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Welcome to the autumn issue of *Planet Earth* magazine. This time we're focusing on one of the most important ways in which the environment threatens people's health throughout much of the world – polluted air.

Whether tiny particles or noxious gases like sulphur dioxide and ozone, air pollutants cause health problems including lung complaints, heart disease and strokes. That's before you even start to look at the other harm pollution can do – causing acid rain, for instance, or endangering food security by damaging crops. It's a particular problem in the developing world, where authorities often have very little information about what's in the air and what it's doing to the people breathing it.

In the UK the problem may be less visible. But it's still more serious than you might think; it's estimated to cause some 29,000 premature deaths every year. This is one case when out of sight definitely shouldn't mean out of mind.

The atmospheric research NERC funds today has potential to help in many different ways. The articles in this issue cover everything from efforts to understand why certain kinds of pollution have stayed so high in London to scientists' investigation of how Indonesian wildfires and Icelandic volcanoes affect air quality, and why when it comes to the new generation of personal pollution sensors the reality falls short of the hype. Other articles look at how air pollution can travel across borders and UK scientists' international efforts to tackle air pollution across the globe including China, India and West Africa.

By the time this magazine reaches you, NERC's *Into The Blue* series of showcase events in the northwest of England will be kicking off. In early October our research ship RRS Discovery is sailing to Merseyside, and then later in the month the UK's advanced atmospheric research aircraft – operated by the Facility for Airborne Atmospheric Measurements (FAAM) – will be in Manchester and open for visits, along with an exhibition of amazing environmental science aimed at enthralling the whole family. An exclusive photoshoot of the two pieces of world-class scientific equipment flying and sailing together off the coast of the Isle of Wight can be seen on page 23 of this edition.

NERC | Into the blue
science we live and breathe

As part of the *Into the Blue* celebrations, in this issue you'll find a fantastic pull-out poster packed with facts about the FAAM plane. If you're in the area, come and join us – to find out more, see **www.nerc.ac.uk/latest/events/blue**. We hope we'll meet as many of you as possible there!

Tackling air pollution: What have we achieved?

NERC invests around £3m a year in air pollution research. Since 1990, NERC-research has influenced policies which have reduced major air pollutants in the UK – generating total benefits worth at least £31bn. In fact, NERC's 2016 impact report estimates the council's investments in managing air pollution could be worth as much at £82bn to the UK economy, based on an analysis commissioned from Deloitte. These benefits arise largely from reductions in premature deaths, as well as from damages to crops and buildings and from avoided damage to ecosystems.

NERC research fed into the first international treaty on acid rain, the 1979 Convention on Long-range Transboundary Air pollution (CLRTAP) which obliges countries to cut emissions of sulphur dioxides, ammonia, heavy metals and other pollutants. From 1983, NERC scientists pioneered the first truly international project on acid rain, leading the UK to begin a £6bn programme to cut air pollution.

In the last ten years, large NERC investments includes the Air Pollution Information System, which lets local governments access the environmental impacts of proposed developments. APIS was used to make sure the £25m London Ashford Airport expansion could go ahead. The Clean Air for London projects helps reduce human exposure to particulate matter pollution, and its data was incorporated into the London Air Quality Network website which offers a mobile app used by more than 20,000 Londoners to view daily air-quality reposts and avoid high pollution areas. Other areas of NERC science help individuals manage their exposure to air pollution to boost health and minimise risks to health.

Spotlight on Chinese air quality

Chinese air quality will be in the spotlight next month as UK researchers travel to the country to help investigate what's causing Beijing's air pollution problem and how it's harming citizens' health.

Five teams of UK scientists have joined forces with their Chinese counterparts to carry out new research into an issue affecting millions in China and touching the lives of many more living in the world's biggest cities.

Air pollution poses a serious threat to human health, putting those in polluted urban areas at higher risk of cancer, heart and lung conditions and premature death. The occurrence of 'haze' – a mist of airborne pollutants – has become more severe and frequent in urban areas of China over the past sixty years. Five hundred million people in 86 cities are thought to be affected by it. As a consequence, there has been a rise in associated health conditions, including an increase in asthma and other respiratory problems in children.

The four-year research projects have £5.5m UK backing as part of the Atmospheric Pollution & Human Health in a Chinese Megacity (APHH China) funded by NERC, the Medical Research Council (MRC) and supported by the National Natural Science Foundation of China (NSFC).

The projects include research into the sources and emission of pollutants led by Professor Roy Harrison, University of Birmingham (see page 15), and a study of air pollution processes led by Professor Ally Lewis at the University of York, who will be heading out with his team in November. The link between air pollution exposure and cardiopulmonary disease will be studied in two projects, led by Professor Frank Kelly, King's College London and Dr Miranda Loh at the Institute of Occupational Medicine. The fifth project will concentrate on the socio-economic impacts of the increase of air pollution in Beijing and offer recommendations for management.

'Air pollution will be an increasing challenge as the process of mass urbanisation continues to unfold, particularly in the developing world,' says NERC's chief executive, Professor Duncan Wingham. 'The programme represents an investment in high-quality scientific research in Beijing, where air pollution is already affecting the population's health. It's a pressing issue and the results of this research will help inform action on what can be done to minimise the risks of air pollution.'

Prevention's better than cure for cold-water corals

The UK's oldest Marine Protected Area (MPA) is doing a good job of defending vulnerable and ecologically precious cold-water coral reefs, a new study by scientists at NERC's National Oceanography Centre (NOC) and University College Cork has found.

But the corals are slow to recover from damage, so it's far better to create an MPA seeing as much ecological harm is done by activities like trawling than to react after the event.

The researchers used underwater robots – including Autosub6000, NOC's deep-diving autonomous submarine – to survey a section of the Rockall Trough, off northwest Scotland, before and after the Darwin Mounds MPA was set up around it in 2003.

They found that coral populations remained stable in areas that hadn't been trawled before, but that areas that had previously been trawled before being closed off, still had hardly any live coral even after eight years of protection.

'These findings are a really good example of how NOC's technology and scientific expertise can help inform the management of marine protected areas to get the best possible outcome,' says Dr Veerle Huvnne from NOC, the lead author of the study, which appears in *Biological Conservation*.

The area is where NOC scientists discovered the first UK cold-water corals, a kilometre beneath the surface, in 1998. They named the area after their research ship RRS Charles Darwin. Cold-water coral reefs provide valuable benefits to the wider marine environment, including sheltering a wide variety of fish, including many commercially-important species.

DOI:10.1016/j.biocon.2016.05.030

Ancient mosses created our oxygen-rich world

Without Earth's oxygen-rich atmosphere, life on the planet would be unrecognisable. Apart from anything else you probably wouldn't be reading these words, given that humans would never have evolved.

All that oxygen wasn't always there, though. We know it appeared on Earth in its current form around 2.4 billion years ago, in what's now known as the Great Oxidation Event. But oxygen didn't approach modern levels in the atmosphere until around 400 million years ago. And for all this development's vital importance, scientists still aren't sure why it happened.

New research led by University of Exeter scientists suggests the first land plants, including the ancient ancestors of modern-day mosses, may have played a key part in this profoundly important shift in the planet's chemical makeup.

'It's exciting to think that without the evolution of the humble moss, none of us would be here today,' says Professor Tim Lenton of Exeter, lead author of the *Proceedings of the National Academy of Sciences* study. 'Our research suggests that the earliest land plants were surprisingly productive and caused a major rise in the oxygen content of the Earth's atmosphere.'

The paper suggests that these early plants, which colonised the land around 470 million years ago, were responsible for raising oxygen levels. Their appearance and development permanently increased the amount of organic carbon being stored in sedimentary rocks, ultimately driving a second oxidation event and establishing a new, stable cycle of oxygen moving between rocks, living things and the atmosphere.

The earliest land plants were simple bryophytes, like moss – non-vascular organisms without vein-like systems to move water and minerals around. The scientists used computer simulations to calculate that by between 420 million and 400 million years ago, bryophytes could have caused modern levels of atmospheric oxygen.

DOI:10.1073/pnas.1604787113

New evidence links bee decline to pesticides

Researchers have found more evidence connecting the use of neonicotinoid pesticides to the long-term decline of wild bee populations.

The study, published in *Nature Communications*, was led by scientists at NERC's Centre for Ecology & Hydrology (CEH). It analysed data on changes in the occurrence of 62 wild bee species against patterns of oilseed rape cultivation between 1994 and 2011 – the period over which neonicotinoid use became common.

The researchers found clear evidence linking the pesticides to large-scale, long-term decline in bee communities. On average the decline was three times stronger in species that regularly feed on oilseed rape, such as the buff-tailed bumblebee (*Bombus terrestris*), than on species that forage on a wide range of flowers. This suggests that oilseed rape – whose seeds are generally treated with neonicotinoids to provide protection from pests – is one of the main ways in which bees are exposed to neonicotinoids.

'As a flowering crop, oilseed rape is beneficial for pollinating insects,' says lead author Dr Ben Woodcock of CEH. But he adds that this benefit 'appears to be more than nullified by the effects of neonicotinoid seed treatment on a range of wild bee species.' He cautions, though, that neonicotinoids are unlikely to be the only factor in bees' decline – other problems have also played a part, including the fragmentation and loss of pollinator-friendly habitats, the spread of diseases, climate change and the effects of other insecticides.

The researchers worked with data provided by Fera Science Ltd and the Bees, Wasps and Ants Recording Scheme. Their study forms part of a growing body of evidence that neonicotinoids have contributed to the trouble many bee species, both wild and domesticated, are in. A review of the risks these pesticides pose by the European Food Standards Authority is underway, and is expected to be completed by January 2017.

Climate change reshuffling UK wildlife calendar

The changing climate is already affecting wildlife in the UK in many ways. One of the clearest is the difference it's making to the seasonal timing of natural events like flowering in plants and breeding in birds.

A new paper published in *Nature* suggests that seasonal events are generally more sensitive to changing temperatures than to shifts in rainfall or snow. And plants and animals are responding differently to temperature changes depending on when they happen in the year.

'This is the largest study of the climatic sensitivity of UK plant and animal seasonal behaviour to date,' says Dr Stephen Thackeray of NERC's Centre for Ecology & Hydrology (CEH), the paper's lead author. 'Our results show the potential for climate change to disrupt the relationships between plants and animals, and now it is crucially important that we try to understand the consequences of these changes.'

These shifts in seasonal timing can have profound effects on ecosystems, particularly since species with different ecological positions are changing their annual schedules at different rates. For example, if an insect species starts appearing later in the year, birds that depend on it for food may go hungry. If they can't find other prey or otherwise adapt, they may struggle to breed and raise their young. Over time, the biodiversity of UK landscapes could suffer badly. The study suggests animals in the middle of food webs, such as insects that feed on plants but are themselves food for other animals, are likely to change their seasonal behaviour most in future.

CEH scientists worked on the study alongside experts from 17 other institutions. They looked at more than 370,000 observations of seasonal events between 1960 and 2012, covering 812 marine, freshwater and land plant and animal species – from plankton to wildflowers and moths to mammals.

DOI:10.1038/nature18608

Ocean heatwave wipes out Australian kelp forests

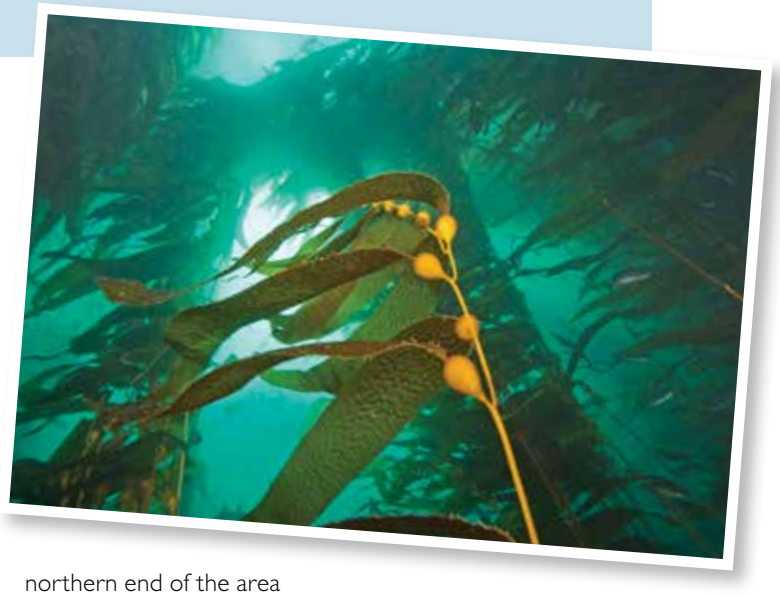
New research suggests that extremely high sea temperatures in 2011 killed large areas of kelp forest in the waters off Western Australia, and that five years on there's little sign they are recovering.

Kelp forests are extremely diverse and productive ecosystems, providing food and shelter for many marine plants and animals. Their widespread loss is likely to have serious knock-on effects in many other areas.

'Temperatures during the 2011 marine heatwave exceeded anything previously experienced by these kelp forests and they collapsed,' says lead author Dr Thomas Wernberg of the University of Western Australia.

The study, published in *Science*, analysed data collected between 2001 and 2015 along 2000km of coastline. It shows that coming on top of decades of more gradual ocean warming, the heatwave broke down long-standing patterns in the distribution of life on the seabed. Five years on, many cool-water fishes, seaweeds and invertebrates have disappeared and been replaced by ecological communities more like those found in the tropics.

Tropical grazing fish in particular have multiplied and are now preventing kelp from re-growing – especially at the northern end of the area the scientists looked at, where kelp forests have disappeared entirely from more than 100km of coastline.



'The Western Australia study represents a compelling example of how quickly temperate marine ecosystems can undergo fundamental and widespread shifts in structure in response to extreme sea temperatures,' comments Dr Dan Smale, a NERC-funded Independent Research Fellow at the Marine Biological Association and one of the paper's authors. 'Given that most ocean regions are warming rapidly, we can expect similar changes to occur elsewhere in the future, with significant socioeconomic implications.'

DOI: 10.1126/science.aad8745