The land time forgot. Even during an ice age, Beringia had few glaciers and greenery enough for large game.

Welcome to Beringia

A flurry of studies suggests that instead of being simply a bridge from Asia to the Americas, Beringia may have beckoned the ancestors of the first Americans to linger

ONE SUMMER DAY DURING THE HEIGHT OF the last ice age, a small herd of elk moved through a now-vanished region of lowland above the Arctic Circle, nosing about small woody shrubs like crowberry and Labrador tea. Far to the west lay glacier-capped mountains, and along the plains between, horses, mammoths, and caribou wandered through patches of wildflowers—violet asters, yellow tansies, red burnets. The large animals and other game made good eating for roaming cave lions and cave hyena, as well as this landscape's top predator, humans.

This vision of a land dotted with elk, blooming with wildflowers, and sprinkled with shrubs for firewood is a far cry from traditional views of the ice age north. For decades, researchers considered Beringia—the now partly submerged landmass that once stretched from Siberia's Verkhoyansk Mountains to northern Canada's Mackenzie River (see map, p. 962)—as chiefly a highway. It served as a "land bridge" that large mammals, as well as the ancestors of the first Americans, hurried across on their way from Asia to a new continent.

Now, a flurry of studies, including analyses of seafloor sediments and ancient DNA from plants and animals, are painting a surprising picture of this lost world. They suggest that Beringia, twice the size of Texas, could have been more welcoming than expected during the Last Glacial Maximum (LGM), a period of intensely cold temperatures from about 17,000 to 28,000 years ago. The research "really expands our knowledge of the ecology of Beringia," says archaeologist Michael Waters of Texas A&M University, College Station. And it fits well with one idea about the peopling of the New World, namely that the ancestors of the first Americans holed up in Beringia for 10,000 years during the LGM before continuing into North America.

The findings are far from conclusive, and direct evidence for a long-term human presence in Beringia is scarce. But the results highlight an urgent need to get archaeological teams searching this now partly submerged and remote region, Waters says. "What I'd sure like to see is the archaeological Manhattan Project of Beringia," he says.

Big chill, big pause

Ancient Beringia is lost to us in more ways than one. The mammoths, woolly rhinos, and most other megafauna have vanished, along with most of the glacial-era vegetation that sustained them. And the central Beringian lowlands were drowned some 10,500 years ago, when melting ice raised sea level by about 120 meters. Areas that remain above water are often difficult to reach except by helicopter, so whole chunks of Beringia are terra incognita to archaeologists.

Some of the most compelling hints of a human presence in Beringia have come from the genes of people living thousands

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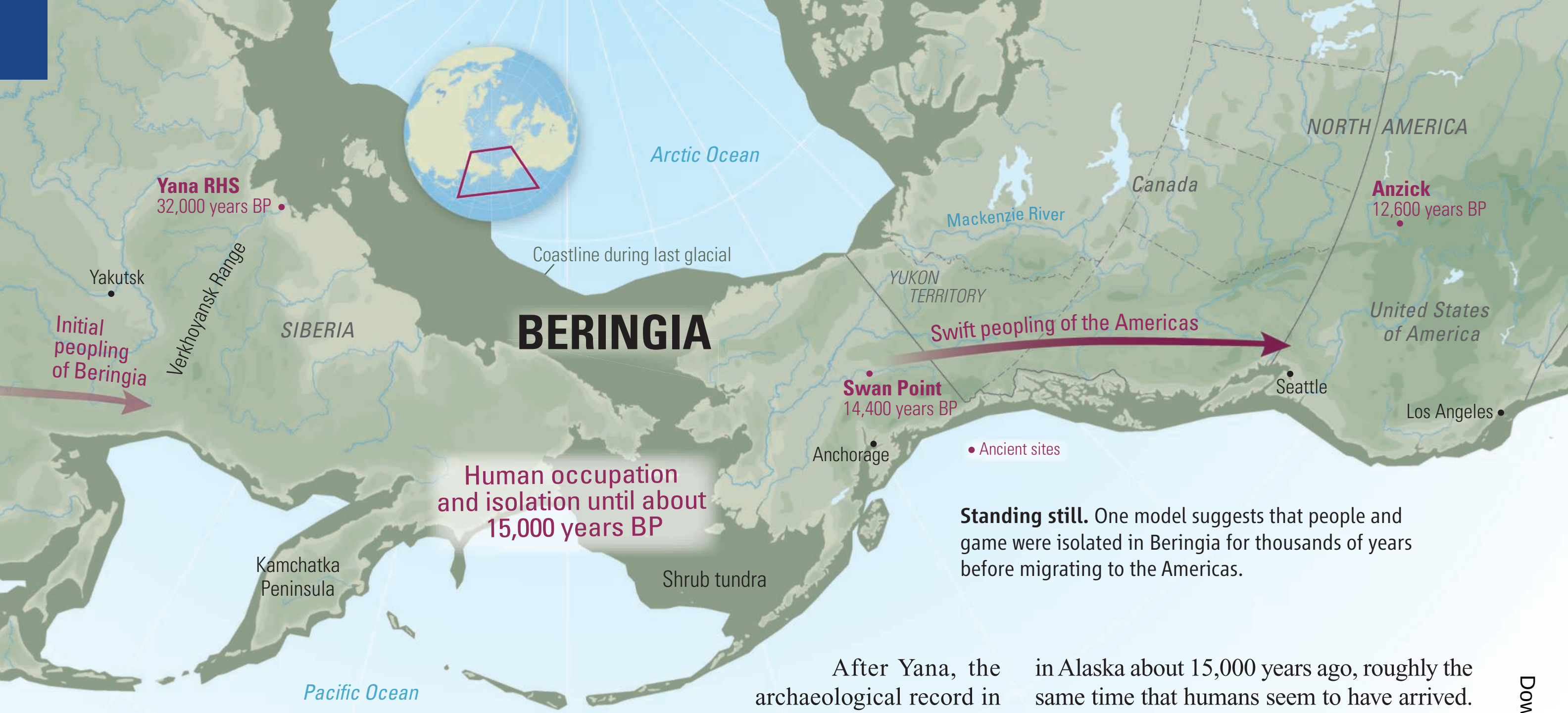

Standing still. One model suggests that people and game were isolated in Beringia for thousands of years before migrating to the Americas.

of miles away. Back in 2007, for example, researchers led by molecular anthropologist Erika Tamm of the Estonian Biocentre in Tartu analyzed mitochondrial DNA from 601 Native Americans and 3764 Asians from geographically diverse populations. The team identified three subclades—C1b, C1c, and C1d—that were widely distributed in Native American groups, but absent in Asians. This pattern, plus a chronology based on mutation rates, strongly suggested that the ancestors of the first Americans were isolated from their Asian kin some 25,000 years ago, diversifying into the C subclades before they entered the Americas some 15,000 years ago.

After analyzing how the genetic signals are distributed geographically, Tamm and her colleagues concluded that the most likely place for this isolation was Beringia. If the ancestors of the Native Americans toughed it out there during the LGM, they would have been well positioned to swiftly people the New World when the cold period ended. Several other analyses of mitochondrial and nuclear DNA have supported this "Beringian standstill" model.

Archaeological evidence for this scenario remains scarce, but some clues come from the Yana RHS locality at 71°N latitude in Beringia's far west in Siberia. This locality, the earliest known in Beringia at 32,000 years old, brimmed with carved ivory ornaments and bone tools such as sewing needles (*Science*, 2 January 2004, p. 52), suggesting a culture well adapted to life in the Arctic interior. Yana's broad-based hunters and foragers appear to have brought down diverse game including steppe bison, reindeer, horses, polar foxes, and birds.

After Yana, the archaeological record in Beringia goes dark. The next site doesn't pop up until 14,400 years ago, at Swan Point, Alaska. Like Yana's occupants, the earliest Alaskans were broad-based hunter-gatherers, targeting everything from horses to hares.

Given the spotty archaeological record, most archaeologists remained skeptical that people occupied northern Beringia throughout the brutally cold LGM. Most of the region escaped glaciation because of its largely arid climate, but winters averaged about 8°C colder than today. "Beringia seemed the last place on Earth that you would put a large population during one of the coldest periods in history," says archaeologist John Hoffecker of the University of Colorado, Boulder.

Light my fire. Woody plants in Beringia's shrub tundra may have supplied firewood and tools for humans.

In search of new clues, a team led by molecular biologists Meirav Meiri of Tel Aviv University and Ian Barnes of the Natural History Museum in London examined another Asian immigrant that passed through Beringia on its way to the New World: the elk, or wapiti (*Cervus elaphus canadensis*). Previous studies had suggested that these temperate and boreal forest dwellers first appeared in Alaska about 15,000 years ago, roughly the same time that humans seem to have arrived. Meiri and Barnes hypothesized that as temperatures rose, the elk swiftly barreled across Beringia and into the Americas.

To test the idea, they collected 113 bone, antler, and teeth samples from ancient elk in museums and 74 specimens from modern elk across North America and Asia. After dating and sequencing most of the samples, they found what Barnes calls an "astonishing" picture, very different from what they had expected, as reported in the 7 February issue of the *Proceedings of the Royal Society B*.

The radiocarbon dates and locality data indicate that elk had pushed into northwestern Beringia by at least 50,000 years ago, but didn't advance into North America until 15,200 years ago. Barnes and colleagues were so surprised that they analyzed hydrogen and oxygen isotopes from the Siberian specimens to double-check the locality data supplied by the museums. (The water and food the elk ingested influenced the isotopes in their bones, and can be used to trace the latitude where the animals lived.) The results confirmed the samples' Arctic origins. The researchers also used DNA data to estimate elk population size, which apparently declined during the LGM. But there was no sign that the population had been wiped out and later replaced.

If the elk stood still in Beringia, perhaps humans did, too. The elk data suggest that humans could have been present in northwestern Beringia "much earlier and longer than we thought," Barnes says. Elk and humans may have migrated into the Americas together, he adds. Some of the oldest known artifacts in North America—13,000-year-old rods buried with Clovis tools and human

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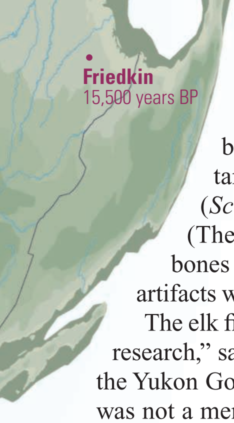

bones at the Anzick site in Montana—are made from elk antler (*Science*, 14 February, p. 716). (The rods are even older than the bones at the site, suggesting that the artifacts were heirlooms when buried.)

The elk findings are "an elegant piece of research," says archaeologist Greg Hare of the Yukon Government in Whitehorse, who was not a member of the team. Hare thinks both elk and humans could have survived in parts of Beringia during the LGM "as long as they had enough to eat."

Early adapters. Denizens of temperate and boreal forests today, elk survived ice age cold in Beringia.

Arctic refuge

The humans could have eaten the elk and any other game. But what were elk and other large herbivores eating? Previous pollen studies of Beringia's vegetation revealed mostly grasses. But grasses make more pollen than other types of plants do, so pollen studies may give a biased view.

To get a more complete picture, an international team led by geneticist Eske Willerslev of the University of Copenhagen used a new technique: They extracted bulk DNA from 18 Beringian permafrost sites and used primers to fish out and sequence fragments of ancient DNA from plants. As they reported in *Nature* this month, their samples spanned the past 50,000 years and came from Beringia and other parts of the Eurasian Arctic. To find out what the megafauna ate, the team also sequenced the gut contents and coprolites of woolly mammoths, woolly rhinoceros, a horse, and a bison.

The data held "a number of surprises," Willerslev says. Broad-leafed herbaceous plants called forbs, including species of thyme, vetch, and anemone, dominated the samples, even during the LGM. More than 60% of the DNA in the giant mammals' guts and poop was from forbs, and these flowering plants may have helped the megafauna survive. Forbs are rich in protein, and "promote easy digestion, so maybe the megafauna were [choosing] the forbs," says Yukon government paleontologist Grant Zazula in Whitehorse, a member of the team.

Willerslev's samples came from areas of Beringia still on dry land. But pollen from what is now the sea floor suggests that different vegetation may have cloaked the lowlands, which would have been slightly warmer and moister than other areas. Pollen from a sediment core drilled near the coast of the central Beringian lowland shows that some trees and shrubs—including spruce, birch, and alder—survived the LGM, as graduate student Rachel Westbrook of the University of Alaska, Fairbanks, and colleagues reported at a 2012 meeting of the Geological Society of America. Pollen, plant, and insect records from other seafloor cores suggest a similar picture.

The now-drowned part of central Beringia was likely covered with shrub tundra—a form of tundra dominated by small woody plants and sprinkled with other vegetation including forbs—according to a Perspective by Hoffecker and colleagues on page 979 of this issue. Hoffecker adds that the woody shrubs, including dwarf birch, dwarf willow, and crowberry, could have been sources of valuable firewood for Beringian hunter-gatherers, helping them survive the ice age cold. Archaeological evidence shows that later indigenous peoples of both Alaska and Northeast Asia often fed their fires with fresh bone, which burns hot and fast, but they also added small quantities of wood. The wood makes the bone easier to ignite and the flames last longer, as shown in experiments reported in 2001 by archaeologist Isabelle Théry-Parisot of CNRS, the French national research agency.

Arctic toolkit. Humans made bone tools as early as 32,000 years ago at Yana RHS in Siberia.

There's no data on whether elk lived in the now-submerged Beringian lowlands, but Hoffecker suspects they might have, noting that wapiti are versatile grazers and browsers. With game to hunt and fuel for fires, "central Beringia could have been a magnet for people during that intense cold period," he says. He, too, thinks Beringia is the most plausible location for the geneticists' standstill model. It "not only gives people the resources to survive, but it's a place that was isolated from everywhere else during the Last Glacial Maximum," he says. Pollen records show that the shrub tundra expanded eastward into Alaska and the Yukon after about 16,000 years ago. Both elk and people could have followed the shifting vegetation into the New World.

Barnes sees a slightly different story in the elk data. Rather than central Beringia being a magnet that caused species to linger, he thinks it was the site of some kind of ecological barrier that kept elk and possibly people in western Beringia—and out of the Americas—during the LGM. "It seems that the land bridge is closed for business before 15,000 years ago, and that humans were affected as well," he says.

Finding out whether central Beringia was refuge or barrier and searching northeastern Siberia's wilderness for traces of ice age Beringian hunters will require a multidisciplinary approach. "Right now we have three stories that have been developing independently in the fields of archaeology, genetics, and paleoecology," says Hoffecker, who's organizing an interdisciplinary workshop on the Beringian standstill to be held in Colorado in the fall. "Now we have to bring the stories together." **–HEATHER PRINGLE**

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