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BRIEFINGS

Climate Change & Environment

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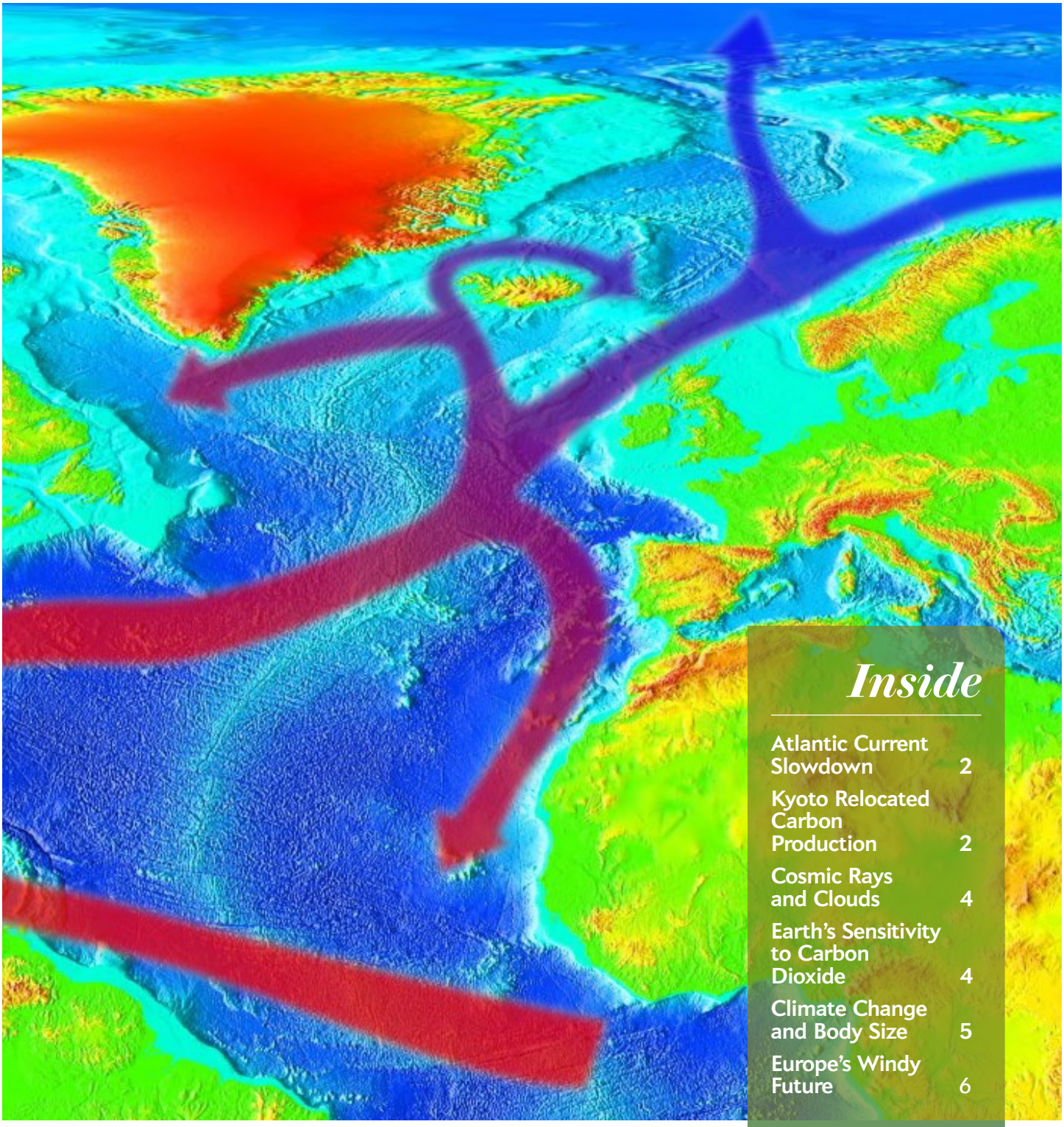

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BRIEFINGS

Scientific American **Briefings: Climate Change & Environment** consists of summaries of recent peerreviewed articles from the scientific literature. It draws these summaries from the journals of Nature Publishing Group, including *Nature*, *Nature Climate Change*, *Nature Geoscience*, *Nature Physics* and the *Nature Reviews* journals.

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OCEANOGRAPHY

Atlantic current slowdown

RESEARCHERS HAVE long theorized that the ocean's thermohaline or meridional overturning circulation — an ocean "conveyor belt" driven by temperature and salinity gradients, which includes the warm North Atlantic Gulf Stream — might slow down as a result of climate change. But this has proven difficult to measure.

Uwe Send of the Scripps Institution of Oceanography in California, and colleagues, looked at readings from three moored buoys that are part of the Meridional Overturning Variability Experiment (MOVE) array, anchored at either end of a single 1,000-km strip running eastwards from Guadalupe, north of Venezuela. Data from January 2000 to June 2009 showed a 20 percent decrease in deep-ocean southward flow across this line. This is the first direct observation of interannual and decadal variability in this current, the team reports.

The slowdown is probably a result of natural variability rather than climate change, the team says, and is likely to reverse within a few years. Understanding such fluctuations is important for climate prediction, and more data will come from the Rapid Climate Change Project's array of 20 moored instruments, installed in 2004 between the Canary Islands and the Bahamas.

—Nicola Jones,
Nature Climate Change

- *Geophys. Res. Lett.* doi: 10.1029/2011GL049801 (in the press)

ECOLOGY

Moving trees

CLIMATE CHANGE is expected to lead to significant shrinkage and/or shifting of habitat for many species. As a result there is growing interest in proactive adaptation strategies, perhaps the most controversial of which is assisted colonization, in which species are moved to new suitable habitat that they could not have reached on their own.

SCOTT VICKERS/ISTOCKPHOTO

Hillside fires in California.

Conservation biologist Helen Regan, at the University of California, Riverside, USA, and colleagues focused on Tecate cypress, a rare fire-dependant tree found in California. They tracked the impacts of climate change on the tree's habitat to investigate whether assisted colonization could help offset threats, such as habitat loss and altered fire regimes.

The results suggest that assisted colonization could be an effective risk-minimizing strategy, so long as there are suitable sites nearby and translocated trees are able to establish successfully. However, assisted colonization may be ineffective where other threats are ongoing, such as where humans have increased the rate or severity of fire outbreaks.

—Alastair Brown,
Nature Climate Change

- *Glob. Change Biol.* doi: 10.1111/j.1365-2486.2011.02586.x (2011)

EMISSIONS TRADE

The effects of Kyoto

THE KYOTO Protocol, which came into force in 2005, was the first multilateral attempt to cap carbon emissions. Its effects on national emissions are debatable, however, because it may encourage so-called carbon leakage, in which carbon-intensive production is relocated outside national borders.

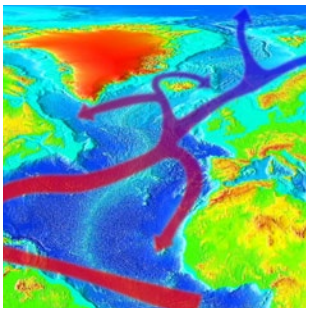
Rahel Aichele and Gabriel Felbermayr of the University of Munich, Germany, compiled a set of annual data on the carbon footprint — the sum of domestic carbon emissions and net emissions embodied in trade — of 40 countries from 1995 to 2007. Their model allowed them to isolate the impact of the protocol commitments on domestic emissions from the impact on the overall carbon footprint. The researchers also estimated the impact of the protocol on the carbon-import ratio — the amount of emissions embodied in imports relative to domestic emissions. An increase in the ratio indicates that carbon leakage has occurred.

SASHA RADOSAVLJEVIC/ISTOCKPHOTO

They found that, on average, the Kyoto commitments have reduced domestic emissions by 7 percent, but the carbon-import ratio increased on average by about 14 percent. This implies a substantial relocation of carbon-intensive production; carbon leakage cancelled out the domestic savings, rendering carbon footprints unchanged.

—Monica Contestabile,
Nature Climate Change

- *J. Environ. Econ. Manage.* doi: 10.1016/j.jeem.2011.10.005 (2011)



ON THE COVER

The North Atlantic Gulf stream, part of the ocean's thermohaline circulation system, exerts a significant influence on the hemisphere's climate. Studies have begun to measure its natural variability. See page 2.

Credit: RedAndr/Wikimedia Commons

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ISTOCKPHOTO/LUOMAN

Logging site in the Amazon.

FORESTRY

Selective logging

TROPICAL DEFORESTATION contributed about 16 percent of the total anthropogenic carbon emissions between 2000 and 2006. In addition to releasing carbon into the atmosphere, deforestation changes land surface reflectivity, which affects regional temperature and precipitation patterns. Reduced-impact logging, which selects certain valuable trees, is intended to minimize disruption of the forest canopy, but the effect of this logging practice on land–atmosphere carbon exchange has not been well quantified.

Scott Miller of the Atmospheric Sciences Research Center at the State University of New York, US, and co-workers measured carbon dioxide exchange and various ecological parameters to investigate the effects of selective logging on carbon exchange in an old-growth Amazonian forest.

Results suggest that the logging caused small decreases in primary production, leaf production and latent heat flux, and increases in respiration, tree mortality and wood production. The net effect of reduced-impact logging was short lived and effects were barely discernible after only one year. The authors suggest that reduced-impact logging provides a potential strategy for managing tropical forest that minimizes risks to the climate.

—Alastair Brown,
Nature Climate Change

- *Proc. Natl Acad. Sci. USA* doi: 10.1073/pnas.1105068108 (2011)

TECHNOLOGY

Liquid hydrogen

FUEL-CELL CARS — which run on hydrogen and emit only water from their tailpipes — offer a compelling way to reduce transport emissions. However, manufacturers have struggled to find ways of safely storing enough hydrogen in a car for long journeys.

Researchers have now taken a step towards an alternative: storing the hydrogen as a liquid. University of Oregon chemist Shih-Yuan Liu and colleagues report the creation of a new material: *BN*-methylcyclopentane, a five-membered cyclic amine borane that is a stable liquid at room temperature and pressure. When a cheap iron chloride catalyst is added, three of these rings chemically join together, releasing hydrogen in the process.

Liu's work was funded by a US Department of Energy project that is aiming to develop a viable liquid or solid storage mechanism for hydrogen fuel by 2017. The team is now working to make recycling of their starting material cheaper and more energy efficient.

—Nicola Jones,
Nature Climate Change

- *J. Am. Chem. Soc.* doi: 10.1021/ja208834v (2011)

GENE CHUTKA/ISTOCKPHOTO

CLIMATOLOGY

Teak record for Burma

THERE ARE few long-term instrument-based climate records in Asia, so researchers turn to natural records instead. This includes tree rings from species, such as teak, that have identifiable rings from the wet and dry seasons in the tropics. In 2010, a tree-ring atlas of droughts and monsoons in Asia over the last 1,000 years was published but some countries were not represented in the regional study.

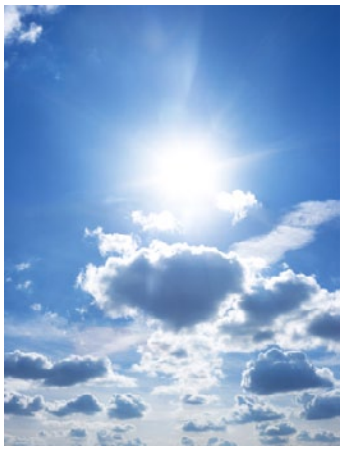
Now, Rosanne D'Arrigo of the Tree-Ring Laboratory at the Lamont-Doherty Earth Observatory in New York, and colleagues, have looked at teak samples from Burma's Maingtha Reserve Forest, revealing a climate record stretching from 1613 to 2009. Their results match well with those from neighboring countries, D'Arrigo's team reports. They recommend stitching together more such records, although intense logging makes it hard to find long-lived trees.

—Nicola Jones,
Nature Climate Change

- *Geophys. Res. Lett.* doi: 10.1029/2011GL049927 (in the press)
  Science doi: 10.1126/science.1185188 (2010)

ASTROPHYSICS

Cloud maker



ISTOCKPHOTO

DO COSMIC rays and solar activity affect our climate? Researchers have proposed that cosmic rays, which hit Earth in greater quantities when sunspot activity lulls, might help to nucleate cloud particles and thus cool the Earth. A long-anticipated particle physics experiment designed to test this link — CLOUD (Cosmics Leaving Outdoor Droplets) — has now yielded its first results.

The experiment, based at Europe's particle-physics laboratory CERN, near Geneva in Switzerland, uses a particle beam to mimic cosmic rays in an ultra-clean steel cloud chamber, where temperature, water vapor and other atmospheric constituents can be carefully controlled. The team aims to quantify the roles of various gases in nucleating the precursors of cloud particles, so that these numbers can be plugged into climate models.

CERN's Jasper Kirkby and colleagues report that sulphuric acid and ammonia vapors can enhance nucleation by up to a factor of ten under the conditions they studied. However, the nucleation rate within CLOUD was, surprisingly, only one tenth to one thousandth of what happens in the real world, so other vapors — perhaps amines — must play a big role. CLOUD will tackle that question next.

—Nicola Jones,
Nature Climate Change

■ Nature doi: 10.1038/nature10343 (2011)

MODELING

Slower warming

HOW MUCH will our planet warm if carbon dioxide levels double from pre-industrial levels? In other words, what is the planet's "sensitivity" to carbon dioxide?

This has proven a hard question to answer, mainly because of uncertainty about how aerosols and the ocean alter heating effects. The 2007 Intergovernmental Panel on Climate Change report set out a best estimate of 3 °C, with a 66 percent chance that the true answer lies between 2 °C and 4.5 °C, and a slight but real possibility of more than 10 °C of warming.

ALXPIN/ISTOCKPHOTO

Now, Andreas Schmittner of Oregon State University, and colleagues, have produced a more precise answer by using a more complete temperature reconstruction of the last ice age — 21,000 years ago — than was previously available. Their warming estimate is 2.3 °C, with a 66 percent chance the answer lies between 1.7 °C and 2.6 °C. More than 6 °C of warming, the researchers conclude, would be implausible.

The latest estimate doesn't fully cover the impact of ice sheets, vegetation or clouds on climate sensitivity, so the numbers shouldn't be taken as definitive, the researchers caution.

—Nicola Jones,
Nature Climate Change

■ Science doi: 10.1126/science.1203513 (2011)

CARBON STORAGE

When peat dries

PEATLANDS LOCK away the large quantities of carbon that build up in these water-saturated environments owing to the presence of phenolic compounds, which inhibit microbial decomposition. Phenolic concentrations remain high in peatlands because anoxic conditions limit the activity of the enzyme responsible for their breakdown. However, droughts introduce oxygen into these systems, and the frequency of these events is increasing.

Nathalie Fenner and Chris Freeman of the Wolfson Peatland Carbon Capture Laboratory at Bangor University in Wales, UK, used *in vitro* manipulations, mesocosm experiments and field observations to examine the impact of drought on peatland carbon.

They found that drought stimulates bacterial growth and activity of the enzyme phenol oxidase, reducing the concentration of phenolic compounds in peat. This further stimulates microbial growth, causing the breakdown of organic matter and the release of carbon dioxide. Furthermore, they show that re-wetting the peat accelerates carbon losses to the atmosphere, owing to drought-induced increases in nutrient and labile carbon levels, which raise pH and stimulate anaerobic decomposition. These findings suggest that severe drought, and subsequent re-wetting,

could destabilize peatland carbon stocks.

—Alastair Brown, Nature Climate Change

■ Nature Geosci. doi: 10.1038/ngeo1323 (2011)

BIOLOGY

Growing up too fast

FOR ECTOTHERMS — cold-blooded animals, including reptiles and amphibians, which cannot regulate their temperature through their own metabolism — environmental temperature changes "literally change the pace of life," according to Wenyun Zuo, of the University of New Mexico in Albuquerque, and colleagues.

Ectotherms develop from infancy to adulthood more quickly in warmer conditions, and increase their body mass faster too. Most ectotherms follow a temperature-size rule, whereby the warmer the temperature, the smaller the animal is at maturity. But for about 15 percent of species, the reverse holds: the warmer it is, the larger they get.

ZIVA K/ISTOCKPHOTO

Salamanders and other ectotherms develop faster in a warmer world.

Zuo's team explains this oddity with a simple mathematical model, in which the rate of biomass accumulation and the pace of maturity have different temperature dependences. The usual size rule applies for those animals in which temperature has a stronger affect on development rate than on body mass accumulation. The model shows that these animals not only mature more quickly at warmer temperatures, but also use less energy to do so, giving them an evolutionary advantage in most conditions. Their model could be used to predict the effects of climate change on various species' body sizes, the authors say.

—Nicola Jones, Nature Climate Change

■ Proc. R. Soc. B doi: 10.1098/rspb.2011.2000 (2011)

CLIMATE CHANGE

Winter breezy, dry and dusty

HIGH-LATITUDE CLIMATE changes can have serious consequences for East Asia. Previous studies have found that, for example, changes in westerly winds and the Mongolian high-pressure system are the reasons behind the increasing episodes of desertification, sandstorms and "muddy rain" in China.

A new study led by Youbin Sun at the Chinese Academy of Sciences in Xi'an has now found that rising temperatures in Greenland may strengthen winter monsoons, promote dust storms and reduce summer precipitation in East Asia.

The researchers performed grain-size analysis and optical dating on loess soils obtained from Jingyuan County, Ningxia, and Gulang County, Gangsu — both located in the depocenter of modern dust storms. Because the grain size of loess soil reflects changes in winter monsoon strength, they were able to reconstruct a record of winter monsoon intensity over the past 60,000 years.

The researchers found strong correlations between East Asian winter monsoon, Greenland ice-core and Chinese cave records. They suggest that temperatures in Greenland may have a direct effect on the winter monsoon intensity, dust grain size and summer monsoon precipitation over East Asia. If this is true, rising temperatures in Greenland are likely to bring increasing episodes of natural disasters.

—Felix Cheung, Nature China

■ Nature Geosci. doi:10.1038/ngeo1326 (2011)

CLIMATE CHANGE

The growth of dying seas

ALEJANDRO DIAZ/WIKIMEDIA COMMONS

Ocean dead zone, featuring a red algal bloom, off the coast of San Diego, Calif.

OXYGEN-DEPRIVED DEAD zones in coastal waters around the world have expanded exponentially since the 1960s and are likely to increase further in a warming climate.

Markus Meier of the Swedish Meteorological and Hydrological Institute in Norrköping and his colleagues used a group of physical–biogeochemical models, driven by data from regional climate models, to project the effects of climate change and changes in nutrient cycles on oxygen conditions in the Baltic Sea.

Most scenarios suggested that oxygen-depleted zones at the bottom of the sea would expand by the end of the century. Driving factors include rising nutrient input from river runoff; reduced oxygen flux from the at-

mosphere to the ocean; and increased oxygen consumption by surface-level organisms that are fed by the boost in nutrients. Similar changes can be expected for coastal oceans worldwide, the authors say.

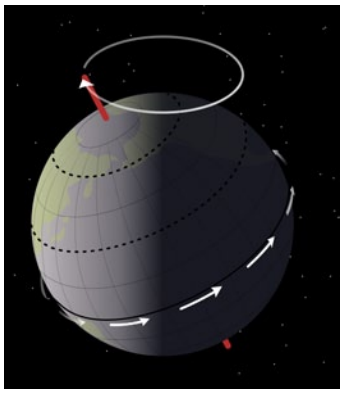
—Quirin Schiermeier, Nature

- *Geophys. Res. Lett.* doi: 10.1029/2011GL049929 (2011)

CLIMATE

Precession control

MARINE SEDIMENT analyses suggest that over the past 400,000 years, the hydrological cycle over the Western Pacific warm pool was controlled by local incoming solar radiation.



NASA

Precession of earth.

Kazuyo Tachikawa and colleagues at Aix-Marseille University, France, determined the geochemistry of marine sediments and associated fossils in a core collected from the northern coast of Papua New Guinea. Using the abundance of elements typically found in the rocks of the island, they reconstructed river run-off, and hence precipitation, over the past four glacial–interglacial cycles. Somewhat surprisingly, precipitation intensity was seemingly unrelated to the glacial cycles. Instead, changes in rainfall were closely linked with the precession of the Earth's orbit, which strongly influences insolation in the tropics on a 23,000-year cycle.

Records in other parts of the warm pool that do show glacial–interglacial shifts in precipitation could reflect the effects of glacial reduction of sea level, which eliminated the shallow seas that serve as a moisture source to the neighboring islands.

—Alicia Newton, Nature Geoscience

- *Quat. Sci. Rev.* doi: 10.1016/j.quascirev.2011.09.016 (2011)

ATMOSPHERIC SCIENCE

Windy future

CLIMATE CHANGE is anticipated to lead to more frequent wind storms in Europe with an associated boost in the incidence of dangerous sea conditions, coastal flooding and property damage. Some modeling studies indicate that an increasing storm trend may already be detectable in observational records, but robust evidence has been missing.

Markus Donat, of the Climate Change Research Centre at University of New South Wales, Sydney, and his co-workers used a newly developed atmospheric reconstruction for the period 1871–2008 to calculate two different measures of storminess — storm frequency and local wind speeds — for six regions across Europe.

In addition to pronounced decadal-scale variability, the researchers found a distinct increase in wind-storm activity towards the end of the twentieth century, which was particularly clear in the North Sea and Baltic Sea regions. It is not yet clear whether this trend can be attributed to climate change.

—Alastair Brown, Nature Climate Change

- *Geophys. Res. Lett.* doi: 10.1029/2011GL047995 (2011)

BIOFUEL

Fuel or housing?

PLUSPHOTO/ISTOCKPHOTO

Cornfields outside Chicago.

SUBSTANTIAL INCREASES in corn production will be required in the United States to meet the 2020 biofuel targets set by the 2007 Energy Independence and Security Act. Initially these targets will consist entirely of corn-starch-based fuels, and the productive Midwest is likely to bear the brunt of these policy goals.

Megan Mehaffey and her colleagues at the US Environmental Protection Agency investigated the landscape changes required to meet these biofuel targets. Their model suggests that 25 million acres of farmland in the American Midwest will need to switch from crop rotation to full-time corn production, with several regions increasing full-time corn production by more than 50 percent. At the same time, urban growth by 2020 is expected to cover more than seven million acres of farmland, potentially pushing corn production into smaller, more intensive areas or onto lower-quality land.

The model indicates where landscape changes are likely to occur, and should help policymakers to evaluate the trade-offs between economic benefits and ecosystem services offered by different land-management options.

—Alastair Brown, Nature Climate Change

- *Ecol. Soc. Am.* doi: 10.1890/10-1573.1 (2011)

ADAPTATION

Coffee futures

IN MAY 2008, tropical storm Alma struck Costa Rica bringing floods and landslides that caused misery to thousands, loss of croplands and US$35 million in damages.

A few months later, Francisco Alpizar of the Environment for Development Centre in Turrialba, Costa Rica, and his colleagues investigated around 200 coffee farmers' attitudes towards investing in adaptation measures to prevent future losses. In an experiment, 95 percent of farmers in the Tarrazu valley, which had been badly hit by Alma, told the researchers that they would invest in adaptation if there was a 10 percent chance of being hit by an extreme weather event. This dropped to 77 percent if there was a 5 percent chance and 31 percent if there was just a 1 percent chance. When the farmers weren't told what their risk was, half of those who had said that they wouldn't invest in adaptation at a 5 percent risk hedged their bets and decided to invest.

JFMDESIGN/ISTOCKPHOTO

When neighboring farmers of differing risk levels were grouped, and told they could pool their resources and share adaptation costs, 69 percent of the groups said they would invest, irrespective of their individual risk.

—Monica Contestabile, Nature Climate Change

■ *Ecol. Econ.* doi: 10.1016/j.ecolecon.2011.07.004 (2011)