

**TIMES
EVOKE**

DISCOVER THE RAINFOREST

Names can be extravagant things — but not in the case of rainforests which truly live up to their moniker. These are the world's oldest living ecosystem, some as ancient as 70 million years. Composed of incredible interwoven tapestries of plants, animals and birds, rainforests house over half of the world's biodiversity. The WWF estimates that a 10-kilometre patch can hold 1,500 flowering plants, 750 different trees, 400 species of birds and 150 types of butterflies, with more kinds of ants on one tree than found in entire countries.

While rainforests hum with this grand richness of life, they also work as scientific motors of our environment. Both tropical ones, like the Amazon in South America, and temperate ones, like North America's Pacific Northwest, produce 20% of Earth's oxygen while the World Economic Forum finds rainforests absorb one-third of CO₂ emissions annually. Through evotranspiration, they add moisture to air, the Amazon alone releasing 20 billion tonnes of water daily. This nudges rain, with over 50% of showers on a rainforest returned to the atmosphere, regulating rainfall — the World Bank finds the Amazon delivers rain as far as Argentina — worldwide. Rainforests store water patiently, the Amazon itself holding one-fifth of the world's freshwater.

These forests full of miracles are now endangered. The FAO finds that while deforestation slowed by 30% between 2010 to 2018, the greatest losses occurred in rainforests which face razing for livestock, logging and agriculture. Since the 1960s, the WEF reports, half of the world's rainforests have been destroyed, with 2,00,000 acres lost daily — this ecosystem has now shrunk to just 6% of Earth. Destroying rainforests is spinning a dangerous feedback loop, releasing CO₂, increasing temperatures and dryness, scientists fearing desertified savannahs where once lush life prevailed. However, the rainforest — and life itself — can still be saved. As Times Evoke's global experts emphasise, multiple methods, from sustainable agroforestry to limiting forest fragmentation and halting defaunation, can preserve these entities. The rainforest symbolises interlaced life and intellectual discovery — a 'new' plant or animal is found in the Amazon every three days. Join Times Evoke on a journey to the rainforest, Earth's great gift of life's renewal and discovery.

'Rainforests create moisture, clouds and store water — human life is embedded in them'

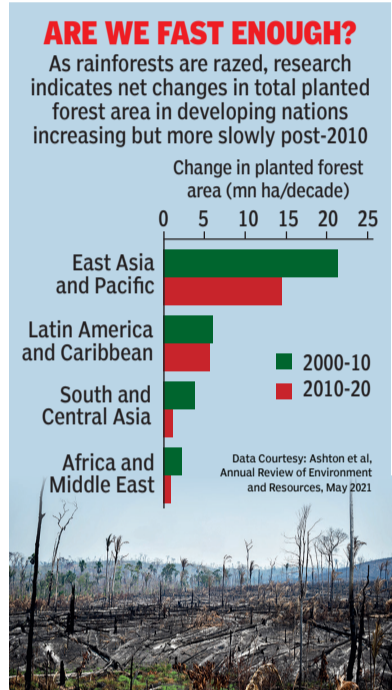
Mark Ashton teaches forest ecology at Yale University. Speaking to Srijana Mitra Das at Times Evoke, he discusses why rainforests are unique — and ways to preserve them:

What is the core of your research?
I work on understanding the dynamics of native forests, particularly disturbance dynamics, and how native forests recover after disturbance. I apply these principles to the restoration, reforestation and sustainable management of forests.

What processes create a forest ecosystem, as opposed to a planted collection of trees?
A forest is not just trees or plants — all the interactions between trees, mushrooms, birds, insects and many different trophic food webs make up what we call a forest ecosystem. A forest is a huge canvas of interactions between organisms, all embedded in the structure of trees.



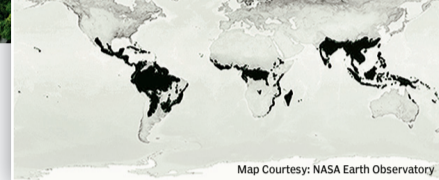
What are some special characteristics of tropical wet forests or rainforests?
Tropical rainforests, compared to temperate, boreal or other kinds, are much more diverse in the interactions of forest life — the climate promotes continuous growth. There is little seasonality in



MAGIC PLACES

Rainforests receive the most rain of all biomes on Earth — these are tropical and temperate, the former close to the equator and the latter near cooler, coastal areas north or south of the equator. The Amazon (below) is the world's largest rainforest, spread over 6.7 million kilometres, home to 10% of Earth's biodiversity

Where They Grow



rainforests — in the Western Ghats or northeast India, for instance, you get much lower seasonality, high rainfall and a relatively short dry period — these climates allow for continuous, complex interactions between all the life embedded in the tree structure. This makes these so richly biodiverse — these organisms have been undergoing these interactions, and the resultant growth, for millions of years. In other forests, these interactions get interrupted by dry seasons and temperature changes.

THE WATER SYMPHONY

How do rainforests generate rain?
They do so, depending on their scale and topography. Very large rainforests, such as in the Amazon or Congo, create their own precipitation by the sheer evapotranspiration they carry out — they take water up from their roots and transpire it out of their leaves, which then moves into the atmosphere where re-precipitation or new rainfall occurs downstream. In the Amazon, these rainforests moderate the dry season by creating convective sources of precipitation. Such large rainforests are also important moderators of global climate — their evapotranspiration creates clouds, another source of precipitation. More

clouds increase albedo above themselves — a lot of solar radiation is reflected back into the upper atmosphere. So, more clouds bring shade and more moderated temperatures.

The relationship between rainforests and water is very deep. Villagers often say how, during the dry season, forests provide sources of spring water. This is true as most source precipitation happens during the wet season and is related to changes in the air and differential effects in the land-sea margin. The monsoon is influenced by the land-sea margin of the Indian Ocean — however, once this falls on a forest, a great deal of water stays within it. The forest's deep roots take up far more water than a grassland. There is deep infiltration of that water into much farther horizons of the soil. So, when the dry season starts, the forest can yield water into streams since this has been safely stored deep in Earth.

Are rainforests valued enough?
All forests are extremely undervalued

for what they provide humanity. We value and over-exploit them for their goods like timber, rubber, medicines and crops like tea and coffee, originally understorey tree crops in forests, now grown in plantations. But we don't recognise all the other amazing features of forests, like climate regulation and downstream agriculture — to have drinking water in the dry season, you need forests. In the US, Boston, New York, Washington, San Francisco and Seattle are completely dependent on intact forested watersheds for their drinking water supplies. The rain falls on these forests, they act as filters, clean pollutants like heavy metals which get sequestered in the living biomass and the water moves through the soil into streams, reaching reservoirs.

Can we have both rainforests and growth?
My colleagues and I have worked on tropical forest restoration for years which designs around the principles of how natural forests grow and then plant or facilitate such natural regrowth — importantly this always factors in the needs and values of local communities, which involves restoring forests that can provide sources of income from mixed cropping, cultivating fishmeal palm, rattan, cardamom, medicinal vines, etc. These crops can also create artificial analogues that allow for the same interactions a tropical rainforest has. We have done this over decades in Brazil, Panama, parts of India, Sri Lanka, the near tropics and the Himalayas. All forests are beautiful and driven by ancient bio-geographies and cultures. Western traditions of industrialisation made people think of forests as separate from us but there is actually a huge and intimate relationship between humans and forests. Our lives are deeply embedded within forests — if they thrive, so do we.



THE CAPE OF CLOUDS: Rainforests help generate clouds which, with the albedo effect, reflect solar radiation back into the upper atmosphere — this creates more shade and a cooler temperature on Earth

THE AMAZON'S STORY

- In 1541, Spanish explorer Francisco de Orellana set off to find El Dorado, a mythical city of gold. As he went down the Rio Napo by boat, de Orellana found a harsh jungle with fierce indigenous tribes. Emerging in the Atlantic in 1542, he returned to Spain with tales of fearless tribes, like the Amazons of Greek mythology — the region was thus named
- In the 17th century, the chincona plant — derivative of malarial treatments — was discovered in the Amazon. Naturalists also found the Brazil nut tree, which can live up to 1,000 years, teak and mahogany. Scientists estimate that 70% of plants useful in cancer treatments are found in rainforests — currently, less than 1% of rainforest species have been analysed for their medicinal value
- Explorers admired the waterproof bags indigenous Amazonians made from rubber tree sap — when Charles Goodyear invented vulcanization, making rubber more durable, the demand for Amazonian rubber rose. As the first pneumatic rubber tyres released in 1890, plantations began to spread
- The exploration of the Amazon yielded amazing goods — but it also decimated indigenous populations. Facing explorers, invaders and diseases, over 90% of the indigenous Amazonian population was wiped out — their territories still protect 80% of the world's biodiversity

Research: Encyclopaedia Britannica, Smithsonian Magazine, Scientific American

THEIR HOME IN PARADISE

The toucan is one of South America's most iconic species, which grows 25 inches long and whose bill is about half its length. The toucan lives high up in the canopies of rainforests, nesting within tree cavities — noisy, cheery birds known for their distinctive grunts, the toucan now faces hunters from the pet trade, its vibrant appearance and intelligence making it vulnerable to 'bird lovers'

Endemic to Brazil's Amazon, the golden lion tamarin lives in a rainforest's closed canopy, often remaining 100 feet off the ground and sleeping inside tree hollows. Named for its flame-coloured lion-like mane, the tamarin forages for fruits and insects between branches — it is an important disperser of seeds but with deforestation for logging and agriculture, only 2%-3% of its original habitat remains

The pink river dolphin lives in the rainforest-edged river basins of Bolivia, Colombia, Ecuador, Guyana, Peru, Brazil and Venezuela — the population of this dolphin, which communicates through whistling tunes in the water, is now halving every decade as poachers hunt it for its fatty blubber while pollution and dams threaten its habitat further, endangering this roseate being

'Rainforest defaunation is huge — these species are key'

Rodolfo Dirzo teaches environmental science at Stanford University. He tells Times Evoke about 'defaunation' — and reviving rainforest fauna:

I am an evolutionary ecologist — I study the evolution of plants, animals and microorganisms on Earth. However, as I completed my PhD, I realised the destruction of ecosystems worldwide was becoming so intense, learning about the conservation of nature was crucial even to understand how life works. So, I combined my interests in evolution, or the amazing interactions created over time between plants, animals and microorganisms, with how these are being modified by human impacts now.



WILL YOU BE MY FRIEND? A red-eyed tree frog, *Agalychnis callidrias*, which helps control algae and the spread of pathogens, wanders about us from its home deep inside the Costa Rican rainforest

loss of forests. But that doesn't let us see the full impacts and implications of the

FAUNA MATTERS

loss of animal life. We hope 'defaunation' will help citizens and policy makers measure the magnitude of this loss. The scale is massive. In the Brazilian Amazon, the most diverse rainforest on Earth, researchers have found we are losing 40 million vertebrates — monkeys, birds, deer — to hunting and poaching each year. Compiling data from the world's rainforests, we found this trend consistent. We then added deforestation or the loss of habitat and the numbers rose even more. These numbers hide other numbers — when monkeys are removed from a rainforest, they could be mothers or fathers of baby monkeys. The latter cannot survive without their parents. Removing animals therefore has cascading consequences. The rate of decline of vertebrates alone has been staggering — over the last four decades, these animals have shrunk by 30%. Tropical defaunation is at an approximately 50% rate of decline

over the last 40 years — human impacts have halved these animals. We once had a panorama of life on Earth. This faces very serious problems now. But there are solutions too. The first step is to spread awareness of defaunation and why this matters so much, exacerbating climate change with the loss of plants. Scientists and ecologists must engage the global public to stop the destruction of habitats, which is the biggest driver of biodiversity loss. We must protect what's left and try to rejuvenate where we can. Reforestation is possible — we can successfully return animals via rewilding and translocation to the homes they have lost. They will help revive vital ecosystem processes and control rodents that carry dangerous pathogens. It is also very important to respect the knowledge of indigenous societies. These have conserved viable forestry and sustainable agriculture through diversified land use, mosaics of agriculture, agri-pastoral and forest management systems that save biodiversity. As rainforests show, fauna supports flora which supports Earth — to sustain our planet, reforestation is key.

'Community evolves slowly in rainforests like India's Kudremukh and Silent Valley'

Meghna Krishnadas is a senior scientist at the CSIR Centre for Cellular and Molecular Biology (CCMB), India. Speaking to Times Evoke, she explains what drives the diversity of a rainforest community:

I am fundamentally a community ecologist — I study how species get together to form a community. When you walk into a forest, you won't see just one species of trees, you'll see many. Part of my research explores why so many diverse kinds of trees exist there and why one species doesn't dominate.

There is incredible diversity in a forest ecosystem — tropical rainforests in South America or Southeast Asia could have 800 to 1,000 different species in one hectare alone. This varies, depending on the history of how species evolved over time and climate. There will be different levels of diversity between a forest in India, Borneo or Panama — but many of the processes that maintain such diversity remain the same. As a scientist, I am very interested in these. Some processes include the 'niche' of the species or the resources they use. Trees are relatively simple creatures — they need light, water and some nutrients. The question is, do all species use these resources at the same level? The answer is no — therein lies



THE SEEDS OF TIME: CCMB scientists plant, tend and study rainforest species



BETWEEN EARTH AND SKY: India has lush rainforests in the Western Ghats (above)

one explanation of how so many different species can coexist. Some species have grown to do well in bright sunshine, some thrive where the forest is really dark and some like dappled sunshine. In complex ecosystems like tropical rainforests, these differences play a large role in preventing any one species from becoming dominant. Even these simple dimensions of light, water and soil nutrients can lead to species differentiating along an available space. This happens over time — in one year, one species does very well, in another year, another thrives. So, when you walk into a forest, you see the result of processes that have played out over decades at least, if not millions of years.

Another key role in enabling diversity is played by the small organisms that eat plants and regulate which trees manage to produce more progeny or seedlings. A tree makes lots of seeds and many get eaten or carried far away — but many also fall right under the parent tree and sit there, facing

'natural enemies' or insects and fungi that eat these. Disease-causing pathogens also increase where there are large gatherings of seedlings. But while those seedlings become vulnerable thus and are often cleared out by predators, other species can then come in and establish themselves in that space. If you scale this up through time, you'll see any species of older, more abundant tree offers more opportunity to its natural enemies. This explains why abundant species at times tend to experience a decline in their population, compared to a rare species, whose seedlings can more easily escape its enemies. This interaction between plants, insects and fungi also plays a critical role in ensuring that no one species becomes dominant and a community is upheld.

Scientists are now investigating whether human actions are impacting these complex interactions. Some effects are visible in a 'human-modified forest' — once a very large place, which has now been chopped up into

smaller pieces for agriculture, roads or logging. Anthropogenic impacts on how plants interact with their natural enemies are more visible near forest edges as compared to interiors. One of my Masters students recently published research comparing the ability of rodents like porcupines and wild rats to eat seeds in an impacted fragment versus a less disturbed forest — the research shows how their ability to do so increases in the former, which has implications for the future of plant communities.

The preservation of rainforests is vital, given their enormous importance in Earth's biogeography. These are also sanctuaries of nature's evolutionary history. I've been very moved by the Silent Valley national park in Kerala which has a rich conservation history, a people's movement stopping a dam and creating a



THE UNDERSTORY HAS A STORY: The undergrowth in a rainforest tells a fascinating tale of evolution and survival

national park there. I also love the Kudremukh national park in Karnataka, one of the first rainforests I saw in the Western Ghats. It has beautiful, diverse systems, rainforests below, grasslands and sholas in the upper regions. These places make you realise the dazzling diversity of a rainforest community — and how important it is to protect this.

READERS WRITE

Dear Times Evoke,
I look forward to TE dearly every Saturday! The beautiful Galapagos Islands page (25th June) was mind-blowing. I felt like I had been transported there simply by reading all the amazing articles in TE!
—Vijashree Sivasamy, Nilgiris

Just reading about the Galapagos filled me with pure bliss. Its giant tortoises are an inspiration for living peacefully. This unique page was the best treat for a weekend morning!
—R. Gupte, Mumbai

TE's articles on Galapagos were mesmerising. It was so interesting to read about all the different species, from giant daisies to marine iguanas!
—Delfiya George, Chandigarh

TOI has proved you can travel without leaving your house! Stunning TE took us to wondrous Galapagos where we met blue-footed birds to 60-foot daisies!
—Mrinalini Sen, Kolkata

Fabulous Times Evoke gives me unique knowledge. I loved how Adalgisa Caccione explained the Galapagos giant tortoise is an ecosystem engineer!
—Rohan Baxi, Class 8, Bhubaneswar

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