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How important are forests and biodiversity to our future?

WEIGHING short-term liquidation benefits against long-term worth, it has been calculated that the monetary value of services that forests provide globally to humanity lies in the region of 30 trillion dollars. In terms of a sustainable future, however, this figure becomes meaningless as forests, being integral to the functioning of the earth as a living system, have an inestimable value.

Forests cover 30% of the land area of the planet and it is estimated that they store 283 gigatonnes of carbon in their biomass alone, with the carbon stored in forest biomass, dead wood, litter and soil together being more than the amount of carbon in the atmosphere.

As vast green carbon sinks, forests regulate atmospheric chemical compositions, taking carbon dioxide out of the atmosphere and breathing oxygen into the air in an essential life-giving cycle that is crucial for life on the planet. And just as a human body cannot survive without its lungs, the biosphere may not be able to survive without its forests.

Important ecological services

Almost all of the water that reaches the atmosphere over land-locked areas comes from trees and plants through transpiration, with just one rainforest tree pumping millions of litres of moisture from the soil to the air during its lifetime.

At ground level, by absorbing rainwater and releasing it into streams and rivulets by a gradual process, soil erosion and flooding are prevented, sedimentation is reduced and the availability of water is extended during hot, dry months when it is most needed by thirsty forest inhabitants – human, animal, bird, amphibian, fish, insect and plant alike.

Forests also regulate nutrient cycles. All organisms require elements, such as carbon, hydrogen, oxygen, nitrogen, phosphorus, iron, magnesium, potassium and sulphur, to sustain life. Tropical rainforests and temperate forest vegetation are no exception and most nutrients in a rainforest ecosystem tend to be locked up in the vegetation rather than the soil, which retains few nutrients.

Nutrients come into forest communities from stream water, weathered rock, and soil, as well as from human and animal activity. Nutrients are also dispersed by wind, rain, snow and fog and, once into the community, animals, plants, water, soil and the roots of other plants circulate them.

When forests are undisturbed they are very efficient at recycling and retaining nutrients. However, once trees are felled, nutrients are lost to the community through water running out of the area in streams and rivulets. Burning of forest biomass also contributes to the loss of nutrients to the ecosystem.

Apart from influencing atmospheric chemical compositions, water regulation and nutrient cycles, forests provide additional important ecological services, such as pollination, water treatment and fisheries protection. They also regulate temperatures and influence climate by the complex interaction of trees, ground, air and water.

Forests and weather

Like the icy white expanses of the Arctic and Antarctic, naked ground reflects the sun's incoming rays back into space, absorbing little heat. Dark green forests, on the other hand, reflect only 10 to 20% of the sunlight that reaches them, which is very significant in terms of weather patterns because the moisture-holding capacity of air increases when it is warmed.

Warmed air is less stable which increases convection currents, the atmospheric circulatory system of the planet, which shares out energy and warmth across the continents. Without moving air, life on the landmasses of the globe would be unendurable with the tropics being searingly hot and the other latitudes being inhospitably cold.

Water would be largely confined to the sea, with the continents being great desert expanses, except for narrow belts of temperate vegetation. There would be little weathering of rock and without erosion, the stripping away of tiny fragments of rock that the wind accomplishes, there would be no soil.

There would be no weather to create cloud cover and water vapour with which to govern the amount of incoming solar radiation reaching the earth. There would be no cleansing of pollution from the atmosphere and people would eventually suffocate under a blanket of waste and greenhouse gases.

Forests and biological diversity

The exact number of species that live in rainforest habitats relative to the global number of species is a subject of wide debate, with some biologists putting this percentage at 50% of all terrestrial species, which is in accordance with the latitudinal species-diversity gradient that puts highest species diversity in the tropics. This translates into 42 000 to 60 000 different species of insects alone per hectare of tropical forest.

This richness of tropical rainforest biodiversity is of great importance both to the natural world and to humankind, and the depredation that a loss of such biodiversity would bring about, should the majority of these species become extinct due to deforestation of their rainforest habitats, is staggering.

Between 1970 and 2003 tropical species populations declined by about 55% and, should deforestation continue at its present rate, biologists believe that as many as 50 000 species of plants, for example, could disappear out of a world total of 250 000 species. One-fifth of the world's butterfly species could disappear, while the number of bird species lost could be 2 000 out of a world total of 9 000 species.

For millennia, organisms have been the only means of sustaining human beings. They have provided food, medicine, clothing, shelter and energy down through the ages. Many of these needs have been derived from plants grown in forests, biologically some of the richest biomes on the planet.

In modern times, countless human headaches have been soothed with aspirin, the most widely used medicine in the world. Salicylic acid, a component of aspirin, was originally discovered in the bark and leaves of the willow tree. Muscle relaxants used during surgery have come from curare, an Amazonian vine.

The rosy periwinkle found only in Madagascar has been found to be effective in treating certain forms of leukaemia, giving children treated with drugs derived from this plant a greater chance of survival. The contraceptive pill, which has been so significant in helping to curb human population figures, improving quality of life for millions of people around the world, was originally manufactured from a wild yam grown in forests in Mexico.

Perhaps a cure for Aids is growing in a quiet forest glade somewhere on the planet but we shall never find it, for instead of valuing forests for the essential services they provide and their importance as a habitat and last refuge to a myriad forest species, forests are being chopped down in a one-time rate of consumption that will never be available again.

And what is not chopped down is burnt. From outer space, it is possible to see the fires that are burning away millions of hectares of the earth's green mantle each year, with what is left after burning being criss-crossed with roads and highways that slice through the forests' integrity, marooning animal and plant populations into fragments of species-destroying isolation.

Climate change and feedback cycles

The earth's self-regulatory energy systems have maintained equilibrium for more than three billion years and for much of that time ancient forests have played a significant part in the links and feedback cycles between the lithosphere, the hydrosphere and the atmosphere.

Yet with blatant disregard for the interconnection between the vitality of the earth as an integrated system, the health and extent of the planet's forests and ultimately the survival of humankind, the planet has been, and continues to be, deforested at a rate that is alarming, to say the least.

Globally deforestation is continuing at a rate of 13 million hectares per year, or the equivalent of 36 football fields per minute, and it is estimated that only 10% of tropical forests globally will still be standing after the first decades of the 21st century.

At risk are important ecosystem services and biological diversity that rainforests provide. However, as rainforests absorb 20% of carbon in the atmosphere, a greater threat from deforestation and degradation of the world's rainforests could be in terms of climate change. For, with the clearing of land and the burning of biomass, there is not only a reduction of carbon sinks, there is the release of stored carbon back into the atmosphere.

Deforestation is the third largest source of greenhouse gas emissions, generating between 15 to 20% of overall carbon emissions. This is changing rainforests from being net absorbers into large-scale emitters or net sources of carbon, which could amplify carbon-induced climate change in a powerful positive feedback loop.

In terms of biodiversity, rising carbon dioxide levels are changing the proportions of trees that make up the canopy. Spurred on by increased carbon dioxide levels in the atmosphere, fast-growing species are powering ahead and crowding out slower-growing ones. As the few rapidly growing species shade out their neighbours, the rainforests' biodiversity is declining as birds and animals that depend on the slower-growing species as food, vanish along with their resources.

Easter Island as a metaphor

The giant stone monoliths or moai of Easter Island, some weighing as much as 270 tons, are among the indisputable wonders of the world. Placed around the perimeter of the island, these iconic statues, carved from soft volcanic tuff, are the haunting legacy of a complex society that disappeared once the carrying capacity of its environment had been exhausted.

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Easter Island was first colonised more than 1 300 years ago when Polynesian seafarers arrived on the South Pacific island to find a pristine sub-tropical habitat that was heavily forested with a giant palm that is now extinct.

Over centuries, as the population on the island grew, the Easter Island Palm provided wood for fuel, building homes and canoes. With their seaworthy canoes, the islanders were able to live well off a diet of porpoise. This seemingly endless supply of resources enabled a technologically sophisticated civilisation to develop. Their success, however, eventually proved to be the Easter Islanders' downfall.

Pollen analysis shows that from about 1200 AD, the tree population of the island was rapidly declining as deforestation took its toll, and by 1400 AD the Easter Island Palm had become extinct due to overharvesting.

The islanders, no longer having the palm wood needed for building canoes, could no longer make journeys out to sea, and consequently their consumption of land birds, migratory birds and molluscs increased.

Soon land birds became extinct and migratory bird numbers were severely reduced, spelling an end for the remaining pockets of Easter Island's forests, as these forests lost their pollinators and seed dispersers with the disappearance of the birds.

Streams and drinking water supplies dried up. Crop yields declined as wind, rain and sunlight eroded topsoils and, lacking access to porpoise meat and having depleted the island of birds, the Easter Islanders began to starve.

When Europeans landed on the island in 1722 they found a barren landscape populated by a small number of emaciated inhabitants who were living in a state of civil disorder, their impressive stone statues, symbols of a once thriving and advanced social order, abandoned.

Easter Island is a compelling metaphor for what can happen to a closed system once its trees have been overharvested for, as the earth is itself a closed system, with occurrences in the northern hemisphere impacting on the southern hemisphere and vice versa, deforestation is everyone's business. Stripping the earth of its forests could well contribute to future global ecocide to an extent that we cannot now imagine for, with the loss of the planet's trees, we risk losing life's basic building blocks.

The Age of Humanity

In the context of vast geological time, life on our planet has been incredibly tenacious as, in order to have survived this far, species have had to run a gauntlet of extinctions and ice ages across landscapes that have challenged only the fittest to survive.

Earth's geological history records five cataclysmic mass extinctions when more than half of the planet's species on land and in the sea disappeared. These catastrophic extinction events redirected evolution of the earth's organisms into radiations of different forms, each reaching a plateau of maximum evolutionary success and then declining, making room for other species to follow.

Extinctions caused by climatic aberrations that abruptly heat the planet, causing massive die-outs, have occurred previously in earth history. Indeed the climate change we are experiencing now is similar in magnitude to that seen at the end of the last Ice Age. The difference, however, is that it is anthropogenically-caused. It is also 30 times faster.

In acknowledgement of the profound effect human influences have had on the earth's climate, a geological period has been ascribed to this significant event. It has been called the Anthropocene or Age of Humanity and, at existing levels of greenhouse gases, it could bring about destabilisation of the carbon cycle with at least one out of every five species on the planet being in danger of extinction.

Should the global mean temperature rise by 1.8 to two degrees centigrade, around a quarter of all living things would become extinct. Beyond an increase of two degrees centigrade, wet tropics ecosystems would begin to unravel and one third of all life on the planet would disappear in massive die-outs.

If temperatures rose by 5.5 degrees centigrade, remaining plants would become stressed to the point that collapse of the Amazonian rainforest would become inevitable. And, with the loss of the rainforest canopy, soils would heat and soil decomposition would proceed at an even more rapid rate, releasing prodigious volumes of carbon dioxide into the atmosphere.

As it takes between 10 and 100 million years before biological diversity begins to approach that, which existed before a die-out, the earth may only recover from the Anthropocene or Age of Humanity long after Homo sapiens sapiens has disappeared from the planet.

Species on the move

Just as the loss of a human being changes his or her family forever, so the loss of even one species irrevocably changes the ecosystem in which it lives. For, as most living things on earth support others in symbiotic relationships, with keystone species influencing and supporting many other plant and animal species, extinctions lead to co-extinctions. In this way, it has been said that the loss of the honey-bee and the pollination services it provides could bring about the end of the world, as we know it.

Climate change is seen as the biggest single threat to the earth's ecosystems. However, not all species are reacting uniformly to climate change, with the capacities of different species to adapt to change varying, as individual species use various cues to initiate events such as breeding and migration.

Studies show that there is a poleward shift in species' distribution of, on average, around 6km a decade, with a retreat up mountainsides of 6.1m a decade. Although this trend might seem small when compared with the rate of change seen over geological time, it is in fact very rapid and decisive.

Many species are, therefore, relocating which is causing a disruption of connectedness between species as, for example, a key prey species may arrive too late for a predator, or move too far north or south to be of use to the predator. Dislocations caused by some species shifting rapidly with others being left behind are causing numerous extirpations and possible extinctions.

In species, such as crocodiles, that have sex ratios determined by the temperature at which their eggs are incubated, global warming represents an even more direct threat.

Lessons from Lake Tanganyika

Lake Tanganyika, which straddles Burundi, the DRC, Tanzania and Zambia, is the deepest lake in Africa, holding the greatest volume of fresh water. With its 450 fish species, most of which are endemic to the lake, and its numerous invertebrate species, such as molluscs, crabs and copepods, from a biodiversity standpoint, it is one of the most significant lakes in the world.

From a fisheries perspective, it is equally important as more than 45 000 people owe their livelihood to the lake, with more than a million people being dependent on the fishers.

Although the enormous depth and tropical location of the lake prevent turnover of water masses, which means that much of the lower depths are so-called "fossil water", in the past seasonal monsoons stirred its waters, breaking down stratification and driving its spectacular biodiversity.

Now, however, global warming has warmed Lake Tanganyika's surface layers, strengthening stratification to the point that nutrients no longer surface and oxygen no longer penetrates to any depth.

This could bring about a possible collapse of the lake's entire ecosystem, a situation found in many of the world's lakes as rising temperatures cause the lakes' surfaces to warm, preventing the mixing of oxygen-rich upper layers with nutrient-rich lower ones, threatening the basis of their productivity.

Climate change, fynbos and ants

Taking up only 0.04% of the world's land area, the magnificent Cape Floristic Region contains an astonishing 3% of plant species, making it one of the richest areas for plants in the world and, with 11 000 marine animal species, 3 500 of which are endemic and 560 vertebrate species, including 142 reptile species, 27 of which are endemic, it is one of the globe's 18 biodiversity hot spots.

Terrestrial biodiversity is not necessarily dependent on rich soils and plentiful rainfall. Indeed in regions with fertile soils and abundant rain only a few plant species can dominate, as the dominant species out-compete the rest.

The Fynbos biome, with its mix of approximately 8 700 species of small shrubby plants and sandstone, shale and limestone soils, is a fine example of a biome where low levels of nutrients and poor soils promote exceptional diversity as niche specialists, plants that can thrive only within very narrow limits, proliferate.

Approximately 60% of fynbos plant species require ant-assisted seed dispersal, with ants as myrmecochores (seed dispersers), being integral to the functioning of Fynbos systems in a synergistic interrelationship that benefits both species.

A recent study on ant assemblages conducted in the Greater Cederberg Biodiversity Corridor shows that a changing climate in the region will directly affect ant assemblages in substantial and complex ways. It will also indirectly affect them via plant responses to climate change. In turn, changes in ant assemblages are likely to affect the ways in which seeds are dispersed owing to different responses in the myrmecochores (seed dispersers), with changing relative abundances of ant populations, differences in behaviour and seed-type preferences influencing ecosystem functioning.

In this way changed responses in ant species in relation to factors, such as plant seed size and depth at which seeds are stored in nests, together with changes in temperature and water availability, are likely to precipitate vegetation changes in the Cape Floristic Region, resulting in fynbos being replaced with a different, unknown vegetation type by the middle of this century.

As one of South Africa's eight World Heritage Sites, the Cape Floristic Region is known internationally for its beauty and biodiversity. To lose the Fynbos biome would be to lose not only an exceptional ecotourism destination with its associated revenue, but an area of such uniqueness that it may never be replicated on the planet again.