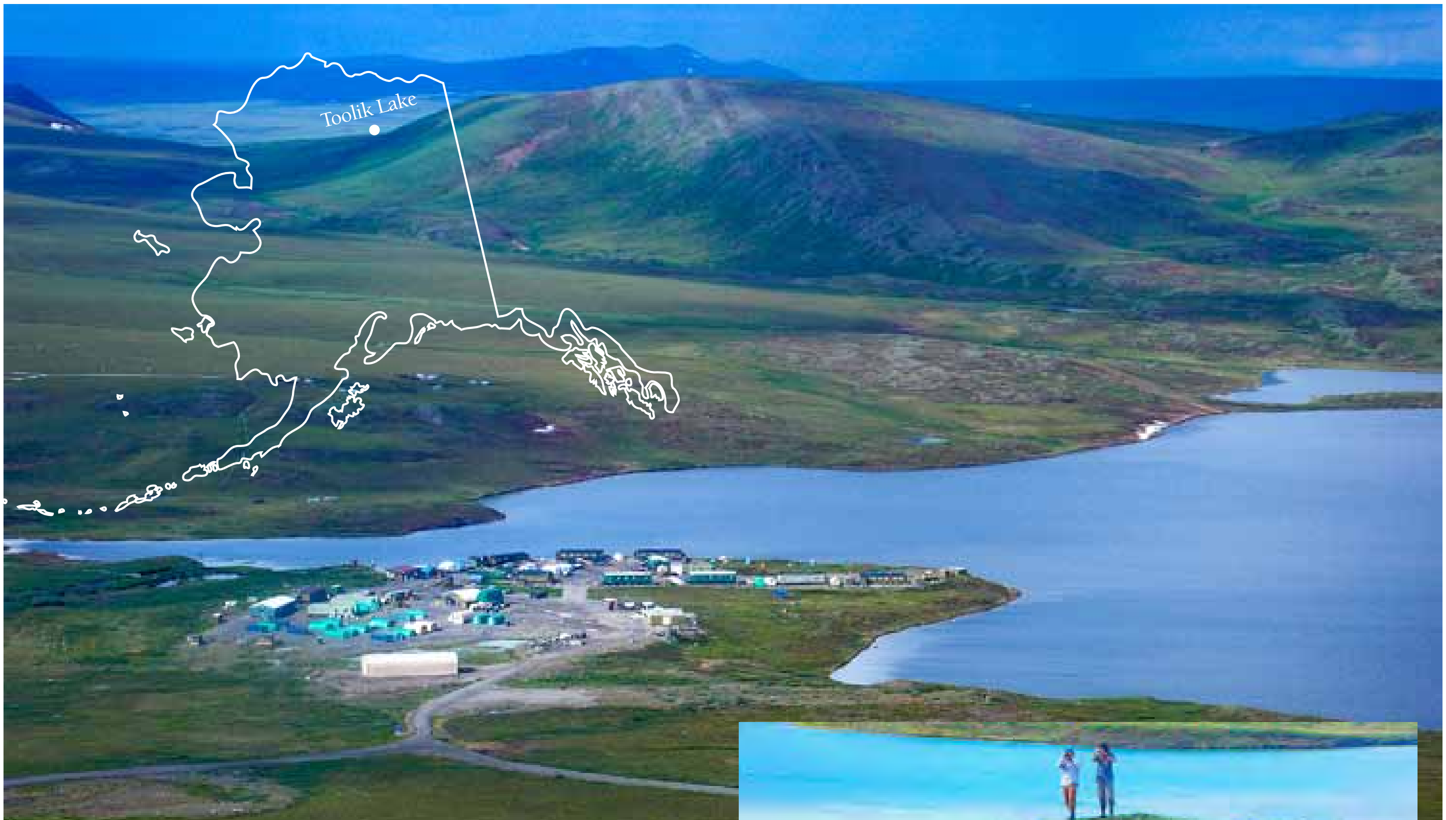
He also took a soil core at each gas sample site to determine soil moisture and composition.

Several days earlier, while taking readings at a much smaller thermokarst, Abbott hollered to Jones across the tundra that when he held the gas chamber a few feet above the ground, it registered a very high level of carbon dioxide.

▲ *Jay Jones, biogeochemist from the Institute of Arctic Biology, heads toward his next gas flux chamber site on the NE-14 thermokarst as his research team's helicopter lands to drop off more scientists.*



The comparatively smooth, concrete-gray, surface in the center of the image is 10,000 to 20,000 year-old, Pleistocene-era ice exposed to the Arctic's summer sun. As this ice melts, the surrounding soil loses its structure and collapses, forming a thermokarst. ▶



▲ *Toolik Field Station in the foothills of the Brooks Range on Alaska's North Slope.*

▲ *Two researchers standing on the edge of the NE-14 thermokarst, near Toolik Field Station, survey the massive landscape failure.*

In most places, "the background level of carbon dioxide is very roughly 380 parts per million," Jones said. "There is a big enough flux of gas coming out of the tundra that Ben saw a reading of about 500 parts per million" — and that was without even putting the apparatus directly on the ground.

Permafrost isn't permanent anymore

Jones and Abbott are just beginning to analyze the measurements from their summer of fieldwork, so they won't know for a few months yet what NE-14 and the other thermokarsts have to tell. The next two summers the pair will return to the area around Toolik Field Station and will also study sites in the Noatak National Preserve. For thousands of years dead plants and animals, and the carbon contained within them, have accumulated and been kept frozen in permafrost. Unfortunately, permafrost isn't so permanent anymore. Understanding the consequences, such as thermokarsts, could help predict the future of the Arctic and the global climate.

Marie Gilbert is the public information officer for the Institute of Arctic Biology.

▼ *Jay Jones attaches a gas flux chamber to a plastic collar marking a spot where he'll measure the carbon dioxide and methane outgassing from an undisturbed area of the tundra.*