



SIBERIA DISPATCH

## Russian Land of Permafrost and Mammoths Is Thawing

Global warming is shrinking the permanently frozen ground across Siberia, disrupting everyday life in one of the coldest inhabited places on earth.

The landscape of the village of Usun-Kyuyol in Yakutia, Russia, is disfigured by thermokarsts, hummocks caused by the shifting temperatures underground.  
Emile Duce for The New York Times

By Neil MacFarquhar  
Photographs by Emile Duce  
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YAKUTSK, Russia — The lab assistant reached into the freezer and lifted out a football-size object in a tattered plastic grocery bag, unwrapping its muddy covering and placing it on a wooden table. It was the severed head of a wolf.

The animal, with bared teeth and mottled fur, appeared ready to lunge. But it had been glowering for some 32,000 years — preserved in the permafrost, 65 feet underground in Yakutia in northeastern Siberia.

As the Arctic, including much of Siberia, warms at least twice as fast as the rest of the world, the permafrost — permanently frozen ground — is thawing. Oddities like the wolf's head have been emerging more frequently in a land already known for spitting out frozen woolly mammoths whole.

The thawing of the permafrost — along with other changes triggered by global warming — is reshaping this incredibly remote region sometimes called the Kingdom of Winter. It is one of the coldest inhabited places on earth, and huge; Yakutia, if independent, would be the world's eighth largest country.

The loss of permafrost deforms the landscape itself, knocking down houses and barns. The migration patterns of animals hunted for centuries are shifting, and severe floods wreak havoc almost every spring.

The water, washing out already limited dirt roads and rolling corpses from their graves, threatens entire villages with permanent inundation. Waves chew away the less frozen Arctic coastline.



Water has inundated the cemetery in Srednekolymsk, shifting the graves.

Credit  
Emile Duce for The New York Times



Vasily P. Okoneshnikov, 54, the head of the village of Nalimsk, inspecting a pole used to tie horses. Due to frequent floods, the poles no longer stand straight, but some, considered sacred, cannot be righted.

Credit  
Emile Duce for The New York Times

Indigenous peoples are more threatened than ever. Residents joust constantly with nature in unpredictable ways, leaving them feeling baffled, unsettled, helpless, depressed and irritated.

“Everything is changing, people are trying to figure out how to adapt,” said Afanasiy V. Kudrin, 63, a farmer in Nalimsk, a village of 525 people above the Arctic Circle. “We need the cold to come back, but it just gets warmer and warmer and warmer.”

Climate change is a global phenomenon, but the shifts are especially pronounced in Russia, where permafrost covers some two-

thirds of the country at depths ranging up to almost a mile.

“People don’t comprehend the scale of this change, and our government is not even thinking about it,” said Aleksandr N. Fedorov, deputy director of the Melnikov Permafrost Institute, a research body in Yakutsk, the regional capital.



Afanasiy V. Kudrin, 63, a farmer in Nalimsk, showing a permafrost cellar whose walls now drip water.

Credit  
Emile Duce for The New York Times



A 32,000-year-old wolf head, which had been frozen in permafrost 65 feet underground.

Credit  
Emile Duce for The New York Times

In Yakutia, almost 20 percent of Russia, distances are vast and transportation erratic. The population is just under one million. Natives joke that every resident could claim one lake.

Yakutia’s 33 districts are the size of countries. In the far northeast, the Srednekolymsk district, which lies entirely above the Arctic Circle, is slightly smaller than Greece. Just 8,000 residents live in 10 villages, including 3,500 in the capital, also Srednekolymsk.

The region has been a synonym for remote for centuries. Empress Elizabeth exiled the first prominent political prisoner to Srednekolymsk in 1744, when it took a year to reach overland from St. Petersburg. There are just two main highways transiting Yakutia, with the one built mostly by Gulag prisoners under Communism still largely unpaved.

In Srednekolymsk, summer used to last from June 1 to Sept. 1, but now extends a couple weeks longer on both ends. Outsiders might not notice that the thermometer in January often hovers around -50 F, rather than -75 F. Residents call -50 “chilly.”



By The New York Times

In a regionwide pattern, the average annual temperature in Yakutsk has risen more than four degrees, to 18.5 F from 14 F, over several decades, said Mr. Fedorov of the permafrost institute.

Warmer winters and longer summers are steadily thawing the frozen earth that covers 90 percent of Yakutia. The top layer that thaws in summer and freezes in winter can extend down as far as 10 feet where three feet used to be the maximum.

Eroding cliffs on riverbanks expose other areas, like where the wolf head appeared, that had long been deeply buried.



A Soviet-era memorial to honor political prisoners exiled to Srednekolymsk under Tsarist rule.

Credit  
Emile Ducek for The New York Times



Across Yakutia, farmers have replaced tens of thousands of cows with native horses who eat less hay, but produce less milk. The market for their meat is limited.  
Credit  
Emile Duce for The New York Times

The thawing permafrost, and increased precipitation, have made the land wetter. The snow and rain create a vicious circle, forming an insulating layer that speeds defrosting underground.

Water backing up behind ice floes now causes ravaging floods virtually every May.

In Srednekolymsk last year, floods swamped the dirt airstrip, with its separate outhouses for men and women. Often battered Soviet turboprops are the lifeline to the world, but the airstrip had to close for a week.

Nalimsk, 11 miles north of Srednekolymsk, has flooded five years in a row. Mosquitoes grown fat in the expanding bogs swarm like kamikaze pilots. "Free acupuncture!" joked Vasily P. Okoneshnikov, 54, the village headman.

Plump black Turpan ducks used to arrive regularly during the first week of June. This year migrating birds began to descend on May 1. There were far fewer Turpans, and suddenly geese, a novelty.



Fishermen hauling their boat off the Kolyma River in northeastern Yakutia around 9 p.m., during the summer nights when the sun never entirely sets.

Credit  
Emile Duce for The New York Times



Appolinariy H. Popov, 55, built his small fisherman's hut in Vyatkin, north of Srednekolymsk, on a bluff overlooking the Kolyma River because floods swept away many similar structures closer to the water.

Credit  
Emile Duce for The New York Times

Elsewhere, the migration routes of wild reindeer have shifted, while unfamiliar insects and plants inhabit the woods.

Nalimsk hunters once stored their fish and game in a 22-foot deep cave dug out of the permafrost, a kind of natural freezer. Now its thawing walls drip water, and the meat rots.

"We buy meat and it is no good, too dry," Mr. Okoneshnikov said. "We have no choice, even if it's shameful" to shop, rather than hunt.

Farther north, residents refuse to abandon their waterlogged, riverfront villages, afraid of losing access to whitefish, their staple diet.

The village of Beryozovka has flooded virtually every spring for a decade, its 300 residents forced onto boats for weeks to run errands like buying bread. They finally accepted a five-year project to move the village 900 yards uphill.

In the district, Beryozovka has the only concentration of Even people, one of various dwindling indigenous tribes.

The Even, who are reindeer herders, were settled only in 1954 through a government drive. They speak a distinct language; individual clans inherit ancestral songs.

“At some point they talked about abandoning the village, but people did not want to move out,” said Octyabrina R. Novoseltseva, chairwoman of the Northern Indigenous People’s Association in the Srednekolymsk region. “They would lose everything, the culture would all disappear.”



“At some point they talked about abandoning the village, but people did not want to move out,” said Octyabrina R. Novoseltseva, the chairwoman of the Northern Indigenous People’s Association in the Srednekolymsk region.

Credit  
Emile Duce for The New York Times



An exhibition at the Museum of Archaeology and Ethnography in Yakutsk displays ancient life of indigenous people in Yakutia. Various small, indigenous tribes, who have herded reindeer for centuries, are under threat as global warming thaws the permafrost.

Credit

Emile Ducek for The New York Times

The government in distant Moscow is an abstract concept. Alaska is closer. Villagers throughout Yakutia bemoan relying on their own resources to adapt to climate change.

Even state-run institutions like the permafrost institute lack the means for the complicated field work needed to assess the full extent of permafrost loss. Nor can they gauge other fallout, like how much methane that microbes in the newly thawed ground produce, adding to global warming.

“We do not really monitor the situation, so we just have to see what it brings,” said Yevgeny M. Sleptsov, the head of the Srednekolymsk district, as he piloted a fishing boat along the Kolyma River at 10 p.m. in the muted light of the endless Arctic day.

The government is also unable to do much about other environmental problems, including wildfires surging through millions of acres of remote forest across Yakutia and the rest of Siberia. Reaching them is too costly.



The north side of Srednekolymsk regularly gets flooded during the spring.

Credit  
Emile Duce for The New York Times



Ivan D. Trofimov, a 63-year-old farmer, inside his old house in the central village of Usun-Kyuyol. The house sank due to melting permafrost.

Credit  
Emile Duce for The New York Times

In 1901, the first woolly mammoth discovered whole in the permafrost emerged from a riverbank near Srednekolymsk, an event immortalized with a stylized red mammoth on [the town's shield](#).

But thawing permafrost is exposing more of the huge hairy beasts, which roamed a more temperate northern Siberia 10,000 years ago. And with agriculture and hunting unreliable, more locals are looking for them.

Digging for mammoths is illegal, so the hunters are secretive, but [one ivory tusk sold to China](#) can earn \$16,000 — enough to live on for a year.

Tusk hunters unearthed the Pleistocene wolf head stored in the Department of Mammoth Studies at the Academy of Science in Yakutsk.

The loss of permafrost also afflicts the capital, Yakutsk. Subsiding ground has damaged about 1,000 buildings, said the mayor, Sardana Avksentieva, while roads and sidewalks require constant repair.

As the permafrost thaws across Yakutia, some land sinks, transforming the terrain into an obstacle course of hummocks and craters – called thermokarst. It can sink further to become swamps, then lakes. From the air, thermokarst looks as if giant warts are plaguing the earth. It makes plowing or grazing on formerly flat fields impossible.



In Srednekolymsk, after a local veteran of the war in eastern Ukraine went berserk, shooting dead a police officer and then himself, the police preserved his corpse in an old natural freezer carved out of the underground permafrost.

Credit  
Emile Duce for The New York Times



The skeleton of a mammoth in the lobby that the Museum of Archaeology and Ethnography shares with the Museum of Mammoths in Yakutsk.  
Credit  
Emile Duce for The New York Times

Thermokarsts besiege the Churapcha region, 120 miles east of Yakutsk.

Thirty-three families once inhabited the northern part of Usun-Kyuyol, a village of 750 people. After their cow barns and fences repeatedly collapsed, 10 families decamped. Those remaining feel beleaguered.

To find flat, dry land to grow hay, farmers work further and further away.

Across Yakutia, farmers have replaced tens of thousands of cows with native horses. Horses consume less hay, but produce less milk, and the market for their meat is limited. They also die in droves when their hooves cannot penetrate thicker snow and ice to forage.

Nikolai S. Makarkov, 62, is building a new house. He tired of jacking up his old one after it sank four times so that the doors would not open. Water also seeped underneath, rotting the floorboards and freezing in winter, chilling the interior.

Years ago, the village road ran straight, with log cabins and cow barns arrayed along its length. Now the potholed muddy track meandering among the hummocks barely resembles a road. Abandoned houses tilt at odd angles.

“There might as well have been a war here,” said Mr. Makarkov, whose new house is raised off the ground on pillars sunk 16 feet, where there is still permafrost. “Soon there will be no flat land left in this village. I only have 30-40 years to live, so hopefully my new house will last that long.”



In Yakutsk more than 1,000 buildings have been destroyed as global warming melts the permafrost under the foundations of buildings. This structure is on stilts to try to prevent its heat from melting the permafrost.

Credit  
Emile Duce for The New York Times

# Fires, floods (and even bugs) are challenging Russia's stance on the climate crisis

By Mary Ilyushina and [Frederik Pleitgen](#), CNN  
Updated 0914 GMT (1714 HKT) August 6, 2019



Batagaika crater - A Gateway to Hell

**Yakutsk, Russia (CNN)** Landing in Yakutsk, six time zones east of Moscow, the first thing you see and smell is thick, acrid smoke. This is one of the coldest inhabited places on Earth, and just one of the dozens of Russian cities choked by the wildfires that have been [ravaging the Arctic](#) this season at unprecedented levels.



"These past weeks it's been impossible to breathe, the smoke is coming from the woods all around us, so we were all warned to stay inside," said Murtaz, a local taxi driver who declined to give his second name, as he drove past a lookout point of the smog-filled city. "But the bugs are the worst -- literally hundreds of them are fleeing the fire and swarming all over you."

Alaska and Canada have also been affected by wildfires. But in Russia the smoke from thousands of kilometers of burning forest has spread over almost half of the country and even reached the west coast of the United States.

Fires in Siberian taiga forests happen annually, but they now have global implications. In the last three years alone, the area affected by forest fires

has tripled, spewing megatons of greenhouse emissions into the atmosphere, according to official Russian estimates.

So as Siberia heats up, it has potential to accelerate global warming. But the Russian response has been slow. Authorities here at first decided not to put the fires out unless they pose a direct threat to settlements as it would be "economically unsound." In other words, local budgets were too constrained.

Complicating matters is the extraordinary logistical burden of working in the vast, undeveloped expanses of eastern Russia. Getting to hard-to-reach forest fires requires a lot of people, aircraft and fuel.

But forest fires are only one part of the cascading effects of climate change. Rising global temperatures, scientists say, are tied to deforestation. Timber is a major Russian export, particularly to resource-hungry China. But as loggers move in, environmental activists say their clearcutting allows vital topsoil to wash away, weakening the ability of the earth to hold extra moisture -- and making the region vulnerable to flooding.

Northern parts of the Irkutsk region were hit by wildfires before its southern areas could recover from deadly floods which took 25 lives and displaced over 30,000 people this June.

The area hasn't experienced floods this strong in years, and is not used to having them this time of the year either. Researchers at Irkutsk State University said the flooding was caused by "anomalous atmospheric processes taking place amid global and regional climate change," warning that Siberia is bound to experience even more weather extremes in the future.

## Climate change at the 'Gateway to Hell'

While the surface of eastern Russia is on fire and flooding, its foundation is literally melting away. Two thirds of the country sit on permafrost, which is degrading rapidly, puncturing places like the Yakutia region with giant sinkholes.

The biggest known one is the Batagai crater, another thousand kilometers north of Yakutsk. Locals dubbed the gaping hole in the permafrost the "Gateway to Hell."



Global climate change is often imperceptible. But at the Batagai sinkhole, you can witness the effects in near-real time.

What sounds like heavy rain from afar is in fact water streaming down the walls of a giant black glacier. This is the sound of melting permafrost. Cracking is audible as ice and frozen earth break loose and falling hundreds of meters from the edges of the crater.

"At first we thought that some meteorite fell here but turns out it was all human factor," says local resident Erel Struchkov. "It used to be a logging area, then people made a little pathway, which turned into a little creek and then, bit by bit, it grew into this massive thing."

[Related: Greenland's ice sheet just lost 11 billion tons of ice -- in one day](#)

And it keeps growing -- about 10-15 meters sink each year. The locals are worried it might envelop their village, and that other holes could endanger more populated areas, where much of the infrastructure sits precariously on permafrost.

"This is massive social issue," said Alexander Fedorov, the lead scientist at Yakutsk Permafrost Institute. "The infrastructure -- buildings, gas lines, water pipes, railroads, roads -- is decaying which comes at a big cost."

And that's where the forest fires are also raising alarms. According to Fedorov, areas where the permafrost sits under trees -- both untouched -- are much less prone to degradation.

## Dependence on fossil fuels

Russian President Vladimir Putin has already ordered the military to send planes and helicopters to help fight the inferno. The fires even took on a geopolitical dimension last week, after US President Donald Trump also offered to send help.

For now, the Russian government is tentatively acknowledging the effects of climate change. Putin paid a visit to Irkutsk flood victims on his way to the G20 summit in Osaka in June, where he delivered a message about climate change.

"I want to remind you that in Russia we are warming 2.5 times faster than the rest of the planet. This is a serious challenge to us. We must understand this," Putin said. "Hence the floods and the melting of permafrost in areas where we have big settlements. We need to understand how to respond to the climate change happening there."

Standing up to this challenge would require an environmental policy to cut dependence on fossil fuels -- a cornerstone of the Russian economy. *The point of no return is almost here, we are at a critical point already when it comes to permafrost.*

**Alexander Fedorov**

But a summer of wildfires and flooding may be changing the way Russians feel about action on climate change.

"We need to lessen the human impact. When climate change meets human factor, the effect is colossal," Fedorov said. "If we don't cut down the forests, if we don't cause fires the permafrost can be more stable... The point of no return is almost here, we are at a critical point already when it comes to permafrost."



## Huge Siberian craters widening as ‘explosions’ heard 100km away and ‘glow in sky’ seen by locals

Reindeer herders almost fell into Deryabinsky crevice when they found it

**Loulla-Mae Eleftheriou-Smith.** Monday 13 June 2016 16:40



A crater on the Yamal Peninsula, northern Siberia. Russian scientists have now discovered seven giant craters in remote Siberia ( *Getty Images* )

One of the large craters that mysteriously appeared in Siberia may be connected to a huge explosion loud enough to

have been heard 100km away, which could have also caused villagers to see a “glow in the sky”.

A number of large-scale craters have been seen across Siberia in the past few years. They are understood to start as metres-wide holes thought to be tens of metres deep, which then rapidly expand in size.

The Deryabinsky crater in the Taimyr peninsula was discovered by reindeer herders in 2013. It was estimated to be four metres wide and around 100 metres deep. The crater has since increased by a reported 15 times in size making it an estimated 70 metres in diameter, filled with water.

And now a loud explosion and strange light has been connected to the crater. Dr Vladimir Epifanov [told the \*Siberian Times\*](#): “There is verbal information that residents in nearby villages – at a distance of 70 to 100km – heard a sound like an explosion, and one of them watched a clear glow in the sky. It was about one month after the Cheyla”.

It is not known what caused either of these incidents to occur, but the expansion of the crevice is understood to be down to the melting of the permafrost. It is predicted that the crevice will expand to the point where its walls collapse cause the lake within it to merge with a nearby, long established lake.

Another crater in Siberia, the Batagaika crater, has been dubbed by locals as “[the Gateway to the Underworld](#)” due to its size. It already measures at about a kilometre long and 90m deep, and is widening by around 20 metres a year.

Russian scientists have now discovered seven giant craters in remote Siberia.



2°C: BEYOND THE LIMIT

# Radical warming in Siberia leaves millions on unstable ground

By Anton Troianovski and Chris Mooney  
Photo and video by Michael Robinson Chavez  
OCT. 3, 2019

ON THE ZYRYANKA RIVER, Russia — Andrey Danilov eased his motorboat onto the gravel riverbank, where the bones of a woolly mammoth lay scattered on the beach. A putrid odor filled the air — the stench of ancient plants and animals decomposing after millennia entombed in a frozen purgatory. “It smells like dead bodies,” Danilov said.

The skeletal remains were left behind by mammoth hunters hoping to strike it rich by pulling prehistoric ivory tusks from a vast underground layer of ice and frozen dirt called permafrost. It has been rapidly thawing as Siberia has warmed up faster than almost anywhere else on Earth. Scientists say the planet’s warming must not exceed 1.5 degrees Celsius — but Siberia’s temperatures have already spiked far beyond that.



Andrey Danilov, a part-time hunter of ancient mammoth tusks, treks through an area of the Zyryanka River in Russia’s Siberia that has been made rich in ivory by thawing permafrost.

A Washington Post analysis found that the region near the town of Zyryanka, in an enormous wedge of eastern Siberia called Yakutia, has warmed by more than 3 degrees Celsius since preindustrial times — roughly triple the global average.

The permafrost that once sustained farming — and upon which villages and cities are built — is in the midst of a great thaw, blanketing the region with swamps, lakes and odd bubbles of earth that render the land virtually useless.

“The warming got in the way of our good life,” said Alexander Fedorov, deputy director of the Melnikov Permafrost Institute in the regional capital of Yakutsk. “With every year, things are getting worse and worse.”

For the 5.4 million people who live in Russia's permafrost zone, the new climate has disrupted their homes and their livelihoods. Rivers are rising and running faster, and entire neighborhoods are falling into them. Arable land for farming has plummeted by more than half, to just 120,000 acres in 2017. In Yakutia, an area one-third the size of the United States, cattle and reindeer herding have plunged 20 percent as the animals increasingly battle to survive the warming climate's destruction of pastureland.

Siberians who grew up learning to read nature's subtlest signals are being driven to migrate by a climate they no longer understand.

This migration from the countryside to cities and towns — also driven by factors such as low investment and spotty Internet — represents one of the most significant and little-noticed movements to date of climate refugees. The city of Yakutsk has seen its population surge 20 percent to more than 300,000 in the past decade.

And then there's that rotting smell.

As the permafrost thaws, animals and plants frozen for thousands of years begin to decompose and send a steady flow of carbon dioxide and other gases into the atmosphere — accelerating climate change.

"The permafrost is thawing so fast," said Anna Liljedahl, an associate professor at the University of Alaska in Fairbanks. "We scientists can't keep up anymore."

Against this backdrop, a booming cottage industry in mammoth hunting has taken hold. The long-frozen mammoth tusks — combined with Chinese demand for ivory — have imbued teetering local economies with a strike-it-rich ethos. Some people bask in instant money. But others watch in dismay as Siberia's way of life is washed away.



Pipes traditionally are built aboveground in Yakutsk, Russia, because of the hard permafrost. As it thaws, it alters Siberia's landscape as well as the region's economy.

## 'Nature is in control'

The first sign of change was the birds.

Over the past several decades, never-before-seen species started to show up in the Upper Kolyma District, an area on the Arctic Circle in northeastern Siberia 1,000 miles west of Nome, Alaska.

The new arrivals included the mallard duck and barn swallow, whose normal range was previously well to the south. A study published last year by Yakutsk scientist Roman Desyatkin said ornithologists in the region have identified 48 new bird species in the past half century, an increase of almost 20 percent in the known diversity of bird life.

Then the land started to change.

Winters, though still brutal, turned milder — and shorter. Fed by the more rapidly thawing permafrost, rivers started flooding more, leaving some communities inaccessible for months and washing others away, along with the ground beneath them.

The village of Nelemnoye was cut off for three months in late 2017 when the lakes and rivers didn't fully freeze, stranding residents who use the frozen waters for transport. With the village in crisis, the government dispatched a helicopter to take residents grocery shopping.

Claudia Shalugina, 63, used to teach at the three-story school in Zyryanka, a 90-minute motorboat ride downriver. Around 10 years ago, the Kolyma River washed away a section of Zyryanka, taking Shalugina's school with it.



The Kolyma River, through the windows of a Siberian hunting lodge.



Andrei Zimzyulin lounges at his fishing camp on the riverbank, where he spends about half of the year.



A decaying bust of Vladimir Lenin sits on the riverbank.

Satellite images show the loss of about 50 acres of land along the riverside, according to the geographic information firm Esri.

Smoking a cigarette on the porch of the village library, Shalugina offered her own analysis of the changing climate: “I think, ‘Lord, it’s probably going to be the end of the world.’”

Just downstream from where the Zyryanka River flows into the mighty Kolyma, three huge tractor-trailers stand abandoned on the forested riverbank. Weeds and wildflowers rise up around them. The frozen river, used as a winter ice road, suddenly became too risky to drive on.

Spring had come early this year — again.

“It used to be man was in control,” said Pyotr Kaurgin, head of the Chukchi indigenous community in the village of Kolymskoye, on the northern reaches of the Kolyma River. “Now nature is in control.”

In the summer, huge blazes tore through Siberian boreal forests, unleashing yet more carbon into the atmosphere. Some scientists fear worsening northern fires are amplifying the permafrost damage.

Meanwhile, six time zones away (but still in Siberia) on the Yamal Peninsula, monstrous craters have opened up in the tundra. Scientists suspect they represent sudden explosions of methane gas freed by thawing permafrost.

Outside Zyryanka, a once-bustling farm has given way to a jumbled landscape of dips, bumps, and puddles. The mud road, what’s left of it, banks and turns at head-spinning angles, until it runs into a widening pond.

“The earth is slowly sinking,” horse farmer Vladimir Arkhipov said. “There’s more and more water and less and less usable earth.”

Thawing permafrost turns into mud along the banks of the Zyryanka River.

The impact on farming has been catastrophic.

Arkhipov produces fermented mare’s milk called kumys, a delicacy among the Sakha, a Turkic people who make up roughly half the population of Yakutia. Arkhipov also raises foals for meat, which in Sakha culture is sometimes consumed sliced thin, raw and frozen.

In the past five years, Arkhipov said, he has lost close to four of his 70-odd acres of hay fields to permafrost-related flooding — meaning he can feed three fewer horses in the winter. And during a freak blizzard in late 2017 — an increasingly common occurrence in the region as the climate changes, scientists say — 10 of his horses died.

Due to thawing permafrost — along with the demise of Soviet-era state farms — the area of cultivated land in Yakutia has plummeted by more than half since 1990. The region’s cattle herds have shrunk by about 20 percent, to 188,100 head in 2017 from 233,300 in 2011. Reindeer herds have also declined sharply.

Fedorov and other scientists say the degradation of crop and pastureland caused by the thawing permafrost helped bring about the collapse of the region’s agriculture.



Native Yakutian horses graze near the wreckage of a Soviet-era helicopter near Zyryanka. The pasture was part of an airport in the 1980s.



Vladimir Arkhipov corralles a horse into a wooden chute. Thawing permafrost is making pastures collapse or become swampland.



A building at a stockyard near Zyryanka illustrates the effects of the shifting ground.

Yegor Prokopyev, the retired head of Nelemnoye, says climate change is the latest shock to befall the Kolyma River region. There was communism and forced collective farming. Then capitalism and government cutbacks.

His grandfather, a peasant, was declared an enemy of the working class and sent to one of this region's many gulag prison camps.

"As soon as you start getting used to something, they'll come up with something else, and you have to adapt to everything all over again," Prokopyev said.

### Visitors from the Ice Age

The idea that warming brings disaster is ingrained in the tradition of the Sakha people of Yakutia, the region laced by the Zyryanka and Kolyma rivers. An old Sakha prophecy says: "They will survive until the day when the Arctic Ocean melts."

Village elders recalled the phrase after an episode of catastrophic flooding in 2005, according to Susan Crate, an anthropologist at George Mason University, who has long studied climate change in Siberia. The radical transformation underway here, she said, should serve as a warning to people in every corner of the globe.

"Changing our ways is imminent," Crate said.



An airport terminal building in Zyryanka. Floods, once uncommon here, often force it to close.



Riverboat workers enjoy a lunch in Zyryanka. Boats and barges are crucial to the area's economy.



A dog basks in the glow of a late Zyryanka evening — which comes late so close to the Arctic Circle.

Over the past 50 years, temperatures in most of Yakutia have risen at double or even triple the global average rate, according to work by Yakutsk-based scientists Fedorov and Alexey Gorokhov. The town of Zyryanka has warmed by just over 2 degrees Celsius from 1966 to 2016, according to their analysis. The Post's analysis, which uses a data set from Berkeley Earth, looks further back. It shows that Zyryanka and the roughly 2,000-square-mile area surrounding it has warmed by more than 3 degrees Celsius when the past five years are compared with the mid- to late 1800s. Some regions of Siberia bordering on the Arctic Ocean are warming even faster, The Post's analysis shows.

The region around Zyryanka has seen warming nearly three times the global average

Source: Berkeley Earth

Desyatkin, at the Russian Academy of Sciences in Yakutsk, found that the changes are even more dramatic underground. From 2005 to 2014, his team found, the number of days with below-freezing temperatures three feet below the surface fell from around 230 days a year to 190. That is significant because enormous wedges of ice lie under Yakutia.

In some parts of the world, permafrost lies in a relatively thin layer just below the ground's surface. But in much of Yakutia, the permafrost is of a special, icy and far thicker variety. Scientists call it Yedoma.

Formed during the late Pleistocene, the Earth's last glacial period, which ended about 11,700 years ago, Yedoma consists of thick layers of soil packed around gigantic lodes of embedded ice. Because Yedoma contains so much ice, it can melt quickly — reshaping the landscape as sudden lakes form and hillsides collapse.

Around Zyryanka, exposed ice wedges glisten along the riverbanks. Their slick, muddy surfaces form ghostly, moonlike grooves. Plant roots dangle like Christmas ornaments from the top layer of soil, left behind as the ice below it melts.

In the 1970s, Desyatkin said, the ground in the Middle Kolyma District, just north of Zyryanka, thawed to a depth of about two feet every summer. Now it thaws to more than three feet. That extra foot of thawing means that, on average, every square mile of territory has been releasing an additional 700,000 gallons of water into the environment every year, according to Desyatkin's calculations. Meanwhile, ancient plant and animal remains trapped inside the Yedoma are exposed to nonfreezing temperatures — or even the open air. That, in turn, activates microbes, which break down the remains and unleash carbon dioxide into the atmosphere, especially from the thawing plant material. Scientists estimate that the Earth's Yedoma regions contain between 327 billion and 466 billion tons of carbon. Were it all released into the atmosphere, that would amount to more than half of all human-caused emissions from greenhouse gases and deforestation between 1750 and 2011.



At the Yakutsk State Museum of History and Culture, a woman looks at a diorama of a landscape that climate change threatens to alter forever.

## Prospecting for mammoth

Although the thawing of these ancient remains raises the threat of terrifying consequences, it is, for some, the bright side of climate change.

“The thawing of the permafrost has a very good effect. The mammoth bone comes out and brings us money,” said Yevgeny Konstantinov, a newspaper editor in the Arctic town of Saskylakh. “Everyone rides Jeeps now.”

In recent years, demand from China has created a booming market for mammoth ivory. People in Yakutia collected almost 80 tons in 2017, according to official figures — a likely undercount, experts say. A Yakutia official recently estimated annual sales to be as high as \$63 million.

As the permafrost thaws and riverbanks erode, more tusks will emerge. Though mammoths disappeared from the Siberian mainland some 10,000 years ago, the government estimates that 500,000 tons of their tusks are still buried in the frozen ground.

Supply and demand are so great that some people are collecting mammoth tusks at near-industrial scale. They use high-pressure hoses to blast away riverbanks and hire teams of young men to comb the wilderness for months at a time. People involved in the business, which isn’t entirely legal, said some tusk prospectors have deployed underwater cameras and scuba gear.



Mammoth bones that could be tens of thousands of years old are strewn near the Kolyma River. They probably were discarded by poachers in favor of valuable tusks.

“You get bit once, you catch the bug. It’s like a gold rush,” said Alexey Sivtsev, a prospector in Zyryanka who said he is licensed to collect tusks. In the glutted market, Sivtsev said, the price for top-quality tusks has fallen from about \$500 a pound five years ago to around \$180.

According to Sakha tradition, tusk hunting violates the sacred ground and brings bad tidings. Some Siberians worry that it also draws young people into an underworld linked to organized crime.

“Since all this is connected to criminality, I’m worried that this mafia, as we call it, is getting a basis for existing in our villages,” said Vyacheslav Shadrin, who studies northern indigenous peoples at the Russian Academy of Sciences in Yakutsk.

Konstantin Gusev, a hunter in Nelemnoye, is still waiting for his mammoth payday.

Once, he found the tusk of an ancient woolly rhinoceros but threw it away. He later learned that such a find sells for \$7,000 a pound, making it among the most valuable animal remains buried underground. Gusev now has his eye on a strip of riverbank where he found a mammoth tooth. He invested in a water pump and hose to try to uncover what’s underneath.

Vanda Ignatyeva, a Yakutsk sociologist, said climate change is leaving people with few choices. “They have to somehow support and feed their families.”

Drone video from Churapcha, Russia, shows land warped by thawing permafrost. (Melnikov Permafrost Institute)

## ‘Trying to survive’

The mammoths aren’t enough to keep Gusev in the countryside, however. The hunter said he is moving to Yakutsk to look for other kinds of work.

The ducks and geese are just about gone, he said, possibly moving to new habitats in Siberia as the climate shifts. The sable pelts aren’t as thick as they used to be. The shorter winters mean that once reliably frozen-over lakes and rivers are now less predictable, making hunting grounds harder to reach and restricting his ability to get goods to market.

“Something is changing,” Gusev said. “People are sitting around, trying to survive.”

In Nelemnoye, the population has declined to 180 from 210 in the past decade, according to village head Andrei Solntsev. Just 82 of the residents have work. Many factors are pushing people to move to the city — lack of Internet access, poor flight connections, limited job opportunities — but the

uncertainty born of a changing climate looms over everything. “We’re already seeing the phenomenon of climate refugees,” Shadrin said. But “it’s not like anyone is waiting for them here” in the city, he said. “No one is ready to help them immediately. . . . They’re breaking away, becoming marginals.” And Yakutsk offers no escape from the warming climate.



A boy rides his bike near the main road of Nelemnoye, Russia — population 180.



Innokenty Dyachkov pulls a pike out of a tub in Nelemnoye. Hunting and fishing are the lifeblood of the village.



Children play on the banks of the Kolyma River in Zyryanka.

As the permafrost thaws and recedes, a handful of apartment buildings there are showing signs of structural problems. Sections of many older, wooden buildings already sag toward the ground — rendered uninhabitable by the unevenly thawing earth. New apartment blocks are being built on massive pylons extending ever deeper — more than 40 feet — below ground.

“The cold is our protection,” Yakutsk Mayor Sardana Avksentyeva said. “This isn’t a man-made catastrophe yet, but it’ll be unavoidable if things continue at this pace.”

An international team of scientists, led by Dmitry A. Streletskiy at George Washington University, estimated in a study published this year that the value of buildings and infrastructure on Russian permafrost amounts to \$300 billion — about 7.5 percent of the nation’s total annual economic output. They estimate the cost of mitigating the damage wrought by thawing permafrost will probably total more than \$100 billion by 2050.

But people here are used to adapting. They survived the forced collectivization of the early Soviet Union. Gulag prisoners taught them to grow potatoes. After the Soviet Union collapsed and the state farms closed, they shifted to a greater reliance on hunting and fishing.

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The latest news about climate change, energy and the environment, delivered every Thursday.

Now, Anatoly Sleptsov, 61, is once again embracing change.

The pastures of the village where he used to live have turned into swamps and lakes. So he moved to firmer ground outside Zyryanka, where he’s leveraging climate change to his advantage.

Though Sleptsov’s attempt to create an Israeli-style kibbutz failed, he figures the region can profit by marketing Omega 3 fatty acids extracted from its fish.

Meanwhile, his potatoes are flowering earlier. And this year, he started growing strawberries.

“Next thing,” he said, “we’ll have watermelon.”



In an effort to embrace climate change, Antonnia Sleptsov and her family have begun growing strawberries at their small farm outside Zyryanka.

John Muyskens contributed to this report.

Credits

Editing by Trish Wilson and Brian Murphy. Design and development by Madison Walls. Graphics by John Muyskens and Harry

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Chris Mooney

Chris Mooney covers climate change, energy, and the environment. He has reported from the 2015 Paris climate negotiations, the Northwest Passage, and the Greenland ice sheet, among other locations, and has written four books about science, politics and climate change.



Michael Robinson Chavez

Michael Robinson Chavez, a staff photographer, recently won a Robert F. Kennedy Award for his coverage of social problems created by the drug trade plaguing Mexico. In 2018 he covered the rise of autocracy in Eastern Europe.



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