ALEX STEFFEN, PEGGY LIU, M. SANJAYAN, ALEXANDRA COUSTEAU & two dozen others take a closer look at how we ***really can*** solve our planet's grand challenges

A Tale of Two Worlds

YOU KNOW THE QUOTATION. "It was the best of times, it was the worst of times." While Dickens was writing about the French Revolution and late 18th century Europe, these words seem particularly relevant in describing the state of the world today.

In fact, you might think modern society lives in two completely different worlds. One is hopeful, peaceful, exciting and moving toward a better future. The other is chaotic, unstable, unjust and inherently unsustainable. Strangely, both worlds seem to exist simultaneously, colliding in this moment in history.

The better world is one we've been building for millennia. It is the world that has risen out of humanity's darkest moments, inspired by art, literature, science and spirituality. It is a world slowly moving beyond imperialism, conquest, ignorance, superstition, bigotry and disease—once norms of our civilization. And as Steven Pinker at Harvard has pointed out, it is a more peaceful world than we have ever seen before. While slavery, genocide and war are not yet completely abolished, they are definitely moving toward the dustbin of history.

Unfortunately, a parallel chaotic, unsustainable world has been asserting itself as well. Born out of the Industrial Revolution, this world is hurtling toward catastrophic environmental damage and the mayhem it would wreak on civilization. You already know the issues: climatic disruptions, rising sea levels, acidifying oceans and massive societal dislocations; biodiversity losses, extinctions and collapsing ecosystems; declining water quality and supplies; and tattered ecosystems, invasive species and emerging diseases. It is a world pushing past planetary limits—skating on the edge, dangerously close to failure.

Both worlds are changing more rapidly now than at any other point in history. Pushed by science, technology, culture and the cumulative progress of previous generations, innovation is building upon innovation, leading to exponential rates of change. In the past 50 years alone, world population has more than doubled, while economic activity grew sevenfold (adjusting for inflation), leading to massive increases in worldwide consumption of energy (4x), water (3x) and food (3x). The changes we have seen in the past 50 years have outpaced those of all previous human generations *combined* several times over.

But this exponential change has also given us amazing new tools and insights that can make us smarter, better connected and more adept at solving problems. In the past year alone, science has detected Earth-like planets elsewhere in the galaxy, and has discovered tantalizing clues about the "God particle," perhaps the most fundamental building block of the universe. Following Moore's law, our computers and phones roughly double in their capabilities every two years. New communication technologies now allow billions to learn, interact and organize, as evidenced by the Arab Spring and Occupy Wall Street. It is a wondrous time to be alive. There is promise in the air, if you only look for it.

Stepping back, it is clear that we are at an inflection point in human history. Changes in population, technology, economics and social movements are colliding with the limits of our planetary environment, and it is still far from clear how things will turn out. Will it be a disaster or a miracle? Or both? No one has a crystal ball, but we can be assured of one thing: The world of 2050 will be unimaginably different than the one we know today.

"Whether we like it or not, **THIS IS *OUR* MOMENT.** We didn't ask for it, but now we have to decide what to do with it."

Whatever happens, make no mistake: This time, *our time,* is the one that will singularly define the world we will have for the next century, the next millennium, and beyond.

Whether we like it or not, this is *our* moment. We didn't ask for it, but now we have to decide what to do with it. Will we simply be the people we tend to be—greedy, lazy and apathetic—or will we become the *people we could be*—brave, compassionate and working for a better world? Will we disappoint future generations, or will they look back on our time and be proud of what we accomplished?

PHOTO BY JOE TRELEVEN

Which path will we choose: the world that *is,* or the world that *can be?*

In this issue of *Momentum,* we ask global thought leaders and innovators: *What would it take to make a better world?* What we found was both sobering and incredibly inspiring. Whether we consider the issues of climate change, environmental justice or preserving the world's forests, there are people and ideas out there that point the way, showing us that a better world is possible—and within our grasp. The ideas are here. The hard part will be turning these ideas into action substantial enough to make a difference.

Robert Anton Wilson once challenged us by saying: "The future is up for grabs. It belongs to any and all who will take the risk and accept the responsibility of consciously creating the future they want." Let us rise to that challenge, and create a future we want—a future our children and grandchildren deserve.

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IonE is committed to sustainability. This magazine is printed on environmentally responsible paper manufactured using 10% postconsumer waste and 100% electricity from renewable sources.

on the cover **ADAM HAYES** is an artist, illustrator and designer based in London. He graduated from the Royal College of Art in 2006 and has since worked on projects for a growing list of clients worldwide. Best known for his hand-rendered typography, Hayes also creates intricate and imaginative maps alongside detailed line drawings for clients such as Toyota, Sony, the *Guardian* and Shakespeare's Globe Theatre. View more of his work at **mrahayes.co.uk**.

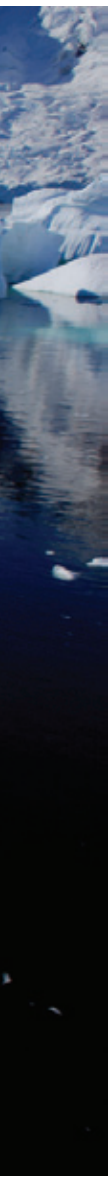
DEPARTMENTS

SPECIAL FEATURE

One Man's Polar Obsession

Photos and text by PAUL NICKLEN

Crabeater seals lounge at the base of a large iceberg (Pleaneau, Antarctica) • A leopard seal bares teeth in a threat display to protect its kill (Antarctic Peninsula, Antarctica) • An arctic fox conceals itself in ryegrass covered with hoarfrost (Nunavut, Northwest Territories, Canada) • A gentoo penguin peeks beneath the water before taking the plunge (Port Lockroy, Antarctica).



I WAS RAISED IN THE CANADIAN ARCTIC, so issues of climate change aren't just science for me. I'm watching my home changing far faster than ever expected, with serious consequences to the people and the animals I grew up with. Loss of sea ice in the poles is like a garden losing its soil. The ice is the foundation for life in that environment, and not only on a microbiotic level. All life, including polar bears, penguins and walrus, is dependent on sea ice.

But people living in concrete jungles can't relate to the devastation that depleting sea ice will cause in the polar habitats. At first I thought I could fight the global warming battle as a biologist. But 15 years ago I realized that a camera is the greatest tool imaginable to protect the places I've remained connected to since my youth.

My mission as a photojournalist is to bring the remote beauty of my world—the polar regions—to people who may never see it themselves, and make everyone care about these ecosystems while we still have a chance to protect them. My images are portraits of survival, showing all we stand to lose if we don't act now.

Join us in Minneapolis April 5 as National Geographic photographer Paul Nicklen leads off the Momentum 2012 event series with a photographic tribute to some of the world's most vulnerable habitats and their inhabitants: environment.umn.edu/momentum/eventseries

PHOTO COURTESY OF PAUL NICKLEN

Updates From IonE

Five-Point Plan

The November 2011 issue of *Scientific American* includes a feature by IonE director Jon Foley that asks, "Can We Feed the World and Sustain the Planet?" The article presents a five-point

plan Foley and colleagues published in the Oct. 30 issue of *Nature* to double global food production while reducing adverse environmental impacts of agriculture.

E3 2011 Recap

More than 300 experts and enthusiasts shared renewable energy success stories and were inspired by a keynote speech by Alexis Madrigal at IREE's E3 2011 conference in November. Read all about it at **z.umn.edu/eee**.

Now Online

You can now follow blogs, tweets, news and more for six of IonE's ongoing programs through their individual websites. Check out updates and subscribe to RSS feeds for Acara, Dialogue Earth, Global Landscapes Initiative, IREE, NorthStar Initiative, River Life and Sustainability Studies by clicking on links at **environment.umn.edu**.

Jolly Good Fellows

Nanotechnology, tree rings, sustainable arts and energy justice are among the topics being explored by IonE's newest resident fellows. The 14 U of M faculty, announced in September, hail from 13 departments in eight colleges. Each will receive funding for three years to pursue cross-disciplinary projects. Learn more at **z.umn.edu/fellows**.

Rain Gardens

"A Neighborhood of Raingardens," a 60-minute documentary by IonE resident fellow Mark Pedelty (CLA), depicts the transformation of a Minneapolis neighborhood through an award-winning community rain garden project. Watch online at **z.umn.edu/raingardens**.

MAPPING TERRA POPULUS

The National Science Foundation recently awarded a five-year, $8 million grant to the IonE-sponsored project Terra Populus, or TerraPop for short. The project will combine historic census information with global environmental data including land cover, land use and climate records and then disseminate this information to researchers around the world. Learn more at environment.umn.edu/terrapopulus.

Going for the Gold

At the 15th annual Minnesota Magazine and Publishing Association Excellence Awards, *Momentum* magazine received honors in 10 categories: Gold for Overall Excellence, Overall Design, Best Single-Topic Issue, Best Cover Design, Best Feature Design, Best Spread Design and Best Letter to the Readers; Silver for Best Feature Article; and Bronze for Best Feature Article and Best Spread Design. *Momentum* was judged as part of the "Special Interest, Under 60,000 Circulation" category, competing against a number of prominent regional magazines. For details and judges' comments, visit **z.umn.edu/mmpa**.

Momentum Takes the Stage

Spring is just around the corner, and with it, Momentum 2012 will bring today's leading environmental visionaries to the Twin Cities for three evenings of engaging ideas and entertainment. IonE's second annual event series will feature Arctic photographer Paul Nicklen (see page 2), Nature Conservancy chief scientist M. Sanjayan (see page 20), and environmental theologian Martin Palmer. Learn more and buy tickets at **environment.umn.edu/momentum/eventseries**.

Fall Mini Grants Awarded

Thirteen IonE Mini Grants of up to $3,000 each are spurring new collaborations among interdisciplinary groups of faculty, staff and students from across the University system. Topics for the one-year grants, awarded in November, include exploring perceptions of corporate sustainability, building communication bridges between the humanities and science, and holding a mock congressional hearing on the topic of non-lead ammunition for deer hunting. See the complete list at **z.umn.edu/minigrants**.

Big Question

Plastics are everywhere and in nearly everything from shoes, planes and trains to phones, clothes

© SHUTTERSTOCK.COM/ALEXROZ

and cars. Most come from nonrenewable fossil fuels like oil and natural gas. This begs the Big Question: Can we make plastics sustainable? Watch for a three-minute answer coming soon to **z.umn.edu/multimedia**.

PHOTO BY JOSH KOHANEK

TEDx Truth

Is climate change the biggest environmental threat we face? Maybe not. Check out IonE director Jon Foley's TEDx talk on "The Other Inconvenient Truth: How Agriculture Is Changing the Face of Our Planet" at **z.umn.edu/tedx**.

Like & Follow

Keep up with the world of environmental solutions: Like Momentum on Facebook and follow us on Twitter at @MomentumIonE. You can also stay updated on IonE news and events on Facebook and Twitter at @UMNIonE.

POWER RANGERS

Two IREE-supported energy research projects at UMD's Natural Resources Research Institute bring hope for new economic activity to Minnesota's Iron Range while advancing our ability to tap renewable energy. Researcher DON FOSNACHT (pictured above) is looking at using abandoned mine pits as a storage facility for renewable energy. KYLE BARTHOLOMEW has figured out a way to make decorative and functional passive solar panels from taconite tailings. Learn more at iree.environment.umn.edu.

KEY TO ABBREVIATIONS: CLA, College of Liberal Arts; IREE, Initiative for Renewable Energy and the Environment; UMD, University of Minnesota Duluth; U of M, University of Minnesota

READ ADDITIONAL INTERVIEWS WITH TED NORDHAUS, JONATHAN PATZ AND MORE ON-LINE AT **ENVIRONMENT .UMN.EDU/MOMENTUM**

WHAT WOULD IT TAKE

to shape a planet on which people, other living things and the systems that support us can sustainably co-exist?

FOR THIS SPECIAL ISSUE, *MOMENTUM* MAGAZINE INVITED EXPERTS FROM AROUND THE WORLD TO SHARE THEIR THOUGHTS ON HOW WE MIGHT CRAFT SOLUTIONS TO SOME OF EARTH'S TOUGHEST CHALLENGES. TURN THE PAGE FOR VISIONARY INSIGHTS INTO HOW WE CAN BUILD BETTER CITIES, BOOST RENEWABLE ENERGY, SAVE THE PLANET FROM CATASTROPHIC FAILURE AND LOTS MORE.

HAVE IDEAS OF YOUR OWN? WE WELCOME YOU TO EMAIL THEM TO **MOMENTUM@UMN.EDU**. WE'LL SHARE THE BEST OF THE BATCH ONLINE.

"Our generation is the last generation to be able to save some of these treasures we have."

Ocean Advocate ALEXANDRA COUSTEAU

WHAT WOULD IT TAKE

to create sustainable ocean fisheries?

ALEXANDRA COUSTEAU EMBARKED ON HER FIRST OCEAN EXPEDITION WHEN SHE WAS 4 MONTHS OLD. TODAY, THE NATIONAL GEOGRAPHIC EMERGING EXPLORER AND GRANDDAUGHTER OF JACQUES-YVES COUSTEAU DEVOTES HER ENERGY TO EDUCATING AND MOTIVATING PEOPLE TO CARE ABOUT AND PROTECT EARTH'S "BLUE LEGACY." *MOMENTUM* CAUGHT UP WITH HER IN WASHINGTON, D.C. **INTERVIEW BY WENDEE HOLTCAMP + PHOTO BY BIL ZELMAN.**

WHAT WOULD IT TAKE TO CREATE SUSTAINABLE OCEAN FISHERIES? It is going to take coordination at the highest levels, coordination between different government entities responsible for managing resources. Nations are struggling to set catch limits and quotas, while still trying to figure out how many fish are there. We don't know enough about the oceans, yet we're reducing the amount of money we're spending on research. A lot of very smart people around the world are working on the problem of sustainable fisheries, but we need to invest more in science. We also need to get the fishermen on board. We need to get them to embrace devices like the Turtle Excluder Devices (TEDs), and to use nets with wider filaments so they're catching their target species, rather than tighter nets that catch everything. It will take fishermen staying out of marine protected areas and catching the species they're allowed to fish and not overexploited species. If we're able to get everyone on the same page, we still can achieve sustainability. But we are running out of time.

HOW ARE WE DOING SO FAR? Right now we are failing miserably. It's a free-for-all out in the ocean. There's no ownership of common spaces, and there's a "get it before the next guy gets it" mentality.

WHAT CAN CONSUMERS DO TO HELP? People should avoid fish that are overexploited, such as Chilean sea bass, swordfish, shark, irresponsibly caught shrimp and all sorts of other species on the brink. In the U.S. alone we have almost 700 different species that are not only safe to eat but also tasty, but we eat the same dozen species every time because we know what they look like, we know our family will eat them. We need to make different choices. If it continues to go on as now, we're going to see some major collapses.

HOW DOES YOUR ORGANIZATION, BLUE LEGACY, WORK WITH SUSTAINABLE WATER ISSUES? Last year, we converted John McCain's Straight Talk Express into a biodiesel mobile workstation, and then went on a 17,100-mile expedition across North America, stopping on many spots along the way to tell the water stories of local communities and local water-keepers. Through film and expeditionary filmmaking, we work to reconnect people with the water in their life, water that shapes the land they live on, shapes the places they live, the communities they have and the quality of life they depend on. The short films are distributed primarily online to media partners, schools, nonprofits and all sorts of organizations so they can tell their stories online to advance their objectives in the communities they serve. When we stopped in a community, we made that day all about them.

HAS HAVING A BABY AFFECTED YOUR OUTLOOK? When I think about projections on what we'll have in five, 10, 50 years, all of a sudden that's a time frame of Clémentine's life, and those milestones are very poignant. When I was young, I had great opportunity to see a lot of extraordinary places, but now they're gone or fundamentally different from how I knew them. That grieves me. There were places that broadened my view of the world, and as we lose those places we impoverish ourselves. I want there to be places she can spend weeks exploring tide pools, and pristine creeks where she can catch tadpoles. I want her to know those things. Our generation is the last generation to be able to save some of these treasures we have. It's our "space race" to protect the quantity and quality of water systems. If we fail, her generation will have lost some really irreplaceable natural places and species. **Q&A**

WHAT WOULD IT TAKE

to make a city carbon neutral?

CO-FOUNDER OF WORLDCHANGING.COM AND EDITOR OF *WORLDCHANGING: A USER'S GUIDE FOR THE 21ST CENTURY,* AUTHOR AND OPTIMIST **ALEX STEFFEN** IS KNOWN FOR HIS BOLD IDEAS ON WAYS WE CAN SHAPE A MORE SUSTAINABLE WORLD. HIS NEW BOOK IN PROGRESS, *CARBON ZERO,* ENVISIONS HOW CITIES OF THE FUTURE COULD BE PROSPEROUS WITHOUT CONTRIBUTING TO CLIMATE CHANGE. *MOMENTUM* ASKED STEFFEN TO SHARE HIS THOUGHTS ON WHAT IT WOULD TAKE TO MAKE A CITY CARBON NEUTRAL.

INTERVIEW BY JEREMY FALUDI + PHOTO BY MIKAEL COLVILLE-ANDERSON.

FIRST, LET'S TALK ABOUT TRANSPORTATION. WHAT ARE YOUR FAVORITE TOOLS OR STRATEGIES THAT CITIES CAN USE? Well, one thing I've learned that's really shocked me is the degree to which transportation planning in the U.S. is really traffic planning. Even progressive cities like Seattle have a sub-department that is about everything else but cars. They don't have any integrated strategy at all. The traffic modeling software used by the planning commission for the five-county metropolitan area here doesn't even account for pedestrian trips or bicycle trips, and only does a one-to-one swap for transit and cars, which we know isn't the way the real world works.

If we're talking about transportation, the best thing a city can do is densify as quickly as it can. That needs to be said every time this issue comes up, because it's the only universal strategy that works. That's the best-documented finding in urban planning—that as density goes up, trip length goes down and transportation energy use goes down. The main question that nearly every city in North America needs to address is how to densify quickly. Once people are grappling with that, though, there are other things people need to do to make that work: making neighborhoods walkable, with green spaces, street life, mixed-use zoning and other qualities that make a place livable. If you have density without that, you just have vertical suburbs.

How you get density is different depending on whether your city is growing or declining. Most cities in the U.S. are growing because the country is having one last population boom. The biggest thing growing cities need to do is minimize barriers to development so that as long as someone is doing good urbanism, they can get permitted quickly and get building quickly. In a lot of places, one of the most expensive parts of building a new building is the delay caused by permitting, public process, etc. Places that have done a really good job, like Vancouver, basically set a high bar for what will get passed, but once you've passed you're good to go, there aren't delays. I think that's one of the most important things, because we know there's already a giant pent-up demand for urban living space. We want to provide that urban living space—but that requires building on a scale we haven't seen in 40 or 50 years.

Futurist ALEX STEFFEN

WHAT ARE THE BEST STRATEGIES TO FILL CITIES WITH CARBON-NEUTRAL BUILDINGS? In most places, the process of land use planning and infrastructure planning is broken—even if it's working well in most ways, it's broken in the slowness with which it grapples with change. In quite a few cities, most civic engagement is mostly a matter of fighting development, people saying, "not in my backyard." Even in cities that are doing good planning, it tends to be marginal and incremental and take decades to come to fruition. There are a number of cities that have fast-track permitting for green buildings.

Vancouver has explicit policies about setting ambitious policy goals and strict building standards, but then really expediting any projects that exceed it. A lot of cities will need to embrace that. We have a lot more to lose by changing too slowly than by changing too quickly. We know enough about how to legislate good urban design that there's no excuse for not picking up the pace.

I THINK PEOPLE ARE FRUSTRATED BECAUSE ALL THESE THINGS ARE SUCH LARGE-SCALE ISSUES THAT PEOPLE FEEL THEY CAN ONLY BE SOLVED THROUGH COMPLICATED BUREAUCRATIC PROCESSES OF CITY GOVERNMENTS, WHICH HAVE GLACIAL PACES. WHAT CAN WE DO ABOUT THAT? One of the most unfortunate side effects of the urban activism of the '60s and '70s is the belief that development is wrong and that fighting it makes you an environmentalist. We know that dense cities are both environmentally better and dramatically more equitable places. Walkable neighborhoods are better than the suburbs for people with a wide range of incomes, and what happens in cities that don't grow is that they gentrify and poor people are pushed out. Trying to fight change makes you less sustainable and more unfair.

I think we need to acknowledge that not everyone will be happy with the results. But you need to be able to charge ahead anyway. I really admire Janette Sadik-Khan, the commissioner of the New York City Department of Transportation. One of the things she's great at is that when there's an idea that's understood to be workable and good because it's worked elsewhere, and with the amount of basic vetting needed to show it won't have unintended consequences, she goes ahead. She just makes changes, rather than submitting things to lengthy process. The most famous thing she did was Times Square, making it a pedestrian plaza. She didn't put it through a five-year plan, she just did it. Same thing with a ton of bike lanes, bus rapid transit, etc. She doesn't get bogged down in debate about things. We need more leadership like that. She's had opposition—some people haven't liked what she's done. But most people really do like it, because it works.

In almost all city governments in America, the small group of people who don't want change are able to block change. Sometimes these people block change for good reasons, but much of the changes we need, that will improve cities, also get blocked—which is a loss for everyone involved.

HOW DO YOU STREAMLINE THE HEARING PROCESS BUT STILL ALLOW PEOPLE'S VOICES TO BE HEARD? FOR INSTANCE, WHEN THE BIG-BOX STORE WANTS TO MOVE IN THAT WOULD KILL LOCAL BUSINESSES, HOW DO PEOPLE HAVE RECOURSE AGAINST THAT? My experience is that, in most cities, the planning process isn't used primarily to block things like that. It's used primarily to block things like extensions of transit, affordable housing, large residential projects, etc. There are bad projects, and people have every right and duty to block them, but most NIMBY opposition isn't to stuff that's actually bad, it's just to stuff people don't like because it's different. And I don't think the public has a duty to listen to the same arguments again and again and again. I think once officials are elected who have a

HOW CAN BIOMIMICRY BENEFIT THE ENVIRONMENT?

JANINE BENYUS, founder of the Biomimicry Institute: I think we need to redesign our world and the way we meet our needs—everything from how we grow food, to how we make materials and manufacture products, to the way we transport and shelter ourselves. In that redesign, we need to find radical new ideas that are also proven to work on this planet.

Biomimicry is innovation inspired by nature's designs. It is a way of seeking sustainable solutions for the planet by emulating nature's blueprints, chemical recipes and ecosystem strategies. It's essential at this time when we need to redesign everything that our designs are innovative and radical and that's what 3.8 billion years gives you. Life evolved 3.8 billion years ago, so biomimicry has that many years of "research and development" to tap into.

I hope the greatest legacy of biomimicry will be an increased respect for organisms and ecosystems as models and mentors waiting to yield sustainable designs and also increased reasons to conserve. —*Wendee Holtcamp*

clearly articulated agenda, they should just go do them. There are converging approaches that are designed to involve more people in the process, change the process itself. Some of this is in the Government 2.0 movement of better data transparency; some of this is in open-source planning, etc. Most of the process in most cities I'm aware of is de facto exclusionary because you can't participate unless you can take time off in the middle of your workday to go to the hearings. So you end up with wealthy NIMBYs, public officials and developers, which isn't a very good mix. Putting pressure to change those systems for civic revival would greatly help.

SO YOU'RE ARGUING NOT FOR SHUTTING DOWN PUBLIC HEARING PROCESS, BUT FOR LETTING CITIES DECIDE ON PROJECTS BY WHOLE CLASSES OF PROJECTS RATHER THAN INDIVIDUAL CASES?

Yes, exactly. You don't get the pace of change that's needed out of case-by-case evaluations. If you're willing to make tough choices right up front, we know it's possible to do a lot of this stuff without taking away anything that people love about their cities. In fact, we can add value to people's neighborhoods.

There's a great plan for the city of Melbourne, which they presented at TEDx Sydney. The city's growing quickly, needs to add a million people over the next decade or two, but they don't want that to be sprawl. So they took a digital map of the city and blocked off everything that's currently single family residences, everything that's a historical building, everything that's green space, working industrial land and other things people are vociferous about valuing. That left a fairly small percentage of land. But they showed that if they concentrated density in those corridors, they could add a million people without expanding the city at all, and it would add all these benefits, like better public transit and such.

> "The best thing a city can do is densify as quickly as it can. That needs to be said every time this issue comes up, because it's the only universal strategy that works."

You can dramatically increase the density of places without taking away things people want—and actually adding things they want but couldn't afford today—because the average suburb isn't dense enough to financially support a tram or the like. But if you add a dense core that can support that, suddenly even the people around it, in their single-family homes, get the benefit, too. I call that "tent-pole density," where extremely high density in a small area brings up the average for a whole neighborhood, even when the rest of the neighborhood doesn't change. I think it's a really important concept, one that most people don't get.

We've run out of time for incremental approaches. For carbon-neutral cities, there are things worth talking about in how our consumption patterns can change—sharing goods, etc.—but those are a fraction of the impacts of transportation and building energy use. If we need to choose priority actions, the most important things are to densify, provide transit and green the buildings. **Q&A**

HOW COULD WE DESIGN A MORE SUSTAINABLE SMARTPHONE?

PAUL FIRTH, manager of science and research for UL Environment: By definition, the most sustainable phone is the one that has the least impacts from a life cycle and human health perspective, while maintaining the best possible functional use.

The screen takes on a lot of the environment impact. First, there's the energy that goes into manufacturing the screen. And then energy usage is dependent on the screen size. Screens are getting bigger—but what's interesting about that is that, at times, a bigger screen on a smartphone allows you to use it instead of a computer. There's an energy benefit to it that typically falls outside the traditional impact assessment.

The sustainable smartphone has to draw its energy in a highly efficient manner. Energy is now delivered from batteries more efficiently, and better battery chemistry reduces environmental impact. There are even smartphones with recharging panels.

The design or durability of a smartphone and its ability to have a second life is a huge factor. You can define that in a variety of ways. You can send some phones to take-back programs that repurpose the parts or send others to reuse programs. In an ideal world I'd like to be able to refurbish my phones with replacement parts I could plug in as necessary. By reusing, regenerating or refurbishing the smartphone, you're giving the phone new life when it would otherwise have entered the waste stream. *—Hannah Hoag*

WHAT WOULD IT TAKE

for social entrepreneurship to make serious inroads into poverty?

SOLOMON PRAKASH IS THE INDIA COUNTRY DIRECTOR OF ASHOKA, AN INTERNATIONAL AGENCY THAT FACILITATES SOCIAL ENTREPRENEURSHIP. AN EX-ENGINEER, HE PREVIOUSLY WORKED WITH MAYA, A NON-GOVERNMENTAL ORGANIZATION HE FOUNDED IN BANGALORE THAT FOCUSES ON EDUCATION, CHILD LABOR AND INCOME-GENERATING PROJECTS IN POOR COMMUNITIES. HE SPOKE TO *MOMENTUM* BY SKYPE FROM A SMALL VILLAGE NEAR PONDICHERRY IN SOUTHEASTERN INDIA. **INTERVIEW BY WAYNE ELLWOOD.**

HOW DID YOU BECOME INVOLVED IN SOCIAL ENTREPRENEURSHIP? I started as an engineer. I worked for a small company in Bangalore for a number of years, mostly in special purpose machine design. Then in 1987 I went to Europe, where I became interested in alternative communities. I visited these communities all across Europe, and I brought that experience back to India with me. In November 1989 I started a nonprofit organization in Bangalore working with young people, connecting homeless kids to jobs and helping them get in touch with their parents.

WHAT WOULD IT TAKE FOR SOCIAL ENTREPRENEURSHIP TO MAKE SERIOUS INROADS INTO POVERTY? If you tackle a problem like poverty head on, you need a set of people on your core team who share your vision. This can be a challenge.

The difference between a social entrepreneur and a business entrepreneur is one of commitment and vision. In a business, you might bail out once you'd made enough money. In social entrepreneurship, you believe you can solve a problem and that others will work with you to solve that problem. That core team needs to grow; otherwise, you don't have the skills to manage the project as it grows. You need talented people who are both committed and dedicated, who are willing to live and work in isolated areas in poor conditions for very little money. Sometimes people want to work in a social enterprise because the work is different. "I may not have much money," they say, "but my soul is satisfied and I feel happy because I've made a contribution."

We also need to think creatively about funding because there are serious challenges in the kind of finances available. Increasingly, granting organizations are looking at things like returnable grants or interest-free loans to make their money last longer. Some people are talking about "social venture" funding, which is a similar model to private venture capital funding. They're expecting returns similar to microfinancing, which was hugely profitable. But that's not going to happen.

WE DON'T USUALLY THINK OF ENTREPRENEURSHIP IN THE CONTEXT OF POVERTY OR SOLVING SOCIAL PROBLEMS. I didn't start off as a social entrepreneur. I started off as a person who wanted to respond to a particular set of problems. But I thought and behaved like an entrepreneur: You have an idea, you put together a team and you try to raise money. You solve issues as you go along, as any entrepreneur typically would build an enterprise.

Many years later I realized that this is what social entrepreneurs do. But I didn't start with that notion. I started as an average person saying, "OK, how do I solve this problem?" I understood the business issues, but I also understood that you are not only looking at profit, you're also looking at other outcomes.

When I started I never thought of myself as selfless. My satisfaction from work was not money but what I love doing most. Of course it had a certain political framework, a framework of justice, a sense of what was fair, and I responded to that.

ARE YOU OPTIMISTIC ABOUT SOCIAL ENTREPRENEURS MAKING SERIOUS INROADS INTO POVERTY? I think the next 10 years will be the decade of social entrepreneurs. I see lots of talented people who want to solve social problems making serious career changes. Some mainstream design firms have actually set up a whole branch around social innovation. Consulting companies are looking at hybrid models of social change. Increasingly, companies are saying it's no longer possible to look at customers just as consumers. More and more people understand that social change is no longer a marginal activity. The opportunity is huge to solve problems and to come up with interesting commercial models that can be sustainable. **Q&A**

WHAT WOULD IT TAKE

to rein in greenhouse gas emissions and solve climate change?

HOW CAN WE MOVE FROM OUR CURRENT CLIMATE-CHANGING ECONOMY TO ONE IN WHICH ATMOSPHERIC GREENHOUSE GAS CONCENTRATIONS ARE STABLE OR DECLINING? IN 2004, PHYSICIST **ROBERT SOCOLOW** AND ECOLOGIST STEPHEN PACALA, CO-DIRECTORS OF THE CARBON MITIGATION INITIATIVE AT PRINCETON UNIVERSITY, PUBLISHED A NOW-FAMOUS PAPER IN *SCIENCE* PROPOSING THAT GREENHOUSE GAS EMISSIONS COULD BE STABILIZED BY MID-CENTURY USING AVAILABLE TECHNOLOGIES TO IMPLEMENT A SET OF ADDITIVE CHANGES THEY CALLED "WEDGES." IN THIS Q&A, SOCOLOW SHARES SOME NEW THOUGHTS ON SOLVING CLIMATE CHANGE BASED ON HIS OBSERVATIONS OVER THE INTERVENING EIGHT YEARS. **INTERVIEW BY BEN JERVEY + PHOTO BY JONATHAN SAUNDERS.**

WHAT WOULD IT TAKE TO REIN IN GREENHOUSE GAS EMISSIONS AND SOLVE CLIMATE CHANGE? The concentration of carbon dioxide in the atmosphere is about 40 percent higher today than it was 200 years ago. It's going up principally because we are burning fossil fuels (coal, oil and natural gas) and secondarily because we are cutting down forests. Fossil fuel energy represents 85 percent of the energy powering the world economy, and exchanging the current fossil fuel energy system for a low-carbon energy system won't happen overnight. It could require a century or more if we fail to take climate change seriously. The current fossil energy system is a very strong competitor to any low-carbon energy system we will invent.

With all the talk about peak oil, it's not surprising that people imagine that the fossil fuel era will come to an end soon because we run out of fossil fuels. That's not going to happen. What we will run out of is low-cost oil. But there are a lot of buried hydrocarbons in the form of lower quality reserves (coal, shale gas, shale oil, oil sands and others) that will keep the fossil energy system humming. So we are in a pickle. We will need policies that modify the current competition between high-carbon and low-carbon energy in favor of the latter. We will also need success in research, development and deployment that lowers the cost of low-carbon energy.

> "We will greatly increase the likely damage from climate change if not achieving the current extremely difficult goal disheartens us and we respond by postponing action for decades."

YOU'VE EXPRESSED CONCERNS ABOUT THE CURRENT DISCUSSIONS OF LONG-TERM CLIMATE TARGETS. The world's diplomats and environmentalists have nearly universally endorsed a target that is extremely difficult to achieve. As a result, there is no appetite for discussion of any goal that is less stringent. Yet a consensus could develop—possibly quite soon—that the very difficult goal will not be attained. It would be desirable to prepare now to discuss some relatively less difficult goal that nonetheless requires, starting immediately, major national commitments and international coordination. We will greatly increase the likely damage from climate change if not achieving the current extremely difficult goal disheartens us and we respond by postponing action for decades.

WHAT IS THIS "EXTREMELY DIFFICULT" GOAL? The extremely difficult global target is known as "preventing 2 degrees." Let me decode this. To prevent 2 degrees, those alive today and our successors

WHAT WOULD IT TAKE TO CONVINCE SKEPTICS THAT CLIMATE CHANGE IS A PROBLEM?

KERRY EMANUEL, Massachusetts Institute of Technology meteorologist and author of *What We Know About Climate Change*: If by "skeptics" one means those who are genuinely skeptical—like most scientists, including me—then almost all of us have already been persuaded by the great preponderance of evidence that we face serious climate risks going forward. But the term "skeptic" has taken on a distinctly Orwellian cast and is now mostly used to describe those who are ideologically predisposed to discount or downplay any notion of climate risk. For such people, objective evidence is largely irrelevant, and ideology will continue to take precedence over evidence in driving their worldview. As for those citizens (and there are many) who do not regard themselves as "skeptics" but who remain unpersuaded that we face serious risks, I am confident that mounting objective evidence will eventually overwhelm the effects of disinformation and lead them to a rational view of the risks we face. *—Ben Jervey*

Climate Strategist ROBERT SOCOLOW

must keep the Earth's average surface temperature from rising more than 2 degrees C (3.6 degrees F) relative to the value of the same temperature before the Industrial Revolution. Because the Earth is already on its way to warming by half this amount, largely as a result of the fossil fuel emissions of the past century, achieving the "2 degrees" target requires the termination of the fossil fuel era in just a few decades. Indeed, "2 degrees" is now widely acknowledged to be shorthand for cutting today's global carbon dioxide emissions rate in half by 2050.

An alternative target is "3 degrees," which is shorthand for allowing the global emissions rate for greenhouse gases at mid-century to be approximately equal to today's rate. The fossil fuel system would be greatly constrained relative to where global economic growth is taking it now. Large deployment of energy efficiency and low-carbon technology would take place during the decades immediately ahead to facilitate the steady curtailment of fossil fuels. But there would still be substantial coal, oil and natural gas in the global energy system at mid-century.

"The '3 degrees' option is the middle option, permitting somewhat greater flexibility and caution."

Not to constrain the global fossil fuel system at all over the next few decades could be called "5 degrees." It is the only outcome currently contrasted with "2 degrees" in most discussions of climate change policy. The "3 degrees" option is the middle option, permitting somewhat greater flexibility and caution but nonetheless requiring immense effort. We should be using the current period to work out the details of the middle option and keep it in play.

CLIMATE SCIENTISTS SUCH AS JAMES HANSEN HAVE WRITTEN THAT A CONCENTRATION OF 350 PARTS PER MILLION (PPM) CARBON DIOXIDE IN THE ATMOSPHERE IS THE "SAFE UPPER LIMIT." THERE'S A WHOLE ORGANIZATION DEVELOPED AROUND THAT NUMBER (WWW.350.ORG). HOW DO THESE TEMPERATURE TARGETS CORRESPOND TO CONCENTRATION TARGETS? Indeed, following the current discussion about targets is a daunting task for the nonspecialist. There is a third way of expressing a climate change target: neither a cap on ultimate surface temperature nor a cap on emissions at mid-century, but a cap on the ultimate concentration of greenhouse gases in the atmosphere. Out of every million molecules in the atmosphere right now, 390 are carbon dioxide molecules. We say that the concentration is 390 ppm, or 390 parts per million. In Shakespeare's time, the concentration was 280 ppm.

350.org is advocating a concentration lower than the present one, setting an agenda for the next century or longer. I think any goal that far out takes our eye off the ball. Our focus needs to be on how quickly we shut down the fossil fuel system over the next few decades, a period when the concentration of carbon dioxide is nearly certain to be rising.

YOU SEEM CONCERNED THAT WE COULD IMPLEMENT WARMING MITIGATION STRATEGIES TOO QUICKLY. The "2 degrees" target emerged from well-meaning but one-sided reasoning. To be sure, the faster the emissions of greenhouse gases are reduced, the smaller will be the disruptions from climate change—the less the severity of storms and droughts, the less the increase in sea level, the less the acidification of the oceans, the less the damage to ecosystems. "Two degrees" was the answer to the question: What temperature rise would occur if the fossil energy system were shut down at the fastest conceivable rate? A two-sided analysis would take into account the disruptions that come from closing down the fossil fuel system quickly.

One reason we need two-sided analysis is that climate change is linked to nuclear war. A rapid global expansion of nuclear power is a step toward avoiding climate change, but it also can encourage the development of nuclear weapons.

"It would be terrible to exchange climate change for nuclear war."

My generation considered our greatest assignment to be avoiding nuclear war. The horror of nuclear war is less on people's minds today, but nuclear weapons are still seen as desirable in many countries. The more worried anyone is about climate change, the more he or she should be working to develop the international institutions that can prevent the diversion into nuclear weapons of the uranium and plutonium associated with nuclear power. It would be terrible to exchange climate change for nuclear war anywhere on the planet.

BESIDES NUCLEAR PROLIFERATION, DO YOU HAVE OTHER CONCERNS THAT KEEP YOU FROM ENDORSING THE QUICKEST POSSIBLE MOVE AWAY FROM FOSSIL FUELS? Yes, I do. An uncritical espousal of the fastest possible renunciation of fossil fuels is also irresponsible from the perspective of industrialization in the developing world. Fossil fuels are currently powering this industrialization, and plans for the decades ahead assume that the dominance of fossil fuels will continue. An alternative is low-carbon industrialization in various forms. Yet, very little detailed analysis has been done to understand what would be

necessary to make low-carbon industrialization attractive.

To understand why such analysis is critical, note that today roughly half of the world's emissions come from industrialized countries and half from developing countries. To meet the goal of cutting global emissions in half by midcentury, even if industrialized country emissions were to go nearly to zero, total emissions from developing countries would need to fall relative to today. By contrast, emissions of greenhouse gases from the developing world have roughly doubled in the past 20 years. Low-carbon industrialization for sure will require much innovation.

DO YOU HAVE SPECIFIC INNOVATIONS IN MIND FOR THE DEVELOPING WORLD? Above all, developing countries undergoing rapid industrialization need to make energy efficiency a priority. Neighborhoods containing blocks of apartment buildings for hundreds of millions of people are being built today, equipped with hundreds of millions of household appliances.

> "Above all, developing countries undergoing rapid industrialization need to make energy efficiency a priority."

To service these neighborhoods, new roads and new grids for electricity, natural gas and water are being provided. Unfortunately, most of this development repeats mistakes made earlier by industrialized countries. First costs rather than life-cycle costs drive investments. Measurements of actual usage of power and fuel are rare, even though such measurements would permit energy-savings strategies to be evaluated and made more effective.

AREN'T YOU VIOLATING A TABOO WHEN YOU TALK ABOUT THE RESPONSIBILITIES OF DEVELOPING COUNTRIES? As someone from an industrialized country, I do indeed find it awkward to lecture counterparts in developing countries about their patterns of development. In effect, I am saying: "Don't do what we did."

I advocate fixing the bad habits in industrialized countries and limiting their adoption in developing countries. "Developed" countries can and should pursue energy efficiency much more aggressively—addressing our own poorly insulated homes, low-mileage vehicles, and inefficient refrigerators, computers, televisions and air conditioners. We can and should establish land use policies that reduce sprawl and long commutes.

TO SUM UP, WHAT WOULD YOU RECOMMEND FOR AN OVERALL CLIMATE CHANGE STRATEGY? We will know more about climate change in a decade or two, and we will also know more about the societal stresses incurred by aggressive climate change mitigation. It is all too easy to imagine outcomes of addressing climate change that bring societal disruptions as severe as climate change itself. I am confident that preventing such outcomes is achievable. But right now there is too much willingness to pretend that such outcomes don't exist.

I recommend, first, the coordinated development of ambitious emissions targets and emission-reduction strategies required to meet these targets. Second, at regular intervals, in accordance with the principle known as iterative risk management, both the targets and the strategies would be revisited and revised in the light of new information and insights. **Q&A**

HOW CAN WE MAKE CLIMATE POLICY IN THE FACE OF UNCERTAINTY?

GAVIN SCHMIDT, NASA climatologist and founding member of RealClimate: Scientists almost by definition spend their time researching uncertainties. They rarely write papers on what is well known because they are supposed to be doing something new. Indeed, it is hard to see why any scientist would remain in the field if they thought everything important was already known.

For topics like climate change, though, the focus on uncertainties dominates not only the technical literature, but also the media. Perhaps nine out of 10 stories that get mass attention are related to new papers in *Nature* or *Science* that are right at the edge of what is known. This tends to skew public attention away from the fundamental science that everyone agrees on. I would argue that it is this far broader knowledge that should inform policy-making, rather than the hot-off-the-press new result that has not been evaluated by the broader community and can occasionally be quite wrong.

Policies should aim to be robust to the remaining uncertainties, and they mostly are. But it is important to note that all policy-making, being concerned with the future, always has to deal with uncertainty.

This is not an alien concept to policy-makers, and climate science is not unique in having uncertainties. —*Mary Hoff*

WHAT WOULD IT TAKE

to create a thriving green economy?

OVER THE PAST COUPLE OF YEARS, THE UNITED STATES HAS WEATHERED A MASSIVE OIL SPILL IN THE GULF OF MEXICO, CANADIAN PIPELINE DEBATES AND THE CHALLENGES OF RECESSION. THROUGH IT ALL, THE PROMISE OF THE GREEN ECONOMY SEEMS TO BE JUST SITTING THERE LIKE A GOLDEN OPPORTUNITY TO CURE OUR ILLS. WHY IS THE U.S. WAITING ON THE SIDELINES WHILE COUNTRIES LIKE GERMANY, CHINA AND JAPAN FORGE AHEAD? TO GET SOME ANSWERS, *MOMENTUM* TURNED TO **PHAEDRA ELLIS-LAMKINS**, CHIEF EXECUTIVE OFFICER OF GREEN FOR ALL—A NATIONAL ORGANIZATION THAT BUILDS SUPPORT FOR THE GREEN ECONOMY.
INTERVIEW BY TODD REUBOLD + PHOTO COURTESY OF GREEN FOR ALL.

WHAT'S IT GOING TO TAKE TO SPUR THIS NATION TO ACT ON THE OPPORTUNITIES THAT A GREEN ECONOMY PRESENTS? First, I think it's important to note that we already have a thriving green economy. More people actually work in the green economy than the fossil fuel sector. The question is, how do you scale it enough that people go back to work? The first step is green incentives. We have to stop providing incentives to fuels that pollute and provide incentives to the industries we want to grow. The United States has to pick winners and losers, and we want to pick winners that put people back to work *and* sustain the planet.

Green Economy Advocate
PHAEDRA ELLIS-LAMKINS

THE "GREEN ECONOMY" INCLUDES A PRETTY BIG SPECTRUM. WHERE SHOULD INVESTMENTS BE MADE NOW TO HAVE THE BIGGEST IMPACT? Right now we're really focusing on water and food. Take water, for example. We think there are just incredible opportunities. We're looking at places where there's infrastructure needed that would provide more access to clean, fresh water and also employment. The city of Philadelphia is spending nearly $2 billion alone on green infrastructure to clean up the city's water.

YOU RECENTLY WROTE ABOUT GREEN JOBS BEING "POLITICALLY TOUCHY." HOW DO WE MOVE THE GREEN ECONOMY DISCUSSION BEYOND ENVIRONMENTALISM OR PARTISAN POLITICS? The reason some people want to kill green jobs bills is because of the coalition of people who support them. If you can bring together the environmental movement, the labor movement, people of color, people who are struggling to make it now, then that's a pretty powerful coalition.

I was testifying in Congress and a Republican member said, "I don't believe in global warming, but I want those jobs." And the reality is, regardless of your politics, you want those jobs. So, in places like Mississippi and Louisiana, both places with Republican governors, they're creating incentives for renewable energy. They're working to attract the jobs.

IF YOU WERE PRESIDENT FOR A DAY, WHAT ADDITIONAL POLICY WOULD YOU PROPOSE TO REALLY LAUNCH THE GREEN ECONOMY? I'd want to have some sort of climate bill that actually dealt with incentivizing growth of the green economy. I'd also look at some best cases like California and others and figure out how we can replicate what they're doing.

WHY IS IT IMPORTANT TO YOUR ORGANIZATION TO CONNECT WITH POPULAR MUSICAL ARTISTS AND OTHERS? It's important because change doesn't have to be painful.

We want people to go to a concert and hear music and see their values reflected. When we went on tour with the Black Eyed Peas or worked with the artist Drake, my nieces wanted to come, too, and it showed me it was a much more powerful tool than almost anything we'd done because then people could understand it based on their own lives.

WHAT'S IN STORE FOR THE FUTURE OF THE GREEN ECONOMY? I think the future is really bright. We're seeing communities stand up across the country and say, "We want what this country promises. We want healthy and sustainable communities."

I feel beyond hopeful, because it wouldn't be this hard if the green economy weren't being this successful. **Q&A**

WHAT WOULD IT TAKE

for scientists to become better communicators?

SCIENCE AND COMEDY—GENERALLY TWO WORDS YOU DON'T THINK ABOUT IN THE SAME SENTENCE, UNLESS YOUR NAME IS **BRIAN MALOW**. THE SELF-PROCLAIMED SCIENCE COMEDIAN IS MAKING SUBJECTS LIKE ASTRONOMY, PHYSICS AND BIOLOGY COOL BY ENTERTAINING AND EDUCATING AUDIENCES ACROSS THE COUNTRY. ALONG THE WAY, HE'S ALSO SHARING TIPS AND TRICKS FOR SCIENTISTS INTERESTED IN BECOMING BETTER PUBLIC SPEAKERS. SO, A SCIENTIST WALKS INTO A BAR … **INTERVIEW BY TODD REUBOLD + PHOTO BY DOROTHY PIERCE.**

WHEN DID YOU START GETTING INTO SCIENCE? Science has been a passion of mine since an early age, so when I started doing comedy it was natural that my interest in science would inform my style of comedy.

HOW DO PEOPLE REACT WHEN YOU WALK UP TO THEM AT A PARTY OR CONFERENCE AND SAY, "HI, I'M BRIAN THE SCIENCE COMEDIAN?" (Laughs.) Well, I rarely do that. You know, comics notoriously don't like to reveal what we do for a living. Part of it is shyness and part of it is people react strangely when they hear you're a comedian. They put you on the spot and want you to tell jokes. I mean if you're a lawyer I'm not going to ask you to practice law right in front of me.

There's a bad taste in some people's mouths about science comedy, too. Maybe they saw a mixture of science and humor that was kind of corny. Maybe they saw a scientist trying to be funny. I think that a lot of scientists are funny. But not all of them are, I guess.

WHY IS SCIENCE COMMUNICATION SO IMPORTANT? There's this growing awareness that in addition to their regular scholarship, scientists need to be good communicators. Especially since there are so many subjects today—like evolution and climate—where it's dangerous or depressing how misinformed the public is.

WHAT ARE SOME THINGS A SCIENTIST COULD START DOING RIGHT NOW TO BE A BETTER COMMUNICATOR? In speaking to the public, it's important to know your audience and be aware that they don't have all the references you have.

It's also important to not just be you, the scientist, but to reveal some personality. It's helpful to reveal some of your passion and curiosity and what drew you into science. People want to know why they should care about something. So, a good place to start is to remember why you care about this. It's not the sort of thing you'd share with a technical audience, but it's the exact sort of thing to share with the general public.

It's also important to be prepared so you aren't reading from a script. You want to be present in order to make a connection.

WHAT WOULD YOU SAY TO SCIENTISTS WHO FEEL UNCOMFORTABLE BEING "UNDER THE SPOTLIGHT"? Some people get thrown off by being onstage, but we get better at everything with time and practice. What you want is to really be yourself up there and not be afraid to reveal a little bit of personality and passion.

Also, talking to an audience is just like talking to an individual. You want to connect with them. You don't want to be looking at your slides or down at your paper. Nonverbal communication can sometimes be as important—if not more important—than the actual words you're saying.

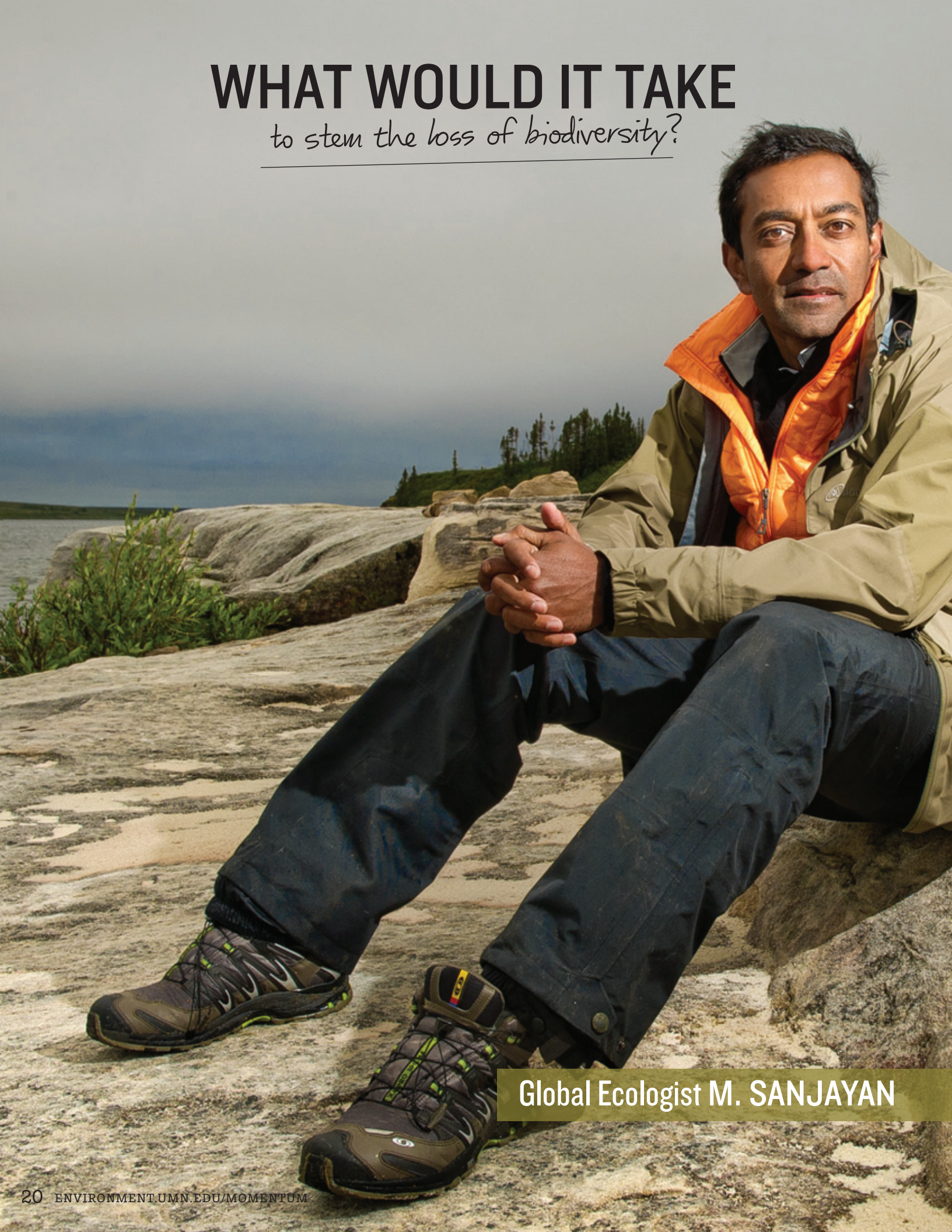
The other thing I really like in terms of communications tools is using analogies, stories and anecdotes. People connect with stories.

IT'S ALMOST LIKE SCIENTISTS HAVE BEEN TRAINED TO TAKE EMOTION OUT OF THE EQUATION. Scientists are supposed to be dispassionate. But, I don't think this means you have to be a Vulcan who's devoid of emotions. You just have to be able to analyze and look at the science separate from your emotions. When you're talking to real people, it's great to be a full, complete human.

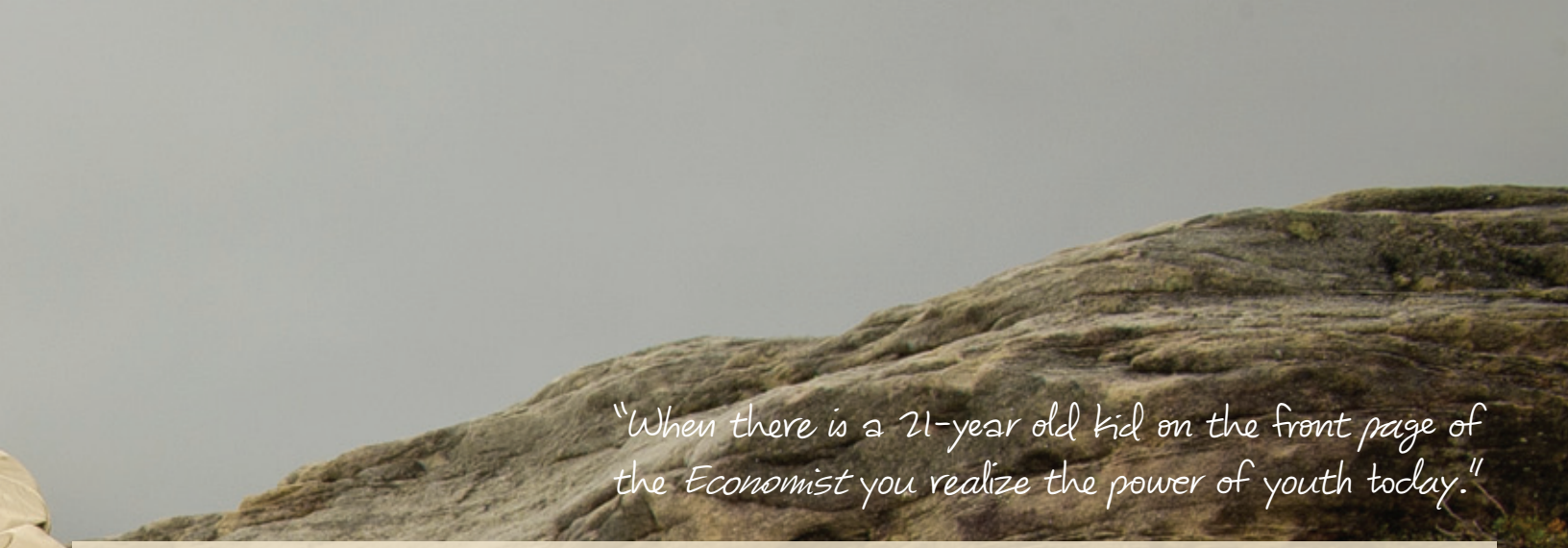
WHO DO YOU THINK ARE THE GREAT SCIENCE COMMUNICATORS OF OUR TIME, AND WHY? Isaac Asimov, Carl Sagan and Arthur C. Clarke are still among the best science explainers ever. Today, there are some scientists who are really great communicators. Neil deGrasse Tyson is one. I've seen him speak live and he's like a science comedian, but it never gets in the way of him communicating science. His passion and love of science also comes across all the time. Lawrence Krauss is another one. He's funny and he's written a couple books about the science behind Star Trek. Richard Feynman was a hoot, too. You can just tell how much he loved science by the way he talked about it. **Q&A**

WHAT WOULD IT TAKE

to stem the loss of biodiversity?



Global Ecologist M. SANJAYAN



"When there is a 21-year old kid on the front page of the Economist you realize the power of youth today."

IT TAKES A PRETERNATURAL OPTIMIST TO SEE A SILVER LINING IN CURRENT BIODIVERSITY TRENDS: GLOBAL BIODIVERSITY HAS DECLINED APPROXIMATELY 30 PERCENT SINCE 1970, AND RECENT STUDIES PREDICT CONTINUING LOSS OVER THE 21ST CENTURY. THANKFULLY, CONSERVATION HAS FOUND A POSTMODERN POLLYANNA IN THE FORM OF **M. SANJAYAN**, A SRI LANKAN–BORN, AFRICAN-RAISED ECOLOGIST. AS LEAD SCIENTIST FOR THE NATURE CONSERVANCY, ONE OF THE WORLD'S LARGEST CONSERVATION ORGANIZATIONS, SANJAYAN JUGGLES ROLES AS PUBLIC SPEAKER, BLOGGER, WILDLIFE ECOLOGIST AND MEDIA FIGURE ON A WIDE ARRAY OF CONSERVATION ISSUES. WE SPOKE WITH SANJAYAN ABOUT WHAT IT WILL TAKE TO SAVE BIODIVERSITY AGAINST THE STEEP ODDS THAT SCIENCE NOW SUGGESTS. **INTERVIEW BY MAYWA MONTENEGRO + PHOTO BY AMI VITALE.**

WE'RE RAPIDLY LOSING GROUND WHEN IT COMES TO SAVING SPECIES AND THEIR HABITATS. WHAT WOULD IT TAKE TO STEM THE LOSS OF BIODIVERSITY? BEYOND EFFORTS TO IMPROVE WHAT'S ALREADY BEING DONE, ARE THERE ANY BOLD NEW IDEAS BREWING IN THE CONSERVATION COMMUNITY? Two big models have dominated conservation for the past 60 years. One is using private capital to buy land for conservation, and the other is using policy to restrict or ban activities—like shark finning—or to declare a national park. The problem is that neither of these models is able to keep up with today's pace of change.

So what I'm very excited about, and what the conservancy is now moving into, are alternate models which are less reliant on private capital and less reliant on legislation but are still highly effective. The simplest case is payments for services around water. For example, a beer bottling company pays people to protect the watershed in the upper Andes using private money. Another example is what Indonesians call "fish banks." (We call them "marine protected areas.") The fish-banking idea is spreading from village to village across Indonesia, not because there's a ton of conservation money going into it, but because local communities understand its value. These alternate models don't protect everything—you can protect the watershed and still lose the Andean bear—so you do still need proactive conservation in the traditional sense. But these new alternative models, I think, carry the biggest hope for future progress.

BRINGING MORE PEOPLE INTO THE FOLD OF THE "CONSERVATION MOVEMENT" SEEMS LIKE AN IMPORTANT FUTURE CHALLENGE AS WELL. DO YOU AGREE? Absolutely. There are three constituencies that we have either ignored, despised or just looked away from. First is the youth. When there is a 21-year old kid on the front page of the *Economist* because of the protests on Wall Street, you realize the power of youth today. The second is the business community. We've long been supportive of "green businesses" like Patagonia. But today mainstream companies are getting in on conservation, not because they necessarily want to be good citizens, but because they're dealing with the biggest uncertainty of all, the uncertainty of raw materials. The third constituency is the poor. The ultimate model for conservation relies on the rural poor, the people who live most closely to the places we want to conserve.

BEYOND TARGETED EFFORTS TO REACH THESE CONSTITUENCIES, WHAT IS ONE THING EVERYONE CAN DO TO HELP CONSERVE NATURE? Practice empathy. Empathy, I believe, means that you make yourself uncomfortable by talking to and listening to people who are unlike yourself. This is a piece that is undermining a lot of what we do in conservation today. We tend to frame things as "The War on Nature" or "The Planet in Peril." In so doing, we polarize the conversation, creating an "us versus them" mentality. And it becomes very, very hard to actually hear what the "them" is saying.

Probably that's why I live where I live—in Montana. Because I know if I lived in New York or in D.C., it would be much too easy for me not to hear other voices. I have a cabin in a place you could best describe as "Ron Paul country." I like being there—because there I hear the echoes of voices very much unlike those of my oldest and closest friends. It teaches me a lot more about empathy and love and how we can find a common way of looking at a shared landscape. **Q&A**

Join us in Minneapolis May 10 as M. Sanjayan shares his vision for biodiversity as part of the Momentum 2012 event series: **environment.umn.edu/momentum/eventseries**

WHAT WOULD IT TAKE

to protect Earth's systems from catastrophic failure?

DO EARTH'S LIFE SUPPORT SYSTEMS HAVE A POINT OF NO RETURN? THREE YEARS AGO, **JOHAN ROCKSTRÖM**, EXECUTIVE DIRECTOR OF THE STOCKHOLM ENVIRONMENT INSTITUTE, HEAD OF THE STOCKHOLM RESILIENCE CENTRE AND PROFESSOR AT STOCKHOLM UNIVERSITY, LED AN INTERNATIONAL TEAM IN DEFINING "PLANETARY BOUNDARIES"—A "SAFE OPERATING SPACE" WITHIN WHICH CHANGES IN NINE PLANETARY SYSTEMS (STRATOSPHERIC OZONE DEPLETION, NITROGEN/PHOSPHORUS CYCLE CHANGE, GLOBAL FRESHWATER USE, LAND USE CHANGE, BIODIVERSITY LOSS, ATMOSPHERIC AEROSOL LOADING, CHEMICAL POLLUTION, CLIMATE CHANGE AND OCEAN ACIDIFICATION) MUST REMAIN TO AVOID THE RISK OF SETTING OFF A CASCADE OF IRREVERSIBLE CHANGE. ACCORDING TO THE TEAM, THREE OF THOSE—BIODIVERSITY, NITROGEN INPUTS AND CLIMATE CHANGE—ALREADY HAVE BEEN EXCEEDED. **INTERVIEW BY MARY HOFF + PHOTOS BY DUNCAN DAVIDSON.**

WHY DO WE NEED TO THINK ABOUT PROTECTING EARTH'S SYSTEMS FROM CATASTROPHIC FAILURE? The basic reason is that major advances in Earth system science now show that humanity is facing the risk of large-scale, potentially catastrophic tipping points that could hamper human development. The evidence shows that we may have entered a whole new geological epoch, the Anthropocene, where humans constitute the main geological force changing planet Earth. The planetary boundaries framework was developed to address this new reality.

But the insight of the Anthropocene gives you only the very first step, because it just indicates we have a high degree of human pressure. The second is the risk of nonlinear change, which comes out of resilience theory and from empirical evidence that particular ecosystems have multiple stable states. We see evidence that lakes and forests and wetlands can have different equilibria—so you have a savanna system that may be stable and thriving, but it can also tip over and become an arid steppe if pushed too far by warming, land degradation and biodiversity loss. A clear-water lake can become a murky, biodiversity-low anoxic lake. Unfortunately, the science is increasingly showing that even large systems can tip. There's paleoclimatic evidence that if oceans get an overload of phosphorus, they could collapse with large dead zones. The largest ice sheets also show evidence of shifts between ice-covered and ice-free states.

We asked ourselves: OK, so if we are in the Anthropocene, and if we are at risk or have evidence of large regional to global tipping points, then what is our desired state for planet Earth? What is the state at which Earth needs to be in order to support human well-being in a world of 7—soon to be 9—billion people?

Paleoclimatic records show clearly that the past 10,000 years, the Holocene, is a remarkably stable period in which we went from being a few hunters and gatherers to become more sedentary agriculture-based civilizations, which then moved us to the current populated modern era. So there's robust evidence that the Holocene is our desired state and the only state we know that can support the modern economy. If we know that, we can also define the biophysical preconditions: What are the Earth system processes that determine the Holocene's familiarity? Can we for those processes identify tipping points we want to avoid? The insight of the importance of the Holocene stability provides humanity with a science-based analysis of global sustainability goals that should be met to provide us safe operating space for human development.

> "Human development has to be subordinate to Earth system boundaries."

WHAT WOULD IT TAKE TO PROTECT EARTH'S SYSTEMS FROM CATASTROPHIC FAILURE? There are so many challenges and steps that need to be taken. But if one thinks of it as entering a funnel, I think a broad entry point is the need for a shift in mind-set. It might sound a bit awkward—the first thing one thinks of is probably new economic paradigms, really hard new governance structures, new policies. All of that is of course required, but the precondition is that modern society reconnect to the biosphere, which in turn requires a mind shift. Today we operate the world with our growth paradigm and our economic imperative and our social imperative as being the supreme goals for our societies. We then add, at best, sustainable development, corporate social responsibility and all the good work we're doing with clean tech and efforts to be more efficient, all with the explicit goal of minimizing environmental impacts within the overarching growth paradigm.

The insights of the Anthropocene and tipping points show this paradigm doesn't work anymore. We have to reverse the whole order and agree that the biosphere is the basis for everything else. This is quite dramatic, because it means human development has to be subordinate to Earth system boundaries. It changes the whole idea of macroeconomic theory, because macroeconomic theory basically states that as long as you put the right price on the environment, you automatically get the most cost-efficient way of solving environmental problems.

The second dimension is the idea of planetary stewardship, which means taking ourselves from 196 nation-states operating in their own interest as individual entities to joint governance at the planetary scale. We need to strengthen global governance. We need a global agency that governs, monitors,

verifies and reports on whether we're on aggregate meeting planetary boundaries. That is something a world environment organization could do. This is not to say bottom-up initiatives are not important. On the contrary, they are a precondition for success. But in the Anthropocene, where we need to urgently bend the global curves of negative environmental change, we need to provide leadership also at the global scale. This is lacking today.

HOW URGENT IS THIS? There is more and more scientific evidence that suggests it is very urgent. For climate, biodiversity and nitrogen, we are already in the slippery danger zone where we cannot exclude tipping over thresholds. On climate, we're seeing evidence of a destabilization of the Arctic ice sheet. On nitrogen, we're seeing clear evidence of major tipping points where lakes are losing their capacity to support human well-being due to overuse of nitrogen and phosphorus, particularly in modern agriculture. On biodiversity, we've reached the point where humanity is causing an extinction of species equivalent to losing the dinosaurs 65 million years ago—at the same time we're also learning how much we depend on biodiversity. We have increasing evidence we need to back off also on phosphorus and that we're approaching dangerous boundaries for freshwater and for land. So we have a decade right now that is very decisive.

And the reason it's urgent is not that we risk catastrophic outcomes in one year or five years or 10 years. It is because what we do today injects changes in Earth systems that may cause thresholds in 50 years' time, 100 years' time. The future of coming generations is thus truly in this generation's hands. And we have already committed ourselves to major risks of tipping points in the coming century. That's why we need to go much, much faster on turning back into the safe operating space.

For the boundaries that we have already transgressed, we can't exclude that this decade is a determining decade, that we need to bend the curves of negative environmental change before 2020. There's a lot of strong evidence that's the case.

WHAT IF WE DO TAKE THIS TO HEART? WHAT COULD WE HOPE FOR? That's a very interesting question, because there's very little or no science to suggest that a global transition to sustainability, a global transition to a future within planetary boundaries, would be a worse world than the world we know today. On the contrary, there is increasing evidence to suggest that a transition can be done while providing us with good chances of prosperity even on a crowded planet.

But there is a big "but": And the big but is, have we already gone too far? And that we simply don't know yet. **Q&A**

WHAT WOULD IT TAKE

to save the world's large carnivores?

AROUND THE WORLD, LIONS, WOLVES AND OTHER PREDATORS ARE THREATENED BY HUNTING, HABITAT LOSS AND ECOSYSTEM DISRUPTION. IN SOME CASES, SPECIES CLING TO THE BRINK OF EXTINCTION, VIRTUALLY ERADICATED BY HUMAN PRESSURE. HELPING LEAD THE CHARGE TO SAVE LARGE CARNIVORES ARE **BEVERLY AND DERECK JOUBERT,** FILMMAKERS FROM BOTSWANA AND EXPLORERS-IN-RESIDENCE WITH THE NATIONAL GEOGRAPHIC SOCIETY. THE JOUBERTS HAVE BEEN WORKING IN AFRICA FOR MORE THAN 25 YEARS, EXPLORING THE CONSERVATION ROLE OF LARGE PREDATORS AND KEY AFRICAN WILDLIFE SPECIES. THEIR WORK HAS BROUGHT THEM FIVE EMMYS, THE WORLD ECOLOGY AWARD AND THEIR RECENT INDUCTION INTO THE AMERICAN ACADEMY OF ACHIEVEMENT. **INTERVIEW BY MAYWA MONTENEGRO + PHOTO BY MIKE MEYERS.**

Filmmaker-Conservationists
BEVERLY & DERECK JOUBERT

WHAT WOULD IT TAKE TO SAVE THE WORLD'S LARGE CARNIVORES? Saving the world's top predators goes hand-in-hand with our own survival on this planet—even though, ironically, on an individual level they threaten us! Our threats to them are enormous. We will lose large carnivores in 10 to 15 years at this rate. As they disappear, we will see ecosystems collapse and economies—in Africa, in particular—dissolve as a large part of their $80 billion ecotourism revenues dries up.

We can't keep treating carnivores and the planet like an endless resource; we've been on this insane "shopping spree" against nature for too long. Like all things though, reality sets in, mortgages dry up, Internet bubbles burst, and we somehow, almost magically, find balance.

We have within us the capacity to find solutions. We understand intuitively the difference between right and wrong. We know it, but sometimes we lie to ourselves that everything will be all right, because we are, if nothing else, "the optimistic ape." The day we stop and take stock of what we are doing we will have taken the first step. Then we can collectively come up with ways to protect the big cats and the land they need.

The solution? It's respect. **Q&A**

HOW CAN WE STOP THE ILLEGAL TRADE IN ANIMAL PARTS?

BELINDA WRIGHT, founder and executive director of the Wildlife Protection Society of India: Wildlife crime is the third largest illegal occupation in the world, after arms and narcotics, and is now more deeply entrenched than ever.

On a practical level, the trade cannot be curbed without unflinching support of political leaders and civil society. In India, we need good intelligence-led enforcement to deter poachers, adequate and equipped field staff, more focus on solving human-animal conflict, better coordination between enforcement agencies, and quick and effective prosecution of wildlife cases. WPSI has records of 882 people accused in tiger-related crimes in the last decade. Of these, only 18 have so far been convicted in a mere six court cases. We need better surveillance of known offenders, international coordination to check cross-border smuggling and a massive awareness campaign to discourage buyers. People will only refrain from buying wildlife products in countries like China if a social stigma is attached.

On a personal level, we should all spread awareness of the problem and express support for strong laws and policies governing poaching and the trade in wildlife. Do not buy exotic pets, however tempting it may be—it often leads to animals being captured and traded illegally. Systems to monitor illegal trade are weak and often exist merely on paper. It may not be possible to entirely halt wildlife crime, but it most certainly can be controlled so that we have something to leave for future generations. *—Maywa Montenegro*

WHAT WOULD IT TAKE

to protect nature while meeting human needs?

HISTORICALLY, CIVILIZATIONS HAVE MET HUMAN NEEDS AT THE EXPENSE OF NATURE. BUT DOES THE WELL-BEING OF HUMAN AND NATURAL SYSTEMS HAVE TO BE AN EITHER-OR PROPOSITION? **GRETCHEN DAILY,** BING PROFESSOR OF ENVIRONMENTAL SCIENCE AT STANFORD UNIVERSITY AND CO-FOUNDER OF THE NATURAL CAPITAL PROJECT, THINKS NOT. IN RESEARCH SPANNING COUNTRYSIDE BIOGEOGRAPHY TO POLICY AND FINANCE MECHANISMS FOR ECOSYSTEM SERVICES, DAILY IS WORKING TO SHOW HOW RECOGNITION OF THE ECONOMIC VALUE OF NATURE CAN SET THE STAGE FOR MUTUALLY BENEFICIAL COEXISTENCE. **INTERVIEW BY MAYWA MONTENEGRO + PHOTO COURTESY OF THE HEINZ AWARDS.**

WHAT WOULD IT TAKE TO PROTECT NATURE WHILE MEETING HUMAN NEEDS? A quote from Confucius strikes at the heart of harmonizing people and nature, humanity's greatest challenge:

There are three pathways to wisdom. The first is through contemplation, and that is the noblest. The second is through imitation, and that is the easiest. The third is through experience, and that is the bitterest.

Progress along the first pathway involves inventive minds increasingly focused on developing new approaches that realize multiple values from lands and waters—in a balanced way that sustains biodiversity and Earth's life-support systems.

Opening up the second, the easiest, path actually requires something very hard: heroic action conducted with vision, compassion and risk. In any revolution, there are many, many heroes. We need to enable latent heroes to act, locally and globally, in creating real-world demonstrations of new approaches. These should be bold enough that they don't all succeed, but all should be designed to yield a success story that is compelling, replicable and scalable.

There's not enough luck in the universe to avoid all of life's bitterness, but with heroic action we can avert the worst and open a much brighter future. **Q&A**

"The easiest path actually requires something very hard: heroic action, conducted with vision, compassion and risk."

Ecologist
GRETCHEN DAILY

HOW CAN WE PROTECT POLLINATORS?

CLAIRE KREMEN, conservation biologist: Pollinators are critically needed to pollinate three-quarters of our crop species, comprising about one-third of our food supply. We can protect pollinators by altering our farming systems. Instead of large monocultures, our farms fields should grow many different crops, should rotate crops across time, and should include non-crop plantings such as insectary strips and flowering plant hedgerows. The landscapes encompassing our farms should not only support many different types of crops but also include pastures, fallows, meadows and woodlots. Diversified farming systems such as these will provide plenty of floral and nesting resources for wild bee species and also honeybees, our semi-domesticated pollinator workhorse. And since what's good for the bees is good for many other critical ecosystem services on the farm—such as generation of fertile soils, efficient use of nutrients and water, and control of weeds, pests and diseases—by utilizing sound agroecological principles we can promote a healthier agroecosystem that produces good food while using less energy, water, chemical fertilizers and pesticides and creating far fewer wastes. *—Maywa Montenegro*

WHAT WOULD IT TAKE

to halt deforestation in the tropics?

SMITHSONIAN TROPICAL RESEARCH INSTITUTE FOREST ECOLOGIST **WILLIAM LAURANCE** HAS STUDIED THE IMPACTS OF LAND USE IN ALL OF THE WORLD'S MAJOR RAIN FORESTS, FROM THE GREAT AMAZON TO THE MYSTERIOUS FORESTS OF NEW GUINEA. HE GOT HIS START IN THE 1980S WORKING TO SAVE THE DWINDLING RAIN FORESTS OF AUSTRALIA BEFORE PUTTING IN DECADES OF WORK IN THE AMAZON AND ELSEWHERE. TODAY HE HAS RETURNED TO AUSTRALIA, WHERE HE IS A DISTINGUISHED RESEARCH PROFESSOR AT JAMES COOK UNIVERSITY. GIVEN THAT RAIN FORESTS ARE THE WORLD'S MOST BIODIVERSE PLACES, LAURANCE HAS ESCHEWED SPECIALIZATION, STUDYING EVERYTHING FROM TREES TO MAMMALS AND BIRDS TO FROGS, BUT ALWAYS WITH AN EYE TOWARD CONSERVATION. **INTERVIEW BY JEREMY HANCE + PHOTO COURTESY OF LAURANCE LAB.**

Tropical Forest Ecologist **WILLIAM LAURANCE**

WHAT WOULD IT TAKE TO HALT DEFORESTATION IN THE TROPICS? There's no single thing we can do, because the ultimate pressures behind forest exploitation are so potent. They include rapid population growth in tropical countries, creating pressure to expand agriculture and livestock farming. Land use pressures for biofuel production are also a growing problem—one that could get a lot bigger.

One key priority is to pressure resource-exploiting corporations that have bad environmental records to clean up their acts.

DO YOU THINK PAYMENTS FOR ECOSYSTEM SERVICES—INCLUDING SAFEGUARDING CARBON, BIODIVERSITY AND WATER—COULD BE EFFECTIVE? Yes, especially for carbon. Quite a lot of money is going into REDD schemes, which refers to "reducing emissions from deforestation and forest degradation." Norway, for instance, has offered Indonesia and Brazil $1 billion each to reduce their deforestation rates.

There are still some significant hurdles to making REDD workable on a large scale, but the bottom line is that it's a potentially powerful new way to save forests while reducing harmful greenhouse gas emissions.

NOT LONG AGO LANDLESS PEASANTS PRACTICING SLASH-AND-BURN AGRICULTURE WERE THE MAIN DRIVERS BEHIND DEFORESTATION. HOW HAS THIS CHANGED? We've seen a big shift in industrial drivers of deforestation. By that I mean things like large-scale cattle ranching, industrial oil palm and wood-pulp plantations, and massive soy and sugarcane farms. These activities are not being done by "little guys" with chain saws and machetes, but by "big guys"—wealthy landowners or corporations—with bulldozers.

Other industrial activities are promoting forest loss indirectly, like selective logging, infrastructure expansion, and oil, gas and mineral developments. These are providing a key economic impetus for road building in tropical frontier areas, which can then open up a Pandora's box of harmful activities.

ARE ENVIRONMENTAL ORGANIZATIONS HAVING SUCCESS IN SAVING TROPICAL FORESTS? They're definitely having an impact. Groups like Greenpeace, Rainforest Action Network and Rainforest Alliance, plus more mainstream organizations—WWF, Conservation International and the Wildlife Conservation Society—are all helping to alert the world to areas suffering serious forest loss and to put a spotlight on the responsible parties. Things would be a lot worse if it weren't for groups like these.

ANY GOOD IDEAS FOR STOPPING DEFORESTATION THAT DESERVE MORE SUPPORT? Realistically, it's more about slowing deforestation—limiting the damage—than stopping it. Given that we're certainly going to see more forest converted into croplands for food and biofuels, there's a strong need to develop better farming methods that are both more productive and more benign environmentally.

Another important way to limit the damage is to focus on halting the most environmentally harmful road projects—those that will penetrate into, and open up, some of the last remaining tropical wildernesses on Earth.

WHY DO TROPICAL FORESTS MATTER? They're the "greatest celebration of life on Earth," to quote ecologist Norman Myers. And they perform a great many ecosystem services that are important for people. These include storing hundreds of billions of tons of carbon, producing massive amounts of water vapor that help to form clouds and maintain rainfall, reducing destructive flooding and protecting soils from serious erosion. That's just scratching the surface. We have lots more compelling reasons to save tropical rain forests. I'd probably need a week to go through them all. **Q&A**

HOW CAN WE CREATE MARKETS THAT PROTECT RAIN FORESTS FOR THE LONG TERM?

BHARRAT JAGDEO, former president of Guyana: Forests are in danger because they are worth more dead than alive. Markets exist for food, minerals and timber, while no markets exist for the vital ecosystem services that forests provide, such as carbon sequestration, water regulation or biodiversity. To reconfigure this reality, we need market mechanisms that value carbon and other ecosystem services more than the current drivers of deforestation.

In the long run, the best way to do this will be to incorporate markets for REDD+ within a legally binding global climate agreement. But before then, we can do two things. One, we can create proxies for markets by using public funds to pay a floor price for forest carbon. This is what Guyana and Norway are doing through the world's second largest Interim REDD+ deal, in which Norway is paying Guyana US$5 per tonne for forest-based mitigation. This idea could be rolled out globally within existing finance commitments from the industrialized world. Second, we can create "sectoral" markets—focused on whole sectors of the economy—for REDD+ by integrating forest-based mitigation in the three major forest basins with existing or proposed carbon trading platforms in places like Europe, California or Australia. *—Erica Gies*

WHAT WOULD IT TAKE

to grow enough food to meet human needs in 2050 while reducing environmental impacts of agriculture?

FROM RUNNING THE FAMILY FARM TO TRANSFORMING GLOBAL MARKETS, **JASON CLAY**, SENIOR VICE PRESIDENT OF MARKET TRANSFORMATION FOR THE WORLD WILDLIFE FUND, KNOWS FOOD PRODUCTION INSIDE AND OUT. HERE, CLAY OFFERS HIS INSIGHTS ON HOW WE CAN OVERCOME THE OBSTACLES TO SUSTAINABLY FEEDING 9 BILLION PEOPLE BY MID-CENTURY. **INTERVIEW BY GREG BREINING + PHOTO COURTESY OF WWF.**

WHAT WOULD IT TAKE TO GROW ENOUGH FOOD TO MEET HUMAN NEEDS IN 2050 WHILE REDUCING ENVIRONMENTAL IMPACTS OF AGRICULTURE? We have to produce as much food in the next 40 years as we have in the last 8,000. That's the challenge. And if we want to do it without expanding further into the environment, we're going to have to produce twice as much food on the same amount of land. Where do we invest our time and money?

WHERE DO WE? We need to look at which crops have the most to gain from genetics. It's not going to be corn and soybeans, because the big gains have been made there. We haven't even really started work on palm oil, cassava, cocoa yams, sweet potatoes, peanuts, bananas or plantain, and sorghum—those are the ones that we really need to work on. And why? We know that the average production on an average farm in Costa Rica in bananas produces 20 times more calories than the average corn production in Iowa on the same unit of land.

SPEAKING OF IOWA, WHERE PRODUCTION IS ADVANCED, AREN'T THERE GAINS TO BE MADE IN EASTERN EUROPE OR AFRICA, WHERE FARMERS ARE USING PRACTICES FROM 50 YEARS AGO? We know globally that the best practices, the best producers in the world, are 100 times better than the worst. But what we're finding is that that's actually true in what we think of as homogeneous places. In a three-county area of northeastern Nebraska, some producers use inputs 10 times more efficiently than others. The only way we can move the bottom is to take the principles of what we're doing with the top producers, and begin to push the bottom—get them on a stepwise approach to improve production.

YOU'VE SAID STRONGER PROPERTY RIGHTS FOR BOTH FARMERS AND BIOTECH COMPANIES WILL BOOST PRODUCTION. In Africa, probably 70 or 80 percent of the farmers don't own the land they're operating on. If you don't actually have legal title, are you going to invest in planting a tree, putting a terrace on the property, leveling land for irrigation, doing any of a number of things that would make you sustainable over time? The answer is probably no.

I would argue it's probably the same for a lot of the genetic stuff, too. If we expect the big seed companies to make the big breakthroughs in productivity, if anybody can just take their seeds and sell them to their neighbors, that's a disincentive for the kind of research we all need.

CAN WE PRODUCE MORE BY WASTING LESS? We are throwing out one of every three calories that are being

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WHAT WOULD IT TAKE TO CLOSE THE "YIELD GAP"—THE DIFFERENCE BETWEEN ACTUAL FOOD PRODUCTION AND HIGHEST POSSIBLE WITH MODERN TECHNOLOGY?

H. CHARLES J. GODFRAY, professor of zoology at the University of Oxford: What would it take to close the yield gap? There's the skills base, economic and physical infrastructure, and finally the global governance of the food system.

One is a lack of a skills base—the lack of human capital, the lack of knowledge among food producers. What it would take to close the yield gap? I think it would take a reinvention of what we used to have—the extension service, teaching farmers not only basic agronomy, but also the skills required to farm sustainably and the business skills today's food producers need.

Secondly, in low-income countries, there are many areas where the food system is divorced from markets, to a certain extent due to physical infrastructure. The roads aren't there. The links to ports aren't there. But also because the economic infrastructure isn't there. They don't have well-functioning markets. So I think that is the other thing that is required to close the yield gap—investment in the physical and economic infrastructure.

Finally, is the governance of the global system appropriate for increasing food production throughout the world? Both in Europe and the States, tariffs, subsidies and import controls have a distorting effect on food production elsewhere in the world. It's legitimate for a rich country to want to support its rural community. But there are ways of doing it that do not distort the food system.

—*Greg Breining*

Market Transformer JASON CLAY

produced. If we could eliminate waste between now and 2050, we'd only have to produce half as much new food. Why are we spending 90 percent of our research dollars on increasing productivity and 10 percent on reducing waste?

YOU'VE WRITTEN THAT WE SHOULD REHABILITATE DEGRADED LAND. There's a lot of land out there we should rehabilitate and produce far more without expanding at all. The farmers we talked to in Brazil buy land at 10 cents on the dollar when it's degraded. Within five years, it's worth 120 percent as much as the neighboring land, and it's producing about 120 percent of the neighboring farms with only half the inputs because they've increased soil carbon so much.

YOU HAVE SUGGESTED CARBON MARKETS AS A WAY TO GROW MORE FOOD. HOW WOULD THAT WORK? Anything farmers can do to increase soil carbon increases productivity, reduces input use and increases farmer income. We could create a carbon market where companies that buy food products also buy carbon from their commodities suppliers. Then we could have a mutually reinforcing system of carbon and commodities. We have to think how we can get these two-fers or three-fers—getting two or three benefits.

> "If you add all these things up, we could probably produce twice as much as we need."

Here's the thing. There's no silver bullet that's going to double food production. But if you add all these things up, we could probably produce twice as much as we need. **Q&A**

WHAT WOULD IT TAKE TO CUT FOOD WASTE IN HALF?

JONATHAN BLOOM, author of *American Wasteland: How America Throws Away Nearly Half of Its Food*: It's morally callous to waste as much food as we do when so many people are without. From an environmental standpoint, there are so many natural resources embedded in our food that when we throw out almost half of it we are squandering those resources. From an economic standpoint, it adds up. It's about $150 billion a year that we are throwing away.

Why do we waste so much? Quite simply, because we can afford to. Food has never been cheaper as a proportion of household spending. In developed nations, it's consumer pickiness and squeamishness about not eating things past the expiration date and larger structural problems, such as not sending to market the carrots that aren't perfect.

To cut food waste in half, we need to know the scope of the problem. Once we know where exactly waste is coming from, we'll be in a much better position to try to reverse some of those losses.

Number two, having someone in the vast federal apparatus whose job it is to think about this topic would help. There was a food recovery coordinator in the U.S. Department of Agriculture under the Clinton administration, but there hasn't been one since.

The biggest opportunity to reverse waste is at the farm level. So [a third] important thing is to try to find secondary and tertiary uses for foods we pick but don't use. —*Greg Breining*

"The real reason we should go to renewables is because of energy independence and the fact that energy security is national security."

Clean Energy Expert **PEGGY LIU**

WHAT WOULD IT TAKE
to supply global energy needs with renewables?

IN HER RELATIVELY BRIEF CAREER, **PEGGY LIU** HAS WORN MANY HATS: COMPUTER PROGRAMMER, MANAGEMENT CONSULTANT, SOFTWARE PRODUCT MANAGER, VENTURE CAPITALIST—JUST TO NAME A FEW. BUT AFTER ORGANIZING THE MIT FORUM ON THE FUTURE OF ENERGY IN CHINA FIVE YEARS AGO, IT WAS CLEAR WHERE HER PASSION LAY: IN ADVANCING CLEAN ENERGY. LIU WENT ON TO COFOUND THE JOINT U.S.-CHINA COLLABORATION ON CLEAN ENERGY (JUCCCE) AND WAS NAMED A 2008 *TIME* MAGAZINE HERO OF THE ENVIRONMENT. TODAY, AS CHAIRPERSON OF JUCCCE, SHE HAS A UNIQUE VANTAGE POINT FOR ENVISIONING A RENEWABLE ENERGY–POWERED WORLD. **INTERVIEW BY DAVID BIELLO + PHOTO BY PHILIP GOSTELOW.**

WHAT WOULD IT TAKE TO SUPPLY GLOBAL ENERGY NEEDS WITH RENEWABLES?

The short answer is utility-scale energy storage, intermittent energy on the grid and technology innovation.

Why do we need large-scale energy storage? The wind is strongest at night and solar is strongest in the day. If you want to replace fossil fuel power plants, such as coal, you want evenly distributed availability of power throughout the day and night. Fundamentally, we need to get very large-scale batteries. But this is not something currently commercially available, though it is being done experimentally.

Technologies like wind and solar are different from coal in another way: Wind is variable at all times and so is solar. We need to use different types of technology that are smarter, more digitally enabled to allow the grid to be able to take this very fickle energy supply. What we need to do is create algorithms, which turn into software, which turns into hardware that integrates into the grid, which can cache energy supply, store it and distribute it on a traditional grid. That's called integrating intermittent energy on the grid. Nobody does it very well.

The price of technology has to come down, too, so the supply of renewable energy can be at parity with coal or oil for transportation fuel. As we deploy at large scale, prices will hopefully come down. It's already happening in solar, where people think the price will come down fairly soon to $1 per kilowatt.

WHY NOT JUST KEEP USING FOSSIL FUELS?

Coal and natural gas are going to be a part of this. Fossil fuels are still going to be a large part of equation.

The real reason we should go to renewables is because of energy independence and the fact that energy security is national security. We will get to 9.2 billion people or more by 2050. Looking at the total amount of energy needed, even if you assume a 20 percent reduction in energy use through energy efficiency and general human cleverness, we still don't have enough energy supply. If we look beyond energy, we don't have enough water and beyond that is food. The new wars are not just going to be based on fossil fuels; they will be based on water, food and arable land.

The real reason China is going green is not climate change at all, even though China as a nation has agreed that climate change is real and man-made and China and every other country needs to do its part. The real reason it's going green is because of this: China has the same landmass as the U.S. but four to five times more people. China has a lot more people on the same amount of land and less coal, less water, less natural gas. That doesn't bode well for a growing China, which realizes energy is tied to economic growth. Energy

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WHEN WE SAVE ENERGY THROUGH EFFICIENCY, WE ALMOST ALWAYS END UP LOSING AT LEAST SOME OF THOSE GAINS TO THE REBOUND EFFECT, IN WHICH THE MONEY SAVED IS USED IN WAYS THAT CONSUME MORE ENERGY. WHAT DOES THAT MEAN FOR THE IDEA THAT WE CAN USE EFFICIENCY TO MITIGATE THE ECONOMIC IMPACT OF COMBATING CLIMATE CHANGE? DOES IT KILL THE DREAM OF DECOUPLING ECONOMIC GROWTH FROM GREENHOUSE GAS EMISSIONS?

KAREN TURNER, economist at the University of Stirling: No. Only the extreme case of rebound, called backfire, where there is a net increase in energy consumption in response to increased energy efficiency, will cause energy use and related emissions to rise with GDP. Where rebound is less than 100 percent (which is most cases in our work and in the wider literature), this simply means that we will not realize one-for-one energy savings in response to an efficiency improvement.

Basically, a decrease in the implicit price of energy triggers rebound, and anything that offsets the decrease will counteract rebound. However, there are important issues to consider. Particularly in production, where the lowering of the implicit price of energy triggers a productivity improvement, rebound is not necessarily a bad thing. (Only the extreme case of backfire increases energy use and emissions.) It just means we have to work harder at achieving desired energy savings—for example, energy efficiency targets may have to be proportionately larger than energy reduction ones to allow for rebound. *—Maggie Koerth-Baker*

supply fuels the growth of nations. If you don't have it, you have to buy energy from the world, or you can try to achieve energy independence through renewables.

"We need better bridges between the U.S., Europe and China."

HOW LONG IS IT GOING TO TAKE CHINA AND THE WORLD TO GET THERE? It could be 20 years or the next five years. It's not immediate.

SO WHAT PROGRESS HAS BEEN MADE? A friend of mine has a start-up, piloting some technology with the largest utility in China, State Grid of China. You typically think of China as the factory of the world, but it's rapidly moving to be the clean technology lab of the world. They deploy a lot of pilots all over the nation, all with slightly different models to tackle the same issue—whether energy storage, electric vehicles, high-speed rail, carbon capture and storage. If one model hits, China can scale up rapidly and deploy it to the rest of the country. Then economies of scale bring prices down. Hopefully, through partnering with China to bring innovative technology into China we can leverage China's ability to deploy at scale. If the prices are lower, that means Africa can deploy the technology someday.

HOW CAN THIS BE ACCELERATED? We need better bridges between the U.S., Europe and China to get people comfortable with each other in the way they do business differently. We need more entities like the Joint U.S.-China Collaboration on Clean Energy in all different parts of the world helping people understand how to do business with China and in China.

We also need a lot more research dollars poured into all areas of renewables, even algae or ocean power. In carbon capture and storage, we need to get it from $100 per ton to $30 per ton. We need to make those insights transparent to the world and the people spending money on energy and the people innovating. It needs to be online. We need to link that to crowdsourcing innovation. It's very basic if you're fluent in the Web world, but it's not available right now in the energy world. **Q&A**

HOW CAN WE TAP THE ENERGY OF THE OCEAN?

PAUL JACOBSON, program manager for waterpower at the Electric Power Research Institute: To tap the energy of the ocean, engineers, environmental scientists and financiers must come together in creative ways to develop devices that can reliably capture and convert ocean energy in a cost-effective and environmentally sound manner. Financial resources are needed to conduct the research and development required to bring down the cost of electricity from emerging ocean energy technologies and to evaluate and mitigate potential adverse environmental effects of devices and projects. The novelty of ocean renewable energy devices results in substantial uncertainty regarding their environmental effects; thus, industry progress requires skillful risk management and cost containment of environmental review. *—David Biello*

HOW CAN WE GET TO A SUSTAINABLE ENERGY FUTURE?

JEREMY RIFKIN, University of Pennsylvania economist and energy visionary: We need to create a sustainable new economic vision by bringing the Internet together with renewable energy. In the 19th century, print technology created a literate workforce with the communication skills to organize a First Industrial Revolution driven by coal and steam. Then, in the 20th century, centralized electricity provided the communication vehicles—telephone, radio, TV—to manage the Second Industrial Revolution, organized around the internal combustion engine. Today, the distributed communication technology of the Internet opens the door to a Third Industrial Revolution, based on adopting distributed energies: the sun, the wind, the geothermal heat under the ground, biomass, small hydro, ocean tides and waves. To get to a sustainable energy future, we need to bring together emerging communications and energy technologies, convert buildings to miniature wind, solar and geothermal power plants, link them through a power grid that uses hydrogen as a storage system, and use Internet communication technology to transform the power grid into an energy Internet that powers our homes and transportation. This Third Industrial Revolution—the democratization of both information and power in one matrix—is what will change the whole frame of reference for everything we do in society. *—Mary Hoff*

WHAT WOULD IT TAKE

to provide all people with access to clean water?

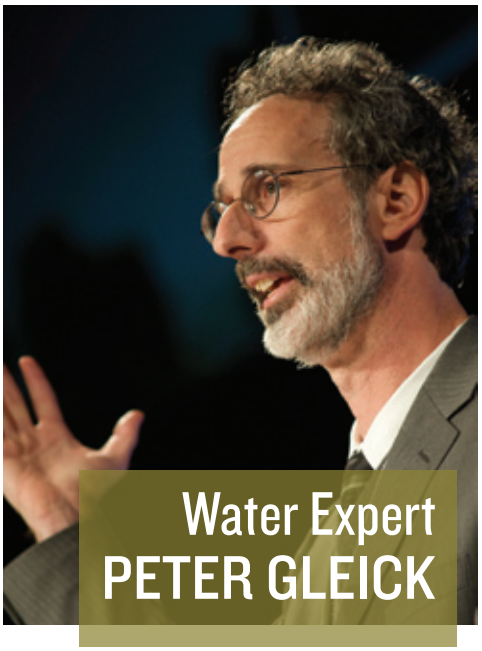
WHEN **PETER GLEICK** IS INVITED TO GIVE A SPEECH, CHANCES ARE GOOD HE'LL RECEIVE A CUP OF TAP WATER TO QUENCH HIS THIRST. "THE PEOPLE WHO PUT BOTTLED WATER ON THE PODIUM ARE INCREASINGLY EMBARRASSED, AND THAT'S GOOD," SAID GLEICK RECENTLY IN A SPEECH AT THE WILSON CENTER IN WASHINGTON, D.C. GLEICK, A HYDROLOGIST, IS CO-FOUNDER AND PRESIDENT OF THE PACIFIC INSTITUTE FOR STUDIES IN DEVELOPMENT, ENVIRONMENT AND SECURITY IN OAKLAND, CALIF. IN 2003 HE WAS NAMED A MACARTHUR FELLOW FOR HIS WORK. HE IS THE AUTHOR OF SEVEN BOOKS, INCLUDING THE BIENNIAL WATER REPORT *THE WORLD'S WATER,* WHICH EXAMINES THE MOST PRESSING FRESHWATER ISSUES; VOLUME 7 OF THAT SERIES WAS PUBLISHED IN OCTOBER 2011. HIS BOOK *BOTTLED AND SOLD: THE STORY BEHIND OUR OBSESSION WITH BOTTLED WATER,* PUBLISHED IN 2010, SHOWS THE JOURNEY OF HOW WATER HAS MOVED FROM A FREE NATURAL RESOURCE TO A COMMERCIAL PRODUCT WITH MULTIMILLION-DOLLAR AD BUDGETS. **INTERVIEW BY LISA PALMER + PHOTO BY TOM ROSTER.**

A BILLION PEOPLE WORLDWIDE ARE WITHOUT ACCESS TO DRINKING WATER, AND 2.5 BILLION PEOPLE ARE WITHOUT ACCESS TO ADEQUATE SANITATION. WHAT WOULD IT TAKE TO PROVIDE ALL PEOPLE WITH ACCESS TO CLEAN WATER? I think we have the technology. I think we have the money. I think we have the knowledge to meet basic human needs for everyone. What's been missing is the commitment and the will on the part of local and national governments to meet those basic needs.

There's this classic expression: It's not rocket science. Part of the problem in the water world is that some of these issues are more complicated than rocket science because they are not technical issues; they are social and political issues, which are always harder than rocket science.

Maybe the shortest answer is what's really needed is a commitment to solve the problem. I am not that optimistic about it. I have been working on these issues a long time. In some ways we've made progress. I sometimes despair that we are going to make the commitments necessary to solve this problem.

WHAT IS KEEPING US FROM MAKING THE COMMITMENT? It has to be the choice of communities or nations to put water issues at the top of their agenda. I think about South Africa, where there is still enormous unmet need, but the government has made progress because they made it a national commitment.



Even here in the United States not everyone has access to safe drinking water. There are poor counties in the central valley of California that don't have safe drinking water. We know that these communities don't have safe drinking water, but the money to either clean up the groundwater or to tie those communities to neighboring water systems that have safe water hasn't been made available. Again, it is not a technological problem, it is not an economic problem—it is a problem of commitment. This is the United States. This isn't Zimbabwe.

What worked in South Africa, won't necessarily work in another place. This is another reason it is a problem. Political models differ from place to place. What works in one region may not work in another. There isn't a single-solution-fits-all answer.

WHAT IS YOUR LEVEL OF OPTIMISM THAT WE'LL ACHIEVE A SOLUTION? With respect to water; if there is any reason for optimism, it is in the fact that it is not a technological problem. We do have solutions. There are success stories out there. We are making progress. But we have to get away from the idea that there is a single solution, and we have to get away from the idea that what worked in the 20th century is going to work everywhere in the 21st century.

The fact that we failed to solve these problems is sad and inexcusable, but it doesn't mean the problems can't be solved. We just have to be smarter and be more committed to solving them. **Q&A**

> "It is not a technological problem, it is not an economic problem—it is a problem of commitment."

Planet *and* People

Protecting vulnerable habitats demands an integrated approach to sustainable development.

by GEOFFREY D. DABELKO

PEOPLE LIVING IN THE MOST BIODIVERSE AREAS of the world tend to be poor, isolated and dependent on natural resources. They often lack reliable access to alternative livelihoods and health services and thus can place stress on these ecologically unique regions.

Conservation efforts will merely slow habitat loss if they don't fundamentally address the living conditions of the human residents as well as the flora and fauna. But programs to assist these communities have commonly focused on one problem at a time, reflecting the interests of the funders: Environmental groups focus on conservation, while health organizations concentrate on disease. We must ask whether investments to protect biologically rich areas are effective and sustainable if they don't respond to the many needs of the people who live there.

But the problems faced by people in these remote areas don't fit our traditional sectors. The way we disburse our funds, divide our bureaucracies, demarcate our disciplines and measure success ignores the reality of intersecting needs. Such stovepiping can disrespect the communities' scarce resources, especially their time. It can waste development aid on duplicate supplies and staff. And it can lead us to miss how the solution to one problem (e.g., providing antiretroviral drugs to treat HIV/AIDS) can be undercut by another (e.g., lacking access to safe water with which to take the pills).

So, what would it take to help particularly vulnerable populations while protecting particularly important ecological systems?

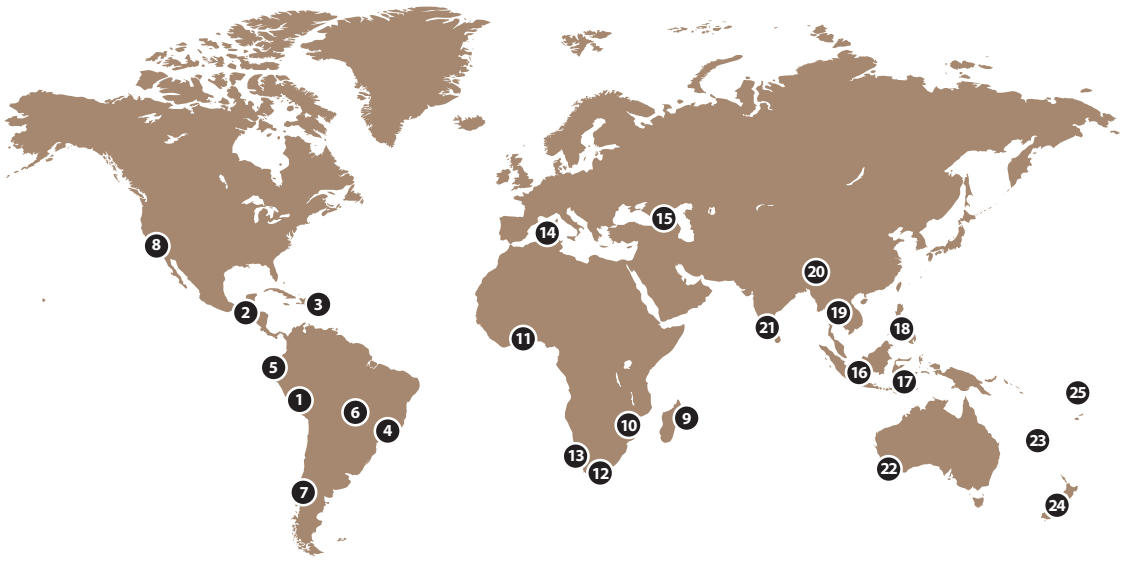
We need to strategically target our help by addressing HELP—health, environment, livelihoods and population—through a truly integrated approach to sustainable development in these areas. Evidence suggests tackling problems concurrently can be more efficient and effective. Key donors such as the U.S. Agency for International Development are increasingly prioritizing integrated responses, providing some funding for sustainable development innovators and supporting evaluation of the results. But we need more evidence that these efforts can achieve results that match or exceed the outcomes of single-sector

projects. To rigorously test this approach, more projects must be funded, implemented and analyzed, over longer periods of time and at bigger scales.

To date, some promising projects and research in diverse locations—Ethiopia, Nepal, Madagascar, Rwanda, the Philippines and Uganda—suggest that the HELP approach offers greater benefits than traditional programs.

In the Philippines, for example, the PATH Foundation Philippines' Integrated Population and Coastal Resource Management (IPOPCORM) program addresses pressing needs for both family planning services and sustainable environmental stewardship in densely populated coastal communities, where local fisheries have been depleted because of increased demand for food. IPOPCORM helps create marine protected areas and promotes alternative economic livelihoods such as seaweed harvesting, thus allowing critical local fish stocks to recover. Concurrently, the initiative mitigates human-induced pressures on the environment and lowers the vulnerability of this underserved population by providing voluntary family planning services. Since its launch in 2001, the IPOPCORM program's approach has yielded measurable benefits, simultaneously reducing program costs and improving health and environmental outcomes—and outperforming compartmentalized, side-by-side sector interventions.

TOP 25 BIODIVERSITY HOT SPOTS: Rich in biodiversity and under threat from human impacts



1) The Tropical Andes · 2) Mesoamerica · 3) The Caribbean Islands · 4) The Atlantic Forest · 5) Tumbes-Chocó-Magdalena · 6) The Cerrado · 7) Chilean Winter Rainfall-Valdivian Forests · 8) The California Floristic Province · 9) Madagascar and the Indian Ocean Islands · 10) The Coastal Forests of Eastern Africa · 11) The Guinean Forests of West Africa · 12) The Cape Floristic Region · 13) The Succulent Karoo · 14) The Mediterranean Basin · 15) The Caucasus · 16) Sundaland · 17) Wallacea · 18) The Philippines · 19) Indo-Burma · 20) The Mountains of Southwest China · 21) Western Ghats and Sri Lanka · 22) Southwest Australia · 23) New Caledonia · 24) New Zealand · 25) Polynesia-Micronesia

SOURCE: RUSSELL A. MITTERMEIER, NORMAN MYERS AND CRISTINA GOETTSCH MITTERMEIER, HOTSPOTS: EARTH'S BIOLOGICALLY RICHEST AND MOST ENDANGERED TERRESTRIAL ECOREGIONS, 2000

How can we bring HELP to biodiversity-rich communities? First, we can encourage scholars, practitioners and policy-makers to step outside their stovepipes by producing and distributing manuals, for example, based on lessons learned from existing cross-disciplinary projects. Second, we must bridge the gap between analysis and field-based programs by developing new metrics that better assess the impact of integrated programs. Third, we must open up bureaucratic funding structures by demonstrating not only the short-term savings but also the synergies that bolster long-term sustainability.

The challenges are significant, but I see promising new opportunities for overcoming them. For example, the new Pathfinder International–led projects around Lake Victoria in Uganda and Kenya mark the entry of a respected health organization into the environmental arena and the return of a leading private funder—the MacArthur Foundation—to HELP programs. With some of Africa's highest population densities, poverty, ethnic diversity and biodiversity, the Great Lakes region is one of the most volatile intersections of human development and environmental change.

Through these and other community-based, integrated projects, we can truly help people and the planet at the same time.

GEOFFREY D. DABELKO is director of the Environmental Change and Security Program at the Woodrow Wilson International Center for Scholars.

Robo Boat

For Volkan Isler, robotics and environmental protection make the perfect pair.

by MARY HOFF | photo by JOSH KOHANEK

THE FIRST THING YOU SEE when you walk into Volkan Isler's electronics-strewn laboratory is not the two-foot-tall humanoids crouched in a corner, or the Spiderman trick-or-treat bucket, or the Marvel comics posters on the wall—or even the roombas with video cameras soldered to their backs. It's the boat.

Red as a fire truck and shiny as a sports car, the 6-foot-long Oceanscience Q-Boat perches on Styrofoam blocks in a shipping crate in the corner of the windowless room—being handled, as the lettering on the side of the crate admonishes, With Care. Except for what looks like a coat-hanger antenna sprouting midship and its intriguing Turkish name—Lavant—it seems an ordinary craft. But it's much more than that: It's the embodiment of Isler's quest to bring advanced robotics to bear on the challenge of building a healthier planet.

Isler is a computer scientist, a College of Science and Engineering professor, a McKnight Land-Grant professor, an Institute on the Environment resident fellow, and an unabashedly big fan of high-functioning inanimate objects. His research goal is to develop robotic systems that can operate on their own in large, complex and dynamic settings. He's particularly interested in doing so in areas that could provide some benefit in the realm of environmental monitoring.

"There's lots of robotics stuff we want to do, both theory and application," he says. "When it solves environmental problems, it's double-good."

Before coming to the University of Minnesota in 2008, Isler had been working on mostly theoretical robotics problems, and was particularly well known for his work in advancing robots' proficiency in winning pursuit-evasion games (think tag, only with no humans allowed). Such research is not only challenging—it involves programming robots to respond rapidly and efficiently to unpredictable changes in the evader's motion in such a way that guarantees eventual "capture"—but also of great practical value, with real-world uses ranging from collision avoidance to search and rescue. In the Land of 10,000 Lakes, Isler found the perfect evader for advancing his pursuit-evasion work: carp.

Turns out a College of Food, Agricultural and Natural Resources faculty member, fisheries professor Peter Sorensen, was exploring ways to control these nonnative invasive fish that involved studying their movements within a lake. To that end, Sorensen had been capturing wild carp, implanting radio-tracking devices under their skin, then enlisting college students to chase them using motorboats and handheld monitoring devices.

"I thought that the robots could track the fish more accurately and for longer periods of time without the need for intensive human effort," Isler says. "However, this requires solving a number of fundamental robotics problems, such as multi-robot search and tracking, which makes the project very appealing for us."

IN THE LAND OF 10,000 LAKES, Isler found the perfect evader for advancing his pursuit-evasion work: carp.

Isler took funds from his IonE fellowship to Home Depot for wood, PVC pipes and big plastic tubs. He and his talented team of students added sensors and computers to the mix and crafted a robotic raft. Then they began working on programming the raft to find and track a moving object. After achieving success with the do-it-yourself project, Isler put in an order for Lavant, since he felt they needed a more robust platform for the hull.

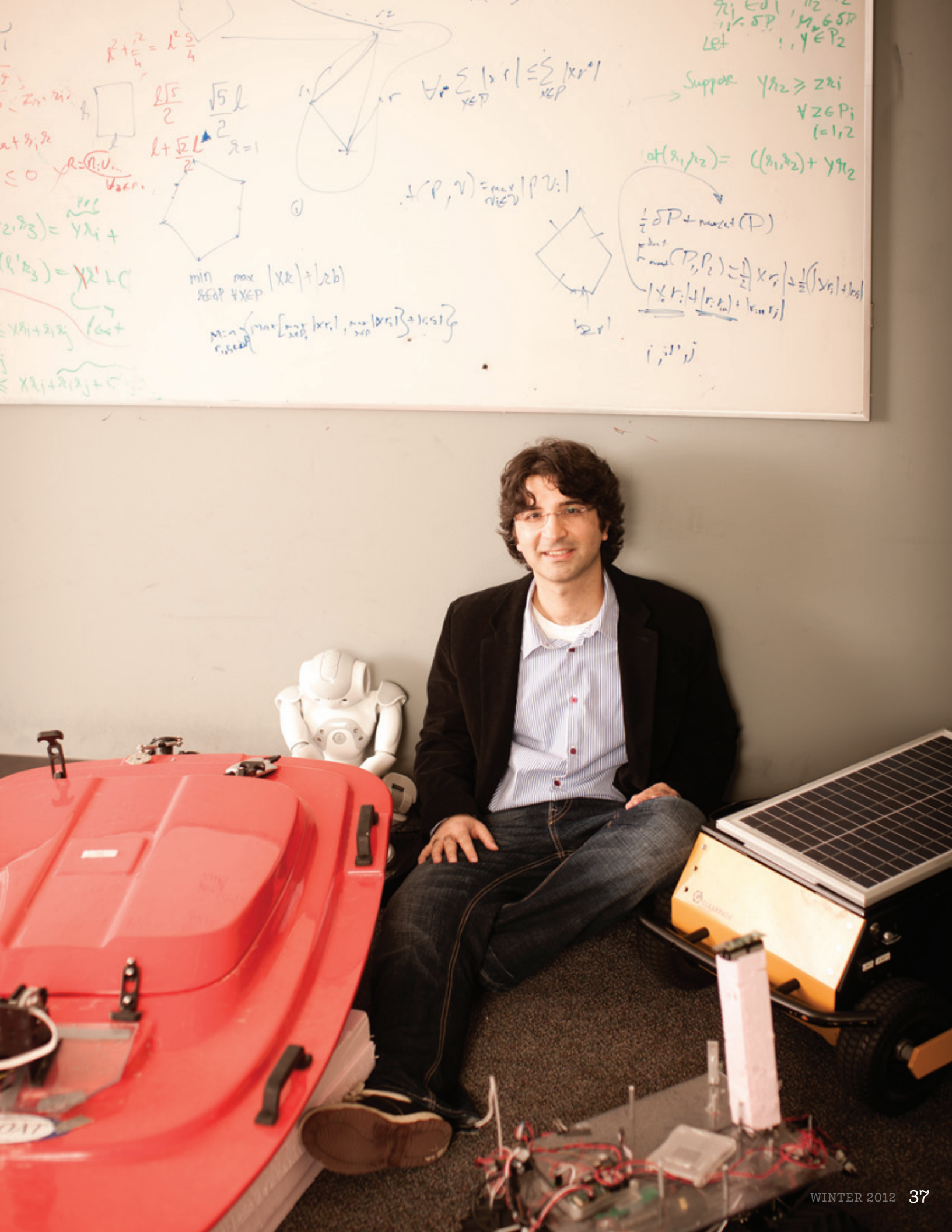
Since the red robotic rover arrived on the scene in the spring of 2010, Isler has been working with his students to construct, test and refine the complex mathematical algorithms it needs to successfully navigate the complex and constantly changing environment defined by wind, current, battery power, and elusive and unpredictable fish. With a series of successful field trials serving as proof of concept, he recently put together a team of roboticists, computer scientists, computer engineers, mathematicians and fish biologists and successfully applied for a $2.2 million National Science Foundation grant to build a network of carp-chasing robotic boats that eventually may be available for use by fisheries managers around the country.

"The project touches fundamental robotics problems I've been working on for 10 years," Isler says. "And it allows us to do something useful for society, so I'm very excited about it."

As enthusiastic as he is about Lavant's success so far, Isler notes there's plenty left to perfect. He and his students are now working to build energy-efficient search and tracking algorithms for multiple robots so they can operate in large and complex lakes in a robust fashion. They're also planning to incorporate solar panels and energy harvesting into their algorithms so the robots can remain on the field for long periods.

But that's just the tip of the iceberg, robot-meets-environment-wise. In the big picture, Isler has his eyes on applying his robotics expertise to developing a global-scale environmental sensing system he calls "Googling the Planet." Based on an international network of robots, the system would make it possible for researchers to remotely gather real-time data about local conditions on command from anywhere in the world.

"Googling the Planet will enable scientists to query nature just like they query the Internet," he says. "That's the grand plan."



Peas on Earth

Crop-boosting aid aims to strengthen hummus supply chain and reduce hunger, too.

by ADAM ASTON

SAY "PEPSI" AND MOST FOLKS THINK of the nose-tickling cola that has been Coke's archrival for over a century. Or chips: About half of PepsiCo's $58 billion in yearly sales comes from snack foods such as Lay's and Doritos.

But chickpeas? Also known as garbanzo beans, the protein-rich legumes are a key ingredient in hummus, one of PepsiCo's fastest-growing products. In 2007, the food and beverage giant inked a joint venture with Israel's Strauss Group to sell Sabra-brand hummus and other foods in North America. Led by demand for the garlicky blend of chickpeas, olive oil and sesame, PepsiCo's sales of dips in its Sabra line soared by 45 percent in 2010. In early 2011, the partners agreed to extend the deal to sell Sabra hummus and other spreads globally.

This lip-smacking growth gives PepsiCo a new challenge: How to secure a steady supply of chickpeas. In 2012, the company expects to buy several thousand tons; two years later, the shopping list calls for roughly twice that amount.

To help meet this need, PepsiCo is combining its business agenda with the development goal of helping 10,000 Ethiopian farmers double their production of chickpeas in a program it's calling Enterprise EthioPEA. "This initiative will positively impact the livelihood of local farmers, address the critical issue of famine in the Horn of Africa and create sustainable business opportunities for PepsiCo," said Indra Nooyi, chairman and CEO of PepsiCo in a statement.

The strategy is as unconventional as it ambitious. After all, Ethiopia is better known for famine than for food export. Enterprise EthioPEA aims to reverse that condition by bringing together international partners with local stakeholders. From overseas, PepsiCo, the United Nations World Food Programme and the U.S. Agency for International Development are joining forces. Within the country, the effort is led by the Ethiopian Institute for Agriculture Research, the Ministry of Agriculture and Omega Farms.

For Ethiopia, where half of all kids are stunted by malnutrition, chickpeas offer a familiar but underexploited dietary option, explains Tara Acharya, PepsiCo's director of global health and agriculture policy.

With around 22 percent protein, chickpeas offer a nutritious alternative to meat and require fewer inputs to grow. The crop is also a rich source of complex carbohydrates, fiber, minerals and vitamins.

Ethiopian farmers routinely grow chickpeas today, but typically as a secondary crop between regular harvests of grains. In addition, dependence on less-productive seed strains and a paucity of irrigation limits harvests, says Acharya. As a result, yields have historically been too low to ensure stable market prices, and farmers tend to keep most of what they grow, for food and as seed stock for future crops. In 2008, Ethiopian farmers produced 287,000 tons of chickpeas, exporting roughly 14 per cent of that. For most farmers, chickpeas "haven't had significant commercial importance," says Acharya.

But with PepsiCo's commitment to buy excess production, if all goes to plan, both output and prices will rise. Working with farmers in Ethiopia's wetter, more fertile north, Enterprise EthioPEA is introducing more vigorous seed strains along with technical and financial assistance to deploy low-cost flood irrigation. "Irrigation would also allow farms to add a second crop of chickpeas, during the dry season," Acharya says, "and once installed, irrigation will help other crops, too."

PepsiCo is combining its business agenda with the development goal of helping 10,000 Ethiopian farmers double their production of chickpeas.

As harvests grow, Enterprise EthioPEA is working with local food processors to create an affordable supply of chickpea-based ready-to-consume supplementary food that will be used to feed 40,000 malnourished Ethiopian children.

Famine continues to take a toll in Ethiopia and neighboring countries. Rains did not fall in southern stretches of the country or in neighboring regions in late 2010, nor did they come in time in 2011 to save spring plantings. In parts of Kenya and Ethiopia, 2010–11 was one of the driest years since 1950–51. The tragic result is that today, some 13 million people face famine across the region. In Ethiopia's southern provinces, 3.7 million are receiving food assistance from WFP.

Making a dent in these numbers will take time. Enterprise EthioPEA started last fall, and is slated to last through August 2013. By the following year, PepsiCo hopes crop yields will have doubled, producing enough to not only supply Ethiopia's domestic needs, but also allow for export of about one-fifth of the crop, thereby doubling export income to farmers. By that time, PepsiCo hopes it can count on Ethiopia for about a tenth of its global chickpea needs. Should Enterprise EthioPEA succeed, PepsiCo hopes to copy and repeat the strategy with other crops in other developing markets, says Acharya. A recipe that successfully blends profit with sustainable development is one few would want to keep secret.

ADAM ASTON is a Brooklyn-based writer covering energy, environment and green biz. Follow his work at adamaston.com or on twitter at @adamanyc.

Finding Hope

"*What would it take?*" When we set out to find answers to that question in many, varied forms for this special issue of *Momentum*, we knew we would encounter many, varied answers. One thread, however, seemed to weave through most, if not all, of the responses: the need for hope. We invited the **VENERABLE TENZIN PRIYADARSHI**, a student of His Holiness the Dalai Lama and founder and director of the Dalai Lama Center for Ethics and Transformative Values at the Massachusetts Institute of Technology, to answer what could be the biggest of the Big Questions: *What would it take to find hope?* »

HOW CAN WE FIND HOPE IN THE MIDST OF THE DAUNTING ENVIRONMENTAL CHALLENGES THAT WE FACE? The first thing is, as individuals, organizations or society, to take into consideration that there are a lot of positive things that are happening. The next thing is to look at the fact that the alternative to hope is not any brighter or not any more optimistic. As individuals and groups, we have to look into deeper aspects within ourselves and society to strengthen the sense of hope—because that is where solutions, that is where a sense of optimism and a sense of brightness, lie. By strengthening this mutual sense of hope, we can survive the challenges that are to come. Hope is not just a nice word or a blank stare arising from desperation. Hope is empowerment—hope is a solution—hope is a game-changer.

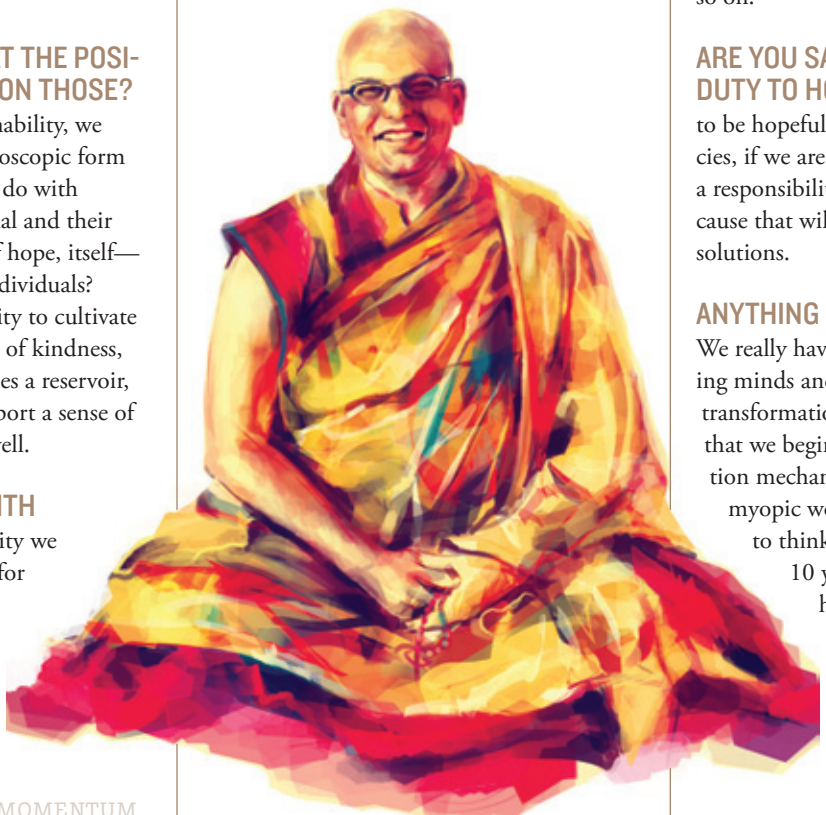
SO—WE NEED TO LOOK AT THE POSITIVE THINGS AND BUILD ON THOSE? Yes. When we speak of sustainability, we have to look into a more microscopic form of sustainability, which has to do with sustainability of each individual and their potentials. So sustainability of hope, itself—what is it that we can do as individuals? Each individual has the capacity to cultivate a sense of compassion, a sense of kindness, a sense of optimism. It becomes a reservoir, in a manner that you can support a sense of hope in other individuals as well.

WHAT SHOULD WE DO WITH THIS HOPE? The whole clarity we find with the sense of hope—for example, looking at particular challenges and solutions, and the way we come to agree on those solutions—comes from relating to other individuals in the ecosystem. Although each individual is a complex organic system, we exist in relation to other things around us.

One way to deepen the sense of hope is by developing a sense of clarity: How can we relate better? How can we build a better society, better environment? When you identify concrete challenges, then you can identify a process of finding concrete solutions. There is a sense of interdependence between clarity and sustainability when it comes to hope. If our hope is fuzzy, it is not sustainable. If our hope is clear, then it has a sense of confidence built into it, and that oozes into the society at large.

Oftentimes people interpret a sense of hope as a sense of complacent behavior, that you sit idle and do nothing and just be hopeful and pray if you are religious, and just wish for a good outcome if you are not religious. That passive sense of hope is detrimental to human society. It can be a serene sense of hope—but it still needs to be active. And it has a cumulative effect. Every time we give up hope, we demolish something in our society. Every time we take a step to strengthen the sense of hope, we become stronger as humans, we become stronger as society.

One has to understand that one's behavior is more contagious than one may care to admit. Once we have this recognition that our behavior influences the positive behavior of the people that surround us, we begin to take hope much more seriously. It is not just about my hope, but it is about the hope of the world, hope of people around me, and so on.



ARE YOU SAYING THAT WE HAVE A DUTY TO HOPE? One has a responsibility to be hopeful. If we are to survive as a species, if we are to survive as a planet, we have a responsibility to have a sense of hope—because that will trigger our ways of finding solutions.

ANYTHING ELSE YOU'D LIKE TO ADD? We really have to look into transforming minds and mind-sets. As a part of this transformation of mind-set, it is important that we begin to add training or education mechanisms that help us abandon the myopic worldview. We cannot continue to think simply in terms of the next 10 years, 15 years, 20 years. We have to go back to this old way of thinking—which is, what do we do for the next seven generations? Q&A

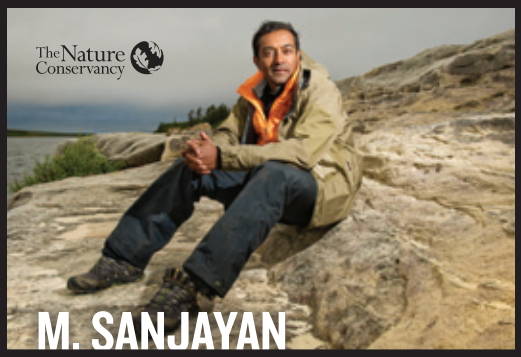
ILLUSTRATION BY ALICE X. ZHANG

momentum 2012

ENVIRONMENTAL SOLUTIONS IN MOTION

PAUL NICKLEN

National Geographic photographer Paul Nicklen uses his camera to reveal the nature of a changing world from Antarctica and the Arctic to the rain forests of British Columbia and beyond.



M. SANJAYAN

M. Sanjayan is lead scientist for The Nature Conservancy, where he specializes in human well-being, Africa, wildlife ecology, media outreach and public speaking on conservation issues.

MARTIN PALMER

Martin Palmer is the secretary general of the Alliance of Religions and Conservation, a secular organization working with major world religions and international organizations to develop environmental initiatives.

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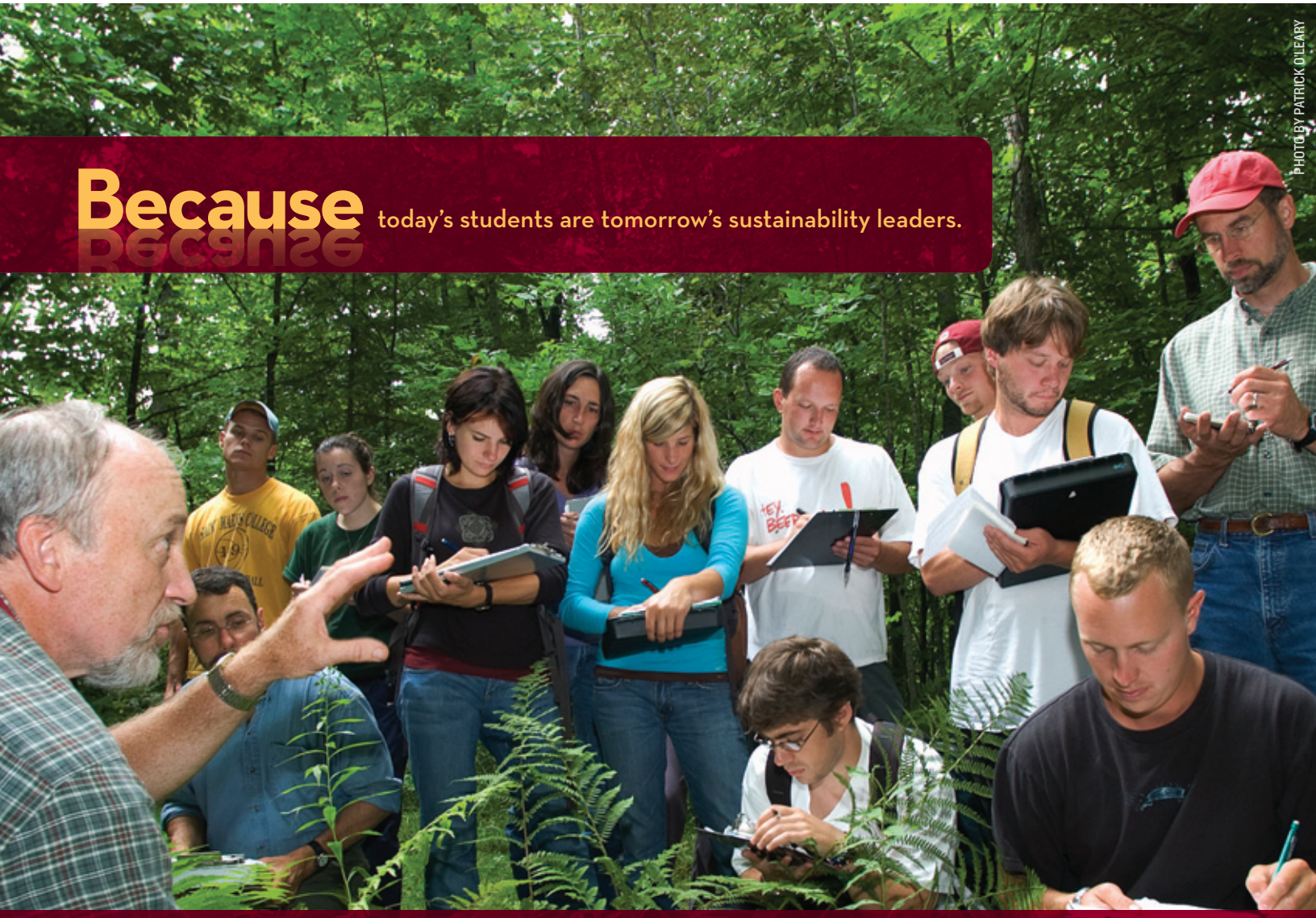

The U of M's sustainability minor offers undergraduate students from all majors an opportunity to study real-world sustainability problems from a variety of academic perspectives, incorporating knowledge from across the natural, social and applied sciences. To learn more, visit sustainabilitystudies.umn.edu.

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