Story by Kate Evans

Photographs by Kate Evans and Arno Gasteiger

In February 2019, Mark Magee was scraping the bucket of his 45-ton excavator through a hillside when it hit something 30 feet down that wouldn't budge.

It was high summer in the Southern Hemisphere, and Magee, a construction foreman, was clearing a platform for a new geothermal power plant near Ngāwhā, a tiny community in New Zealand's Northland Region, the long peninsula that stretches from the city of Auckland to the country's northern tip.

He called in additional digger drivers to help. Gradually, as the machines peeled away the mudstone encasing the obstinate object, they realized it was a tree—and no ordinary tree. More and more of it appeared, a seemingly endless log. When the thing lay uncovered, complete with a medusa-like rootball, it measured 65 feet long and 8 feet across, and weighed 65 tons.

It was a kauri tree, a copper-skinned conifer endemic to New Zealand. The indigenous Māori hold the species sacred, and use its honey-colored softwood for traditional carvings and ocean-going canoes. Though this kauri tree had clearly been buried for thousands of years, Magee was astonished to see leaves and cones stuck to its underside that were still green.

The power company, Top Energy, called in a local sawmiller named Nelson Parker to examine Magee's find. Parker, a champion woodchopper with powerful shoulders and a missing finger, had been digging up, processing, and selling kauri logs like this one since the early 1990s. As soon as his chainsaw bit into the bark, he knew from the color of the sawdust (dark yellow) and from the smell (subtle, resiny) that this tree was very old, and worth a lot of money.

Parker also knew that swamp kauri, as the buried trees are known, are worth a lot to science. One this large would be of special interest to a group of scientists who study the information that the ancient trees have coded into their rings. After removing the roots, he cut a four-inch-thick slice from the base of the trunk and sent it to them for analysis.

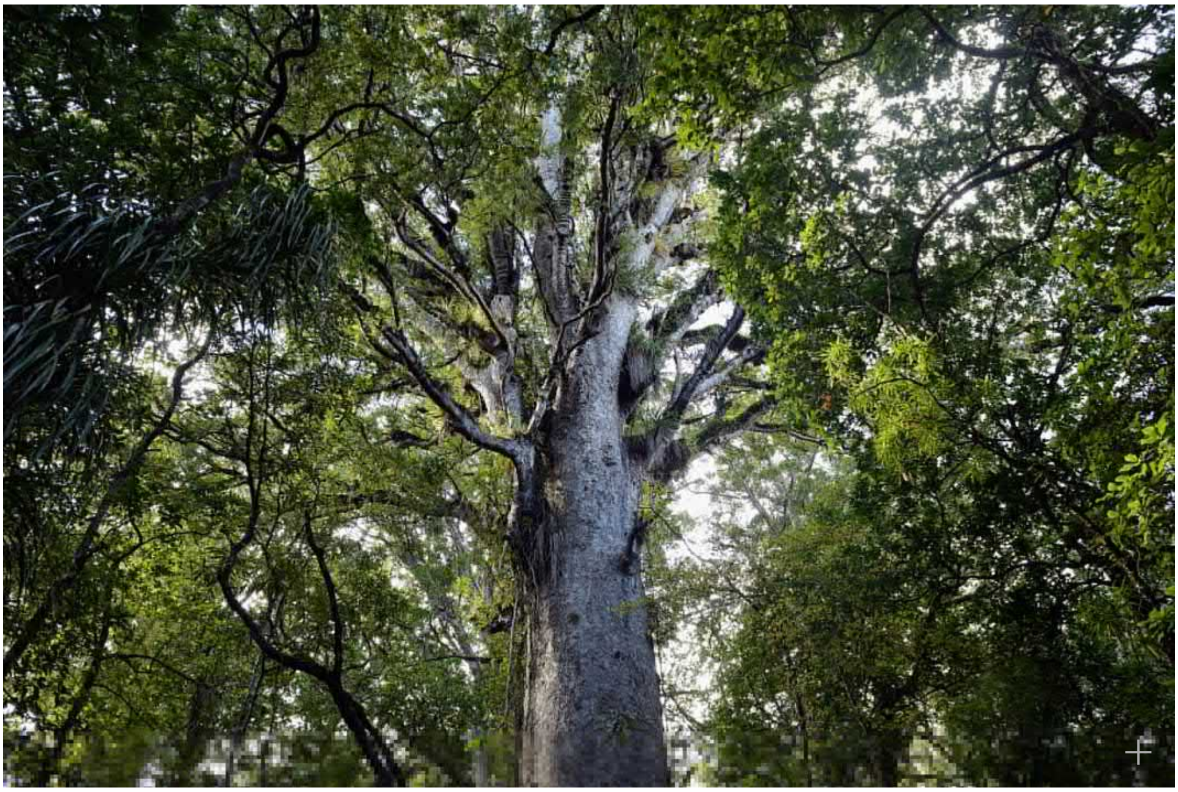
What he couldn't know then was that this particular tree held the key to understanding an ancient global catastrophe, and how it may have shaped our collective past.

The kauri tree, or *Agathis australis*, is one of the largest and longest-lived tree species in the world. An individual kauri can live for more than two millennia, reaching 200 feet tall and more than 16 feet in diameter. Today, the living trees grow only in remnant pockets in northern New Zealand, where the national Department of Conservation lists them as threatened, due to a century of heavy logging, forest clearing for agriculture, and, more recently, the onslaught of a deadly fungus-like pathogen.

Yet for tens of thousands of years, kauri forests dominated a vast swath of the upper North Island. As the trees grew, they recorded information in their annual rings about the climate and makeup of the atmosphere. When they fell, some of the heaviest plunged deep into nearby peat bogs, where they stayed mostly unchanged for millennia.

Itinerant 19th century gumdiggers, who sought the swamp kauri's preserved golden resin for use in varnish and jewelry, were the first to exploit the trees for profit, digging up fields and wetlands in search of buried gum. In 1985, after environmentalist protests, the New Zealand government banned loggers from cutting live kauri on public land, and Parker and other Northland timber merchants turned their attention to swamp kauri. They clawed the trees from the earth with excavators and sold the exotic wood to furniture makers in New Zealand, the United States, and several European and Asian countries.

The industry grew slowly until around 2010. Then, it exploded, thanks to demand from a booming China, where customers are often willing to pay more for materials with antiquity. Fetching up to $200 per cubic foot, swamp kauri became one of the most valuable timbers in the world. Chinese agents roamed rural Northland, New Zealand's poorest region, offering farmers cash in exchange for the right to prospect on their land.



The lure of a fast buck also attracted a host of dubious kauri extractors. Among them were the aptly-named "Swamp Cowboys," who drained endangered wetlands—only 8 percent of Northland's wetlands are still intact—to reach their quarry. In the years that followed, conservation groups successfully fought to restrain the swamp kauri industry and hold the national Ministry for Primary Industries and regional council accountable. Finally, in 2018, New Zealand's Supreme Court issued a unanimous decision limiting swamp kauri exports. By then, the shadiest companies had gone bankrupt, and swamp kauri exports dropped from more than 200,000 cubic feet in 2013 to around 10,000 cubic feet in 2019.

The end of the swamp kauri boom was a big victory for wetland advocates—and a big relief for the scientists who study the ancient trees. The slowdown has made it easier for them to take samples from every piece of unearthed swamp kauri before it disappears into the mill and heads out of the country. Every single tree, they know, has a story to tell.

In a windswept paddock on Northland's remote Karikari Peninsula, on a cool October day in 2019, I watch Andrew Lorrey use a chainsaw to cut a four-inch slab called a "biscuit" off the end of a huge kauri trunk. Around him, beached on the surface like stranded whales, lie dozens more unearthed logs, their forms twisted and gum-encrusted, the tortured roots of their massive stumps reaching for a squally sky.

Lorrey, a stocky, bearded American originally from New England, is a climate scientist at New Zealand's National Institute of Water and Atmospheric Research (NIWA). He came to the country in 2002 to study swamp kauri for his PhD. During the "gold rush" years, he felt a lot of pressure to "scurry around" collecting samples, knowing most of the wood was slipping through his fingers. But over time, he and a handful of other scientists forged relationships with the main timber extractors. "I want to look back and say I did what I could to get this precious natural archive preserved for science," he tells me.

Swamp kauri fall into two age clusters: "young" trees that died anywhere between a few thousand and around 13,000 years ago, and "ancient" ones that were alive more than 25,000 years ago. No one has yet found a kauri from the roughly 12,000-year span in between. That was the height of the last glacial period, when temperatures were cooler and sea levels more than 300 feet lower. Scientists speculate that the kauri's range may have shrunk during that time because of the cold, or that the forests moved to lower elevations on the continental shelf when sea levels fell, and were later submerged as the climate warmed and seas rose again. Or perhaps the trees from that time are simply still out there, waiting to be discovered.

The landowner here on the Karikari peninsula, a taciturn, pipe-smoking farmer named Chris Hensley, found this batch of buried logs when he was converting an old pine forestry plantation to pasture. For Hensley, the kauri are a nuisance. "They bugger up the farm equipment," Lorrey says. But for Lorrey, they're treasure. After learning about them, he quickly organized an expedition, driving more than four hours from Auckland to examine them. Hensley had used his digger to lay the huge haul—104 individual trees—on the ground like matchsticks. "When I got there, I said, 'I've got gold,'" Lorrey remembers.

Now, Lorrey moves from log to log, slicing biscuits from the heavy end of each one, making detailed notes about their measurements and where they were found, then brushing the cut faces with a white glue-based paint to protect the wood from the elements.

While Lorrey works, Hensley arrives to watch. A tiny white fluffy dog jumps from his truck and runs frenetically among the dark logs. Knowing the age of the timber will help him sell it later, Hensley says. “This way I get them dated for free.”

What the scientists get in return is something they can’t find anywhere else.

There are other ancient trees in the world, but none as old, as long-lived, or as numerous as the kauri. Because migrating ice sheets demolished everything in their path, few trees survived the glacial periods in the Northern Hemisphere and scientists have found only a handful, including one 23,000-year-old cypress buried in a volcanic mudflow near Mount Fuji in Japan. Northland, however, remained ice-free. “The kauri are globally unique,” Lorrey says. “There’s no other wood resource like it for this part of Earth’s history, full stop.”

> ***“There’s no other wood resource like it for this part of Earth’s history, full stop.”***
>
> — Andrew Lorrey, climate scientist

Other natural climate archives, such as ice cores, lake sediments, and stalactites and stalagmites, also allow scientists to peer into the past. But trees are the “gold standard,” Lorrey says, because they directly sample the atmosphere, and make a new record of it and other aspects of the environment in each annual growth ring of wood they lay down. Unlike ice cores and lake sediments, tree rings don’t compress over time. Multiple trees growing at the same time can be cross-referenced, too, smoothing out any local or individual variation that might interfere with broad conclusions about the climate. (Imagine a single tree growing poorly for a few seasons because its roots were waterlogged or it was shaded by others.) Long-lived, well-preserved kauri are therefore a kind of “high-resolution time-capsule,” Lorrey says.

Tree rings illuminate the past in several ways. Most simply, counting them under a microscope reveals how long a tree lived. The biscuit that Nelson Parker cut from the log found near the village of Ngāwhā, for instance, indicates that the kauri was about 1,600 years old when it died: 1,600 rings, 1,600 years. Measuring the varying width of the rings from year to year allows scientists to observe changing growing conditions. Chemical analysis of each ring can indicate relative humidity, rainfall patterns, and soil moisture. And by using computer programs and eyeballing tree-ring patterns to string together multiple samples from different times and locations, scientists can create long tree-ring sequences, called "chronologies," that span millennia and help reveal larger regional climate patterns.

University of Auckland dendrochronologist Gretel Boswijk and collaborators, for example, used 700 samples of both ancient and living kauri to piece together a continuous 4,491-year chain of trees that had lived between 2488 BC and today. The chronology allowed Boswijk's colleague, Anthony Fowler, to figure out that kauri are especially sensitive to the El Niño Southern Oscillation (ENSO), a climate pattern in the Pacific Ocean that affects annual temperatures and rainfall around the world. "When we have an El Niño year, here in the north of the country we'll get more southwesterly flow—clearer skies but also cooler average temperatures," Boswijk says. "Kauri tend to respond well in those conditions, so they tend to put on a wide ring." Conversely, in a warmer, cloudier La Niña year, kauri add narrower rings. "They get stressed, they don't grow as well."

Using this information, the team was able create a 700-year reconstruction of ENSO variability in northern New Zealand, providing a lengthy picture of the country's natural climate variation. For comparison, historical climate records date back only 150 years. The longer timeline is crucial for climate modelers trying to predict how ENSO will respond to future anthropogenic warming.

Scientists have also assembled a handful of other kauri chronologies that go even further back in time, each covering a few millennia of the past 60,000 years. But because they're not connected to the present, they're called "floating chronologies," meaning that their calendar ages remain relatively uncertain. Lorrey dreams of one day finding the right logs to link all of them into one unbroken chain.

In the meantime, the floating chronologies and ancient kauri samples are already proving incredibly valuable for global science in other ways. For a start, they can help scientists to determine the ages of other plant, human and animal artifacts, from as far back as tens of thousands of years ago.

The walls of the University of Waikato's radiocarbon dating lab are lined with a maze of interconnected glass tubes, wire mesh, vacuum pumps, gas taps, and tanks of liquid nitrogen frozen white around their rims. Round glass balloons for catching gas are covered in stripes of masking tape, like a half-finished papier-mâché project.

"In case they explode," says the lab's director, Alan Hogg, as he shows me around. It's happened before: shards flew out the door and embedded in the wall across the corridor. "That's why you're wearing safety glasses," Hogg says.

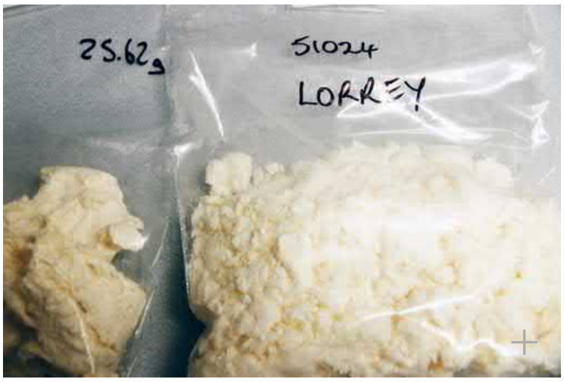
The rangy, bespectacled scientist is a globally-recognized expert in radiocarbon dating—the process of determining the age of objects containing organic material by measuring the radioactive isotopes they contain. Dating swamp kauri doesn't just tell scientists how long ago the trees lived: By combining that data with radiocarbon information scientists already know from other natural archives, like lake sediments or stalagmites, they can reconstruct more precise timelines of the deep past.

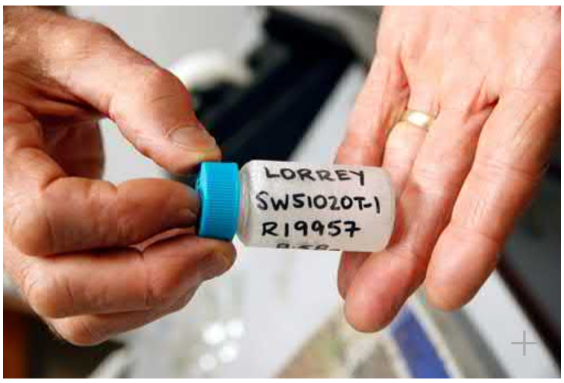
After the Ngāwhā log was unearthed, fist-sized samples of it ended up here, in Hogg's lab. Each chunk contained 40 rings, representing four decades of time. Technicians first ground the wood to a fine, cinnamon-like powder, tipped it into a row of bubbling glass percolators that removed any impurities, then bleached and dehydrated the remains until they turned into a fluffy white substance resembling sheep's wool. The techs then fed the fluff into the sequence of glass tubes arrayed on the wall and guided it through chemical reactions that transformed the wood's carbon into a vial of pure benzene. It no longer looked like a piece of kauri, but the amount of carbon in the sample remained constant.

Tiny amounts of radiocarbon, or 14C—a radioactive carbon isotope—build up in plants as they absorb carbon dioxide from the atmosphere through photosynthesis. Animals, including humans, acquire 14C, too, by eating the plants. From the moment the plant or animal dies, the radiocarbon in its cells begins to decay at a constant rate, Hogg explains. "If you had a pile of 14C atoms in your hand, in about 5,730 years, half of them would be gone."

Another 5,730 years after that, there would be half as many again. After around 60,000 years, there would be so few left that they become impossible to detect—the outer limit of radiocarbon dating.

To count the 14C atoms in the Ngāwhā sample, Hogg's team added a light-emitting chemical called a "scintillator" to the benzene that "gets excited if there's any energy produced," he says. Then they placed it for a week inside a freezer-sized liquid scintillation spectrometer, which detects pulses of light.





The 14C atoms in the vial continued their slow, regular decay, just as they had since the giant Ngāwhā tree fell to the ground. As each atom winked out, the scintillator produced a flash of light, and the spectrometer counted it: the fewer flashes per minute, the older the wood. Several repetitions of the process confirmed the result: the Ngāwhā kauri had a radiocarbon age of between 36,000 and 39,000 years.

That radiocarbon age is not the same as the tree's calendar age, however, because while the rate of C14 decay remains constant, the amount of C14 in the atmosphere varies through time as a result of changes in solar radiation, the strength of the Earth's magnetic field, and more recently, human activities, such as setting off nuclear bombs. That means tree rings from two different years can end up with the same amount of C14.

To correct this variance, scientists must assemble a reliable historical record of radiocarbon variation—a calibration curve—that translates radiocarbon ages into calendar dates. A group of international scientists, including Hogg, spent seven years working on the latest version of the calibration curve, released in 2020. They mapped the radiocarbon patterns in the swamp kauri chronologies onto those from corals, stalagmites, and others in a technique called "wiggle-matching." Because tree rings provide annual data points, scientists can see abrupt changes that they can't detect using the other natural archives. "The kauri have increased the resolution of the curve," says Paula Reimer from Queen's University Belfast, who leads the calibration group.

The more precise curve will help to date old buildings more accurately and clarify the frequency of volcanic eruptions and earthquakes. It has already led to new insights. Around 15,000 years ago, melting ice sheets caused sea levels to rise more than 50 feet and flood Southeast Asia's Sunda Shelf, which stretches from the Malay Peninsula across Borneo to Bali. The new curves reveal that the flooding took place even faster than scientists thought, over just 160 years—three feet a decade. The lesson that sea levels can rise suddenly, rather than steadily tracking global temperatures, may have implications for us as the Antarctic ice sheets melt.

The new curve also indicates that modern humans and Neanderthals coexisted in Europe for only 4,000 years, not 6,000 as previously thought. Likewise, scientists now know that the oldest painting in France's Chauvet Cave is around 450 years older than previously thought, dating back 36,500 years.
Each ancient kauri discovered and sampled has the potential to add more detail to the curve, increasing its accuracy further, and revealing more about climate change, extinctions, and human prehistory. "What happened when is everything," Lorrey says. "If we can pin down the timing, we can understand cause and effect – and that's what kauri can help us figure out. It's the cipher."

Beyond their use in dating, the radiocarbon patterns in kauri rings may also have something to teach us about changes in Earth's geomagnetic field. In 1859, the sun erupted in a massive solar flare and coronal mass ejection, sending a barrage of radiation toward Earth. The resulting day-long geomagnetic storm—called the Carrington Event—took out the nascent telegraph system. The aurora was visible in Mexico, Cuba, Hawaii, and Queensland. The flares were so bright in the northeastern United States that people could read the newspaper by their light, and gold miners in the Rocky Mountains began preparing breakfast in the middle of the night because they mistook the glow for dawn.

Radiocarbon research has pinpointed even larger solar storms further back in history. In 2012, Japanese researcher Fusa Miyake used Japanese tree rings to show that a much more powerful flare—now called a Miyake Event—occurred around 774 AD, leaving a dramatic radiocarbon spike in the wood. The same year, the medieval Anglo-Saxon Chronicle—a history written in the 9th century—recorded an eerie "red crucifix" in the heavens. An identical radiocarbon spike showed up in swamp kauri rings at the same time, according to a Swiss study that included contributions from Hogg and Boswijk. Scientists identified similar Miyake Events in 994 AD and 5480 BC. High-resolution swamp kauri records could reveal yet more from tens of thousands of years ago.

Researchers' interest in these events is not merely academic. Even a Carrington-sized geomagnetic storm, while not harmful to humans, might be powerful enough to knock out electrical and communications systems across the planet, including satellites, GPS, power grids, and the internet. "We need to know if something 100 times more powerful than a Carrington Event could happen," says Hogg. "This is not scaremongering. These are huge events that could literally fry everything. We want to know, 'What is the most damage that the sun can do?'"

Solar storms aren't the only geomagnetic events to write themselves into kauri wood. Around 42,000 years ago, the Earth's magnetic field went wandering for a millennium—and briefly reversed entirely—in what's called a geomagnetic excursion. Scientists named it the Laschamps Event, after the French village where they first detected the excursion's magnetic signature in a lava flow. If one happened today, it too could cause serious problems for global communications systems, with financial losses estimated in the billions. Given that satellite data has shown that the Earth's magnetic field is weakening and the magnetic North pole is moving more rapidly than expected, some scientists speculate that an excursion is nigh. We don't know enough about these events to be able to predict when they're going to happen, and what effect they might have on life on Earth when they do, but the Ngāwhā kauri offers some stunning clues.

When Hogg adjusted the radiocarbon dates of the tree based on the calibration curve, he realized they spanned the onset of the Laschamps Event. The kauri had sprouted into a sapling around 42,715 years ago; 1,600 years later, it crashed into the mud. Hogg and Lorrey worked with Alan Cooper of the South

Australian Museum and Chris Turney of the University of New South Wales to match the information in the tree's rings with other natural archives to build a precise sequence of events. The story they tell, relayed in a paper published in Science this February, is one of global environmental catastrophe.

When the Ngāwhā kauri was a few centuries old, Earth's magnetic field weakened dramatically. Coincidentally, the sun went into one of its periodic, century-long dormant periods, called a "Grand Solar Minima," in which it produces many fewer sunspots than usual and gives off less energy.

This, in turn, decreased the flow of solar wind around the planet, which normally provides another protective magnetic field. With little defense against cosmic and solar radiation, Earth's atmosphere was bombarded for a few hundred years with ionizing particles from space. Lightning likely raged, auroras shimmered even in temperate skies, and weather patterns abruptly altered. "It would have been freaky as," says Cooper. The Ngāwhā kauri lived through it all.

Over the following centuries, ice sheets rapidly expanded across North America, while Australia shifted to a more arid climate, its inland lakes drying up. Cooper suggests those changes are what drove the extinction of numerous species of Australian megafauna—like the giant, wombat-like diprotodon—more than 10,000 years after modern humans arrived on the continent. The implication is that humans alone weren't responsible for the extinctions: They had only to stake out diminishing waterholes to finish off the ill-fated animals.

42,000 years ago is also when figurative art first appeared in caves all over the world, from Europe to Indonesia. Cooper thinks the onset of the Laschamps Event might have something to do with that, too. Perhaps the adverse weather conditions and very high UV levels forced our ancestors into caves, where the images they would normally have painted on more ephemeral surfaces like cliffs or trees were instead preserved for millennia on cave walls. Intriguingly, Neanderthals went extinct just afterwards – around 40,900 years ago. The study's authors suggest the combination of the solar minima and the weakened magnetic field triggered the climate changes and the flow-on effects on humans and animals. "It explains a bunch of patterns around 42,000 years ago that had previously been mysteries," says Cooper.

Thats' part of the reason he and his co-authors propose calling this turbulent transition period at the start of Laschamps the "Adams Event," after Douglas Adams. In the British author's cult *Hitchhiker's Guide to Galaxy* novels, the answer to "Life, the Universe, and Everything" is 42. "The Adams Event appears to represent a major climatic, environmental, and archeological boundary that has previously gone largely unrecognized," the paper's authors write.

The study also suggests that, contrary to the established wisdom, severe geomagnetic and solar events can affect global climate, though the scientists are quick to point out that they don't explain current warming. The prospect opens up a whole new multi-disciplinary field of research, Cooper says. "It gives you a view of a much more changeable planet, and a much more changeable climate system."

The kauri dug up in Ngāwhā was the key to it all—a kind of Rosetta Stone. "It's very unusual to get the Earth's geomagnetic field this low," says Hogg, "and to get such a long-lived tree that grew right through it—we should be doing more with it. This is just the start."

Today, the Ngāwhā kauri lies in three massive pieces in the parking lot of a *marae*—a communal Māori meeting house—in the tiny hamlet for which the tree was named. The kauri trunk sits next to its upright root ball, as if it has just been felled. The ends are sealed with a clear lacquer to keep moisture out of the wood, and its scalloped bark is slowly peeling off to land in curled flakes on the gravel.

When I arrive in May 2020, after New Zealand has relaxed its strict COVID restrictions, Donna Tukariri, a community elder, is waiting for me. She serves on the committee that organized the tree's arrival in Ngāwhā, a small clutch of dwellings with a Māori-language kindergarten and a historic wooden church. "There was a lot of chatter in my dreams at the time that we found it," she tells me. She sensed the tree's confusion—as though it had awakened from a long coma into a changed world. She now considers herself a *kaitiaki*: a guardian of the log. "It felt like it was coming into the right hands," she says.

The energy company that owns the land where the tree was discovered could have sold it for a small fortune. Instead, they decided to give it to the nearby *marae*. The log is in pieces because it was too big to transport whole. Nelson Parker, the sawmiller who first assessed it, cut off the root ball and the crown. It took two cranes to lift the pieces onto semi-trailers for the three-mile trip to this place, winding among low volcanic hills, paddocks and remnants of native bush.

When the tree arrived, elders blessed it in a powerful traditional ceremony, similar to the one performed when dead bodies are brought into the *marae*. Women performed a welcoming *karanga*; and a *tohunga whakairo* (master carver) blessed the log in a mixture of Māori and Christian spirituality.

Tukariri and I walk over to the end of the main trunk, the largest piece. She places her forehead against the cut face, and closes her eyes. Her breath flows over the tiny concentric rings—all 1,600 of them—that record each year of the tree's long life. She's offering a *hongi*, a traditional greeting of respect in her culture. "The *hongi* is the sharing of breath," she says. Although this tree has been dead for so many years, she believes it still has *mauri*, or life essence. "For Māori, everything has life essence, whether it's living or dead."

But kauri is particularly special. Some tribes regard the biggest kauri as the legs of the god of the forest, Tāne Mahuta. Other stories tell of a kinship between kauri and the whale. In one version, they swapped skins, which is why the kauri's bark is "thin and full of resin."

The community is still deciding what to do with the log. According to the agreement with the energy company, the people here are to use it for “Māori cultural purposes.” “That means we can give it away,” Tukariri says. “That would be a normal practice in Māori culture—to share it with others.”

It will likely be cut into smaller pieces and distributed around the wider tribe for carving or other ceremonial purposes, to forge friendships and alliances. But for now, when events are held at the *marae*—meetings, birthdays, funerals—Tukariri encourages people to take some time to commune with their tree.

She suggests I do, too.

“For Maori, everything has life essence, whether it’s living or dead.”

— Donna Tukariri, Māori community elder

It’s late afternoon, and the end of the log glows golden in the low winter light. When I stretch my arms out, I can’t reach all the way across the trunk. The wood is rough and sun-warmed against my cheek and I can smell the spicy, piney scent of its resin.

It feels and smells as if it could have toppled a year ago. Yet when this tree last stood up-right and felt the sunlight on its leaves, Neanderthals and Denisovans still walked the Earth. *Homo sapiens*—still many millennia away from reaching New Zealand—had only recently colonized Europe and begun to make art.

Tukariri is too shy to sing with me beside her, but that’s what she normally does when she comes here. “Just some *waiata* [songs] that I know. It’s similar to when I go and visit my mother’s grave. You sing a song and say, ‘Hey, thinking of you.’ This is the same sort of thing.”

She tears up, moved by this 65-ton long-dead tree that—for Māori and scientists alike—is alive with stories, a messenger from another time.

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Kate Evans is a freelance journalist who lives by the sea in rural New Zealand. She is a contributor to *New Zealand Geographic*, *Scientific American*, and *The Guardian*, and is obsessed with how human lives are entwined with those of plants. Five years ago she planted a kauri tree on her daughter's placenta, a traditional practice for Māori and other New Zealanders. You can follow her on Twitter @kate_g_evans.

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Arno Gasteiger specializes in exploring contemporary issues and presenting them in a thoughtful body of visual work. Since becoming the primary photographer of *New Zealand Geographic* magazine, he has produced more than 100 assignments for the magazine, which has taken him to all parts of New Zealand and the South Pacific. Gasteiger's work has covered subject matter as diverse as the effects of global warming on the Tokelau Islands to the state funeral of Sir Edmund Hillary. He lives with his family in the subtropical rainforest of Titirangi, Auckland.

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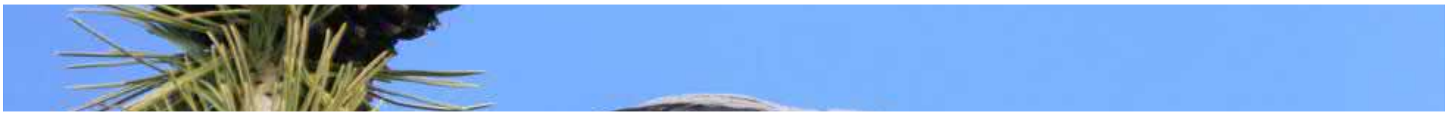

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