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SPRING 2014 | ENVIRONMENTAL SOLUTIONS IN ACTION

ACRES AWAY

WHAT DO BIG LAND DEALS
MEAN FOR PEOPLE AND
THE ENVIRONMENT?

PLUS:

**WHEN SPRING
COMES TOO SOON**

ENERGY *from the* **OCEAN**

... infinite innovation, mock lion hunts, GMOs, technofixes & more

THE TROUBLE WITH GMOs

AGAINST MY BETTER JUDGMENT, I'm dipping my toe into the genetically modified organism debate.

These are rough waters. GMOs seem to polarize people more than almost anything else — especially in terms of whether they are safe to eat or to grow. I try to stay open-minded on the topic, but it's obvious that the use of GMOs in agriculture has created some big problems.

The problem facing GMOs isn't with the technology per se; it's with how they have been deployed. Despite promises of improved food security, increased yields, decreased chemical use and more nutritious crops, GMOs end up causing many disappointing failures.

To begin, while GMO efforts may have started with good intentions to improve food security, they ended up focusing on crops that are better at improving profits, such as feed corn (mostly for animal feed and ethanol), soybeans (mostly for animal feed), cotton and canola. While the technology might have “worked,” it wasn't applied to crops that actually feed the world's poor.

Furthermore, GMOs have had uneven success in boosting yields. Instead of improving plant growth, they have mainly replaced

GMO crops, this was apparently more than offset by an increase in *herbicide* use on U.S. croplands, likely because weeds have become resistant to Roundup. Here there seems to have been a lack of systems thinking — which would have anticipated the “rebound” problems inherent in chemical weed control.

I also become skeptical when GMO approaches are pursued instead of simpler ways to address the same problem. For example, we hear a lot about biotech crops that are drought tolerant, fix their own nitrogen and so on, but they are a long way from being ready for the real world. Why not focus on agronomic approaches — such as using cover crops, mulching and organic-style techniques — instead, which could yield results *today*?

Similarly, instead of engineering better nutrition into crops to make GMOs such as golden rice, why not grow conventional nutrient-rich crops such as fruits and vegetables? Why focus on more technical solutions, where a simple approach might be as (or more) effective?

Finally, many GMO advocates bristle at efforts to require labeling of GMO food because they see “no substantial biological difference” between GMO and traditional crops. Maybe, but that's not the point. It's

GMOs have frequently failed to live up to their potential, not because they are inherently flawed, but because they have been poorly deployed into the complex social and environmental contexts of the real world.

old forms of pest control with new ones. In the U.S. this has had more impact on farmer profits and labor than on yield. To be fair, it seems that Bt cotton in India *did* substantially improve yields, and canola in Canada is seeing a measurable boost. But overall, GMOs are not yet substantially enhancing world food supplies.

Ironically, it appears that some GMOs may have failed to reduce overall pesticide use, too. In the U.S. there appears to have been a net *increase* in pesticide use for GMO corn, soybeans and cotton since the late 1990s. While *insecticide* application was down for

about trust. When people say GMO labels are misguided, I ask, “Would you be happy if all the meat in grocery stores was simply labeled ‘animal,’ even if an ‘expert’ assured you they were all basically the same?”

What do all of these issues have in common? They show that GMOs have frequently failed to live up to their potential, not because they are *inherently* flawed, but because they have been poorly deployed into the complex social and environmental contexts of the real world. And I worry that GMOs are sometimes the victims of reductionist



PHOTO BY JOSH KOHANEK

thinking, where the focus is on technology and business models, and less on the social and environmental impacts.

I urge GMO advocates to take a step back and think more *holistically* about GMO technologies in the context of the larger systems connecting agriculture, food, culture, people and the environment. I encourage them to build more *interdisciplinary* research teams — with social scientists, ecologists, organic farmers and GMO critics. I suggest supporting more of their work with public funding, to help ensure that social and environmental benefits are put ahead of profits. And I would strongly urge *both* sides of the GMO debate to do a better job of engaging with each other and the broader public.

Ultimately, we'll have to work through this together as a society — because how we decide to use, or not use, GMOs is too important to leave to just one way of thinking. 🌱

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H₂OPPORTUNITY

From Fortune Brainstorm Green to SXSW Eco and beyond, **Will Sarni** is one of world's most sought-after speakers on global water and sustainability issues — and with good reason. Author of *Corporate Water Strategies and Water Tech: A Guide to Investment, Innovation and Business Opportunities in the Water Sector* and director and practice leader for enterprise water strategy with Deloitte Consulting LLP, he advises some of the world's leading companies on water-related risks looming over business and industry. Ensia caught up with Sarni at his home base in Denver.

INTERVIEW BY TODD REUBOLD | PHOTO BY JEFF NELSON



More and more stakeholders are becoming aware that water scarcity is a business issue.

WHY IS WATER RISK SUCH A GLOBAL CONCERN? If you look at projections of supply versus demand, assuming business as usual, globally there's roughly a 40 percent shortfall that's projected by 2030. In certain

countries it's a little bit less, others a little bit more, and really what it takes into account is there's this increase in demand for a finite resource. So population growth, increasing economic activity, increased urbanization, demand for energy, agriculture, changing

diets are all coming together to form this perfect storm that's driving more and more demand for this finite resource.

OVER THE PAST FEW YEARS THE NUMBER OF INVESTORS CALLING FOR

GREATER CORPORATE TRANSPARENCY ON WATER HAS QUADRUPLED. WHAT'S THE MAIN DRIVER?

Two big factors are education and awareness. More and more stakeholders are becoming aware that water scarcity is a business issue. And if it's a business issue, then it's an issue for investors. Investors are really looking to understand what business risk might be tied back to water vulnerability. The flip side to that is, in certain sectors and certain companies it's a business opportunity. If you're in the business of water treatment or information technology, then your business can potentially grow to address some of these critical resource issues.

WHAT ARE SOME OF THE BUDDING WATER-RELATED CLEANTECH BUSINESS OPPORTUNITIES?

There's certainly a lot going on in water treatment. How do you treat water with less energy and fewer chemicals? Also, efficiency is a big trend. More people are asking, "How do you do more with less?"

Big data is also growing in importance. How do you collect water data, analyze it and visualize how to manage it? It's essentially the application of big data into sectors like agriculture and elsewhere. I think that holds a lot of promise. If you can understand how you're using a resource, then you can better manage it.

IRRIGATION IS ONE OF THE BIGGEST WATER USERS ON THE PLANET. IS THAT ANOTHER AREA THAT'S RIPE FOR INNOVATION?

Absolutely. You have a big move towards precision agriculture and smart agriculture using drip irrigation technologies, as opposed to flood irrigation. We're also seeing food and beverage companies essentially reach into their agricultural supply chain to help them improve efficiency of their use of water.

SHIFTING GEARS, YOU'VE WRITTEN IN THE PAST ABOUT "GREEN PERFORMANCE." WHAT'S YOUR TAKE ON SUSTAINABILITY'S POSITION IN THE BUSINESS WORLD? I think it's essentially

mainstream now. And I think companies to varying degrees understand the value that it brings to their business through reduced operating costs and increased revenue. Now the question is, how do you connect sustainability initiatives at the company level to consumers and stakeholders that care so they can gravitate towards what you have to offer? That connection between sustainability programs and digital marketing and leveraging social media is an interesting trend also.

WHAT DO YOU THINK SOME OF THE EMERGING SUSTAINABILITY TRENDS MIGHT BE OVER THE NEXT YEAR OR SO?


I think sustainable consumption will be one — reaching out to consumers directly to improve sustainability. I think resource risk issues are another emerging trend — water being one of them — as a constraint for growth, essentially. I think there will be growing interest around reporting disclosure and transparency, especially in the world of water. I also think big data — the ability to collect large bodies of data, make sense of it and then report out performances — will continue to grow in importance.

WHAT'S SURPRISED YOU THE MOST IN YOUR YEARS OF WORKING ON SUSTAINABILITY ISSUES?

I think the progress we've made and the progress we haven't made. That's going to sound [like] a bit of a contradiction, but 10 years ago few people knew what I did. Now I can tell people I'm a sustainability consultant and I focus on water, and they're like, "Yeah, cool, I get it." In 10 years sustainability has pretty much become mainstream.

On the other hand, there's so much more to be done. And it's just gotten more and more sophisticated as to what people are doing and how they're dealing with some of these key issues.

WITH THE SCALE AND COMPLEXITY OF SUSTAINABILITY CHALLENGES INCREASING, WHAT GIVES YOU HOPE THAT WE'LL FIGURE THINGS OUT IN TIME? By nature I'm a hopeful person. I don't think you can do work on these issues

and not be. So, I believe in our ability to change, to adapt and to innovate, not just on the technology side, but on the partnership side. If I think about what's going on in the world of water, exciting innovation opportunities around partnership are taking place in addition to the technology piece. That gives me hope. Going back to your earlier question about the 40 percent [global water] shortfall, that assumes business as usual — and I don't believe in business as usual. 

RISKY BUSINESS

Will Sarni and colleagues at Deloitte contributed substantially to the CDP Global Water Report 2013 — one of the world's most comprehensive assessments of water risk management. Among the highlights of that report:

180

number of global companies contributing to the 2013 report statistics

112

number of countries where these companies have operations

70

percent of participating companies that identify water as a substantive business risk

53

percent of participating companies that are already experiencing detrimental water-related impacts

82

percent of energy sector companies citing exposure to substantive water risks

63

percent of participating companies that have set concrete goals or targets managing risk within direct operations

FULL CIRCLE

For environmental artist Martin Hill, circular forms underscore the importance of cyclical systems in nature. Recognizing the power of imagery to reach people's hearts and minds, Hill creates and photographs ephemeral sculptures in natural landscapes to illustrate the interconnectedness of living systems. Here, flax threads use the structural principle of tensegrity to shape plant stems into a dynamically balanced arc above Lake Wanaka, New Zealand.

“Our culture — a linear system in which we take, make and waste — is bankrupting us,” says Hill. “Nature is cyclical. We need to shift our consciousness and practices to align with natural systems, or we won't survive.”

+ SEE MORE IMAGES AND READ HILL'S STORY: [ENSIA.US/CIRCLE](https://www.ensia.us/circle)





FUND IN THE SUN

Individuals interested in helping bring solar power to poor, off-grid communities have a new opportunity in SunFunder. The crowdfunding initiative channels investments as small as \$10 into prescreened solar energy companies in developing countries to help them build their business. Once a recipient is generating revenue, investors can get their money back or reinvest it in another project.

2.5 BILLION
number of people in the world
who lack improved sanitation

—United Nations

BANKING ON PLASTIC

Can plastic trash help people find a way out of poverty? Social entrepreneurs David Katz and Shaun Frankson think so. Their new business, Plastic Bank, sets up plastics recycling centers in developing areas where local residents can exchange plastic trash they collect from beaches and roadsides for basic necessities, use of a 3-D printer or assistance in setting up their own businesses.

**THE WORTH OF A TREE**

Trees provide communities with many benefits: They offer energy-saving shade and shelter from wind, absorb carbon dioxide, create habitat for birds and other wildlife, and add beauty and value to homes and businesses. But how to quantify that benefit? The USDA Forest Service's i-Tree software provides a free tool that homeowners, city planners and others can use to put a dollar value on the ecosystem services urban trees offer for better planning, education and action. Check it out at ensia.us/itree.



PHOTO BY HEIDEMOYER/CREATIVE COMMONS

CONSERVATION CRYSTAL BALL

When it comes to conservation, what you don't know can hurt you. That's why a group of experts gathers each year to identify emerging opportunities and threats with potentially big impacts on biological diversity. Picks for 2014 include financial markets' response to unburnable carbon, peatland subsidence in Southeast Asia and the resurrection of extinct species. Read the rest at ensia.us/2014.

OLD FRIENDS

Need another reason to protect, value and spend time in outdoor green spaces? According to British clinical microbiologist Graham Rook, because humans evolved in the presence of microorganisms found in nature, exposure to environmental microbes could be important for maintaining immune system health. Learn more at ensia.us/oldfriends.

70 estimated percent
of national parks
worldwide that were first
preserved by religious groups

—Martin Palmer

>10.8 BILLION
projected global population
in 2100 —United Nations

NOT ABOUT MONEY

You might think putting a dollar value on conservation would help motivate people to trim their energy use. But a recent UCLA study suggests otherwise. When cost savings or monetary rewards were the focus of energy-saving messaging, recipients on average increased their energy use. Programs that provided customized advice on how to save energy or that compared people's energy use with that of others, however, yielded savings.

SUPER SALT REMOVER

Researchers at the Massachusetts Institute of Technology have developed a one-step process for removing not only salt from seawater, but particulates and bacteria as well. Though it's early in the game, hope is the technology could one day be used to supply clean drinking water where it's in short supply. Learn more at ensia.us/cleanwater.

TROPICAL WONDER

A team of field biologists led by Conservation International's Rapid Assessment Program recently discovered up to 60 species in Suriname, including reptiles, amphibians and insects that are likely new to science and may exist nowhere else on Earth.



MAKING LIGHT OF GRAVITY

Combine a weight, a rope, an LED, inspiration and some savvy crowdfunding, and what do you get? GravityLight. Developed by British inventors Martin Riddiford and Jim Reeves, this pulley-based lamp produces up to 30 minutes of light each time a bag at the other end of the rope is hoisted. The invention is now being tested in Africa and Asia, bringing new light to some of the estimated 1.5 billion-plus people around the world who lack reliable access to electricity.



DATING GAME

Americans discard billions of pounds of edible food each year, thanks to a labeling system that blurs the relationship between food safety and food package dates. A report by the Natural Resources Defense Council and the Harvard Food Law and Policy Clinic proposes three solutions: 1) make "sell by" dates invisible to the consumer, 2) establish a uniform dating system for consumer use and 3) improve food safety labeling.

\$15
BILLION
value bees add
to U.S. crops
each year

—U.S. Department
of Agriculture

4,000
species of bees
known to be
native to the U.S.

—The Xerces Society

INSTANT OIL

U.S. Department of Energy researchers have developed a process that can convert algae to biocrude in a matter of minutes and also produce fuel gas, water and fertilizer. Expect to hear more from Utah-based Genifuel Corp., which licensed the technology and is moving forward with plans to build a pilot plant.

FOR MORE NOTABLES, VISIT ENSIA.COM/NOTABLES



BIG DEALS



**Large cross-border
land investments have
far-reaching ramifications.**

**Can we minimize
downsides and maximize
benefits for people and
the environment?**

by **FIONA HARVEY**

Papua New Guinea, the world's top target for large international land deals, has turned over millions of hectares of land to foreign interests for logging and conversion to oil palm plantations.

“When [the trucks] came through they could not get access to their objective. They really had to push their way through here. The people did not actually accept this idea of palm oil, and these things. The people said ‘No, we will not allow the road.’”

That’s how Micheal Kyibah, clan leader of Bugain Baglos in Papua New Guinea, described the scene in the nonprofit Oakland Institute’s film “On Our Land” after a logging company tried to build a road and clear land for new palm oil plantations in his area. Local people were not consulted, he said, and objected to the development. After the plans went through anyway, residents lined the route of the new road to try to have their voices heard. “People in higher places force the villagers to go through this,” Kyibah said.

This kind of deal is commonly known as a “land grab”: Companies or countries, mostly in the developed world, buy up tracts of land — as much as a million hectares at a time — in poorer nations to boost their capacity to produce food or biofuels, obtain minerals, or conduct other activities such as logging. Such transactions have increased in the past decade, with more than 55 million hectares targeted in more than 1,000 cross-border deals in scores of countries, according to the Land Matrix global land monitoring initiative, which tracks such deals.

EDITOR’S NOTE: *Although we have used the best available sources of large multinational land purchase data for this story, it is important to note that no current data on purchases of land, or the rights to its amenities, can be definitive because there is no comprehensive international register of land rights. Most developed countries have land registries of various kinds, but even these can disguise the ultimate buyers of land, and many developing countries lack any such registries or the means of enforcing them. In addition, companies can pursue deals through complex systems of national subsidiaries. It is safe to say that the numbers we report in this article are almost certain to be an underestimate of the true extent of global land purchases.*

Many have raised concerns about these deals because of the risk that poorer countries will give up their land to richer ones without receiving appropriate compensation or because of the environmental destruction that can ensue. Others, however, regard at least some of them as much-needed investment in the development of natural resources and agriculture in areas that have suffered from a lack of attention.

Can large transnational land deals be beneficial? If so, what can we do to make sure the benefits sufficiently outweigh the costs and are appropriately distributed? As with so many things, the devil is in the details.

ACCESS TO ADVANTAGES

Cross-border land investments have been a significant feature of international relations in the past decade for a number of reasons. Rising food prices play a major role, and growing populations with a rapidly rising middle class in countries such as China and India have increased the pressure on fertile land. As climate change also takes hold, some countries express fear that their own resources are under threat, and have looked to find resources elsewhere that will secure their future food supplies.

By growing crops in other countries, governments and companies from regions where resources are being depleted can gain access to natural advantages elsewhere. A metric ton of wheat grown abroad, for example, can save 1,300 cubic meters of domestic water for an arid country.

“We believe this is more about water than it is about land,” says Carin Smaller, advisor on agriculture and investment at the International Institute for Sustainable Development. Smaller cites one deal by a company she cannot name whereby an extensive tract of land has been bought up because of the access it gives to a mountain and an important river. “The company said to me they had bought that land in order to have control of the water supply,” she says.

Water insecurity is the key factor behind Middle Eastern companies’ increasing interest in overseas land deals, say Smaller and other analysts. For decades, Saudi Arabia and other Gulf of Arabia states had focused on a policy of self-sufficiency, trying to grow enough wheat and other staple crops on their own land to feed their burgeoning populations. But this policy was ecologically disastrous — water from underground aquifers was needed to feed the endless thirst of the crops, resulting



in rapid depletion at an unsustainable rate. In the late 2000s, these countries made a conscious change of policy: Instead of trying to grow enough at home, they would invest in fertile and well-watered land abroad, where the same crops could be grown at a fraction of the cost.

Mineral rights are also a consideration. In many countries, landowners own the rights to the extraction of subsurface resources, such as coal, oil and metal ores. This appears to be the motivation behind many speculative deals, particularly the big deals that involve hundreds of thousands or millions of hectares, according to Smaller. “What’s below the surface is clearly the target in some deals,” she says. “This often happens before the potential minerals have been fully explored, and companies stake claims with the intention of prospecting over a wide area.”



A worker looks on as an excavator clears vegetation in southern Sierra Leone to make way for an oil palm plantation on land controlled by Socfin, an agricultural company based in Europe.

TENUOUS\$ TENURE

Why are international land transactions so much more problematic than domestic ones? One reason is that in many developing countries, land rights law has not kept pace with modern investment practices in the West — and that puts the countries selling or leasing their land at a disadvantage. In sub-Saharan Africa alone, more than 90 percent of land is unregistered, with no legal title held by individuals or communities. Most people occupying that land assume they have tenure because they have lived there all their lives, or their families have farmed there for generations. Such informal arrangements, however, can easily be mowed down by governments or corporations anxious to cash in on investor appetite.

But why should land rights be codified exclusively according to Western norms? Chief Seattle, a 19th-century Native American leader, in the midst of the vast land grab by white settlers of indigenous land, is said to have asked how one could own the sky or the water or the land. The speech may be apocryphal, but the sentiments are still familiar across much of the globe.

Whatever the motivation, there is no question that transnational land deals are a big deal. An area of more than 44 million hectares — close to the size of Spain — has been targeted in transnational deals, counting those that have been completed, are underway or have run into trouble or failed (a small percentage — only 76 out of more than 1,000 deals), according to Land Matrix. The U.S. tops the list of investor countries, with 7 million hectares of deals, and the United Kingdom comes in fourth place with 2.3 million, but much of this is due to companies and investment vehicles domiciled or incorporated in these countries but with their main operations elsewhere. The second biggest investor country is Malaysia, with investments totaling more than 3.3 million hectares in other countries, while the United Arab Emirates comes in third with 2.8 million. India, Singapore and Brazil are also

completing an increasing number of deals, and China — perhaps surprisingly, given the publicity some of its deals have received — takes 10th place, according to the Land Matrix, with 1.3 million hectares targeted.

New evidence is emerging that the phenomenon that was concentrated on Africa for most of the last decade is now having massive impact elsewhere. Topping the list of countries targeted by land buyers is Papua New Guinea, where 3.8 million hectares are subject to interest, followed by Indonesia and South Sudan, with close to 3.5 million hectares each under target. Most of the other target countries are in Africa, including Mozambique, Democratic Republic of the Congo, Liberia and Sudan. But Ukraine also ranks highly on the list, with investors interested in 1.6 million hectares there.

And although the rate at which land is being bought up has tailed off of late, with fewer mega

FISHING GRABS

Resource access is not purely a land-based issue: With most of our planet covered by water, it is not surprising that the long arms of grabbers have reached into the deep seas as well. As overfishing takes its toll on fragile ocean ecosystems, companies and countries that are exhausting their own dwindling stocks have rising incentive to buy up fisheries in other areas. This takes two broad forms: for developed countries and their companies, buying up fishing rights originally awarded to the indigenous fleets of poorer nations; and for rich fishing fleet owners, buying up vessels that can fly a flag belonging to another nation that confers on them rights to exploit resources beyond their real national limits. The two can often coincide.

The European Union has initiated a campaign against deals it sees as unfair or putting developing countries at a serious disadvantage. As a result, licensing rights deals that have allowed European fleets to denude the waters of developing countries are being renegotiated, and countries that fail to properly police their vessels flying under “flags of convenience” are being cut off from trade with the EU bloc. There are new rules on fisheries partnership agreements between EU states and developing countries, and increased enforcement against illegal, unreported and unregulated fisheries.

“The external dimension is an important part of the reform [of the EU’s fisheries policies],” says Maria Damanaki, the EU’s fisheries commissioner. “We need to project the principle of sustainability and its rules on the international arena, ensuring that EU vessels are subject to the same clear rules when they fish in international waters as when they fish at home.”

deals reaching fruition than in the peak year of 2010, millions of hectares now under contract have not yet been put to their full use. Only when that starts to happen on a large scale will we be able to see the true impact of these deals.

THE GOOD AND THE BAD

When done poorly, without proper consultation, impact assessment and local buy-in, large-scale international land deals can be a source of bitter conflict, sometimes involving the wholesale displacement of indigenous peoples, the break-up and impoverishment of established communities, and, in the worst cases, dozens or even hundreds of deaths. Environmentalists recently commemorated the 25th anniversary of the death of Chico Mendes, a campaigner against land grabs in Brazil, who was shot dead by a cattle rancher’s son. His death was just one among many hundreds in South America and

presaged what has become an increasing toll throughout the world.

“We have worked with people who have been displaced, who have suffered intimidation and violence, and in some cases have been killed,” says Kate Geary, a policy advisor at Oxfam. “It can be very dangerous for people to try to stand up for their land rights in the face of land grabs.”

When done well, however, transnational land deals can be a boon to developing countries, says Lorenzo Cotula, a principal researcher at the International Institute for Environment and Development and author of a recent book on land grabs. “The fact that there is renewed interest in investing in agriculture is very positive — for far too long, this has been neglected, and this is a big public and private investment.”

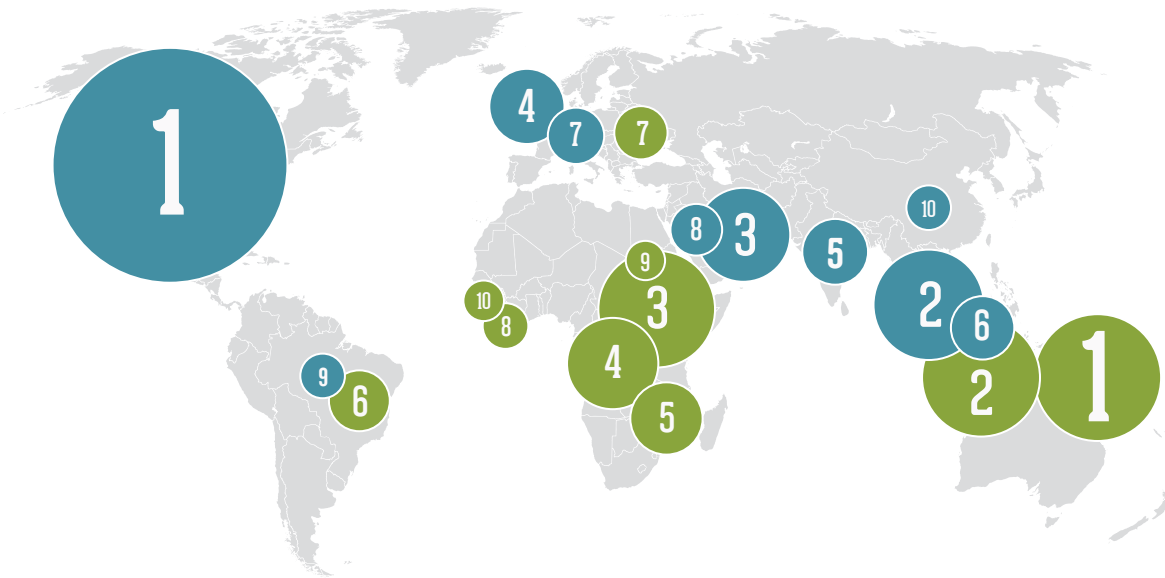
Smaller agrees. “The rural sector desperately needs investment,” she says. “Obviously not all investment is going to have great results, however.”



Villagers in North Sumatra are using GPS to document destruction of forests containing benzoin trees from which they and their ancestors have harvested resin for centuries. The forests are at the heart of a land dispute with a pulp manufacturer intent on expanding eucalyptus plantations.

BUY OR SELL? TOP 10 INVESTOR AND TARGET COUNTRIES FOR CONCLUDED TRANSNATIONAL LAND DEALS, 2000–TODAY

SOURCE: LAND MATRIX, LANDMATRIX.ORG | MAP LAYOUT BY TODD REUBOLD



TOP 10 INVESTOR COUNTRIES

1) USA	7,095,352*
2) Malaysia	3,349,571
3) U.A.E.	2,819,223
4) UK	2,296,669
5) India	1,990,223
6) Singapore	1,880,755
7) Netherlands	1,684,896
8) Saudi Arabia	1,573,218
9) Brazil	1,368,857
10) China/Hong Kong	1,342,034

TOP 10 TARGET COUNTRIES

1) Papua New Guinea	3,799,169
2) Indonesia	3,549,462
3) South Sudan	3,491,313
4) D.R. of the Congo	2,717,358
5) Mozambique	2,167,882
6) Brazil	1,811,236
7) Ukraine	1,600,179
8) Liberia	1,361,213
9) Sudan	1,191,013
10) Sierra Leone	1,181,105

* hectares

So far there have been many more bad examples of these deals than good ones. A wide-ranging study of Africa by Cotula came to a clear conclusion that the large-scale deals that have been done to date there have failed to bring the advantages that some have claimed, with most people on the lands involved instead seeing their livelihoods removed and their lives damaged, sometimes irreparably.

“The growing body of evidence shows that the majority of large-scale land deals have had net negative impacts on local populations,” says Cotula. “They have rendered people landless without compensation, have broken links between land and livelihoods, culture and social identity — and, in some cases, have sparked conflict.”

That conflict is not surprising. “Land is one of the most emotional subjects there is,” says Geary. “People naturally feel an enormous attachment to the land they live on — it provides everything they have — and we need to understand and respect that. Land is not a commodity.”

ENVIRONMENTAL IMPACT

What about the environmental impact of large transnational land deals? Studies by Cotula and others have found that often there is little research done in advance on the likely effects of such transactions on local natural resources.

Bringing modern farming techniques and technologies to poor countries can be advantageous. However, problems that often come with such technologies, such as the over-use of fertilizers and pesticides, could upset the balance of the natural world, as they have in many developed countries. Similarly, ad hoc rather than strategic diversion of water resources to large-scale agriculture could harm natural systems. There are also potential

the acquisitions are “thinly veiled illegal logging operations,” destroying large tracts of the world’s third-largest rainforest.

GET IT RIGHT

Since land grabs and resource investments are not going away, the question we need to ask is this: Can we make them more socially and environmentally acceptable? Experts agree

“Land is one of the most emotional subjects there is. People naturally feel an enormous attachment to the land they live on — it provides everything they have — and we need to understand and respect that. Land is not a commodity.”

— Kate Geary, Oxfam

impacts on biodiversity: In many cases, the supposedly underused land that is the target of deals is in reality valuable habitat for animals and plants.

In Papua New Guinea, for example, nearly one-third of the country has now been appropriated by foreign companies, according to the Oakland Institute, which also notes that researchers on the ground claim many of

that clearer rules are needed to govern what corporations, banks and other investors, governments and international institutions such as development banks may do when acquiring land. Enforcement and land rights law must also be more rigorous, they say.

Recognizing land held in common under international law is key, says Smaller, so newcomers cannot steamroll over it. “There are

PHOTO BY GREGOR MACLENNAN/DIGITAL DEMOCRACY



The ability to document ownership plays an important role in keeping land transactions fair for local people. In Ukraine, reduced document fees and a 2011 law providing free legal aid have made it easier for citizens to claim and manage property rights.

PHOTO COURTESY OF UNDP UKRAINE

ways of doing this, so that you recognize local customs and respect people's rights but ensure they can be legally enforced."

Governments have often been portrayed as colluding in questionable land grabbing practices. One researcher, who did not want to be named so as not to inhibit future relations with governments, says corruption has been a key problem, with a lack of transparency on many of the existing deals enabling politicians to get away with taking land from local communities with little or no accountability.

But there are signs that some politicians in the developing world are waking up to the need to monitor land deals more closely and to involve local communities. A meeting in November 2013 in Malabo, the capital of Equatorial Guinea, brought together more than 60 parliamentarians from central Africa to discuss the issues. At the meeting, Patrick Mucheleka, an independent member of parliament from Zambia, called for laws and policies that protect people's land rights, as well as

monitoring and systems to make sure they do the job. "We need to create linkages with the private sector, but it should be a win-win situation for our smallholder farmers as well as the investors," he said. "Contracts signed between our government and investors are not ... done in a transparent manner."

Roger Nkodo Dang, Cameroon's first vice president of the Pan-African Parliament, added: "We really need to attract investments in the agricultural sector and members of parliament need to work on that. [But] somebody who comes to invest is told, for the first five years they will not pay taxes. It's a problem. This is happening in the whole of Central Africa. The national investors are not protected in this way."

Whether these calls will be heeded will also depend on effective international institutions. Organizations working on setting up better rules for economically, socially and environmentally sustainable land investment include the World Bank, the Organisation for Economic Co-operation and Development, and

some private sector initiatives, such as the Equator Principles, which many banks sign on to and which stipulate that local people's rights should be respected.

"The World Bank is a key actor," says Oxfam's Geary. "They have a huge influence on the whole sector, as they have the ability to set standards. They are working on this, and it is absolutely crucial that they get this right."

COMPANY COMMITMENT

Some international companies have shown a clear commitment to improving their own practices. After Oxfam produced a report on sugar supply chains for international companies, in which it alleged multiple land-grabbing operations were involved, Coca-Cola announced it would be operating "zero tolerance" on land grabbing.

"Our company does not typically purchase ingredients directly from farms, nor are we owners of sugar farms or plantations," said director of global workplace rights Ed Potter in a statement released by Coca-Cola, "but as a major buyer of several agricultural ingredients, we acknowledge our responsibility to take action and use our influence to help protect the land rights of local communities. We are committed to being part of a solution in addressing land rights, and look forward to continuing to engage with Oxfam and other stakeholders to advance this important dialogue and bring about meaningful change."

Unilever has also taken a leading role. In 2010, the company embarked on a major program to support small farmers in developing countries, helping them become part of its global supply chain. Previously, large companies had often preferred to deal with larger conglomerates or middlemen, who were easier to manage than a plethora of smallholders. But the benefits of doing business that way often failed to "trickle down" to individual suppliers who were producing the goods, and often favored the consolidation into larger farms that has helped put smallholders at a disadvantage. So when Unilever CEO Paul Polman shifted the focus to making small farmers equal partners in the supplier relationship, it was a major step. Oxfam hailed the move as a lifeline for smallholders who would otherwise be excluded from such vast markets or be vulnerable to exploitation.

Small farmers don't need to be excluded from larger land investment projects, says Smaller. "It's called outgrowing — the investor can give contracts to existing small farmers to

grow their crops and buy [those crops] from them.” If that involves a mutually beneficial arrangement to give the farmers access to better productivity, with the profits shared in some way, it can transform the local community. However, it can also lead to exploitation and profiteering.

For Cotula, the key is to have a tight legal framework capable of ensuring that companies and investor governments share the benefits with local communities and behave with due

ending expansion begun to hit problems, and only in the past few decades have the extraordinary impacts of our depredations become apparent: the extinction and near-extinction of hundreds of species, the hacking down of forests, the impacts on the atmosphere of our greenhouse gas emissions.

We have not yet made the philosophical and economic transitions necessary to deal responsibly and equitably with the new reality that key resources — water, soil, clean air —

COLD FRONT

A new, and decidedly cold, front is opening in the battle for mineral resources: Greenland, beneath whose vast ice sheet are thought to lie millions of tons of unexplored riches — rare earths as well as coal, iron ore, uranium and possibly precious stones.

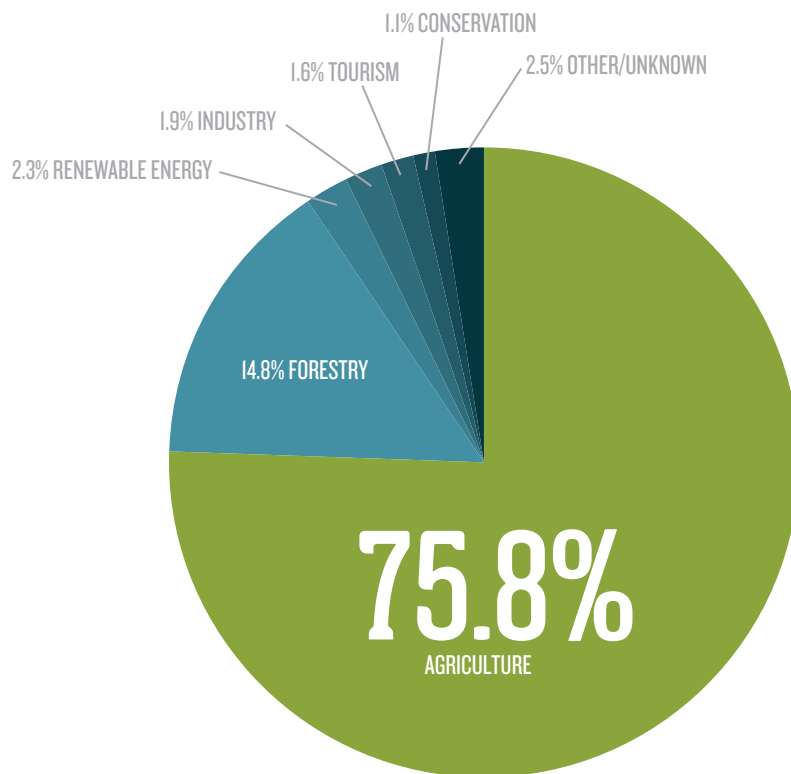
These minerals lie under 150 meters of solid ice, but modern exploration techniques mean that these are becoming accessible.

Greenland has the opportunity to escape the “resource curse” that has left oil-rich developing countries around the world with massive disparities of wealth and large populations unable to share in their countries’ natural riches. The indigenous people of Greenland have lived in one of the globe’s harshest landscapes for thousands of years, and most still live a simple lifestyle dependent mainly on fishing and hunting, with the recent addition of some tourism and service jobs.

Anxious to avoid “land grabs” — several international companies have expressed a keen interest in mining exploration — the government has been cautious in granting licenses, and is assessing potential impact. A recent vote in the country’s home rule parliament opened the way to exploration for uranium and rare earths.

Greenland benefits from its close relationships with Europe, the U.S. and Canada. If exploration can be harnessed correctly, this region could become a shining example of how to manage resource grabs, and how to exploit Earth’s subsurface resources without destroying a pristine landscape.

FOREIGN LAND TRANSACTIONS, 2000–PRESENT



regard to those communities, land rights, and biodiversity and other environmental impacts.

BIG “IF”

In a world in which resources are increasingly constrained by a growing population and by our failure to use what we have as efficiently as possible, the pressures to invest in land will only grow. Mark Twain is widely supposed to have advised: “Buy land — they’re not making it anymore.”

For most of human history, land and resources have been available for our global population, though often unevenly distributed. Only within the past century has our never-

are far from inexhaustible. If land investment can become an equitable process and a social good for the communities involved, instead of a blight that destroys lives and landscapes and causes conflict and distress, that would be an important step to learning to live within our global means. If not, it will be another step on our long road to natural destruction. ☹

Fiona Harvey is an award-winning environment journalist for the *Guardian*. She previously worked for the *Financial Times* for more than a decade. She has reported on major environmental issues from as far afield as the Arctic and the Amazon, and her wide range of interviewees include Ban Ki-moon, Tony Blair, Al Gore and Jeff Immelt.

TOMORROW'S TODAY'S TECHNOLOGY WILL SAVE US

Do we already have what we need to solve our greatest environmental challenges?

by DAVID DOODY

Technology is often touted as the savior that will rescue us from our misbegotten ways, redeem us and put us on the track to utopia.

Then there are the dystopian views, where the future is dominated by technology that either rules over us or saps us so completely of our humanity that we might as well be a bunch of gadgets ourselves.

Whatever your view, there's no denying that technology has both made life better for billions of people and produced unfortunate side effects. In his book *The Infinite Resource*, for example, technologist Ramez Naam argues that the green revolution was beneficial even though it created problems that still plague us today. "As is often the case," he writes, "the solutions to one problem

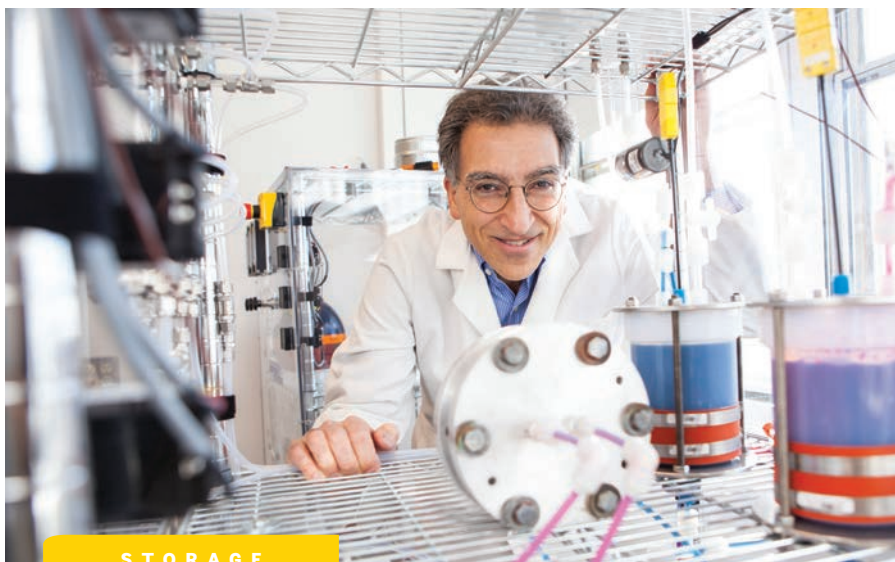
have created new problems. But, had we not boosted yields through the green revolution, we either would have had billions starving or would have been forced to chop down the world's remaining forests to feed the world. Either of those would be a worse result than the side effects we face now."

There are countless environmental challenges today — most a by-product of something else — and it seems like we're always looking for the next big thing to solve them. But what if we took a break from finding the next thing and focused on doing the *last* big thing better? Might we already have what we need to solve our greatest environmental challenges?

Here is just a sampling of existing technologies that, if scaled up, might be able to truly address some of our most pressing global issues. >

SOLUTION-
FOCUSED GPS
PAGE 18





STORAGE

Organic Batteries

Energy storage may be the one thing holding renewables back. Conventional battery technologies are capable, but cost is a huge roadblock. Still, with funding from the U.S. Department of Energy's Advanced Research Projects Agency-Energy helping to come up with

things like an organic flow battery from Harvard researchers, a changed game feels more and more like it's right around the corner. Because flow batteries use external tanks instead of housing all components inside a battery case, they're able to store larger amounts

> MICHAEL J. AZIZ (PICTURED) AT HARVARD UNIVERSITY AND OTHERS DEVELOPED THE METAL-FREE FLOW BATTERY.

of energy than conventional batteries. The metals used within them, though, have been cost prohibitive. The Harvard battery uses organic molecules, drastically reducing the cost.

95

percent of U.S. grid storage in 2013 that was pumped hydro

1.2

percent of U.S. grid storage in 2013 that was supported by batteries



GOOGLE

Better Maps

It's hard to find a conservation initiative these days that is not taking advantage of Google Earth Engine. Researchers from University of Maryland, for example, used Google's collected satellite images and free Landsat data to create a global map that details forest change down to the local level. What would have taken one computer 15 years to accomplish was sped up to just days because of cloud computing through Google Earth Engine.

To read about tropical ecologist Greg Asner's use of a spectrometer and lasers to create the first large-scale biodiversity map of the Amazon rain forest, go to ensia.us/map.

FOOTPRINT

Commercialized Carbon

Sure, we can grab carbon and shove it underground, but why not make it into something else — like baking soda or chairs — and sell it instead? Marc Gunther, author of *Suck It Up: How Capturing Carbon From the Air Can Help Solve the Climate Crisis*, points to Carbon Engineering and Global Thermostat as promising carbon



> CARBON ENGINEERING USES "STRUCTURED PACKAGING" TO CREATE A LARGE SURFACE AREA OF LIQUID FILM TO ABSORB CARBON DIOXIDE FROM THE AIR PASSING THROUGH SMALL FLOW CHANNELS.

36 BILLION
METRIC TONS OF CO₂
EMITTED BY HUMAN ACTIVITIES IN 2013
— A 61% INCREASE OVER 1990

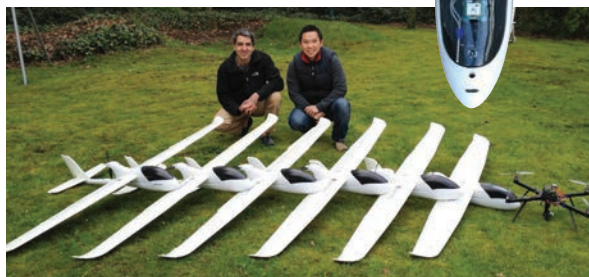
capture companies. Once captured through these companies' technologies, carbon can be used in industrial or commercial production, to produce low-carbon fuels or for other applications. Meanwhile, Skyonic Corporation is building a commercial CO₂ capture plant that is scheduled to begin operating this year. Once the plant is up and running, the company expects it to reduce 300,000 tons of CO₂ emissions per year through a combination of direct capture from a cement plant and offsets from the commercial products it will create, such as baking soda. And an idea of Princeton and Northwestern University students back in 2003 has, a decade later, turned into a technology that captures carbon and turns it into a material known as AirCarbon that can be used to make carbon-negative products such as phone covers and chairs.



DRONES

Fly Over Country

With the ability to do jobs that are usually extremely time consuming and require a lot of human attention, drones hold potential for many environmental benefits. Flying quickly over wildlife reserves, counting animals and noticing poachers, drones are helping conservationists protect endangered species



> SERGE WICH (LEFT) AND LIAN PIN KOH, FOUNDERS OF THE CONSERVATION DRONE PROJECT, WITH A FLEET OF DRONES.

across the globe. Meanwhile, crop-monitoring drones could lead to substantial decreases in farming inputs such as water and fertilizer.

For a story about the use of drones to study the effect of deforestation on orangutans in the jungles of Indonesia, go to ensia.us/drones.

ENERGY

Nuclear Innovations

Nuclear energy technology holds the potential to dramatically reduce greenhouse gas emissions. But rather than ramp up conventional, highly controversial approaches, why not mobilize technologies that address concerns with today's reactors, such as meltdowns and waste? Some possibilities are nuclear reactor design company Transatomic Power's Waste-Annihilating Molten Salt Reactor and Bill Gates-backed traveling wave reactors, both of which are designed to use by-products of conventional nuclear power production as fuel. In the case of the WAMSR, that means using spent nuclear fuel that would be destined for storage, while the TWRs look to use depleted uranium, rather than leaving it to be stored or used in other applications, such as ammunition. Both also utilize technologies meant to avoid meltdowns like that seen at Japan's Fukushima Daiichi plant.

435

Number of operable civil nuclear power reactors in the world today, according to the World Nuclear Association

Go to ensia.us/backyardnuclear to find out more about "small modular reactors" in development that would come in a kit and be installed underground, reducing the threat of terrorist attack or meltdown.

BRIGHT FUTURE

“The big problem with solar energy for the last 50 years is it's so damn expensive. And now, maybe it's not. ... The idea that solar energy could be cost effective is a radical, game-changing and brand new idea.”

—MICHAEL NOBLE, EXECUTIVE DIRECTOR OF FRESH ENERGY



TRACKING

Solution-Focused GPS

Tracking animals for wildlife research goes “all the way back to [John James] Audubon, who tied a string around the leg of a bird to see if it would come back the next season,” says Jonathan Hoekstra, chief scientist at World Wildlife Fund. Tracking systems have come a long way since strings, making it possible to go beyond just collecting data to using them to solve problems. The organization Save the Elephants uses its own software with Google Earth to track elephants in real time. The data are then used to a) create migratory corridors based on the animals' movements, and b) set up what Hoekstra calls a “virtual fence,” where wildlife officers can be notified if elephants are getting too close to certain areas, such as farmland, and respond by scaring them away. Both are meant to minimize

contact with local communities and therefore human-elephant conflict.

Meanwhile, Drexel University researchers are using GPS to track leatherback turtles — among the world's most endangered animals — in the Pacific Ocean in hopes of reducing the unintended killing of turtles by commercial fishing. Given the location of the turtles, fishing vessels may be able to adjust their location to avoid them.

3-5 MILLION

— ESTIMATED NUMBER OF AFRICAN ELEPHANTS IN THE 1940S

410,000-650,000

— ESTIMATED NUMBER OF AFRICAN ELEPHANTS TODAY



DATA

Crowdsourcing

The little connected computers in our pockets offer huge conservation potential. Whether for compiling data about rare species, as the Texas Parks and Wildlife Department does using iNaturalist; fighting illegal fishing and pollution through the Center for Ocean Solutions' FishNET project; or helping scientists conduct climate and habitat research through Zooniverse, the ability to collect and analyze mass quantities of data from people around the globe is fast becoming a defining aspect of our time. World Wildlife Fund's Jonathan Hoekstra calls Eyes on the Forest — a project of WWF and two other environmental organizations that enables citizens to report forest activities such as illegal logging in Sumatra — “a great example of using technology to empower people to participate in the protection of their environment.”

Go to ensia.us/bees to see a crowdsourced database that includes hundreds of high-resolution images of bees used for identification and maintained by the U.S. Geological Survey's Bee Monitoring and Inventory Lab.



FOOD

Stop Wasting

Globally, one-third of the food produced for human consumption is not consumed, adding up to 1.3 billion tons of uneaten food annually. Go to ensia.us/foodwaste to learn about low- and high-tech solutions to this problem.

33
percent of food wasted
or lost globally each year

BIOMIMICRY

Nature's Tech

As the field of biomimicry shows, nature's technologies and designs are more often than not far superior to our own. Yet, instead of being scaled up, nature is taking a hit as more and more land gets used for human purposes. Serious discussions about protecting and re-creating systems such as wetlands, oyster beds and mangroves as natural buffers against storms is a sign that nature's engineering principles and practices are finally being recognized for their utility, not just their beauty.



To read about technologies that could deliver abundant carbon-free electricity from the oceans, turn to page 24.

TREES

Root Protection

When it comes to planting urban trees, “we have an obsession with stem count,” says Peter MacDonagh, director of design and science at the landscape architecture firm Kestrel Design Group. Instead of planting a million trees, MacDonagh says, we would do better planting far fewer in the proper soil conditions. “The average street tree is living less than 20 years in most American cities. It's not getting big enough to provide the ecological services that we want it to provide,” he says. MacDonagh champions a technology called Silva Cells, essentially a post-and-beam system that transfers the load of urban infrastructure from trees' root zones to soil below. This means that the soil in which the trees are growing can be less compacted,



letting roots grow better and allowing trees to live long enough to create an urban forest that can reduce stormwater runoff, boost energy efficiency in nearby buildings and suck pollutants from the air.

20 YEARS
average
lifespan of an
urban tree

100 YEARS
average
lifespan of an
American chestnut

130 YEARS
average
lifespan of a
red maple

200 YEARS
average
lifespan of a
northern red oak

1,250 YEARS
average
lifespan of a
redwood

5,000 YEARS
estimated life-
span of the oldest
bristlecone pines



Bloom
or
BUST

Increasingly common false spring events are leaving crops and wild plants vulnerable to subsequent freezes, creating a cascade of consequences for ecosystems.

by ELIZABETH GROSSMAN

THE ARRIVAL OF SPRING weather in 2012 was the earliest recorded across the United States since 1900. In many states, signs of spring arrived almost three to four weeks earlier than expected. Unseasonable warmth prompted unusually early blooms, particularly on fruiting trees in the Northeast and Great Lakes regions. Observers in Massachusetts and Wisconsin reported that flowering came earlier than it had since Henry David Thoreau took note of when plants began to bloom near Walden Pond in the 1850s or since Aldo Leopold observed flowering times at “The Shack” in Sauk County in the 1930s and ’40s.

Then, in what has come to be recognized as a characteristic trait of climate change — unusual variability — the exceptionally early warm temperatures were followed abruptly by a hard freeze.

“We thought 2010 was weird. But 2012 was really weird,” says Jake Weltzin, executive director of the USA National Phenology Network.

Unusually early warming, known as “false spring,” is becoming increasingly common as climate changes. Its effects are also prompting increasing concern. For when warm temperatures awaken dormant plants and animals prematurely, they can throw off kilter the timing of seasonal events crucial to an entire ecological food web. The results can cause devastating harm to both wild and cultivated species. False spring events have caused enormous losses in U.S. fruit crops, damaged large swaths of forest and decimated sensitive California butterfly populations.

DISTINCT TREND

Naturalists and scientists, farmers and gardeners have long taken note of when plants leaf out and bud each year — part of the study of seasonal events known as *phenology*. Scientists and more casual backyard observers alike have noted an ongoing shift toward earlier springs across North America over the past 50 to 100

years. At the same time, a growing number of scientific studies have documented the advancing emergence of buds, blooms and hibernating animals.

Since the early 1900s, about two-thirds of the species studied have shifted toward earlier spring blooming, breeding or migrating. This

“We thought 2010 was weird.
But 2012 was really weird.”

— Jake Weltzin, USA National Phenology Network

is true for every major group of species studied, including amphibians, birds, fish, invertebrates and mammals as well as trees, nonwoody plants, corals and plankton. These changes have been observed on every major continent and ocean, according to Camille Parmesan, a professor at the University of Texas at Austin, whose research focuses on the biological impact of climate change.

The USA National Phenology Network, which gathers leaf-out and bloom data along with information about when species migrate and reproduce from across the U.S., has helped confirm that the advancing onset of spring and precipitous shifts between warm and cold temperatures are part of ongoing trends. While the network was officially established in the mid-2000s, observations recorded by its contributing scientists and volunteers date back to the 1950s. Some of the longest running records, which chronicle first leaf growth of honeysuckle and lilacs across the lower 48 states, show a noticeable shift toward earlier dates since the 1980s. Like the temperatures recorded as part of climate change research, the leaf-out dates show great variability from year to year but the trend is distinct — earlier warmer temperatures and earlier first buds and blooms.

While occasional false springs are not new, what is new in recent years is the combination of increasingly warmer springs and extreme temperature swings, overall shorter times

throughout fall and winter of below-freezing temperatures, and the altered precipitation patterns associated with global climate change.

The fall and winter warm spells in both 2010 and 2012, for example, were longer than others. This phenomenon increases the likelihood that plants will emerge from dormancy prematurely, producing young leaves, buds and blooms. When unusually mild temperatures and subsequent plant growth are followed by freezing temperatures, early buds and blooms killed by a hard frost can mean failure to flower and fruit for the rest of that year.

And, in addition to the acute impact on fragile plant parts, early warming can also cause problems by truncating the winter cooling period many plant seeds need for proper germination, plants need for budding and blooming, and hibernating animals need to complete their yearly cycles in good health.

RIPPLE EFFECT

The prospect of a freeze after a crop has leafed out, bloomed or set fruit presents obvious problems for farmers. The 2007 false spring, for example, hit agricultural crops and deciduous trees in the U.S. Midwest to Southeast and Mid-Atlantic regions particularly hard, causing crop damage — particularly to fruit trees and berries — that prompted a request for a disaster declaration in North Carolina. In 2012, losses in fruit tree crops in Michigan due to the false spring bloom and freeze cycles were estimated at half a billion dollars.

False spring can harm not only the plants that put forth early sprouts, leaves or blooms, but other species and entire ecosystems. The timing of leaf and flower development has effects that ripple throughout an ecosystem because these changes prompt the flow of sap, nectar and nutrients within plants and so affect the availability of shelter and sustenance for other organisms. This can have profound consequences, particularly when species



PHOTO BY BILL BOUTON

Bye-Bye, Butterfly

THE POTENTIAL FOR trickle-down effects of false spring on species that rely on blooms that appear at a particular time of year is sobering. One such example is what's happened to the checkerspot butterflies that University of Texas at Austin professor Camille Parmesan has studied in California's Sierra Nevada mountains. The repeated mismatch of temperature, bloom, butterfly emergence and migration can take a toll on a species' population from which it can be difficult to recover.

"Two false springs and an anomalous event have a huge impact on the whole community," explains Parmesan.

In fact, a series of false spring events led to the extirpation of a population of Edith's checkerspot butterflies in the Sierra Nevada in the 1980s and '90s. At the high altitude where these butterflies lived, effects that elsewhere might have been smaller became magnified for these sensitive populations. Waves of high temperatures increased the asynchrony between the time the butterflies emerged to feed and the blooming of the plants they rely on for food. The heat and lack of moisture caused plants to dry up at a time when caterpillars needed them, depriving them of food.

Parmesan and colleagues also observed that lower snowpack in the mountains prompted the butterflies to emerge from cocoons abnormally early. Many of these early hatching butterflies were then killed off by what are considering seasonal or "normal" freezes. At the same time, some butterflies that survived to lay eggs did so in conditions that were too hot.

emerge from hibernation or during migration. Desynchronization of seasonal events has been reported around the world, from the American Southeast to New England, and the Rockies to the Tibetan Plateau and across Europe. Rocky Mountain marmots have emerged to find the plants they rely on for food buried beneath snow. Butterflies in California's Sierra Nevada have wriggled out of their cocoons in what seemed like spring warmth, only to be felled by the freeze that followed.

Another disturbing effect of false spring is the damage it can cause to plant and tree cover. If a false spring freeze substantially reduces the success of trees' summer leaf cover across wide swaths of landscape as it did in the U.S. Southeast in 2007, it can also reduce the amount of carbon and other nutrients those trees can process. This can lead to impaired soil health and also jeopardize the health of insects and other organisms that rely on plants' nutrient cycling. And depending on which species a false spring freeze affects, such events could also alter the balance of under- and overstory plants, thus introducing other potential ecosystem disruptions.

Anthony Barnosky, University of California, Berkeley, professor of integrative biology and author of *Heatstroke: Nature in the Age of Global Warming* — a 2009 book that examines the effects of climate change on various species in the wild — says when trying to understand global warming's implications, including those related to the false spring phenomenon, it's important to consider how different affected species interact. "There are all sorts of complexities we need to be looking at in more detail," he says.

TRYING TO ADJUST

"Species' primary response to climate change is to move around the landscape and try to reclaim their climate space," Barnosky explains. In other words: They try to find conditions that replicate those of the places where they had previously thrived. Indeed, University of Texas at Austin's Parmesan reported in 2013 that a summary of numerous research studies conducted around the world over the past 10 years shows that since the early 1900s, approximately half of all species studied have shifted their ranges closer to the poles — between about 30 and 995 miles poleward — or upwards in altitude, as much as about 1,300 feet, seeking cooler temperatures.

From a food production standpoint, farmers around the world are trying to adjust to the

growing likelihood of false springs by planting in ways that accommodate both early warming and temperature and moisture extremes, says Sharon Muzli Gourджи, postdoctoral fellow in energy and environment at Stanford University. Varieties of wheat are being bred for heat tol-

Northern Hemisphere. “Farmers are adapting,” says Parmesan.

Meanwhile, wild species are on the move in search of conditions suitable for their entire life cycle under increasingly unpredictable circumstances. But when success at a particular life stage depends on a steady transition from one season’s conditions to the next — a progression false spring disrupts — that’s when many species are now beginning to encounter difficulties. “The phenology issue could be a really big problem,” says Barnosky.

According to Parmesan, we “don’t have any evidence yet of any evolutionary changes of the kind that would suggest species are adapting”

to extreme temperature swings despite the fact that some species may already be capable of dealing with such extremes. Some species are responding to or accommodating these changes, she explains, but that does not necessarily mean an evolutionary adaptation. Weltzin, at the USA National Phenology Network, uses the term “adjustment.”

The consensus among scientists studying climate change is that the disruptions in what have been considered normal patterns of seasonal temperature and precipitation set in motion by the build-up of greenhouse gases are with us for some time to come. Even if there were a precipitous decrease of such emissions worldwide, what’s now in the atmosphere would continue to affect global climate patterns for years to come. Given this reality, early and false springs are also likely to become increasingly familiar phenomena. So among scientists’ next steps are to learn not only more about how species are responding to these events but also how to predict them.

While predicting false springs can’t help wild species in the same ways it can agriculture — or solve the root causes of the problem — it may point the way to conservation efforts that could help protect some vulnerable species. As Parmesan said of farmers’ adaptive strategies, “It may be very important to get that right.”

Elizabeth Grossman is an independent journalist and writer specializing in environmental and science issues. She is the author of *Chasing Molecules*, *High Tech Trash*, *Watershed* and other books. Her work has appeared in a variety of publications, including *Scientific American*, *Yale Environment 360*, *Environmental Health Perspectives*, *Washington Post*, *TheAtlantic.com*, *The Nation* and *Mother Jones*.

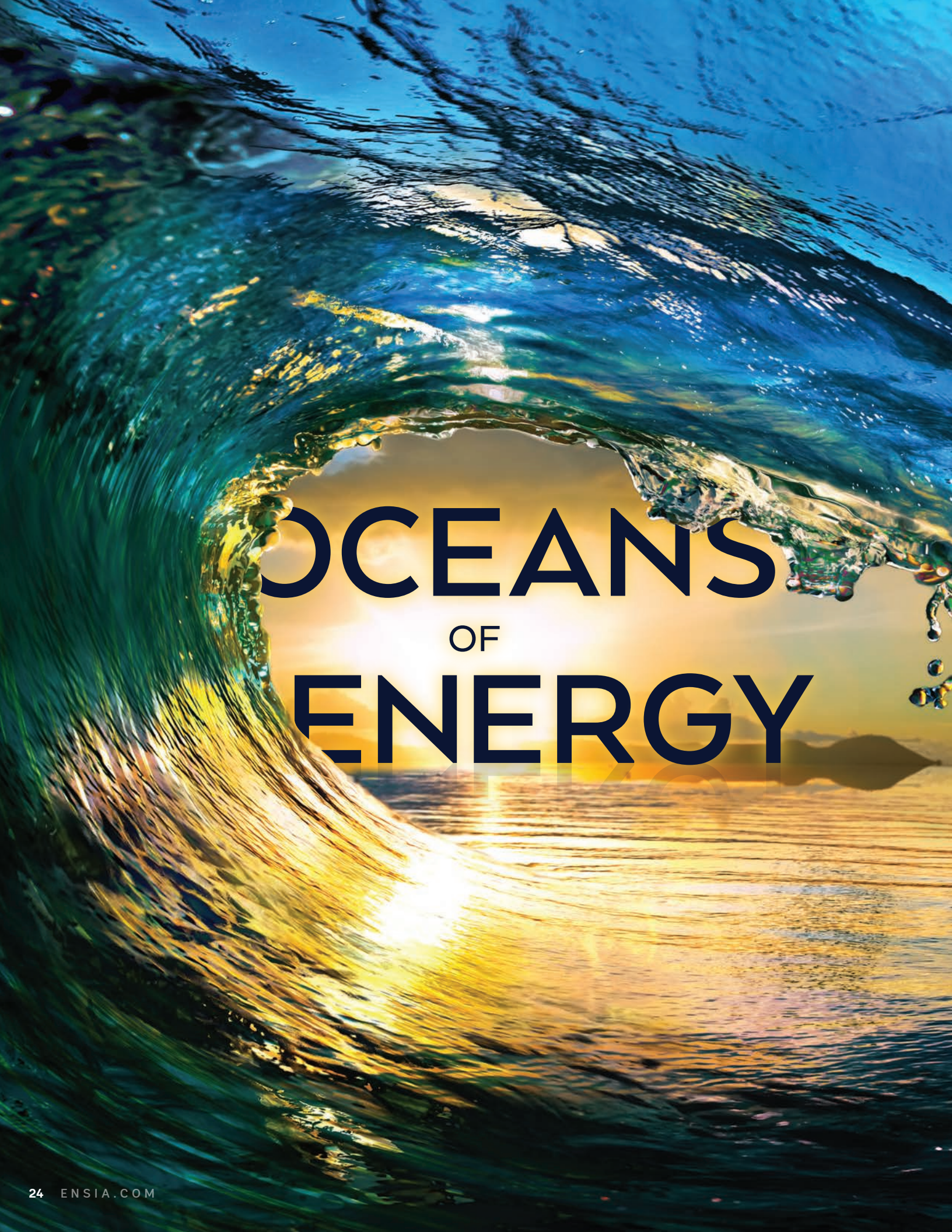
“Species’ primary response to climate change is to move around the landscape and try to reclaim their climate space.”
— Anthony Barnosky, University of California

erance and other variables that come with climate change so they can endure warming temperatures in the tropical regions of Asia, Africa and South America as well as the challenges of both warming and extreme variability in the



SEA CHANGE | Oceans, too, at certain latitudes have been warming fastest in winter and spring, changes that could significantly alter marine species’ growth and reproduction and have repercussions as well for the health of species, both terrestrial and marine. Recent studies, including one by researchers at the University of California, Santa Barbara, show that marine plants and animals associated with specific isotherms — locations where particular temperatures historically occur — are shifting geographically and exhibiting changes in phenology at least as fast as, if not faster than, terrestrial species.

Ocean-dwelling organisms that appear to be responding most quickly to temperature changes include phytoplankton, zooplankton and aquatic invertebrates, which play key roles in the ocean food web. As on land, when conditions change so that low-on-the-food-chain species become available at different times and places, it can create problems related to development, reproduction and survival for the fish, mammals and birds that eat them.



OCEANS OF ENERGY



TECHNOLOGIES THAT HARNESS **THE ENERGY OF MOVING WATER** OR **TEMPERATURE DIFFERENTIALS IN THE OCEANS** PROMISE TO DELIVER ABUNDANT CARBON-FREE ELECTRICITY — IF WE CAN SURMOUNT THE REGULATORY AND FINANCIAL HURDLES.

by JUSTIN GERDES

LONG BEFORE HUMANS got hooked on fossil fuels, we learned how to harness the power of water to do work. Rivers ran mills that ground flour, sawed logs or spun looms that transformed fibers into textiles. Later generations realized that moving water could also be used to turn electricity-generating turbines. But dams erected with electrical turbines blocked waterways, compromising riverine ecosystems to deliver power to growing cities.

Devices now under development in the United Kingdom, the United States and elsewhere generate electricity by tapping the movement of ocean waves and tides or the differences in temperature of water between an ocean's surface and its depths. The sector is ripe with promise, but to reach its potential, the engineers, entrepreneurs and policy-makers working to wring carbon-free electricity from moving water and thermal gradients must overcome formidable regulatory and financial barriers.

HIGH POTENTIAL

Proponents of marine hydrokinetics or ocean thermal energy conversion often note that the technologies deliver electricity that is both dependable and in the right place. After all, waves and tides can be predicted. And humans tend to cluster near water: Nearly 40 percent of Americans live in counties directly on a shoreline, and more than half the world's population lives within 125 miles of a coast.

Government and academic estimates project that marine renewable energy could supply a significant share of the electricity used in coastal areas. Assessments commissioned by the U.S. Department of Energy found that "the maximum of theoretical electric generation" that could be produced from waves, tidal and riverine currents, and ocean thermal gradients in U.S. waters is 2,116 terawatt-hours annually, a little over half of the electricity consumed in the country each year. One TWh of electricity can power 85,000 homes. According to the California Energy Commission, the exploitable ocean wave energy generation potential of the state is about 7,400 megawatts, equivalent

to 17 percent of the peak load managed by the California grid operator in recent years.

Research published by engineers from Oxford University and Edinburgh University in January 2014 found that tidal turbines placed in the Pentland Firth, a narrow stretch of water separating the north coast of mainland Scotland from the Orkney Islands, could generate 43 percent of Scotland's electricity. According to RenewableUK, a trade association, the wave energy potential in U.K. and Irish waters is 840 TWh annually, equivalent to half the total European wave energy resource and nearly two-and-one-half times the U.K.'s current annual electricity demand.

FAST-DEVELOPING INDUSTRY

At an ocean energy panel convened at the University of California, Berkeley, School of Law in September 2012, Bill Toman, then a project manager with Science Applications International Corporation's Ocean and Marine Systems division, noted the flourishing of innovation in the sector. Toman, now a principal with Pacific Marine Renewables, estimated that some 80 different marine renewable energy technologies were under development around the world, with about a dozen at a mature stage.

"It's advancing at a faster rate than wind was 30 years ago," says Paul Jacobson, ocean energy leader with the Electric Power Research Institute. Jacobson says he doesn't believe the marine renewables industry will need 30 years to reach where the wind sector is today because design engineering has advanced so much in recent years.

**SOME 80 DIFFERENT
MARINE RENEWABLE
ENERGY TECHNOLOGIES
ARE UNDER DEVELOPMENT
AROUND THE WORLD.**

CURRENT EVENTS

ICONS BY SARAH WINDISCH

Technologies that tap the oceans' energy fall into five main categories: wave, tidal, current, thermal and salinity gradient. Within each, inventors have devised a spectrum of devices that converge on the common theme of turning a turbine to produce electrical current.



WAVE » Among the most common ocean energy sources are technologies that transform wave motion into electricity. Some wave devices are attached to the ocean floor. Others bob on the surface, using the motion of waves to turn turbines. The best waves occur between 30 and 60 degrees latitude.

TIDAL RANGE » Tidal range technologies capture water at high tide and release it at low tide, creating a water flow similar to that of a hydropower dam. Fewer than 50 known places around the world have a sufficient tide differential to make this application feasible.



CURRENT » Directional ocean currents and tide-generated currents can turn turbines directly, much as breezes turn wind turbines on land. Major directional currents are found off southern Africa, eastern Asia, eastern Australia and eastern North America.

THERMAL » Ocean thermal energy conversion technology uses the temperature difference between deep ocean and surface waters to boil water or another liquid, creating turbine-turning steam. Thermal energy is particularly promising in the tropics.



SALINITY » Salty ocean water can be used to create a salinity gradient with fresh or brackish water. As water flows via osmosis across a semipermeable membrane from the less saline to the more saline body, it creates pressure that can be tapped to produce electricity.

A handful of developers in the U.K., U.S. and China have secured approval for, or signed deals to build, commercial-scale projects. In September 2013 the Scottish government gave the go ahead for construction of the first phase of the 398 MW MeyGen tidal energy project. The first six turbines are scheduled to be installed in Scotland's Pentland Firth in 2015.

In January 2012, Verdant Power received the first commercial license for a tidal energy project in the U.S. The Federal Energy Regulatory Commission authorized Verdant to install up to 30 turbines with a combined capacity of just over 1 MW in New York City's East River to capture the energy of water moving with the tides. During its demonstration phase, the project delivered 70 megawatt-hours of electricity to two customers in New York City.

Dean Corren, director of marine current technology with Verdant, says the company plans to install its next-generation commercial turbine, Gen5, at the site. Financial support from the DOE, he says, will enable testing of key components — steel, gearbox and blades — over the next year to determine the reliability of the new turbines under water. The first Gen5 turbines should be in the East River in 2015.

In October 2013, Lockheed Martin signed a contract to build the world's largest ocean thermal electric power plant, a 10 MW facility likely to be constructed in southern China. Lockheed plans to build a closed-loop system that uses the heat from warm surface waters to convert ammonia, which has a low boiling point, to a gas used to power a steam turbine. Cold water deep below the surface is then used to convert the steam back to liquid.

Dan Heller, vice president of new ventures for Lockheed Mission Systems and Training, told Reuters that Lockheed planned to begin work on a 100 MW design and expected to be able to start marketing the 100 MW and 10 MW versions globally in about five years.

ROUGH WATERS

Even as technology advances, industry and government experts agree that significant hurdles must be overcome if electricity generated by marine renewable energy technologies is to compete on price anytime soon with power from fossil fuels or from more mature sources of renewable energy such as solar, wind and geothermal. According to Max Carcas, external liaison for the European Marine Energy Centre, marine energy costs \$0.42 to \$0.50 per kilowatt-hour today, more than two times the average price of electricity from offshore wind farms.

Regulatory challenges and technical limitations have made building utility-scale wave, tidal and ocean thermal projects difficult. In August 2012, Ocean Power Technologies received the first Federal Energy Regulatory Commission license for a wave power plant in the U.S., for a 1.5 MW array of devices to be located off the Reedsport, Ore., coast. A year later, *The Oregonian* reported that regulatory and technical hurdles had stalled the project and that "OPT now makes vague promises to test their first buoy in Oregon waters no later than 2016."

Delays have not been limited to the U.S. The Wave Hub, a marine renewable energy test platform located on the seabed 10 miles off the Cornwall, U.K., coast and connected to the onshore grid via a subsea cable, was completed in 2010 but has yet to be used. OceanEnergy, an Irish wave energy firm, had planned to deploy its OE Buoy at the site by the end of 2012. In December 2013, Wave Hub announced the wave energy company Seatricity plans to develop a 10 MW array at the site over the next two years.

"The past five years have been pretty brutal for developers in trying to site ocean wave, tidal and hybrid wind-wave projects," Pacific Marine Renewables' Toman said at the 2012 Berkeley gathering. Project developers, many of them start-ups, find it difficult to stay afloat financially as they work to obtain the required permits.

"A lot of the engineer folks who wanted to put something in the water, once they got a glimpse of the regulatory framework, their eyes went big and they decided, 'OK, I'm going to need a lot more money, and I'm going to need to talk to some more consultants who know something about this,'" Laura Engeman, a project manager with the California Ocean Protection Council, told the same panel.

The challenge for regulators, Engeman added, is "balancing opportunities for testing with providing the necessary environmental precautions. Industry developers are financially limited. It's often a big hurdle for them to develop the kind of baseline information that most permitting agencies require."

"Because these are new technologies that are being placed in environments where this sort of thing hasn't been done before, there is a lot of environmental uncertainty," says EPRI's Jacobson. "The industry is being held to a very high standard." A report prepared for the California Ocean Protection Council and California Energy Commission, published in November 2008, found that "few major

impacts of wave energy conversion installations on marine birds and mammals are anticipated,” but that baseline data collected before devices are placed in the water “will be critical for evaluating post-installation effects.” The authors concluded that “while significant technological and economic issues remain, ecological issues, at this stage, appear manageable.”

Still, things look better on the horizon. To help developers navigate the regulatory process, the California Ocean Protection Council published permitting guidance for ocean renewable energy projects in December 2011. And in August 2013, U.S. senators Ron Wyden, D-Ore., and Lisa Murkowski, R-Alaska, introduced the Marine and Hydrokinetic Renewable Energy Act of 2013, which would promote the development of and streamline permitting for marine renewable technologies. On January 20, 2014, the European Commission released a two-step Blue Energy Action Plan under which the EU will first convene stakeholders to identify and propose solutions to challenges facing the marine renewables industry and then develop a strategic road map by 2016 to guide the sector toward commercialization.

SHOW US THE MONEY

Then there’s financing. “It has to be understood that one issue completely dominates this scene and limits the rate of growth, and that is capital availability,” says Verdant Power’s Corren. “For emerging energy, venture capital does not exist anymore.”

“A lot of the wave stuff is just too early stage for even venture capital,” Toman told his Berkeley audience. “It’s been estimated that it costs about \$100 million to go from a cocktail napkin drawing to a commercial wave device. That’s a frightful amount of capital to ask your garage inventor to come up with.”

Where marine energy is setting roots, it’s often thanks to government intervention.

“That’s why Europe is eating our lunch,” Corren says. “Our government now has the philosophy — at least half of it has the philosophy — that government shouldn’t be doing anything.”

Proponents acknowledge the importance of government assistance provided to the industry — they just wish there were more of it. “Since the election of President Obama, the Department of Energy has reconstituted its hydropower program and also has made a commitment to marine renewable energy, both tidal and waves,” says Corren, “but it’s still far beyond where it really ought to be if we want to be a major player in the world industry.”

EPRI’s Jacobson notes that the DOE has sponsored marine renewable energy resource and environmental assessments (EPRI led the wave and riverine resource assessments), technology development of components, and project development.

“DOE contract support has been incredibly helpful,” Corren says. “The state of New York has been unbelievably helpful since the ’80s.” The DOE recognized it needed to boost the cost share of its grants to match what other countries offered, he says. Before, contracts came with 50/50 cost share; now, contracts can come with up to an 80/20 cost share. In August 2013, DOE awarded \$16 million to advance 17 projects that capture energy from the waves, tides and currents.

BRIGHT FUTURE

Industry backers agree that marine renewables have a bright future even if, in the near term, they may advance more rapidly outside the U.S. Corren says this will likely mean that most U.S.-based companies will move overseas. “Either Europe, particularly the U.K. and

devices have been tested at the \$59-million facility — staked with funding from the Scottish and U.K. governments and the EU, but self-supporting since 2011 — than any other site in the world. According to the European Commission, some 2 GW of marine renewable energy projects are in the pipeline in Europe.

Experts are convinced that marine renewables will become more competitive over time as the technology matures. “There is a lot of carnage out there among early projects,” Toman said. “However, a tremendous amount of experience has been gained. Subsequent projects are going to benefit from the great hard work that has been done by these earlier projects.”

“This isn’t the cheapest way to generate electricity right now,” says Jacobson. “If there is not some form of demand for renewable energy, then it is that much harder to make the financing work to further develop the technology to the point that it can be cost competitive down the road.” Policies such as the feed-in tariff recently approved in Nova Scotia for tidal energy projects are necessary, he says, to scale up the industry.

“WAVE AND TIDAL IS GOING LIKE GANGBUSTERS IN EUROPE, ESPECIALLY THE U.K. AND SCOTLAND. I SEE THAT MIGRATING HERE TO THE U.S. THEY VIEW THE CALIFORNIA MARKET AS KIND OF THE HOLY GRAIL.”

— BILL TOMAN, PACIFIC MARINE RENEWABLES

Scotland, or South Korea,” he says, adding that Verdant already has a company in England. “We’ve been in conversations with China. These are countries with important resources and important commitments to investing in the technology to make it happen,” he says.

At the Berkeley talk Toman agreed, saying, “Wave and tidal is going like gangbusters in Europe, especially the U.K. and Scotland. I see that migrating here to the U.S. They view the California market as kind of the Holy Grail. We may be in a slow period at the moment, but I see the European efforts reaching out to colonize us.”

Prototypes of nearly a dozen marine energy devices are operating at sites run by the European Marine Energy Centre, a grid-connected test center in Scotland’s Orkney Islands established in 2003. More wave and tidal energy

Writing at the European Marine Energy Centre’s blog, Carcas predicts, “it is not inconceivable that once the first 1,000 [MW] of marine renewables is installed (equivalent to one conventional power station) costs could be similar to that of offshore wind.”

“This industry has a future. It’s going to be a small but significant piece of the puzzle for putting together all the sources we need that are at the very most sustainable end of things,” says Corren. “It has a bright future.” ☺

Justin Gerdes is a San Francisco Bay Area-based independent journalist specializing in energy and climate change. His work has appeared at the *Guardian*, *Yale Environment 360*, *Forbes.com*, *MotherJones.com*, *Smithsonian.com*, *Chinadialogue*, the *Christian Science Monitor* and *GreenBiz.com*, among other outlets.

BRIDGING THE GAP

New Delhi environmental educator and entrepreneur **Vimlendu Jha** is changing the world one child at a time.

BY MRIDU KHULLAR RELPH | PHOTOS BY SIMON DE TREY-WHITE

EVERY FEW MONTHS, Vimlendu Jha makes a trip to some of New Delhi's best private schools, gathers up the students — some of whom come from the richest families in the country — and leads them into the world of waste.

Under the umbrella of Swechha, an environmental nonprofit he founded in 2000, Jha gives these kids an almost cradle-to-grave analysis of their trash. He teaches them what is in their dustbin. He helps them explore where their garbage comes from and where it will go. He shows them the people, usually poor, who dispose of their waste.

For this, Jha charges the private schools a large amount of money. He then funnels the money into providing similar programs, as well as health services, to the children of some of India's poorest communities. Swechha, a Sanskrit word that means "one's free will," offers the same programs at a reduced rate to government-run schools for low-income families and runs a small school for children in a south Delhi slum. "[The rich schools] pay for the program and that in turn helps our campaigns on other issues," Jha says. "It's a self-sustainable model."

Swechha's story began when Jha moved to Delhi in the late 1990s to attend college. He became involved in an anti-dam movement, an anti-nuclear campaign and other activist work. But what really moved him was seeing the Yamuna River flowing through the capital almost black with pollution. "The entire civil society, bureaucracy, ministers — everyone stays in Delhi, and still Delhi has such a pathetic river," he says. "I had an interest in the environment, but while many of the other environmental issues were larger, they weren't very visible. This was the most visible issue

that disturbed me." So when he finished college, Jha started a yearlong campaign, "We for Yamuna," to raise awareness about the need to clean up the Yamuna.

"The idea was to just do something, my personal bit for one whole year," he says. "It was here, in Delhi, that I discovered myself."

After the year was over Jha went off to graduate studies at the Tata Institute of Social

into the plains," Jha says. "And it's not mere coincidence that this happens. We explain the reasons why our forests disappear and our rivers dry up and turn black as soon as they come into the areas where people speak English, eat pizza and watch environmental documentaries. Why is it so clean when it's with people who are illiterate? We try to understand how conservation perhaps is also cultural and not necessarily a virtue that can only be earned through a great private school education."

Jha says lessons about the environment are best delivered young. And he feels strongly about targeting environmental education to some of the richest kids in the country. "We all know that almost 70 to 80 percent of the leadership of our country in every walk of life, be it media or business or politics, comes from the elite," he explains. "It's better that we engage with them at an early stage because otherwise there's no point making this intervention when they're in college. This, now, is when the learning happens."

In the Swechha program Bridge the Gap, Jha asks students two questions that have become the backbone of his work: Can humans and nature co-exist? Can humans and prosperity co-exist? "Our current education system and our economic paradigm creates a conflict between these two," Jha says. "We have to look at these issues not as something that's distant, happening somewhere in somebody else's life, but right here, happening in mine." 🌱

Mridu Khullar Relph is a journalist and editor based in New Delhi, India. She reports on the environment, women's issues and eco-friendly businesses for publications such as *Time*, the *New York Times* and the *Christian Science Monitor*.



Sciences. "When I came back, there was nothing left of this campaign that I'd started," he explains. He worked in a non-governmental organization for a while, then for an international bank, but found his heart wasn't in either job. So he started Swechha.

One of Swechha's most popular offerings is the "Yamuna Yatra," a 12-day program in which 40 to 50 kids track the river as it flows from its source in the Himalayas through the plains of Agra and Delhi. An eco-trip that is part adventure, part fun and part learning, the Yatra teaches kids the importance of natural river systems and the need to rescue and preserve them. "We look at how the river is so clean when it is with uneducated people in the villages and how it dies as soon as it comes



TRASH TO TREASURE

When he's not working with Swechha, Jha runs a for-profit organization, Green the Gap. Green the Gap is about two things: upcycling, or giving a better life to waste; and utility, or creating products that have real value and purpose. It's the first organization in India to create products out of waste and sell them on a large scale. Products include scarves sewn from old saris, wallets fashioned out of beer cans and note cards made from elephant dung.

In keeping with the theme, Jha's office is fashioned entirely out of trash. "We went to the kabadi [recycling] market and whatever we found we brought it in and ended up finding a utility for [it]," he explains. "The walls of our meeting room are made out of false cable hiding sheets that are used in airports, the separators are made out of bicycle parts, our lamps are created out of motor parts, and all the book racks in the office are made out of green, yellow and blue fruit crates. The seating in our meeting room is made out of tires, my planters are all bottles and our flooring is all waste wood." Even the pets are repurposed: Jha shares his office space with a puppy named Gap he adopted as a stray off Delhi's streets.

LION LIFE SAVERS

Maasai warriors and biologists team up to defuse human-lion conflict in Kenya.

BY STEPHANIE M. DLONIAK | PHOTOS BY PHILIP J. BRIGGS

ON A SCRUBBY PLATEAU just beyond the shadow of Mount Kilimanjaro, in a canvas tent under a metal roof resembling an airplane hangar, Philip Briggs deals three lions from a deck of cards.

“These females all had cubs in early 2010, right after the drought broke,” he says. “They started hitting bomas [livestock enclosures] constantly, and Narika was speared by a hunting party in retaliation.”

The cards were created by the Kenya-based nonprofit organization Lion Guardians to help local conservationists get to know individual lions. Each has a photo and description of a lion living in the vicinity of Amboseli National Park in Kenya. Arranging the cards into family trees and sliding them across the wooden dining table just as though they were big cats moving through the landscape, Briggs and Stephanie Dolrenry, biologists with the Lion Guardians, tell the story of chronic livestock-killing lions and how Narika’s death helped inspire a tool for managing such problem lions — mock traditional hunts.

The Maasai, the indigenous pastoralists of southern Kenya and northern Tanzania, have always hunted lions — in response to attacks on livestock and as a celebrated rite of passage into manhood. During a hunt, a party of warriors tracks a lion on foot, closes in with traditional chanting and screaming, and finally attacks and spears it in a noisy frenzy.

“After Narika was killed, her sisters, their cubs, and a male named Lomunyak all left the area and stopped killing livestock for two months,” Dolrenry explains. “We saw this huge behavior change.”

The Lion Guardians team wondered whether mock hunts — which closely mimic real hunts, except the animal isn’t speared in the end — could achieve the same result in behavior while helping protect the big cats. Lions now occupy just 25 percent of their historical African range and their populations are declining, largely due to loss of habitat and prey, and retaliatory killing.

“[The Maasai] believe lions are bright animals, so they know when they have done something wrong,” says Lion Guardians community manager and Maasai elder Eric Ole Kesoi, who has participated in several of the mock hunts. “If they are reprimanded after attacking livestock, they can learn.”

The Lion Guardians aim to conserve lions by melding traditional ecological knowledge and values of the local Maasai people with modern technology and data analyses. The Maasai warriors who are chosen to become guardians are trained and then armed with radio-tracking equipment, GPS units, decks of lion cards and mobile phones in addition to their traditional clubs and knives. The young men track lions, record problems with wildlife, warn herders when lions are present and find lost livestock. The Lion Guardians appear successful so far; the local lion population has more than doubled in the past four years and very few lions have been killed. The mock hunts add one more important tool to their toolbox.



So far the Lion Guardians have conducted six mock hunts against individually identified lions that were known to have repeatedly attacked livestock in bomas and could be tracked immediately afterwards. The preliminary results are promising: All mock-hunted lions stopped killing livestock for one to two months.

Ole Kesoi sees value for both lions and the Maasai. Using mock hunts as a kind of aversion therapy could lead to less conflict and fewer



dead lions. At the same time, the hunts allow the Lion Guardians to take active roles in protecting their community.

Not everyone is sold on the idea, however. Craig Packer, an ecologist at the University of Minnesota, has studied lions in neighboring Tanzania's Serengeti ecosystem since 1978.

"Although the Lion Guardians have certainly been valuable and innovative, I worry about the long-term sustainability of the program," Packer


says. "The challenges of long-term lion conservation are going to require a lot more than 'culturally appropriate' conflict-mitigation strategies."

Susan Alberts seems more hopeful. A biologist at Duke University, Alberts has worked in the ecosystem for more than 20 years with the Amboseli Baboon Research Project.

"The main threat to wildlife in Amboseli is human population growth. We all know what's required to deal with that — education, some voluntary resettlement, probably compensation. There's no magic bullet. Having said that, the application of knowledge about the predators, as well as making the community feel that they have a stake in the ecosystem remaining intact, seem completely essential to going forward."

Lion Guardians such as Ng'ida (left) track lions, record problem interactions with livestock and conduct mock hunts as needed to minimize conflicts between the big cats and humans.



Using mock hunts to change the behavior of problem lions is certainly not a magical solution for conservation in Africa. But along with other approaches — in particular, those that draw on local traditions and values — they may help both wildlife and the people who live with wildlife win life's games with the cards they have been dealt. 

Stephanie Dloniak studies the behavioral ecology of carnivores and writes about wildlife and the environment. She has a Ph.D. in ecology, evolutionary biology and behavior, and is an adjunct assistant professor of zoology at Michigan State University. She wrote this article as a participant in the Ensia Mentor Program with mentor Michelle Nijhuis.

THE INFINITE RESOURCE

Thanks to innovation, the future may be brighter than we think.

BY RAMEZ NAAM

“THE BATTLE TO FEED HUMANITY IS OVER. In the 1970s the world will undergo famines — hundreds of millions of people are going to starve to death.”

With those words, biologist Paul Ehrlich opened his 1968 bestseller, *The Population Bomb*. Alarmed by the growth of human population in the 20th century, Ehrlich predicted that food supplies could not keep up. Others did as well, including agronomist William Paddock and diplomat Paul Paddock in *Famine 1975!* and the Club of Rome in *The Limits to Growth*.

These past predictions were all wrong. But, what’s most important is they were all wrong in the *same way*, and for the *same reason*. They all ignored or underestimated the most critical human faculty that exists: Innovation.

They made the mistake of looking at the physical resource — land — as the most important determiner of future output. They assumed that the invisible resource — our knowledge of how to maximize yields from that land — would have only a small effect on overall productivity.

What we’ve seen is the opposite. Physical resources matter. But the change in our knowledge resources has made far more impact over the course of history. Knowledge acts as a multiplier of physical resources, allowing us to extract more value (food, steel, living space, health, longevity or something else) from the same physical resource (land, energy, materials, etc.).

The bow and arrow, for example, allowed humans to do more with less. The bow brought in more meat with less risk, more calories with fewer expended. Its utility comes not primarily from its parts, but from the way those pieces work together. The key ingredient that adds value to the pieces is human knowledge.

Knowledge, in the language of economists, is non-rival. Rival goods can only be used by one person, or a set number of people, at a given time. A non-rival good is something of value that any number of people can enjoy the benefits of.

The key turning point in human evolution was the day we achieved the ability to create sophisticated ideas and to communicate them clearly to one another — to tap into this non-rival resource. We were no longer bound by the same constraints of population, food and scarce resources that we and all other creatures on Earth always had been.

There’s a saying that “you can’t eat information.” That may be so, but the food we eat today is the fruit of thousands of years of increasingly high-quality information.


Greater food production and productivity of fields led to larger populations, which in turn led to faster rates of innovation. Among those innovations were sanitation, vaccination and penicillin, which dramatically reduced the impact of disease that had kept populations down. And so, in the 19th and 20th centuries, the world’s population boomed.

While Ehrlich was writing that the battle to feed humanity had already been lost, it was in fact being vigorously fought. In Mexico, a young plant scientist named Norman Borlaug led an effort to develop new strains of wheat that could be planted more often, that would produce more and bigger seeds, and that could resist common wheat diseases. Inspired in part by his success, researchers in other parts of the world created dwarf, disease-resistant, high-yield varieties of rice, corn and other crops. Due to this green revolution, crop yields in the developing world more than tripled overall and the massive famines predicted in the late 1960s never happened.

Before agriculture, a square mile could feed roughly a quarter of a person. Today a square mile of cropland producing average yields feeds almost 1,300 people. Better agricultural technology is working to reduce the land use impact of each person. Innovation and the accumulation of knowledge are substituting for land, a physical resource. Even now, innovations point the way to potential yield increases, drought- or flood-resistant crops, fertilizer and water efficiency, and more.

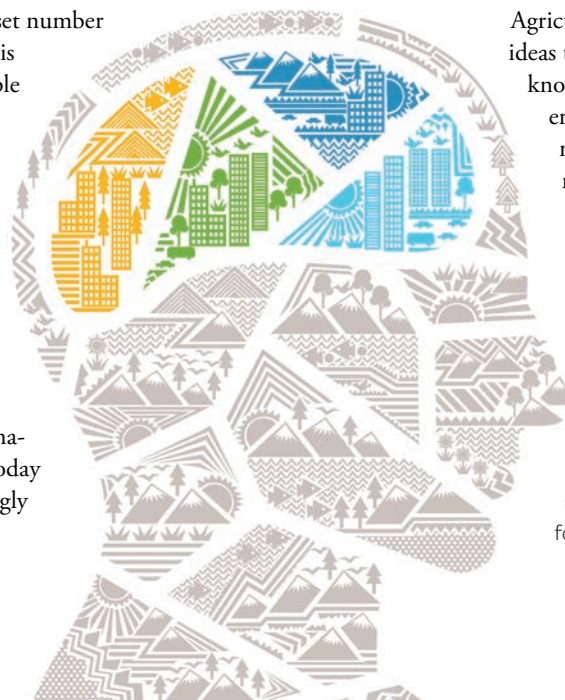
This is not to say that modern agriculture is without negative impacts. Its production of greenhouse gases and fertilizer runoff, and its use of water and pesticides, all deserve scrutiny. But over the last few decades, innovation has reduced the amount of energy, water, insecticide and most dangerous herbicides necessary to feed one person. With the right incentives, right rules and right innovation in new technologies,

there’s no reason to believe that we can’t fix those problems.

Agriculture is an amazing example of the power of ideas to multiply our land resources. And the right knowledge has multiplied the value of nearly every other resource we’ve ever encountered. The most valuable resource we have isn’t energy or minerals or land. It’s our ever-increasing store of ways to put those physical things together in new and more inventive forms. 

Adapted from *The Infinite Resource: The Power of Ideas on a Finite Planet (2013)* by Ramez Naam. Published by permission of University Press of New England.

Ramez Naam is a Seattle-based computer scientist, futurist and award-winning author of four books.



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