

Expedition to Siberia: A Firsthand Account

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Introduction

Nowhere on Earth is warming faster than the Arctic. In northern Siberia, average temperatures have risen 3–5°F over the past 30 years, whereas the worldwide average increase in that time is 1°F.

Between July 28 and August 12, 2007, a small international team of remote sensing and forest ecosystem scientists from NASA and Russia's Academy of Science set off on a three-week scientific expedition through the heart of the remote, wild forests of Siberia. They traveled southward down the Kochechum River observing the gradual transition from tundra to taiga, taking inventory of plant species along the way, and making ground-truth measurements to validate data being collected by several NASA satellites flying 700 kilometers overhead.

Jon Ranson, Head of the Biospheric Sciences Branch at NASA's Goddard Space Flight Center, and **Slava Kharuk**, of the Sukachev Forest Institute were the co-leaders of the expedition. Ranson and Kharuk have been collaborating since 1991, when Ranson first visited the Forest Institute's field camp; this is the pair's seventh Siberian expedition together.

While he was on the expedition, Ranson compiled a blog that reported on the team's activities to give a day-by-day record of their journey. Ranson phoned in each day to report on the team's progress so updates could be posted on *The Earth Observatory* website. (It's the first time *Earth Observatory* has posted a blog reporting on science research as it happens.) *The Earth Observer* has obtained permission to print a summary of the expedition, including excerpts from the blog, for our audience. The reader can see the complete account along with color photos at: earthobservatory.nasa.gov/Study/SiberiaBlog.

Why Study Siberia?

As you might imagine, the team had to put forth a great deal of effort and planning to access and explore a remote place like Siberia, but it was well worth the effort. The Russian forest is of particular interest to scientists studying Earth's carbon cycle, land ecosys-

tems, and biodiversity because it contains about 43% of the world's temperate and boreal forests, and yet scientists estimate that two-thirds of its area is being disturbed by natural or man-made stresses. As Earth's temperature rises, scientists want to know what is happening to the great northern forests? Will the trees in this ecosystem (called *taiga*) begin to grow faster and to gradually extend their reach farther north into the treeless *tundra*, as some scientists predict? Or will hotter, drier conditions stress the trees, thereby inhibiting growth and leaving the forest prone to invasive species and wildfires, as new evidence suggests?

Siberia is a great place to explore to find out answers to these and other questions. Thick stands of spruce, pine, aspen, and larch trees occupy a vast stretch of land across northern Asia and Europe, straddling roughly half of the Arctic Circle. It is a place of stunning natural beauty and biodiversity that serves as a *living laboratory* where scientists can learn whether or not the measurements they get from satellites in space actually match what they see with their own eyes.

The Team's Itinerary

The expedition team's journey to study these forests started above the Arctic Circle near the source of the Kochechum River. There are no roads there, so the team flew in by helicopter, piled their gear into the three boats they brought, and then set off down river. They rode the river for 15 days and ended their trek at Tura, a small town of about 5,000 people. Until they reached Tura, they had to be completely self-sufficient. Their satellite phone was their only link to civilization.

At specific points along their journey, team members took measurements that will be used to validate the forest height measurements made by the Geosciences Laser Altimeter System (GLAS) onboard NASA's Ice, Cloud, and land Elevation Satellite (ICESat). To reach these locations, the team had to traverse through rugged terrain, carrying all of their equipment, and pinpoint the precise locations measured by ICESat's laser. At each site they used standard forestry equipment (e.g., diameter tapes, 50-meter tapes, and laser angle-finder devices) to collect data to compare to the satellite observations.

DAILY PROGRESS REPORTS FROM JON RANSON'S BLOG

Saturday, July 28, 2007

8:25 p.m. Siberia (8:25 a.m. EDT)

Ranson and Kharuk met at Krasnoyarsk Airport in Siberia. They spent the day attending to last-minute details, including a shopping trip for boots and other gear for Jon, whose bag was lost in travel. Then it was off to the hotel for a short night's rest before departure for Tura, where his team boarded a helicopter to take them to their first camp site on the Kochechum River.

The expedition team is pictured here on the helipad in Tura on July 28 beside the M8 helicopter that flew them to their start point above the Arctic Circle. From left to right: Slava Kharuk, Paul Montesano, Sergei Im, Pasha Oskorbin, Jon Ranson, and Guoqing Sun.

Hello to all! We are now above the Arctic Circle!

It is fantastic to be here, and how beautiful it is! The sky is sunny and blue with a few clouds. It is warm with a good breeze at times. We've set up camp on a rocky gravel sandbar beside the Kochechum River. I see green forest all around and there are big moose tracks going through our camp.

The ride in was good. As soon as we touched down, all hands tossed the gear out. Within ten minutes the helicopter was gone. We are in the middle of forest—but not like the forest I'm used to. The trees are quite small and very far apart. Our camp is close to the base of a small mountain. We'll do a transect up [the mountain] tomorrow. We'll measure tree size, how many trees are in a given area, how old they are, and how fast they have been growing over the last 40 years. We should get some good data on how the forest changes due to elevation and also due to warmer temperatures.

Right now two of our Russian colleagues are putting the boats together and making sure they work. Slava is setting nets for fish. We need the fresh protein to supplement the food we brought. We're all very excited. It's always great to start an expedition.

**Sunday, July 29, 2007**

9:10 p.m.

Today the scientists spent their first full day in the wilderness studying the forest ecology. They had to push through thick underbrush and hike over fields of boulders, stopping often to measure the height, circumference, and age of trees, and to observe variations in the forest related to elevation gain and warming temperatures.

This has been one tough but interesting day. We walked up the mountain beside our camp with the idea that we'd see the tundra that was supposed to be at the top. **But there was no tundra.** Just forest. We've got a Russian map from 50 years ago, and it clearly states this mountain is tundra. The maps were based on aerial photography. It's also interesting that today's age measurements showed some of the trees were 90 years old.

The forests are larch here, which is the only tree that is well adapted to conditions this far north. We also see some willow, alder, and juniper—all in small, bushy forms due to the harsh environment. As we head to the south, the species will begin to change. That's exactly why we wanted to start this far north, so we could observe the changes. This transition between two different ecosystems is called an *ecotone*. The ecotone changes with latitude and elevation.

What strikes me today is just how tenacious life is. Every place in which it's possible, something is growing. We've seen signs of moose, bear, and elk, and we hear birdsong everywhere. The forest is stark, but it teems with life. It also seethes with mosquitoes. We are dressed head to toe in protective bug gear. I glanced over at a colleague earlier. They had swarmed his mosquito netting and it looked like he was wearing a carpet of bugs on his head.

Speaking of feasting, Slava caught a pike and something that looks like trout. We had fish soup for breakfast and fish soup for lunch.

Tomorrow we plan to move down river to locate and verify measurements made by NASA satellites. But that's tomorrow. Now it's supper time. Mmm...fish soup.



Pasha Oskorbin and Paul Montesano measure the height of a fallen larch tree, July 29, 2007.

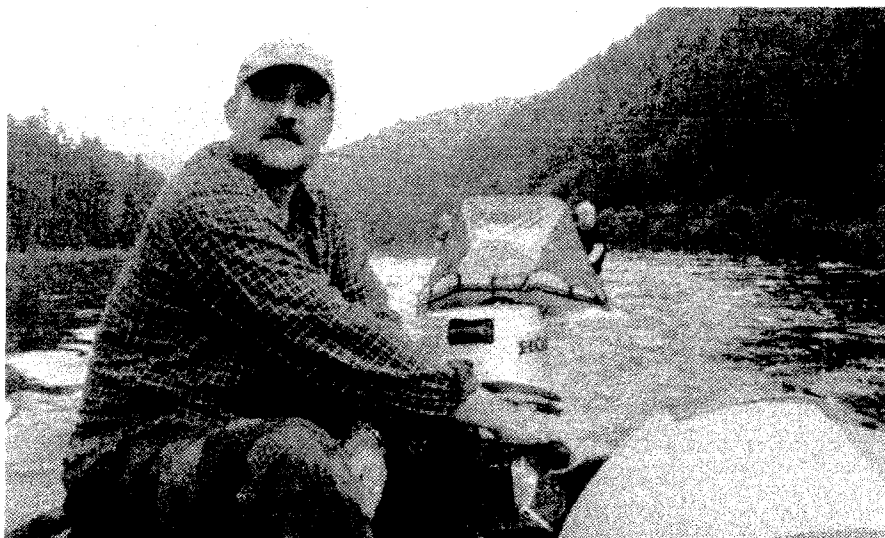
Monday, July 30, 2007

9:15 p.m.

It is a quiet day here on the Kochechum River. We broke camp this morning, packed all our gear into the boats and headed down river. Our mission of the day was to locate the areas where GLAS has made prior measurements. Tomorrow we'll begin taking ground-truth measurements to validate the satellite data.

The GLAS system measures tree height and produces what is called a *wave form*. That wave form can be used to measure *canopy closure*—the percentage of land covered by forest. The best way to verify the satellite's measurements is to come here and make those same measurements by hand with old-fashioned forestry instruments. Of course, it is really hard and time-consuming to travel here, force our way through this tough terrain, and swim through mosquitoes, but it's worth it.

If GLAS is actually accurate here, then we'll verify that and be happy. But even if we find error, it's good. We'll bring home lots of *ground-truth* data and field observations that will help NASA scientists and engineers design a better instrument. So we can't lose. Still, it's hard work.



Jon Ranson at the "helm" as the team cruises down the Kochechum River.

It was also great to rest my feet after yesterday's extreme hike up the mountain. The rocks were slippery and the underbrush seemed to grab and tear at our clothes and gear. But the pain in my feet was more than offset by the incredible beauty of this place. I really love it here.

Tuesday, July 31, 2007

10:06 p.m.

Rainy weather can be a nuisance to all of us but when one is on a science expedition in a remote location, rain has another, more critical, impact. To stay in touch with the outside world, the scientists rely on satellite phones and a small laptop computer. These need frequent recharging, so the team brought along two portable solar panels. There is sunlight 24 hours a day above the Arctic Circle, but to work well the panels require bright daylight. Cloudy days won't work. The dimmer light of the polar night doesn't do so well, either.

The computer has been offline since day two—recharging simply takes too long. The phones charge quickly, but several rainy days could deplete the phone's charge as well and sever the team's last link to civilization.

Wednesday, August 1, 2007

9:05 p.m.

Today we traveled about 35 km down river. We have made camp on a rocky island. On one side is an 800-m mountain that Slava will study tomorrow. Just upriver are many GLAS points that I will visit. It's still raining. The river is rising too. We actually had to move our camp to higher ground this afternoon.

The view is beautiful from here. The mountain tops are covered with basalt, which is a dark black rock.

We crossed below the Arctic Circle today. Just below the line we were greeted by a raven and a family of geese. A little bird, probably a red-throated pipit, has joined us in camp. He eats mosquitoes so we like him. We attract mosquitoes so he seems to like us too.

As we traveled down river, I saw what the Siberians call a *drunken forest*. This area is *permafrost*, where the soil stays firmly frozen year round. When permafrost melts, the trees lose their footing and tilt to the side. It's a curious sight, but it's also a **clear sign that the temperature in that spot has been warm enough to melt the permafrost.**

The river had also exposed a nice cross section of peat bog, several meters thick. A huge pool of carbon is stored in peat bogs and similar areas. Trapping this much carbon helps keep global temperatures down. But if the climate warms, then rapid decomposition could release lots of carbon dioxide and methane—both greenhouse gases—thus fueling greater temperature rise.

Paul took a turn in the kitchen today. I never knew he could cook! There's just no end to today's remarkable discoveries.

Thursday, August 2, 2007

9:20 p.m.

Because the rain and the gray skies persist, it has been impossible to charge the phone from the solar-panel charger. This means that until the sun shines again, the team has lost the ability to communicate with the outside world. So today's communication from the field is quick and short.

I was looking at the forest and just was blown away by the beauty. That larch forest was so very green and it looked as if it was actually glowing—as if sun were shining on it even on this gray day. Just amazing!

But then I wondered, how it could be glowing like that? As we got nearer, we could see the glow actually was from the soil, UNDER the trees. In fact, it turns out that the soil was covered with very tiny, very light, lichens. The lichens reflect the sunlight extremely well.

This **background reflectance is important to how GLAS measures forest canopies**; if the reflectance of the soil changes significantly from place to place or season to season then the height measurements may also change. The lichens are present only at certain times of the year because of snow cover so the background reflectance is changing significantly throughout the year—something we do not allow for yet in our analysis.

I'm not saying this is the answer to the anomalies we've seen in our data, but it is sure worth studying! This is what we come here for; this is why we get in the field.

Saturday, August 4, 2007

10:32 p.m.

From Slava Kharuk ...

Today's rains began gently, and then a single thunderclap brought hard rain. This will be the last thunderstorm of summer, I am sure. The river is as high as it is in spring thaw, and that is a concern. We boated through a lot of choppy white water today. In one spot, the river narrowed tightly and the rapids became quite significant. We did fine, but I am happy to arrive at this campsite tonight.



Slava Kharuk pilots the lead boat down the Kochechum River.

From Jon Ranson ...

This morning we headed downstream to make our measurements. We pulled the boat well ashore, then started into the forest. But we didn't get very far. Floodwater had broken away from the main riverbed and was cutting a new channel right where we needed to go. The water was fast and too deep to wade.

We decided it was best to only take samples of the fire-scarred trees, then to get as far downriver as we could. From our boats, we again observed many large fire scars on the land. This evening we found a safe camp near many GLAS sites, so we will take measurements tomorrow.

For the first time we heard sounds of our own species. We paused to listen to a jet, very faint and far away. It is a reminder that our species, too, is part of one great ecosystem. That **we are, truly, all connected.**



The team takes time out from the river to share refreshments with Valeri and his assistant, who are preparing a nature camp for a Tura high school on the Kochechum River. These are the first people the team has seen since the expedition started 11 days ago.

Monday, August 6, 2007
10:15 p.m.

This morning we had the hardest rain yet... Finally, about 9 a.m., it lightened up enough to start the day... And then it turned gorgeous. The sky is a beautiful blue. It feels great to be in sunlight again!

We worked 11 GLAS footprints today and measured over 600 trees. We're in an area scarred by fire. The regenerated forest here is about the same height and age as the old forest was when the fire burned it down. So **we see the green and the blackened trees, the living and the dead, all standing at similar heights.**

It is a great opportunity to use our *ground-truth* to see how the satellite lidar system records an area like this. The tree heights are similar, but the dead trees don't have any branches, so we aren't sure that the system will even take a reading from them. We'll take our measurements back to the lab and compare data, and we'll see.

This is one great reason to get out in the field. We have the data for this area from various satellite systems. We did know it was a fire scar. But **it's our time and our eyes on the ground that let us know there are unusual conditions here**—conditions that our remote-sensing tools may not be designed to handle.

Not only to understand present conditions, but also to make future predictions, we need to make sure our remote-sensing systems can both record standing dead wood and differentiate it from living trees.

So this has been an important day for our science. But that's not the only thing important about today. One year ago today Gouqing became a grandfather for the first time. He wants to be with his first granddaughter, Jasmine, on her first birthday. But he is here, a half-world away, measuring trees to help understand the forest, the carbon cycle, the local forest ecosystems, and how they all combine in the global ecosystem of which we are each a vital part.

We are studying changes here, in this remote and wild world. The world you grow up in, Jasmine, may be much different than the world we knew as children. Your Grandfather let me know that he is here with us not because he loves you less, but because he longs to see your Earth be vibrant, beautiful, and healthy. **We have a responsibility, each person in this world, to pass on to you a world worth living in.**

So today, Jasmine, in Russian tradition, we raise a toast to you from the wilderness—**С днём рождения! Happy Birthday!**

Guoqing Sun (left) and Jon Ranson (right) plan the day's work. One of the major goals of the expedition is to acquire ground-truth data to verify tree height measurements made by the Geosciences Laser Altimeter System (GLAS) on NASA's ICESat Satellite. To decide how to reach these GLAS "footprint" areas, they use a combination of topographic maps and images from sensors on NASA's Landsat and Terra satellites.



Tuesday, August 7, 2007

10:20 p.m.

It is another wonderful day! We woke up to fantastic sunshine, got into dry clothes, then went to work. We spent about three hours collecting samples for the fire-return-interval study, broke camp, then went about 20 km down river to the GLAS footprint sites.

For the first time, we saw willows that are grown enough to be called trees. We've seen willow before but they were all quite small and shrubby. **This is the first sign of the change into the more southerly forests.**

Ever since we started on this journey, I've been looking at the boat motors. I keep wondering—to myself and out loud—why can't these motors do more than one thing? Why can't we use that power for something else, too?

Well, just a little while ago Slava very quietly revealed to me that the motors do, in fact, have a 12-volt outlet of sorts. Gouqing and I think we have what we need to convert that 12-volt DC outlet to 110-volt AC. If that is the case, then I will be able to get the computer up soon! Of course, I don't have a surge suppressor, so I suppose it's possible that we could end up frying the computer, but—no—won't happen. We'll try to make it work.

Speaking of home, Paul keeps talking about pizza. He has been on this topic for days now . . . pizza! Now I hear that the vegetable supply is getting low but there is plenty of canned beef left. Lots of it. Hmm. I suspect I will be wishing for fish soup very soon.

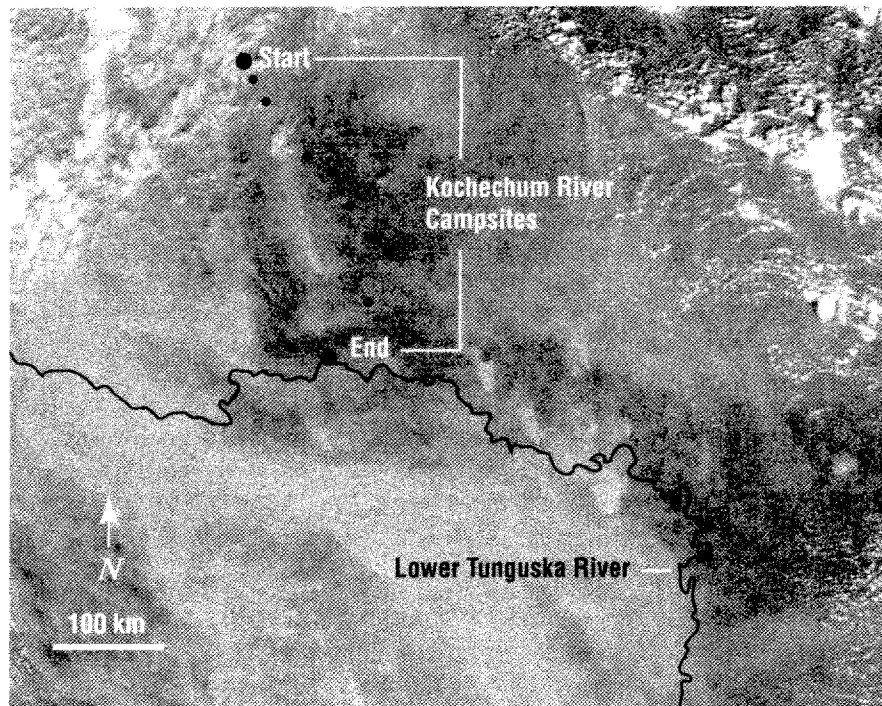
Wednesday, August 8, 2007

10:38 p.m.

The Kochechum is a curious river. The chilly headwaters begin in snowmelt and rain in the basaltic mountains north of the Arctic Circle. These waters flow southerly to the town of Tura and join the Lower Tunguska River. The Lower Tunguska heads northwest until the waters spill into the Yenisey River near the town Turukhansk. The Yenisey turns northerly, ending at the Kara Sea which opens to the Arctic Ocean. After looping away from the Arctic Circle and back, the waters of the Kochechum end up farther north than they begin.

We met our first people today! We stopped by a new structure on the riverbank, and soon a man and a teenaged boy motored in on their boat. It turns out they are working on a camp for high school students from Tura. They gave us dried fish, and we shared what we had with them. It was nice to hear other people talking and to get the latest news of the river lands.

Speaking of boats and motors, our experiment with re-wiring the 12-volt plug on our motors has not worked. I don't know why—everything looks exactly right. I have learned that next time I'll bring extra batteries for the computer. I'll bring a volt-meter, too, in case I want to do some more experiments on the wiring. We are here to learn, aren't we?



Thursday, August 9, 2007
10:48 p.m.

Tonight I'm calling in from my sleeping bag! It's late already, and I am tired, so I snuggled in before I called. My impressions from here: the ground is stony, but better than farther north. This beach has a bit of gravel between the rocks, and the stones are smaller than other beaches we've been on. I'll sleep just fine.

Also, the mosquitoes aren't as bad here as upriver. It's a habit now each morning to check the net on my tent to see how many mosquitoes wait for me to "come out and play." There are definitely many less hanging on that net now. Before sometimes I saw a carpet of them. Here, just handfuls. I guess you could say I have plenty of friends in Siberia.

We still have about 200 km to go to arrive in Tura and to end the expedition. Let me put that another way. When we were in our lab in Maryland, we identified 35 GLAS points of interest on the river, places we would investigate if we could. They are measured from north to south. The most northerly was #1. Today we made it to site 19. So you can see that there is a long way to go yet. We won't measure much more on this trip, but we still need to pass by all those points before we reach Tura.

We spent all day making our tree measurements. We were able to complete 10 GLAS plots today—over 600 trees. **This area is one of the best we could hope for in terms of allowing us to understand the satellite data.**

Friday, August 10, 2007
10:15 p.m.

It has been a long day on the river. The weather was blustery. Wind came up the river at us on and off all day. For the first time we were covered in spray from the river, and I got pretty chilly.

Yesterday we saw our first birch tree; it was very small, but still a birch. Today we saw more birch and our first spruce. The forest is still dominated by larch, but it is changing.

The Kochechum looks really big to me; it's over 100 m wide in many spots. That's about the length of an American football field. But for Russia, this is a very small river. The waters run into the Lower Tunguska, which is a big river, and then to the Yenisey, which is huge—see map on previous page. Then into the Arctic Ocean.

These rivers carry a huge volume of fresh water into the salty Arctic Ocean each day. As the temperatures in Siberia increase, there will be more melting of snow and permafrost. The rivers will carry a greater volume of fresh water, spilling it into the ocean. What happens to the ocean as the salinity drops? What changes will we see in the ocean ecosystems? How might that change affect Earth—the climate and the ecosystems? Hydrologists want to know, and they are actively studying the changes in the world's rivers and oceans. **There is much to learn, here in Siberia.**

Saturday, August 11, 2007
11:56 p.m.

I've said our destination was Tura, but that isn't exactly precise. We are in a cabin just north of [Tura] at a field camp run by the Sukachev Forest Institute. It's still basically wilderness, but instead of rocks and tents we have beds and a cabin. We also have running water and electricity here, so I should be able to get online, finally!

On the river today we saw boats coming towards us for the first time. I guess everyone was feeling good, because they started some teasing. "Look, they are delivering Paul's pizza!" someone shouted. Then to my surprise, someone said, "Oh, maybe they are delivering Jon's bag!" Now, I know Paul has talked about pizza non-stop for days, but I thought I'd been quite stoic about that lost bag of mine. Well, maybe not!

Today's amazing find was a huge area of burned forest. It was tens of kilometers wide and long. It was fairly freshly burned—sometime in the spring we think. In the lab I'll look at data from our remote-sensing systems—especially MODIS and GLAS—and be able to tell the date and extent of the fire.

When we entered the area, we could smell smoky, charred ashes. The ground was covered by dried, fallen needles from the dead larch. The fire had been a low, hot ground fire that burned all moss, brush, and grass from the ground and scorched the tree trunks. It killed the larch trees by heating the soil and scalding the shallow roots, but it left the crowns of the trees untouched. With all the trees dead, the needles slowly dried and fell down like Christmas trees left too long in a house after the holiday.

It had struck me just how much impact forest fires here have on erosion. Of course, this forest sediment then gets carried from this little river to other rivers far, far downstream. Could this sediment make it into the Arctic Ocean? Or will it be deposited elsewhere? If so, how will it change the shape of the land? We have come on this expedition to find answers to our questions, and we have made great progress. It is clear, however, that **there are many, many more questions begging to be studied.**

Sunday, August 12, 2007
10:06 p.m.

I still can't believe we are here! It's amazing, having a bed and hot water. And fine food, too! Our dinner last night was bread and butter. We haven't had bread or butter in so long—how wonderful it tasted.

Today was a day of packing up, cleaning up, sorting out, and getting ready to leave the river. **It is time to leave the Kochechum to return to my office.** There I'll check out this great data we collected, work for understanding of it, then share the information with the science community.

We celebrated the end of the expedition (as well as my birthday) by simply sitting around the forestry camp, eating and talking. It was the only time we actually sat down together, all six of us, to just relax. In the woods, someone was always working. They offered toasts to my health—maybe too many toasts! It was a fabulous birthday.

Looking back, I have to say **the expedition was quite a success.** We did everything we came here to do and more. We have good, solid data that will really help us understand our remote-sensing systems better, fire samples, and excellent, unexpected observations. It was hard and exhausting work, but it was worth it.

Before we sign off, I want to mention some of our sponsors. These groups have been essential to this expedition: NASA Terrestrial Ecology Program, the Land Cover–Land Use Change Program, Northern Eurasia Earth Science Partnership Initiative (NEESPI), and, of course, the Russian Academy of Sciences, Siberia Branch; and the Sukachev Forest Institute. We could not have accomplished so very much without the support of these organizations. ■