Global warming adds to forest stress

Climate change and the pressure on tropical forests

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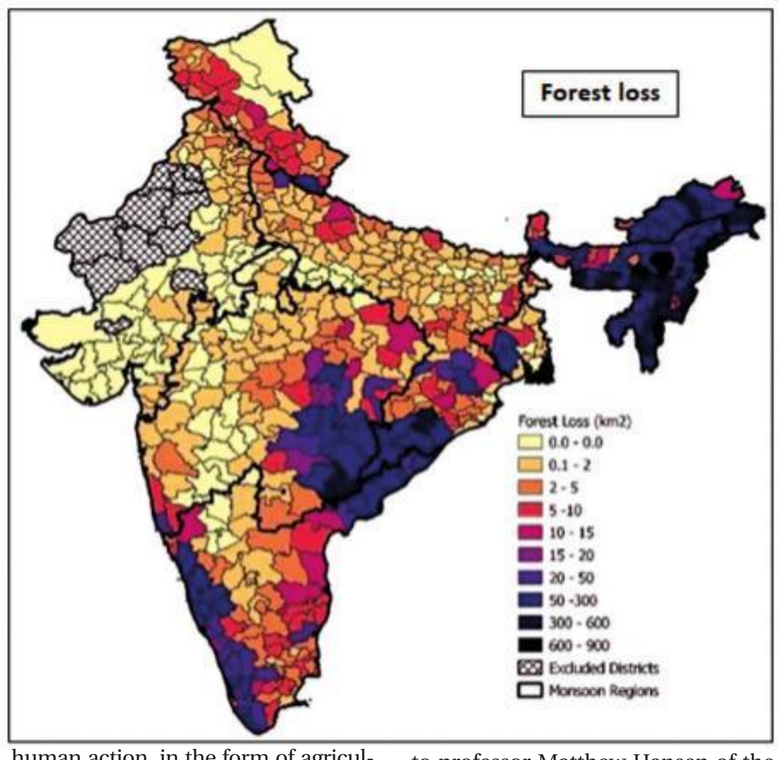
Forest cover is dwindling in the face of human encroachment. Is climate change a silent agent that does as much to cause forests to die out?

Alice E Haughan, Nathalie Pettorelli, Simon G Potts and Deepa Senapathi, from the University of Reading, United Kingdom, and the Zoological Society of London, describe in the journal, *Global Change Biology*, a first, comprehensive study of forests in India, from 2001 to 2018. "Understanding the different regional and seasonal relationships between climatic conditions and forest distributions will be key to effective protection of the country's remaining forests as climate change accelerates," the study says.

And in the same week, the journal *Science* reports a study that compares the efficacy of reforestation, in the form of tree plantation, that the plantations hope to replace, with the value of natural forests. Fangyuan Hua, L Adrian Bruijnzeel, Paula Meli, Phillip A Martin, Jun Zhang, Shinichi Nakagawa, Xinran Miao, Weiyi Wang, Christopher McEvoy, Jorge Luis Peña-Arancibia, Pedro H S Brancalion, Pete Smith, David P Edwards, Andrew Balmford, from Peking and Yunnan Universities, the Universities of Cambridge, Sao Paulo, New South Wales, Aberdeen, Sheffield and La Fontera, in Chile, and King's College, London, find that in respect of carbon storage, water provisioning, soil erosion control and biodiversity, younger plantations perform poorly, in comparison to native and naturally regenerated forests.

The group writing in *Global Change Biology* notes that it is direct human action, in the form of agricultural expansion and deforestation, that have been studied as the reason for the alarming decline of tropical forests in India during the last century. As for climate change, although things like global warming, drought and floods are rising and are projected to rise, the potential of climate change in affecting the productivity of forests has not been studied. While changes in land use, arising from demand for food grain and timber, are clearly a large reason for the decline, there is concern now that the effects of climate change "could be eclipsing those of land use change on 60 per cent of the global land surface," the paper says. And with tropical forests facing the largest decline, there are "implications for biodiversity that is reliant on tropical forests, and the ecosystem services tropical forests provide in the form of carbon capture and the water cycle," the paper says.



The group took up detailed records of tree cover in India, over the period from 2001 to 2018. The source of records was the "Hansen Global Forest Change dataset", a resource attributed to professor Matthew Hansen of the University of Maryland, which uses satellite data to compile a high-resolution global map of forest cover. The data covers the period from 2001 to 2018, and records changes at each pixel of the area of interest, taking into account all trees that are more than five metres in height. And the data was compiled from this record for all 577 districts (administrative, geographical divisions) in India.

There are several factors, the location and interplay of climate variables, that affect forests, the paper says. While the temperature has been studied as an important factor of tree mortality, so has the level of rainfall. But the relationship is complex and the effect of climate change on tree growth and survival is still an area that is not understood, the paper says.

Mostly, the paper says, it is the time progression of climate variables that are considered, and not the variation in the physical landscape. To this end, the group considered a new metric, called "*climate velocity*", which proposes that "areas where climate is changing quickly, and similar climates are further away, will be at greater risk to climate change".

The idea is that the population of species, and in this case, of tree cover, could be expected to move, during climate change, to a contiguous area where the suitable climate is found. But if such an area is far removed, or the change in climate is too fast, the population is expected to decline. Areas of high velocity are hence of high risk, while those of low velocity are "climate refuges".

The result of the study is that climate change has been a significant factor in the forest loss that India has seen. And the study is the first analysis of climate velocity as a measure of risk arising from climate change. The "emerging drying trends and the locations and magnitude of singular high velocities in India's remaining forest strongholds" are matters of concern regarding future forest loss, the paper says. And while the National Forest Policy, of 1988, is being reviewed, it is crucial that an earnest look be taken at data and the multiplicity of threats faced, the paper says.

Reforestation strategy

The paper in the journal, *Science*, looks into whether the current practice of replacing lost forest cover with comparatively simple, that is less heterogenous tree species, would serve the purpose. While the objectives of restoring forests are generally recovery of ecosystem services such as carbon storage, soil erosion control, water provisioning and wood production, the restoration drive seems to assume that "these services can be effectively delivered by forests regardless of their composition," the paper says. While this assumption is yet to be tested, there is a risk that tree plantation, as opposed to natural restoration, may negatively impact biodiversity and "large-scale forest restoration, may hamper progress toward global commitments to halt and reverse ecosystem degradation".

The group hence brought together data from the world's main forest systems, to assess the merits or shortcomings of different reforestation approaches. "By simultaneously considering forests' performance in carbon, soil, water, and biodiversity (i.e., environmental outcomes), plus in wood production, our study also provides a critical assessment of the trade-offs likely to confront forest restoration decision-makers," the paper says.

The data collected was farmed into pairs -- data that involved tree plantation and data of restoration of matching native forest. The second group consisted of "secondary forests resulting from natural regeneration, as well as actively restored native forests resulting from the planting of a diverse native tree mix," the paper says.

The result of the pairing was that in respect of recovery of environmental services, the naturally restored forest performed significantly better than tree plantations. Although, in respect of wood production, tree plantation does score higher. "These findings provide evidence that if the goal of forest restoration is to recover environmental services on the land being restored, and if wood production is not a primary concern, native forest restoration should be prioritised, using site-appropriate measures including unassisted and assisted natural regeneration and active planting of diverse native species.

"Beyond biodiversity, the stakes are especially high for soil erosion control -- given its far poorer delivery by tree plantations relative to native forests. Our synthesis refutes the implicit assumptions of ecosystem service-oriented forest restoration initiatives such as China's Grain-for-Green Programme… and a large collection of projects targeting carbon storage, soil conservation, and water provisioning that have focused mostly on establishing (monoculture) tree plantations," the paper says.

Losses likely to increase

India's loss of forest cover during 2019-20 was 38.5 thousand hectares. Despite the government going on record to say that the loss is under control, it is feared that natural forces would drive the decline further in coming decades.

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Bracing for impact

A large solar storm could knock out the power grid and the Internet -- an electrical engineer explains how

DAVID WALLACE

On 1 and 2 September 1859, telegraph systems around the world failed catastrophically. The operators of the telegraphs reported receiving electrical shocks, telegraph paper catching fire, and being able to operate equipment with batteries disconnected.

During the evenings, the Aurora Borealis, more commonly known as the Northern Lights, could be seen as far south as Colombia. Typically, these lights are only visible at higher latitudes, in northern Canada, Scandinavia and Siberia.

What the world experienced those days, now known as the Carrington Event, was a massive geomagnetic storm. These storms occur when a large bubble of superheated gas called plasma is ejected from the surface of the Sun and hits the Earth. This bubble is known as a coronal mass ejection.

The plasma of a coronal mass ejection consists of a cloud of protons and electrons, which are electrically charged particles. When these particles reach the Earth, they interact with the magnetic field that surrounds the planet. This interaction causes the magnetic field to distort and weaken, which in turn leads to the strange behaviour of the Aurora Borealis and other natural phenomena. As an electrical engineer who specialises in the power grid, I study how geomagnetic storms also threaten to cause power and Internet outages and how to protect against that.

Geomagnetic storms

The Carrington Event of 1859 is the largest recorded account of a geomagnetic storm, but it is not an isolated event.

Geomagnetic storms have been recorded since the early 19th century, and scientific data from Antarctic ice core samples has shown evidence of an even more massive geomagnetic storm that occurred around 774 CE, now known as the Miyake Event. That solar flare produced the largest and fastest rise in carbon-14 ever recorded. Geomagnetic storms trigger high amounts of cosmic rays in the Earth's upper atmosphere, which in turn produce carbon-14, a radioactive isotope of carbon.

A geomagnetic storm 60 per cent smaller than the Miyake Event occurred around 993 CE. Ice core samples have shown evidence that large-scale geomagnetic storms with similar intensities as the Miyake and Carrington events occur at an average rate of once every 500 years.

Nowadays, the United States' National Oceanic and Atmospheric Administration, or NOAA, uses the Geomagnetic Storms scale to measure the strength of these solar eruptions. The "G scale" has a rating from one to five with G1 being minor and G5 being extreme. The Carrington Event would have been rated G5.

It gets even scarier when you compare the Carrington Event with the Miyake Event. Scientists were able to estimate the strength of the Carrington Event based on the fluctuations of Earth's magnetic field as recorded by observatories at the time. There was no way to measure the magnetic fluctuation of the Miyake event. Instead, scientists measured the increase in carbon-14 in tree rings from that time period. The Miyake Event produced a 12 per cent increase in carbon-14. By comparison, the Carrington Event produced less than one per cent increase in carbon-14, so the Miyake Event likely dwarfed the G5 Carrington Event.

Knocking out power

Today, a geomagnetic storm of the same intensity as the Carrington Event would affect far more than telegraph wires and could be catastrophic. With the ever-growing dependence on electricity and emerging technology, any disruption could lead to trillions of dollars of monetary loss and risk to life dependent on the systems. The storm would affect most of the electrical systems that people use every day.

Geomagnetic storms generate induced currents, which flow through the electrical grid. The geomagnetically induced currents, which can be in excess of 100 amperes, flow into the electrical components connected to the grid, such as transformers, relays and sensors. One hundred amperes are equivalent to the electrical service provided to many households. Currents this size can cause internal damage in the components, leading to large scale power outages.

A geomagnetic storm three times smaller than the Carrington Event occurred in Quebec, Canada, in March 1989. The storm caused the Hydro-Quebec electrical grid to collapse. During the storm, the high magnetically induced currents damaged a transformer in New Jersey and tripped the grid's circuit breakers. In this case, the outage led to five million people being without power for nine hours.

Breaking connections

In addition to electrical failures, communications would be disrupted on a worldwide scale. Internet service providers could go down, which in turn would take out the ability of different systems to communicate with each other. High-frequency communication systems such as ground-to-air, shortwave and ship-to-shore radio would be disrupted. Satellites in orbit around the Earth could be damaged by induced currents from the geomagnetic storm burning out their circuit boards. This would lead to disruptions in satellite-based telephone, Internet, radio and television.

Also, as geomagnetic storms hit the Earth, the increase in solar activity causes the atmosphere to expand outward. This expansion changes the density of the atmosphere where satellites are orbiting. Higher density atmosphere creates drag on a satellite, which slows it down. And if it isn't manoeuvred to a higher orbit, it can fall back to Earth.

One other area of disruption that would potentially affect everyday life is navigation systems. Virtually every mode of transportation, from cars to airplanes, use global positioning system, or GPS, for navigation and tracking. Even handheld devices such as cell phones, smart watches and tracking tags rely on GPS signals sent from satellites. Military systems are heavily dependent on GPS for coordination. Other military detection systems such as over-the-horizon radar and submarine detection systems could be disrupted, which would hamper national defence.

In terms of the Internet, a geomagnetic storm on the scale of the Carrington Event could produce geomagnetically induced currents in the submarine and terrestrial cables that form the backbone of the Internet as well as the data centres that store and process everything from email and text messages to scientific data sets and Artificial Intelligence tools. This would potentially disrupt the entire network and prevent servers from connecting to each other.

Just a matter of time

It is only a matter of time before the Earth is hit by another geomagnetic storm. A Carrington Event-size storm would be extremely damaging to the electrical and communication systems worldwide with outages lasting into the weeks. If the storm is the size of the Miyake Event, the results would be catastrophic for the world with potential outages lasting months if not longer. Even with space weather warnings from the NOAA's Space Weather Prediction Center, the world would have only a few minutes to a few hours' notice.

I believe it is critical to continue researching ways to protect electrical systems against the effects of geomagnetic storms, for example by installing devices that can shield vulnerable equipment like transformers and by developing strategies for adjusting grid loads when solar storms are about to hit. In short, it's important to work now to minimise the disruptions from the next Carrington Event.

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PLUS POINTS

Swimming dinosaur

Spinosaurus, the biggest known predatory dinosaur, was a "water-loving" carnivore that swam after its prey while fully submerged, according to new research.

Palaeontologists have long thought the late Cretaceous giant -- which stretched more than 10 average adult men in length -- hunted water-dwelling creatures but whether it would swim or simply snap up its prey from the shallows was a matter of debate.

A new paper published in *Nature* by a group of palaeontologists drew on research into the bone density of swimming species to determine that the Spinosaurus would indeed have headed underwater to hunt. A team led by Nizar Ibrahim, University of Portsmouth palaeontologist and National Geographic explorer, unearthed different parts of a Spinosaurus skeleton in North Africa's Sahara Desert.

The skeleton had retracted nostrils, short hind legs, paddle-like feet, and a fin-like tail -- all signs that suggested an aquatic lifestyle. Ibrahim said, "We battled sandstorms, flooding, snakes, scorpions and more to excavate the most enigmatic dinosaur in the world and now we have multiple lines of evidence all pointing in the same direction -- the skeleton really has 'water-loving dinosaur' written all over it!"

The team sought to prove their theory by comparing the bone density of the Spinosaurus skeleton with known swimmers. Matteo Fabbri, a palaeontologist at Chicago's Field Museum and lead author of the paper, said, "There are certain laws that are applicable to any organism on this planet. One of these laws regards density and the capability of submerging into water."

Across the animal kingdom, bone density can reveal whether an animal is able to sink beneath the surface and swim. "Previous studies have shown that mammals adapted to water have dense, compact bones in their postcranial (behind the skull) skeletons," said Fabbri, an expert on the internal structure of bone.

Dense bone helps with buoyancy control and allows an animal to submerge itself. Animals that submerge themselves underwater to find food have bones that are almost completely solid throughout, while cross-sections of land-dwellers' bones look more like doughnuts, with hollow centres.

The team assembled a dataset of femur and rib bone cross-sections from 250 species of living and extinct species -- both land-dwellers and water-dwellers from mice to whales. They also collected data on extinct marine reptiles like mosasaurs and plesiosaurs.

Cross-sections of bone from these animals were compared to cross-sections from Spinosaurus and its relatives Baryonyx and Suchomimus. The Spinosaurus was found to have the type of dense bone associated with full submersion.

The independent

Tech aid

An Artificial Intelligence companion for people with dementia is being developed. The technology will aid memory recollection, boost confidence and combat depression in people living with Alzheimer's Disease and other types of dementia.

Memory loss in people with Alzheimer's Disease occurs in reverse chronological order, with pockets of long-term memory remaining accessible even as the disease progresses. While most current rehabilitative care methods focus on physical aids and repetitive reminding techniques, the new project, named Amper (Agent-based Memory Prosthesis to Encourage Reminiscing) will take an AI-driven, user-centred approach and focus on personalised storytelling to help bring a patient's memories back to the surface.

The research team is led at Heriot-Watt University and the National Robotarium, a partnership between Heriot-Watt University and the University of Edinburgh. Mario Parra Rodriguez, senior lecturer in psychology, director of the Applied Cognition Lab and the University of Strathclyde's lead on the project, has developed cognitive-oriented frameworks to equip technologies with capabilities to personalise assessments and interventions. He said, "The aim of Amper is to assist people in retrieving their memories and we hope this will help to strengthen people's self-esteem and feelings of belonging, thus leading to better quality of life and prolonging independent living."