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The Future of Forests

Our species' origin and destiny are entangled with the roots and branches of trees. We evolved in and around trees, and we've learned to breed and plant them for their fruit, nuts, wood, and blossoms, taking their seeds with us as we migrated—hence the English walnut, native to Persia, and the Georgia peach, native to China. It's a relationship that has carried us around the globe, often in boats or carts made from trees.

While human communities have benefitted immensely from trees, tree communities (i.e., forests) haven't always fared so well in the bargain. In this article, we'll trace the ups and downs of this relationship and inquire why it has grown more one-sidedly abusive in recent decades. Unsurprisingly, many recent challenges to the health of forests have emerged because of climate change—even as forests are proving to be one of the planet's primary climate-stabilizing systems.

Finally, we'll explore what we can do to defend and restore forests in the face of global warming and other threats. Along the way, we'll dip into some of the most intriguing recent scientific findings about trees and forests.

The Ghosts of Forests Past

During recent millennia, the world's forests have changed in size, composition, and sometimes location. Consider central Europe: During glacial times, the region was mostly treeless; but starting about 10,000 years ago, with higher temperatures and melting ice came the flourishing of dense oak, lime, and hazel forests, forming a mosaic pattern across the landscape. During this period, human settlements gradually expanded, adding farms, gardens, and pastures to the mosaic. As centuries passed, and as agriculture and metal smelting proliferated, more trees were cut for wood, for fuel, and to clear land for planting annual crops and for pasturing animals. Forests contracted and sometimes expanded according to human priorities. However, by the 16th century, holznot (German for "wood shortage") had become a persistent problem—one that contributed to the widespread adoption of coal and, later, other fossil fuels. Today the ancient central European forest is nearly gone, and its remnants are under threat.

North America saw a similar evolution. In 1800, the region of what is now the southeastern United States was covered by a vast, 93-million-acre expanse of old-growth longleaf pine stretching from Virginia to Texas.

This arboreal ecosystem had been carefully tended for centuries by Native peoples, who used managed burning to create clearings among towering, fire-adapted trees. Early explorers recorded extraordinary plant and animal biodiversity in a dense, mature silvan landscape. But by 1820 the forest was facing rapid clearing for settlement, agriculture, and roads, a process that accelerated greatly with the advent of steam locomotives, which initially burned wood for fuel while also lugging timber to distant cities.

Altogether, nearly one-third of the world's forests have been lost over the last 10,000 years, with forest cover on habitable land shrinking from 57 percent to 38 percent (forests formerly covered 40 percent of Earth's total land surface, while today they cover 30 percent). The pace of loss accelerated greatly in the last century, with half of all historic deforestation occurring after 1900.

Although global deforestation rates peaked in the 1980s and later slowed, they remain high, especially in tropical regions, due to logging and agriculture. But, in the current century, a new threat is emerging that could result in the loss of over half the area of the world's remaining forests by 2100 from wildfire, drought, flood, and heat stress.

Forests as Climate Victims

Recent research suggests that climate change will have a range of impacts on forests, most of them destructive. It's widely understood that tree species that have adapted to conditions prevalent over the past few thousand years will need to migrate toward the poles to thrive in a warmer world. However, forests are lagging up to 200 years behind the necessary rate of migration, raising the prospect of widespread forest collapse. Further, the composition of most forests is shifting toward faster-growing, less resilient tree species.

A 2020 study showed that forests are becoming younger and shorter—largely due to the climate crisis but also to the human introduction of non-native trees—and this is reducing their overall carbon storage capacity. They're also becoming simpler, populated by fewer species. Unfortunately, the species that appear to be losing out are ones that grow more slowly and anchor forest ecosystems, supporting diverse webs of life—especially in the tropics, where biodiversity is highest.

When fast-growing trees dominate a forest, storms, drought, and pests can cause more damage. Slower-growing, long-lived trees often have deeper roots, sturdier trunks, and denser wood that help forests resist drought and pests. Further, pollinator insects, birds, and mammals are often adapted to slow-growing trees.

Finally, due to climate change and shifts in forest composition, wildfires are getting worse, currently burning more than twice as much tree cover annually as they did 20 years ago. Carbon emissions from forest fires increased by 60 percent globally between 2001 and 2023, with boreal forest emissions nearly tripling, according to NASA research. Particularly in the tropics, forests are facing tipping points where they may become carbon sources rather than sinks due not just to wildfires but also intensified droughts and reduced soil carbon stability.

Forests as Climate Heroes

As all this is happening, we are learning more about forests' role in stabilizing the global climate. Trees provide shade, cool the local environment through transpiration, moderate global water cycles, and remove carbon from the atmosphere. Through these four benefits, forests offer perhaps our best realistic hope for minimizing the climate crisis.

You've surely noticed that it's cooler to sit under a tree than to stand in blazing sunlight. That's why cities with more trees enjoy lower surface temperatures in summer months. Forests provide the same service on a vast scale, and as forests are cut, local surface temperatures rise significantly.

Forests also cool the land through transpiration. Trees draw water from the soil up to their leaves, where it evaporates. Much of the energy needed to evaporate the water comes from heat in the air; as that heat energy is transferred to water, the air cools. This is the same mechanism that makes you feel colder when you step out of a pool.

A single tree in a tropical forest can cool local land and air equivalent to the work of two household air conditioners, evaporating up to 150 gallons of water per day. Forest canopies cover a large surface area, which can evaporate millions or billions of gallons a day. When forests in tropical regions are cut down, this evaporative cooling stops, and the land surface warms. This is happening with the enormous Amazon rainforest, and the consequences will be global. Borneo is seeing a similar pattern. In 2018, researchers surveyed people in 477 villages, and found that the villagers clearly understand that deforestation on the island is resulting in hotter temperatures that threaten the health of their families.

With all that evaporation going on, you might think forests would have a net drying effect on the surrounding land. But the opposite is true. Forests create their own rain and fog, regulating water cycles to keep soils moist year-round. Meanwhile, tree roots minimize erosion and provide habitat for beneficial soil organisms. Forests reduce weather extremes (including droughts and floods) and maintain conditions that benefit not only trees themselves, but the entire web of life in sylvan ecosystems.

Trees also remove carbon and store it in their roots, trunks, branches, and leaves. Altogether, the world's forests store roughly 860 billion tons of carbon in their biomass, deadwood, litter, and soil. As a critical carbon sink, they actively absorb a net 7.6 billion tons of CO_2 annually—about 1.5 times more than the United States emits each year.

The authors of a recent meta-study offered this summary:

> "The substantial body of research we review reveals that forest, water, and energy interactions provide the foundations for carbon storage, for cooling terrestrial surfaces, and for distributing water resources. Forests and trees must be recognized as prime regulators within the water, energy, and carbon cycles."

The Intelligence and Resilience of Trees

As we're learning more about the vital role trees play in maintaining stable, habitable environments, we're also beginning to appreciate trees' intelligence, sociality, and resilience. Research reveals that trees form complex, interdependent networks that enable them to both cooperate and compete.

While some scientists maintain that "intelligence" implies conscious thought in brains—which plants, of course, don't have—Canadian forestry scientist Suzanne Simard argues that the complex, agency-driven behavior of trees constitutes a form of intelligence. Trees express this intelligence through communication, memory, and resource sharing.

Trees communicate both below and above the ground. Under the soil surface, they connect their roots via fungi, allowing them to share nutrients. Research suggests this network (the "Wood Wide Web") can, in some cases, transfer nutrients from older "mother trees" to younger seedlings. Trees also send chemical and electrical signals root-to-root, prompting neighbors to prepare for threats like disease or drought. Above ground, trees release volatile organic compounds (VOCs) into the air when attacked by pests such as caterpillars, signaling nearby trees to strengthen their defenses by producing tannic or phenolic compounds.

In addition to communicating, trees sense their environments in ways we're just beginning to understand. Recent studies suggest trees can react to the sound of running water or the vibrations of pollinator wings. Simard and German forester and author Peter Wohlleben posit that trees can learn from past experiences, such as droughts, and make decisions about resource allocation. Dying trees even seem to know the future: before they expire, they warn their offspring to start making new root connections.

Much of this recent forest research focuses on the role of large, old trees acting as hubs in arboreal networks, nurturing young trees and maintaining forest stability. Simard contends that mother trees are anchors of forest communities, and are remembered by other trees after they die.

What We Can Do for a Forested Future

The intelligence of trees creates and maintains resilient arboreal communities. If we humans are to survive, we must similarly build and restore our own resilient communities. We can learn from trees as we continue to benefit from them. But for that to happen, humanity must begin treating the forest as more than just a monetarily valuable resource.

Given the current accelerating rate of destruction, our top priority must be to defend native forests and the mother trees that anchor them. Globally, the most dedicated forest defenders are Indigenous peoples, who according to some estimates currently protect 80 percent of the world's biodiversity. In the Brazilian Amazon, Indigenous communities' efforts to assert collective land rights have reduced deforestation by 66 percent. In Sumatra, Farwiza Farhan (co-founder of HAkA, an NGO protecting the Leuser Ecosystem) has confronted illegal palm oil companies to protect old-growth forests. In Zambia, Honorary Forest Officers (HFO) protect the Imanda mushitu forest from illegal logging and inspire the next generation of conservationists. In Nigeria, Forest Guards risk their safety to stop poachers and loggers, offering a first line of defense against forest destruction.

Beyond forest defense, our next priority must be reforestation. While major global reforestation projects like Africa's 8,000km Great Green Wall and the Bonn Challenge (aiming to restore 350 million hectares) attract significant funding, community-driven efforts in the Amazon, Madagascar, and Indonesia often achieve their goals with lower cost; such efforts depend on the work of dedicated campaigners like Leah Namugerwa of Uganda, a youth climate activist.

However, it's essential to consider *where* we should be planting trees in a warming world. This can start with forecasting the likely future climate regime for areas targeted for reforestation efforts and then planting trees that will thrive in that climate; in effect, helping forests migrate. A 2026 study found that strategic planting with future climate considered, such as in Canada's boreal forest edge, could significantly boost carbon removal.

More thought must also be given to the kinds of trees being planted. Commercially driven reforestation efforts often focus on fast-growing species that yield straight, easily milled timber. However, this results not in a forest ecosystem but in a tree plantation. In recent decades, tree plantations have been growing in total acreage while native forests have been shrinking, though native forests are far better for climate change remediation and maintenance of biodiversity. We should be planting more slow-growing native trees, in mixed patterns that reproduce healthy, self-sustaining ecosystems—and *that* requires creating habitat for animal species that have evolved with native forests. Like all other organisms, trees depend on relationships: with other plant species, and with pollinators and seed spreaders. Holistic reforestation programs in Nevada, Oregon, and Idaho, as well as proponents of "mini-forests," are taking steps in this direction.

In 2023, about 84 billion dollars were spent globally on reforestation and forest protection. This year, roughly 700 billion dollars are likely to be spent just on AI data centers. Humanity would get by just fine without AI, as we have done for 99.999 percent of our history. But without trees, humans may not persist.

The future of forests and that of humanity will be intertwined, like our pasts. The decisive question facing us is: Will it be a balanced relationship that can endure, or an extractive one doomed to failure?