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1.The Treeline, Ben Lawrence, 2022

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Cartographers have traditionally relied on the ten-degree July isotherm as the boundary of the Arctic Circle and the treeline, but this relationship is being uncoupled as the planet heats up.

The trees are on the march. While forests are being destroyed by fire, parasites and humans every year, the tundra is being colonised by trees. In his book The Treeline, Ben Lawrence describes his travel through the boreal which he refers to as the lungs of the world. It covers one fifth of the globe, contains one third of all the trees on earth, and has a major effect on the climate. The treeline is on the move, invading frozen tundra and hastening the melting of permafrost and consequently the release of methane. At the same time more frequent fires are moving the southern boundary of the treeline northwards.

Between 2018 and 2020, Ben Lawrence visited the treeline in the Scottish Highlands, Norway, Russia, Alaska, Canada and Greenland. His book records his observations and his talks with various experts during his journey. He also visited remaining indigenous populations across the treeline, observing how they had adapted their lives to the freezing conditions and the challenges they are encountering as the climate changes. Some of the stories he has to tell are well worth reading.

Only a few species of tough trees make up the treeline: these include Scots pine in Scotland, birch in Scandinavia, larch in Siberia, and spruce in Alaska.

In the Scottish Highlands the author swims to Loch Maree, one of the very few places in Scotland deer cannot reach. The islands have been continuously wooded for nearly 8,000 years. No-one lives there at present. He also visited Glen Feshie where the pine forest is being regenerated. A key has been reducing the deer population from 50/km^2 in the 1800's and 1900's to only one or two. Deer keep the grass down and encourage herbs, but too

many stop the trees from growing by eating the young growth. Glen Feshie is the jewel in the crown of Wildland Ltd. the private property of Danish businessman Anders Poulson, which is dedicated to rewilding.

The Russian taiga is the greatest forest in the world. It covers more than 3 million square miles and half the land mass of Russia. It is a green carpet of trees atop permafrost. The taiga is predominantly larch (37%) which is the keystone species. Larch's resistance to fire as well as ability to colonise burnt ground mean it has shaped the architecture of the taiga forest of Siberia.

What Ben Lawrence describes as Russia's elite forest research institution, the V N Sukachev Institute of the Forest of the Siberian Division of the Russian Academy of Sciences, is located in the city of Krasnoyarsk. The district is also the home of Ary Mas, the most northerly trees on earth. Krasnoyarsk is located slightly north of the point where the borders of Kazakhstan, Mongolia and Russia meet. It is also the home of one of the world's largest aluminium smelters, and is famed for the hazy smog that affects the health of its residents.

Vladimir Sukachev is described as a larch specialist and a little-known pioneer in global ecology and environmentalism. He was the first to discover that larch will put out adventitious roots (from non-root tissue) in order to extract moisture from permafrost. Larch is the only deciduous conifer. It is responsible for absorbing 55% of the carbon dioxide that the taiga sequesters. Because larch is deciduous it transpires a lot more water than evergreens, taking in 20% more carbon dioxide than pine, and the soils beneath the larch emit a quarter less carbon dioxide than pine.

The author also met with Elena Kukovsky at the institute, described as one of the foremost experts on wildfires in Siberia. She informed him that the intensity and frequency of forest fires increase as you go south. In the lower latitudes the fire interval was 5-30 years depending on rainfall. As temperatures have increased the soil has grown drier, and fires are now hotter, longer and more frequent, making it harder for larch to re-establish afterwards.

The book includes a description of his exhausting trip by trekol to Syndassko village, Gulf of Khatonga, the most northern settlement in Russia. On the way he has the chance to eat kyspyt – frozen fish sliced into long strips, eaten with tea, mustard, salt and a small dish of chilli powder. On arrival in February the weather was a 'warm' -27 degrees overnight (below -30 degrees had been unheard of in the past). The Dolgan people, traditionally nomadic reindeer herders, now find fishing far easier and more lucrative (25kg frozen fish = one litre vodka). Cut a hole in the ice, place a net in the hole ensuring it is held in place, walk away, wait and return. The inhabitants had not seen large shifts in temperature or vegetation when he visited, but had noticed several small changes – unfamiliar sightings of birds, bugs and butterflies and strange bubbles under the ice. The sea ice in the bay was taking longer to freeze in winter.

The author quotes climate modelling (by Nadezhda Tchebakava) which indicates that as the climate warms up, up to half of Siberia will become 'favourable' for human settlement. Within decades parts of the Middle East and South East Asia will become too hot for

humans to work outside or sleep without air conditioning. He suggests that Siberia is the obvious refuge for the large populations further south already under pressure from heat stress, flooding, drought and famine.

In Canada, Ben Lawrence visited Diana Beresford-Kroeger described as one of the foremost scholars of the boreal forest which still covers about half of Canada. She forged relations with the First Nations indigenous people of Canada, whose knowledge and wisdom she respects immensely. Diana combined what she knew from botany, organic chemistry and nuclear physics with what they told her and published two landmark peer-reviewed reference books, Arboretum America and Arboretum Borealis. These explain in detail the critical role that the northern forest plays in regulating the water, the air, the soil, climate and feeding foundations of oceans, and catalogues the huge untapped potential of trees to supply food and medicines for the modern world. Among the Mohawk and Cree people she is known as the keeper of medicines.

The balsam poplar is the key species within the Canadian boreal. It is a deciduous tree with large plate-like leaves which are full of oils and resins. Each spring the poplars of the boreal flush tonnes of oleoresin into the atmosphere which have many health benefits for humans. The balsam poplar creates the chemicals from the minerals it mines deep underground from its deep taproot. Th trees produce a high volume of leaf litter in winter. Shrubs growing under the forest canopy, including berry producing bushes, need the shade of the poplar just as much as the minerals they excavate.

The author visited the Anishinaabe, an indigenous people in a designated World Heritage Site with an area of nearly 30,000 km^2. They believe that in the beginning the land was raised out of the water and gifted to man as a gift for his survival. In return he was to care for the land in trust. In his book, Ben describes an expedition with a group of local people by canoe to Thunder Lake for a weekend.

The above is only a taste of the contents of the book which I borrowed from our local library. I found it well worth reading despite very little knowledge of trees and the boreal. The importance of the boreal trees and the tundra to the climate and our future is really just beginning to be understood.

2. Diet for a hotter climate: five plants that could help feed the world

Cecilia Nowell, Guardian website, 20 Aug 2022

Over the course of human history, scientists believe that humans have cultivated more than 6,000 different plant species. But over time, farmers gravitated toward planting those with the largest yields. Today, just three crops – rice, wheat and corn – provide nearly half of the world's calories.

That reliance on a small number of crops has made agriculture vulnerable to pests, plant-borne diseases and soil erosion, which thrive on monoculture – the practice of growing only

one crop at a time. It has also meant losing out on the resilience other crops show in surviving drought and other natural disasters.

As the impacts of the climate crisis become starker, farmers across the world are rediscovering ancient crops and developing new hybrids that might prove more hardy in the face of drought or epidemics, while also offering important nutrients.

Here's a look at five crops, beyond rice, wheat and corn, that farmers across the world are now growing in hopes of feeding the planet as it warms.

Amaranth: the plant that survived colonization

From leaf to seed, the entirety of the amaranth plant is edible. Standing up to eight feet tall, amaranth stalks are topped off with red, orange or green seed-filled plumes. Across Africa and Asia, amaranth has long been eaten as a vegetable – whereas Indigenous Americans also ate the plant's seed: a pseudocereal like buckwheat or quinoa.

While amaranth leaves can be sautéed or cooked into a stir-fry, the seed is commonly toasted and then eaten with honey or milk. A complete protein with all nine essential amino acids, amaranth is a good source of vitamins and antioxidants.

In the Americas, Spanish colonizers banned the Aztecs and Maya from growing amaranth when they arrived on the continent. However, the plant continued to grow as a weed and many farmers saved amaranth seeds, passing them down for generations, until their descendants were allowed to grow it again.

Today, Indigenous farmers in Guatemala, Mexico and the US are collaborating to grow this drought-resistant crop. Like fonio, an African grain, amaranth is not a new crop, but one that is experiencing a resurgence as communities adapt to the climate crisis.

Fonio: the drought-resistant traditional grain

For thousands of years, farmers across west Africa have cultivated fonio – a kind of millet that tastes like a slightly nuttier couscous or quinoa. Historically, fonio is considered to be Africa's oldest cultivated cereal and was regarded by some as the food of chiefs and kings. In countries such as Senegal, Burkina Faso and Mali, fonio would be served on holy days, like at weddings and during the month of Ramadan.

Today, attention is increasingly focused on fonio for its resilience and health benefits. As the climate continues to change, fonio's drought resistance and ability to grow in poor soil has

made it a standout crop in water-scarce regions. It also has important nutritional value as a low glycemic, gluten-free grain – making it a good source of amino acids for people with diabetes or gluten intolerance.

The Italian company Obà Food helped introduce fonio to the EU in December 2018. And in the US, the Senegalese chef Pierre Thiam sources fonio from the aid organization SOS Sahel for his brand Yolélé, also the name of his cookbook celebrating west African cuisine.

Cowpeas: the fully edible plant

In the 1940s, more than 5m acres of cowpeas were grown in the US – the majority, as their name suggests, for hay to feed livestock. But long before cowpeas – also called southern peas or black-eyed peas – came to the Americas, they were grown for human consumption in west Africa. Although cowpea production has declined in the US in recent decades, the crop is hugely important in much of Africa. Nigeria is the world's largest cowpea producer.

Although historically people have mostly eaten cowpeas' seeds, the leaves and pods are also a good source of protein. Because cowpeas are highly drought tolerant, they're also a good candidate as the climate changes. At Tennessee State University, a team is studying the introduction of cowpeas to Latin America, as an alternative to beans, like pinto and black beans, with similar flavour profiles that may soon become more difficult to grow.

Taro: adapting the tropical crop for colder climes

In the tropics of south-east Asia and Polynesia, taro has long been grown as a root vegetable, not unlike the potato. But as rising temperatures threaten cultivation of the crop in its natural habitat, farmers in the continental US are trying to adapt the tropical perennial to grow as a temperate annual, because it cannot survive the cold of US winters.

At the Utopian Seed Project in North Carolina, founder Chris Smith and his team have been experimenting with tropical crops, looking for ways to help the plants survive the winter. Today, they're growing eight varieties of taro, including ones sourced from Korea, the Philippines, Hawaii, China and Puerto Rico.

"We want to introduce taro because we truly believe that that will give us a more secure food system," Smith says. "But the beautiful by-product is that that also allows us to engage with foods that are traditionally from either indigenous or peasant farming communities. And I think it really gives those traditionally underserved populations an opportunity to engage with the food system that they don't usually get."

Kernza: the crop bred for the climate crisis

While many alternative crops are just plants that were grown somewhere else in the world generations ago, others have been cultivated specifically to withstand climate change. In the 1980s, researchers at the Pennsylvania-based Rodale Institute identified a wheat-like grass called intermediate wheatgrass as a perennial cereal crop that could be developed as a substitute for annual grains like wheat. The goal was to minimize the environmental impacts of grain production.

In 2019, the Kansas-based Land Institute, a non-profit research organization focused on sustainable agriculture, introduced Kernza, a cereal crop developed from intermediate wheatgrass and trademarked to ensure farmers know they've bought seeds from the official breeding program. Although researchers are still working to improve the grain's yield, farmers in Minnesota, Kansas and Montana are today growing nearly 4,000 acres of Kernza.

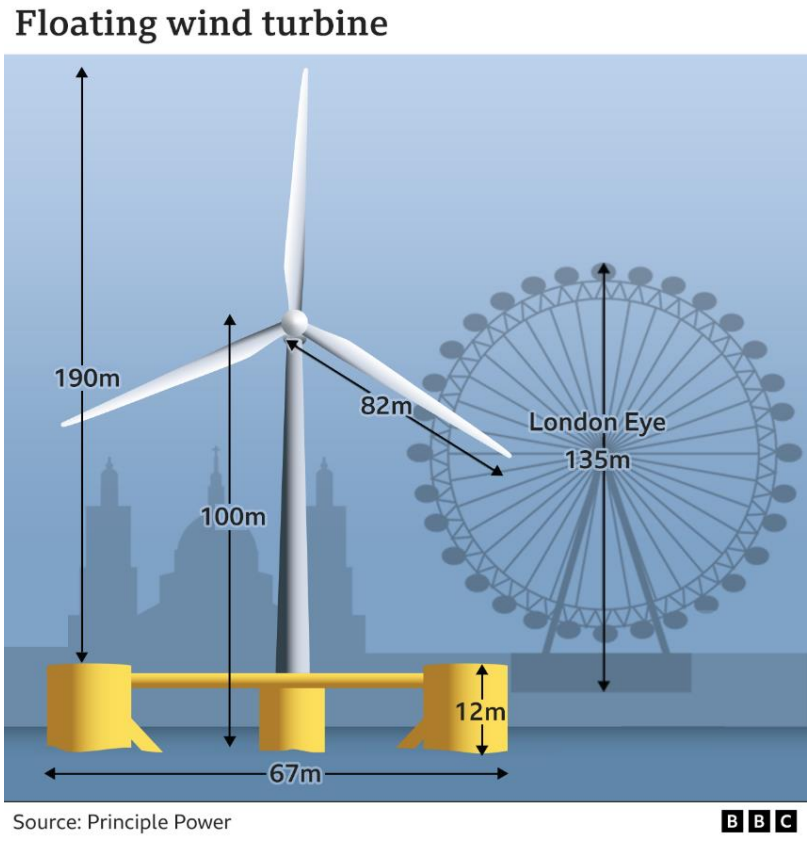
3. Floating wind turbines

From an article by Justin Rowlatt, BBC Climate editor, 20 October 2022

Ten miles off the coast of Aberdeen in Scotland, five turbines tower over the North Sea. Each is as tall as the giant towers of Canary Wharf in London's docklands. Kincardine is the world's largest floating wind farm.

In much of the world, the seabed takes a sudden dive close offshore, ruling out the use of conventional offshore wind turbines. These are built up from the sea floor on concrete foundations and can only be deployed in relatively shallow water, up to about 60m.

The solution sounds obvious - installing turbines on floating platforms - but imagine for a moment the fearsome forces these structures must withstand. The turbines at the wind farm must stand tall in the heaviest swells and fiercest storms the tempestuous North Sea brings their way. The success of the technology draws on Britain's expertise in offshore engineering, honed as it developed the oil and gas resources in the North Sea. Each tower sits atop three huge cylindrical floats. They are painted bright yellow and welded into a triangular platform each side of which is 67m long.



This is not a passive structure, explains Greg Campbell-Smith, of Principle Power, the UK company that developed the platform technology. The floats need to adapt to changes in the wind and sea conditions. In strong winds the tower "heels" or leans away from the wind, says Mr Campbell-Smith. A network of pumps and valves shift liquid ballast between the three floating cylinders to rebalance the platform and set the turbine at the ideal angle for the wind. Below the surface, weighted subsea cables attached to huge anchors make sure the platform is firmly secured to the seabed.

Companies around the world are producing their own designs for floating wind platforms. Last month the US government offered $50m of new funding to encourage American companies to install 15GW of floating wind in US waters by 2035. The aim is to drive down costs by 75% and "help the US lead on offshore wind", according to the White House. There is certainly a huge potential market.
The UK's independent climate advisors, the Climate Change Committee (CCC), says that about half of the 100GW of offshore wind it expects will have been installed by 2050 will be on floating platforms.

Some two-thirds of the US potential for offshore wind is reckoned to be in deep water, 80% of the European seabed is all only accessible using floating technology and much of the sea off Japan is also deep. The total worldwide pipeline of floating wind projects has doubled in the last year alone and now totals to180GW, suggests RenewableUK.

The big challenge now is cost. This new technology is expensive. Kilowatt hour for kilowatt hour, floating wind comes in at about the same price as new nuclear power.
But, unlike nuclear power, the expectation is that costs will tumble as the market grows. But the industry warns that investment will be needed to deliver on the promise this new technology holds. It requires deep ports with huge workspaces to allow the manufacturing and assembling of the vast floating structures.

Oil and gas platforms tend to come as one-off orders, but floating wind platforms will need to be constructed on a "production line". The biggest floating wind farms will consist of 100 or more platforms. The UK government has promised £160m to beef up the country's port infrastructure but RenewableUK believes more investment will be needed.

4.Information extracted from IPCC AR6 WG III Final Government Distribution Technical Summary, November 2019 Draft

Table TS.1: Signs of Progress and Continuing Challenges

Signs of progress	Continuing challenges
Emissions trends	
The rate of global GHG emissions growth has slowed in recent years, from 2.1% per year between 2000 and 2009, to 1.3% per year in between 2010 and 2019. (TS.3) {2.2}	**GHG emissions have continued to grow at high absolute rates**. Emissions increased by 8.9 $GtCO_2eq$ from 2000-2009 and by 6.5 $GtCO_2eq$ 2010-2019, reaching 59 $GtCO_2eq$ in 2019. (TS.3) {2.2}
At least 24 countries have reduced both territorial carbon dioxide (CO_2) and GHG emissions and consumption-based CO_2 emissions in absolute terms for at least 10 years, including consumption-based CO_2 emissions. Of these, six are Western and Northern European countries that started reducing in the 1970s, six are former Eastern Bloc countries with consistent reductions since the 1990s, and 12 more have reduced since the mid-2000s. Some have done so at rapid sustained CO_2 reduction rates of 4% per year. (TS.3) {2.2}	**The combined emissions reductions of these 24 countries were outweighed by rapid emissions growth elsewhere**, particularly among developing countries that have grown from a much lower base of per capita emissions. Uncertainties in emissions levels and changes over time prevents a precise assessment of reductions in some cases. The per capita emissions of developed countries remain high, particularly in Australia, Canada, and the United States. {2.2}
Lockdown policies in response to COVID-19 led to an estimated global drop of 5.8% in CO_2 emissions in 2020 relative to 2019. Energy demand reduction occurred across sectors, except in residential buildings due to teleworking and homeschooling. The transport sector was particularly impacted and international aviation emissions declined by 45%. (Box TS.1) {2.2}	**Atmospheric CO_2 concentrations continued to rise in 2020 and emissions have already rebounded as lockdown policies are eased.** Economic recovery packages currently include support for fossil fuel industries. (Box TS.1; Box TS.8)
Sectors	
Multiple low-carbon electricity generation and storage technologies have made rapid progress: costs have reduced, deployment has scaled up, and performance has improved. These include solar photovoltaics (PV), onshore and offshore wind, and batteries. In many contexts solar PV and onshore wind power are now competitive with fossil-based generation. (TS.3) {2.5, 6.3}	**Although deployment is increasing rapidly, low-carbon electricity generation deployment levels and rates are currently insufficient to meet stringent climate goals.** The combined market share of solar PV and wind generation technologies are still below 10%. Global low-carbon electricity generation will have to reach 100% by 2050, which is challenged by the continuous global increase in electricity demand. The contribution of biomass has absolute limits. (TS.5, 2.5)
The rate of emissions growth from coal slowed since 2010 as coal power plants were retired in the United States and Europe, fewer new plants were added in China,	**Global coal emissions may not have peaked yet**, and a few countries and international development banks continue to fund and develop new coal capacity,

Signs of progress	Continuing challenges
and a large number of planned global plants were scrapped or converted to co-firing with biomass. (TS.3) {2.7, 6.3}	especially abroad. The lifetime emissions of current fossil-based energy infrastructures may already exceed the remaining carbon budget for keeping warming below 1.5°C. (TS.3) {2.2; 2.7, 6.7}
Deforestation has declined since 2010 and net forest cover increased. Government initiatives and international moratoria were successful in reducing deforestation in the Amazon between 2004 and 2015, while regrowth and regeneration occurred in Europe, Eurasia and North America. (TS.5.6.1) {7.3.1}	**The long-term maintenance of low deforestation rates is challenging.** Deforestation in the Amazon has risen again over the past four years. Other parts of the world also face steady, or rapidly increasing, deforestation. {7.3.1}
Electrification of public transport services is demonstrated as a feasible, scalable and affordable mitigation option to decarbonise mass transportation. Electric vehicles (e-vehicles) **are the fastest growing segment of the automobile industry, having achieved double-digit market share by 2020 in many countries.** When charged with low-carbon electricity, these vehicles can significantly reduce emissions. {10.4}	**Transport emissions have remained roughly constant, growing at an average of 2% per annum between 2010-2019** due to the persistence of high travel demand, heavier vehicles, low efficiencies, and car-centric development. The full decarbonisation of e-vehicles requires that they are charged with zero-carbon electricity, and that car production, shipping, aviation and supply chains are decarbonized. (TS.3) {2.4}
There has been a significant global transition from coal and biomass use in buildings towards modern energy carriers and efficient conversion technologies. This led to efficiency improvements and some emissions reductions in developed countries, as well as significant gains in health and well-being outcomes in developing regions. Nearly Zero Energy (NZE) Buildings or low-energy Buildings are achievable in all regions and climate zones for both new and existing buildings. {9.3; 9.8}	**There is a significant lock-in risk in all regions given the long lifespans of buildings and the low ambition of building policies.** This is the case for both existing buildings in developed countries, and also for new buildings in developing countries that are also challenged by the lack of technical capacity and effective governance. Emissions reductions in developed countries have been outweighed by the increase in population growth, floor area per capita and the demand for electricity and heat. {9.9; 9.3}
The decarbonisation of most industrial processes has been demonstrated using technologies that include electricity and hydrogen for energy and feedstocks, carbon capture and utilisation technologies, and innovation in circular material flows. (TS.5.5) {11.2}	**Industry emissions continue to increase, driven by a strong global demand for basic materials.** Without reductions in material demand growth and a very rapid scale-up of low-carbon innovations, the long lifetimes of industrial capital stock risks locking-in emissions for decades to come. (TS.5.5) {11.2}
Policies and investment	

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Signs of progress	Continuing challenges
The Paris Agreement established a new global policy architecture to meet stringent climate goals, while avoiding many areas of deadlock that had arisen in trying to extend the Kyoto Protocol. (TS 6.3)	**Current national pledges under the Paris Agreement[3] are insufficient to limit warming to 1.5°C with no or limited overshoot, and would require an abrupt acceleration of mitigation efforts after 2030 to *likely* limit warming to 2°C.** (TS 6.3)
Most wealthy countries, and a growing list of developing countries, have signaled an intention to achieve net zero GHG (or net zero CO_2) emissions by mid-century. National economy-wide GHG emissions targets covered 90% of global emissions in 2020 compared to 49% in 2010. Direct and indirect climate legislation has also steadily increased and this is supported by a growing list of financial investors. (TS.6.2)	**Many net zero targets are ambiguously defined, and the policies needed to achieve them are not yet in place.** Opposition from status quo interests, as well as insufficient low-carbon financial flows, act as barriers to establishing and implementing stringent climate policies covering all sectors. (Box TS.6) {13.4}
The global coverage of mandatory policies – pricing and regulation – has increased, and sectoral coverage of mitigation policies has expanded. Emission trading and carbon taxes now cover over 20% of global CO_2 emissions (TS 6). Allowance prices as of April 1, 2021 ranged from just over USD1 to USD50, covering between 9 and 80% of a jurisdiction's emissions {13.6.3}. Many countries have introduced sectoral regulations that block new investment in fossil fuel technologies.	**There is incomplete global policy coverage of non-CO_2 gases, CO_2 from industrial processes, and emissions outside the energy sector**. Few of the world's carbon prices are at a level consistent with various estimates of the carbon price needed to limit warming to 2°C or 1.5°C {13.6}
There has been a marked increase in civic and private engagement with climate governance. This includes business measures to limit emissions, invest in reforestation and develop carbon-neutral value chains such as using wood for construction. There is an upsurge in climate activism, and growing engagement of groups such as labour unions {1.3.3, 5.2.3}. The media coverage of climate change has also grown steadily across platforms and has generally become more accurate over time. (TS 6.2)	**There is no conclusive evidence that an increase in engagement results in overall pro-mitigation outcomes**. A broad group of actors influence how climate governance develop over time, including a range of civic organisations, encompassing both pro-and anti-climate action groups. Accurate transference of the climate science has been undermined significantly by climate change counter-movements, in both legacy and new/social media environments through misinformation. (TS 6.2)

Covid-19

"The impacts of COVID-19 may have temporarily set back development and the delivery of many SDGs. It also distracts political and financial capacity away from efforts to accelerate climate change mitigation and shift development pathways to increased sustainability. Yet, studies of previous shock periods suggest that waves of innovation that are ready to emerge can be accelerated by crises, which may prompt new behaviours, weaken incumbent systems, and initiate rapid reform. Institutional change can be slow but major economic dislocation can create significant opportunities for new ways of financing and enabling 'leapfrogging' investment. Given the unambiguous risks of climate change, and consequent stranded asset risks from new fossil fuel investments, the most robust recoveries may well be those which align with lower carbon and resilient development pathways."

Ross Rutherford

ESR Newsletter Editor

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