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IN THIS ISSUE

EDITORIAL

The **biodiversity** gamble

Missing the Biodiversity Target of slowing biodiversity loss by 2010 sent a shock wave through the international community that may yet prove to be salutary. The news created a sense of urgency which favoured the adoption of the Nagoya Biodiversity Compact in October 2010. As readers may recall, the compact fixes some ambitious targets to 2020, including those of halving the loss of natural habitats and increasing nature reserves from 12% to 17% of the world's land area and from 1% to 10% of coastal and marine areas.

Governments also agreed in Nagoya on the need to create a body to evaluate progress in reaching these targets. Known as the Intergovernmental Science–Policy Platform for Biodiversity and Ecosystem Services (IPBES), this body will be cosponsored by UNESCO, UNEP, FAO and UNDP. The Secretariat's location should be known in April, when the results of a competitive bidding process are announced at the second IPBES plenary.

The question is, will the biodiversity targets to 2020 suffer the same fate as the 2010 Biodiversity Target? Or is there now sufficient awareness of how much humanity stands to lose if it allows the rate of extinctions to continue at the same alarming pace? The figures speak for themselves: 70% of all known plant species are threatened, 35% of invertebrates, 30% of amphibians, 22% of mammals…

Climate regulation, water purification and soil fertility are all dependent on biodiversity, yet these crucial ecosystem services are being crippled in many parts of the world by pollution, habitat loss and other stresses like human population growth: the number of *Homo sapiens* officially hit the 7 billion mark on 31 October.

Everyone agrees on the need to protect ecosystem services but conservation also has to be financially feasible. One approach is to 'pay the protector.' In the Serra do Espinhaço Biosphere Reserve in Brazil, home to no fewer than three biodiversity hotspots but also the most intensely mined biosphere reserve in the world, an ecotax provides revenue for municipalities with large protected areas, as we shall see in this issue.

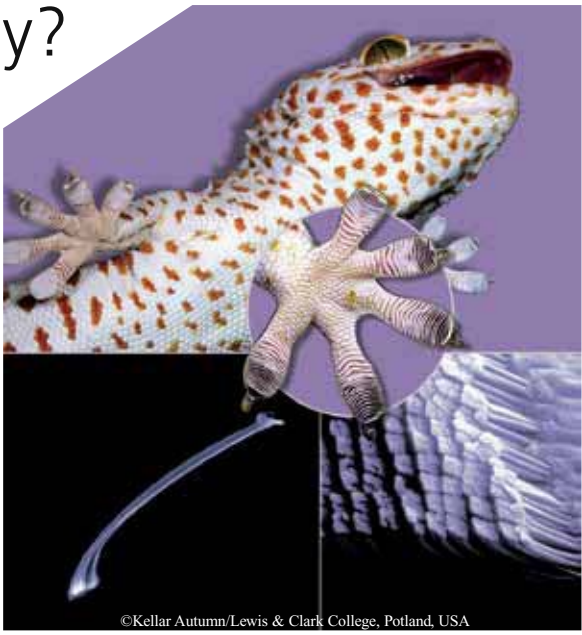
UNESCO was instrumental in the adoption of an International Decade of Biodiversity to 2020, one aim of which will be to explain why we, as humans, have so much to gain from maintaining the planet's biological diversity. In an article beginning overleaf, Thomas Lovejoy gives us a glimpse into what the future might hold for biodiversity… and hence for us.

At the risk of concluding this editorial on a low note, the financial difficulties UNESCO is encountering at the moment oblige me to turn *A World of Science* into a purely e-journal in 2012. If you are not an e-subscriber and would like to receive an e-mail alert each time the journal appears, simply register at *www.unesco.org/en/a-world-of-science*. If you would like to express your support for the journal or for UNESCO's work on the ground, the Director-General has set up a 'Donate to UNESCO' portal at *www.unesco.org*.

Gretchen Kalonji
Assistant Director-General for Natural Sciences

What future for biodiversity?

As UNESCO prepares to publish the proceedings of the scientific meeting which launched the International Year of Biodiversity in January 2010, we take a moment to recall some of the major challenges facing biodiversity, in an article from the proceedings written by a legend in the field of conservation biology, Thomas Lovejoy, the man who coined the term 'biological diversity' back in 1980 and to whom we owe the concept of debt-for-nature-swaps, conceived during his time as director of the World Wildlife Fund's conservation programme (1973–1987).



The paws of a gecko have the best-known adhesive. This small reptile can develop a force of contact of over 100 kg. More and more, scientists are looking to biodiversity for inspiration in developing innovative products, in what is known as biomimicry.

As we embark upon the International Decade of Biodiversity (2011–2020), it is remarkable that we still have such an incomplete overall sense of the variety of life forms with which we share a four billion-year heritage.

Certainly, the outlines of life on Earth have become clearer in recent decades. The two sturdy trunks (plants and animals) of the Tree of Life of my childhood classroom in the 1950s have been replaced in one presentation by something akin to a low spreading bush, with three terminal branches on one side representing plants, fungi and animals. The rest represents a variety of micro-organisms, many deriving from the early history of life. Many have strange appetites and metabolisms that make them potentially useful for industrial purposes and remediation. We now know there are entire biological communities which depend on the primal energy of the Earth (chemosynthesis), rather than on solar energy through photosynthesis, and that organisms live kilometres below the surface of the Earth.

The exploration of life on Earth: one of the great scientific challenges

Yet, even the more obvious groups like plants and animals remain only partially explored and described by science. Joppa *et al.*[1] (2011) take a new approach based upon the number of species described per taxonomist per year; they estimate, for example, that about 18% of the Rubiaceae (the family that includes coffee) remain to be discovered and that, generally for flowering plant families, about 15% remain undescribed. In many cases, this is because the unknowns have small ranges, which means that the number of endangered species per plant family (and in total) is currently underestimated.

Basically, the exploration of life on Earth remains one of the great scientific priorities and challenges: a grand adventure of immense direct and indirect value to society. As US myrmecologist (ant specialist) Edward O. Wilson periodically reminds us, we do not in the end know the number of species on Earth to perhaps even an order of magnitude. There could be ten million, thirty million or one hundred million species, depending on microbial diversity, soil biodiversity and the like.

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Clearly, as the 2005 *Millennium Ecosystem Assessment*[2] revealed with greater clarity than understood before, ecosystems and their constituent biodiversity provide multiple human benefits, ranging from direct harvest benefits to flows of benefits like watersheds, pollination and disaster mitigation – such as the protection mangroves offer from storm surges. Most of the benefits are treated as being free and so are undervalued by society.

*This small tree (*Psychotria bacteriophyla*) in the family of Rubiaceae grows in tropical forests.*

The Bushmaster's venom, or the value of biodiversity

There is a group of completely unacknowledged services provided by biodiversity: knowledge services. It is useful to think of biological diversity as an enormous library, with each species representing a unique set of solutions to a particular and unique set of biological problems. Humans have a huge stake in flourishing life sciences.

Edward O. Wilson once calculated that the amount of information (as a computer would count) in a single strand of DNA from a chromosome of a species like the domestic mouse was equivalent to the information in all editions of the *Encyclopedia Britannica* combined.

Today, hundreds of millions of people live longer, oblivious to the benefit conferred by a nasty snake in a faraway rainforest.

©Christopher Murray/Wikipedia

Bushmaster snake (Lachesis muta)

A compelling example of value to the life sciences involves the Bushmaster, a poisonous viper native to the tropical forests of Latin America. Its venom is quite effective and generally ends in death for the prey by driving blood pressure to zero. Scientists at Brazil's Butantan Institute in São Paulo studied the mechanism and uncovered a previously unknown system of blood pressure regulation in mammals, the angiotensin system. That was interesting but not instantly practical because snake venom taken as an oral medicine is neither poisonous nor practical because the digestive system simply denatures the protein, much as an egg white becomes a solid when cooked. Knowledge of the angiotensin system, however, made it possible for pharmacologists at the Squibb Company to devise a compound to work on it. That was given the brand name Capoten and was the first of the angiotensin-converting enzyme (ACE) inhibitors. Today, there are a number of ACE inhibitors and hundreds of millions of people live longer, healthier and more productive lives, oblivious to the benefit conferred by a nasty snake in a faraway rainforest.

An important footnote to this example is that, in the absence of major pharmaceutical industry research in Brazil at the time, the benefits all flowed to developed country corporations rather than to Butantan. The molecule of the Bushmaster's venom was not the medicine. (Nor does that snake species occur only in Brazil.) Had the venom been usable directly as medicine, there are at least some ways today in which the benefit would flow to Brazilian entities. If Brazilian scientists had teamed with foreign pharmaceutical chemists, the benefit flow would have been shared. The important lesson here is that advances often depend on free sharing of scientific information and that a strong national industry could have created an opportunity for Brazil to capture benefit nationally more easily.

Another example of a knowledge service: PCR

In 1993, the American Kary Mullis received the Nobel Prize in Chemistry for conceiving of the Polymerase Chain Reaction. Known by its acronym of PCR, it is widely included in press stories with almost no reference to what it is or its history. PCR is an extraordinary magnifying reaction that allows tiny amounts of DNA to be multiplied thousands of times over in a very short time. This has revolutionized diagnostic medicine because, in most instances, it is no longer necessary to culture the suspected disease agent until it can be identified. It has revolutionized forensic medicine. It has made all kinds of science dependent on genetic information either possible or more powerful – including the Human Genome Project – with major benefits to humanity. The Indian economist Pavan Sukhdev believes a proper analysis of the benefits from PCR could total a trillion dollars or more.

The reaction has two parts – heat separating the two strands of a chromosome and an enzyme causing the two separate strands to build their missing partner – repeated over and over again very rapidly. At the time of Kary Mullis's conception, however, there was no known enzyme that could trigger the second part because it had also to be heat-resistant; so, no chain reaction. Eventually, such an enzyme was found in the bacterium *Thermus aquaticus*, recovered from a Yellowstone hot spring in the USA. That was the knowledge service that makes the entire trillion dollar benefit possible.

Capturing the value of biodiversity in decision-making

Much of the value of the biodiversity library is not captured in the decision-making process; nor, for that matter, does it capture many other contributions of nature. If there is to be a sanguine outlook for the future of biodiversity on our planet, that must change. The Economics of Ecosystems and Biodiversity project[3] addresses that specifically and suggests ways in which a lot of that value can be incorporated in economic decision-making. Led by Pavan Sukhdev, its reports were submitted to the Conference of the Parties to the Convention on Biological Diversity in Nagoya in October 2010.

A classic example is that of whether to clear mangroves to create an opportunity for shrimp aquaculture. In the standard economic analysis, there would be no question about going ahead with the shrimp farm. If, however, the subsidies were subtracted, suddenly the choice would not be clear at all. If, in addition, the benefits the mangroves contribute to fishery productivity were added to the equation, the desirability of leaving the mangroves intact would become abundantly clear. That doesn't even include the protection of coastlines and coastal settlements that mangroves provide.

One of the difficult aspects is the use of discount rates – according to which, the less immediate a benefit, the lower its value –, which tend to undervalue benefits to future generations or to the poor, who depend on ecosystems for a significant part of their 'income' (between 39% and 89% of the total, according to studies of specific populations). Another anachronism is that expenditure on disaster relief or medical treatment gets counted in gross domestic product, whereas disaster prevention provided by ecosystems and the benefits of cleaner air or water do not.

I have long been interested in the possible economic analogy to the two forms of biological growth: one whereby the organism simply gets larger and consumes more (such as an alligator) and the other in which the organism does not grow in size, does not consume more but rather grows in complexity[4]. In discussing this with Pavan Sukhdev, I offered the example of a caterpillar becoming a butterfly and the slogan 'an economy like a butterfly' emerged. Perhaps more practical is the notion of moving in that direction from the high consumption growth pattern towards a lower consumption intensity. It would seem wise to do that in a creative fashion before we are left with no choice but to force it upon ourselves.

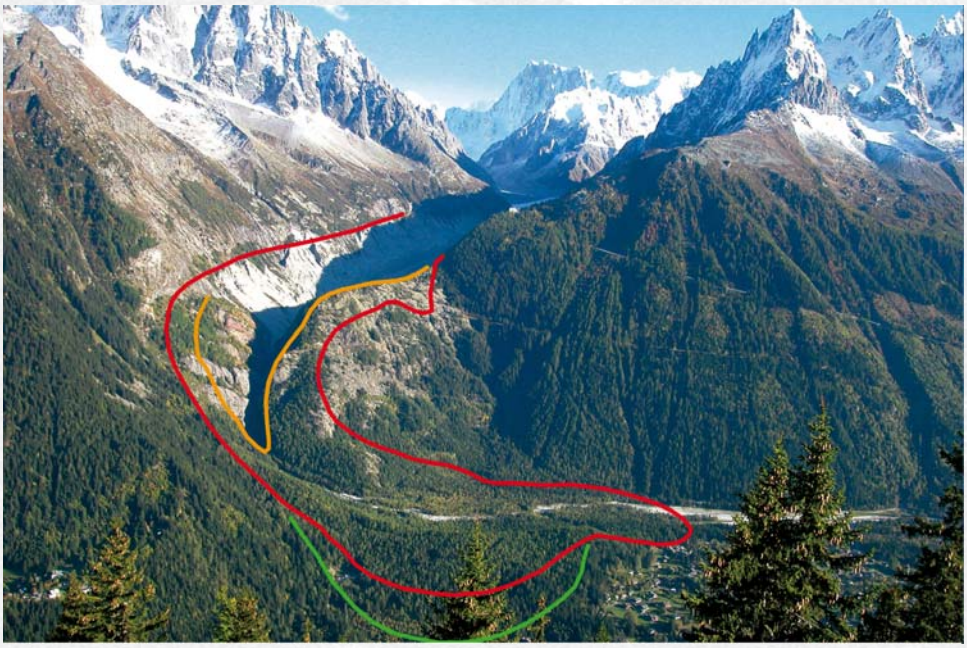
It would seem wise to move from a high consumption growth pattern towards a lower consumption intensity in a creative fashion before we are left with no choice.

Ecosystems have enjoyed a stable climate for 10 000 years

In 1896, the Swedish scientist Svante Arrhenius addressed an extremely important question: why is the Earth a habitable temperature for humans and other forms of life? Why isn't the Earth too cold? The answer in his famous paper was the greenhouse effect and the heat-trapping capacity of certain gases, most notably carbon dioxide (CO_2). It is interesting – in a world that still includes people who deny this venerable and well-tested science – that, with pencil and paper, Arrhenius calculated what the temperature would be for a world with double the pre-industrial levels of CO_2. His result came very close to what the modern super-computer models project.

What Arrenhius would not have known was the actual temperature of the planet over the last hundred thousand years and, in particular, that the planet has had a very stable climate for the past 10 000 years. That period includes all recorded human history, plus some unrecorded history, as well as the origins of agriculture and human settlements. In other words, the entire human enterprise is based on the assumption of a stable climate. That is why, in part, people talk so much about the weather. Over that same 10 000-year period, all ecosystems have adjusted to a stable climate. That has begun to change.

Atmospheric concentrations of CO_2, which were at 280 parts per million (ppm) in pre-industrial times, are now close to 400 ppm. Despite a brief downturn in emissions because of the global recession, emissions are now climbing faster than the worst-case scenario described in the last report of the Intergovernmental Panel on Climate Change



The Mer de Glace on Mont Blanc is the longest glacier in France (7 km), even after retreating by 2 km over the past 150 years. In this photograph from 2003, the lines show the area covered by the Mer de Glace in 1644 (green) and 1821 (red), during the Little Ice Age, and in 1895 (orange). Between 1821 and 1895, the glacier retreated by 1.2 km.

Tropical Cyclone Gonu showed up in an unusual place on 4 June 2007. NASA's Aqua satellite captured this image of the cyclone approaching the northeastern shore of Oman, a region better known for hot desert conditions.

(IPCC, 2007). The planet's climate system is responding with an overall temperature increase of about 0.8°C since 1850.

That increase is already causing dramatic, visible changes in physical aspects of nature, most notably between the solid and liquid phases of water. The summer extent of ice on the Arctic Ocean has diminished dramatically in recent years and the first ice-free Arctic Ocean period is projected to be less than 20 years off. Glaciers are retreating in most parts of the world. Soon, the USA's Glacier National Park, a biosphere reserve, will have glaciers only in name. As for France's alpine glacier known as the Mer de Glace, it is the subject of major efforts to slow its melting. All tropical glaciers will be gone in less than 15 years; some, as in Bolivia, are the main source of water for cities, as in the case of La Paz. That will of course have effects on downslope ecosystems.

Sea-level is rising, originally because of the thermal expansion of water resulting from warmer air temperatures but now because of ice melt, particularly at the poles and in Greenland. The IPCC has consistently underestimated sea-level rise, in part because of its very conservative approach. Sea-level rise, coupled with the natural subsidence of the land, is turning the Blackwater Wildlife Refuge of Maryland's Eastern Shore in the USA into a marine refuge (*see map overleaf*). A greater frequency of major storms and intense tropical cyclones is also being experienced around the world.

Biodiversity is responding to climate change

Not surprisingly, the biology of our planet is also responding to climate change. The first signals have been changes in life-cycle timing. Flowering plants are blooming earlier in the spring in the temperate and boreal regions. Animals are changing their annual cycles, with some bird species, such as tree swallows (*Tachycineta bicolor*) in North America, migrating, nesting and laying eggs earlier than before.

Species are also beginning to change the places where they occur. In North America, Edith's Checkerspot (*Euphydryas editha*), an extremely well-studied butterfly species that does normally roam, has clearly moved northward and upslope. Similar shifts have been observed in some other butterfly species. A recent analysis of many cases shows the distributional changes are happening three times faster than previously recognized.

Indeed, it is clear that this is no longer a matter of anecdotal examples; the change and movement in nature is statistically robust.

Virtually everywhere scientists have looked, nature is on the move. It is happening in the oceans with changing plankton and fish distributions. In Chesapeake Bay in the USA, the sea grass habitats so important for blue crabs and other life forms are very sensitive to rising temperatures: the southern boundary of eel grass, a particular type of sea grass, is steadily moving north year after year.

Change is occurring not just in boreal and temperate regions. In Costa Rica's legendary Monteverde cloud forest, change has been detected not so much in temperature but in moisture. Cloud formation is now occurring more frequently at higher altitudes – a very serious change for an ecosystem almost totally dependent on condensation from clouds for its source of moisture. The first terrestrial extinction from climate change may be the Golden Toad of Monteverde (*Bufo periglenes*).

Photo: Wikipedia

Endemic to the cloud forests of Monteverde (Costa Rica), this Golden Toad may be the first victim of climate change. The most likely contender for its extinction is an outbreak of a highly pathogenic fungus whose growth was encouraged by climate change.

What will the future hold?

These changes are relatively minor ripples in the fabric of life on Earth. The more important question is: what does it look like ahead? One thing is clear: change will be not only be related to temperature but also to moisture. This is typified by the recurrent drought in the American southwest, which persists despite La Niña cycles, and by drying in the Prairie pothole region in the Midwest – the latter being critical to the great North American flyway for migratory waterfowl (*see map overleaf*). Decoupling events are occurring when

Photo: Gordon Robertson/Wikipedia

The Black Guillemot is an ice-dependent species with a circum-polar breeding distribution

Prairie potholes. Stretching over about 715 000 km² either side of the US–Canadian border, the prairie potholes were formed by glaciers scraping over the landscape during the Pleistocene. These depressions form freshwater marshes primarily. Although they are extremely important for birdlife, more than half have been drained.

Phto: US Geological Survey

The snowshoe hare sporting its summer and winter coats

Photos: Walter Siegmund/Wikipedia (summer coat) and US Forest Service

Photo: Walter Siegmund/Wikipedia

The American Pika is a diminutive relative of rabbits and hares. This specimen was photographed in 2008 at an altitude of 600 m in Mount Baker-Snoqualmie National Forest near the Canadian border.

This katydid from the family of Tettigoniidae is also known as a bush-cricket. It tends to prefer a temperate or tropical climate.

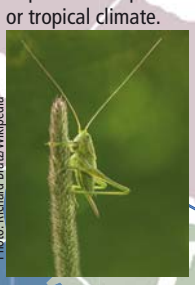


Photo: Richard Bratz/Wikipedia

Seen here in New Hampshire in the autumn, the Sugar Maple is native to northeastern North America, extending as far south as the State of Texas in the USA.

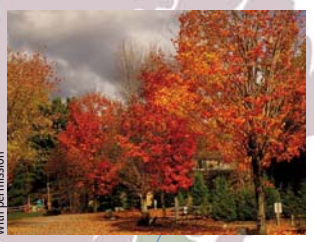


Photo: Jean Pawek, reproduced with permission

Photo: Walter Siegmund/Wikipedia

Checkerspot butterfly photographed in the Olympic National Park in the USA.

During a La Niña event, which can last several years, temperatures in the tropical Pacific Ocean drop to below normal. In the USA, this tends to cause wetter than normal conditions across the Pacific northwest and drier, warmer than normal conditions across the southwest.
The current drought in the southwest (in red) has persisted, however, between La Niña cycles.

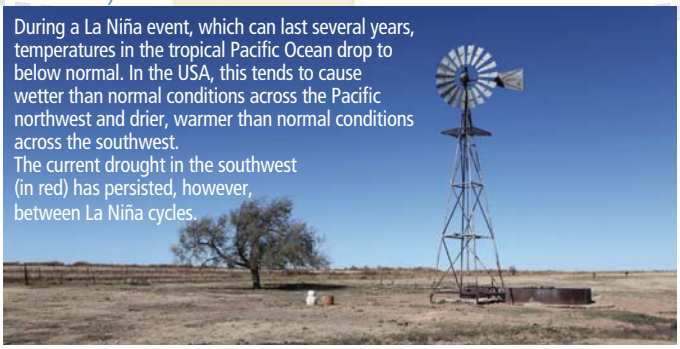


Photo: Wikipedia

RUSSIA
BERING STRAIT
ARCTIC OCEAN
Greenland (DENMARK)
Arctic Circle
USA (ALASKA)
YUKON
CANADA
ROCKY MOUNTAINS
WASHINGTON
Glacier National Park
Yellowstone Park
USA
COLORADO
NEW MEXICO
TEXAS
MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
New York
Pittsburgh
Chesapeake Bay/ Blackwater National Wildlife Refuge
FLORIDA
GULF OF MEXICO
Florida Keys
CUBA
HAITI
DOMINICAN REP.
JAMAICA
CARIBBEAN SEA
Tropic of Cancer

two linked aspects of nature are responding to different timing mechanisms: daylight versus temperature. While the amount of daylight remains the same, the atmosphere is warming at a faster rate than species can evolve to cope with the consequences. Found only in North America, Snowshoe hare (*Lepus americanus*) are now being caught against a snowless background with their bright white winter pelage – making them totally obvious for predators. Black Guillemots (*Cepphus grille*) nesting on the Arctic Ocean shore of Alaska fly to the edge of the Arctic Ocean ice to feed on Arctic cod. Now, with more of this ice melting in summer than before, they must fly farther on the round trip from their nests – so far, in fact, that at least one nesting colony has failed.

Looking ahead for species with well-understood requirements, it is possible to project where those conditions might occur. For the Sugar Maple (*Acer saccharum*), so well known for its autumn foliage (see photo), as well as for maple syrup and sugar, its home will be in Canada once CO_2 levels climb to twice that of the pre-industrial area. In fresh waters, cold water species like trout will certainly have their ranges changed, if not reduced or even eliminated.

Species which live at high altitudes, like the American Pika (*Ochotona princeps*), isolated populations of which can be found at high points in the Rocky Mountains, will move upward like the Checkerspot until, finally, there is no further up to go. A projection for endemic vertebrates in the rainforests of Eastern Australia shows a major loss of species with a warming climate; some of the species seem very sensitive to warmer temperatures physiologically.

Coastal species will be affected by sea-level rise but may successfully move inland. Species on low-lying islands, like the Key Deer in the Florida Keys, will have nowhere to go. Those on higher islands may in the end run out of a suitable microclimate and be unable to move on.

More worrisome, ecosystem failure is already being recorded. One example concerns tropical coral reefs, which are particularly sensitive to warmer water. That causes the fundamental partnership of the coral ecosystem between the coral animal and an alga to break down. The coral expels the alga, which leads to a 'bleaching event' in which the diversity, productivity and benefits to local communities crash – almost as if the lights go out. Only first recorded in 1983, bleaching events are occurring with greater frequency every year, making the future prospects for tropical reefs quite grim.

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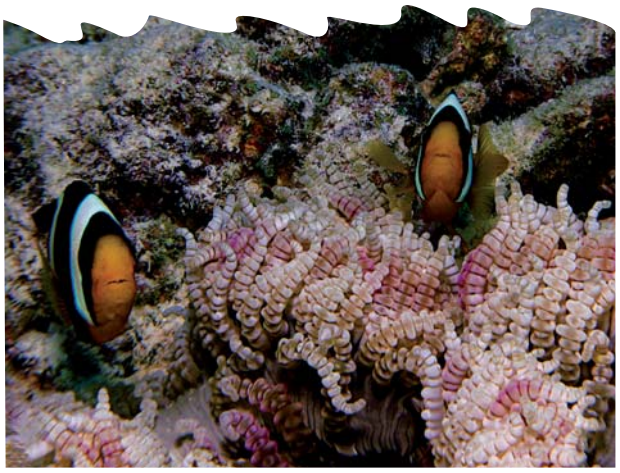


Clownfish among coral on reefs at Baa Atoll in the Maldives, which joined UNESCO's World Network of Biosphere Reserves last year.

Will bricks and mortar prevent some species from dispersing?

On land, another case of ecosystem failure – or at least major ecosystem transformation – is being observed in the coniferous forests of western North America. From Alaska to Colorado, there is massive coniferous tree mortality from longer summers and milder winters, tipping the balance in favour of the native bark beetles which at high density kill the trees, which feed on dead trees. The growing mass of dry, rotting wood is creating an enormous fire hazard and forest management problem, making it hard to imagine what those ecosystems will become.

Looking ahead, it appears that there will be greater and more complex ecosystem disruption. One cause will be the interaction between species dispersal and human modification of landscapes.

Climate change, of course, has always been a part of life on Earth. Glaciers came and went in the great Pleistocene (*circa* 2.5 million – 11 700 years ago) ice ages, with little apparent loss of biodiversity. Species clearly were able to track their required conditions.

Landscapes have been highly modified by human use, basically creating obstacle courses which could prevent species dispersal in reaction to climate change and cause extinction. .

Today, however, landscapes have been highly modified by human use, basically creating obstacle courses to dispersal. The degree to which some human modification acts as a barrier will vary with a species' biology. I once observed a katydid (*see photo*) on the rooftop terrace of a six-storey building in lower Manhattan in New York and, more recently, an invasive species, the Brown Marmorated Stinkbug (*Halyomorpha halys*[5]), on the 20th floor of a Pittsburgh skyscraper but, for others, modified landscapes could prevent dispersal and cause extinction.

There is clear evidence from present-day minor shifts, as well as from much greater past change, that biological communities do not move as a unit. Rather, it is the individual species that moves, each at its own rate and in its own direction, as specific conditions are tracked. The result is that, with greater climate change such as could lie ahead, the ecosystems we currently know will disassemble and the surviving species will assemble into ecosystems hard to imagine in advance. The challenge to manage that process would be enormous.

What if the climate changes abruptly, as in the past?

It is also clear that whatever change could lie ahead will be more abrupt than that which we have observed in recent decades. That certainly is the case in the climate system. For example, the southwestern USA, known for citrus fruit-growing, is already gripped by a drought that is proving exceptional not only in terms of duration but also in its severity and geographical extent.

Most of the negotiations have focused on 2°C of global warming; 1.5°C seems a much safer target.

The global 'conveyor belt' that distributes heat around the oceans has been known to shut down in geologic times. The climate 'jumped' most recently at the end of the last ice age about 12 000 years ago, when the melting North American Ice sheets released masses of freshwater into the North Atlantic, causing the conveyor belt to stop and average temperatures in the North Atlantic region to plunge by 5°C within a decade.

Acid rain on the oceans

Major systemic change is already occurring, the most notable sign being the acidification of the oceans. Mostly overlooked until 2005 (although it could be deduced from high school chemistry), the excess CO_2 absorbed by the oceans has produced enough carbonic acid in the process to change the pH of the oceans by 0.1 pH unit.[6] That seems a trivial amount, except that the pH scale is logarithmic, so this means the oceans are 30% more acidic than in 1950.

About 50 ppm of CO_2 could be sequestered over a 50-year period via reforestation and better forest management, restoration of grassland and degraded pasture lands and agro-ecosystems.

The acidification of the oceans is of enormous consequence for all marine organisms that build shells and skeletons of calcium carbonate. The carbonate equilibrium is affected by temperature and pH and is weaker in water that is more acidic or colder. The failure of oyster spawning in the State of Washington in the USA has been attributed to rising acidity. Many of the tiny organisms that exist in astronomical numbers at the base of food chains will be imperiled, such as the pteropods – tiny snails with a modified 'foot' that can flap like a wing and maintain the organism at a given level in the water column – and the entire food chain with them. Acidification is truly a profound change for the oceans that comprise two-thirds of the planet.

Could Amazon dieback be around the corner?

Another major change that may be on the horizon involves the possibility of dieback of the Amazon rainforest in the southern and southeastern part of the Amazon. First projected by the Hadley Centre (UK) model to occur at about 2.5°C of global warming, a revised projection dating from about 2005 indicates it could occur at even 2.0°C.

More recently, the World Bank invested US$1 million in a study that modelled the effects of climate change, deforestation and fire on the Amazon. This was the first time they had been modelled together; the results suggest a tipping point to Amazon Dieback could occur at 20% deforestation, when the current figure is 18%. Disturbingly, what was then the greatest drought in the recorded history of the Amazon occurred in 2005 – only to be followed by an even greater one in 2010. These are perhaps early signals of what could lie ahead.

Even a global temperature rise of 2°C will be hard on biodiversity

In the meantime, most of the discussions and negotiations have focused on stopping at an average of 2°C global warming this century. Under current approaches, global emissions will have to peak in 2016 if warming is to stop at 2°C. Yet even this is clearly too much for many of the ice systems and for the ecosystems of the planet. The obvious things to do to assist ecosystem resilience are to restore natural connections in the landscape (such as by creating ecological corridors like that linking Yellowstone Park to the Yukon's Territorial Parks in North America) and to reduce other stresses to avoid negative synergies with climate change. But even these stresses will pale in comparison to the effects of continued global warming.

In sum, a global average temperature rise of 2°C (roughly 450 ppm of CO_2) is too much. Something in the order of 350 ppm of CO_2 – roughly equivalent to a temperature rise of 1.5°C –seems a much safer target to settle for.

A lot of excess carbon could be removed by restoring ecosystems

The energy agenda is clear and urgent but, in addition, there is a critical need to remove substantial amounts of excess CO_2 from the atmosphere to avoid the warming it would otherwise cause. That might seem Quixotic[7] but, in fact, the history of life on Earth shows that twice in the history of the planet, there have been extremely high concentrations of CO_2

and, twice, these have been brought down to pre-industrial levels biologically. The first drawdown occurred with the appearance of plants on land, by their photosynthesis and the accumulation of plant biomass. Simultaneously, soil formation reduced CO_2 – not just the physical process but also aided and abetted by the soil biota. The second drawdown occurred with the appearance of modern flowering plants, which performed the same role more efficiently.

Those two major alterations to atmospheric composition took tens of millions of years, which might make biological potential seem irrelevant. It would be, except that perhaps 200–250 billion tons of carbon have accumulated in the atmosphere over the past three centuries because of the destruction and degradation of ecosystems via deforestation, the deterioration of grasslands and agricultural practices that lose soil carbon. Greater recourse to crop rotation, for instance, could reduce soil erosion, which releases a lot of stored carbon into the atmosphere. Roughly half of the current excess CO_2 is of modern biological origin and a significant portion of it can be removed by ecosystem restoration on a planetary scale.

The reduction of CO_2 is infinitely preferable to almost any scheme for geo-engineering. Geo-engineering schemes address the symptom, not the cause.

The numbers are approximate but about 50 ppm of CO_2 could be sequestered over a 50-year period – the difference between 350 ppm and current levels of close to 400 ppm. That could be achieved by sequestering about half a billion tons of carbon per year in reforestation and better forest management, another half billion per year through restoration of grassland and degraded pasture lands – resulting in better grazing – and a third half billion per year by managing agro-ecosystems to restore soil carbon – resulting in greater soil fertility. Such an approach to managing the planet is obviously more complex than simply making this statement and must take into account the needs of feeding at least another 2 billion people over and above the current population but the potential is clear. Such a solution also has the great advantage of making biodiversity and ecosystems more resilient in the face of the climate change and other stresses that will affect them.

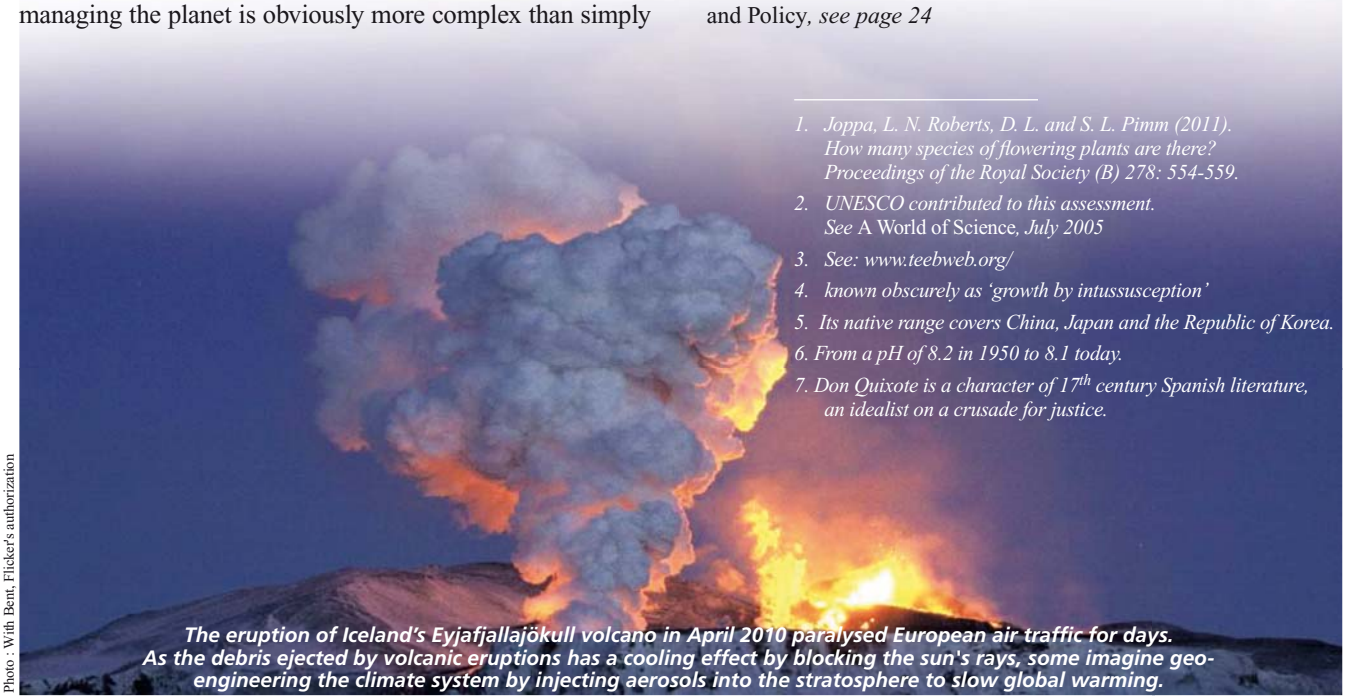
Since this is not enough, given current emission trends, clearly non-biological ways need to be sought to remove CO_2 not just from smokestacks but also from the atmosphere. Economically feasible means need developing to this end. For instance, one could imagine a process by which CO_2 would combine with other molecules to become an inert substance like concrete.

The reduction of CO_2 is infinitely preferable to almost any scheme for geo-engineering aimed at reducing temperature, except locally. Geo-engineering schemes that would reduce the planet's temperature in the end address the symptom, not the cause. They do nothing to combat ocean acidification and, being planetary in scale, their downside will, by definition, also be planetary in consequence. In addition, any time the intervention ceases, the temperature of the planet will go right back up to where it would have been otherwise.

Far preferable will be to manage our living planet as just that, a living planet, by using Earth's living systems to regreen it and make it more habitable for all life forms.

Thomas Lovejoy

Read this article in Tracking Key Trends in Biodiversity Science and Policy, *see page 24*



1. *Joppa, L. N. Roberts, D. L. and S. L. Pimm (2011). How many species of flowering plants are there? Proceedings of the Royal Society (B) 278: 554-559.*
2. *UNESCO contributed to this assessment. See* A World of Science, *July 2005*
3. *See: www.teebweb.org/*
4. *known obscurely as 'growth by intussusception'*
5. *Its native range covers China, Japan and the Republic of Korea.*
6. *From a pH of 8.2 in 1950 to 8.1 today.*
7. *Don Quixote is a character of 17th century Spanish literature, an idealist on a crusade for justice.*

The eruption of Iceland's Eyjafjallajökull volcano in April 2010 paralysed European air traffic for days. As the debris ejected by volcanic eruptions has a cooling effect by blocking the sun's rays, some imagine geo-engineering the climate system by injecting aerosols into the stratosphere to slow global warming.

Photo : With Bent, Flicker's authorization

UNESCO combating drought in **Horn of Africa**

UNESCO begins mapping groundwater in January in the drought-stricken Horn of Africa, in order to bring the population a sustainable water supply. Drought has caused the region's worst famine in 60 years, with 12 million people at risk of starvation. Those living in refugee camps are particularly vulnerable.

The first stage of the project is being supported by Flemish funds to the tune of US$396,000 with an additional US$100,000 from UNESCO. It involves a series of national consultations organized by UNESCO to mobilize stakeholders, partners and potential donors, followed by a regional workshop and the mapping of groundwater at pilot sites in Ethiopia and Kenya.

The first national consultation took place in Ethiopia on 1–2 November. This was followed by field visits by experts to assess the situation in the Dolo Ado refugee camp in the southeast of the country from 4 to 10 November and in the Fafen upper valley from 12 to 14 November (*see map*). A second national consultation in Kenya this time on 9–10 November was followed a month later by a field visit to Kakuma refugee camp in Turkana.

Following close on the heels of the third national consultation in Somalia on 1 December was a regional workshop in Addis Ababa. On 5 and 6 December, specialists from UNESCO's offices in Nairobi and Addis Ababa met with ministerial staff and experts from six countries belonging to the Intergovernmental Authority on Development (IGAD) to share the outcome of the national consultations, agree on the scope of regional activities and mobilize partners at the regional level.

Mapping will begin in the Fafen upper valley in January and should be complete by the end of April.

Thanks to advances in geosciences, it is now possible to detect the precise location of groundwater in arid climates like that of the Horn of Africa. UNESCO is using new remote-sensing technology developed by Radar Technologies International to generate high-resolution groundwater potential maps of the area under study. These maps will in turn guide partners in determining where to drill boreholes to bring the water to the surface in a cost-effective manner. These partners include UNHCR, UNICEF, USAID and a number of NGOs.

The technology developed by Radar Technologies International has already proven its worth in Darfur (South Sudan) and in a UNESCO groundwater survey in Iraq last year. The technology processes remote-sensing data, including data from the LANDSAT and RADAR satellites, in combination with ground truth data provided by a ground penetrating radar and other information drawn from geological, hydrogeological, geographical, hydrological and climate data and, when dealing with deep aquifers, seismological data.

Once the maps and a related database have been produced, these will become the property of the countries concerned. UNESCO will maintain a presence, however, to ensure sustainable management of the groundwater for generations to come.

UNESCO plans to consult experts and commission studies before extending the project into the northern arid and semi-arid parts of Ethiopia and Kenya, as well into refugee camps in Somalia. For this second stage, UNESCO will need additional funding. A decision is expected by late January on a proposal UNESCO has submitted to the Government of Japan for US$1.5 million over eight months.

UNESCO's action plan for the region also covers the longer term. UNESCO will be offering medium- to long-term support in drought monitoring and preparedness, in order to ensure the Horn of Africa is better prepared next time a severe drought strikes. The Organization also plans to strengthen institutional and technical capacities in the region with the support of the Regional Groundwater Training and Research Centre in Kenya, which operates under the auspices of UNESCO.

UNESCO's action plan has been devised in line with the *Nairobi Declaration* adopted by Heads of State during their emergency summit on the crisis in the Horn of Africa on 9 September 2011.

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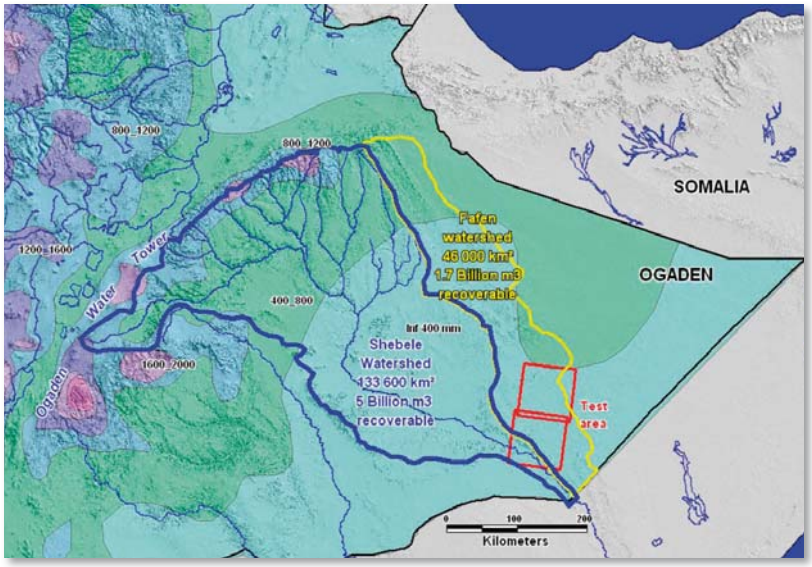
A family using a hand-pump to collect water from a well in the Fafen Upper Valley in Ethiopia.



Source: Alain Gachet/ RTI

The Ogaden Water Tower originates in the Ahmar mountains of central Ethiopia. The Fafen watershed due to be mapped in January is shown in red.

Towards a global framework for **groundwater governance**

UNESCO and its partners have given themselves three years in which to establish a Global Framework for Action for mainstreaming key issues of groundwater governance in national, regional and international political agendas.

The project was launched on 6–7 September by UNESCO's International Hydrological Programme during the project inception meeting and is being implemented together with FAO, the International Association of Hydrogeologists and the World Bank, with US$1,750,000 in funding from the Global Environment Facility.

The first regional consultation for Latin America and the Caribbean will be hosted by Uruguay in Montevideo from 18 to 20 April. The African consultation will take place in Kenya in May, followed by a third in Jordan in September for the Arab States and a fourth in China in December for the Asia–Pacific region. The Netherlands will host the last regional consultation in early 2013 for Europe and the private sector.

The aim of each consultation will be to acquire first-hand knowledge of regional issues from local groundwater experts; raise awareness and promote a global groundwater agenda; as well as build partnerships among collaborating project agencies, cross-sectoral stakeholders, decision-makers and specialists.

The outcome of each consultation will be captured in a specific report that will in turn feed into the *Global Groundwater Diagnostic Report* and, ultimately, into the *Global Framework for Action*.

The format of the European consultation differs slightly from the others, as countries have decided to include a roundtable with representatives of the oil, geothermal and bottled water and soft drink industries (Danone, Nestle, Coca Cola, etc.). This roundtable will explore opportunities for collaboration with the private sector in defining key messages, sharing information and disseminating the *Global Framework of Action*.

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Ten proposals for **safeguarding the ocean**

Four UN agencies launched a plan on 1 November to improve the management of the ocean and coastal areas. The plan includes a proposal to create a global blue carbon market.

The *Blueprint for Ocean and Coastal Sustainability* sounds the alarm about the health of the ocean. It has been prepared by UNESCO's Intergovernmental Oceanographic Commission (IOC), UNDP, the International Maritime Organization and FAO for consideration by the UN Conference on Sustainable Development (Rio+20) in June this year.

The *Blueprint* proposes a series of concrete measures to:

- ✓ create a global blue carbon market to channel direct economic gain through habitat protection;
- ✓ fill governance gaps in the high seas, by reinforcing the UN Convention on the Law of the Sea;
- ✓ support the development of green economies in small island developing states;
- ✓ promote research on how to adapt to ocean acidification and mitigate it;
- ✓ increase institutional capacity for scientific monitoring of oceans and coastal areas;
- ✓ reform and reinforce regional ocean management organizations;
- ✓ promote responsible fisheries and aquaculture in a green economy;
- ✓ strengthen legal frameworks to address aquatic invasive species;
- ✓ green the nutrient economy to reduce ocean hypoxia (lack of oxygen) and promote food security;
- ✓ enhance co-ordination, coherence and effectiveness within the UN system on ocean issues.

The *Blueprint* emphasises that 60% of the world's major marine ecosystems have been degraded or are being used unsustainably, resulting in huge socio-economic losses. Mangrove forests have lost 30–50% of their original cover in the past 50 years, while coral reefs have lost 20%.

The ocean absorbs close to 26% of atmospheric CO_2 emissions. This saturation is provoking acidification that is already threatening some varieties of plankton and poses a threat to the entire marine food chain and dependent socio-economic activities.

The new members of the Global Network of National Geoparks

- **Hong Kong Geopark** (China) highlights the natural parts of this industrial site, particularly its 150 km long coastline and hilly topography interspersed with plains. Despite its modest area of 49.85 km^2, the geopark boasts world-class acidic volcanic rock columns and a geological history that exhibits sedimentary environments deposited in the Palaeozoic, 520–250 million years ago (MA). Coastal processes have resulted in diverse erosional and depositional landforms, including fossils.
- **Tianzhushan Geopark** in Anhui Province (China) is a large mountainous landscape dotted with granite peaks and caves, waterfalls and springs. It is rich in mammalian fossils and sports an ultra-high pressure metamorphic belt of eclogite, an unusually dense rock important for driving convection within the solid Earth. The geopark integrates a healthy ecology and rich cultural elements with scientific research, education and tourism.
- **Bauges Geopark** (France) is part of the Bauges Regional Park. An area of middle elevation mountains in the northwestern French Alps, the geopark looks like a rocky fortress from afar; a preserved natural island emerging from an urbanized sea. The massif features cliffs of resistant limestone and sedimentary rocks. ajor tectonic fault lines bear witness to strong mountain-building processes and the karst landscape is crisscrossed by large and small defiles in the cretaceous limestone that create wetlands, lakes, springs and caves.
- **Katla Geopark** (Iceland) is home to the now famous Eyjafjallajökull volcano, the eruption of which paralysed air travel over Europe in April 2010. Glacier outburst floods, caused by subglacial eruptions, have created outwash plains in the lowlands. Features useful for geological dating include pieces of rock trapped in other types of rock (xenoliths) that contain fossils, pseudocraters and layers of volcanic ash that freeze in time a past eruption (tephra layers).
- **Burren and Cliffs of Moher Geopark** (Ireland). Situated on the west coast between the cities of Limerick and Galway, Burren is a geological landscape of rolling limestone hills and plateaux, dramatic sea cliffs and waterways that disappear underground and emerge from a vast network of caves. Most of the coastline is marked by the celebrated 200 m-high Cliffs of Moher. The Burren is home to more than 70% of Ireland's native plants, including unusual combinations of Arctic, Alpine and Mediterranean species, and has been settled by humans for more than 6000 years.
- **Apuan Alps Geopark** (Italy) comprises the Apuan Alps Regional Park and surrounding areas in the Apuan Alps mountains. It stretches from northwest Tuscany in central Italy to the northern limits of the peninsula at the transition of the Middle-European and Mediterranean biogeographical regions. The geopark hosts many endemic species, as well as rocks, minerals, fossils and tectonic structures. It is famous for its beautiful marbles, deep canyons and large karst caves.
- **Muroto Geopark** (Japan) is located on Shikoku Island in the southwest and was once submerged by the sea. Formed underwater, its caves were later uplifted by earthquakes every 100–150 years, sometimes triggering tsunamis that wash the coast away. The geopark is a living laboratory in a subduction zone: a place where one section of the Earth's crust descends below another. The motion of tectonic plates resulted in magmatic activity that created the dark, coarse-grained gabbroic rocks that form the Muroto Peninsula. Cape Muroto is being uplifted 1–2 m every 1000 years, one of the fastest rates in the world. The geopark offers an example of prediction and protection from geohazards through the use of state-of-the-art science and technology.
- **Sierra Norte di Sevilla**, (Spain) is one of the largest natural parks in Andalusia (177 484 ha), located in the mountainous alignments of the Sierra Morena, between the geological zones of Ossa-Morena and Sudportuguese. Most rocks date back to the Precambrian (4,5 billion years – 540 Ma), followed by the Paleozoic (540 Ma), or Permian (290 Ma) and Lower Triassic (258 Ma), except in the southeast, where there are outcrops of 20 Ma Miocene sedimentary rocks.
- **Villuercas Ibores Jara Geopark** (Spain) features an isolated mountain range in the southeast of Cáceres, a province in the Spanish Extremadura region. The area is named after its highest peak, La Villuerca (1601 m). The magnificent vista includes the famous Monastery of Guadalupe. The geopark features the oldest rocks in Europe, from between 650 and 400 Ma. It is also rich in protected birds, biodiversity corridors and monumental trees. Vestiges of a mining culture and decorated menhir stones, or monoliths, date back to the Bronze and Iron Ages.

Moreover, ecosystems situated in the deep ocean, where biodiversity and habitats are often extremely valuable but poorly understood, benefit from virtually no protection at all.

The international community pledged to tackle these challenges at the Summits of Rio (1992) and Johannesburg (2002). However, the commitments made at the time remain largely ineffectual and their objectives have not been met, such as the pledge to restore fish stocks to sustainable levels by 2015 and the promise to create networks of protected marine areas by 2012. Few countries have adopted legislation to reduce land-based marine pollution, leading to an increase in the number of dead ocean areas deprived of oxygen. More than 400 marine areas have been listed as 'biologically dead' to date.

The authors attribute the present situation to insufficient political will and resources, inadequate institutional capacities, insufficient scientific data and market imbalances.

'Greening the blue economy will be science- and technology-driven,' they conclude. 'But success will depend on sound policy processes and effective institutional arrangements and will therefore require commitment and funding from the international community as well as from nations and industry.'

Read the Blueprint: www.unesco.org/new/en/rio20

Nine sites added to Global Geoparks Network

©Hong Kong Geopark

At the information centre in the Hong Kong Geopark (China)

The Global Geoparks Network Bureau admitted nine new members from seven countries during the 10th European Geoparks Conference in the Gea Norwegica Geopark (Norway) from 16 to 18 September (*see table*).

Created under the aegis of UNESCO in 2004, the Global Network of National Geoparks today numbers 87 geoparks in 27 countries.

To be selected as geoparks, sites must contain geological heritage of exceptional scientific and educational importance, rarity or beauty. They must also possess an effective management structure, clearly defined boundaries and a sufficiently large area to permit significant sustainable economic development, primarily through tourism.

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Forum calls for **greater equity** in new era of global science

Participants in the fifth World Science Forum have called for the responsible and ethical conduct of research, a better dialogue with society, the promotion of international collaboration and greater capacity-building for science, in a declaration adopted on 19 November in Budapest (Hungary).

The declaration echoes key trends identified by the *UNESCO Science Report 2010*, which inspired the theme of this year's forum on the changing landscape of science. For example, the declaration states that 'the former triadic dominance of North America, Europe and Japan in global knowledge production has been seriously challenged […] by the rise of new scientific powerhouses. […] Science diplomacy is now an acknowledged tool to promote partnership among nations by fostering scientific co-operation.'

A new programme in science diplomacy was announced in Budapest by the American Association for the Advancement of Science and the Academy of Sciences for the Developing World. Together, they will publish a journal on *Science and Diplomacy* to help decipher some of the key issues debated in international fora like the climate talks.

The declaration advocates solidarity at a time of widespread financial crisis. 'It is the responsibility of those who promote science and scientists,' it states, 'to maintain the primacy of moral and social concerns over short-term economic interest in the selection and implementation of industrialised research projects.'

'There is an urgent need to elaborate new, effective science policies at national, regional and global levels to better co-ordinate and monitor scientific research worldwide, to harmonise university education systems and to facilitate global and regional scientific co-operation based on equity and participation.'

With the difficult obtention of visas often hindering the mobility of students and scientists, the declaration states that 'the free co-operation and movement of scientists should be promoted by the elimination of harmful bureaucracy and false regulation and by providing the funds to further international co-operation.'

The declaration also calls for 'comprehensive actions' to 'strengthen the role of women in science and innovation and to expand the participation of women in science and science policy making.'

The forum was organized by the Hungarian Academy of Sciences, in partnership with UNESCO and the International Council for Science. It drew 700 participants from 108 countries.

For details: www.unesco.org/science /psd

Sharing science education expertise in Asia

The Science, Technology and Engineering Exchange Laboratory (STEEL) was launched on 7 September at the Science Centre Singapore, one of the initiative's three partners along with UNESCO's Regional Bureau for Science in Asia-Pacific and National Instruments, a US firm specializing in computer-based measurement and automation.

Teachers studying the user manual for the myDAQ hardware at the launch of STEEL in September. This hardware introduces students to electronics theory and allows them to build and test preselected circuits that typify some of the basic elements of electronics found in cell phones, automobile control systems, etc.

The aim of STEEL is two-fold: to give technical and vocational teachers in Southeast Asia a refresher course in the latest developments in science and technology, as well as relevant teaching aids and methods, with a knock-on benefit for pupils, and; secondly, to provide Ministry of Education officials with curriculum development training.

In parallel, STEEL will collaborate with science centres and museums in Southeast Asia, as well as with private sponsors, to popularize science, technology and engineering in the wider community.

More than 40 teachers from Indonesia, Thailand and Timor-Leste joined educators in Singapore at the inaugural event in September. The programme included a seminar on engineering curriculum development and a visit to the Senoko Power Plant in preparation for a renewable energy session during the STEEL workshop. Participants also received training on circuit experiments using myDAQ hardware provided by National Instruments (*see photo*).

Associate Professor Lim Tit Meng, Chief Executive of the Science Centre Singapore, commented when signing a Memorandum of Understanding with UNESCO last July that his centre was 'eager to share our knowledge and expertise in science, technology and engineering with the region.' He said that STEEL would have a strong focus on infrastructure engineering and sustainable technologies.'

The second phase kicks off in June with a STEEL training workshop for master trainers from Cambodia, Indonesia, Malaysia, Singapore, the Philippines, Thailand, Timor-Leste, Laos and Vietnam. During the second phase, STEEL will introduce innovative teaching processes and develop training topics based on emerging and urgent issues for the members of the Association of Southeast Asian Nations.

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A book on the 'world's most complex machine'

At UNESCO headquarters on 10 November, UNESCO Assistant Director-General for Natural Sciences Gretchen Kalonji and Rolf-Dieter Heuer, Director-General of the European Organization for Nuclear Research (CERN), presented a new, richly illustrated book from the Austrian publisher Editions Lammerhuber on the world's largest and most powerful particle accelerator, the Large Hadron Collider (LHC, pictured).

The LHC lies in a tunnel 27 km in circumference 100 m below the Franco-Swiss border near Geneva. It was inaugurated by CERN in 2008 and now hosts 10 000 scientists and engineers from over 100 countries.

Described as 'the largest and most complex machine ever imagined', the LHC is being used by scientists at CERN to recreate conditions that existed in the first fraction of a second after the Big Bang by colliding protons head-on at high energy to create both known and unknown particles. 'We make the link from the microcosm to the early Universe', says CERN Director-General Rolf-Dieter Heuer, 'and look at what the elementary building blocks of matter are and how they behave.'

These experiments will allow CERN to put numerous theories about the creation of the Universe to the test and – hopefully – provide answers to many unsolved mysteries in modern physics. We know that gravity acts on mass, for example, but not why the fundamental particles have the masses they do. The LHC should provide an answer. Scientists will also probe the mysterious dark matter of the Universe: visible matter seems to account for just about 4% of what must exist. More than 60 years ago, Swiss astronomer Fritz Zwicky showed that the gravitational pull of the visible content of a galaxy could not explain the speed of the galaxy's rotation. There had to be an invisible mass present, what we call dark matter. Today, this dark matter is estimated to make up around 22% of the Universe with dark energy accounting for a further 74%. But as to what dark matter is made of, we still cannot say.

The LHC cannot determine all the properties of a particle, however. Proton accelerators like the LHC may have higher energy than electron accelerators but the latter can be more precise in identifying some properties of particles.

CERN caused a stir on 23 September last year when scientists presented the results of an experiment known as OPERA which, if confirmed by complementary experiments, could question the assumption of Albert Einstein's Special Theory of Relativity that nothing in the known cosmos travels faster than the speed of light: 299 792.458 km/second.

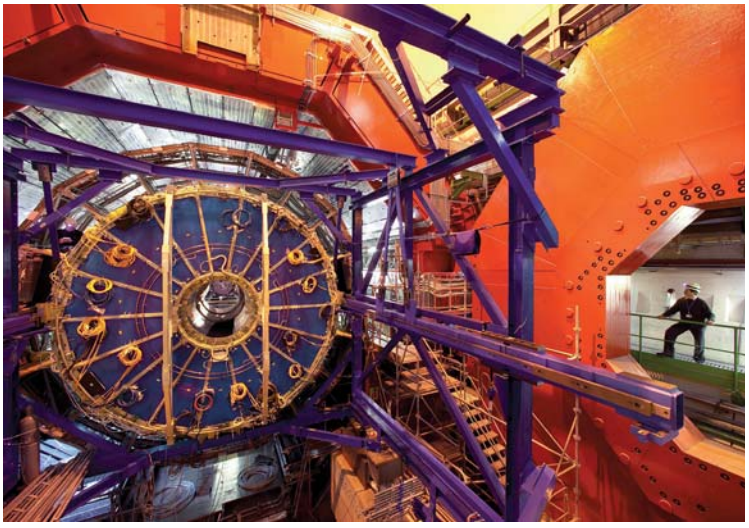
The LHC had produced very-high energy protons which had resulted in a neutrino beam. A neutrino is such a tiny particle that no barrier can stop it: it can pass through all kinds of matter, including rock, as if it were flying through the air.

The OPERA experiment found that this neutrino beam had travelled from CERN in Switzerland through the soil and rocks at a depth of 11 km to the Gran Sasso Laboratory in central Italy 730 km away at a speed slightly faster than the speed of light! The neutrinos' flight time was determined with an accuracy of less than 10 nanoseconds by using sophisticated instruments that included advanced global positioning systems and atomic clocks.

The result came as a complete surprise. 'If this measurement is confirmed,' said CERN Research Director Sergio Bertolucci, 'it might change our view of physics but we need to be sure that there are no other more mundane explanations. That will require independent measurements.'

CERN and UNESCO enjoy special ties dating back to the creation of CERN under UNESCO's auspices, in 1954, after a series of UNESCO-sponsored meetings. 'It is very relevant that our two organizations are now co-operating via UNESCO's International Basic Sciences Programme (IBSP),' observes Maciej Nalecz, who runs the IBSP. 'For example, the IBSP is chaired by a former Director-General of CERN, Herwig Schopper. UNESCO and CERN have tuned their partnership to pursuing the common goals of promoting scientific co-operation, improving science education and facilitating access to scientific knowledge in order to create a more just world'.

To order the book entitled LHC, see page 24;
for details: www.cern.ch; www.youtube/cerntv; s.bahri@unesco.org; m.nalecz@unesco.org



©CERN/Peter Günter

Wangari Muta Maathai

Tribute to a green militant

Professor Wangari Maathai was given a state funeral after losing her battle with cancer on 25 September at the age of 71. An environmental and pro-democracy activist, Professor Maathai founded the Green Belt Movement in 1977, which used tree-planting to empower rural women and raise environmental awareness. It is estimated that the movement has so far planted up to 45 million trees in Kenya.

Wangari Maathai was a keynote speaker at the International Conference on Biodiversity: Science and Governance, held at UNESCO in 2005. We pay tribute to this extraordinary woman by reproducing below part of an interview she gave to the *UNESCO Courier* in December 1999, before going on to become the first African woman to win the Nobel Peace Prize in 2004.

You once said that the quality of the environment cannot be improved unless and until the living conditions of ordinary people are improved. Could you enlarge on this?

If you want to save the environment you should protect the people first because human beings are part of biodiversity. If we can't protect our own species, what is the point of protecting tree species? It sometimes looks as if poor people are destroying the environment. But they are so preoccupied with their survival that they are not concerned about the long-term damage they are doing to the environment simply to meet their most basic needs. […]

For example, in certain regions of Kenya, women walk for miles to get firewood from the forests, as there are no trees left nearby. When fuel is in short supply, women have to walk further and further to find it. Hot meals are served less frequently, nutrition suffers and hunger increases. If these women had enough resources, they would not be depleting valuable forest.

What is at stake in the forests of Kenya and East Africa today?

Since the beginning of [the 20th] century, there has been a clear tendency to cut down indigenous forests and to replace them with exotic species for commercial exploitation. We have now become more aware of what this involves and have realized that it was wrong to cut down indigenous forests, thereby destroying our rich biodiversity. But much damage has already been done.

When the Green Belt Movement started its campaign in 1977 to plant trees, Kenya had about 2.9% of forest cover. Today, the forested area has further dwindled to around 2%. We are losing more trees than we are planting.

The other important issue is that the East African environment is very vulnerable. We are very close to the Sahara desert and experts have been warning that the desert could expand southwards like a flood if we keep on felling trees indiscriminately, since trees prevent soil erosion caused by rain and wind. By clearing remaining patches of forests we are in essence creating many micro-Sahara deserts. We can already see evidence of this phenomenon. We hold civic education seminars for rural people, especially farmers, as part of campaigns to raise public awareness about environmental issues. If you were to ask a hundred farmers how many of them remember a spring or a stream that has dried up in their lifetime, almost 30 of them would raise their hands.

What has your Green Belt Movement achieved and in particular to what extent has it prevented environmental degradation in Kenya?

The most notable achievement of the Green Belt Movement in my view has been in raising environmental awareness among ordinary citizens, especially rural people. Different groups of people now realize that the environment is a concern for everybody and not simply a concern for the government. It is partly because of this awareness that we are now able to reach out to decision-makers in the government. Ordinary citizens are challenging them to protect the environment. Secondly, the Green Belt Movement introduced the idea of environmental conservation through trees because trees meet many basic needs of rural communities.

We started out by planting seven trees in a small park in Nairobi in 1977. At that time, we had no tree nursery, no staff and no funds, only a conviction that ordinary country people had a role to play in solving environmental problems. We went on from there and have now planted over 20 million trees all over Kenya.

The act of planting trees conveys a simple message. It suggests that at the very least you can plant a tree and improve your habitat. It increases people's awareness that they can take control of their environment, which is the first step toward greater participation in society. Since the trees we have planted are visible, they are the greatest ambassadors for our movement.

Despite the Earth Summit of 1992 and the Kyoto climate summit in 1997, there has been no significant progress in environmental protection programmes and campaigns at a global level. Why?

Unfortunately, for many world leaders, development still means extensive farming of cash crops, expensive hydroelectric dams, hotels, supermarkets and luxury items, which plunder human and natural resources. This is short-sighted and does not meet people's basic needs for adequate food, clean water, shelter, local clinics, information and freedom.

As a result of this craze for so-called development, environmental protection has taken a back seat. The problem is that the people who are responsible for much of the destruction of the environment are precisely those who should be providing leadership in environmental protection campaigns. But they are not doing so.

Also, political power now is wielded by those who have business interests and close links with multinational corporations. The only aim of these corporations is to make profit at the expense of the environment and people. We also know that many world political leaders are persuaded by multinational corporations not to pay attention to declarations made in international environmental conferences. I strongly believe that, as citizens, we should refuse to be at the mercy of these corporations. Corporations can be extremely merciless, as they have no human face.

You started your career as an academic. Later, you became an environmentalist and now you are called a pro-democracy activist. How would you describe your evolution in the last 25 years?

Few environmentalists today are worried about the welfare of bees, butterflies and trees alone. They know that it is not possible to keep the environment pure if you have a government that does not control polluting industries and deforestation.

In Kenya, for example, real estate developers have been allowed to go into the middle of indigenous forests and build expensive houses. As concerned individuals, we should oppose that. When you start intervening at that level, you find yourself in direct confrontation with policy-makers and you start to be called an activist.

I was teaching at the University of Nairobi in the 1970s when I felt that the academic rights of women professors were not being respected because they were women. I became an activist at the university, insisting that I wanted my rights as an academic.

Meanwhile, I found myself confronted with other issues that were directly related to my work but were not clear to me at the outset, like human rights. This directly led me to another area, governance. As a result, I was drafted into the pro-democracy campaign.

I realized in the 1970s that, in a young democracy like ours, it was very easy for leaders to become dictators. As this happened, they started using national resources as though they were their personal property. I realized that the constitution had given them powers to misuse official machinery. So I became involved in the pro-democracy movement and pressed for constitutional reforms and political space to ensure freedom of thought and expression. We cannot live with a political system that kills creativity and produces cowardly people.

With your academic qualifications, you could have lived a comfortable life in the West. But you decided to come back and settle down in Kenya. In the last 25 years, you have been verbally abused, threatened, beaten, put behind bars and on many occasions forbidden to leave the country. Have you ever regretted returning to Kenya and becoming an activist?

I did not deliberately decide to become an activist but I have never regretted the fact that I decided to stay here and contribute to the development of this country and my region. I know that I have made a little difference. Many people come up to me and tell me that my work has inspired them. This gives me great satisfaction because, in the earlier days, especially during the dictatorship, it was difficult to speak.

Until a few years ago, people used to come up to me in the street and whisper 'I am with you and I am praying for you.' They were so scared of being identified with me that they did not want to be heard. I know a lot of people were afraid of talking to me and being seen with me because they might be punished. I have been a greater positive force by staying here and going through trials and tribulations than if I had gone to other countries. It would have been very different to live in the West and say my country should do this and that. By being here, I encourage many more people.

Do you think you were subjected to virulent attacks and abuse because you questioned men's decisions?

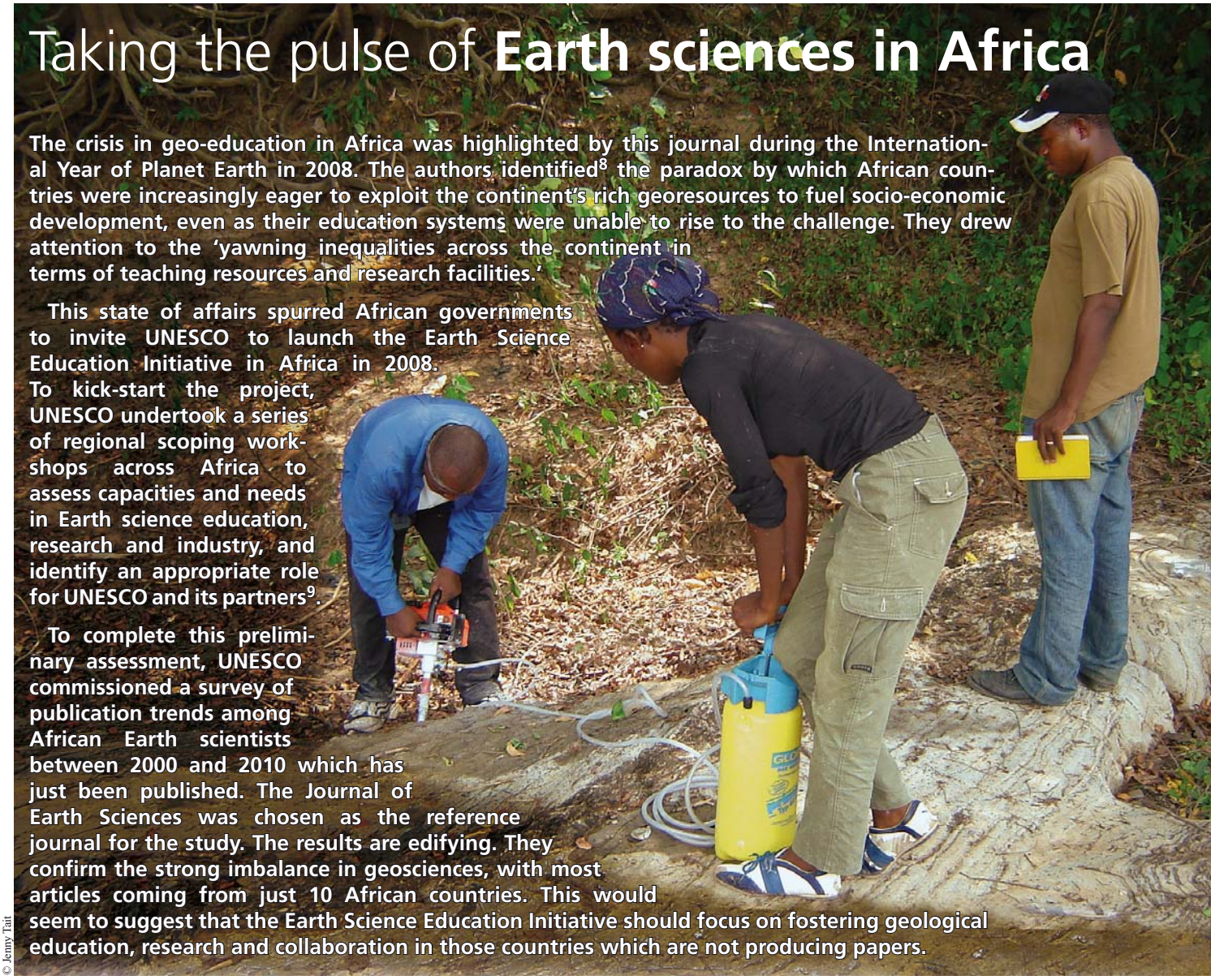
Our men think African women should be dependent and submissive, definitely not better than their husbands. There is no doubt that, at first, many people opposed me because I am a woman and resented the idea that I had strong opinions. I know that, at times, men in positions of influence, including President Daniel Arap Moi (Ed: President from 1978 to 2002], ridiculed me. At one time, Members of Parliament accused me and ridiculed me for being a divorced woman. I have felt that deep inside they were hoping that, by calling into question my womanhood, I would be subdued. Later, they realized they were wrong.

In 1989, for example, we had a big confrontation with the authorities when we were fighting to save Uhuru Park in Nairobi. I argued that it would be ridiculous to destroy this beautiful park in the centre of the city and replace it with a multistoreyed complex. Uhuru Park was the only place in Nairobi where people could spend time with their families outdoors. […] When I launched the campaign opposing the construction of the 'Parkmonster', as the project later came to be known, I was ridiculed and accused of not understanding development. I did not study development but I do know that you need space in a city. Fortunately, other NGOs and thousands of ordinary people joined our protests and finally the park was saved. The government, which wanted to destroy that park, has since declared it a national heritage. [...]

Interview by Ethirajan Anbarasan

Read the full interview in the UNESCO Courier: http://unesdoc.unesco.org/images/0011/001182/118279e.pdf

Taking the pulse of **Earth sciences in Africa**



The crisis in geo-education in Africa was highlighted by this journal during the International Year of Planet Earth in 2008. The authors identified[8] the paradox by which African countries were increasingly eager to exploit the continent's rich georesources to fuel socio-economic development, even as their education systems were unable to rise to the challenge. They drew attention to the 'yawning inequalities across the continent in terms of teaching resources and research facilities.'

This state of affairs spurred African governments to invite UNESCO to launch the Earth Science Education Initiative in Africa in 2008. To kick-start the project, UNESCO undertook a series of regional scoping workshops across Africa to assess capacities and needs in Earth science education, research and industry, and identify an appropriate role for UNESCO and its partners[9].

To complete this preliminary assessment, UNESCO commissioned a survey of publication trends among African Earth scientists between 2000 and 2010 which has just been published. The Journal of Earth Sciences was chosen as the reference journal for the study. The results are edifying. They confirm the strong imbalance in geosciences, with most articles coming from just 10 African countries. This would seem to suggest that the Earth Science Education Initiative should focus on fostering geological education, research and collaboration in those countries which are not producing papers.

Students drilling for carbonate samples in the Central African Republic. The direction of the Earth's magnetic field has often reversed through geological time (palaeomagnetism), facing north then south and vice versa. This change is recorded by rocks when they form at the surface of the Earth. By studying rocks of different ages, it is possible to reconstruct successive reversals and track past continental drift (plate movements). It is thought that the magnetic field is generated by the Earth's molten iron core. The magnetic field faces the North Pole today but geophysicists have detected signs that the Earth's magnetic poles may once again switch ends in the next few thousand years.

The scoping workshops in 2009 and 2010 pinpointed some common issues for Africa. Participants observed, for instance, that the Earth sciences were currently taught only at university level and recommended that they be incorporated in primary and secondary school curricula. In tertiary education, the main concern was how to attract more students – and above all the brightest among them – to a field suffering from a low status compared to other disciplines like biology, chemistry or physics which are present across all levels of education. Even in North Africa where there are a large number of well-organized geology departments and geological surveys, enrollment in Earth science programmes is dropping.

Participants bemoaned the inadequacy of analytical facilities in all but South Africa and called for greater interaction between universities and industry to overcome weak linkages. African geoscientsts are isolated, they observed. 'Not only are strong connections with the international research community missing,' noted the UNESCO report on the workshops, 'but also interactions across the continent, within regions and across countries like the Democratic Republic of Congo, are weak to non-existent.'

The report also identified striking differences on the continent, beginning with the geological environment. Among cultural differences, 'language seems to have been a divisive factor rather than a uniting element,' observed the report

Contribution of all authors from African countries to the Journal of African Earth Sciences*, 2000–2010*

Why the *Journal of African Earth Sciences?*

There were some compelling reasons for choosing *Elsevier's Journal of African Earth Sciences* as the reference journal for the study. For one thing, this periodical is specifically devoted to Earth sciences in Africa and the Middle East. It also covers all fields of Earth sciences, contrary to other international journals which tend to occupy a niche, such as *Precambrian Research*, the *Journal of Petrology*, *Journal of Sedimentology* or the *Journal of Volcanology*.

The *Journal of African Earth Sciences* covers all of these and more, including the geodynamics of the African and Arabian plates and their contained mobile belts, cratons and sedimentary basins; the crustal evolution, tectonics and structural geology of this region; the economic geology of major mineral deposits and hydrocarbon resources; stratigraphy and palaeontology; petrology and mineralogy; geochemistry and the isotope geology of Africa and the Middle East.

Another advantage is the journal's policy of publishing papers on applied geology, rather than highly specialized technical papers; this approach tends to appeal to a wide audience. The journal serves as a resource for mining and oil companies, for example. The South African diamond conglomerate De Beers regularly updates geological maps based on information they collect from articles about Africa, most of which appear in the *Journal of African Earth Sciences*. UNESCO Programme Specialist Sadrack Felix Toteu, who happens to be co-editor of the *Journal of African Earth Sciences*, observes that most of the new data that permitted the refining of the Tectonic map of Africa* came from this journal.

The journal is open to both Africans and non Africans and is the official journal of the Geological Society of Africa. Currently, it publishes 15 issues per year online and in print. It ranks highly, with an impact factor of 1.186 in 2011 and a five-year impact factor of 2.063.

Read the journal:
www.sciencedirect.com/science/journal/08995362

* see A World of Science, July 2011

'and must be overcome for pan-African cooperation. In one example of the extreme cultural discrepancies present in the region,' stated the report, 'while most workshops were predominantly male and academic, the participants in the workshop in Angola were at least half female, coming from backgrounds in industry and speaking only Portuguese.' This did not stop the workshop participants in Luanda from expressing 'a great interest in collaborating with colleagues regionally and establishing relevant regional centres of excellence with the support of the government and industry.'

The workshops all came to the same conclusion, that there was an urgent need for greater networking on the continent. UNESCO has taken up this recommendation and is in the process of setting up an African Network of Earth Sciences Institutions.

UNESCO is initiating two other projects in response to the workshops. This year, it will be working with the Government of Djibouti on an experimental pilot project to introduce geology courses into schools, with plans to extend the project to other interested countries. A third activity targets young Earth science professionals; UNESCO is currently developing a mobile training course in geological field mapping, in recognition of the important role geological mapping plays in a practical Earth science education and in helping countries to identify and manage their mineral wealth better.

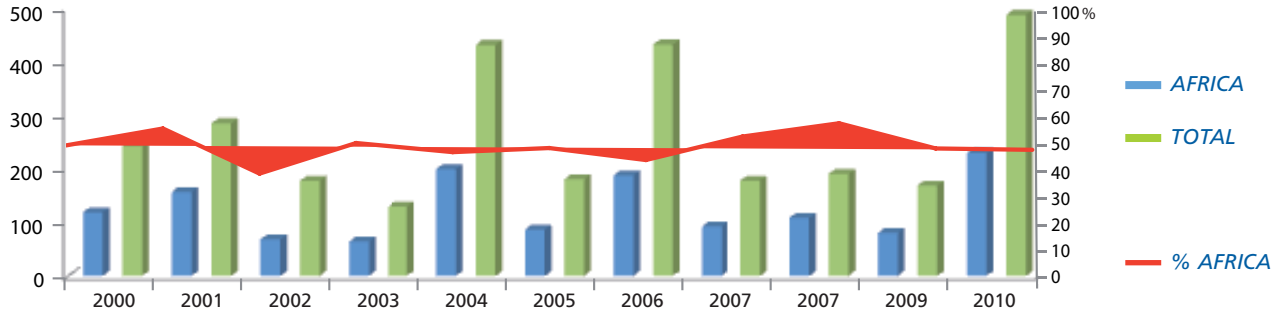
A relatively low proportion of African authors

The bibliometric survey commissioned by UNESCO in 2011 found that a total of 1 387 authors from 36 African countries had published in the *Journal of African Earth Sciences* between 2000 and 2010. Of these, 1200 (86.5% of African authors) came from just ten countries (*see figure*). Geoscientists from the top four countries (Morocco, South Africa, Egypt, Cameroon) contributed more than 62% of the total, although Tunisia's contribution did increase markedly towards 2010.

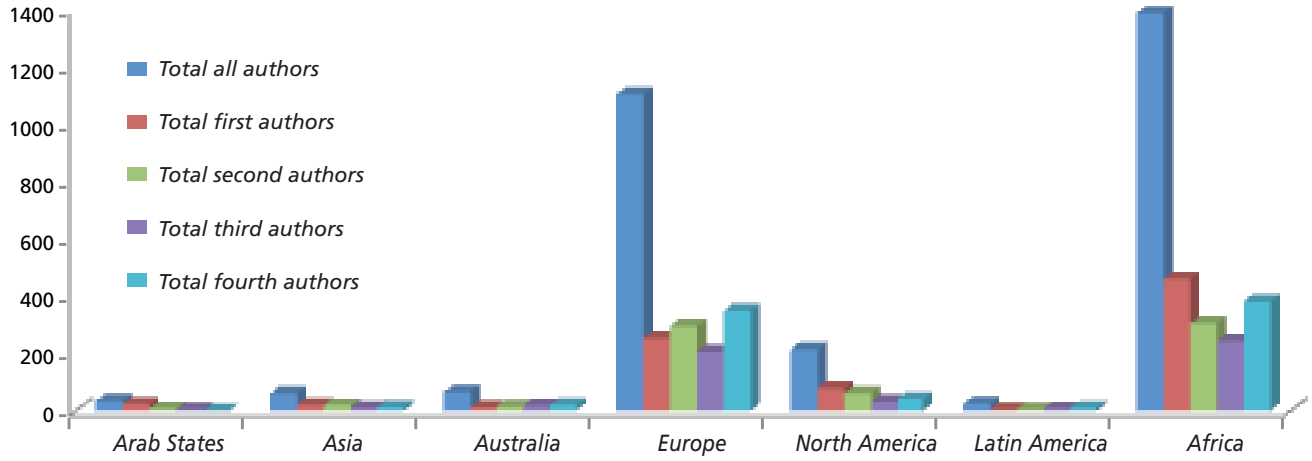
The order changed slightly when it came to the geographical coverage of research. For this indicator, Egypt topped the list, followed by Morocco, South Africa, Cameroon, Ethiopia, Tanzania, Algeria, Tunisia, Nigeria and Kenya. More than one-third of research papers concerned sites in North Africa.

There were small fluctuations in volume but, overall, the African contribution to the journal remained more or less constant between 2000 and 2010. For the purposes of the study, all authors primarily affiliated to an institution in Africa were considered to be African contributors. Allowing for authors who published more than one article in the journal, a total of 2 894 authors were counted over the study period. Of these, 48% (1 387 authors) were primarily affiliated to African institutions. This is lower than would be expected for a journal fully devoted to African Earth sciences (*see figure*).

Authors from European institutions made up the next biggest pool, at about 38%. North American authors represented just 7.5% of the total, with authors from Australia, Asia, the Arab States and Latin America



Yearly evolution of African contribution to Journal of African Earth Sciences, *2000–2010*



Total number of authors of Journal of African Earth Sciences, *sorted by continent of origin, 2000–2010*

together making up the remaining 6.5%, in decreasing order of volume (*see figure*).

The study found that individual articles had been written by a maximum of eight authors, with rare exceptions. About 77% of articles counted four authors or less. Interestingly, the number of multi-author articles rose slightly over the study period at the expense of single-authored papers. This could be indicative either of a rise in collaborative research, or of the journal's preference for collaborative research, or both. This said, about 99% of multi-authored papers involved collaboration among African institutions from the same country, notably in South Africa, Egypt, Morocco and Cameroon. There was also a clear trend towards bicontinental collaboration, such as that involving Africa and Europe or Africa and North America.

Women made a minimal contribution to the journal. Here, the survey only looked at first authors, owing to the difficulty in identifying the gender of authors, who tended to be listed only by their initials and last names. As only senior (first) authors could be identified from other sources like institutional webpages, it was decided to limit the gender study to this group. Just 8% of first authors (68 out of 853) turned out to be women, irrespective of continent. Among these, just 35 (about 4%) were African women.

The bibliometric study confirms that, in most African countries, there is a clear need to strengthen education and foster research in Earth sciences. The isolation of African scientists also needs to be broken through greater co-operation among African institutions and researchers. Be it in education or research, greater institutional networking will be a priority of the Earth Science Education Initiative.

Sarah Gaines[10], Asfawossen Asrat[11]
and Sadrack Felix Toteu[12]

Read the full report: http://unesdoc.unesco.org/images/0021/002148/214888e.pdf

For details (Nairobi) : sf.toteu@unesco.org;
(Paris) s.gaines@unesco.org

8. *See What future for geo-education in Africa?* A World of Science, *April 2008*
9. *UNESCO's main partners in this initiative are the Geological Society of Africa, the Centre international pour la Formation et les échanges en géeosciences (CIFEG), the African Association of Women in Geoscience, the Royal Museum of Central Africa and the International Union of Geological Sciences.*
10. *Programme Specialist in Earth sciences at UNESCO headquarters in Paris*
11. *Associate Professor, Department of Earth Sciences, Addis Ababa University, Ethiopia: asrata@geol.aau.edu.et*
12. *Programme Specialist in Earth sciences in UNESCO's Regional Bureau for Science in Africa, based in Nairobi*

Putting a price on conservation

The Serra do Espinhaço Biosphere Reserve covers 3 million hectares in the heart of the State of Minas Gerais and is home to a population of 3.4 million. The biosphere reserve is dominated by much of Brazil's most extensive mountain range, Serra do Espinhaço, which rises to 2 000 m above sea level and harbours not one but *three* biodiversity hotspots: Caatinga, Cerrado and Mâta Atlantica.

Serra do Espinhaço also happens to be the most intensely mined biosphere reserve in the world. The compensation that municipalities receive from mining companies remains their greatest source of income but an ecological tax introduced nearly 20 years ago is making conservation an attractive alternative investment option for municipalities. Against the backdrop of the mining boom in the State of Minas Gerais over the past decade, we examine the potential of these two funding mechanisms for promoting sustainable development in the biosphere reserve.

More than 300 years before the Serra do Espinhaço became a biosphere reserve in 2005, Portuguese settlers discovered a wealth of mineral deposits in 1693 in a region they would later call Minas Gerais (literally General Mines), including bauxite, gold, gneiss, granite, iron ore, limestone, quartz and silver.

From the late 17th century until the 19th century, Serra do Espinhaço served as a major thoroughfare for travellers arriving first from São Paulo along the Camino Velho (Old Route) and, later, from Rio de Janeiro along the Camino Novo (New Route), which has also been dubbed the Estrada Real (Royal Route). The Historical Town of Ouro Preto (*see photo and municipality #36 on the map overleaf*), the Santuario Bom Jesus in Congonhas and the Vila de Diamantina Historical Centre bear testimony to this intense period of human settlement. Today, all are World Heritage sites sporting outstanding baroque art and architecture.

A small population with a large mining industry

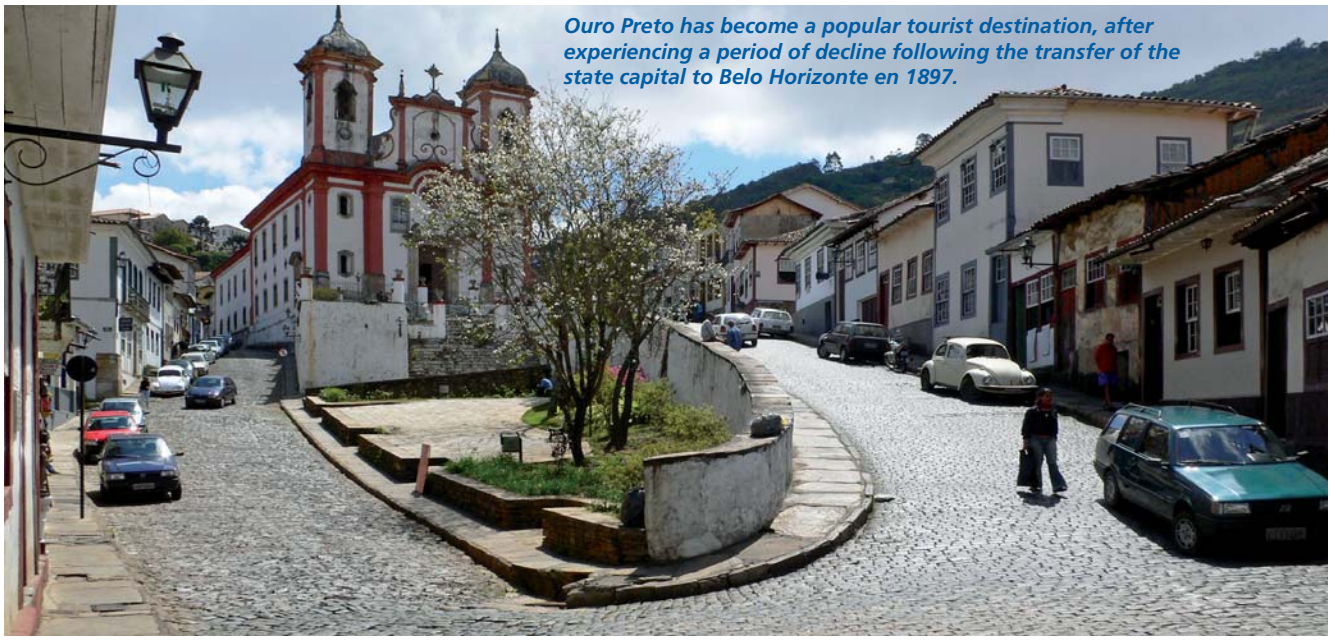
Two-thirds of the inhabitants of Serra do Espinhaço (2.3 million) live in the state capital, Belo Horizonte (#4 on the map). Most of the biosphere reserve's 53 municipalities count a relatively small population. More than half (29) have fewer than 10 000 inhabitants, 17 fewer than 50 000 inhabitants and a further six around 150 000 inhabitants.

Mining is the primary economic activity in Minas Gerais, although there is also open-range animal husbandry, subsistence agriculture and plant harvesting). In the buffer zones, agriculture, crafts, tourism and biodiversity prospecting have all benefited from the creation of the Serra do Espinhaço Biosphere Reserve.

According to the Instituto Brasileiro de Mineração, mining has transformed the profile of local employment because the industry employs a specialized work force at

©Miguel Andrade

These youngsters from the traditional community of Parauninha earn income from growing native plant species for reforestation and ornamentation.



Ouro Preto has become a popular tourist destination, after experiencing a period of decline following the transfer of the state capital to Belo Horizonte en 1897.

©Geoff Mason

almost all levels of qualification. Generally speaking, the mining projects have generated jobs, raised income levels, fostered domestic trade and expanded the tax system.

All mining companies operating in Brazil pay the municipalities royalties, via what is known as Compensation for the Exploitation of Mineral Resources. These royalties are calculated on the basis of net invoicing obtained from product sales; in other words, once all marketing taxes and expenditure related to transportation and insurance have been deducted.

Compensation for the Exploitation of Mineral Resources is calculated on a percentage basis: 0.2% for precious stones, coloured and carbonated stones and precious metals; 1.0% for gold; 2.0% for iron; 3.0% for aluminium, manganese, rock salt and potassium. Two-thirds (65%) is allocated to the municipality from which the mineral was extracted. A further 23% goes to the state and 12% is retained by the nation.

The two states which produce the most minerals are Minas Gerais (45%) and Pará in the far north (33%). Consequently, these two states receive the greatest share of mining royalties: 43% of all those collected in Brazil from January to August 2009 went to Minas Gerais.[13]

Population growth in Serra do Espinhaço Biosphere Reserve was uneven between 2000 and 2010. Not surprisingly, it was greatest in the 15 municipalities which received the greatest share of mining royalties. In those municipalities lacking mineral deposits, economic growth tended to be stagnant or even negative.

Paying the protector

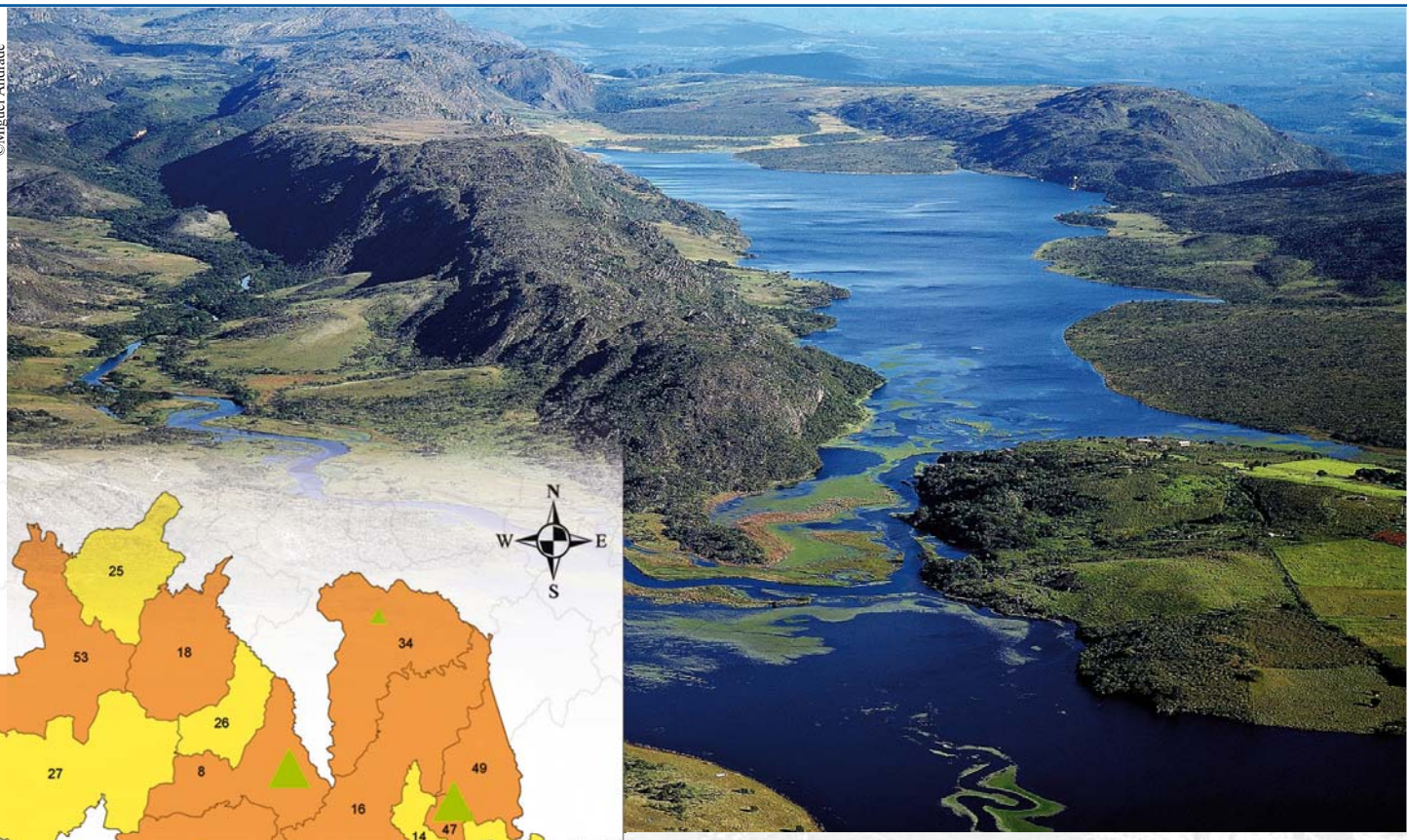
The State Tax on the Circulation of Goods and Services (*Imposto sobre Circulação de Mercadorias e Serviços, ICMS*) dates from the 1950s. This tax on consumption of about 18% – depending on the state – today represents 90% of state revenue, one-quarter of which is paid to the municipalities.

In 1988, Brazil adopted a new Federal Constitution authorizing states to define their own criteria, via legislation, for sharing revenue from the ICMS with the municipalities. Shortly thereafter, several municipalities in the States of Paraná and Minas Gerais with large protected areas complained of being penalized by the restrictions on the type of economic activity they could develop on their territory. May et al. recount, for instance, in *Selling Forest Environmental Services* (2002) how those municipalities in Minas Gerais which harbour the Rio Doce State Park, the state's largest unbroken stretch of Atlantic forest, launched a movement in the early 1990s calling for some form of fiscal compensation, such as a share of revenue from park entry fees.

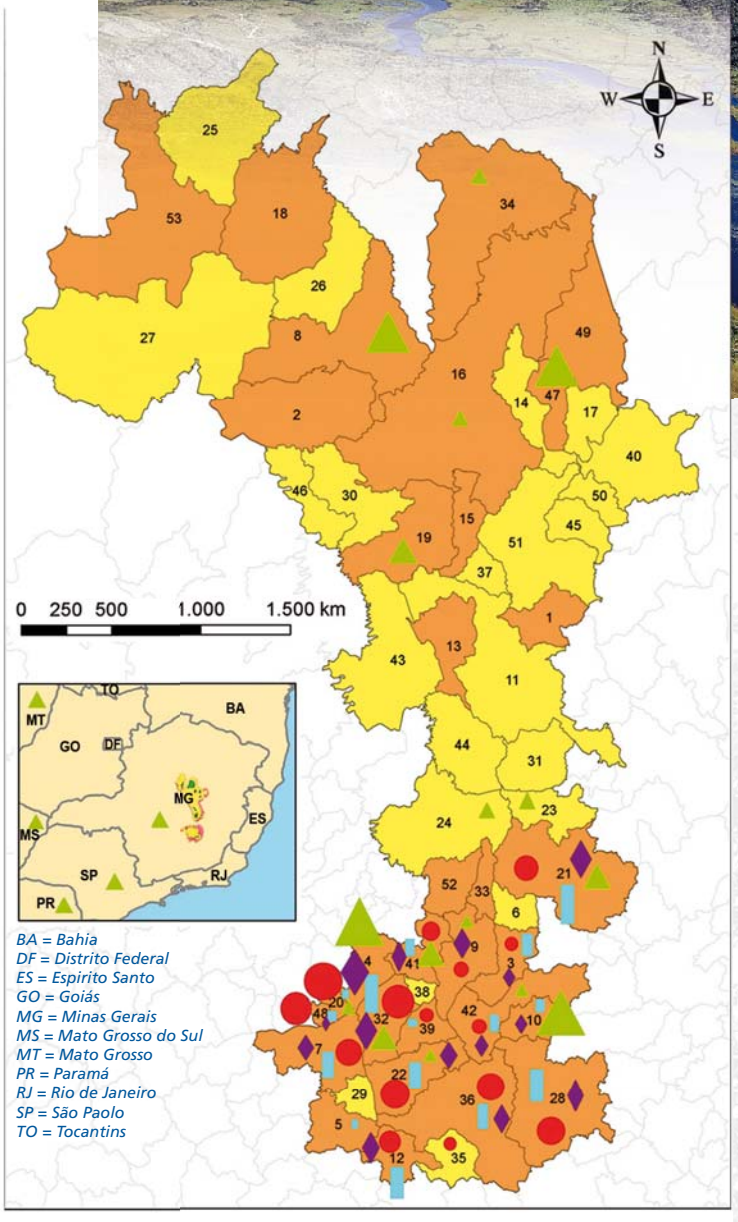
Minais Gerais reacted in 1992 by adding ecological criteria to the State Tax on the Circulation of Goods and Services. The aim of this new ecotax (ICMS-E) was to compensate municipalities with large protected areas for the restrictions they faced but, above all, to provide incentives for them to invest in conservation. The ecotax was based on the principle that 'you pay the protector.'

Two decades on, ten states out of 26 have adopted the ICMS-E mechanism. A municipality may benefit from the tax through the establishment or extension of a protected area, or through investment in an existing area to improve conservation, whether the decision originates from the municipality itself or from the state. The percentage share of revenue to which each municipality is entitled is defined according to an index which measures the municipality's Biodiversity Conservation Coefficient.

In Minas Gerais, the area under protection has grown considerably since the ecotax was first implemented by participating municipalities. In the first three years following the law's adoption, the number of conservation units doubled, even though the majority of these new protected areas were actually created for sustainable use rather than purely for conservation.



The Serra do Espinhaço mountain range has the highest rate of endemic plants in Brazil, particularly in the Serra do Cipó, pictured here with the village of Lapinha. Serra do Cipó is one of the biosphere reserve's 13 core areas. The mountain range represents a huge spring, for it is the source of the São Francisco, Doce and Jequitinhonha Rivers that drain into the Atlantic Ocean; it provides freshwater to millions of Brazilians, including the traditional communities who are particularly dependent upon it. Unfortunately, these rivers are threatened by deforestation, fires, sedimentation and contamination.



Municipalities in Serra do Espinhaço Biosphere Reserve

By 2009, Minas Gerais had a total of 72 conservation units – offering integral protection and promoting sustainable use – registered with the Instituto Estadual de Florestas, 14 of which were managed by the municipalities directly. Of the 3 076 million hectares covered by the Serra do Espinhaço Biosphere Reserve, two-thirds (2 085 million hectares) are conservation units today. Twenty-one of these conservation units are located in the biosphere reserve's buffer zones: 16 protected environmental areas, one state forest and four private natural reserves.

The ecotax: still the poor relation

As a pioneering economic mechanism for conservation, the ICMS-E shows considerable promise. However, its impact has been greater in some municipalities than in others. The annual revenue of the municipality of São Gonçalo of Rio Preto (*#47 on the map)*, for instance, has grown by 3 691% since the creation of the ecotax.

Revenue from the ecotax remains modest in comparison to the value of the ecosystem services rendered by the biosphere reserve: R$22.7 million was transferred to municipalities in 2009, representing an average of just R$10 per hectare per

year. Revenue from the ecotax also tends to be poorly distributed, as municipal protected areas tend to be fairly small. For this reason, some municipalities have tended to prefer other sources of revenue, such as property speculation.

In comparison, the mining royalties collected by municipalities in 2010 totalled R$389.3 million, 17 times the earnings from the ecotax. More than half of these royalties went to just three municipalities: Nova Lima (R$81.4 million, #32 on the map), Itabura (R$74.6 million, #21) and Mariana (R$65.4 million, #28). It would thus be extremely beneficial for the municipalities to team up with the mining sector to invest these royalties in promoting 'green municipalities' and to cover the cost of maintaining and restoring damaged eco-systems which ensure such services as a clean water supply and fertile soils.

Currently, there is an antagonism between the need to protect these ecosystem services on the one hand and the boom in mining, urban and infrastructure development on the other. The price per ton of iron ore has increased considerably over the past ten years. As a consequence, the mining sector is able to pay high dividends, acting as a stimulus for the economy.

This economic boom is in turn attracting people to the region. However, with a larger, more affluent population comes a greater demand for raw materials. This is exerting considerable pressure on the Serra do Espinhaço. Moreover, this situation is penalizing the mining sector itself, for the increase in mining operations has not only damaged the environment but is also depleting mineral resources.

Still room for improvement

The *Madrid Action Plan for Biosphere Reserves* (2008–2013) makes three key recommendations for the financial management of biosphere reserves: better funding mechanisms; payment for ecosystem services; and the forging of partnerships for the management of forests and water bodies.

In Brazil, neither the mining royalties, nor the ecotax are ideal mechanisms for remunerating ecosystem services. The disadvantage with the current compensation system is that it prevents corporate leaders from forging ties with the areas where their mining companies are active. At present, there are no mandatory environmental criteria for the investment of royalties from mining. As a result, conservation units and the wider territories of biosphere reserves receive inadequate financial benefits from the mining industry's use of their land and water.

The drawback with the ecotax is that revenue is indexed on consumer spending. Herein lies an uncomfortable paradox, for the state will only be able to reduce the pressure on ecosystems by adopting more sustainable patterns of consumption for goods and services. This will take more than the adoption of a new management system or laws. Public policies which offer ecosystems better protection will also need to be devised, with provisions for restoring ecosystems whenever necessary.

©Vale S. A.

Iron mining in the municipality of Itabirito (#22 on the map)

Although both the mining royalties and the ecotax have their shortcomings, they could still be used to promote dialogue among the different stakeholders. The biosphere reserve management team plans to develop a dialogue with mining companies to persuade them to adopt extraction methods which maintain healthy ecosystems. The team also plans to encourage private interests to develop protected areas of their own, in order to compose a mosaic of private and public protected areas across the biosphere reserve. There are a host of other priorities, such as restoring mining areas and adjacent rivers or improving the relationship between mining companies and local communities.

Thanks to a recipe blending dialogue and co-operation, the management team of Serra do Espinhaço hopes to see the biosphere reserve become a model for sustainable development.

Sérgio Augusto Domingues[14],
Cláudia Santiago Karez[15],
Isabella Virgínia Freire Biondini[16]
and Miguel Ângelo Andrade[17]

For more on good practices in Latin American biosphere reserves, see the compilation of studies published by the Ibero-MAB Network in 2010 (in Spanish and Portuguese):

www.unesco.org.uy/mab/es/areas-de-trabajo/ciencias-naturales/mab/publicaciones/libros.html

13. *About R$218.38 million out of a total of R$500.45 million*
14. *Manager of the Serra do Espinhaço Biosphere Reserve: sergioguto@gmail.com*
15. *Programme Specialist in UNESCO's Regional Bureau for Science for Latin America and the Caribbean, based in Montevideo*
16. *João Pinheiro Foundation*
17. *Pontifical Catholic University of Minas Gerais*

Diary

15 January
Deadline for Michel Batisse Award
for Biosphere Reserve Management. Deadline for applications: *www.unesco.org/mab; mab@unesco.org*

1–3 February
Measuring development: how science and politics work together
UNESCO-MOST conf. Social phenomena are measured in an attempt to objectify reality. These indicators are useful for policy-making, assessment, scientific work, etc. but changes in data and indicators have become a major scientific and political issue. UNESCO Paris: *g.solinis@unesco.org; gemdev@univ-paris1.fr*

16–17 February
The Great East Japan tsunami
Japan–UNESCO–UNU symposium on March 2011 tsunami. United Nations University, Tokyo (Japan): *m.yamamoto@unesco.org*

20–23 February
International Geoscience Programme
Scientific board meeting (20–21) followed by 40th anniversary (22) and geology trip (23). Anniversary theme: how do we see the next 40 years of Earth sciences and the role of IGCP? Among discussion topics: climate change, natural hazards, the role of minerals in our lives and the planet's future. UNESCO Paris: *m.patzak@unesco.org*

23 February
Earth Science Education Initiative in Africa *inter alia*
Update on implementation of UNESCO's Earth Science Education Initiative in Africa, followed by a workshop on status of geoscience education with focus on the critical relationship between research and education. (*See also page 17*). UNESCO Paris: *s.gaines@unesco.org*; (Nairobi): *sf.toteu@unesco.org*

12 March
Launch of World Water Development Report
4th in series, on *Managing Water under Uncertainty and Risk* at 6th World Water Forum, Parc Chanot-Palais des congrès et des expositions de Marseille (France): *h.edwards@unesco.org*

26–29 March
L'Oréal–UNESCO for Women in Science Awards
Award of prizes to 5 laureates and 15 fellows. UNESCO Paris : *www.forwomeninscience.com*; *s.bahri@unesco.org*

New **Releases**

UNESCO Biodiversity Initiative
Brochure co-ordinated by S. Arico. Exists in English and French, 11 p.
Download: *http://unesdoc.unesco.org/images/0021/002133/213313e.pdf*

Tracking Key Trends in Biodiversity Science and Policy
Aricò, S. and L. A. Brooks (eds). Scheduled for online publication in March. Exists in English only, circa 150 pp.
Proceedings of the UNESCO Conference on Biodiversity Science and Policy, held at UNESCO headquarters in Paris in January 2010, to launch the International Year of Biodiversity. *See also page 2*. Download: *www.unesco.org/new/biodiversity-initiative*

A Blueprint for Ocean and Coastal Sustainability
Joint UNESCO-IOC, IMO, FAO, UNDP paper towards preparation of UN Conference on Sustainable Development (Rio+20, June 2012). English only, 44 pp. Summary also in French and Spanish. See also page 11. Download: *www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/interagency_blue_paper_ocean_rioPlus20.pdf*

Engineering the Climate:
Research Questions and Policy Implications
UNESCO, SCOPE and UNEP Policy Brief no. 14, English only, 6 pp.
Geo-engineering is the intentional alteration of the climate system on a large scale and includes anything from ocean fertilization to large-scale cloud seeding. These proposed interventions are at various degrees of testing with uncertain consequences. This policy brief aims to build awareness of this rapidly evolving field.
Download: *http://unesdoc.unesco.org/images/0021/002144/214496e.pdf*

Impacts of Climate Change on Groundwater in the Arab Region
By Ahmed R. Khater. Technical report produced by UNESCO's Regional Bureau for Science in the Arab States, based in Cairo (Egypt), within UNESCO-IHP. Exists in English, 126 pp.
Provides an overview of the aquifer systems in the Arab region and the possible impact of climate change on the region's groundwater resources, potential measures for groundwater management in this context. Includes recommendations for action, research and studies on climate change adaptation mechanisms.
Download: *www.unesco.org/new/uploads/media/Impacts_of_Climate_Change_on_Groundwater_in_the_Arab_Region-2_Aug_2010-a.pdf*

Surveys and Activities on Post-earthquake Disaster
Proceedings of international workshop held on 6-8 July 2010 in Padang, Indonesia, hosted by Research Institute for Human Settlements and Ministry of Public Works of Indonesia, in co-operation with Provincial Government of West Sumatra, with support of UNESCO and Japan International Cooperation Agency. Exists in English, 220 pp.
Case studies from around the world presented by experts. For details: *y.katsumi@unesco.org*.
Download: *http://unesdoc.unesco.org/images/0021/002138/213843e.pdf*

From Space to Place
An Image Atlas of World Heritage Sites on the In Danger List of UNESCO
Produced by United States Geological Survey in co-operation with UNESCO.
Detailed satellite photos of the 31 sites on the List of World Heritage in Danger. For details: *ma.hernandez@unesco.org*; download: *http://unesdoc.unesco.org/images/0021/002143/214371E.pdf*

Large Hadron Collider (LHC)
Photographic album of the LHC. Peter Ginter, Rolf-Dieter Heuer, Franzobel. UNESCO Publishing / CERN / Editions Lammerhuber. ISBN: 978-3-901753-28-2, 64,00€. Trilingual edition: English/French/German, 274 pp. For details, see page 14.
Features the images of leading photographer Peter Ginter, paired with the words of well-known Austrian writer and playwright Franzobel. Includes the transcript of a conversation between Franzobel and CERN Director-General Rolf Heuer on the science behind the LHC. Richly illustrated and weighing in at almost 5 kg, this book is a fine example of the old adage that a picture is worth a thousand words.

ICT for Higher Education
Case studies from Asia and the Pacific
UNESCO Bangkok office with support of Japanese Funds in Trust. ISBN: 978-92-9223-384-6 (print), 978-92-9223-385-3 (electronic). English only, 160 pp.
Case studies resulting from UNESCO research on the use of ICTs for higher education in Asia–Pacific in three areas: open and distance learning; blended learning; administration and management practices.
Download: *http://unesdoc.unesco.org/images/0021/002141/214143E.pdf*

The Performance of African Earth Scientists in the *Journal of African Earth Sciences 2000–2010*
Study commissioned by UNESCO's Regional Bureau for Science in Africa, English only, 27 pp. See page 17 for details.
Download: *http://unesdoc.unesco.org/images/0021/002148/214888e.pdf*

From Green Economies to Green Societies
UNESCO's Commitment to Sustainable Development
*Brochure prepared for Rio+20 Summit in June 2012 by UNESCO Bureau of Strategic Planning with UNESCO-wide contributions on projects and programmes. English and French, 76 pp.*Download: *http://unesdoc.unesco.org/images/0021/002133/213311e.pdf*

New website for UNESCO-IOC Perth
UNESCO's Intergovernmental Oceanographic Commission has a Regional Programme Office in the Australian city of Perth. The office's new website offers links to the Global Ocean Observing System's regional alliances for the Pacific Islands and Indian Ocean, the Indian Ocean Panel, Sustained Indian Ocean Biogeochemistry and Ecosystem Research and the Indian Ocean Observing System Resources Forum.
Go to: *www.iocperth.org*; or write to: *N.D'Adamo@bom.gov.au*

Portal on underwater cultural heritage
To mark the 10th anniversary of the entry into force of the Convention on Underwater Cultural Heritage in 2001, UNESCO has launched a portal for multiple audiences with animated and documentary films on archaeological sites and museums and photo galleries. Includes a kid's page with games and information on opportunities for research and training:
www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/

World Heritage Forests
Peridodical, no 61. UNESCO Publishing/Publishing for Development Ltd. ISSN: 1020-4202, in English, French and Spanish, 7.50€
Features articles on the forests of the Congo Basin, Sequoias, Río Plátano Biosphere Reserve and the Tropical Forests of Sumatra.

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