DECEMBER 2012

NAT GEOG

FREE POSTER

THE WORLD'S LARGEST TREES

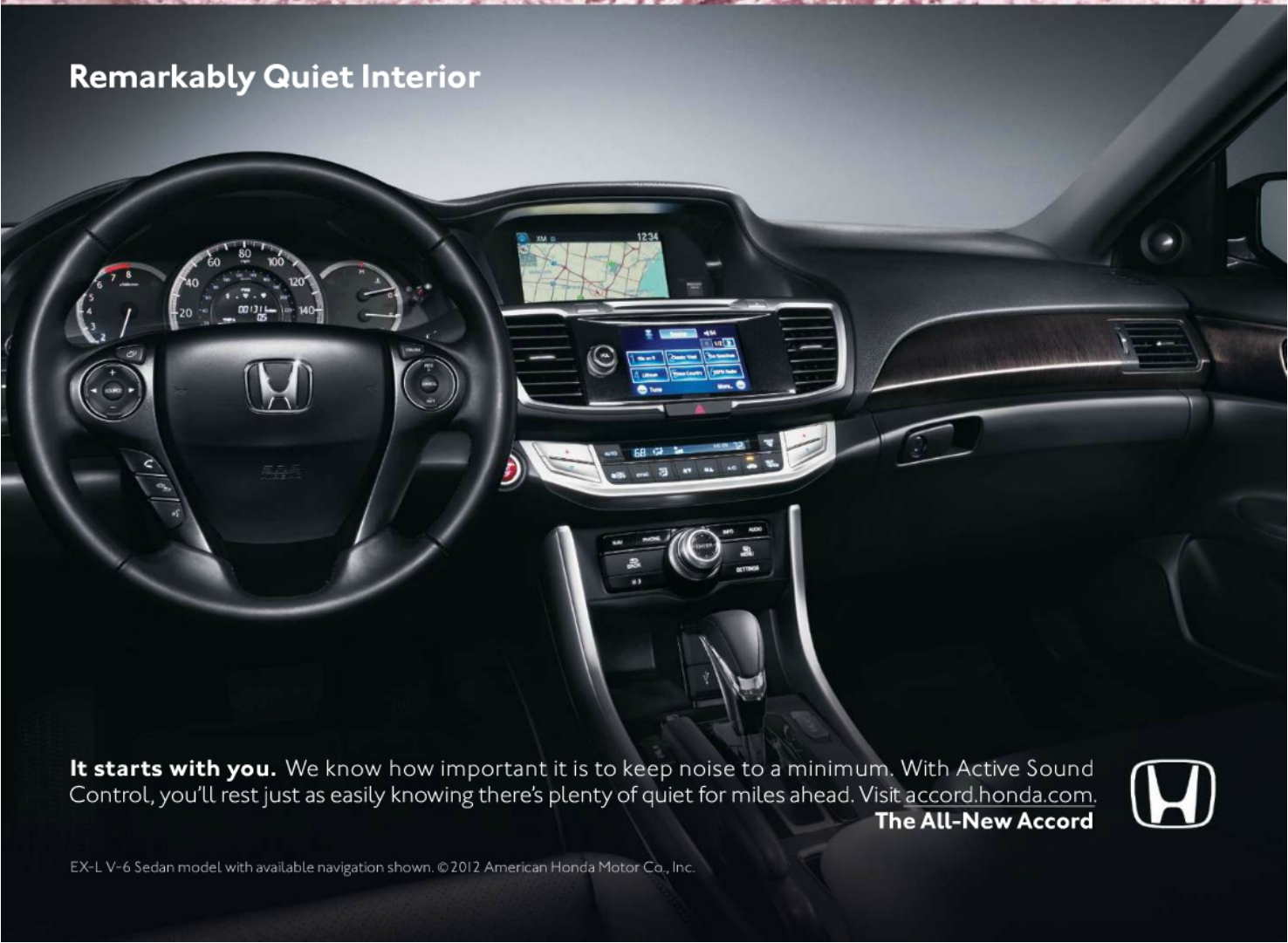
The President
GIANT SEQUOIA
SEQUOIA NATIONAL PARK
CALIFORNIA

The Truth About Fracking

Mongolia: Spiritual Healers

The Lost World of Doggerland

Remarkably Quiet Interior



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EX-L V-6 Sedan model with available navigation shown.

VOL. 222 • NO. 6

NATIONAL GEOGRAPHIC

One operator told of the time he tried to smuggle in a lion for a Gaza zoo.
page 64

MARK THIESSEN, NGM STAFF

How to confirm there's methane trapped in an Alaska lake: pierce a pocket of ice with a spear, dangle a lit cotton swab over it. Escaping methane will create a flare.

December 2012

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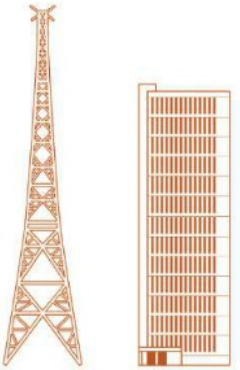

On the Cover For 17 days, a photographic team snowshoed 45 minutes through Sequoia National Park to reach the tree called the President, braving three blizzards. *Photos by Michael Nichols, NGM Staff*

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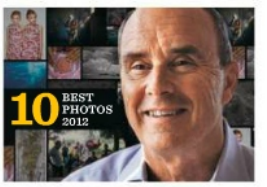
DIGITAL EDITIONS

National Geographic is available on the iPad, the Kindle Fire, and the iPhone.

Giant Sequoia
Video
Join the photographic team on a winter climb.

Birds of Paradise
Video
Get a bird's-eye view of the male's mating dance.



Top 10 NGM Photos
Video
Editor Chris Johns picks the best of 2012.

PHOTOS: NATHAN WILLIAMSON (TOP); EDWIN SCHOLES (MIDDLE)

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The Snow Tree

It's practically a given among photographers that bad weather makes a better picture. It adds mood, nuance, and sometimes, mystery. In the case of the 3,200-year-old, 247-foot-tall sequoia known as the President—the centerpiece of our cover story on giant sequoias—it also added challenges and a few headaches.

The image of the snow-covered sequoia is a cousin of the photo of a 300-foot-high redwood tree on the foldout poster we ran in our October 2009 issue. It's a testimony to the passion of Michael (Nick) Nichols, who made both images, that no sooner had he finished photographing the redwood than he started wondering, What next?

The stakes were raised. Nick planned to shoot in a blizzard.

We wanted a different look this time, and the sequoia provided the platform. The stakes were raised. Nick planned to shoot in a blizzard. He envisioned a veil of white snowflakes softening the image of the tree.

Easier said than done. Every morning for 17 days, the team made a 45-minute trek to the site on snowshoes. Gear, including two heavy-duty batteries for power, had to be dragged in on sleds. The cold and wet caused technical difficulties. Picturesque snow sometimes turned to dreary rain. Still, Nick and his team succeeded.

Team members Jim Campbell Spickler (left) and Giacomo Renzullo stretch while working on the tree.

"I wanted to honor the tree," he said.

He has.

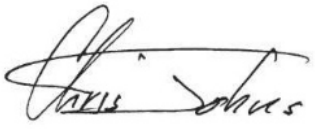

PHOTO: MICHAEL NICHOLS, NGM STAFF

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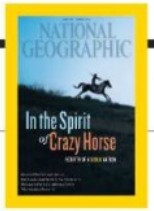


In the Shadow of Wounded Knee

The Oglala used to thrive in that country because it gave them the richness of the prairie. They lived where the buffalo lived, and the buffalo gave them food, robes, a fierce and exciting occupation, and a spiritual connection to the land. Others killed off almost all the buffalo and with their guns squeezed the people into a small corner of the buffalo range. The land was amputated and the heart torn out. Now the people live on the body of a corpse. How can we restore the spirit of the buffalo? Perhaps we should restore the buffalo.

CHRIS TOLKING
Sherborn, Massachusetts

Alexandra Fuller's article contains several quotes from Native Americans but omits what is probably the most evocative of all said in relation to their relationship with the whites. A Sioux elder said of the white man: "They made us many promises, more than I can remember, but they never kept but one; they promised to take our land and they took it."

COLIN WILLSHER
Eye, England

The author uses the term "medicine man," an American-English term I think has connotations that belong to the last century. I prefer the terms "spiritual or native healer" because many native healers use cultural methods such as prayers, brushing with eagle feathers, lighting incense, and others that are understood in the native cultures in ways that the term "medicine" does not cover.

THOMAS H. JOHNSON
Stevens Point, Wisconsin

As a former history teacher, I find it curious that Alexandra Fuller groups the recognizable places of Auschwitz and Nanjing with Robben Island. When discussing the slaughter of innocent people, why does she not instead refer to Soweto? Many black students were killed during the Soweto uprising, though not on the scale of Nanjing or Auschwitz. Most of us recall Robben Island as the place of Nelson Mandela's incarceration but not as a killing field.

MORRIE SCHNEIDER
Fresno, California

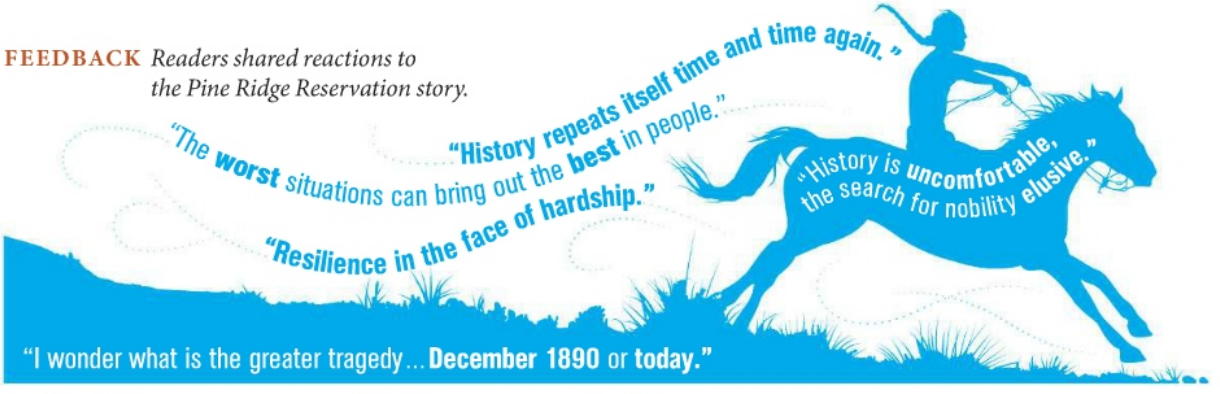
The Lakota seem to center attention on how they have battled and warred (and lost). They could heal their culture if they could learn how to make peace with their greatest enemy: themselves.

HOLLY SCHMIDT
Clarinda, Iowa

Corrections

AUGUST 2012, NOW: PHONE BOOTHS
Guitarist Brian May continues to perform with the rock band Queen.

FEEDBACK *Readers shared reactions to the Pine Ridge Reservation story.*



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GRAPHIC: JOSHUA MAXWELL

YOUR STORY
HAS A SURPRISE BEGINNING

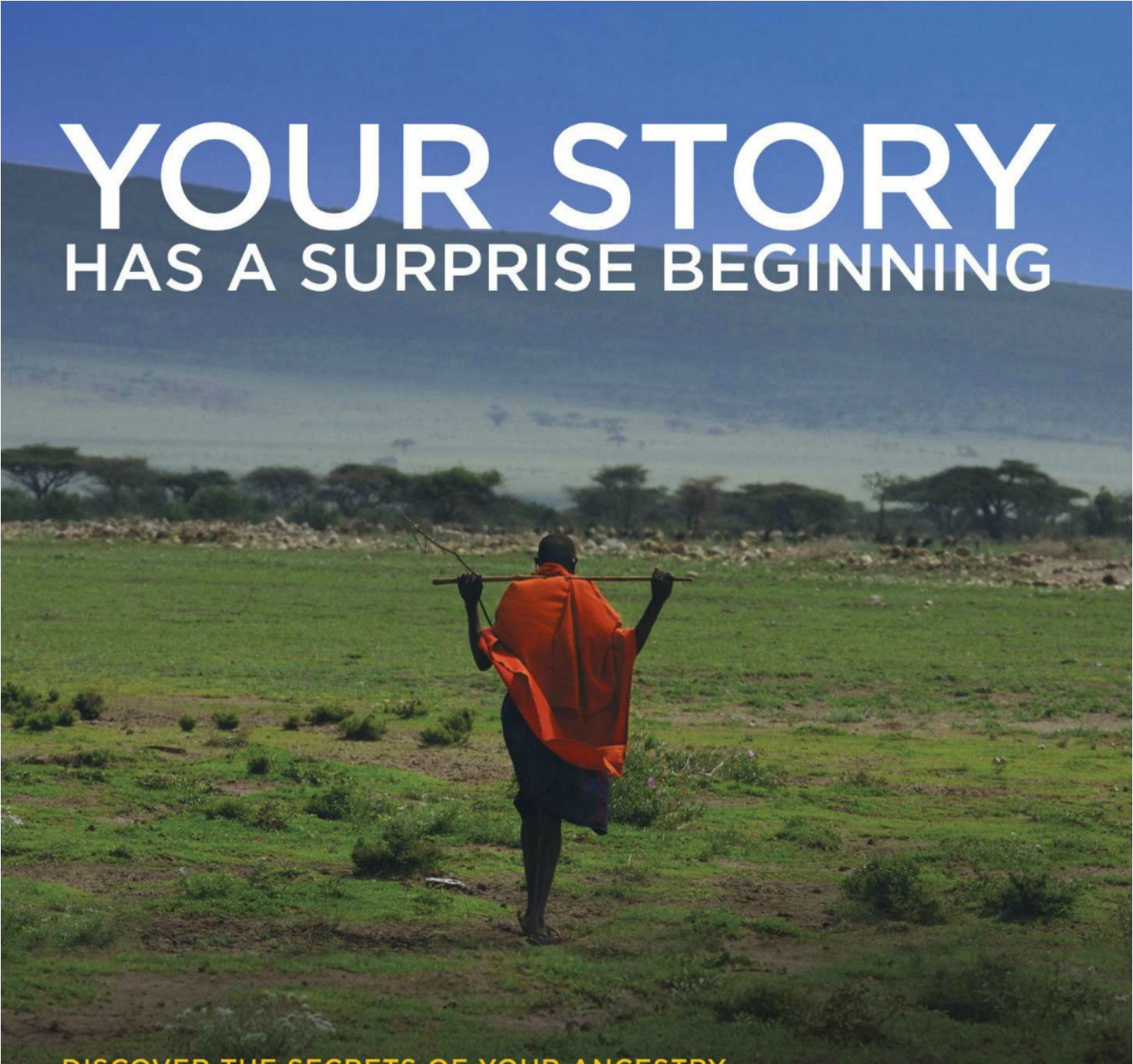

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Photo credits: Randy Olson, David Evans

My fascination with the lives of American Indians grew from the *National Geographic* magazines my grandmother brought with her to Italy when she visited us before WWII. Americans should be proud of them, but instead, sadly, they don't seem to fit in.

GIULIANA DOOLEY
Richmond, Virginia

Honoring one's forefathers is commendable, but trying to live in their world is not reasonable.

BILL LAUDEMAN
Chattanooga, Tennessee

Americans should be proud of them, but instead, sadly, they don't seem to fit in.

I am a full-blooded Ho-Chunk. I was taken aback by your article because there were some pictures that were offensive to me as a Sun Dance leader, spiritual leader, medicine person, and spokesperson for the Grey Eagle Society. I was taught that sacred or ceremonial practices of any type were not to be photographed, much less published in a magazine. I consider this an invasion of our sacred ways.

MICHAEL DAY
Viroqua, Wisconsin

Photographer Aaron Huey responds: During my seven years of travels to Pine Ridge, two spiritual leaders (appearing both in the print article and in video interviews in our digital editions) of separate spiritual communities have been generous enough to educate and mentor me. They were among the first people I had meaningful relationships with on the reservation. Permission to photograph their ceremonial spaces was always asked before any images were made. And once permission was given, it was communicated to the other members of their communities. They also granted me clearance to publish selected images.

The heyoka *in the ritual on pages 32-33 is a close friend of mine. He allowed me to make that intimate photograph. One thing that became clear to me after seven years of working on Pine Ridge is that each spiritual leader and each community has an individual vision, and they maintain the right to interpret that vision as they wish.*

Tibet's Golden "Worm"

I am curious about the sustainability of the *yartsa gunbu* harvest. How do some of the larvae escape infection by *Ophiocordyceps sinensis* while others fall victim to the parasitic fungus. Are some immune?

MARIS SOVOLD
Seattle, Washington

Scientists still don't know the answer. But several laboratories affiliated with Beijing's Chinese Academy of Sciences are currently researching parasitism of ghost moths by the fungus.

East London

Your implied answer as to whether the inner-city region (in which I have lived most of my adult life) is to be reborn may be the optimistic hope of naive outsider anthropologists. But it by no means represents the consensus among most hardheaded, experienced locals.

IAN-RAY-TODD
London, England

The luminous topping on author Cathy Newman's pie and mash is called liquor sauce.

HARRY HARRIS
Maidenhead, England

Photographing Storms

What a wonderful surprise to read the description of the camera (Kahuna) that Tim Samaras uses to try to catch lightning strikes. My father, Willard Buck, designed the camera when he worked at Los Alamos right after the war, to take pictures of aboveground nuclear tests. Not the kind of thing you bring home, but my father used to test the mirrors in the basement sometimes.

CORNELIA ALLEN
Fredericksburg, Texas

Gannets

Am I the only one who saw Salvador Dalí reincarnated as a gannet on pages 68-69?

JOSEPH LOSINSKI
North Pole, Alaska

NOW: Phone Booths

Just a thought, but maybe someone could refit these old icons as Wi-Fi hot spots and mobile charging stations for cell phones. They could then be back in the public and serve a purpose.

DAVID IVORY
Covington, Kentucky


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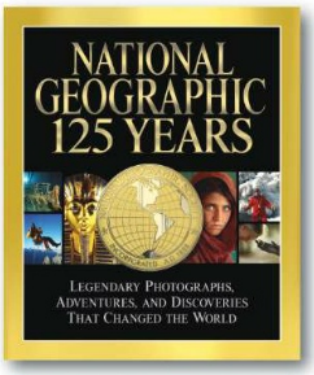

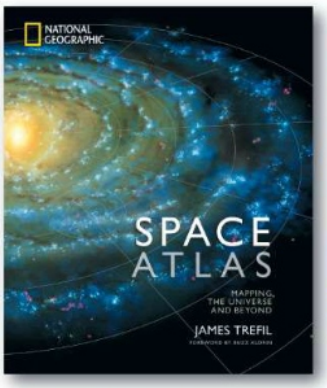

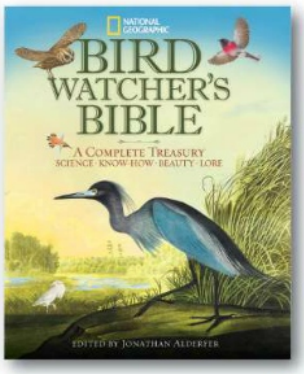

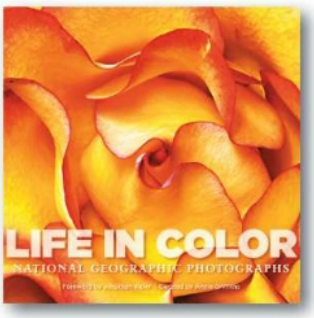

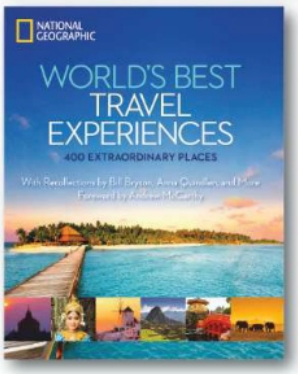

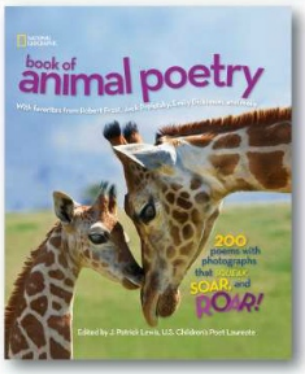

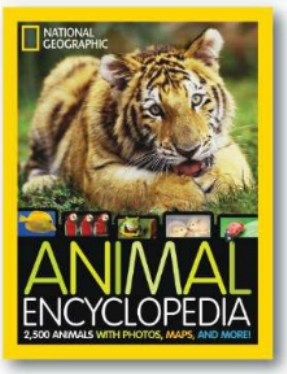

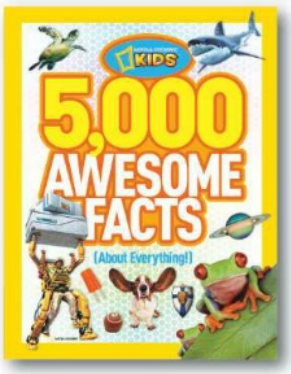

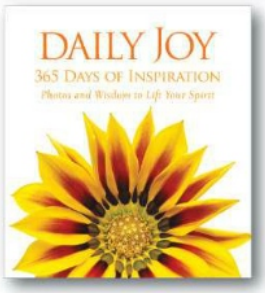

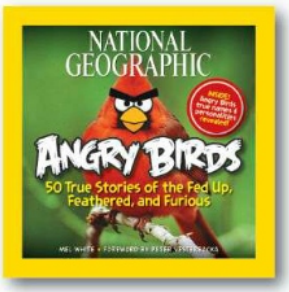

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VISIONS

Afghanistan
Overnight snowfall slows the pace of a Monday-morning commute in residential Kabul. The street is lined with flags heralding the opening of the Afghan parliament.

PHOTO: MUSADEQ SADEQ, AP IMAGES


STOP

Russia
Rosy from the bitter cold, the children of reindeer herders pause during play on the windswept tundra of Russia's Yamal Peninsula. Their coats, called *malitsas*, are sewn from reindeer hide, with the fur facing inward.

PHOTO: SERGEY ANISIMOV

United Kingdom
A merlin turns momentarily from the snipe in its grip after an attack on moorland near Whitby, in northern England. The raptor eats small birds, along with occasional mammals and insects.

PHOTO: STEVE MILLS

This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to ngm.com/yourshot.

EDITORS' CHOICE **Li Xin** Beijing, China

One summer evening Li was snapping shots of clouds from his Beijing rooftop when lightning (at center left) lit up this towering thunderhead. The effect, says the 31-year-old photojournalist, reminded him of a mushroom cloud from a nuclear explosion.

READERS' CHOICE

Lisa Franceski
Glen Cove, New York

Ever mindful not to disturb baby birds, Franceski crawled through goose poop to photograph this flapping gosling at a pond on Long Island, New York. "I couldn't stop laughing," says the registered nurse, 48. "It looked like a football referee calling, Touchdown!"

How to Make a Splash Without Getting Wet

Limited to the First 1,500 Responders!

Bring home 300 carats of aquamarine, the legendary "sailor's gem". In tradition, it's considered the most precious of gemstones — now for under $130!

This is not a necklace. It's the World's Most Beautiful Personal Flotation Device. Ever since ancient times, sailors have sworn by aquamarine for protection on the open water. For them, it was a sacred gem connected to Neptune. But today you don't have to leave shore to reap the benefits of this legendary blue gem, because your ship has come in. Today, you can wear this spectacular ***300-Carat Maré Aquamarine Necklace for only $129!***

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Claim your "Mermaid's Treasure." On any vessel crossing the oceans, there was no more precious cargo than aquamarine. Sailors paid handsomely for its power, considering it their most valuable commodity. In scientific terms, the chemical composition of our ***Maré*** Necklace beads are cousins to precious emeralds. They begin life as geological twins underground, colorless until something sparks a change. Sprinkle in a dash of minerals and one becomes vivid green and the other becomes brilliant blue. That's the beauty of chemisty.

A legend among luxury jewelers. Named for the Latin words for "water of the sea," aquamarine shines with all the colors of the ocean. Each bead is like a droplet of the sea frozen in space and time. Walk into the most exclusive retail jewelers and you'll find aquamarine in a place of honor. Fifth Avenue thinks nothing of offering a strand of aquamarine "pebbles" for $12,000. But with a color this captivating, you deserve more than a dollop. That's why we collected the bluest stones from three continents, polished them to perfection and arranged them in this double-stranded, 300-carat masterpiece.

Order now and we'll send you the 20" ***Maré Aquamarine Necklace***, featuring two loops of graduated beads with a lobster clasp and spacers layered in gleaming 14K gold. Previously offered for $395, this necklace is yours today for only $129! Nobody but Stauer can give you this much genuine aquamarine for so little.

Your Satisfaction is Guaranteed. If you don't fall in love with the ***Maré***, send it back within 30 days for a complete refund of your purchase price. It's that simple. Call now to set sail on your own incredible aquamarine deal while they last!

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Winning Photos

More than 20,000 images were submitted to the 2011 annual National Geographic Photography Contest, representing more than 130 countries. Our judges selected images by Shikhei Goh, George Tapan, and Izabelle Nordfjell as winners in the categories of nature, places, and people. The grand-prize winner received $10,000 and a trip to National Geographic headquarters in Washington, D.C.

For more information, go to *ngphotocontest.com.*

NATURE AND GRAND-PRIZE WINNER
Shikhei Goh
Batam, Indonesia

Aided by a water-spraying friend, Goh sought to capture the magic of a dragonfly in rain. He titled the image "Splashing."

PLACES **George Tapan**
Muntinlupa City, Philippines

Windblown hair and a fisherman's boat infuse serenity into this scene from Onuk Island. The moment of calm—and rainbow—followed a storm.

PEOPLE **Izabelle Nordfjell**
Örnsköldsvik, Sweden

A Sami man prepares to take aim at a reindeer in northern Sweden as his son braces for the shot. The successful hunt provided food for the winter.

Options shown.

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toyota.com/priusfamily

The coal-fired Drax plant in North Yorkshire is the United Kingdom's largest power station.

Industrial Wonderland

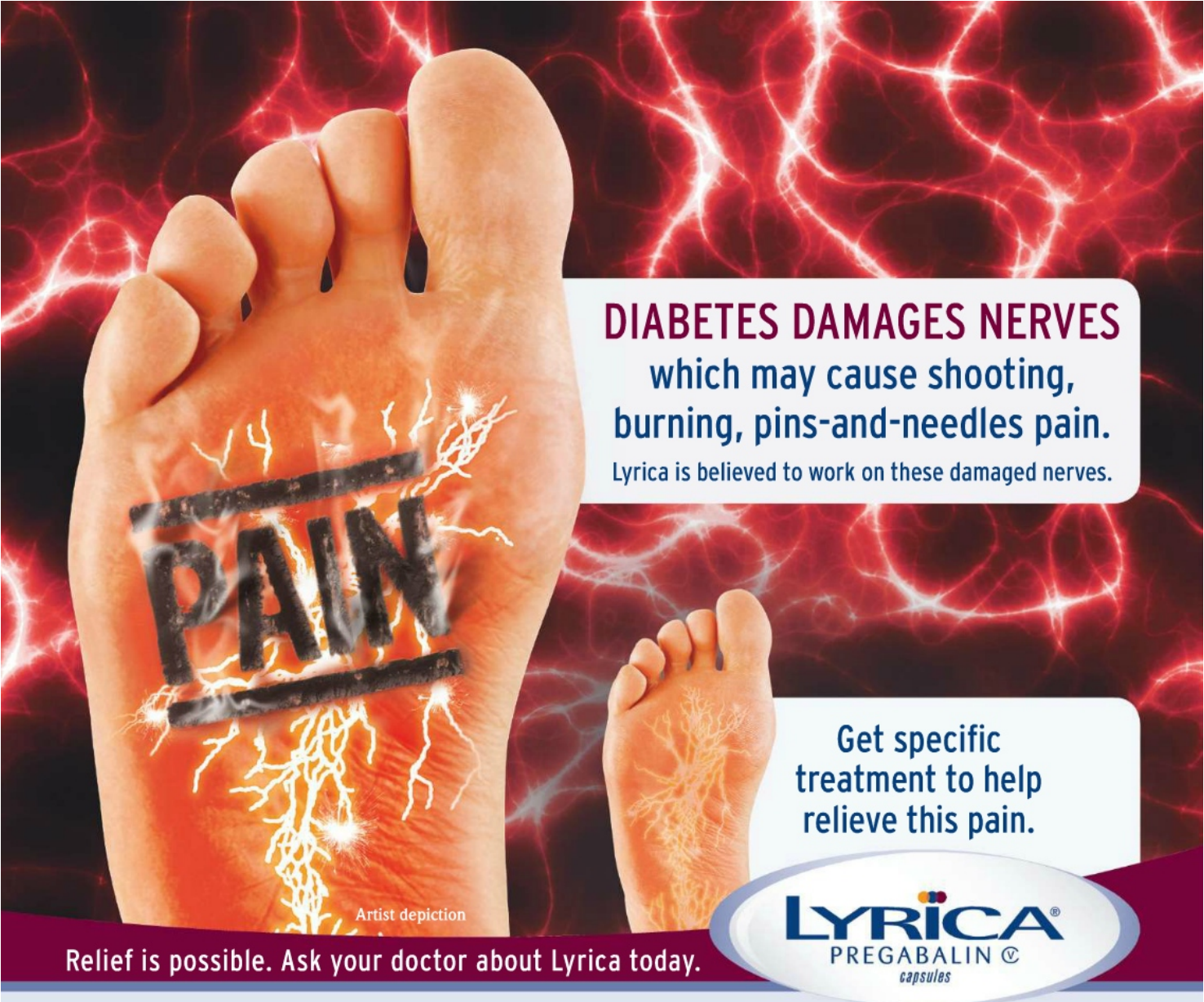
Dozens of power stations dot the English countryside. Like many people who live here, I find them oddly beautiful: architecturally alluring icons of our past that burn fossil fuels, polluting the present. Since 2008 I've explored that double layer of symbolism by photographing them at night, using large format and long exposures to show the ceaseless production occurring on the fringes of our landscape—and consciousness.

Before this series I was fishing for a timely topic that would clarify things for me as an artist. I've found it here, as well as a personal confluence. For instance, I used to do recon work in an infantry regiment; while I never trespass to get a shot, I did draw on that experience to scout locations. And I used to study environmental science, so it's somehow fitting that polluting structures are my subjects.

Personally I'm an advocate of renewable energy, but I don't see this project as an ideological pulpit. I want to document the issue and raise awareness, but let people form their own opinions. All the power plants I've shot in this series are unsustainable, yet they still serve our ever growing needs. I aim to illuminate that complicated relationship between power generation and the environment.

THE PHOTOGRAPHER

Toby Smith is a London-based photographer for Reportage by Getty Images who focuses on sustainability and environmental issues. He publishes and exhibits internationally.



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*Individual results may vary. †Those who have had a drug or alcohol problem are more likely to misuse Lyrica.

Prescription Lyrica is not for everyone. Tell your doctor right away about any serious allergic reaction that causes swelling of the face, mouth, lips, gums, tongue, throat or neck or any trouble breathing or that affects your skin. Lyrica may cause suicidal thoughts or actions in a very small number of people. Call your doctor right away if you have new or worsening depression, suicidal thoughts or actions, or unusual changes in mood or behavior. Lyrica may cause swelling of your hands, legs and feet. Some of the most common side effects of Lyrica are dizziness and sleepiness. Do not drive or work with machines until you know how Lyrica affects you. Other common side effects are blurry vision, weight gain, trouble concentrating, dry mouth, and feeling "high." Also, tell your doctor right away about muscle pain along with feeling sick and feverish, or any changes in your eyesight including blurry vision or any skin sores if you have diabetes. You may have a higher chance of swelling, hives or gaining weight if you are also taking certain diabetes or high blood pressure medicines. Do not drink alcohol while taking Lyrica. You may have more dizziness and sleepiness if you take Lyrica with alcohol, narcotic pain medicines, or medicines for anxiety. If you have had a drug or alcohol problem, you may be more likely to misuse Lyrica. Tell your doctor if you are planning to father a child. Talk with your doctor before you stop taking Lyrica or any other prescription medication.

Please see Important Risk Information for Lyrica on the following page.

To learn more visit www.lyrica.com or call toll-free 1-888-9-LYRICA (1-888-959-7422).

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.FDA.gov/medwatch or call 1-800-FDA-1088.

IMPORTANT FACTS

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(**LEER**-i-kah)

IMPORTANT SAFETY INFORMATION ABOUT LYRICA

LYRICA may cause serious, even life threatening, allergic reactions. Stop taking LYRICA and call your doctor right away if you have any signs of a serious allergic reaction:

- Swelling of your face, mouth, lips, gums, tongue, throat or neck
- Have any trouble breathing
- Rash, hives (raised bumps) or blisters

Like other antiepileptic drugs, LYRICA may cause suicidal thoughts or actions in a very small number of people, about 1 in 500.
Call your doctor right away if you have any symptoms, especially if they are new, worse or worry you, including:

- New or worsening depression
- Suicidal thoughts or actions
- Unusual changes in mood or behavior

Do not stop LYRICA without first talking with your doctor.

LYRICA may cause swelling of your hands, legs and feet.
This swelling can be a serious problem with people with heart problems.

LYRICA may cause dizziness or sleepiness.
Do not drive a car, work with machines, or do other dangerous things until you know how LYRICA affects you. Ask your doctor when it is okay to do these things.

ABOUT LYRICA

LYRICA is a prescription medicine used in adults 18 years and older to treat:

- Pain from damaged nerves that happens with diabetes or that follows healing of shingles
- Partial seizures when taken together with other seizure medicines
- Fibromyalgia (pain all over your body)

Who should NOT take LYRICA:

- Anyone who is allergic to anything in LYRICA

BEFORE STARTING LYRICA

Tell your doctor about all your medical conditions, including if you:

- Have had depression, mood problems or suicidal thoughts or behavior
- Have or had kidney problems or dialysis
- Have heart problems, including heart failure
- Have a bleeding problem or a low blood platelet count
- Have abused prescription medicines, street drugs or alcohol in the past
- Have ever had swelling of your face, mouth, tongue, lips, gums, neck, or throat (angioedema)
- Plan to father a child. It is not known if problems seen in animal studies can happen in humans.
- Are pregnant, plan to become pregnant or are breastfeeding. It is not known if LYRICA will harm your unborn baby. You and your doctor should decide whether you should take LYRICA or breast-feed, but not both.

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal supplements.
LYRICA and other medicines may affect each other causing side effects. Especially tell your doctor if you take:

- Angiotensin converting enzyme (ACE) inhibitors. You may have a higher chance for swelling and hives.

BEFORE STARTING LYRICA, continued

- Avandia® (rosiglitazone)*, Avandamet® (rosiglitazone and metformin)* or Actos® (pioglitazone)** for diabetes. You may have a higher chance of weight gain or swelling of your hands or feet.
- Narcotic pain medicines (such as oxycodone), tranquilizers or medicines for anxiety (such as lorazepam). You may have a higher chance for dizziness and sleepiness.
- Any medicines that make you sleepy

POSSIBLE SIDE EFFECTS OF LYRICA

LYRICA may cause serious side effects, including:

- See "Important Safety Information About LYRICA."
- Muscle problems, pain, soreness or weakness along with feeling sick and fever
- Eyesight problems including blurry vision
- Weight gain. Weight gain may affect control of diabetes and can be serious for people with heart problems.
- Feeling "high"

If you have any of these symptoms, tell your doctor right away.

The most common side effects of LYRICA are:

- Dizziness
- Blurry vision
- Weight gain
- Sleepiness
- Trouble concentrating
- Swelling of hands and feet
- Dry mouth

If you have diabetes, you should pay extra attention to your skin while taking LYRICA and tell your doctor of any sores or skin problems.

HOW TO TAKE LYRICA

Do:

- Take LYRICA exactly as your doctor tells you. Your doctor will tell you how much to take and when to take it. Take LYRICA at the same times each day.
- Take LYRICA with or without food.

Don't:

- Drive a car or use machines if you feel dizzy or sleepy while taking LYRICA.
- Drink alcohol or use other medicines that make you sleepy while taking LYRICA.
- Change the dose or stop LYRICA suddenly. You may have headaches, nausea, diarrhea, trouble sleeping, increased sweating, or you may feel anxious if you stop taking LYRICA suddenly.
- Start any new medicines without first talking to your doctor.

NEED MORE INFORMATION?

- Ask your doctor or pharmacist. This is only a brief summary of important information.
- Go to **www.lyrica.com** or call **1-866-459-7422 (1-866-4LYRICA).**

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Rx only

How to Outsmart a Millionaire

Only the "Robin Hood of Watchmakers" can steal the spotlight from a luxury legend for under $200!

Mr. Bigshot rolled up in a roaring high-performance Italian sports car, dropping attitude like his $22,000 watch made it okay for him to be rude. That's when I decided to roll up my sleeves and teach him a lesson.

"Nice watch," I said, pointing to his and holding up mine. He nodded like we belonged to the same club. We did, but he literally paid 100 times more for his membership. Bigshot bragged about his five-figure purchase, a luxury heavyweight from the titan of high-priced timepieces. I told him that mine was the ***Stauer Corso, a 27-jewel automatic classic now available for only $179.*** And just like that, the man was at a loss for words.

The Stauer *Corso* is proof that the worth of a watch doesn't depend on the size of its price tag. Our factory spent over $40 million on Swiss-made machinery to insure the highest quality parts. Each timepiece takes six months and over 200 individual precision parts to create the complex assembly. Peer through the exhibition back to see the 27-jeweled automatic movement in action and you'll understand why we can only offer the ***Corso*** in a limited edition.

Our specialty is vintage automatic movements. The ***Corso*** is driven by a self-winding design, inspired by a 1923 patent. Your watch will never need batteries. Every second of power is generated by the movement of your body. The black dial features a trio of date complications including a graphic day/night display. The ***Corso*** secures with a two-toned stainless steel bracelet and is water-resistant to 3 ATMs.

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Killingholme is a natural gas plant in North Lincolnshire. It was built in the 1990s, with a modern design and grassy grounds. I found this vantage point in the mature woodlands like those that once blanketed the site.

More than 40 years old, the Fawley station in Hampshire is considered one of England's most efficient oil-fired plants. Stabilizing my camera is one of the biggest photographic challenges I face, since a gust of wind will ruin a shot. I find that heavy tripods are essential.

Turn on these headphones and the world becomes a quieter place, as noise around you fades into the background. You can **focus on your music,** perhaps even discovering new depths and subtleties. Or take advantage of the noise cancellation to quietly **relax and think in peace.** The QC®15 headphones are our best, the quietest we've ever made. No other headphones offer you the same combination of less noise, lifelike music, lasting quality and a comfortable fit. "These are fabulous," says Murray Hill of Canada.com. "Simply put, the sound is beautiful." We invite you to hear the difference these highly acclaimed headphones make on planes, at home and in the office for 30 days, risk-free. When you call, ask about making 12 easy payments, with no interest charges from Bose.* And when you order now, you'll receive **free shipping.**

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Ratcliffe-on-Soar, a coal-fired station I shot in this five-and-a-half-hour exposure, can generate enough electricity for some two million people. It's loomed over Nottinghamshire for 40-plus years, yet people rarely give it a second glance.

Oxfordshire's Didcot stations—a natural gas plant and an adjoining one that burns gas and coal—glow across a ripe cornfield in this one-hour exposure. The British poet Kit Wright once wrote a tongue-in-cheek "Ode to Didcot Power Station": "Thy consummate immensity / Enshrines the rare propensity / Of fumes to form eternal acid rain!"

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featuring reporter **DANIEL STONE**

NOVEMBER *to* **DECEMBER**

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Daniel Stone, *National Geographic*'s new e-reporter, is taking an environmental road trip throughout California in search of the people, institutions, and ideas that may help reset the future. His blog will cover concepts such as the tiny house movement, car sharing, water-saving landscapes, and more. He'll also take story suggestions from readers on Twitter.

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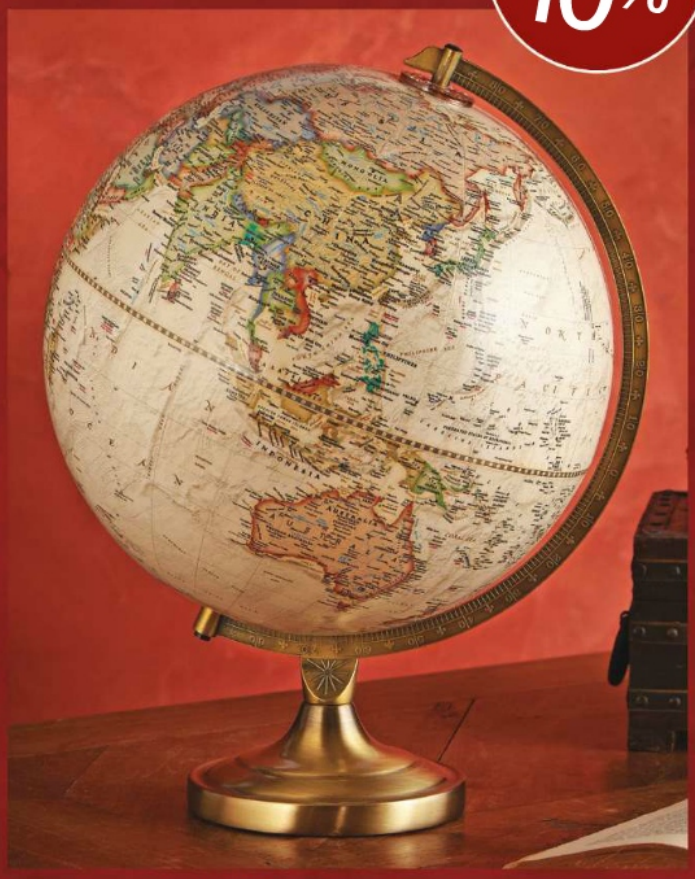

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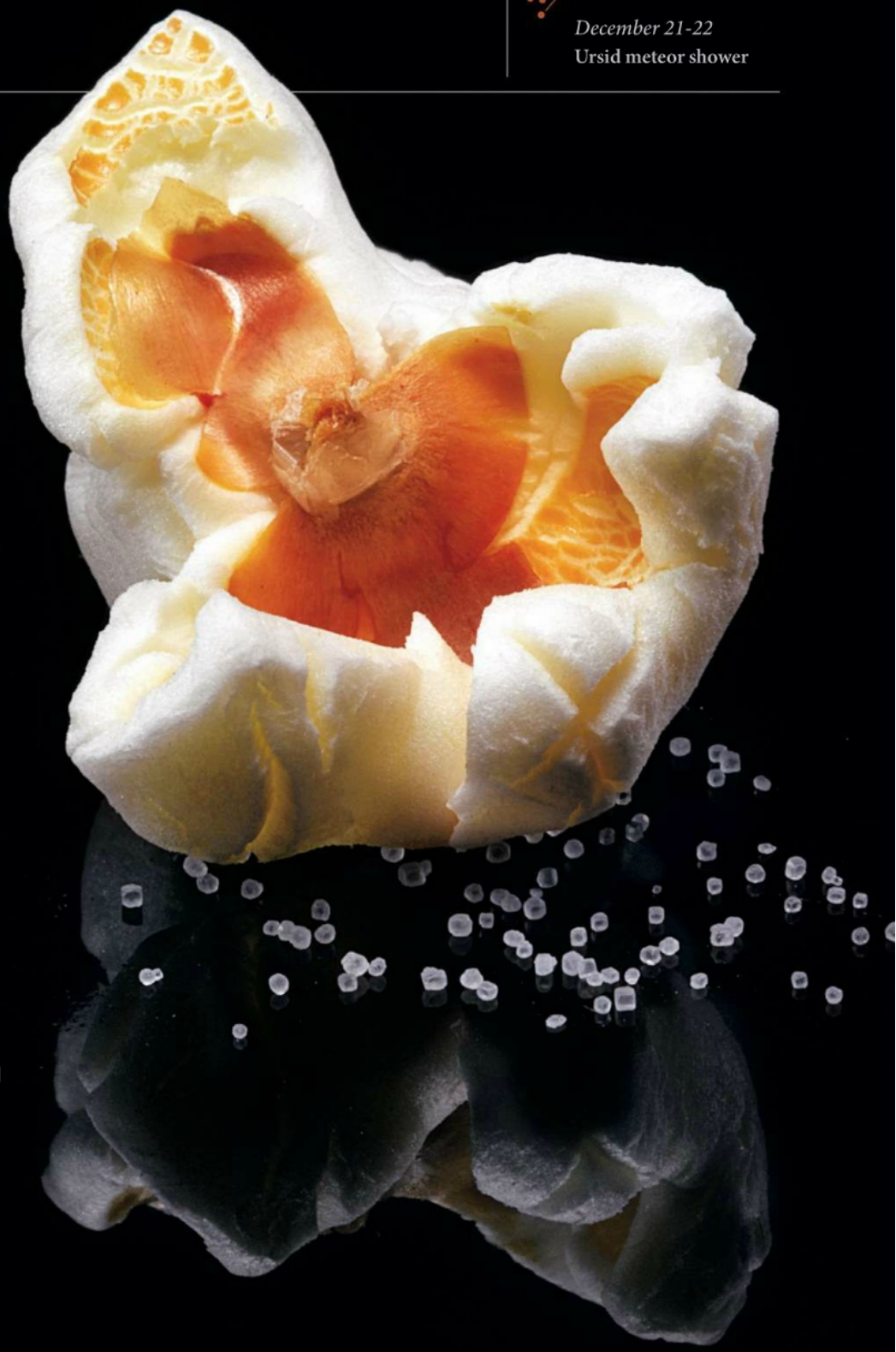
Geminid meteor shower

December 21-22
Ursid meteor shower



Pop Culture

Before they even had pots to cook it in, ancient Peruvians knew the joys of eating popcorn. So says a team of scientists who have found fossilized cobs, husks, stalks, and tassels dating back 6,700 years—ahead of the arrival of ceramics—along the northern coast of Peru. The remains, the oldest ever identified in South America, help put the now ubiquitous crop's chronology in order. According to study co-author Tom Dillehay, the findings place maize in the area 2,000 years earlier than previous discoveries had indicated.

So how did these people pop kernels without cookware? Burned cobs suggest they used heated stones (which were also found with scorch marks). As to consumption practices, Dillehay says popcorn likely wasn't a habitual indulgence but rather signaled a special occasion.

—Catherine Zuckerman

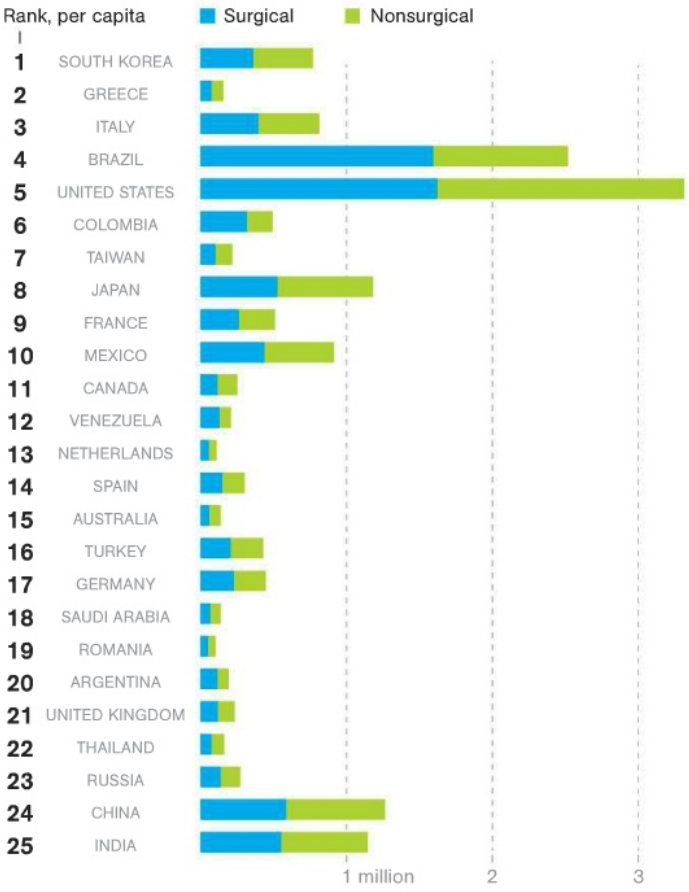
PHOTO: REBECCA HALE, NGM STAFF

Beauty Markets

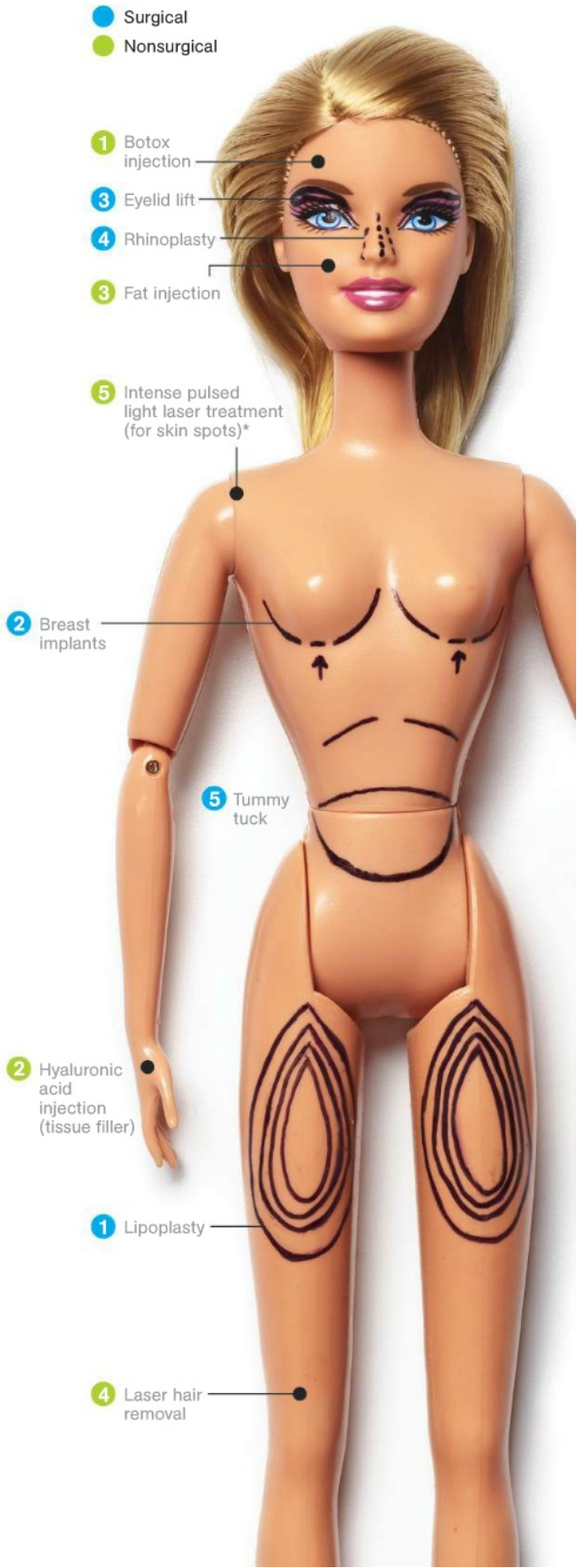
The face of plastic surgery is changing. Once a purely surgical specialty, the field's morphed with the advent of neurotoxins, tissue fillers, and laser treatments over the past 20 years. Patients—mostly women—are now turning more to nonsurgical options for nips and tucks. By one estimate, these make up 82 percent of cosmetic procedures in the U.S.

The quest for beauty is universal, but tastes can vary. Brazilians favor buttock enhancements; Americans tend to seek bigger breast increases than Brazilians, says Renato Saltz, vice president of the International Society of Aesthetic Plastic Surgery. Cultural preferences lead surgery innovations too: facial work in the U.S., rhinoplasty techniques in parts of the Middle East. The U.S. and Brazil top the world in plastic surgeons and procedures, says Saltz, with Asia's numbers expected to rise. *—Luna Shyr*

Countries with top number of procedures, 2010



Top five procedures worldwide, 2010



*Placement of some procedure labels is approximate.

PHOTO: REBECCA HALE, NGM STAFF. GRAPHIC: LAWSON PARKER, NGM STAFF
SOURCE: INTERNATIONAL SOCIETY OF AESTHETIC PLASTIC SURGERY; MICHAEL OLDING

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The average life expectancy of a child born in Japan is almost double that of one born in Afghanistan.

Jaguar Corridor

Big cats need room to roam. In the case of jaguars that's a stretch from Mexico to Argentina, and human development is getting in their way. Conservationists can usher them across highways with underpasses, but the jaguars balk at crossing the cultivated fields that have replaced their natural cover—especially soy, corn, and oil palm crops in Colombia's Magdalena River Valley. The farms are massive, with no way around besides the prohibitively high Andes.

The first camera-trap photos of a mother and cubs (above) in one sprawling oil palm plantation indicate hope for range preservation for the next generation. Females signal not just quick passage but a stay for reproduction, says Panthera's Howard Quigley. *—Johnna Rizzo*

Get updates on our Big Cats Initiative at **causeanuproar.com.**

Gene Slice

Botanists say it's a fruit; the U.S. Supreme Court ruled it a vegetable. One thing's certain: The tomato has about 7,000 more genes than a person. Surprising? Not to the USDA's Jim Giovannoni, who helped lead the newly completed sequencing of the tomato genome. Big genomes allow immobile plants to tolerate genetic changes that can spur new ways of coping with adversity, he explains. Decoding the tomato makes breeding easier—and it revealed a 92 percent genomic match with the potato. *—Luna Shyr*

PHOTOS: PANTHERA (TOP); JEANNE M. MODDERMAN, NGM STAFF. NGM MAPS. GRAPHIC: ÁLVARO VALIÑO
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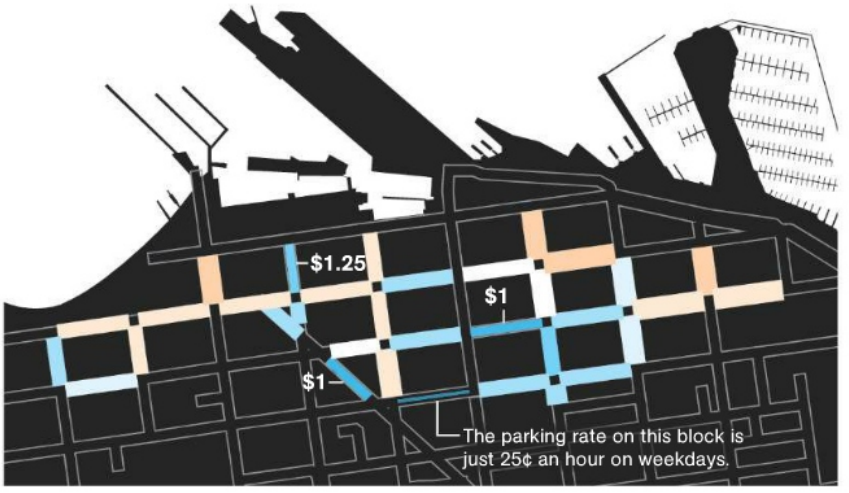
BASF
The Chemical Company

*TINOSORB® M, TINOSORB® S AND UVINUL® T 150 PRODUCTS ARE NOT AVAILABLE IN THE US AND CANADA.



FLUID PARKING RATES
A popular place, like Fisherman's Wharf in San Francisco, can involve parking headaches. To make spots available at peak times, the city is testing variable parking rates. Prime spots and busier periods mean higher prices.

Weekday, 3 to 7 p.m.

$2.75
Median rate per hour

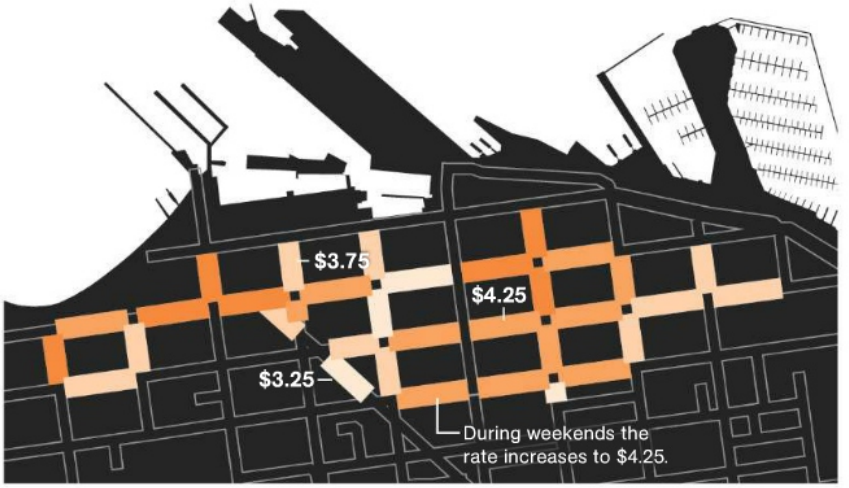
68%
Average occupancy

PARKING RATE (per hour)

25¢ $1 2 3 4 5

OCCUPANCY

0% 50 100



Weekend, 3 to 7 p.m.

$4.25
Median rate per hour

91%
Average occupancy

Smart Parking

The hunt for street parking in busy cities is enough to drive motorists around the bend. Nonstop circling isn't just a drag for drivers—it's a drag on cities. Donald Shoup, a UCLA professor hailed as the "prophet of parking," estimates that a third of traffic on congested downtown streets involves drivers seeking spots. San Francisco is taking aim with a pilot program that prices parking based on demand.

Sensors in 7,000 of the city's parking spaces provide data for mobile apps that alert drivers when spaces are open. Meanwhile, prices around local hot spots go up at peak times to encourage parking on sleepier streets, where prices go down. Rates are reevaluated every six weeks. Downtown Los Angeles is now following suit; Washington, D.C., and New York City aren't far behind.

The goal is to make parking easier and more convenient. Says Jay Primus, the San Francisco project's leader, "We want people to stop worrying about parking and be free to enjoy themselves." *—Gretchen Parker*

MAPS: LAZARO GAMIO (LEFT). SOURCE: JAY PRIMUS, SAN FRANCISCO MUNICIPAL TRANSPORTATION AGENCY. NGM MAPS

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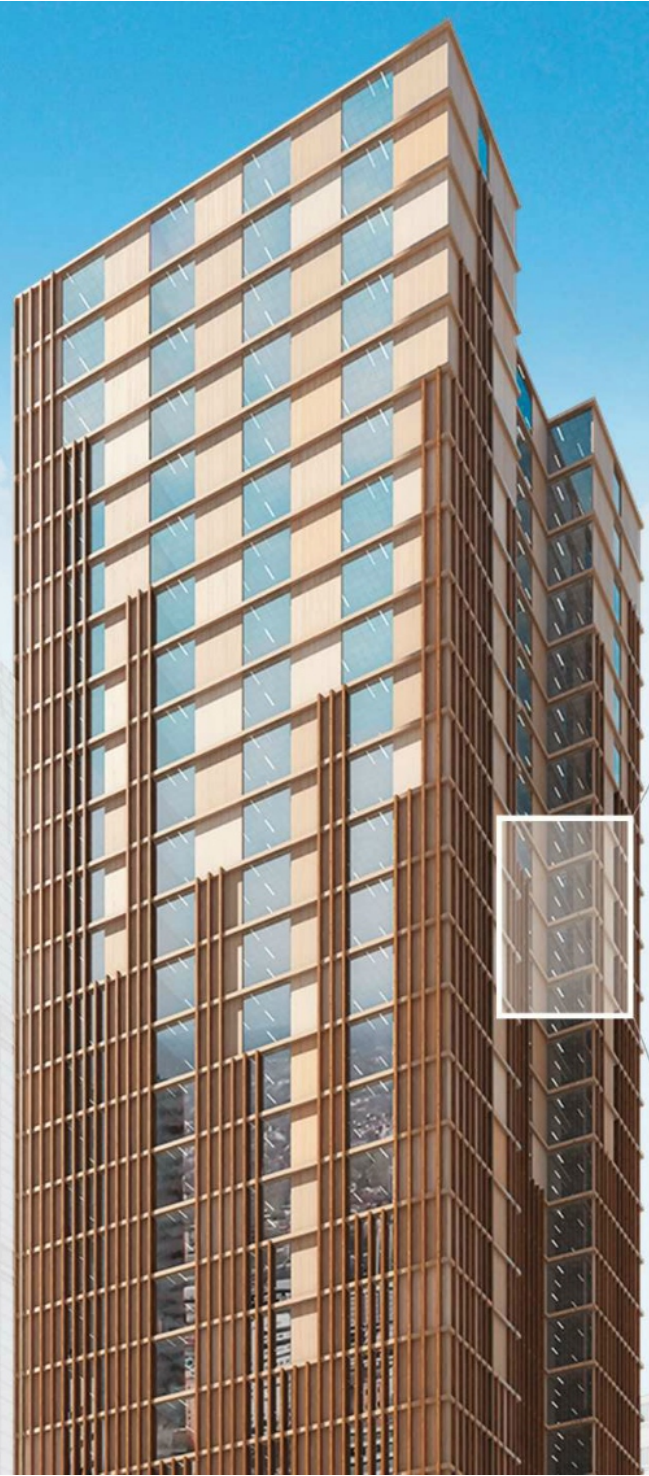
*In digital cameras vs. Energizer MAX®. Results vary by camera.**Use less batteries, create less waste.

Hail, Timber

In Nara, Japan, a 122-foot-tall wooden pagoda has stood for more than 1,300 years. Very few modern structures like it exist, largely due to fire-safety concerns and building codes that limit the height of timber structures. Canadian architect Michael Green aims to change that with a proposed wooden skyscraper up to 30 stories high in Vancouver. He explains that giant panels of laminated wood known as mass timber are more fire-resistant than typical two-by-fours, just as logs are harder to ignite than kindling.

The bigger advantage? The production of concrete and steel emits high levels of carbon dioxide, whereas wooden buildings store carbon that would otherwise be released when trees decay or burn. London already has a nine-story mass-timber apartment building, and a 16-story wooden skyscraper is slated for Kirkenes, Norway. Green's ultimate ambition for timber towers is even loftier: provide affordable housing for people living in slums. *—Alex Hoyt*

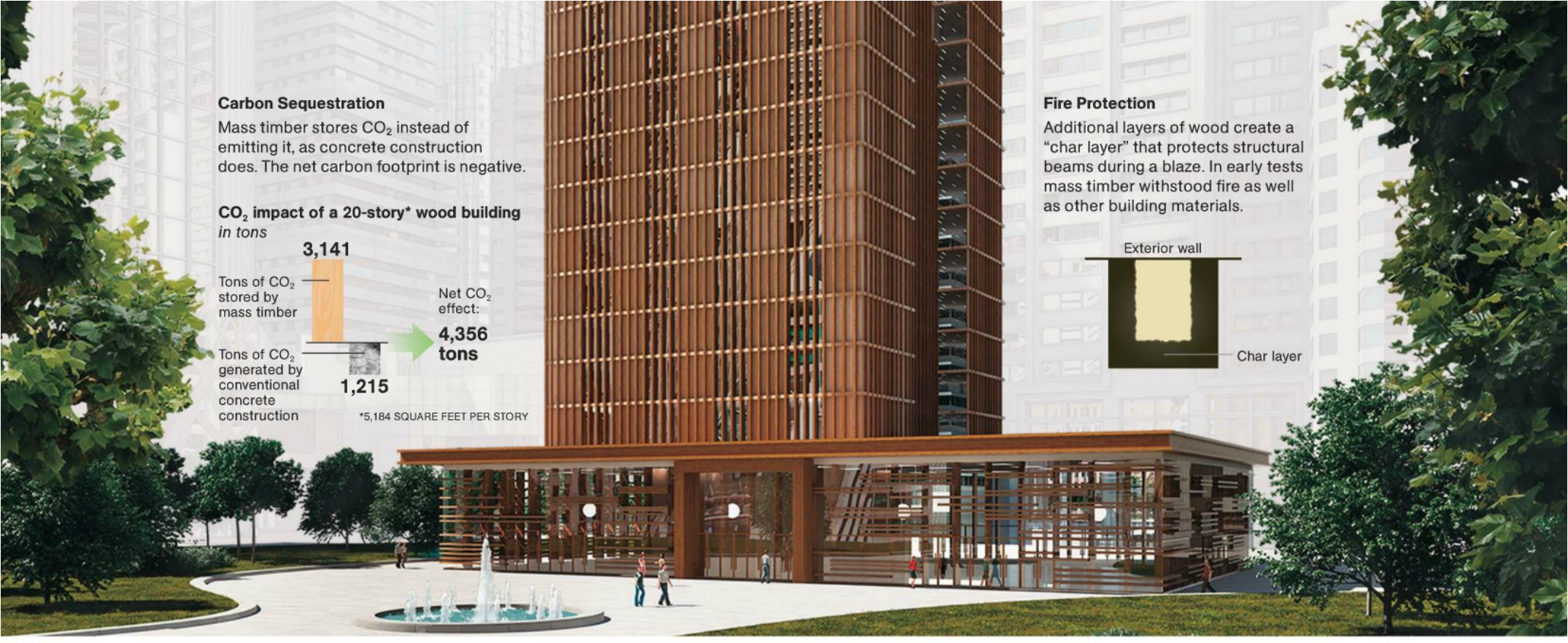


Mass Timber

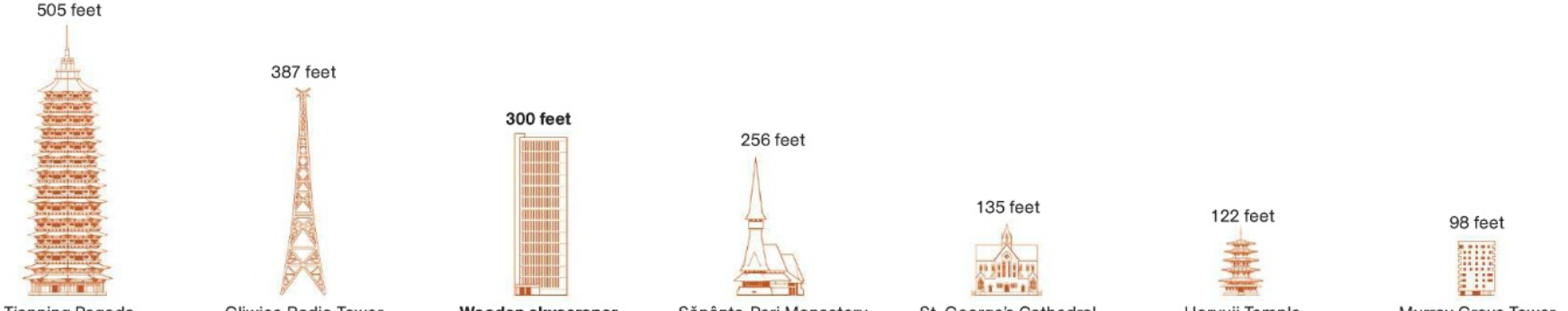
Instead of traditional lumber, mass timber uses laminated boards and plywood made of sustainably grown lower-grade wood—such as fast-growing birch and aspen—that wouldn't normally be suitable for commercial use.

Laminated Panels
Based on tree species and regional production, several types of panels can be combined for floors and walls or used alone for a whole building.

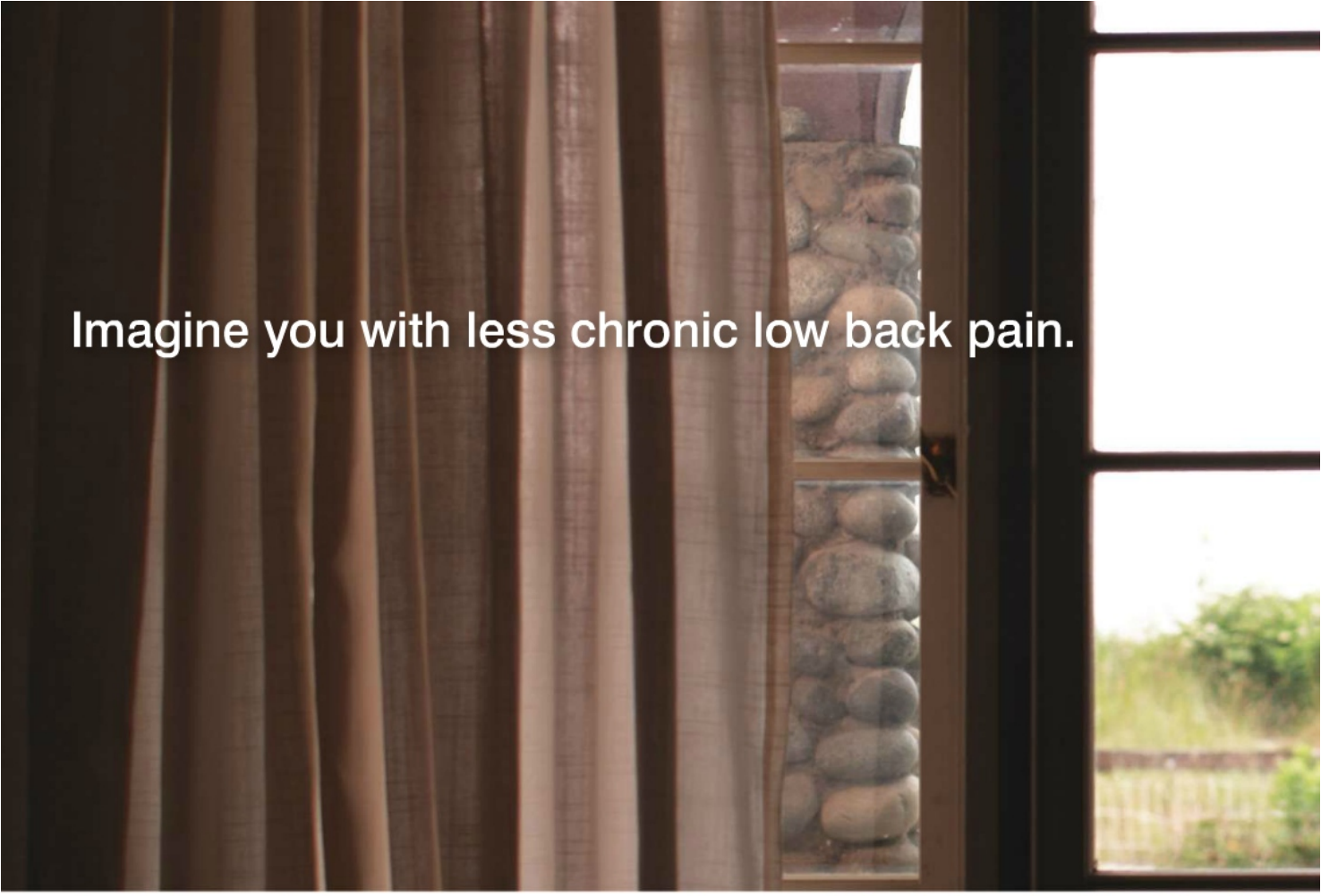
Glulam
Small-scale lumber glued together creates very strong and fire-resistant beams and columns.



Examples of Tall Wooden Structures



JASON TREAT, NGM STAFF. ART: PURE RENDERING GMBH
SOURCE: MICHAEL GREEN AND ERIC KARSH. BUILDING DRAWINGS: LAZARO GAMIO



Cymbalta can help.

Cymbalta is a once-daily, non-narcotic pain reliever. And it's not addictive.

When taken once a day, every day, Cymbalta is proven to significantly reduce chronic low back pain.

You may have to rethink the way you treat your pain. You might be used to taking pain medications only after you feel your chronic low back pain getting worse. Managing this pain with Cymbalta is a little different. It's important to take Cymbalta every day, as prescribed by your doctor, to manage your pain over time.

Did you know that your body has a natural pain-suppressing system that can help regulate the amount of pain you feel? Although the exact way that Cymbalta works to reduce chronic low back pain is unknown, it is believed that Cymbalta helps lessen pain by enhancing the body's natural pain-suppressing system by increasing the activity of serotonin and norepinephrine in the brain and spinal cord.

Visit cymbalta.com or call 1-877-CYMBALTA (1-877-296-2258) to learn more. Ask your doctor about Cymbalta and a free trial offer.

Cymbalta is a prescription medication approved for the management of chronic musculoskeletal pain in people with chronic low back pain or chronic osteoarthritis pain.

Important Safety Information About Cymbalta

The most important information you should know about Cymbalta:

Antidepressants can increase suicidal thoughts and behaviors in children, teens, and young adults. Suicide is a known risk of depression and some other psychiatric disorders. Call your doctor right away if you have new or worsening depression symptoms, unusual changes in behavior, or thoughts of suicide. Be especially observant within the first few months of treatment or after a change in dose. Approved only for adults 18 and over.

Cymbalta® (duloxetine HCl) is not for everyone. Do not take Cymbalta if you:

- have recently taken a type of antidepressant called a monoamine oxidase inhibitor (MAOI) or Mellaril® (thioridazine)
- have uncontrolled narrow-angle glaucoma (increased eye pressure)

Before taking Cymbalta, talk with your healthcare provider:

- about all your medical conditions, including kidney or liver problems, glaucoma, diabetes, seizures, or if you have bipolar disorder. Cymbalta may worsen a type of glaucoma or diabetes
- about all your prescription and nonprescription medicines. A potentially life-threatening condition has been reported when Cymbalta was taken with certain drugs for migraine, mood, or psychotic disorders
- if you are taking NSAID pain relievers, aspirin, or blood thinners. Use with Cymbalta may increase bleeding risk
- about your alcohol use

Important Safety Information (continued)

- about your blood pressure. Cymbalta can increase your blood pressure. Your healthcare provider should check your blood pressure prior to and while taking Cymbalta
- if you are pregnant or plan to become pregnant during therapy, or are breast-feeding

While taking Cymbalta, talk to your healthcare provider right away:

- if you have itching, right upper-belly pain, dark urine, yellow skin/eyes, or unexplained flu-like symptoms, which may be signs of liver problems. Severe liver problems, sometimes fatal, have been reported
- if you have high fever, confusion and stiff muscles, which may be symptoms of a potentially life-threatening condition
- if you have skin blisters, serious or peeling rash, hives, mouth sores, or any other allergic reaction. These may be serious, possibly life-threatening, skin reactions
- if you experience dizziness or fainting upon standing. This tends to occur in the first week or when increasing the dose, but may occur at any time during treatment
- before you stop Cymbalta or change your dose
- if you experience headache, weakness, confusion, problems concentrating, memory problems, or feel unsteady, which may be signs of low sodium levels
- if you develop problems with urine flow

Most common side effects of Cymbalta (this is not a complete list):

- nausea, dry mouth, sleepiness, fatigue, constipation, dizziness, decreased appetite, and increased sweating

You are encouraged to report negative side effects of Prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.

Other safety information about Cymbalta:

- Cymbalta may cause sleepiness and dizziness. Until you know how Cymbalta affects you, you should not drive a car or operate hazardous machinery.
- People age 65 and older who took Cymbalta reported more falls, some resulting in serious injuries.

How to take Cymbalta:

Take Cymbalta exactly as directed by your healthcare provider. Cymbalta should be taken by mouth. Do not open, break or chew capsule; it must be swallowed whole. Cymbalta can be taken with or without food.

Cymbalta is available by prescription only.

DD CON ISI 28NOV2011

See next page for additional information about Cymbalta, including Boxed Warning about antidepressants and risk of suicide.

Cymbalta® duloxetine HCl 20 mg, 30 mg, 60 mg DELAYED RELEASE CAPSULES

Lilly

Information For Patients About Cymbalta

Please read this information carefully before you or your family member start taking Cymbalta (sim-BALL-tah), and each time your prescription is refilled, in case anything has changed or new information is available. This information is not meant to take the place of discussions with your healthcare provider. Talk with your healthcare provider or pharmacist if there is something you do not understand or if you want to learn more about Cymbalta. Always follow your healthcare provider's instructions for taking Cymbalta.

What is the most important information I should know about Cymbalta?

Warning: In clinical studies, antidepressants increased the risk of suicidal thinking and behavior in children, adolescents, and young adults with depression and other psychiatric disorders. Anyone considering the use of Cymbalta or any other antidepressant must balance this risk with the clinical need. Short-term studies did not show an increase in the risk of suicidal thinking or behavior with antidepressants in adults older than 24; there was a reduction in risk with antidepressants in adults 65 and older. Suicide is a known risk of depression and some other psychiatric disorders. All patients starting antidepressant therapy should be monitored appropriately and observed closely. Families and caregivers should discuss with the healthcare provider right away any observations of worsening depression symptoms, suicidal thinking and behavior, or unusual changes in behavior. Cymbalta is not approved for use in patients under age 18.

Patients on antidepressants and their families or caregivers should watch for new or worsening depression symptoms, unusual changes in behavior, and thoughts of suicide, as well as for anxiety, agitation, panic attacks, difficulty sleeping, irritability, hostility, aggressiveness, impulsivity, restlessness, or extreme hyperactivity. Call your healthcare provider right away if you have thoughts of suicide or if any of these symptoms is severe or occurs suddenly. Be especially observant within the first few months of treatment or whenever there is a change in dose.

What is Cymbalta?

Cymbalta is a prescription medicine approved to treat multiple conditions: the treatment of major depressive disorder (MDD), also called depression; generalized anxiety disorder (GAD); the management of fibromyalgia (FM); the management of diabetic peripheral neuropathic pain, also called diabetic nerve pain (DNP); and the management of chronic musculoskeletal pain due to chronic osteoarthritis pain and chronic low back pain.

Who should NOT take Cymbalta?

You should not take Cymbalta if:

- You are taking a type of antidepressant known as a monoamine oxidase inhibitor (MAOI), such as Nardil® (phenelzine sulfate), Parnate® (tranylcypromine sulfate), or Emsam® (selegiline transdermal system). Using an MAOI with many prescription medicines, including Cymbalta, can cause serious or even life-threatening reactions. You must wait at least 14 days after you have stopped taking an MAOI before you take Cymbalta. You need to wait at least 5 days after you stop taking Cymbalta before you take an MAOI
- You have uncontrolled narrow-angle glaucoma (increased eye pressure)
- You are taking an antipsychotic medicine known as Mellaril® (thioridazine)

What should I talk to my healthcare provider about before taking Cymbalta?

- About any medical conditions you may have, including kidney or liver problems, glaucoma, diabetes, seizures, or if you have bipolar disorder. Cymbalta may worsen a type of glaucoma or the control of blood sugar in some patients with diabetes
- If you are taking or plan to take any prescription or nonprescription medicines, as Cymbalta may interact with some of these products
- If you take medicines known as triptans, commonly prescribed for migraines or medicines for mood or psychotic disorders. A potentially life-threatening condition may occur if taken with Cymbalta
- If you take NSAID pain relievers, aspirin, or blood thinners. Use with Cymbalta may increase risk of bleeding
- About your alcohol use
- About your blood pressure. Cymbalta can increase your blood pressure. Your healthcare provider should check your blood pressure prior to and while taking Cymbalta
- If you are pregnant, plan to become pregnant, or are breastfeeding. (Lilly has a voluntary registry to collect information about Cymbalta use during pregnancy. To learn more, call 1-866-814-6975 or visit www.cymbaltapregnancyregistry.com)

What should I talk to my healthcare provider about while taking Cymbalta?

Call your healthcare provider right away:

- If you have itching, right upper-belly pain, dark urine, yellow skin/eyes, or unexplained flu-like symptoms, which may be signs of liver problems. Severe liver problems, sometimes fatal, have been reported
- If you have high fever, confusion and stiff muscles, which may be signs of a potentially life-threatening condition
- If you have skin blisters, serious or peeling rash, hives, mouth sores, or any other allergic reaction. These may be serious, possibly life-threatening, skin reactions
- If you experience dizziness or fainting upon standing. This tends to occur in the first week or when increasing the dose, but may occur at any time during treatment, or when used in combination with certain other drugs
- Before stopping Cymbalta or changing your dose. Stopping Cymbalta may result in symptoms including dizziness, nausea, or headache **(not a complete list)**. Your healthcare provider may wish to decrease the dose slowly
- If you experience headache, weakness, confusion, problems concentrating, memory problems, or feel unsteady, which may be signs of low sodium levels
- If you develop problems with urine flow

What should I avoid while taking Cymbalta?

- Cymbalta may cause sleepiness and dizziness. Until you know how Cymbalta affects you, you should not drive a car or operate hazardous machinery

What are the most common side effects of Cymbalta?

- In clinical studies for approved indications, the most common side effect was nausea
- Other common side effects included dry mouth, sleepiness, fatigue, constipation, dizziness, decreased appetite, and increased sweating

This is not a complete list of side effects. See Boxed Warning, "Who should NOT take Cymbalta?" and "What should I talk to my healthcare provider about while taking Cymbalta?" See prescribing information at www.cymbalta.com. Talk to your healthcare provider if you have questions or develop any side effects.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

What else should I know if I'm 65 or older?

- People age 65 and older who took Cymbalta reported more falls, some resulting in serious injuries

What should I do if I think I have taken an overdose of Cymbalta?

If you have taken more Cymbalta than prescribed for you, contact your healthcare provider, a hospital emergency room, or the nearest poison control center immediately.

How should I take Cymbalta?

- Take Cymbalta exactly as directed by your healthcare provider
- Take Cymbalta by mouth. Do not open, break, or chew capsule; swallow it whole
- Cymbalta can be taken with or without food
- If you miss a dose, take it as soon as you remember. However, if it is time for your next dose, skip the missed dose and take only your regularly scheduled dose. Do not take more than the daily amount of Cymbalta prescribed for you
- Talk with your healthcare provider before stopping Cymbalta or changing your dose

General advice about Cymbalta

- Store Cymbalta at room temperature and out of reach of children
- Medicines are sometimes prescribed for purposes other than the ones listed. This medication has been prescribed for your particular condition. Do not use it for another condition or give this drug to anyone else
- If you have any questions or concerns, want to report any problems with the use of Cymbalta, or want more information, contact your healthcare provider or pharmacist

Additional information can be found at www.cymbalta.com.

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PLAN FOR A BETTER WORLD

PHOTO: NEL CEPEDA

In 2007, Pat Minnick decided to establish a charitable gift annuity to support National Geographic. She now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet. She says, "I feel good knowing that National Geographic is doing so much to protect endangered wildlife."

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Two if by Sea

Explorers-in-Residence Enric Sala and Mike Fay are tag teaming in the name of the unprotected oceans. Sala dives and documents, while naturalist Fay walks islands and atolls to assess connections between locals on land and the surrounding seas. The combined data help the duo propose sanctuaries sustainable for people and ocean life under the Pristine Seas project.

In 2012, Pristine Seas and partner Pew Environment Group started a process of protecting the 200 miles around the Pitcairn Islands. At up to 320,000 square miles, it would be one of the world's largest marine reserves, include at least eight new species of fish, and maybe change the way oceans are understood. "Most studies focus on wrecked seas," Sala says. "Places like the Pitcairns show us how oceans can be." *—Johnna Rizzo*

Middle-size predators like the yellow-edged lyretail prowl Oeno Island in the Pitcairns.

ET CETERA

The discovery of a 62-mile **PHYTOPLANKTON BLOOM** beneath Arctic ice surprised scientists who thought sea ice limited the growth of microscopic marine plants. ▪ The largest **3-D MAP OF THE UNIVERSE**, created by the Sloan Digital Sky Survey III, includes galaxies up to six billion light-years from Earth. ▪ **GIRAFFE SPOTS** reveal clues about the animal's age, darkening around puberty, a study found. ▪ A rare copy of a 1507 Martin Waldseemüller world map known as **AMERICA'S BIRTH CERTIFICATE** turned up in Munich.

PHOTO: ENRIC SALA, NGM MAPS


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world beat

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For each surname in the U.S. there are 350 people on average.
In China there are 174,696.

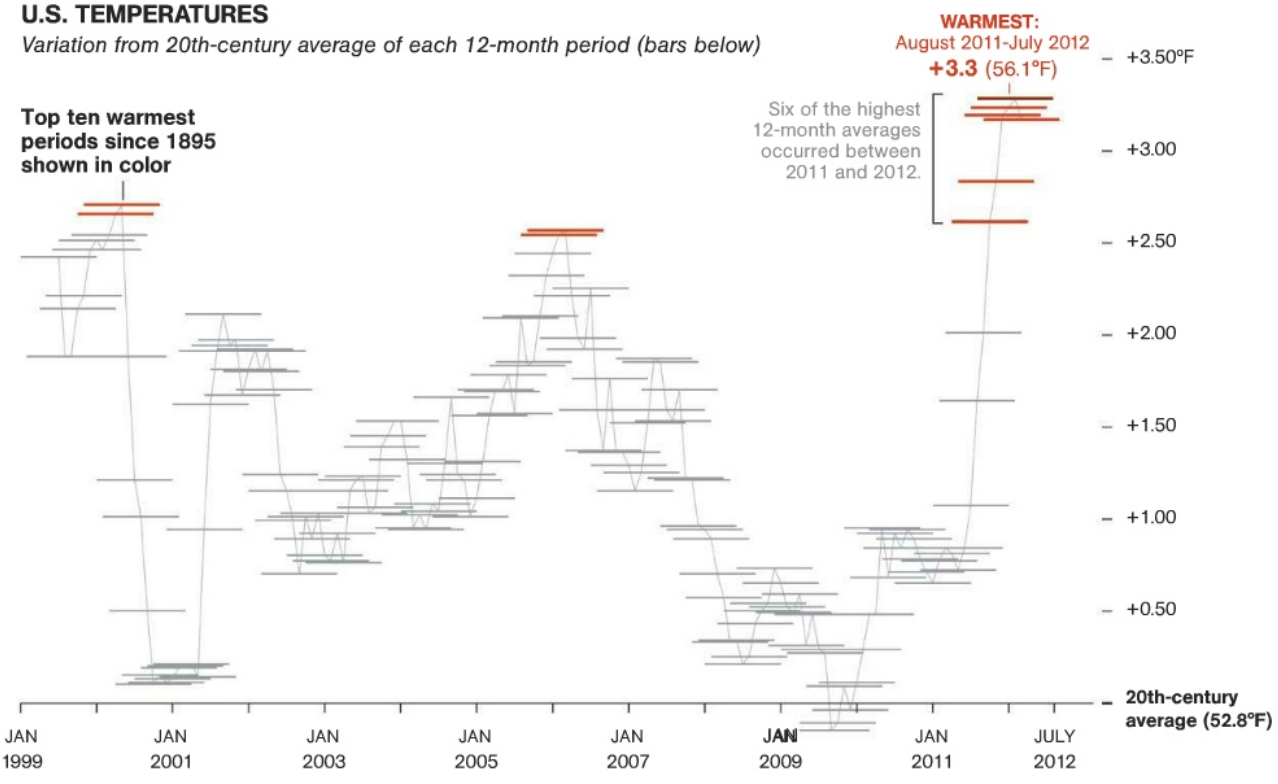
Mercury Rising

This past summer capped the hottest 12-month period on the books in the mainland United States. According to the National Climatic Data Center, it was also part of an unprecedented 15-month stretch (as of August) of above-average temperatures that began in June 2011, surpassing even the scorching Dust Bowl days of the 1930s.

Last year's abnormally mild winter was one reason for the spate of records. Another was a brutal July 2012, which set a new mark as the hottest month (77.6°F average) since record-keeping began in 1895. Don't bet on the trend ending anytime soon: NOAA scientists predict the northern U.S. will remain warmer than usual into 2013. *—Erin Friar McDermott*

U.S. TEMPERATURES

Variation from 20th-century average of each 12-month period (bars below)



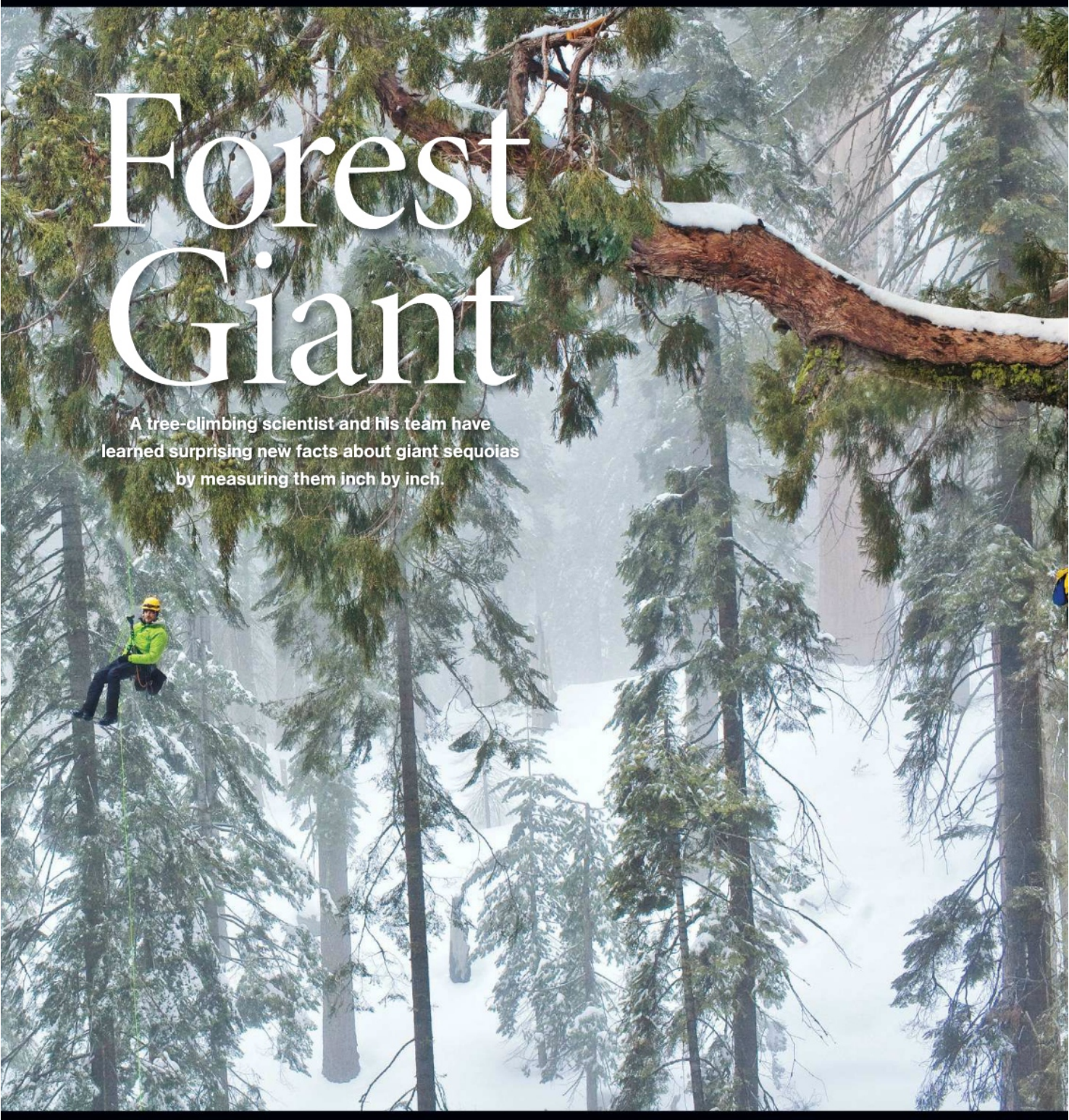
Saving Soap Saves Lives

Where does all that partially used hotel soap and shampoo go after guests leave? Traditionally it went in the trash, but now millions of bars and bottles go to Clean the World, a nonprofit that recycles and redistributes the products globally. The goal: to fend off pneumonia and diarrheal diseases. The leftover bars are melted and sterilized, then pressed into new, fresh cakes. More than 1,600 North American hotels participate in the program, which includes delivery to poor communities—with a side of education. Kids are taught to sing songs, including a Spanish one with the refrain "Wash your hands, healthy children. Wash your hands." *—Catherine Zuckerman*

GRAPHICS: ÁLVARO VALIÑO. SOURCES: YAN LIU, "A STUDY OF SURNAMES IN CHINA THROUGH ISONYMY"; U.S. CENSUS BUREAU (SURNAMES); NOAA (CHART). PHOTO: MIKE KEMP, RUBBERBALL/GETTY IMAGES

Forest Giant

A tree-climbing scientist and his team have learned surprising new facts about giant sequoias by measuring them inch by inch.



Giant sequoias live at high elevations, enduring cold, heavy snows, lightning strikes—and growing bulky and strong, though not so tall as coast redwoods. This individual, the President, is the second most massive tree known on Earth.

The living crown (this one atop the General Sherman, at center) was once a distant mystery. Scientist Steve Sillett's new arboreal studies have yielded revelations, including this: These old trees are still growing fast.

By David Quammen

Photographs by Michael Nichols

On a gentle slope above a trail junction in Sequoia National Park, about 7,000 feet above sea level in the southern Sierra Nevada, looms a very big tree. Its trunk is rusty red, thickened with deep layers of furrowed bark, and 27 feet in diameter at the base. Its footprint would cover your dining room. Trying to glimpse its tippy top, or craning to see the shape of its crown, could give you a sore neck. That is, this tree is so big you can scarcely look at it all. It has a name, the President, bestowed about 90 years ago by admiring humans. It's a giant sequoia, a member of *Sequoiadendron giganteum,* one of several surviving species of redwoods.

It's not quite the largest tree on Earth. It's the second largest. Recent research by scientist Steve Sillett of Humboldt State University and his colleagues has confirmed that the President ranks number two among all big trees that have ever been measured—and Sillett's team has measured quite a few. It doesn't stand so tall as the tallest of coast redwoods or of *Eucalyptus regnans* in Australia, but height isn't everything; it's far more massive than any coast redwood or eucalypt. Its dead spire, blasted by lightning, rises to 247 feet. Its four great limbs, each as big as a sizable tree, elbow outward from the trunk around halfway up, billowing into a thick crown like a mushroom cloud flattening against the sky. Although its trunk isn't quite so bulky as that of the largest giant, the General Sherman, its crown is fuller than the Sherman's. The President holds nearly two billion leaves.

Trees grow tall and wide-crowned as a measure of competition with other trees, racing upward, reaching outward for sunlight and water. And a tree doesn't stop getting larger—as a terrestrial mammal does, or a bird, their size constrained by gravity—once it's sexually mature. A tree too is constrained by gravity, but not in the same way as a condor or a giraffe. It doesn't need to locomote, and it fortifies its structure by continually adding more wood. Given the constant imperative of seeking resources from the sky and the soil, and with sufficient time,

David Quammen's new book, Spillover, *is about zoonotic diseases. Michael Nichols photographed California's giant redwoods for the October 2009 issue.*

The giant sequoia is a snow tree, Sillett says, adapted for long winters in the Sierra. But it's a fire tree too. Thick bark protects it from burning in lightning-caused fires, which open cones and clear the understory, allowing saplings to find light and prosper.

a tree can become huge and then keep growing. Giant sequoias are gigantic because they are very, very old.

They are so old because they have survived all the threats that could have killed them. They're too strong to be knocked over by wind. Their heartwood and bark are infused with tannic acids and other chemicals that protect against fungal rot. Wood-boring beetles hardly faze them. Their thick bark is flame resistant. Ground fires, in fact, are good for sequoia populations, burning away competitors, opening sequoia cones, allowing sequoia seedlings to get started amid the sunlight and nurturing ash. Lightning hurts the big adults but usually doesn't kill them. So they grow older and bigger across the millennia.

Another factor that can end the lives of big trees, of course, is logging. Many giant sequoias fell to the ax during the late 19th and early 20th centuries. But the wood of the old giants was so brittle that trunks often shattered when they hit the ground, and what remained had little value as lumber. It went into shingles, fence posts, grape stakes, and other scrappy products. Given the difficulties of dealing with logs 20 feet thick,

Download our iPad and Kindle Fire editions to watch a video about how these giants were photographed by Michael Nichols and his team.

THE PRESIDENT

Sequoiadendron giganteum

HEIGHT: 247 feet
AGE: at least 3,200 years
DIAMETER AT BASE: 27 feet
TOTAL VOLUME: 54,000 cubic feet

LIMBS The four largest limbs range in diameter from five to nearly seven feet; the largest is about 60 feet long. The tree's total number of branches: 534.

FOLIAGE The scientists who measured every part of the tree estimate it has nearly two billion leaves and more than 82,000 cones. Each cone, the size of a chicken's egg, holds about 200 seeds.

SHAPE The President reached its current height well over a thousand years ago but continues to expand in volume of wood, its crown growing more intricate.

SCARS Fire damage extends 50 feet up one side of the trunk. The top 40 feet of the main trunk, struck by lightning, has been dead for more than a thousand years.

GROVES Sequoias rarely grow in pure stands, but by sheer size they dominate their groves, which hold a variety of tree species.

MARTIN GAMACHE AND MATTHEW TWOMBLY, NGM STAFF
ART: ROBERT VAN PELT, HUMBOLDT STATE UNIVERSITY (HSU)

SOURCES: STEVE SILLETT, HSU; BLM; NATIONAL PARK SERVICE; USGS; BILL KRUSE, KRUSE IMAGING; DWIGHT WILLARD; SIERRA NEVADA ECOSYSTEM PROJECT; D'ARCY TRASK, CYARK

Where the Giants Grow

A slender, 250-mile-long corridor on the western slope of the Sierra Nevada is the giant sequoia's only natural habitat. No tree surpasses it in volume of wood. Fortunately, logging proved impractical, and in 1890 many of the titans gained protection with the creation of Sequoia and Yosemite National Parks.

NORTHERN LIMIT
Only six giant sequoias form this isolated old-growth grove.

Placer County Grove

Reno

Lake Tahoe

39°

SIERRA NEVADA

NEVADA
CALIFORNIA

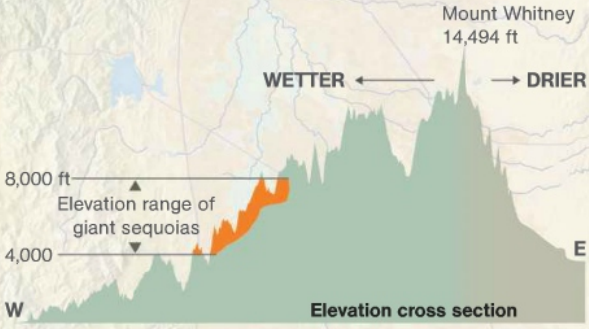
CALAVERAS BIG TREES STATE PARK

SEQUOIA MYSTERY
Scientists remain uncertain why the northern stretch of the range supports only a few scattered groves.

YOSEMITE NATIONAL PARK

Mono Lake

38°

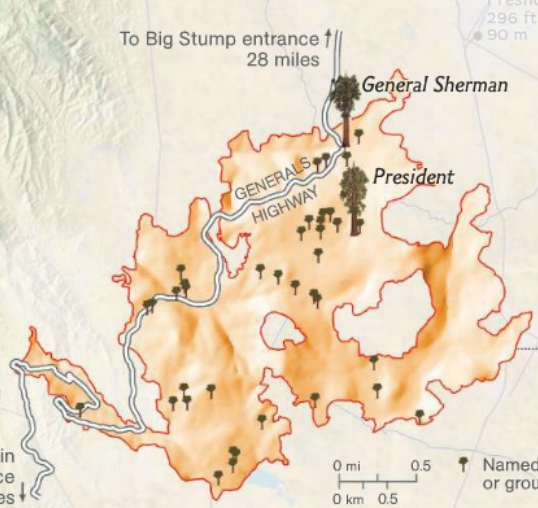


SEQUOIA SWEET SPOT Conditions that suit the tree's growth and reproduction exist in a narrow elevation range. The Sierra's eastern slope is too dry for sequoias, which need rain and the deep moisture of heavy snowmelt.

GROVE DISTRIBUTION
All but 8 of the 67 identified sequoia groves lie south of the Kings River. These southern groves usually hold more—and larger—trees.

Fresno
296 ft
90 m

Bishop



Kings

KINGS CANYON NATIONAL PARK

W
Elevation cross section
E

Giant Forest

Mount Whitney
14,494 ft
4,418 m

SEQUOIA NATIONAL PARK

Giant sequoia grove

0 mi 10
0 km 10
N

TULE RIVER INDIAN RESERVATION

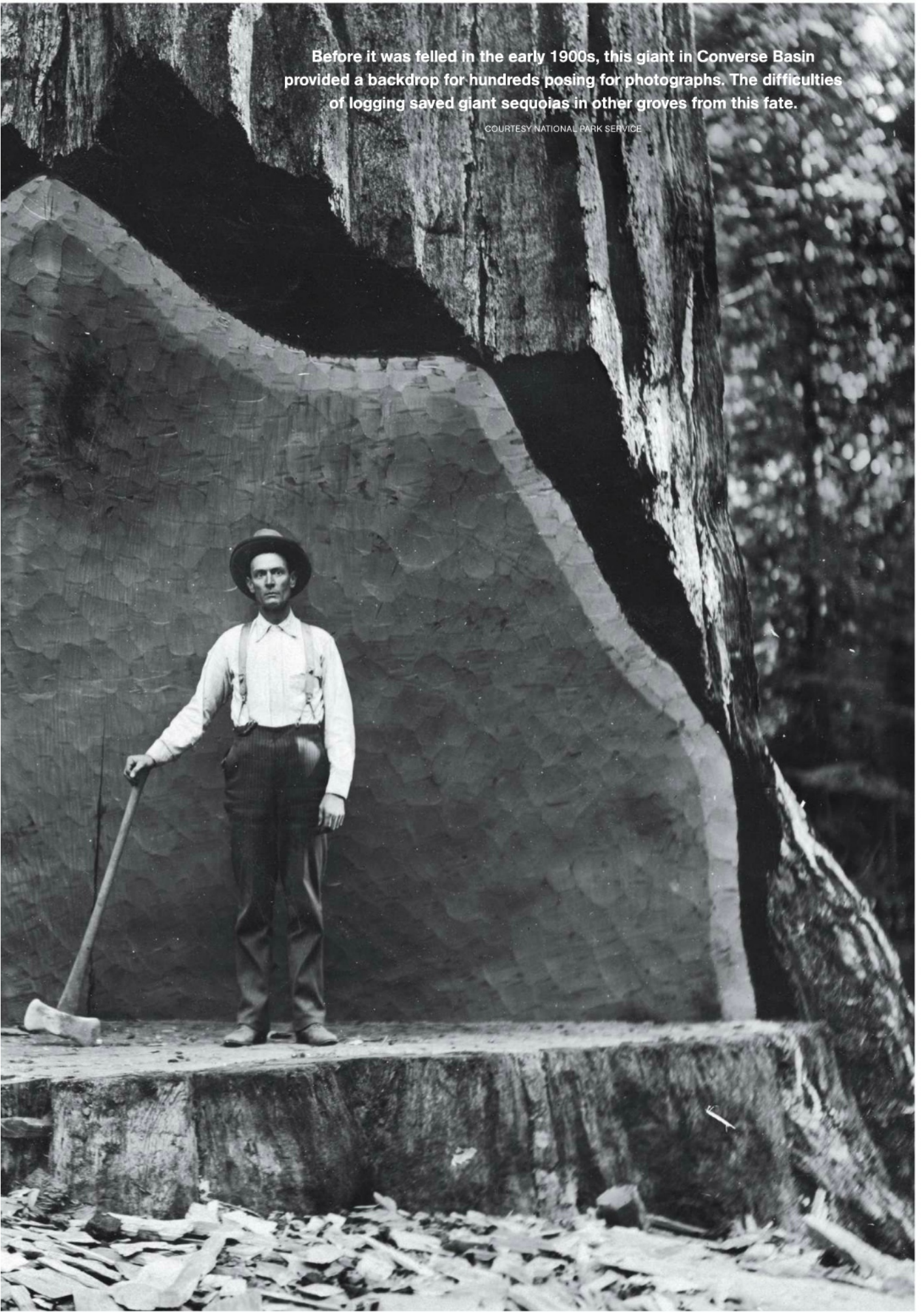
37°

119°

36°

118°W

CATHEDRAL OF TREES The Giant Forest, a grove in Sequoia National Park, protects 41 named sequoias and sequoia groups, including the President and, measuring only slightly bigger, Earth's most massive tree, the General Sherman.



Before it was felled in the early 1900s, this giant in Converse Basin provided a backdrop for hundreds posing for photographs. The difficulties of logging saved giant sequoias in other groves from this fate.

COURTESY NATIONAL PARK SERVICE

broken or unbroken, the trees were hardly worth cutting. Sequoia National Park was established in 1890, and automobile tourism soon showed that giant sequoias were worth more alive.

One thing to remember about them, as Steve Sillett explained to me during a conversation amid the trees, is that they withstand months of frigid conditions. Their preferred habitat is severely wintry, so they must be strong while frozen. Snow piles up around them; it weights their limbs while the temperature wobbles in the teens. They handle the weight and the cold with aplomb, as they handle so much else. "They're a snow tree," he said. "That's their thing."

Among the striking discoveries made by Sillett's team is that even the rate of growth of a big tree, not just its height or total volume, can increase during old age. An elderly monster like the President actually lays down more new wood per year than a robust young tree. It puts that wood around the trunk, which grows wider, and into the limbs and the branches, which grow thicker.

This finding contradicts a long-held premise in forest ecology—that wood production decreases during the old age of a tree. That premise, which has justified countless management decisions in favor of short-rotation forestry, may hold true for some kinds of trees in some places, but not for giant sequoias (or other tall species, including coast redwoods). Sillett and his team have disproved it by doing something that earlier forest ecologists didn't: climbing the big trees—climbing all over them—and measuring them inch by inch.

With blessings and permits from the National Park Service, they performed such high-altitude metrics on the President. This was part of a larger study, a long-term monitoring project on giant sequoias and coast redwoods called the Redwoods and Climate Change Initiative. Sillett's group put a line over the President's crown, rigged climbing ropes into position (with special protectors for the tree's cambium), donned harnesses and helmets, and went up. They measured the trunk at different heights; they measured limbs, branches, and burls; they counted cones; they took core samples using a sterilized borer. Then they fed the numbers through mathematical models informed by additional data from other giant sequoias. That's how they came to know that the President contains at least 54,000 cubic feet of wood and bark. And that's how they detected that the old beast, at about the age of 3,200, is still growing quickly. It's still inhaling great breaths of CO_2 and binding the carbon into cellulose, hemicellulose, and lignin in a growing season interrupted by six months of cold and snow. Not bad for an oldster.

That's the remarkable thing about them, Sillett told me. "Half the year, they're not growing aboveground. They're in the snow." They grow bigger than their biggest compeer, the coast redwood, even with a shorter growing season.

It was fitting, therefore, that Michael (Nick) Nichols made his portrait of the President in snow. Nick and Jim Campbell Spickler, an expert climber and rigger, came up with a plan. With a crew of assistants and climbers drawn heavily from Steve Sillett's team, they arrived in mid-February, when the snowbanks along the plowed road were 12 feet high. They rigged ropes on the President and on a tall nearby tree, both for human ascent and for raising cameras. They waited through blue skies, slushy conditions, and fog until the weather changed and the snow came again and the moment was right. They got the shot. (Actually there were many individual shots, assembled as you see on the poster.) By the time I showed up, they were packing to leave.

Nick had spent more than two weeks commanding this operation, composing the image and engineering it from the ground. But before the last ropes came down, he wanted to climb the tree himself. Not to take photos, he explained. "Just to say goodbye." He put on a harness and a helmet, clipped onto a rope, fit his feet into the loops, clutched the ascender, and up he went.

Society Grant This project was funded in part by your National Geographic Society membership.

We thank Sequoia National Park for its generous cooperation in the production of this article.

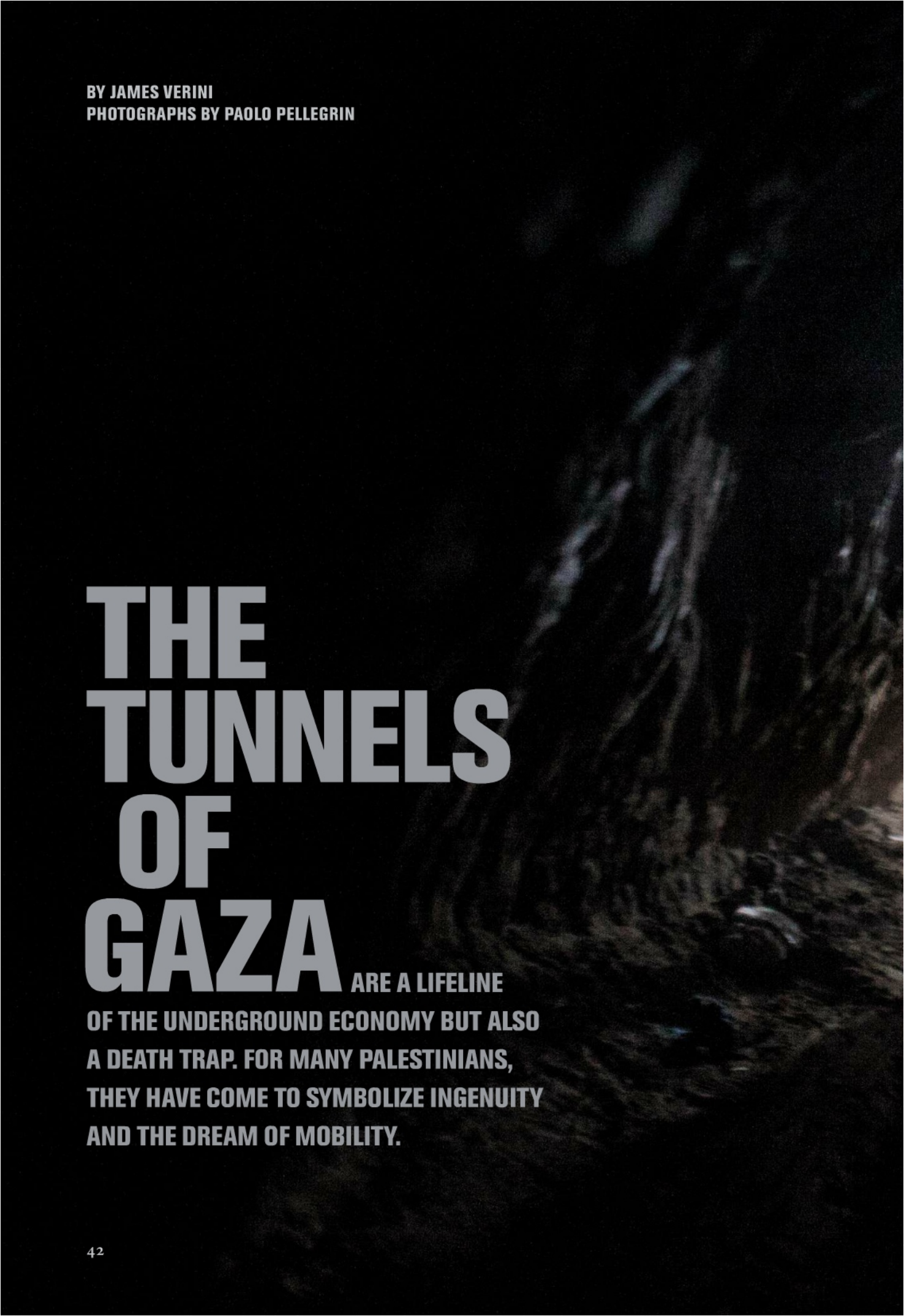
Resolute and anchored in their remote habitat, the giant sequoias withstand the weight of winter snow and many other stresses. They have seen times and trends and peoples come and go; we are merely the latest.

Once Nick was down, I went up myself—slowly, clumsily, with help from Spickler. Ascending, I braced my feet gratefully against the great trunk. I stood for a moment, with Spickler beside me, on one of the huge limbs. After half an hour, I found myself in the crown of the President, 200 feet above the ground. I saw the big burls at close range. I saw the smooth, purplish bark of the smaller branches. All around me was living tree. I looked up, dizzily, noticing small cracks in the deadwood and channels of cambium that flowed between trunk and limbs like a river of life. I thought: What an amazing place. Then I thought: What an amazing creature.

Next afternoon, with Nick and the others gone, I snowshoed back to the President alone. There had been too much to take in, and I wanted another look. For a while I gaped at the tree. It was magnificent. Serene. It didn't sway in the breeze; too solid to sway. I wondered about its history. I contemplated its durability and its patience. The day was warmish, and as I stood there, the President released a small dollop of melting snow from a high branch. The snow scattered as it fell, dissipating into tiny flecks and crystals, catching the light as they tumbled toward me.

"Gesundheit," I said. □

BY JAMES VERINI
PHOTOGRAPHS BY PAOLO PELLEGRIN



THE TUNNELS OF GAZA

ARE A LIFELINE OF THE UNDERGROUND ECONOMY BUT ALSO A DEATH TRAP. FOR MANY PALESTINIANS, THEY HAVE COME TO SYMBOLIZE INGENUITY AND THE DREAM OF MOBILITY.

A worker emerges from one of hundreds of smuggling tunnels that connect the Gaza Strip and Egypt.

FOR AS LONG AS THEY WORKED IN THE SMUGGLING TUNNELS BENEATH THE GAZA STRIP, SAMIR AND HIS BROTHER YUSSEF SUSPECTED THEY MIGHT ONE DAY DIE IN THEM.

When Yussef did die, on a cold night in 2011, his end came much as they'd imagined it might, under a crushing hail of earth.

It was about 9 p.m., and the brothers were on a night shift doing maintenance on the tunnel, which, like many of its kind—and there are hundreds stretching between Gaza and Egypt's Sinai Peninsula—was lethally shoddy in its construction. Nearly a hundred feet below Rafah, Gaza's southernmost city, Samir was working close to the entrance, while Yussef and two co-workers, Kareem and Khamis, were near the middle of the tunnel. They were trying to wedge a piece of plywood into the wall to shore it up when it began collapsing. Kareem pulled Khamis out of the way, as Yussef leaped in the other direction. For a moment the surge of soil and rocks stopped, and seeing that his friends were safe, Yussef yelled out to them, *"Alhamdulillah!*—Thank Allah!"

Then the tunnel gave way again, and Yussef disappeared.

Samir heard the crashing sounds over the radio system. He took off into the tunnel, running at first and then, as the opening got narrower and lower, crawling. He had to fight not to faint as the air became clouded with dust. It was nearly pitch black when he finally found Kareem and Khamis digging furiously with their hands. So Samir started digging. The tunnel began collapsing again. A concrete-block pillar slashed Kareem's arm. "We didn't know what to do. We felt helpless," Samir told me.

After three hours of digging, they uncovered a blue tracksuit pant leg. "We tried to keep Samir from seeing Yussef, but he refused to turn away," Khamis told me. Screaming and crying, Samir frantically tore the rocks off his brother. "I was moving but unconscious," he said. Yussef's chest was swollen, his head fractured and bruised. Blood streamed from his nose and mouth. They dragged him to the entrance shaft on the Gazan side, strapped his limp body into a harness, and workers at the surface pulled him up. There wasn't room for Samir in the car that sped his brother to Rafah's only hospital, so he raced behind on a bicycle. "I knew my brother was dead," he said.

I WAS SITTING WITH Samir, 26, in what passed for Yussef's funeral parlor, an unfinished-concrete room on the ground floor of the apartment block in the Jabalia refugee camp where the brothers grew up. Outside, in a trash-strewn alley, was a canvas tent that shaded the many mourners who had come to pay their respects over the previous three days. The setting was a typical Gazan tableau: concrete-block walls

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Correspondent James Verini is based in Nairobi, Kenya. This is his first story for the magazine. Frequent contributor Paolo Pellegrin lives in Rome.

NGM MAPS

A NEW TUNNEL OWNER, in white cap, watches his son descend into the well shaft to continue digging. Wealthy owners can afford mechanized winches, but this man, who saved for years to get a share of the tunnel trade, must rely on his family and a horse.

pocked by gunfire and shrapnel from Israeli incursions and the bloodletting of local factions, children digging in the dirt with kitchen spoons, hand-cranked generators thrumming—yet another Gaza power outage—their diesel exhaust filling the air.

"I was so scared," Samir said, referring to the day in 2008 when he joined Yussef to work in the tunnels. "I didn't want to, but I had no choice." Thin, dressed in sweatpants, a brown sweater, dark socks, and open-toe sandals, Samir was nervous and fidgety. Like the others in the room, he was chain-smoking. "You can die at any moment," he said. Some of the tunnels Yussef and Samir worked in were properly maintained—well built, ventilated—but many more were not. Tunnel collapses are frequent, as are explosions, air strikes, and fires. "We call it *tariq al shahada ao tariq al mawt,*" Samir said—"a way to paradise or a way to death."

Everybody, it seemed, had injuries or health problems. Yussef had developed a chronic respiratory illness. Khamis's leg had been broken in a collapse. Their co-worker Suhail pulled up his shirt to show me an inches-long scar along his spine, a permanent reminder of the low ceilings. "In Rafah," Samir said, "it felt like a bad omen was present all the time. We always expected something bad to happen."

In the Gaza Strip today hero status is no longer reserved for the likes of Yasser Arafat and Ahmed Yassin—the late leaders, respectively,

LAMB IS A LUXURY most Gazans can afford only on important Muslim holidays. With many farms devastated by war, and with other land lying unproductive in areas restricted by Israel, livestock comes in by tunnel from Egypt.

THIS GAZAN UNIVERSITY STUDENT works in a tunnel, hauling goods to earn money for tuition. Many workers put in 12-hour shifts six days a week—or more—in the cramped spaces. Gas explosions, electrocutions, and Israeli air strikes are common.

of Fatah and the Islamic Resistance Movement, better known as Hamas—or for Palestinians who've died in the fighting that has rocked this wisp of land since its creation 63 years ago. Now tunnel victims like Yussef—28 when he died—are also honored.

"Everybody loved him," Samir said. He was "so kindhearted." On the walls of the makeshift funeral parlor hung posters with Koranic verses of sympathy sent by the family that ran the grade school where Yussef had studied, by the imam of his mosque, and by the local functionaries of Gaza's bitter political rivals: Fatah, the former ruling party, and Hamas, the militant group that now governs the strip. The most prominent poster was from the local mukhtar, a traditional Arab leader. It showed Yussef in a photograph taken five months earlier, on his wedding day. He was wearing a white dress shirt and a pink tie. He had short-cropped hair and eager, gentle eyes. The poster read, "The sons of the mukhtar share condolences with the family in the martyrdom of the hero Yussef."

The Rafah underground isn't new—there have been smuggling tunnels here since 1982, when the city was split following the 1979 Egypt-Israel Peace Treaty, which left part of it in Gaza and part in Egypt. Back then the tunnel well shafts were dug in home basements. The Israeli military, knowing that the tunnels were used for arms trafficking, began demolishing homes that harbored tunnels, as did some Palestinians who

BOXES OF COOKING OIL from Egypt—an essential item in Gazan homes—are stacked at the covered entrance to a tunnel in Rafah. Construction materials such as cement, steel bars, and gravel make up the greatest volume of tunnel imports.

wanted to keep the tunnel economy under their control. When that didn't end the smuggling, Israel later expanded the demolitions, creating a buffer zone between the border and the city. According to Human Rights Watch, some 1,700 homes were destroyed from 2000 to 2004.

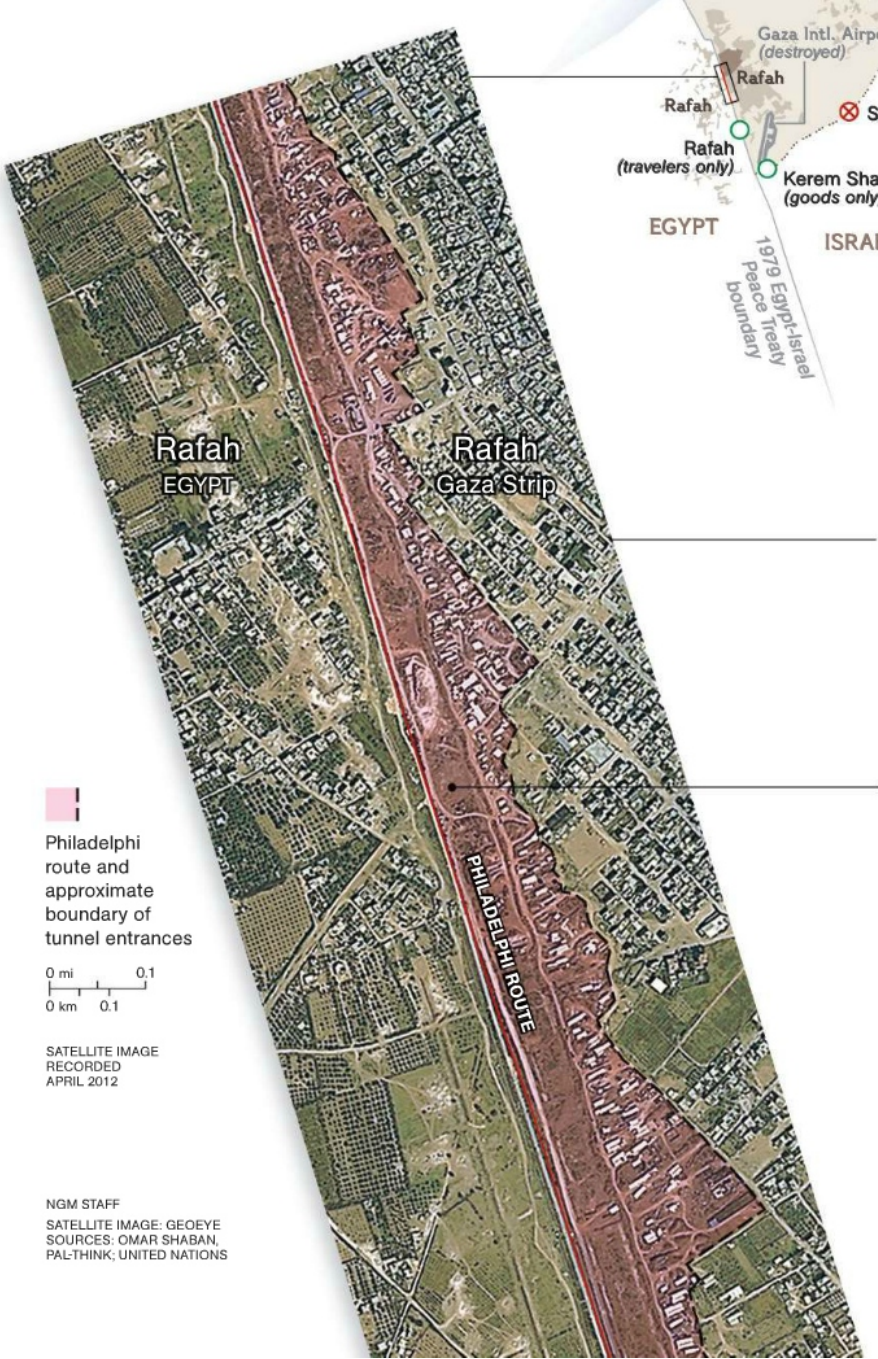
Gaza's tunnels became imprinted on the Israeli public consciousness in 2006, when a group of Hamas-affiliated militants emerged in Israel near a border crossing and abducted Cpl. Gilad Shalit. Shalit became the embodiment of a ceaseless war, his face staring out from roadside billboards much like the faces on martyrdom posters that adorn the walls in Jabalia and the other camps. (He was finally released in a prisoner exchange in the fall of 2011.)

After Hamas won elections in 2006, it and Fatah fought a vicious civil war—which Hamas won the next year, taking control of the Gaza Strip—and Israel introduced an incrementally tightening economic blockade. It closed ports of entry and banned the importation of nearly everything that would have allowed Gazans to live above a subsistence level. Egypt cooperated.

Since Hosni Mubarak's departure in early 2011, Egyptian officials have expressed remorse for cooperating with Israel. Egypt has reopened the small Rafah border crossing, though it still prevents some Gazans from coming through. Its new president, Mohamed Morsi, who wants to keep Hamas at a distance, has not pledged to help Gaza in a way that many Gazans had hoped

GAZA IN BETWEEN

A satellite image of the divided city of Rafah shows the corridor, shaded pink, where white tents mark entrances to some of the hundreds of smuggling tunnels. Two-thirds of goods entering Gaza come from Egypt via the tunnels. Israeli imports come by truck through the Kerem Shalom crossing (map). Because of attacks by Palestinian militants, Israel has blockaded its border as well as Gaza's airspace and 25-mile-long coast since 2007.



Philadelphi route and approximate boundary of tunnel entrances

0 mi 0.1
0 km 0.1

SATELLITE IMAGE RECORDED APRIL 2012

Rafah was split between Egypt and Gaza in 1982, per the 1979 Egypt-Israel Peace Treaty. Israel continued to control Gaza but in 1993 agreed to Gaza's transition to autonomy, withdrawing in 2005.

The Philadelphi route was created as a linear military buffer by the 1979 treaty. In adjacent areas in Rafah, Israel later bulldozed some 1,700 homes suspected of hiding tunnels used to smuggle weapons.

The tunnel economy accelerated as Israel tightened its border blockade. Concerned about militants, Egypt too restricts movement of goods and people and has destroyed some tunnel entrances.

NGM STAFF

SATELLITE IMAGE: GEOEYE
SOURCES: OMAR SHABAN, PAL-THINK; UNITED NATIONS

he would. In August, after a group of 16 Egyptian soldiers were killed by gunmen in northern Sinai, Egypt temporarily shut down the Rafah crossing and demolished at least 35 tunnels.

After Israel introduced the blockade, smuggling became Gaza's alternative. Through the tunnels under Rafah came everything from building materials and food to medicine and clothing, from fuel and computers to livestock and cars. Hamas smuggled in weapons. New tunnels were dug by the day—by the hour, it seemed—and new fortunes minted. Families sold their possessions to buy in. Some 15,000 people worked in and around the tunnels at their peak, and they provided ancillary work for tens of thousands more, from engineers and truck drivers to shopkeepers. Today Gaza's underground economy accounts for two-thirds of consumer goods, and the tunnels are so common that Rafah features them in official brochures.

"We did not choose to use the tunnels," a government engineer told me. "But it was too hard for us to stand still during the siege and expect war and poverty." For many Gazans, the tunnels, lethal though they can be, symbolize better things: their native ingenuity, the memory and dream of mobility, and perhaps most significant for a population defined by dispossession, a sense of control over the land. The irony that control must be won by going beneath the land is not lost on Gazans.

THE REGION OF GAZA has been fought over—and burrowed under—since long before Israel assumed control of it from Egypt in 1967. In 1457 B.C. Pharaoh Thutmose III overran Gaza while quashing a Canaanite rebellion. He then held a banquet, which he enjoyed so much that he ordered chiseled into the Temple of Amun at Karnak: "Gaza was a flourishing and enchanting city." Thutmose was followed by Hebrews, Philistines, Persians, Alexander the Great (whose siege of Gaza City required digging beneath its walls), Romans, Byzantines, Arabs, Tatars, Mamluks, and Ottomans. Then came Napoleon, the British, Egyptians again, and Israelis, though to this day there is disagreement about whether Gaza would have been considered part of the land the Bible says God promised the Jews. This is partly why expansionist-minded Israelis have focused more intensely on the West Bank than on Gaza; the last Israeli settlement in Gaza was vacated in 2005.

But Gaza is the heart of Palestinian resistance. It's been the launching area for a campaign, now in its third decade, of kidnappings, suicide bombings, and rocket and mortar assaults on Israel by Gazan militants—much of this sanctioned, if not expressly carried out, by Hamas.

GAZA HAS BEEN THE LAUNCHING AREA FOR KIDNAPPINGS, SUICIDE BOMBINGS, AND ROCKET AND MORTAR ASSAULTS ON ISRAEL.

The tunnels supply the government with all the materials used in public works projects, and Hamas taxes everything that comes through them, shutting down operators who don't pay up. Tunnel revenue is estimated to provide Hamas with as much as $750 million a year. Hamas has also smuggled in cash from exiled leaders and patrons in Syria, Iran, and Qatar that helps keep it afloat.

Samir told me that Hamas leaders and local officials are in business with tunnel operators, protecting them from prosecution when workers like his brother die needlessly. He's convinced that corruption and bribery are rampant. His friends agreed. "Damn the municipality!" Suhail blurted out as Samir spoke.

In 2010, after Israeli naval commandos attacked a Turkish flotilla off the Gaza coast, to international outrage, Israel said it had relaxed the blockade. But today there is still only one ill-equipped access point for goods, whereas the West Bank has many more. Israel makes it extremely difficult and expensive for the UN's Relief and Works Agency and other aid agencies—the source of life and livelihood for

GAZA CITY APARTMENTS rise beyond the broken gates of a waterfront restaurant. The beach once bustled with fishing boats and cafés, but the Israeli naval blockade, sewage, and lack of resources for rebuilding have taken their toll.

thousands of the 1.6 million Gazans—to import basic materials for rebuilding projects, such as machinery, fuel, cement, and rebar.

According to a Gazan customs official I spoke with, the spring of 2011 saw imports at their lowest level since the blockade began. And what did get through, he said, was often degraded: used clothing and appliances, junk food, cast-off produce. It was impossible "to meet basic needs," the official said, insisting that the *hesar,* or siege, as Gazans call it, was crippling them. Even some of Israel's oldest supporters agreed. British Prime Minister David Cameron lamented that under the blockade, Gaza had come to resemble a "prison camp."

PHOTOGRAPHER PAOLO PELLEGRIN and I made many trips to Rafah's tunnels. The drive from Gaza City, an hour to the north, afforded a dolorous tour. The aftermath of the civil war and of Israel's most recent invasion of the strip—Operation Cast Lead in 2008–09—was evident everywhere. Stepping out of our hotel each morning, often after a night torn open by Israeli air strikes on reported militant hideouts, we took in the absurd sight of a five-story elevator shaft standing alone against the skyline, the hotel that had once surrounded it reduced to rubble. The Palestinian Authority's former security headquarters cowered nearby, a yawning missile hole in its side. Bullet-chewed facades and minarets marked the horizon.

Driving south, we passed Arafat's bombed-out former compound, littered with rusted vehicles, then proceeded along the coastline, once one of the prettiest on the eastern Mediterranean but now home to the skeletons of seaside cafés and to fetid tide pools. Heading inland, we passed abandoned Israeli settlements, their fields sanded over, their greenhouses lying in tatters. South of Rafah the ruins of the Gaza Airport languished as if in a Claude Lorrain landscape—used only by herders grazing their sheep and Bedouin their camels. Our interpreter, Ayman, told us that after the airport was built, he was so proud of it that he took his family there on weekends for picnics. "Look


القسام
شهادة

AT RAFAH'S HECTIC Saturday market, vendors sell everything from flavored water and vegetables to cotton candy. Many goods come through the tunnels from Egypt, but the plump strawberries on display in front of a Hamas billboard are homegrown.


RUST
SECURITY

GAZANS FIX A DONKEY CART for collecting mountains of rubble left in 2008-09 by Operation Cast Lead, a military campaign in Gaza launched by Israel, officially in response to ongoing rocket fire from the strip. Rubble is recycled into gravel for new construction.

THE PLACARD NOTES that Allah will reward those who are patient. The young men are Salafi jihadists with one or more of the radical Islamic splinter groups that call for armed struggle against non-Muslims. They gathered in support of the uprising in Syria.

at the destruction," he said, shaking his head. "Everything. Everything is…destructed." "Destructed" is a favorite malapropism of Ayman's. It's apt. "Destroyed" doesn't quite capture the quality of ruination in Gaza. "Destructed," with its ring of inordinate purpose, does.

As we arrived in Rafah, life teemed again. A byword for conflict, Gaza is also synonymous in Middle Eastern memory with that other staple of human history, commerce. Armies marching into the desert depended on its gushing wells and fortress walls, but to merchants through the millennia, Gaza was a maritime spur of the spice routes and agricultural trade. Travelers sought out its cheap tobacco and brothels, and even today Israeli chefs covet its strawberries and quail. From the 1960s to the late 1980s, Gaza and Israel enjoyed a symbiotic commercial relationship not unlike that of Mexico and the U.S. Gazan craftsmen and laborers crossed the border every morning to work in Tel Aviv and Jerusalem, while Israelis shopped in the tax-free bazaars of Gaza City, Khan Younis, and especially Rafah, which some old Gazans still call Souk al Bahrain: "the market of the two seas." The first intifada, which lasted from 1987 to 1993, put an end to much of that.

Passing a jammed intersection overlooked by a Hamas billboard showing a masked militant wielding a bazooka, we entered the Rafah market. The din and fumes of generators commingled with the shouts of vendors, the braying

of donkeys, and the sweet smoke of *shawarma* spits. Block after block of shops and stands sold consumer items, much of which had come through the tunnels.

It's no secret that Gaza's tunnel operators are brazen, the more so since the Arab Spring began. Just how brazen was not apparent until we emerged from the market, and an expanse of white tarpaulin tent roofs opened up before us. It stretched along the border wall in both directions, tent after tent as far as the eye could see. Beneath each was a tunnel. They were all in the so-called Philadelphi route, the patrol zone created by the Israeli military as part of the 1979 Egypt-Israel Peace Treaty. All were in full view of Egyptian surveillance towers and sniper nests.

Unable to hide my astonishment, I exclaimed to no one in particular, "This must be the biggest smuggling operation on Earth."

Every few hundred yards bored-looking cops barely out of adolescence sat outside tents and shacks, AK-47s on their knees. Hamas forbids journalists here, so we drove to the farthest end of the corridor and parked behind a dirt hill. Furtively, we walked into the first tent we saw. There we met Mahmoud, a man in his 50s who used to work on a farm in Israel. He lost his job when the border was closed during the second intifada, so he and a group of partners pooled their savings. In 2006 they started digging, and a year later they had a tunnel.

After nervous negotiations with Ayman, Mahmoud agreed to show me how it worked. "Come here," he said, leading me to the well shaft. Suspended over it was a crossbar with a pulley, from which hung the harness for lifting and lowering goods and workers. The harness was attached to a spool of metal cable on a winch that could lower a worker the 60 or so feet down the shaft to the tunnel opening. Mahmoud's tunnel was about 400 yards long, but some can extend half a mile. On this day boxes of clothing, mobile phones, sugar, and detergent were coming in; the day before it had been four tons of wheat. Mahmoud earned anywhere from several hundred to a few thousand dollars a shipment, depending on what he brought in. Like many tunnel operators, he made enough to keep his tunnel open and support his family but not much more.

Five to 12 men work in 12-hour shifts, day and night, six days a week, and Mahmoud communicated with them via a two-way radio that had receivers throughout the tunnel. The men earned around $50 a shift but sometimes went weeks or months between payments.

"DESTROYED" DOESN'T QUITE CAPTURE THE QUALITY OF RUINATION IN GAZA. "DESTRUCTED," WITH ITS RING OF INORDINATE PURPOSE, DOES.

On the dirt floor beneath the tarpaulin were dusty cushions where they could rest after a shift. There was also a charred black kettle on the remnants of a wood fire, a strand of prayer beads, and stacks of halved plastic jerricans, the ad hoc sleds that are used to move goods along the tunnel floor.

"Would you like to go down?" Mahmoud asked. Before I could say no, I said yes. Moments later his men were enthusiastically strapping me into the harness and lowering me into the cool, dank well. I tried to imagine what it would be like if this were my daily routine, going to work by descending six stories into the earth at the end of a cable. At the bottom it was chaotic: dim lightbulbs flickering, radio traffic blaring, dust-covered workers hauling sacks out of the sleds. The mouth of the tunnel was large enough to accommodate several stooping men, but it soon became so narrow that I had to crouch, my shoulders scraping the walls.

When I got back to the surface, a group of police suddenly appeared. They had seen our car. "You shouldn't be here," their leader said. Ayman apologized, and soon the officer was regaling me with his account of uncovering a load of cocaine and hashish at a tunnel the day before. Smuggling drugs is lucrative but very risky. They arrested the operator, the officer said, and

SURAQA QUDAIH, 18, WAS KILLED by a missile from an Israeli drone while returning home with two cousins, one of whom was also killed. He was a member of the armed wing of the Popular Resistance Committees, a militant organization.

TWELVE-YEAR-OLD KHAMIS ABU ARAB (at left) was playing outside when he found an undetonated shell. He brought it home, where it exploded in his face. A series of operations in an Israeli hospital removed shrapnel from his eyes but couldn't restore his sight.

MEMBERS OF THE MILITANT GROUP Islamic Jihad patrol the border with Israel to prevent incursions by the Israel Defense Forces. The average Gazan family has six people, and with so few jobs to be had, disaffected young men are drawn to extremist groups.

the well was filled in. He then ordered Paolo and me to go, saying we'd have to get permission from the central government in Gaza City if we intended to come back. "Don't go into the tunnels," another cop warned. "You'll die."

In the tunnels death comes from every direction. One operator told of the time he tried to smuggle in a lion for a Gaza zoo. The animal was improperly sedated, awoke in the tunnel mid-trip, and tore one of the workers apart. Another operator showed me a video on his mobile phone of three skinny young men lying dead on gurneys. They were his cousins, he said, and had worked in his tunnel. I asked why they had no contusions or broken limbs. "They were gassed," was the reply. According to some Palestinians, when Egypt has been pressed by Israel to cut down on smuggling, its troops have occasionally poisoned the air in tunnels by pumping in gas. Egypt has denied this.

AFTER DAYS OF WRANGLING with assorted offices, we returned to the tunnel corridor. Word had spread that an American reporter was snooping around, and even with our official escort, many operators shunned us. But some warmed up.

The most welcoming was Abu Jamil, a white-haired grandfather and the unofficial mukhtar of the Philadelphi corridor. Abu Jamil is credited with having opened the first full-time tunnel. It quickly attracted too much business to be serviced by a well, so he dug an enormous trench

for loading and unloading goods. Abu Jamil had opened several more tunnels, and his sons, grandsons, nephews, and cousins worked for him. He claimed to no longer care about the profit. "For me it's a way to challenge our circumstances," he said, as a dump truck backed into the trench to pick up a load of Egyptian sandstone. Asked what else he's brought in over the years, he smiled wearily. "Oh, everything." By which he meant cows, cleaning supplies, soda, medicine, a cobra for the zoo.

At a tunnel nearby we saw a shipment of potato chips arrive; at another, mango juice; at another, coils of rebar; at another, the familiar blue canisters of cooking gas. We reached one tunnel as 300 dripping Styrofoam boxes filled with fish packed in ice were being unloaded. Taxis and cars sent by restaurants and wives had pulled up to take delivery. The partners who ran this tunnel were young, in their 30s. They specialized in lambs and calves, they said, but fish was cheaper, and since Gazan fishermen were kept within a tight nautical limit by the Israeli Navy, seafood was always in demand.

Just then a man entered the tent and whispered to one of the partners. He didn't want sardines—he wanted to be smuggled into Egypt. This is common. Some Gazans go by tunnel to the Egyptian side of Rafah for medical treatment. Some use the tunnels to escape, others to have a good time for a night. I heard that there were even VIP tunnels for wealthy travelers, with air-conditioning and cell phone reception.

As the two men haggled, there was yelling outside the tent. I rushed out to find a tunnel worker about to punch Paolo. The man was screaming that he didn't want his picture taken. Every time a journalist comes here, he shouted, a tunnel is bombed. How, he yelled, could he tell that we weren't spies? I'd noticed that when Ayman tried to persuade tunnel operators to speak with me, the word "Mossad" was often uttered. They presumed that if Paolo and I weren't with the CIA, we must be with the Israeli spy agency. The tunnel worker's paranoia is understandable, given that Israel's surveillance of Gaza is constant, as the ceaseless buzz of drones overhead attested. And in recent memory, Israeli commandos have entered the tunnel zone. A few, as the Israeli press has documented, died in bomb explosions—booby traps set by Palestinians.

I RUSHED OUT TO FIND A TUNNEL WORKER ABOUT TO PUNCH PAOLO. EVERY TIME A JOURNALIST COMES HERE, THE MAN SHOUTED, A TUNNEL IS BOMBED.

ALTHOUGH UNEMPLOYMENT is endemic—the rate in Gaza is more than 30 percent—the Gaza Strip is full of would-be entrepreneurs. On the shore north of Gaza City, next to bombed-out cafés, fish farms are being built. On the roofs of buildings pockmarked by machine-gun fire, hydroponic vegetable gardens are being planted, and in Rafah, just west of the tunnels, a sewage-processing plant is now running, its pond lined with concrete pylons taken from the border wall.

Yet for the majority of Gazans, the tunnels remain the lifeline. One day in Rafah I met a man who was digging a well with the help of his two sons, using a horse in place of a winch. I asked if he worried about his sons' safety. He said yes, of course. But he had no other job prospects and couldn't afford to keep his sons in school. Fixing me with a skeptical look that suggested all the distance in the world between us, he said curtly, *"Insa."* One of Arabic's beautifully expressive idioms, the word means essentially, "That's life."

Alongside the tunnel economy is another, born of destruction. The UN estimates that Operation Cast Lead created more than half a million tons of rubble, which has become a currency in its own right. It's everywhere, and the rubble collectors are usually teams of children wielding mallets and hammers, breaking down the stuff, sifting it, loading it onto donkey carts, and bringing it to one of the many

AT A BEDOUIN WEDDING in Al Maslakh, a village south of Gaza City, 12-year-old flower girl Hassna Abu Wakid enters the procession to the groom's house. Weddings are still festive public occasions that can last three days.

concrete-block factories that have sprung up. This is how Gazans, unable to legally import construction materials, are rebuilding. A government economist told me that rubble alone accounted for a 6 percent drop in unemployment in 2010.

Gazans are still hopeful that the Arab Spring might bring a change in their circumstances, though so far it has not. There is talk of opening the border with Egypt, but when that might happen, or indeed whether it will at all, is unclear.

The economy of destruction takes on permutations that might have pleased Thutmose III: One night Paolo and I attended a wedding celebration in a bomb crater. It also takes ugly turns: According to an interview in an International Crisis Group report, "a handful of rockets are launched by young militants hired by local merchants whose profits would decline if Israel's closure were further relaxed." This is hideous enough to be believable, but the militants I met were entrepreneurially minded in a more peaceful way. One afternoon I interviewed an Islamic Jihad fighter at a patrol ground near Bayt Hanun. Wearing head-to-toe camouflage and a headband advertising his willingness to die for Allah, an AK-47 in his hands, and a 9-mm pistol strapped to his chest, he admitted that most days he studies business administration at the university. "Jihad is not a job," he said.

Back in Jabalia, I talked with Samir about his future. "There is no chance I can go back to the tunnels," he said. I asked what he'd do instead, and he waved his hand to indicate the room we were sitting in. As it turned out, his brother Yussef had signed a contract to rent this space. When Yussef wasn't working in the tunnels, Samir explained, he was learning to become a beekeeper. He'd planned to open a honey shop here. Samir wanted to take it over in Yussef's stead. And when I last heard from Samir, in September, the shop was up and running. When Yussef died, his wife was three months pregnant with their first child. She miscarried shortly afterward. She is now married to Yussef's youngest brother, Khaled, who manages the honey shop with Samir. They keep a picture of Yussef on the wall. □

ISRAEL'S NAVAL BLOCKADE to stop smuggling of arms and other goods into the strip also restricts Gazans to within three nautical miles of shore. But the sea is one place where Gazans have an open horizon.

A lesser bird of paradise flaunts his flank plumes to entice females.

NINE YEARS AGO, TWO MEN BEGAN

AN EXTRAORDINARY QUEST: TO BE THE FIRST TO FIND

AND DOCUMENT ALL 39 SPECIES OF THE LEGENDARY

BIRDS OF PARADISE.

AFTER 18 EXPEDITIONS AND

OVER 39,000 PHOTOGRAPHS, THEIR VISION IS COMPLETE.

Paradise found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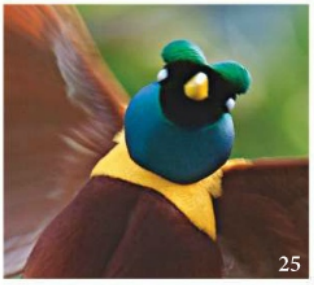
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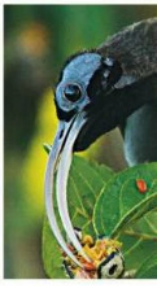
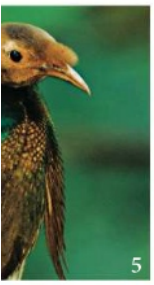
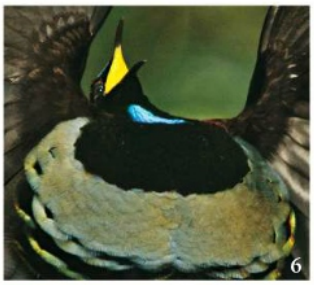
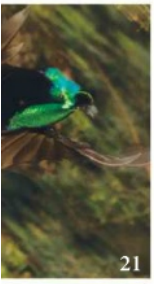




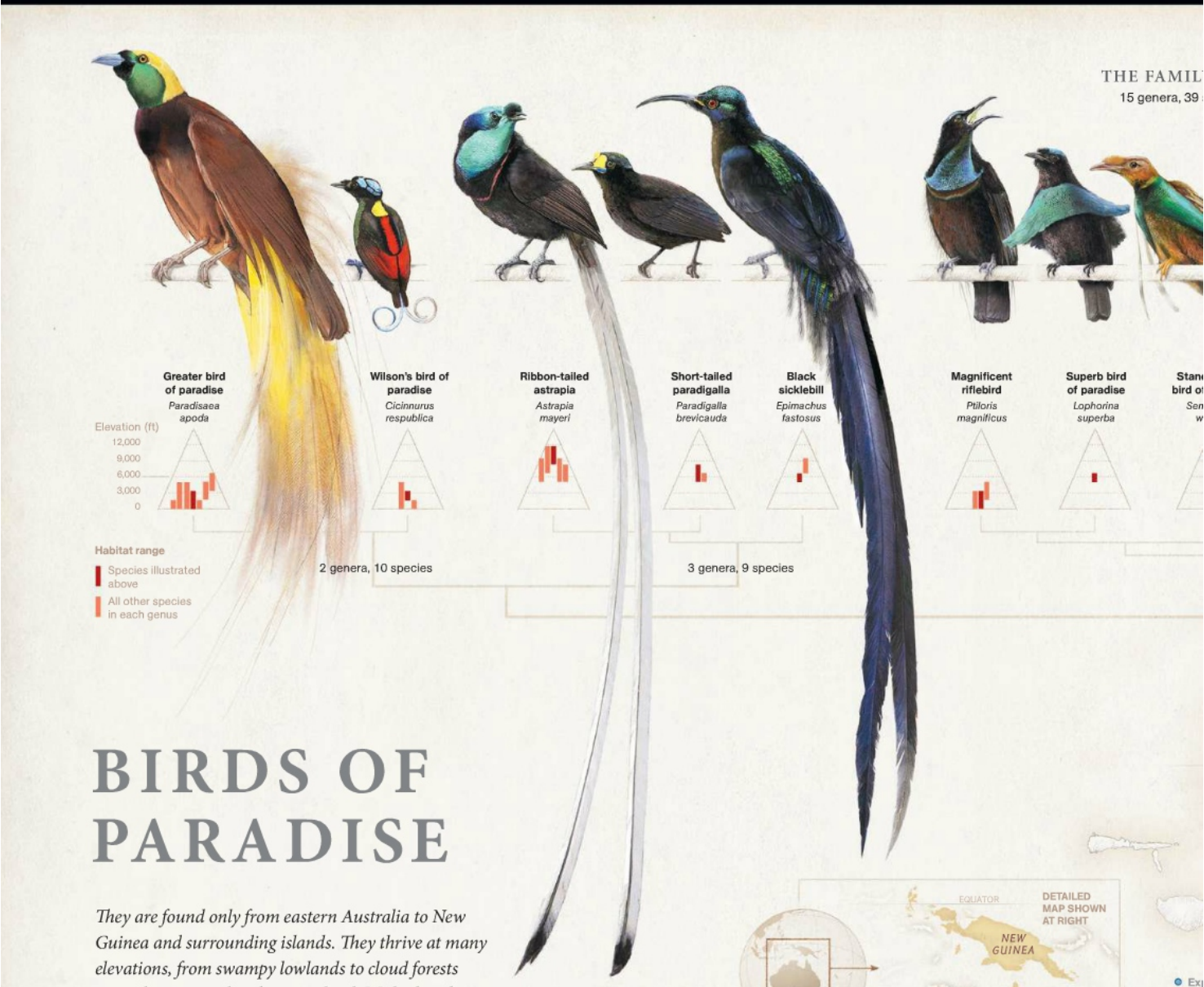




BIRDS OF PARADISE

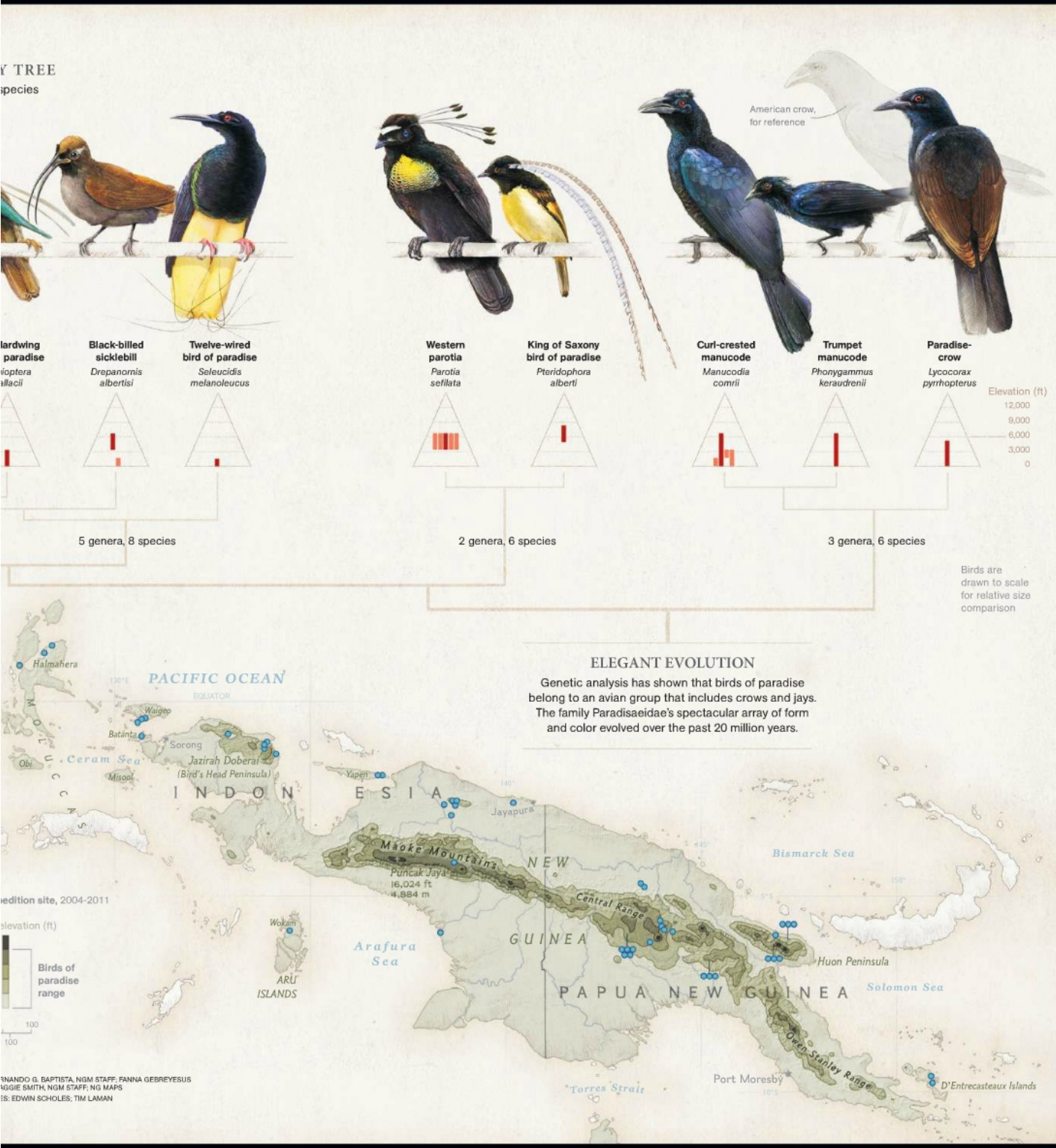
39 SPECIES

1 Huon astrapia **2** Emperor bird of paradise **3** Wahnes's parotia **4** Black-billed sicklebill **5** Standardwing bird of paradise **6** Victoria's riflebird **7** Brown sicklebill **8** Magnificent bird of paradise **9** Lesser bird of paradise **10** Splendid astrapia **11** Arfak astrapia **12** King bird of paradise **13** Crinkle-collared manucode **14** Long-tailed paradigalla **15** Greater bird of paradise **16** Paradise riflebird **17** Carola's parotia **18** Paradise-crow **19** Short-tailed paradigalla **20** Curl-crested manucode **21** Ribbon-tailed astrapia **22** Stephanie's astrapia **23** Twelve-wired bird of paradise **24** King of Saxony bird of paradise **25** Red bird of paradise **26** Trumpet manucode **27** Jobi manucode **28** Goldie's bird of paradise **29** Wilson's bird of paradise **30** Black sicklebill **31** Western parotia **32** Raggiana bird of paradise **33** Bronze parotia **34** Magnificent riflebird **35** Pale-billed sicklebill **36** Superb bird of paradise **37** Glossy-mantled manucode **38** Lawes's parotia **39** Blue bird of paradise



BIRDS OF PARADISE

They are found only from eastern Australia to New Guinea and surrounding islands. They thrive at many elevations, from swampy lowlands to cloud forests more than two miles above sea level. With abundant food, varied habitats, and few predators, the birds have been free to evolve with great diversity. The 39 species can be as small as 8 inches or as large as 49 inches, and plumage ranges from drab to dazzling.


Y TREE
species
American crow, for reference
lardwing paradise
ioptera allacii
Black-billed sicklebill
Drepanornis albertisi
Twelve-wired bird of paradise
Seleucidis melanoleucus
Western parotia
Parotia sefilata
King of Saxony bird of paradise
Pteridophora alberti
Curl-crested manucode
Manucodia comrii
Trumpet manucode
Phonygammus keraudrenii
Paradise-crow
Lycocorax pyrrhopterus
Elevation (ft)
12,000
9,000
6,000
3,000
0
5 genera, 8 species
2 genera, 6 species
3 genera, 6 species
Birds are drawn to scale for relative size comparison
ELEGANT EVOLUTION
Genetic analysis has shown that birds of paradise belong to an avian group that includes crows and jays. The family Paradisaeidae's spectacular array of form and color evolved over the past 20 million years.
Halmahera
PACIFIC OCEAN
EQUATOR
130°E
Waigeo
Batanta
Sorong
Jazirah Doberai (Bird's Head Peninsula)
Obi
Ceram Sea
Misool
INDONESIA
Yapen
Jayapura
Maoke Mountains
Puncak Jaya
16,024 ft
4,884 m
NEW GUINEA
Bismarck Sea
Central Range
Wokam
Arafura Sea
ARU ISLANDS
Huon Peninsula
PAPUA NEW GUINEA
Solomon Sea
Owen Stanley Range
Port Moresby
Torres Strait
D'Entrecasteaux Islands
edition site, 2004-2011
elevation (ft)
Birds of paradise range
100
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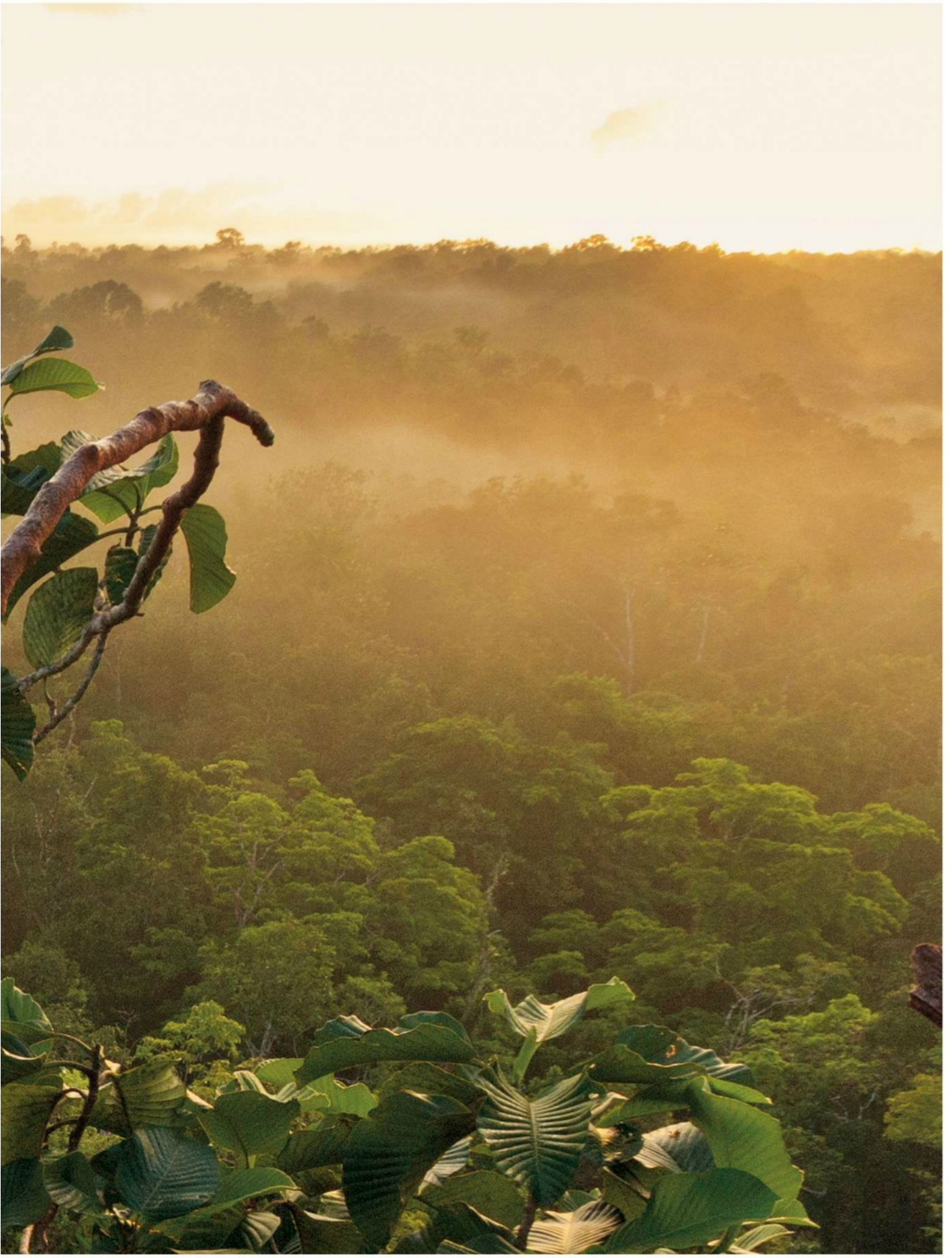
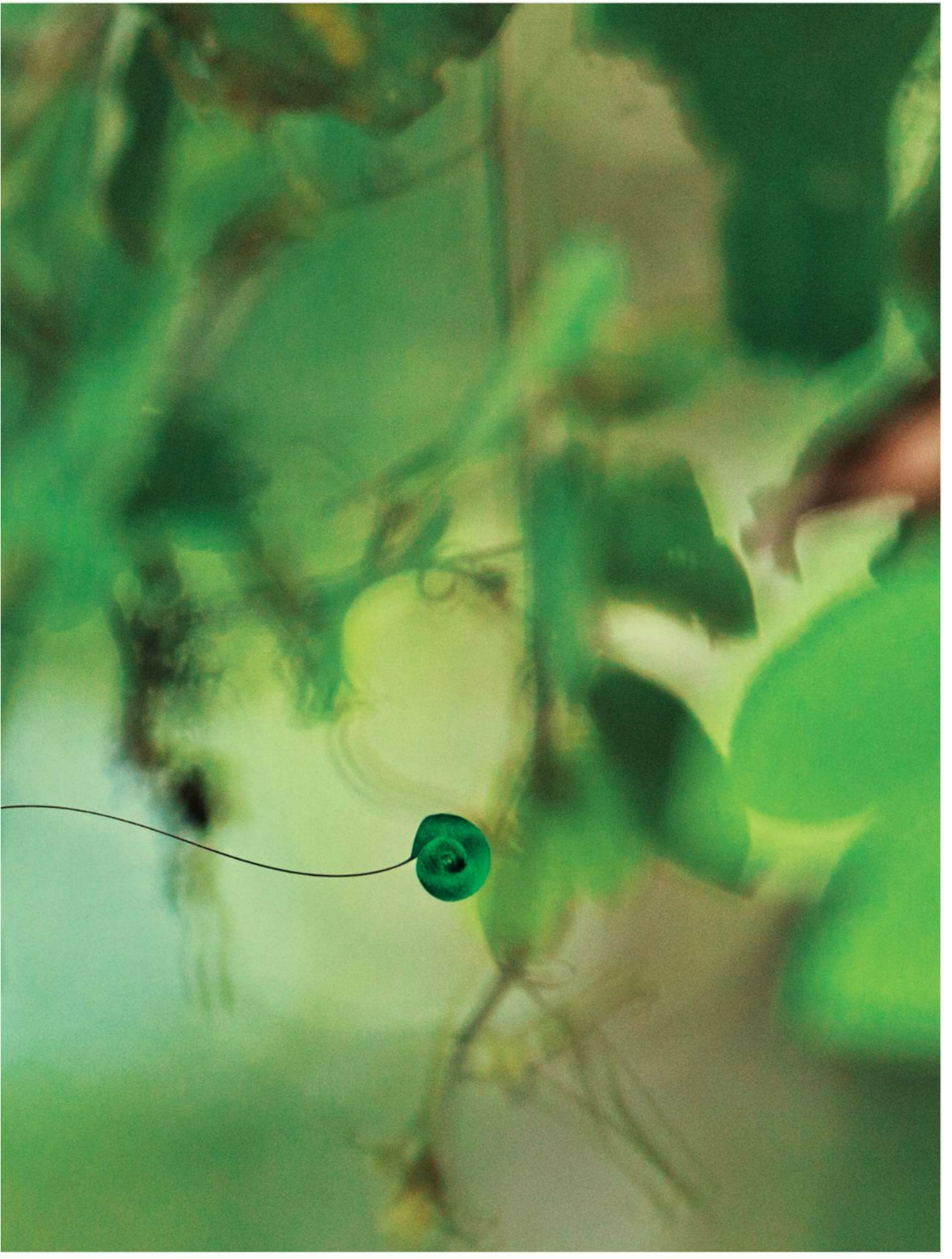
RNANDO G. BAPTISTA, NGM STAFF; FANNA GEBREYESUS
GGIE SMITH, NGM STAFF; NG MAPS
ES: EDWIN SCHOLES; TIM LAMAN



The rising sun spotlights the courtship display of a greater bird of paradise on Wokam Island, south of New Guinea. Males strip leaves from treetop branches to clear the stage for mating rituals.



Constantly trailed by his own flying saucers, a king bird of paradise clings to a vine in the New Guinea rain forest. His vivid colors and bizarre tail feathers evolved from millennia of competition for female favor.

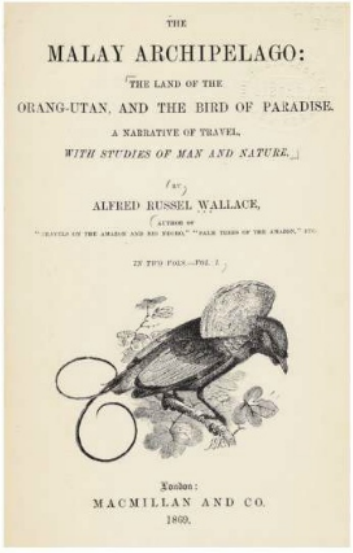
By Mel White

In New Guinea kangaroos climb trees, and butterflies the size of Frisbees dart through rain forests where egg-laying mammals scuttle across the muck. Frogs sport noses like Cyrano's, and the rivers are full of rainbow fish.

Yet none of New Guinea's wild wonders have fascinated scientists as deeply as the creatures that 19th-century naturalist Alfred Russel Wallace called "the most extraordinary and the most beautiful of the feathered inhabitants of the earth": the birds of paradise.

The 39 species are found only in New Guinea and a few nearby areas, and despite decades of exploration and research, no one had ever succeeded in seeing them all—until now.

In 2003 Cornell ornithologist Edwin Scholes and Tim Laman, a biologist and photographer, began planning a quest to document every species of the birds of paradise. It took them eight years and 18 expeditions to some of the planet's most exotic landscapes. With still images,


THE

MALAY ARCHIPELAGO:

THE LAND OF THE

ORANG-UTAN, AND THE BIRD OF PARADISE.

A NARRATIVE OF TRAVEL,

WITH STUDIES OF MAN AND NATURE.

BY

ALFRED RUSSEL WALLACE,

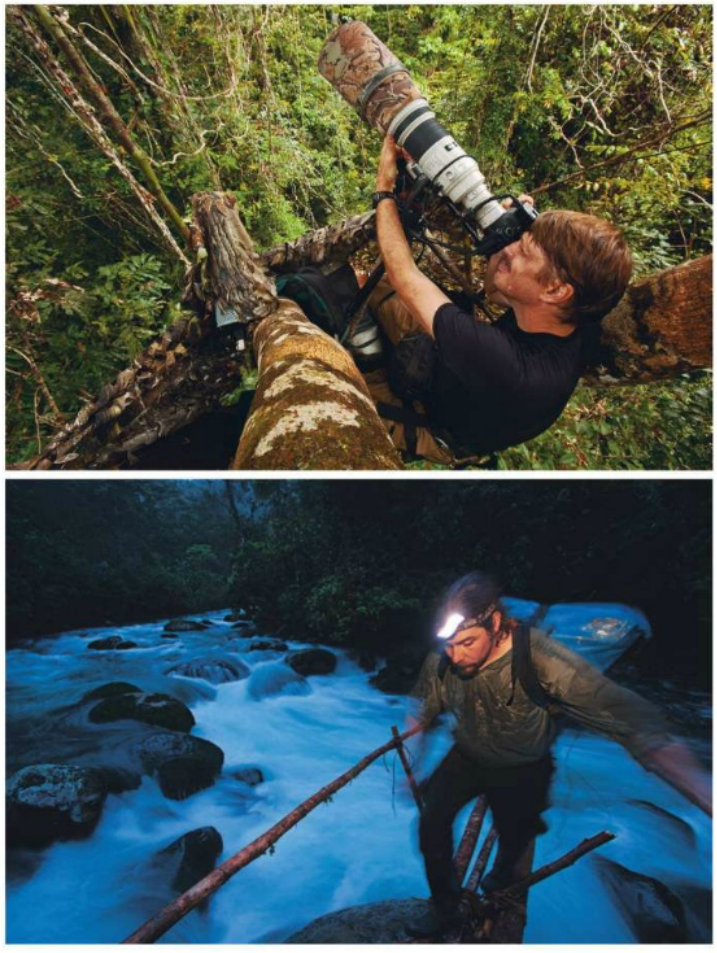
AUTHOR OF

IN TWO VOLS.—VOL. I.

London:

MACMILLAN AND CO.

1869.



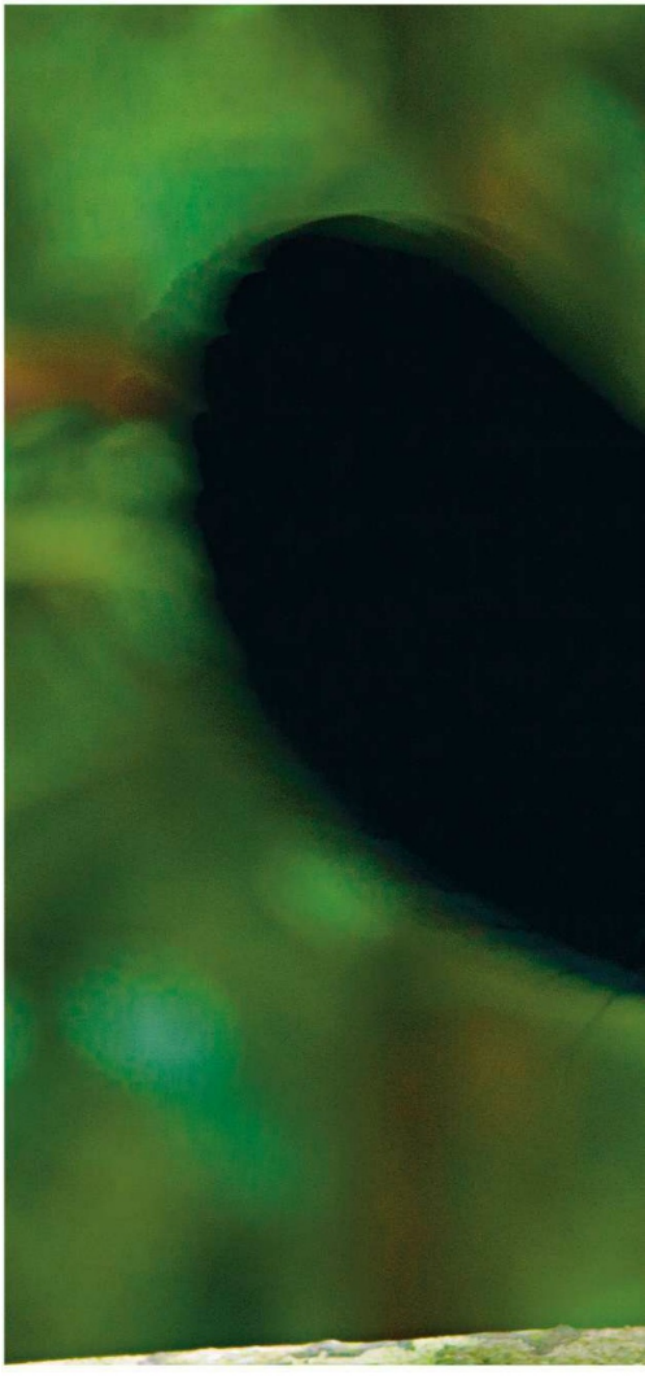
Nineteenth-century explorer Alfred Russel Wallace was among the first to study birds of paradise in the wild. Following in his footsteps, Tim Laman (top right) and Edwin Scholes visited 51 sites. They found the jewel-like Wilson's bird of paradise (left) on Indonesia's Waigeo Island.

PHOTOGRAPHS BY TIM LAMAN

videos, and sound recordings—not to mention old-fashioned notebooks and pens—Scholes and Laman captured courtship displays and behavior previously unknown to science.

The natural world offers few spectacles as bizarre as the mating rituals of the males in the family Paradisaeidae. Explosions of golden plumes, comically stylized dancing, tactile wires like robot antennae, iridescent ruffs and puffs, gorgets and fans, and colors that outshine any gem—all this extravagance has but a single purpose. And that, of course, is to attract the attention of as many females as possible.

Birds of paradise represent an extreme example of Charles Darwin's theory of sexual selection: Females choose mates based on certain appealing characteristics, thus increasing the odds that those traits will pass from one generation to the next. In New Guinea an abundance of food and a scarcity of predators have allowed the birds to flourish—and to exaggerate their most attractive traits to a degree that



A male magnificent riflebird uses what Scholes calls "shape-shifting" to impress a potential mate (above). Rapid head-wagging transforms the bird's iridescent breast shield into a glittering advertisement of sexual fitness.

Society Grant This project was funded in part by your National Geographic Society membership, and through a partnership with the Cornell Lab of Ornithology.

even literal-minded scientists have called absurd.

The brilliant plumes have been prized as decorative objects in Asia for thousands of years. Hunters who traded the first specimens to Europeans in the 16th century often removed the birds' wings and legs to emphasize plumes. This inspired a notion that they were literally the birds of the gods, floating through the heavens without ever alighting, gathering sustenance from the paradisiacal mists.

In the 21st century Laman and Scholes set a goal of documenting the birds in a way that people have never seen them before: from the females' perspective. On Batanta Island, west of New Guinea, Laman climbed 165 feet into the rain forest canopy to photograph the mating ritual of the red bird of paradise. On the Huon Peninsula, 1,200 miles east, he mounted a camera pointing down from a tree branch to get a female's view of the colorful breast feathers and ballerina-like "tutu" of a male Wahnes's parotia.

Though both men had experience in the

Hear the birds' calls and watch them dance on our iPad and Kindle editions.

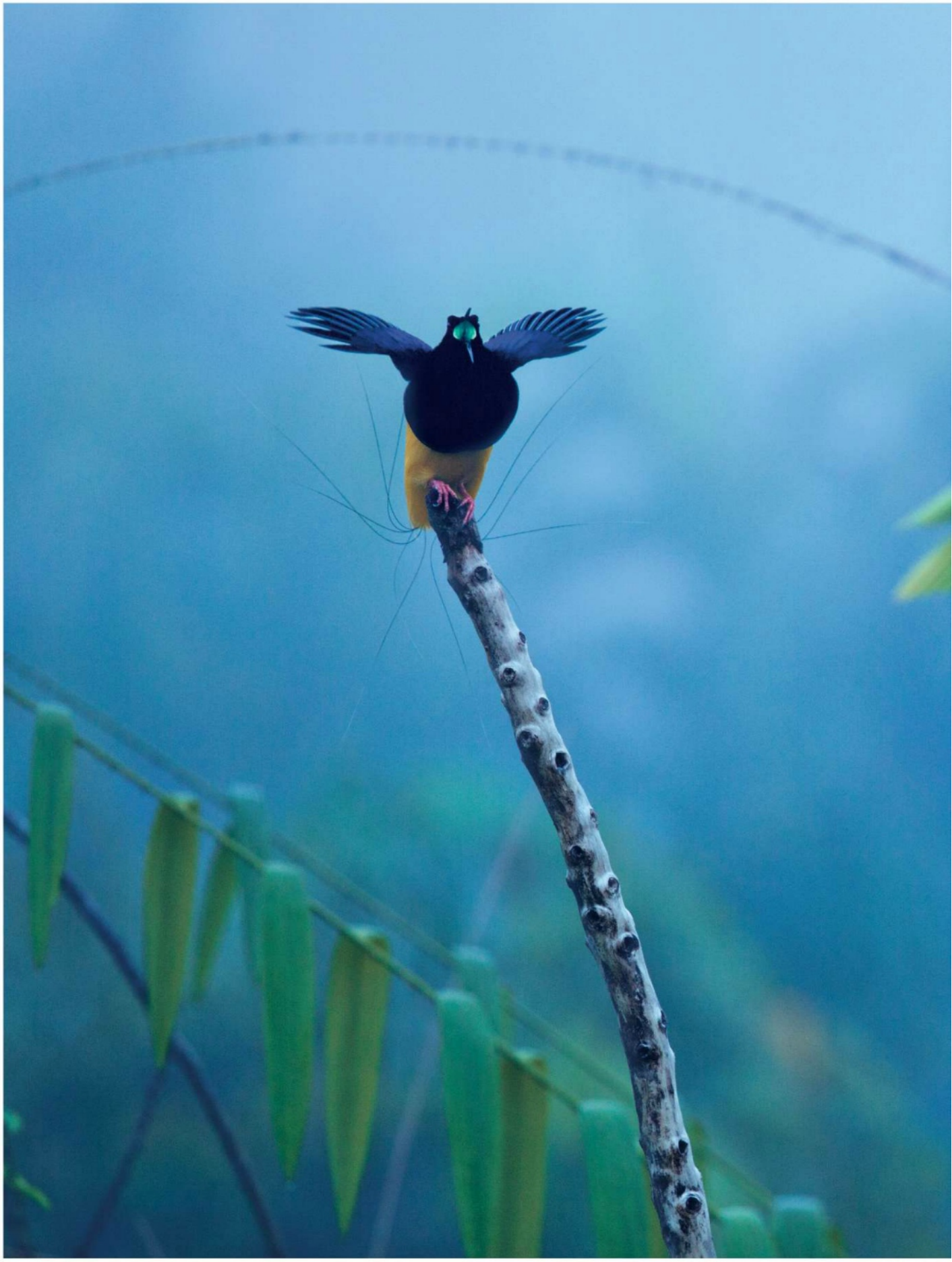
tropics before they began their endeavor, neither could have anticipated the adventure that awaited. They endured harrowing helicopter rides and long treks along flooded trails, and twice found themselves adrift at sea when boat engines failed. In exchange for moments of thrilling discovery, such as the first view of the Arfak astrapia's upside-down courtship posture, they logged a total of over 2,000 hours simply sitting in blinds, waiting and watching.

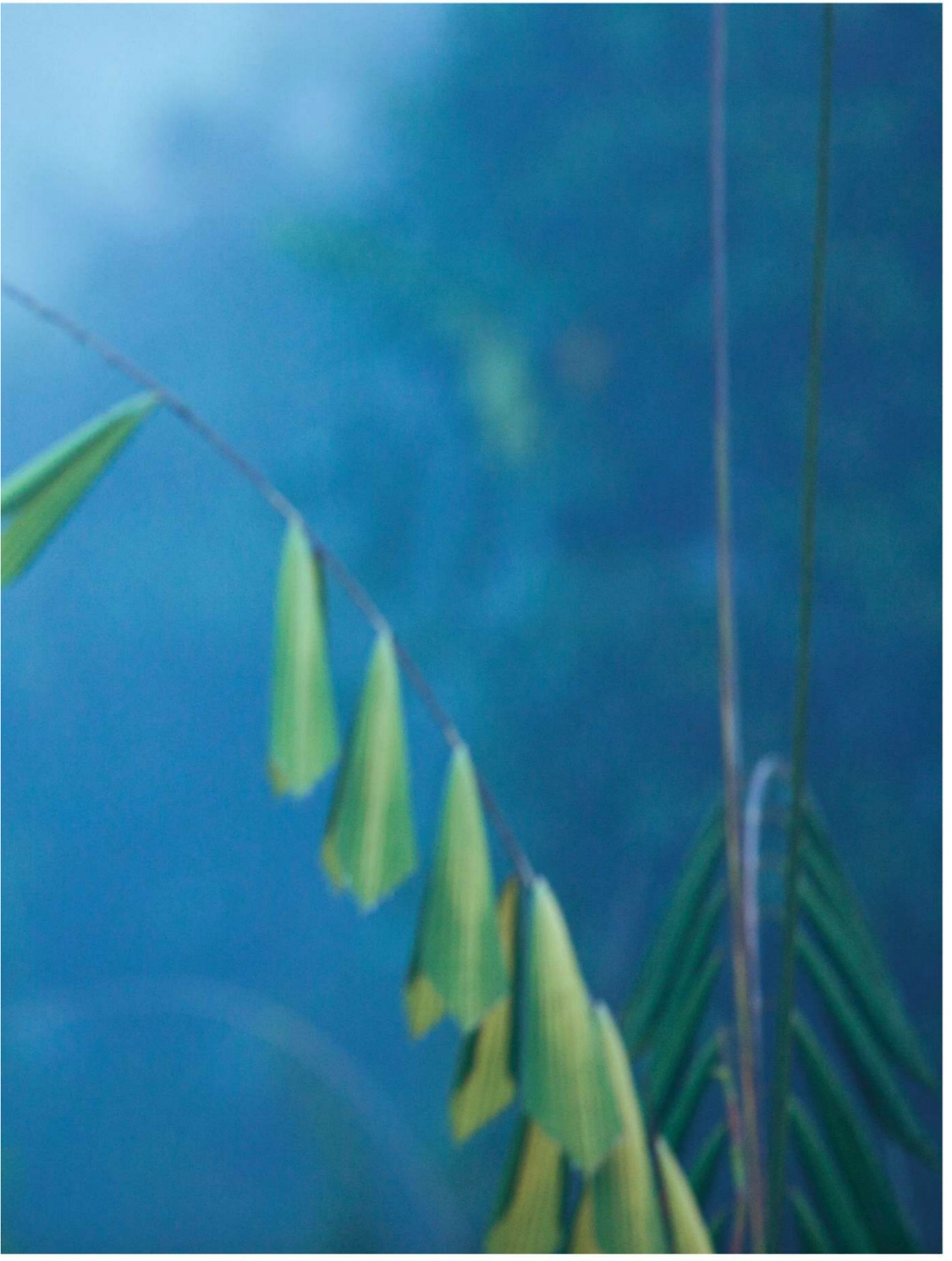
The sight of a glossy blue-black Jobi manucode marked the quest's end in June 2011. Scholes and Laman hope their work will encourage conservation in New Guinea, where the birds' habitat has so far been protected by its sheer remoteness. As Wallace wrote: "Nature seems to have taken every precaution that these, her choicest treasures, may not lose value by being too easily obtained." □

Mel White writes frequently about natural history. Tim Laman and Edwin Scholes co-authored a new National Geographic book: Birds of Paradise.

Watch *Winged Seduction: Birds of Paradise* on **National Geographic Channel.** Check local listings.

Special muscles let the King of Saxony bird of paradise swing each antenna-like head feather through a 180-degree arc during courtship. Rows of miniature pennants decorate plumes that can grow to 20 inches.





A twelve-wired bird of paradise calls in a New Guinea swamp. Males brush the dozen stiff feather shafts on their lower torsos against females' faces before mating. Scientists aren't sure why—perhaps it tickles.

BURN NATURAL GAS AND IT WARMS YOUR HOUSE. BUT LET IT LEAK, FROM FRACKED WELLS OR THE MELTING ARCTIC, AND IT WARMS THE WHOLE PLANET.

GOOD GAS BAD GAS

Methane is bubbling from lakes all over the warming Arctic. Here ecologist Katey Walter Anthony (right) ignites a large bubble that was trapped by the fall freeze—then freed by an ice pick.

The tree sap that engulfed the termite above and then hardened into amber also preserved the methane bubbling from its hind end. Termites and their wood-digesting gut microbes emit millions of tons of methane each year.

Fuel of the future or climate bomb? A clump of icelike methane hydrate melts at room temperature and sea-level pressure, releasing the ignitable gas inside. The stuff is stable only under the seafloor or under Arctic permafrost, where there are vast deposits.

THE LAST RAYS OF SUN FILTER THROUGH THE SNOW-COVERED SPRUCES ALONG THE SHORE OF GOLDSTREAM LAKE, JUST OUTSIDE FAIRBANKS, ALASKA.

Out on the lake Katey Walter Anthony stares at the black ice beneath her feet and at the white bubbles trapped inside it. Large and small, in layer upon layer, they spread out in every direction, like stars in the night sky. Walter Anthony, an ecologist at the University of Alaska Fairbanks, grabs a heavy ice pick and wraps the rope handle around her wrist. A graduate student holds a lighted match above a large bubble; Walter Anthony plunges the pick into it.

Gas rushing from the hole ignites with a *whoomp* that staggers her. "My job's the worst, because usually you catch on fire," she says, smiling. In the gathering twilight she and her team ignite one bubble after another.

The flames confirm that the bubbles are methane, the main component of natural gas. By counting and measuring them, Walter Anthony is trying to gauge how much methane is rising from Goldstream Lake—and from the millions of similar lakes that now occupy nearly a third of the Arctic region. The Arctic has warmed much faster than the rest of the planet in recent decades, and as the permafrost has melted, old lakes have grown and new ones have formed. Methane bubbles from their muddy depths in a way that is hard to quantify—until the first clear ice of fall captures a snapshot of the emissions from an entire lake.

Sometimes as Walter Anthony walks that ice, in Alaska, Greenland, or Siberia, a stamp of her boot is enough to release an audible sigh. Some lakes, she says, have "hot spots" where the methane bubbling is so strong that ice never forms, leaving open holes big enough to spot from an airplane. "It could be 10 or 30 liters of methane per day from one little hole, and it does that all year," she says. "And then you realize there are hundreds of spots like that and millions of lakes."

By venting methane into the atmosphere, the lakes are amplifying the global warming that

BY MARIANNE LAVELLE
PHOTOGRAPHS BY MARK THIESSEN

created them: Methane is a potent greenhouse gas. Carbon dioxide is the main one, because the atmosphere holds 200 times as much of it. But a given amount of methane traps at least 25 times as much heat—unless you burn it first. Then it enters the atmosphere as CO_2.

That's the other side of this Jekyll-and-Hyde story: A lot of methane is being burned these days. In the past decade the technology called hydraulic fracturing, "fracking" for short, has enabled drillers in the United States to extract natural gas from deeply buried shales they couldn't tap before. Natural gas supplies have surged; prices have plummeted. Fracking is now spreading around the world, and it's controversial. The gas boom has degraded landscapes and polluted water. But it has also had environmental benefits. Natural gas burns much cleaner than coal. In part because American power plants have been switching from coal to cheap gas, U.S. emissions of CO_2 from fossil fuels fell last year, even as the world set another record.

The catch is, methane emissions are rising. What's coming out of Arctic lakes is troubling, Walter Anthony says, because some of it seems to be coming not from bottom mud but from deeper geologic reservoirs that had hitherto been securely capped by permafrost—and that contain hundreds of times more methane than is in the atmosphere now. Still, most methane emissions today come from lower latitudes, and most are related more directly to human activities. A growing amount seems to be leaking, for instance, from gas wells and pipelines. Just how warm Earth gets this century will hinge in part on how we balance the good and bad of methane—on how much of it we capture and burn, and how much we inadvertently let loose.

METHANE is the simplest hydrocarbon—a single carbon atom surrounded by four hydrogen atoms. It usually forms when larger organic molecules are broken down, either by microbes or by heat. The microbes produce it when they eat dead plant matter in wet, oxygen-poor environments. They're the source of the methane bubbling up from Goldstream Lake; from swamps and marshes all over; from human-made rice fields, landfills, and manure lagoons; and from the stomachs of cows and other ruminants. Termites emit a lot of methane too.

Most of the natural gas we tap for fuel, however, was formed not by microbes but by heat and pressure deep underground—as oil and coal were, and often in the same places. In coal mines methane is an explosion hazard; in oil fields it was long considered a nuisance to be burned off or, worse, vented directly into the atmosphere. Liquid oil was more valuable as fuel and much easier to transport to markets. Then pipelines built during the post–World War II construction boom made gas more transportable. The energy industry began to exploit massive natural gas reservoirs in places like Russia, Qatar, and Iran.

The United States produces the bulk of its own gas, but U.S. production peaked in 1973. By 2005 the country seemed to be running short, and the industry was building expensive new tanker terminals to import liquefied natural gas. The fracking boom changed that. Since 2005 gas production from deep shales has increased more than tenfold; it now accounts for more than a third of total production, which last year surpassed the 1973 record. Within a decade, according to a Department of Energy (DOE) forecast, the U.S. will become a net exporter of gas.

Estimates of how much gas is locked up in shales and how long the boom can last have varied widely. In 2011 DOE put the amount of "unproved resources" of shale gas at 827 trillion cubic feet; in 2012 it cut that estimate by more than 40 percent. Production from fracked wells has declined faster than DOE analysts had expected. So some critics believe the boom is a bubble that will soon burst. But DOE still projects that U.S. gas production will rise rapidly and that shale gas will make up half the total by 2035.

And deep shales are not the last methane source. DOE and the industry are trying to

Marianne Lavelle is the energy editor at national geographic.com. *Staff photographer Mark Thiessen has a professional fascination with fire.*

THE SHALE BOOM

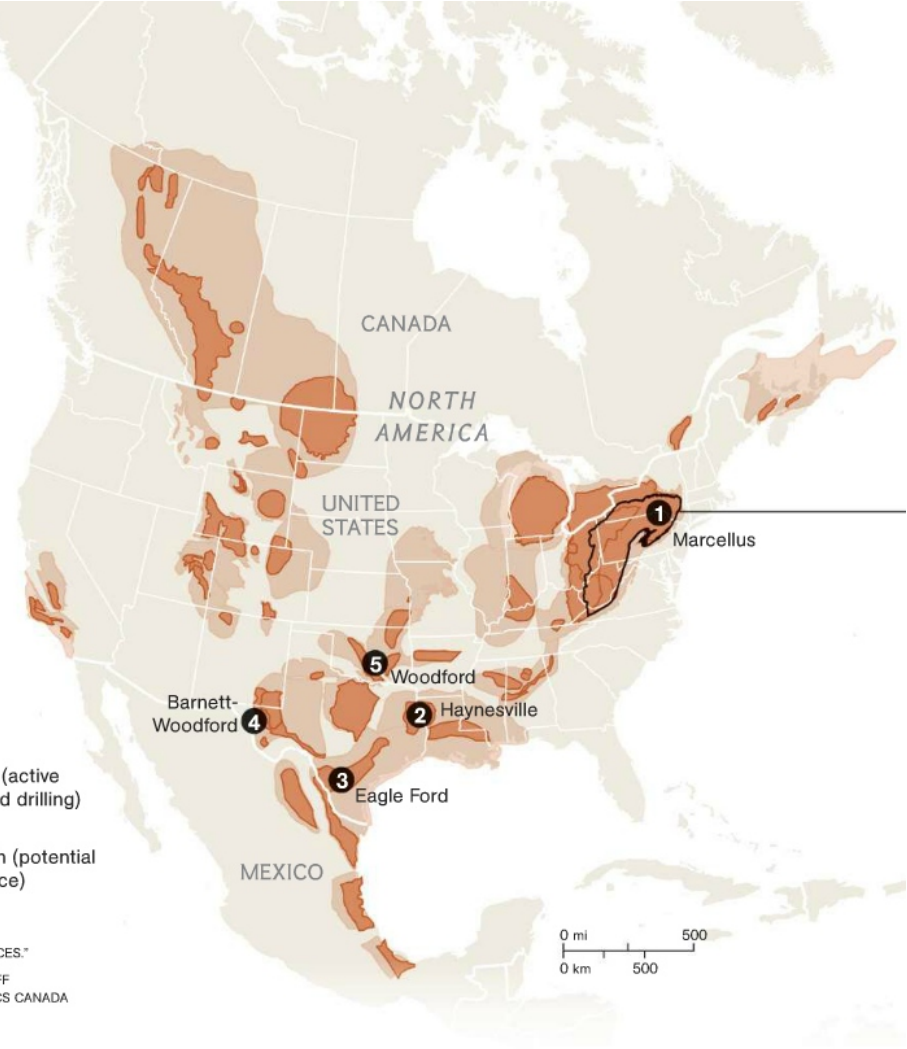
The technology for pulling natural gas from deep shale, refined in the 1990s in Texas, has since spread to other "plays"—parts of a shale basin where large quantities of gas have been found. More than a third of U.S. gas now comes from shale.

Richest shale deposits
Recoverable gas, in trillion cubic feet (tcf)
Total for continental U.S. **542***

1. Marcellus	**141**
2. Haynesville	**66**
3. Eagle Ford	**50**
4. Barnett-Woodford	**27**
5. Woodford	**24**

Shale play (active or expected drilling)

Shale basin (potential gas resource)



ONE TCF CAN HEAT 15 MILLION HOMES FOR A YEAR.
*TOTAL INCLUDES "PROVED RESERVES" AND "UNPROVED RESOURCES."

VIRGINIA W. MASON, NGM STAFF; ALEXANDER STEGMAIER, NG STAFF
SOURCES: U.S. EIA; FRACTRACKER; U.S. CENSUS BUREAU; STATISTICS CANADA

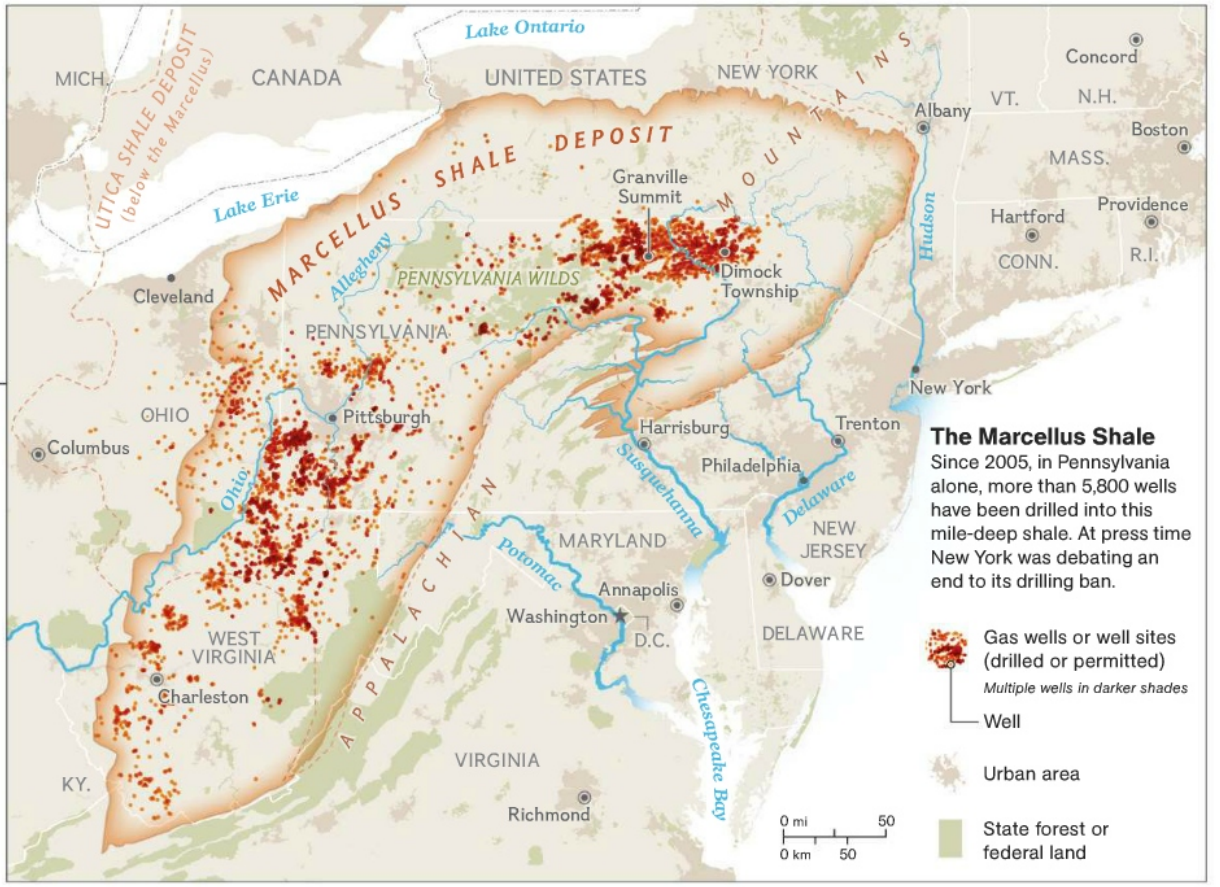
figure out how to tap the largest one of all—the methane hydrates that lie frozen under vast areas of seafloor and Arctic permafrost. Worldwide, hydrates may contain more energy than all other fossil fuels combined. They're usually snow-white and look like ice, but they're strange stuff, and extracting the methane is tricky. Each molecule is trapped in a cage of water molecules that's stable only at high pressure and low temperatures; change either just a bit, and the cage crumbles. The escaping methane balloons in volume by a factor of 164.

Oil companies working on continental margins have to take care that extracting oil through an overlying hydrate layer does not disrupt it and perhaps damage the well. Climate scientists worry that global warming could destabilize hydrate layers, on land or at sea, triggering a massive methane release that would amplify the warming. A few scientists take seriously a catastrophic scenario in which the release happens rapidly, within a human lifetime, and the planet's temperature spikes.

The atmospheric methane concentration has risen nearly 160 percent since preindustrial times, to 1.8 parts per million. For a few years, from 1999 to about 2006, it seemed to level off. Some researchers credit Asian rice farmers, who began draining their paddies during the growing season to conserve water—which reduced methane emissions as well. Another theory credits the oil industry, which started capturing and selling methane it used to simply vent. Since 2006, though, atmospheric methane has been rising again. Many observers believe it's no coincidence that the number of wells punched into deep shales has been soaring too.

THE LARGEST U.S. shale formation, the Marcellus, lies about a mile under the Appalachian Mountains, in an arc that runs from West Virginia to New York through Ohio and Pennsylvania. The Pennsylvania stretch is pretty country: rolling hills and pastures and, in the northwest, the forests of the Pennsylvania Wilds, which boast some 2,000 trout streams and one of the darkest night skies in the East.

These days tank trucks, sand haulers, flatbeds stacked with pipe, and cement mixers rumble continually over the winding two-lane roads.



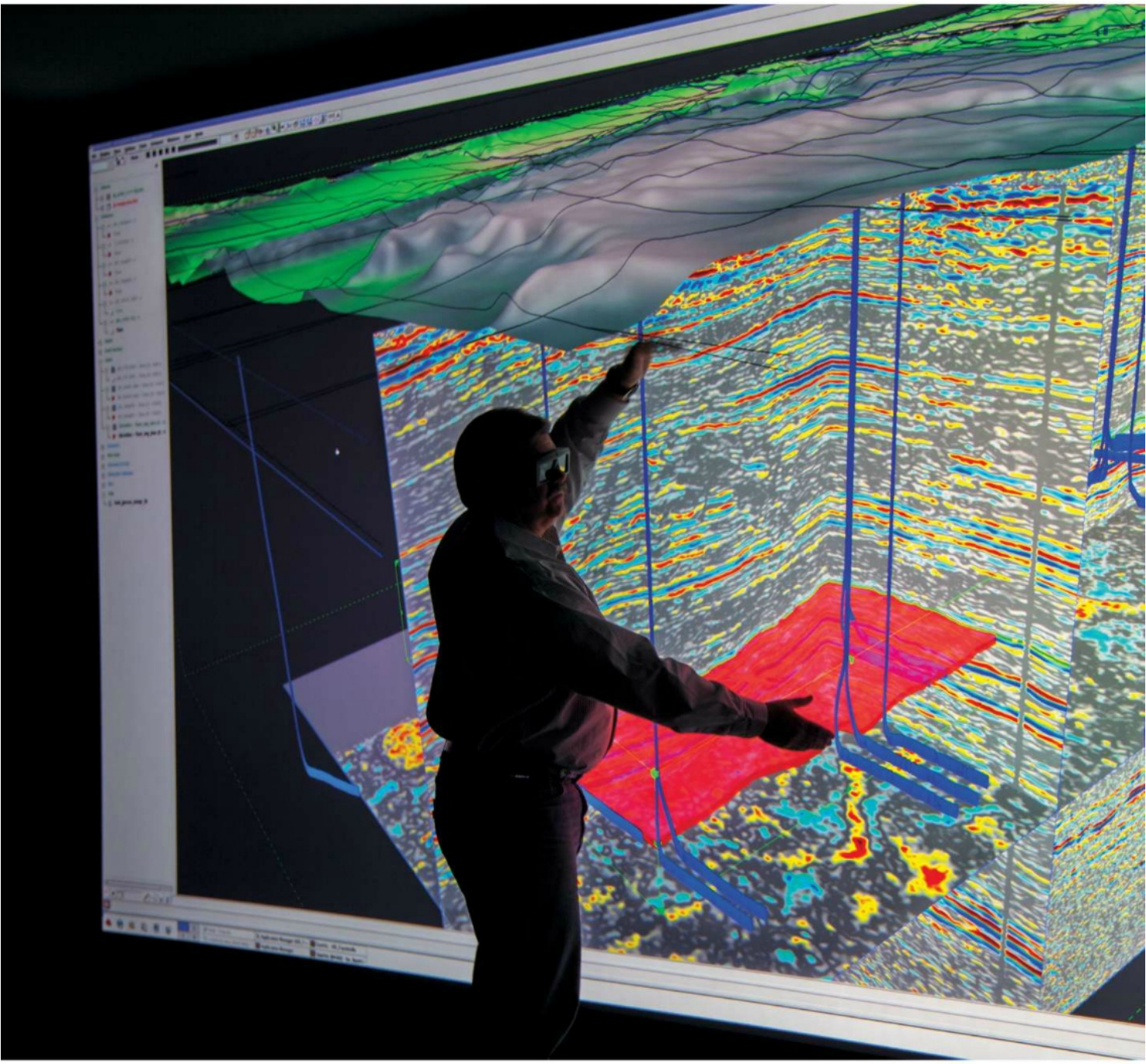
Here and there in patches cut from forest or farm are flattened, four-acre mounds of fresh dirt. For a few weeks at a time tall derricks rise from these drill pads, and the trucks and trailers congregate around them. Contaminated water from the new wells pours into tank trucks or into lagoons lined with dark plastic. The derricks soon disappear, but the wells stay, connected by clusters of green pipes and valves to permanent new pipelines, condensate tanks, and compressor stations. Much of Pennsylvania has been transformed since 2008.

The boom's roots go back to the 1980s and to Texas, where a wildcatter named George Mitchell, facing dwindling reserves, began probing the Barnett Shale near Dallas. Black shales, the compressed mud of ancient seas, were known as petroleum source rocks. But over geologic time much of the oil and gas had migrated out of the shales into porous sandstone traps—and that's where the industry sank its wells. Wells ending in shale never yielded much; the shales were too dense and impermeable to allow gas to flow.

Mitchell Energy's workaround, developed over 20 years with support from DOE, became the recipe for the fracking boom. It has two parts. First, drill down to the shale, then continue drilling horizontally for a mile or so inside it; that puts more gas close to the well. Second, inject millions of gallons of water, chemical lubricants, and sand at high pressure to shatter the shale, allowing methane to rush into the well.

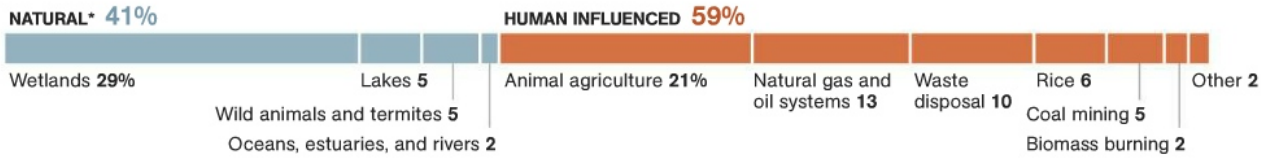
The gas from fracked wells has benefited consumers; 55 percent of the homes in the U.S. have gas heat, and prices last winter reached a ten-year low. In Pennsylvania the boom has revived businesses; created some 18,000 jobs, by the state's reckoning; and paid millions of dollars in lease-signing bonuses and royalties. However, some landowners who leased their land to gas companies have since had second thoughts.

Sherry Vargson is one. In 2008 Chesapeake Energy began drilling on her family's 197-acre dairy farm in Granville Summit, in northeastern Pennsylvania. In June 2010, after a crew had been working on the well, Vargson turned on her kitchen tap to find it backed up with what she thought was air. "It was like drawing a glass of Alka-Seltzer, very sizzly and bubbly," she recalls. Testing showed the water contained more

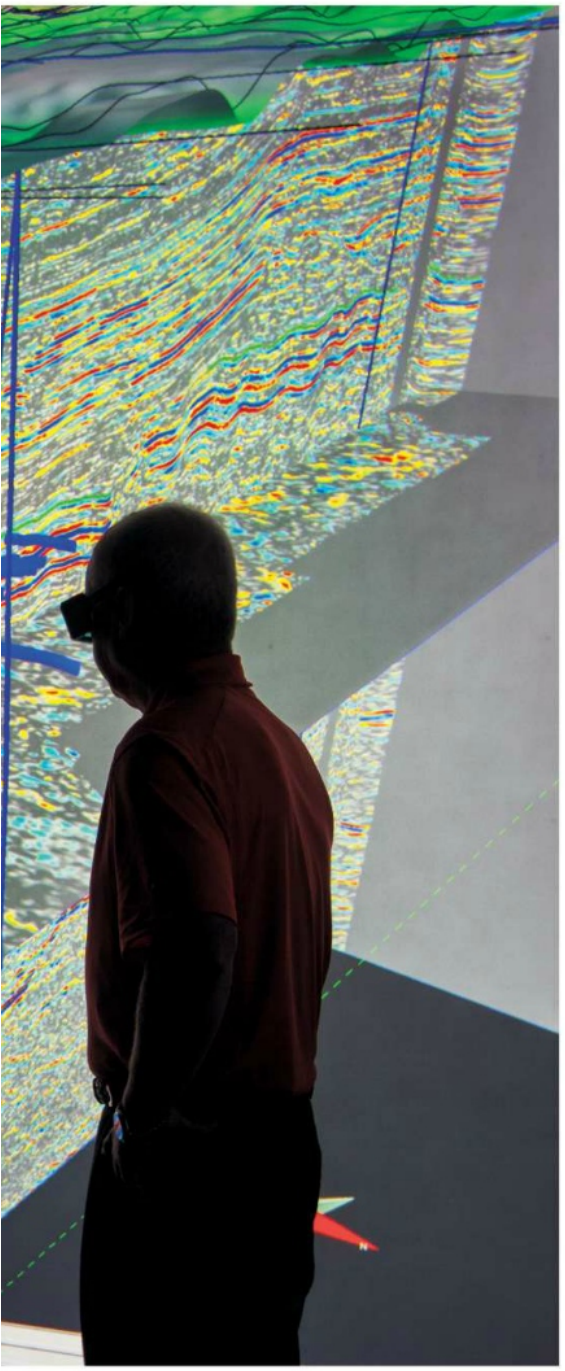


METHANE EMISSIONS *(global estimates)*

Human activities account for roughly three-fifths of methane emissions globally. In the U.S. the fossil fuel industry is the biggest emitter, surpassing livestock and manure.



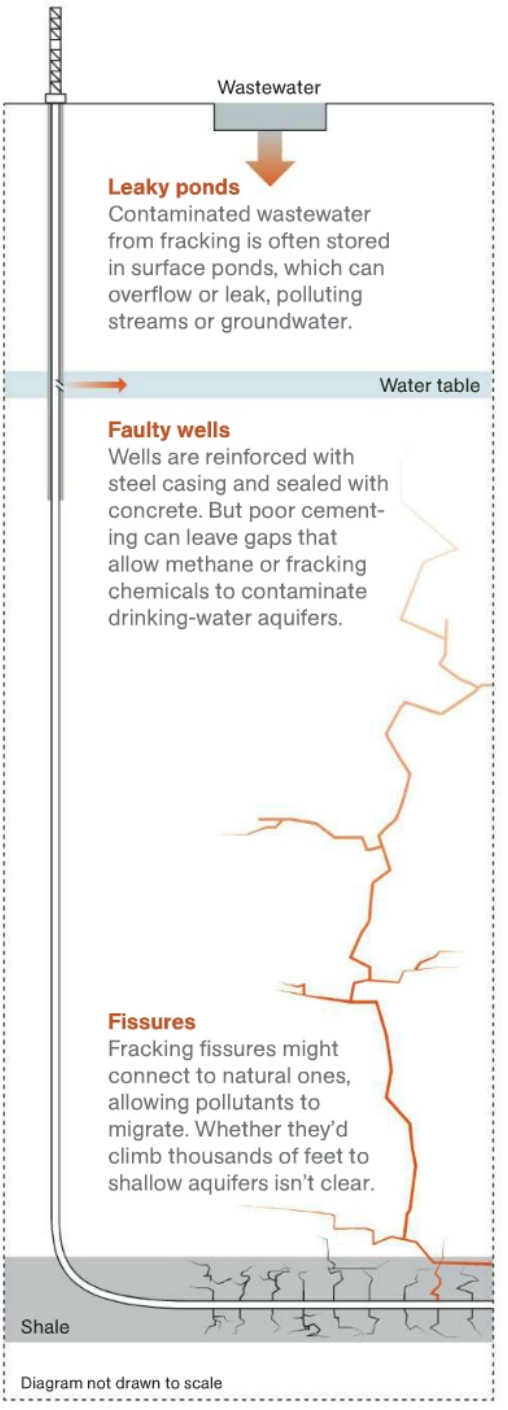
*Other possible sources exist but are omitted due to uncertainty.



The blue lines on this 3-D map are shale-gas wells. Assembled from seismic data, the map helps scientists at Chesapeake Energy's Oklahoma City headquarters choose the best spots to drill. A typical well plunges a mile and a half, then turns horizontal inside the shale.

FEAR OF FRACKING

A key technique in shale drilling is hydraulic fracturing, aka fracking. A fluid mix of water, sand, and chemicals is pumped down the well at high pressure, creating fissures in the shale that let gas flow into the well. But the whole drilling process may also create pathways that allow gas or chemicals to pollute drinking water.



GRAPHICS: LAWSON PARKER AND MATTHEW TWOMBLY, NGM STAFF
SOURCES: U.S. EPA (EMISSIONS);
ANTHONY INGRAFFEA, CORNELL UNIVERSITY (DRILLING)

So much methane fizzes from Sherry Vargson's tap that she can light it like a stove. The contamination began, she says, after Chesapeake Energy drilled on her Pennsylvania farm. The company denies responsibility. "I keep about three windows open year-round so we don't blow up," Vargson says.

SO FAR, THE IMPACT OF SHALE-GAS DRILLING SEEMS MUCH SMALLER THAN THAT OF COAL MINING.

than twice the methane that's considered an explosion threat. Chesapeake has been supplying her with bottled water ever since, while arguing that the contamination is natural. Meanwhile Vargson's monthly royalty checks have shrunk from more than $1,000 to less than $100, as production from the gas well has plummeted.

The industry's main argument in attempting to reassure a worried public in Pennsylvania and elsewhere has been that shales typically lie thousands of feet below drinking-water aquifers. So contamination, whether by shale gas or fracking wastewater—which contains fracking chemicals, salt, heavy metals, and radioactive elements leached from the rock—should be physically impossible. The argument makes intuitive sense, but the jury is still out. Duke University scientists have recently reported evidence that fluids—albeit not fracking fluids—have migrated upward from the Marcellus Shale through natural fissures.

In an earlier study the Duke researchers sampled 60 private water wells in northeastern Pennsylvania and found no sign of fracking fluids. But they did find that methane levels were on average 17 times higher in wells near drilling sites and that some of the methane had the chemical signature of shale gas. It may have leaked into the shallow aquifers, they said, through faulty casings around the gas wells. The Pennsylvania Department of Environmental Protection (DEP) also blamed faulty casings in 2009 when it fined Cabot Oil & Gas for contaminating the drinking supplies of 19 homes in Dimock Township, 60 miles east of the Vargson farm. In that case the methane came not from the shale but from shallow deposits traversed by the gas wells. DEP has also fined gas companies for mishandling fracking wastewater and allowing spills that polluted creeks and rivers.

In Pennsylvania and elsewhere, shale-gas drilling has raced far ahead of efforts to understand and limit its impact. So far, however, its impact seems much smaller than that of coal mining—which in Pennsylvania has caused far worse river pollution, in West Virginia has lopped the tops off numerous mountains, and in the U.S. still kills hundreds of miners a year, mostly through black lung disease. The comparison is relevant because cheap natural gas is reducing coal burning. As recently as 2007, coal generated nearly half of U.S. electricity. Last March its share fell to 34 percent.

John Hanger, a Pennsylvania lawyer who helped author the state's renewable-energy standards, ran the DEP from 2008 to early 2011. Though he tightened regulations on the gas industry and handed out substantial fines, he was attacked by opponents who wanted a complete halt to fracking. Hanger believes such critics are missing the big picture. "The massive switching from coal to gas has done more to clean Pennsylvania's air, and America's air, than probably any other single thing we've ever done," he says.

Unlike coal, natural gas burns without spewing sulfur dioxide, mercury, or particulates into the air or leaving ash behind. And it emits only half as much carbon dioxide. The greenhouse gas inventory compiled by the U.S. Environmental Protection Agency (EPA) shows that the nation's CO_2 emissions in 2010 were lower than in 2005 by just over 400 million metric tons, or 7 percent. (Preliminary data for 2011 indicate a further decrease.) Reduced emissions from power plants, mostly because many have switched from coal to gas, accounted for a bit over a third of that.

Some environmentalists who once welcomed shale gas with precisely that expectation changed their minds after watching the boom in Pennsylvania. But Hanger hopes it spreads around the world, as it seems likely to. "In China they're sitting on potentially huge supplies of shale gas," he says. "It would be an enormous climate benefit if China were to substitute gas for some of its coal burning. And it's an immediate benefit—you don't have to wait until 2040 or 2050."

UNLESS TOO MUCH METHANE LEAKS into the atmosphere. As U.S. CO_2 emissions fell between 2005 and 2010, methane emissions rose. By 2010, EPA says, the rise was equivalent in global warming potential to around 40 million metric tons of CO_2 annually, which means it offset 10 percent of the CO_2 decline. More than half of that

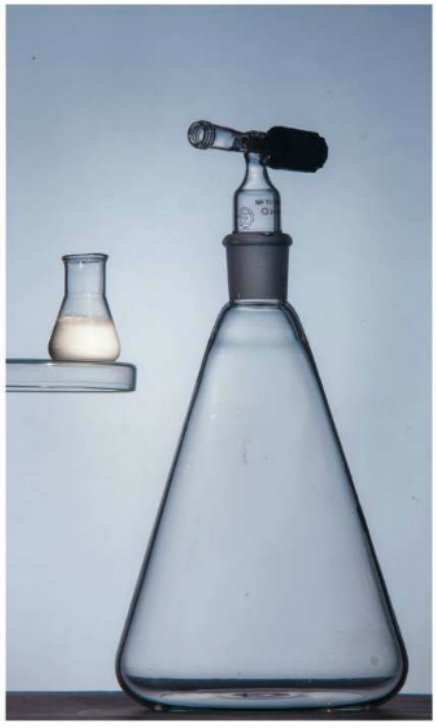
methane increase, says EPA, came from the natural gas industry—the country's biggest emitter.

Judging by EPA's numbers, fracking still seems like a clear win for the climate. But some scientists, notably Robert Howarth and his coworkers at Cornell University, believe EPA has underestimated methane emissions and, more important, the global warming potential of each methane molecule. They argue that methane leaking from wells, pipes, compressors, and storage tanks actually makes shale gas worse for the climate than coal. Other researchers question Howarth's approach. The debate persists in part because methane numbers are so uncertain.

New rules issued by EPA this year will require the gas industry to measure its emissions and also to reduce them. One of the biggest leaks occurs when a fracked well is completed and high-pressure fracking fluids surge back up the well, bringing methane with them. The new rules will require gas companies to start capturing that methane by 2015, using technology that's already required in Wyoming, Colorado, and parts of Texas.

Some experts consider methane capture a great opportunity: an easier way than controlling CO_2 to slow global warming, at least in the short term, because small amounts of methane make a big difference and because it's a valuable fuel. China, for instance, the world's largest coal producer, vents huge amounts of methane from its mines to prevent explosions. In the 1990s, when Egyptian geologist Mohamed El-Ashry headed the Global Environment Facility, an agency created by the United Nations and the World Bank, it devoted ten million dollars to projects that siphoned methane from several Chinese mines and delivered it as fuel to thousands of nearby households. Hundreds of such projects await funding worldwide, El-Ashry says.

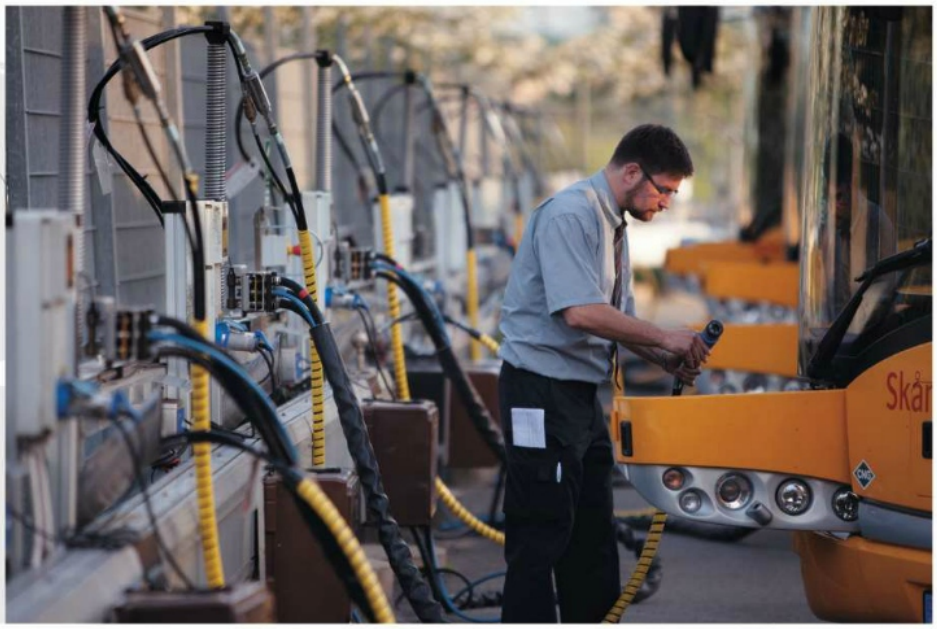
Drew Shindell, a climate scientist at NASA's Goddard Institute for Space Studies, recently led a global team of scientists in analyzing seven methane-reduction strategies, from draining rice fields to capturing the gas that escapes from landfills and gas wells. Unlike CO_2, methane affects human health, because it's a



The little flask holds as much methane as the big one—as a powder rather than a gas. The University of Liverpool researchers who made the powder, a form of methane hydrate, think it could become a convenient way to store and transport natural gas.

IN KRISTIANSTAD, OFFAL ISN'T AWFUL—IT'S FUEL

Without fossil fuel reserves of its own, Sweden leads the European Union in the share of energy it gets from renewable sources—48 percent—and has one of the EU's lowest rates of carbon emissions. Hydropower is the biggest renewable source, followed by biofuels. Kristianstad, an agricultural center close to the Baltic Sea, aims to free itself entirely from fossil energy, largely by extracting methane-rich biogas from pork offal, household food scraps, and other waste.



When Kristianstad's cavernous new biogas reactor (right) is full, it contains 1.6 million gallons of sludge, much of it pig intestines from the region's slaughterhouses (left). The propeller-like agitators stir the organic waste, making it easier for microbes to digest—and in the process produce methane. Kristianstad uses this biogas to generate electricity and heat and to fuel cars and municipal garbage trucks and buses (below). Its two refineries produce enough biofuel to replace 1.1 million gallons of gasoline each year.

No gassy belch goes unrecorded at the Teagasc Food Research Centre in Ireland. "Cows are walking fermentation chambers," says researcher Matthew Deighton. But adding fat to their diet might reduce their copious methane emissions.


121
121
154
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precursor of smog. When health impacts are included, Shindell's group found, the benefits of methane controls outweigh the costs by at least 3 to 1, and in some cases by as much as 20 to 1.

"There are some sources that are difficult, if not impossible, to control," says Shindell. "The Arctic emissions—I'd probably vote those as being near impossible. But then you have long-distance gas pipelines, and we know exactly how to control leaks from those: put in and maintain high-quality seals. And there are other places, especially in oil, gas, and coal production. It's really straightforward to get a substantial fraction of methane emissions under control."

LAST SPRING, as the annual thaw began in Alaska, Katey Walter Anthony heard from her friend Bill Wetzen, who owns Goldstream Lake and sometimes brings her coffee out on the ice. When Wetzen bought the property 20 years ago, he built his bungalow about 20 yards from the lake; by last year it was nearly at the water's edge. Now, Wetzen said, with the permafrost thawing beneath it, the walls and floors were tearing apart. He was going to have to move.

Also last spring, DOE-funded researchers on Alaska's North Slope successfully tested a method of extracting methane from buried hydrates. Though the process "may take years" to become economically viable, said the DOE press release, "the same could be said of the early shale gas research… that the Department backed in the 1970s and 1980s." If even a small fraction of methane hydrates becomes recoverable, DOE estimates, that could double U.S. gas resources.

Some of the methane bubbling from Arctic lakes, Walter Anthony says, might come from hydrates. Around 56 million years ago, in the Paleocene, a long planetary warming culminated in a sudden temperature spike of 9°F; many scientists suspect a massive destabilization of methane hydrates. Most, including Walter Anthony, do not think such a catastrophe is likely now. But Arctic methane could add a lot to global warming over the next few centuries.

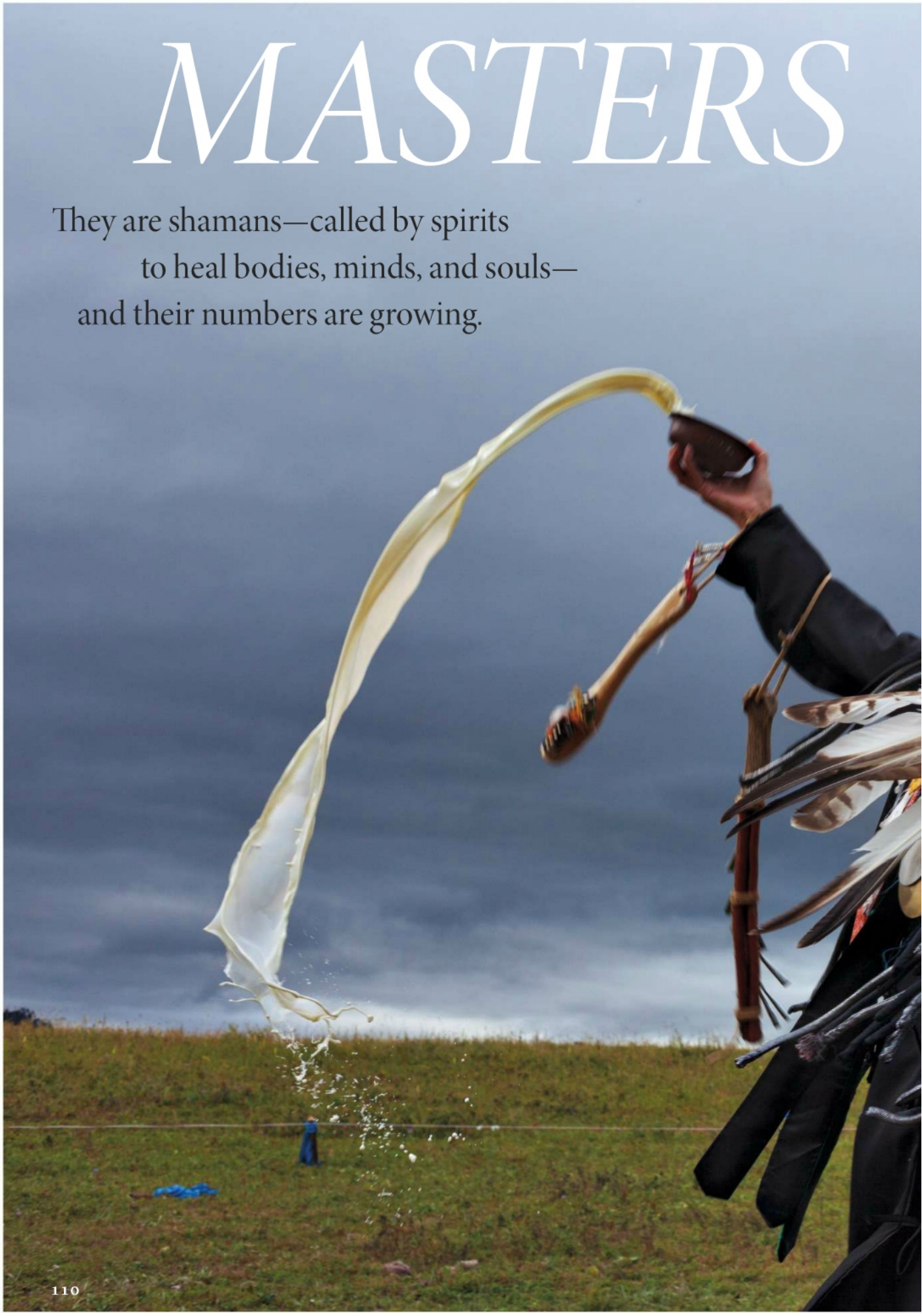
"If we could only capture it, it would make a great energy source," Walter Anthony says. □

ARCTIC METHANE COULD ACCELERATE GLOBAL WARMING OVER THE NEXT FEW CENTURIES.

The first clear ice of fall on an Alaskan lake captures methane that all summer long has bubbled from the bottom mud. In spring it will be released into the air. As permafrost melts, new lakes are forming all around the Arctic.

MASTERS

They are shamans—called by spirits
to heal bodies, minds, and souls—
and their numbers are growing.



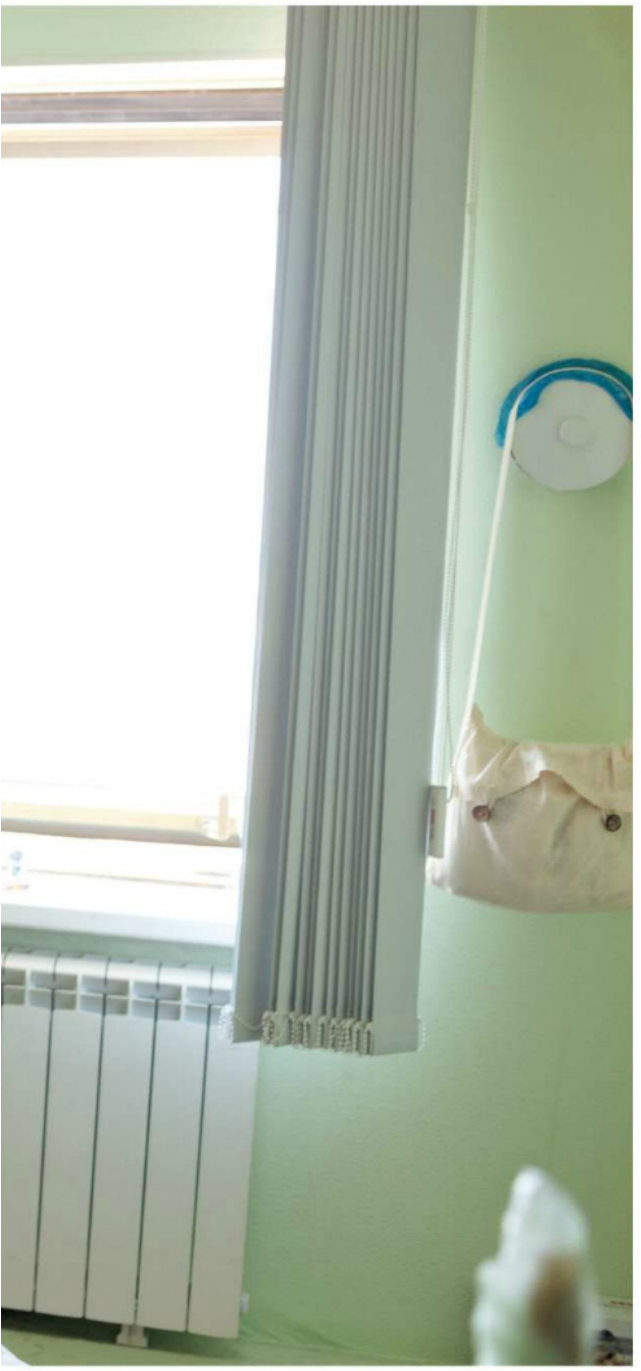
OF ECSTASY

By David Stern
Photographs by Carolyn Drake

A novice shaman makes an offering of milk to the spirits at her initiation outside the Mongolian capital of Ulaanbaatar.

Symbol of eternity, this "mother tree," a pine in northern Mongolia, draws pilgrims from all over. It gave out under the weight of cloth offerings, the blue ones representing everlasting heaven and peace.

Driving out evil spirits with a mini-drum, Lyubov Lavrentiyeva wards off spells and ministers to the sick in her office in Irkutsk, Russia. In the postcommunist era shamanism is undergoing a revival. Lavrentiyeva advertises in the local paper and calls herself "a seamstress of souls."



Nergui stood in the center of the room, swaying from side to side, chanting, "Great sky, please come here." His eyes were closed, and he gripped a cluster of multicolored cloth strips. His voice was rough and the melody repetitive, like an ancient ballad: "Oh, great blue sky, which is my blanket, come to me."

Nergui is a *boo,* as Mongolians call male shamans. He believes himself to be an intermediary between the visible world and the hidden world of spirits and gods. Mystical figures like him are reviving old traditions throughout Mongolia, Central Asia, and Siberia and finding a receptive audience for their charismatic rituals.

After meditation and chants Nergui moved into a trance, the moment when the spirit from the invisible realm would be free to enter his body. "Oh, my spirit, I would ride ten Mongolian cows to see you. Please let the golden cuckoo guide me to the spirit."

Eight of us had gathered around, sitting on stools and metal-framed beds pushed up against the walls of Nergui's one-room wooden cabin. Outside, the temperature on this mid-November day was 10°F. It was just after midday, the "horse hour," according to the Chinese zodiac clock. For Nergui the noon hour is the perfect time to go on an otherworldly ride.

"Sky of the wolf, please help me. A man in need, with a heart of peace, has come. Great sky, please come here."

Nergui is a slight, unassuming man with a hangdog look that reminded me of the actor Walter Matthau. He was unshaven and dressed in a dull brown *del*—a traditional Mongolian robe—with a yellow belt and a blue silk sash

Shamans are found around the globe, but the word "shaman"—meaning "one who knows"—comes from the Evenki, an indigenous reindeer-herding people in northern Siberia.

around his neck. A pair of faded blue corduroys peeked out from under his robe. On his feet were specially made reindeer-skin shaman boots.

He's a Darhad, one of the ethnic groups indigenous to northern Mongolia, next to the Russian border. Numbering some 20,000, the Darhad have largely preserved their traditional nomadic lifestyle: Nergui's day job, so to speak, is taking care of his cows, goats, sheep, and horses. The Darhad also practice shamanism in one of its purest forms, as an integral part of their lives. The region's remoteness helps explain why little has changed. Getting here involved a jolty plane ride from the Mongolian capital, Ulaanbaatar, followed by a bone-shaking 13-hour trip in a rickety Soviet-era minibus over frozen rivers, icy mountain passes, and snow-packed tundra.

Nergui's chanting picked up speed as his swaying became more like a dance. He made *giddyap* sounds and whipping motions with his strips of cloth, as if spurring on a horse.

Juniper twigs burning in a cast-iron stove gave off a fragrant scent; the smoke is believed to attract spirits. Blankets draped on the walls to keep in the heat made the room seem even smaller, and in the corner opposite the door was a collection of amulets, figurines, colored scarves, bits of cloth, and other talismans—a shrine to Nergui's guardian spirits.

Suddenly he collapsed. Two helpers caught him, and he gave a wolflike howl. Then he cackled like the villain in a horror movie. "The spirit has entered him," Zaya Oldov, my guide and translator, whispered.

They brought him to the back of the room, and he sat down, cross-legged, eyes still shut. One by one the members of our group approached him. The shaman—or the spirit speaking through him—described each person's past and doled out advice.

Then it was my turn; I kneeled next to him. "You were a very quiet person when you were young." Nergui's voice was deeper now, more

assured. "You love animals. Wherever you have gone, you have given things to people, and this put a smile on their face." All this was true, but so general it could apply to almost anyone.

He continued, "You have a unique mark on your right side, under your armpit." (Not true—my skin there is blemish free.) Other specific, cryptic comments followed. "A man with the sign of the dog and the sheep will soon help you." Nergui then concluded: "By my power I will look after your family and your loved ones. Take these juniper twigs and burn them in your home." After I took them, he reached for something and held out his hand. "Here is the anklebone of a wolf. Carry it in your right pocket—it will protect you from harm."

He began to exit his trance, gyrating and flailing his arms. His eyes were full of fear (or was it pain?), and he was hyperventilating. His wife, Chimgee—a wiry woman in a gray-blue del and green kerchief—approached him and put a lit cigarette in his mouth. Still shaking, he chewed it, burning end and all, and swallowed.

Eventually Nergui calmed down. A second cigarette was offered, which he smoked this time. Chimgee smiled at her husband. "Did you have a good journey, dear?" she asked.

THE WORD "SHAMAN" comes from the Evenki, a Siberian people, but shamans can be found in practically every corner of the planet—including in shamanic centers now in London, Boston, and many other Western cities. Shamans believe that unseen spirits permeate the world around us, act upon us, and govern our fates. By turns doctors, priests, mystics, psychologists, village elders, oracles, and poets, they are the designated negotiators with this hidden reality, and they occupy an exalted position within their societies.

There is no precise definition of shamanism. "It would be better to speak of 'shamanisms,' in the plural," says Marjorie Mandelstam Balzer, an anthropologist at Georgetown University in Washington, D.C. Beliefs, practices, and rituals vary from person to person, she told me, because the path to becoming a shaman is above all a highly individual one. Similarities do exist, though: The ecstatic trance, or soul journey, as it's sometimes called, is a signature phenomenon. But how shamans employ their instruments and spiritual insights varies greatly, as can the ritual's ultimate purpose. Many shamans work alone, while others join large urban organizations that act as trade unions; the Golomt Center for Shamanic Studies in Ulaanbaatar claims around 10,000 members.

Most shamans in Central Asian countries, such as Kyrgyzstan and Kazakhstan, where Islam predominates, regard themselves as devout Muslims, and their rites are infused with the mystic traditions of Sufism. Swathed in virginal white smocks, they conduct their rituals at Muslim holy sites, and every ceremony includes extensive prayers from the Koran. In Siberia and Mongolia, shamanism has merged with local Buddhist traditions—so much so that it's often impossible to tell where one ends and the other begins.

In Ulaanbaatar I met a shaman, Zorigtbaatar Banzar—an outsize, Falstaffian man with a penetrating stare—who has created his own religious institution: the Center for Shamanism and Eternal Heavenly Sophistication, which unites shamanism with world faiths. "Jesus used shamanic methods, but people didn't realize it," he told me. "Buddha and Muhammad too." On Thursdays in his *ger* (a traditional Mongolian tent) on a street choked with exhaust fumes near the city center, Zorigtbaatar holds ceremonies that resemble a church service, with dozens of worshippers listening attentively to his meandering sermons.

AFTER NERGUI HAD RECOVERED from his trance, he opened the bottle of vodka I'd brought as a gift and poured us each a shot into a shallow teacup. I accepted the cup with my right hand—to receive anything with your left can be a grievous insult—and before drinking, I made an offering to the spirits in three directions. I lightly dipped my fingers in the liquid, flicked a few drops into

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Based in Kiev, Ukraine, journalist David Stern concentrates on Central Asia. Photographer Carolyn Drake, a frequent contributor, works out of Istanbul.

By day Sain Tsetseg (Good Flower), of the Tsaatan ethnic group, tends her reindeer in northern Mongolia (above). At night in her tepee-like ortz, *she beats a drum to enter a trance while an assistant burns juniper twigs, whose fragrant smoke draws in the spirits.*

the air and then toward the ground, and finally dabbed my forehead.

Shamanism is something you're born with, Nergui said, slugging down a large shot of vodka. You can't just decide to become a shaman—you must be chosen by the spirits. The shamanic calling is usually passed down from one generation to the next. "My father is a shaman," Nergui said, adding that he was 25 when he became aware that he too had an aptitude for communicating with the spirit world. "I've been doing this 25 years, and I have 23 spirits I can call on."

But, he added, a shamanic gift is just the beginning. All shamans must undergo an intense apprenticeship, learning the timeworn practices

Shamans invest their own ritualistic equipment with a holy spirit; it becomes "alive."

of their vocation. These rituals facilitate the shaman's interaction with the spirit world—like the trance I had just witnessed—as well as dictate the methods used in paying respect to the spirits. Shamans invest their own special ritualistic equipment with a holy spirit; it becomes "alive." Nergui's includes a reindeer-hide drum, a mouth harp, the colored strips of cloth, and his costume.

During the Soviet era, all religion, including the shamanic tradition, was suppressed. Many shamans died in labor camps. "A shaman I knew named Gombo got caught during a ritual and was sent to jail for a year and a half," Nergui said. By the time Nergui started practicing, the worst of the purge was over, but shamanism was still forbidden, and shamans had to perform in secret. "We hid our religion so that it wouldn't fade away," he said. "There were two places where we would do the ritual. The first one was at home, and we would have somebody sit by the door to see if anyone was coming. The second place was hidden in the mountains. Then around 1995, things changed, and we could practice freely." Indeed, shamanism is now undergoing a great reawakening throughout its historic heartland in Central Asia, Siberia, and Mongolia—feeding a spiritual craving after 70 years of enforced atheism.

By this point Nergui was looking more hangdog than ever, and he seemed gripped by a deep melancholy. Shamanism is above all about serving the community, he told me. "When you become a shaman, you have the responsibility of taking care of people around you." That takes a heavy psychological toll, and it may explain why alcohol abuse seems to be common among shamans. "Sometimes you have to do black things," he said, falling silent.

AS SHAMANISM'S POPULARITY has grown, its rituals have become major events—and even big business. On an August day in a sun-drenched meadow in Russia's Republic of Buryatiya, in Siberia, some two dozen people in indigo robes from a local shamanic group called Tengeri (Sky Spirits) performed an energetic ritual called a *tailgan,* in honor of a sacred spot on a nearby mountain. Clouds of gnats and the smell of boiled mutton hung in the air. The sheep had been ceremonially slaughtered and quartered and was simmering away in a massive pot.

Chanting and beating on circular animal-skin drums, the shamans sat in a line facing the holy site, Bukha-Noyon, a treeless patch on the mountainside said to house holy spirits, including the male ancestor spirit of the same name. In front of them were tables bearing candles, multicolored sweets, tea, vodka, and other spirit offerings. Vendors sold *buuza,* succulent Buryat dumplings, from the back of SUVs, and children played in the parched grass. Above Bukha-Noyon two eagles circled—indicating, I was told, that the spirits were descending.

I stood behind the shamans in a half circle of about 200 onlookers. The crowd was mixed: ethnic Russians, members of the local Buryat community, and a number of Westerners. Oleg

A female shaman leading an initiation for novices outside Ulaanbaatar holds up the heart she has just removed from a sheep. She sees this sacrificial offering as a symbol of her power over life and death.

At the initiation ceremony the shaman squeezes blood from the sheep's heart to mix with vodka. The drink is believed to help the newly minted shamans connect with the souls of ancestors. Later, another shaman drums as family members lend support to a novice in a trance.

Dorzhiyev, one of the shamans, hunched forward in concentration as his chanting and pounding accelerated to fever pitch. All at once he stopped and stood up. The crowd fell silent. A spirit had entered him.

Dorzhiyev approached one side of the group. His headdress was like a warrior's helmet, and his face was a murky shadow through a veil of thin black tassels. He walked slowly, mechanically, and his breathing sounded labored. People averted their gaze. "It is forbidden to look a shaman in the eyes when a spirit is in him," said a man next to me, staring resolutely at the ground. "Bad things can happen to you."

A helper brought the shaman-spirit a stool to sit on, and a crowd of about 20 people massed around him, some kneeling, others prostrating themselves on the ground. They asked him questions. Why am I unsuccessful in business? Why can't I get pregnant? The shaman responded in a low, gravelly voice.

Dorzhiyev hunched forward as his chanting and pounding accelerated to fever pitch.

Around us other shamans were also entering trances, stumbling around and holding court. The scene brought to mind a Siberian version of *Night of the Living Dead.* Near me, a shaman with horns on the top of his headdress channeled a spirit that chain-smoked and demanded copious amounts of vodka. Another spoke in a high-pitched voice, as if possessed by a woman. After about 20 minutes it was time for Dorzhiyev's spirit to leave. Helpers led him a few feet away and made him jump up and down. He removed his headdress and blinked in the summer sun. Trance over.

I met with Dorzhiyev later at his spartan, dimly lit office in the Tengeri headquarters on the outskirts of Ulan-Ude, the sedate capital of Buryatiya. Outside the low wooden building stood a huge sculpture shaped like a Christmas tree and bedecked with blue banners, moose horns, and a bear skull.

"As you start to fall into the trance, you feel some force of energy coming closer to you," he said, his voice rising. "You can't see it—it's like a human form in the fog. And when it comes even closer, you see who it is, that it is a spirit. Someone who lived long ago.

"He enters you, and your consciousness departs," Dorzhiyev continued. "Your consciousness goes to somewhere beautiful. And the spirit takes over your body. And then when you're finished, it departs, and your consciousness returns. And you feel such a tiredness—it takes a long time for you to recover."

Before he became a shaman, Dorzhiyev was a lawyer working for the Justice Ministry—and from his reasonable, unruffled manner, this was easy to imagine. "I wore a white shirt and necktie," he said. "My salary was good." Twelve years ago, when he was 34, he was struck by what's called a "shamanic illness"—an extended period of intense psychological, professional, personal, or physical difficulties, when the spirits are thought to be sending a sign. The problems persist until the person finally relents and picks up the shamanic mantle.

"My head hurt, my back hurt. Since I'm a fairly rational person, I went to a doctor," Dorzhiyev said. But the doctor couldn't find anything wrong. "I felt guilty, as if I were faking it." The discomfort lasted four years, until a shaman friend entered a trance to cleanse him. During the ritual the spirits revealed that Dorzhiyev was one of the select. He has been a practicing shaman for eight years now, and the pains have ceased.

Dorzhiyev helped found Tengeri in 2003 because he wanted to feel part of a community. The organization has recently come under heavy criticism. The unspoken code is that shamans never demand money, but a number of prominent Buryat shamans have accused Tengeri's members of charging exorbitant sums for their services and of being publicity seekers,

Ulaanbaatar shaman Zorigtbaatar Banzar drums a rhythm while worshippers circle a cloth-draped tent post he calls the "white spirit." He believes it holds the energy of the sun and the power of Genghis Khan.

At her Ulaanbaatar home a student (above) seeks a shaman's help to secure documents she needs to study abroad. A stone mound, or ovoo, *in Mongolia marks a place where spirits are thought to have shown themselves; respectful travelers walk around it three times.*

whipping up circuslike spectacles for an impressionable public. The shamanic community, it should be said, is riven by factions and competing groups, so some of the ill will might be attributed to jealousy.

"We don't have a salary—we live on what people decide to give us," Dorzhiyev said. While I was with him, he seemed to take his professional responsibilities very seriously, and I never saw him ask clients for money. He; his wife, Tatyana; and their two sons and a daughter live in a modest, two-room apartment in a building Tatyana manages. "We get by. We have enough for bread," he said, laughing.

The very idea of a shamanic organization strikes many observers as odd—heresy even—

Many local communist officials tolerated shamanism. Some even visited shamans.

since shamans have traditionally been a rural phenomenon, working independently in their villages and nomadic tribes. Tengeri's members counter that if they were not a registered association, they'd be overwhelmed by the mainstream religious groups that have gained a foothold since the end of communism. "Religion is marketing," Dorzhiyev said.

SHAMANISM REPRESENTS more than spiritual rebirth and good business. It is also a catalyst for the post-Soviet cultural revival among the native peoples of Buryatiya. On the shore of Lake Baikal, the world's deepest body of fresh water and one of the most sacred sites in Siberia, I witnessed shamanism as self-determination—a ceremony by Buryats for Buryats.

Buryats are a Mongol people who also practice Buddhism and Christianity. About 300 years ago the Russian Empire swallowed them in its inexorable expansion across the Eurasian landmass. During the Soviet period they, along with the region's other indigenous groups, suffered massive population losses, and their culture was smothered. In Buryatiya today Buryats make up less than a third of the population.

With Baikal's waters lapping just beyond a small ridge, under a sky with clouds so low it looked as if you could reach out and grab a puff, three shamans wearing green, purple, and blue robes had gathered to ask the spirits for a good harvest and for unity. They stood to the side and, almost imperceptibly, murmured invocations, sprinkling milk and vodka into a small campfire. There were no trances, no spiritual fireworks, just the whisper of prayers offered and the sizzle of liquid meeting fire.

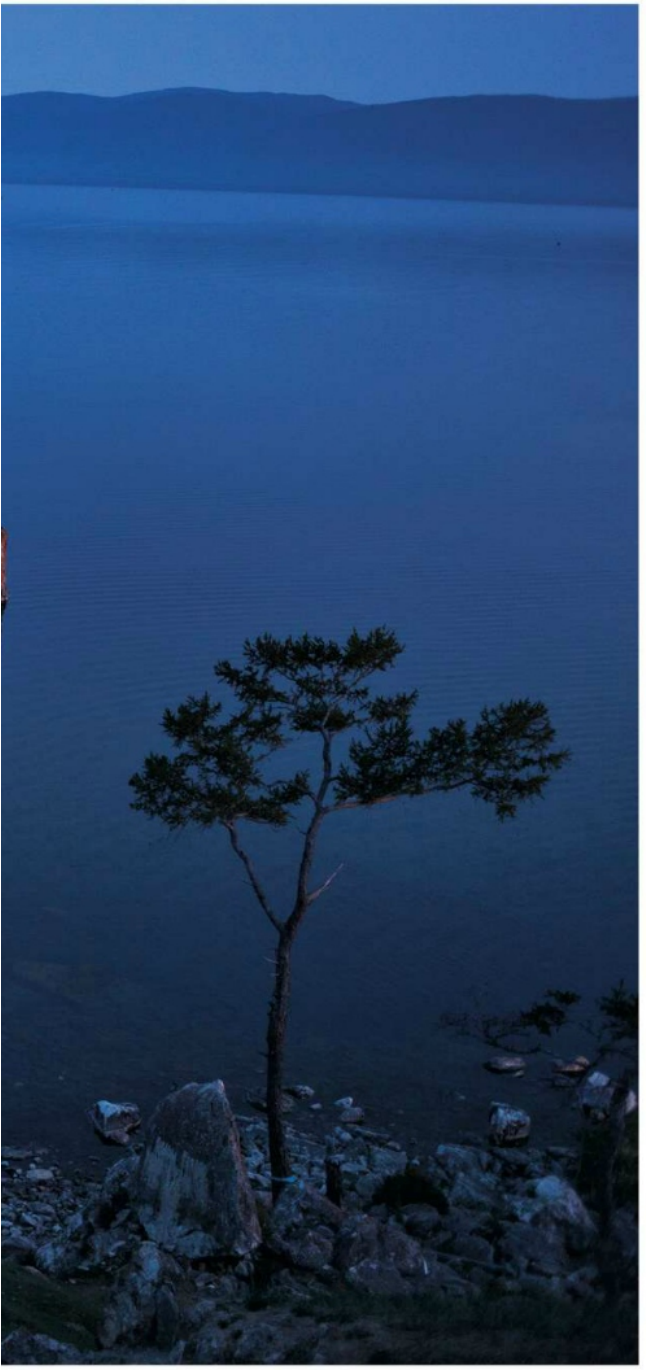
Next to me was Petr Azhunov, a hyperkinetic sprite of a man with a ponytail and wispy beard who is both a shaman and an anthropologist. For him shamanism is as much a political statement as a religious movement—an effort to restore a Buryat sense of nationhood after Russian hegemony. Under communism, Azhunov said, rituals like this sometimes had to be held in the dead of night. Still, many local communist officials tolerated shamanism, and some even visited shamans. "Moscow is afraid of authentic shamans like us," Azhunov said. "Muslims are controllable, Buddhists are controllable, organized groups like the Tengeri are controllable—but real shamans cannot be controlled." He poured to the ground an offering of a few drops of the local brew, *tarasun*—a pungent drink made from fermented milk—before taking a sip.

Azhunov is a traditionalist who believes that women should be barred from certain shamanic rites. "Your photographer, Carolyn, cannot photograph this ceremony," he said apologetically. "Women are at risk of being unclean." The men nearby nodded gravely in agreement.

A few hundred yards away at another sacred spot, Carolyn Drake and I encountered three female shamans conducting their own ritual. Their leader, Lyudmila Lozovna Lavrentiyeva, wearing a yellow scarf, red pants, and jangling necklaces, laughed at the idea that only men could be shamans. "The Buryats believe that

Oleg Dorzhiyev concludes the Bukha-Noyon ceremony with some two dozen other shamans in Siberia's Republic of Buryatiya as a woman flings a gift of milk toward the sacred rock on the hillside.

The peaks of Burkhan Rock rise like twin spires from Siberia's Lake Baikal, the world's largest body of fresh water. People across Asia believe that spirits associated with Baikal live in this rocky outcropping on Olkhon Island, destination of a steady stream of pilgrims.



once upon a time an eagle was flying and saw a pregnant woman sleeping under a tree and filled her with a holy spirit. She gave birth to a boy who became a shaman. So you see," she said with evident satisfaction, "the first shaman was actually a woman."

LEAVING BAIKAL, I thought about something Oleg Dorzhiyev had told me. In shamanic thinking, the universe is a unified whole—a giant network in which we humans are linked to mountains and lakes, just as we are to each other and to our ancestors. "For us," he said, "our gods are foremost our grandfathers and grandmothers, who are our guardian angels. They're real people. And our love for them is strong. This is the love of children for their parents, and parents for their children and grandchildren. And this energy never disappears."

I was moved by this idea, just as I had been stirred by other aspects of shamanism—its strong sense of individualism, deep respect for nature, and connection to the past. At its worst shamanism is quackery, and potentially dangerous, as when I saw a shaman tie a cloth strip tightly around the head of a man who may have suffered a skull fracture. The man's eyes rolled back in his head, and he cried out in what sounded like excruciating pain. Some shamans claim that they can cure cancer, which strains credulity.

Adherents swear that it is genuine, recounting life transformations and miraculous cures. In 2007 author Rupert Isaacson and his wife, Kristin, took their five-year-old son, Rowan, who has autism, to a Tsaatan shaman in Mongolia named Ghoste. When I spoke to Isaacson recently, he conceded that he can't prove that the shaman helped his son—all he can do is point to the change that occurred almost instantaneously: "When we went out," he said, Rowan was "incontinent, had tantrums all the time, and was unable to make friends. And when he came back, he was without those three dysfunctions." Rowan continues to do better.

On balance I'm not about to convert to shamanism. But I still have that wolf anklebone the shaman Nergui gave me—just in case. □

8000 B.C.: After retreating inland from a storm, a group of hunter-gatherers in Doggerland return to find their camp flooded. Eventually there would be no dry land to come back to.

JOHN TOMANIO AND AMANDA HOBBS, NGM STAFF
ART: ALEXANDER MALEEV. SOURCES: SIMON FITCH, VINCENT GAFFNEY, AND BENJAMIN GEAREY, UNIVERSITY OF BIRMINGHAM, U.K.

Searching for DOGGERLAND

For decades North Sea boatmen have been dragging up traces of a vanished world in their nets. Now archaeologists are asking a timely question: What happens to people as their homeland disappears beneath a rising tide?

By Laura Spinney
Photographs by Robert Clark

Low tide in the Severn estuary at Goldcliff, Wales, exposes a hunter's footprint laid down 7,500 years ago, when gradually rising seas meant a shrinking world. Bone and antler arrowheads, at right, recovered from the North Sea off the Dutch coast, pay witness to a way of life now long submerged.

When signs of a lost world at the bottom of the North Sea first began to appear, no one wanted to believe them.

The evidence started to surface a century and a half ago, when fishermen along the Dutch coast widely adopted a technique called beam trawling. They dragged weighted nets across the seafloor and hoisted them up full of sole, plaice, and other bottom fish. But sometimes an enormous tusk would spill out and clatter onto the deck, or the remains of an aurochs, woolly rhino, or other extinct beast. The fishermen were disturbed by these hints that things were not always as they are. What they could not explain, they threw back into the sea.

Generations later a resourceful amateur paleontologist named Dick Mol persuaded the fishermen to bring him the bones and note the coordinates of where they had found them. In 1985 one captain brought Mol a beautifully preserved human jawbone, complete with worn molars. With his friend, fellow amateur Jan Glimmerveen, Mol had the bone radiocarbon-dated. It turned out to be 9,500 years old, meaning the individual lived during the Mesolithic period, which in northern Europe began at the end of the last ice age some 12,000 years ago and lasted until the advent of farming 6,000 years later. "We think it comes from a burial," says Glimmerveen. "One that has lain undisturbed since that world vanished beneath the waves, about 8,000 years ago."

THE STORY OF that vanished land begins with the waning of the ice. Eighteen thousand years ago, the seas around northern Europe were some 400 feet lower than today. Britain was not an island but the uninhabited northwest corner of Europe, and between it and the rest of the continent stretched frozen tundra. As the world warmed and the ice receded, deer, aurochs, and wild boar headed northward and westward. The hunters followed. Coming off the uplands of what is now continental Europe, they found themselves in a vast, low-lying plain.

Archaeologists call that vanished plain Doggerland, after the North Sea sandbank and occasional shipping hazard Dogger Bank. Once thought of as a largely uninhabited land bridge between modern-day continental Europe and Britain—a place on the way to somewhere else—Doggerland is now believed to have been settled by Mesolithic people, probably in large numbers, until they were forced out of it thousands of years later by the relentlessly rising sea. A period of climatic and social upheaval ensued until, by the end of the Mesolithic, Europe had lost a substantial portion of its landmass and looked much as it does today.

Many have come to see Doggerland as the key to understanding the Mesolithic in northern

This is science writer Laura Spinney's first story for National Geographic. *Robert Clark's photographs of Roman walls appeared in the September 2012 issue.*

MUSEUM OF ANTIQUITIES, LEIDEN, NETHERLANDS (TOP)

Europe, and the Mesolithic, in turn, as a period that holds lessons for us—living as we are through another period of climate change. Thanks to a team of landscape archaeologists at the University of Birmingham led by Vince Gaffney, we now have a good idea of what this lost country looked like. Based on seismic survey data gathered mostly by oil companies prospecting under the North Sea, Gaffney and his colleagues have digitally reconstructed nearly 18,000 square miles of the submerged landscape—an area larger than the Netherlands.

At the university's IBM Visual and Spatial Technology Centre, which he heads, Gaffney projects images of this terra incognita onto huge, full-color screens. Just off the map, the Rhine and the Thames met and flowed south into the Channel River. Gaffney sweeps a hand across other river systems, comparably large, that we have no names for. In the climate of the day—perhaps a couple of degrees warmer than today—the contours on his screen translate into gently rolling hills, wooded valleys, lush marshes, and lagoons. "It was a paradise for hunter-gatherers," he says.

The publication in 2007 of the initial section of this map allowed archaeologists for the first time to "see" the Mesolithic world, even identify likely locations for settlements, with a view to potentially excavating them. The expense of underwater archaeology and the poor visibility in the North Sea have kept those settlements tantalizingly out of reach, at least for now. But the archaeologists have other ways to reveal who the Doggerlanders were, and how they responded to the inexorable creep of the sea into their homeland.

First, there are the treasures brought up in the fishermen's nets. In addition to the human jawbone, Glimmerveen has accumulated more than a hundred other artifacts—animal bones

Archaeologist Lisa Snape-Kennedy traces footprints of a crane at Goldcliff. Now rare in Britain, cranes would have been a valuable food source for Mesolithic people here and in Doggerland to the east.

The Europe That Was

At the end of the last ice age, Britain formed the northwestern corner of an icy continent. Warming climate exposed a vast continental shelf for humans to inhabit. Further warming and rising seas gradually flooded low-lying lands. Some 8,200 years ago, a catastrophic release of water from a North American glacial lake and a tsunami from a submarine landslide off Norway inundated whatever remained of Doggerland.

Ancient shorelines, ice sheets, and rivers are approximate.

WILLIAM E. McNULTY AND JEROME N. COOKSON, NGM STAFF

SOURCES: SIMON FITCH AND VINCENT GAFFNEY, UNIVERSITY OF BIRMINGHAM, U.K.; NORTH SEA PALAEOLANDSCAPES PROJECT

showing signs of butchery and tools made from bone and antler, among them an ax decorated with a zigzag pattern. Because he has the coordinates of these finds, and because objects on the seabed tend not to move far from where erosion liberates them, he can be confident that many come from a specific area of the southern North Sea that the Dutch call De Stekels (the Spines), characterized by steep seabed ridges. "The site or sites must have been close to a river system," he says. "Maybe they lived on river dunes."

Another way to understand the Doggerlanders is to excavate shallow-water or intertidal sites of similar age nearby. In the 1970s and 1980s a site called Tybrind Vig, a few hundred yards off the coast of a Danish island in the Baltic Sea, yielded evidence of a surprisingly advanced late Mesolithic fishing culture, including finely decorated canoe paddles and several long, thin canoes, one of them over 30 feet long. More recently, Harald Lübke, of the Centre for Baltic and Scandinavian Archaeology in Schleswig, Germany, and his colleagues have excavated a series of underwater settlements in Wismar Bay, on the German Baltic coast, dating between 8,800 and 5,500 years ago. The sites vividly document the people's shift in diet from freshwater fish to marine species, as the sea rise transformed their land over centuries from inland lakes surrounded by forests, to reedy marshes, to fjords, and eventually to the open bay there now.

A similar metamorphosis took place at Goldcliff on the Severn estuary in Wales, where archaeologist Martin Bell from the University of Reading and his team have been excavating for 21 years. In the Mesolithic, a narrow, incised valley initially contained the River Severn. As the sea rose, the river spilled over the valley's sides and spread out—perhaps within as little as a century—creating the outlines of the modern estuary. At some point the estuary would have been dotted with islands.

One August day, during an exceptionally low tide at Goldcliff, I followed Bell and his co-workers out across the sucking, streaming mudflats, past huge black trunks of prehistoric oaks lying preserved in the mud. We had less than two hours to work before the tide would pour back in. We arrived at an unremarkable ridge that, 8,000 years ago, formed the edge of an island. A team member blasted it with water from a high-pressure hose, and suddenly a sequence of ancient footprints was thrown into relief—39 in all, made by three or four individuals and heading in both directions along the ridge. "They may have been heading out from their campsite to check their fish traps in a nearby channel," says Bell.

There were numerous camps in the estuary at any one time, Bell believes, each of which was inhabited by an extended family group of perhaps ten individuals. The camps were not permanently occupied. The oldest one would have been submerged at very high tides, so it's clear the visitors were seasonal, and that each time they returned they built their camp a little higher up the slope. The remarkable thing is that they kept coming back, over centuries and possibly millennia, finding their way through a landscape that was changing beyond all recognition. They would have witnessed the engulfing and death of the oak forest. "There would have been a time when colossal oak trees were sticking up, dead, through the salt marsh," says Bell. "It would have been a weird sort of landscape."

Summer and autumn would have been times of plenty at the coast, with grazing on the marsh attracting wild animals to hunt. There would be good fishing, and hazelnuts and berries in abundance. At other times the groups moved up to higher country, probably following the valleys of the Severn's tributaries. With only an oral culture, older individuals would have been vital repositories of environmental knowledge, able to read the migration patterns of birds, for example, and so tell their group when the season had come to leave for the coast or head for the highlands—decisions on which their survival depended.

Finds of much larger concentrations of artifacts suggest that Mesolithic people, like later North American hunter-gatherers, came together for annual social events—possibly in the early autumn, when the seals came in and the salmon were running. In western Britain, these

Members of the Goldcliff archaeological team unfold a plastic sheet etched in black with the footprints of Mesolithic people, deer, and cranes. Red tracings mark the edges of annual sediment bands.

gatherings took place on cliff tops, overlooking sealing grounds. They would have allowed young men and women from localized groups to find mates, and information to be exchanged about other river systems beyond each group's territory—knowledge that became crucial as the sea continued to disrupt the landscape.

The most rapid rises of sea level were on the order of three to six feet a century, but because of the variable topography of the land, the flooding would not have been even. In areas as flat as modern-day East Anglia, a six-foot rise could have shifted the coast inland by miles; in hillier places, less. Down in low-lying Doggerland, the rising sea turned inland lakes into estuaries. Gaffney's digital reconstruction shows that one in particular, the Outer Silver Pit, contains massive sandbanks that could only have been created by fierce tidal currents. At some point the currents would have made it dangerous to cross in a log boat, and eventually, created a permanent barrier to once familiar hunting grounds.

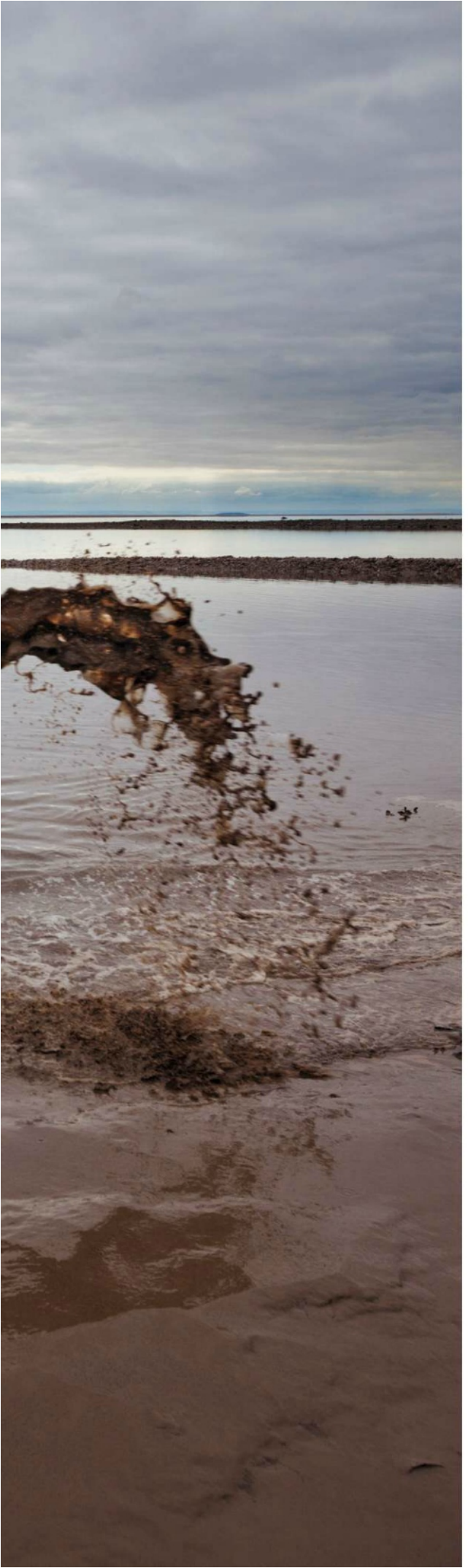
HOW DID MESOLITHIC HUNTERS, so attuned to the rhythm of the seasons, adapt as their world began to dissolve around them? Jim Leary, an archaeologist with English Heritage, has mined the ethnographic literature for parallels with Inuit and other modern hunter-gatherers confronting climate change. For those who learned to exploit the rising sea, becoming skilled boatbuilders and fishermen, the new resource would have been a boon—for a while. But eventually there would come a tipping point, when the loss of territory offset those rich pickings. Older Mesolithic people, those "storehouses of knowledge," as Leary calls them, would no longer have been able to read subtle seasonal variations in the landscape and help the group plan accordingly. Cut off from ancestral hunting, fishing, or burial grounds, the people would have felt a profound sense of placelessness, says Leary—"like Inuit whose way back is barred by melting ice floes."

"There would have been huge population shifts," says Clive Waddington of Derbyshire-based Archaeological Research Services Ltd. "People who were living out in what is now the North Sea would have been displaced very quickly." Some headed for Britain. At Howick in Northumberland, on the cliffs that run along

Murdered, then buried together in a grave festooned with antlers, two women from a Mesolithic cemetery on Téviec Island in Brittany, France, pay witness to a violent age. The shrinking of territories due to sea-level rise may have brought neighboring populations into conflict.

TOULOUSE MUSEUM, FRANCE

As the tide recedes, lead archaeologist Martin Bell of the University of Reading rushes to expose a footprint. With one of the world's largest tidal ranges, the Severn estuary allows a mere two hours to work before the sea returns.



Britain's northeast coast and would therefore have been the first hills they saw, his team has found the remains of a dwelling that had been rebuilt three times in a span of 150 years. Among the earliest evidence of a settled lifestyle in Britain, the hut dates from around 7900 B.C. Waddington interprets its repeated habitation as a sign of increasing territoriality: the resident people defending their patch against waves of displaced Doggerlanders.

"We know how important the fishing grounds were for the subsistence of these people," says Anders Fischer, an archaeologist at the Danish Agency for Culture in Copenhagen. "If each generation saw its best fishing grounds disappear, they would have to find new ones, and that would often be in competition with neighboring groups. In societies of low social complexity, where you have no authorities to handle conflicts, it would probably have ended with violence."

MIGRATION, TERRITORIALITY, conflict: stressful ways of adapting to new circumstances, but adaptations nonetheless. There came a time, however, when the sea exhausted the Doggerlanders' capacity for survival. Some 8,200 years ago, after millennia of incrementally rising seas, a massive release of meltwater from a giant glacial lake in North America, called Lake Agassiz, caused sea levels to jump by more than two feet. By slowing the circulation of warm water in the North Atlantic, this influx of frigid water triggered a sudden plunge in temperature, causing Doggerland's coasts—if any remained—to be battered by frigid winds. If that were not enough, around the same time, a landslide on the seafloor off the coast of Norway, called the Storegga slide, triggered a tsunami that flooded the coastlines of northern Europe.

Was the Storegga tsunami the coup de grâce, or had Doggerland already disappeared beneath the sea? Scientists can't yet be sure. But they do know that sea-level rise slowed down after that. Then, around 6,000 years ago, a new people from the south arrived on the thickly forested shores of the British Isles. They came in boats, with sheep, cattle, and cereals. Today the living descendants of these early Neolithic farmers, equipped with vastly more sophisticated technology than their Mesolithic counterparts, once again look to a future contending with a rising sea. □

NATIONAL GEOGRAPHIC

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NATIONAL GEOGRAPHIC ON TV

Cheetah: Fatal Instinct

Big Cat Week is back this month on Nat Geo WILD. Witness what life is like for the world's fastest land mammal: the cheetah. A young mother and her cubs (left) take the spotlight as they struggle to survive among enemies. Watch her nurture and protect her brood while simultaneously transforming them from roly-poly kittens into menacing hunters.

EXHIBIT

INDIANA JONES Uncover the science behind modern archaeology and peruse artifacts and movie props—including the golden idol from *Raiders of the Lost Ark* (left)—in this interactive exhibit. Catch Indy at the Discovery Science Center in Santa Ana, California, through April 21. Go to *discoverycube.org* for ticket information.

LECTURE

BIRDS OF PARADISE For more on this month's feature story, join Tim Laman and Edwin Scholes as they share images, video, and tales from the field. Visit *nglive.org* for dates in the U.S. and Canada.

APP

LOOK & LEARN: ANIMAL ALPHABET National Geographic's app for preschoolers has six games packed with animal images, fun facts, and sound effects. Look for it in the App Store.

BOOK

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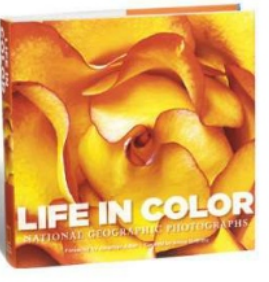


Free Download of the Month

Rupa & the April Fishes *Build*

San Francisco quintet Rupa & the April Fishes draws inspiration from the far-flung origins of its members. Led by singer and songwriter Rupa Marya—a practicing physician in her downtime—the band hopscotches across languages and genres on its latest album, *Build.* For a free download go to *natgeomusic.net/free.*

PHOTO (TOP): REINHARD RADKE, NDR NATURFILM

If You Paid for the Heart Medication, Toprol XL® or its Generic

You Could Get Money from a Class Action Settlement

A Settlement has been reached in a class action lawsuit involving the heart medication, Toprol XL® and its generic equivalent, metoprolol succinate. AstraZeneca AB, AstraZeneca LP, AstraZeneca Pharmaceuticals LP, and Aktiebolaget Hassle (the "Defendants") will pay up to $11 million. After payment of fees and expenses, approximately 50% of the net fund will be paid to consumers, and approximately 50% will be paid to insurers and employee welfare benefit plans.

The lawsuit claims that the Defendants violated antitrust and consumer protection laws by keeping lower cost generic versions of Toprol XL® off the market. The Defendants deny this. **No one is claiming that Toprol XL® or its generic are unsafe or ineffective.**

Who's Included?

Generally, you are included if you purchased, paid for and/or reimbursed others for Toprol XL® or its generic equivalent at any time from May 5, 2005 through September 27, 2012. Purchases made directly from the Defendants are not included under the Settlement.

What Can You Get?

Payments will be based on the valid claims filed (that is, how much you and others paid for Toprol XL® or its generic and when you paid for it). More details are available in the Plan of Allocation, which will be available at www.ToprolSettlement.com or by calling 1-877-854-3273.

How to Get a Payment?

You must submit a Claim Form to get a payment. The Claim Form, and instructions on how to submit it, are available at www.ToprolSettlement.com or by calling 1-877-854-3273. The deadline to submit a Claim Form is **April 1, 2013**.

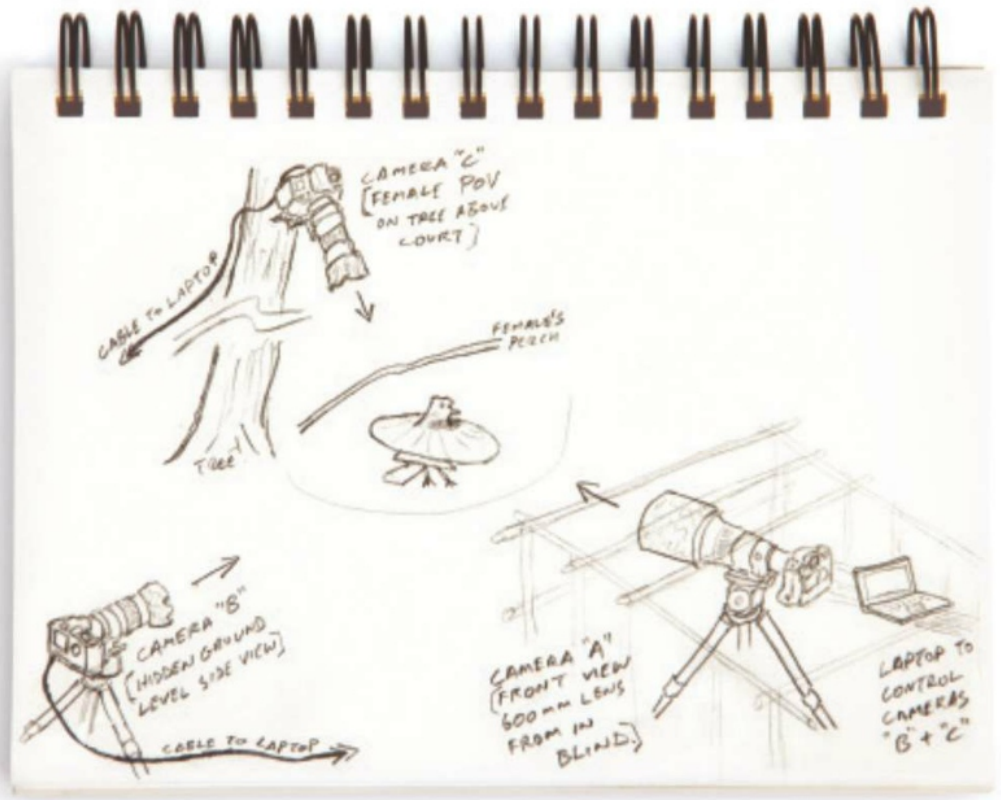
Your Other Rights.

If you do nothing, your rights will be affected. If you do not want to be legally bound by the Settlement, you must exclude yourself from the Settlement by **January 18, 2013**. If you do not exclude yourself you will not be able to sue the Defendants for any claim relating to the lawsuit. If you stay in the Settlement, you may object to it by **January 18, 2013**.

The Court will hold a hearing on **March 7, 2013** to consider whether to approve the Settlement and a request for attorneys' fees up to $3.5 million, reimbursement of costs, and incentive awards. You can appear at the hearing, but you don't have to. You can hire your own attorney, at your own expense, to appear or speak for you at the hearing.

For complete information and a Claim Form:

Visit: www.ToprolSettlement.com Call: 1-877-854-3273



To capture different angles of a male parotia's courtship dance (below), Tim Laman devised a special camera setup, which he sketched here.

See the Wahnes's parotia dance on the iPad/Kindle Fire.

Bird's-Eye View

Ground observers marvel at the courtship dance of the Wahnes's parotia, a bird of paradise. For some 30 seconds, the male shakes his head and pushes his feathers out to form a "tutu" in the New Guinea rain forest. Photographer Tim Laman and ornithologist Edwin Scholes, out to document all 39 species, wondered, What does the female see from her overhanging branch? To find out, Laman rigged a tree with a laptop-controlled camera to record video as he and Scholes watched, hidden in a blind. *—Luna Shyr*


Camera A


Camera B


Camera C

BEHIND THE LENS

How does this dance look to the lady bird?

TL: It's incredible how different it looks from above. You just see a black oval instead of a ballerina with a tutu on. The iridescence of the breast shield is so much brighter because it's catching the light from above. We also saw a bright patch on the back of the head we didn't know was part of the mating display. That was a real wow moment.

Where's the dance floor?

The bird picks a place with a horizontal perch where females can watch, and he removes leaves. He clears the area daily—about six feet across—so he can dance without falling over things.

Did the bird meet with success?

Matings are rare. During the two weeks we worked on these shots, the male had no luck.

PHOTOS: TIM LAMAN (A); TIM LAMAN AND EDWIN SCHOLES (VIDEO CAPTURE, B AND C)

Liquid Assets.

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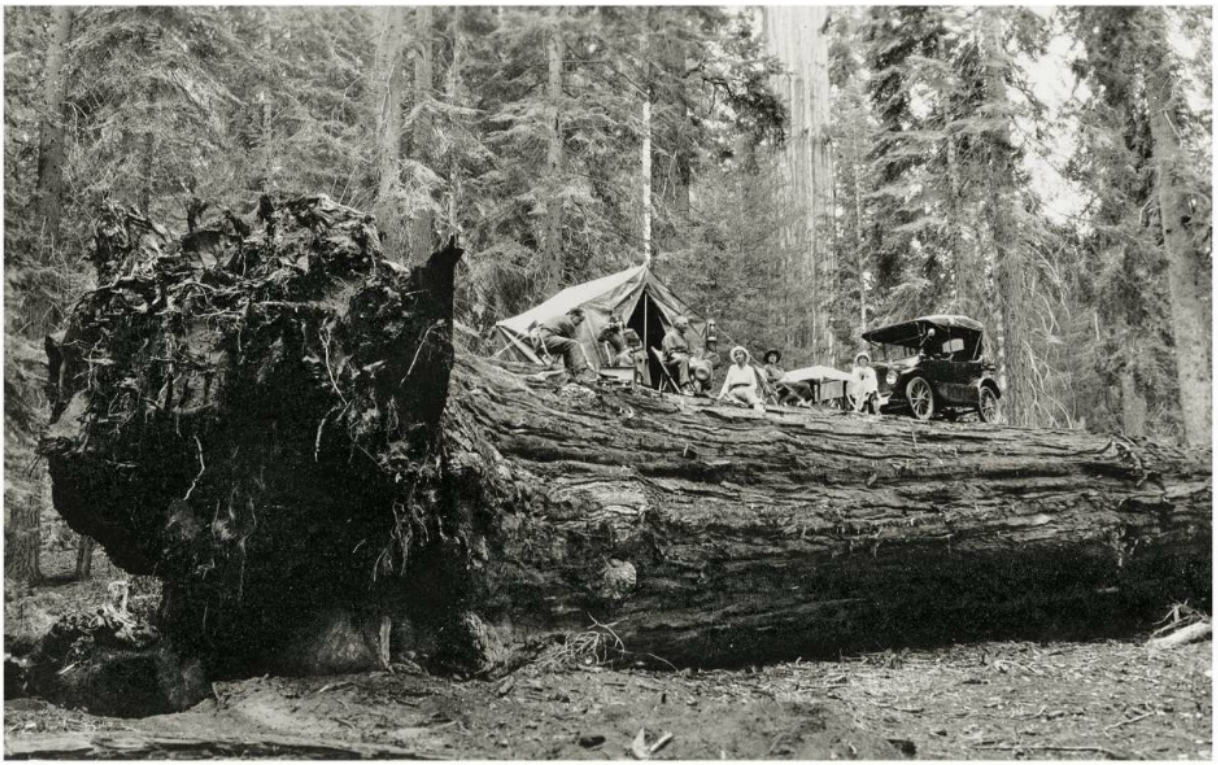

Parking It "In the scenic heart of the Sequoia National Park," noted the January 1917 *National Geographic*, "the only section of the magnificent 160,000-acre playground…accessible to motor-driven and horse-drawn vehicles, stands a group of trees, the *[Sequoiadendron giganteum]*, known as the Giant Forest." Acquired by the magazine eight months later, this photo captured a camping party taking full advantage of that access, using a toppled giant as both picnic spot and parking space.

The park was just 26 years old at the time, and some sections weren't totally worked out. The U.S. Department of the Interior had secured a six-month option on the sequoias still in private hands in 1916 and allocated $50,000 for the purchase, but hadn't included the price of adjacent property needed to complete the transaction. The National Geographic Society pitched in the $20,000 balance. —*Johnna Rizzo*

Flashback Archive Find all the photos at **ngm.com.**

PHOTO: H. E. PARK, NATIONAL GEOGRAPHIC STOCK

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Royal Penguin *(Eudyptes schlegeli)*
Size: Head and body length, 65 - 75 cm (25.6 - 29.5 inches) **Weight:** 4.4 - 6.1 kg (9.7 - 13.4 lbs) during breeding season **Habitat:** Endemic to its breeding islands: Macquarie Island and Clerk and Bishop Islets in Australia **Surviving number:** Estimated at 1,700,000 individuals

Photographed by Sue Flood

WILDLIFE AS CANON SEES IT

Teamwork works. By dividing responsibilities, male and female royal penguins give their young the best start in life. The female takes the first two-week shift incubating her egg, then it's the male's turn. After the egg hatches, the male assumes guard duty while the female forages for food to bring back to their hungry chick. At about 20 days, the chick joins a crèche, freeing both parents to bring meals home. However, the food sources on which the penguins depend are becoming uncertain due to the effects of climate change. And squeezed into small breeding islands, these team players are vulnerable to disease and disaster.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

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