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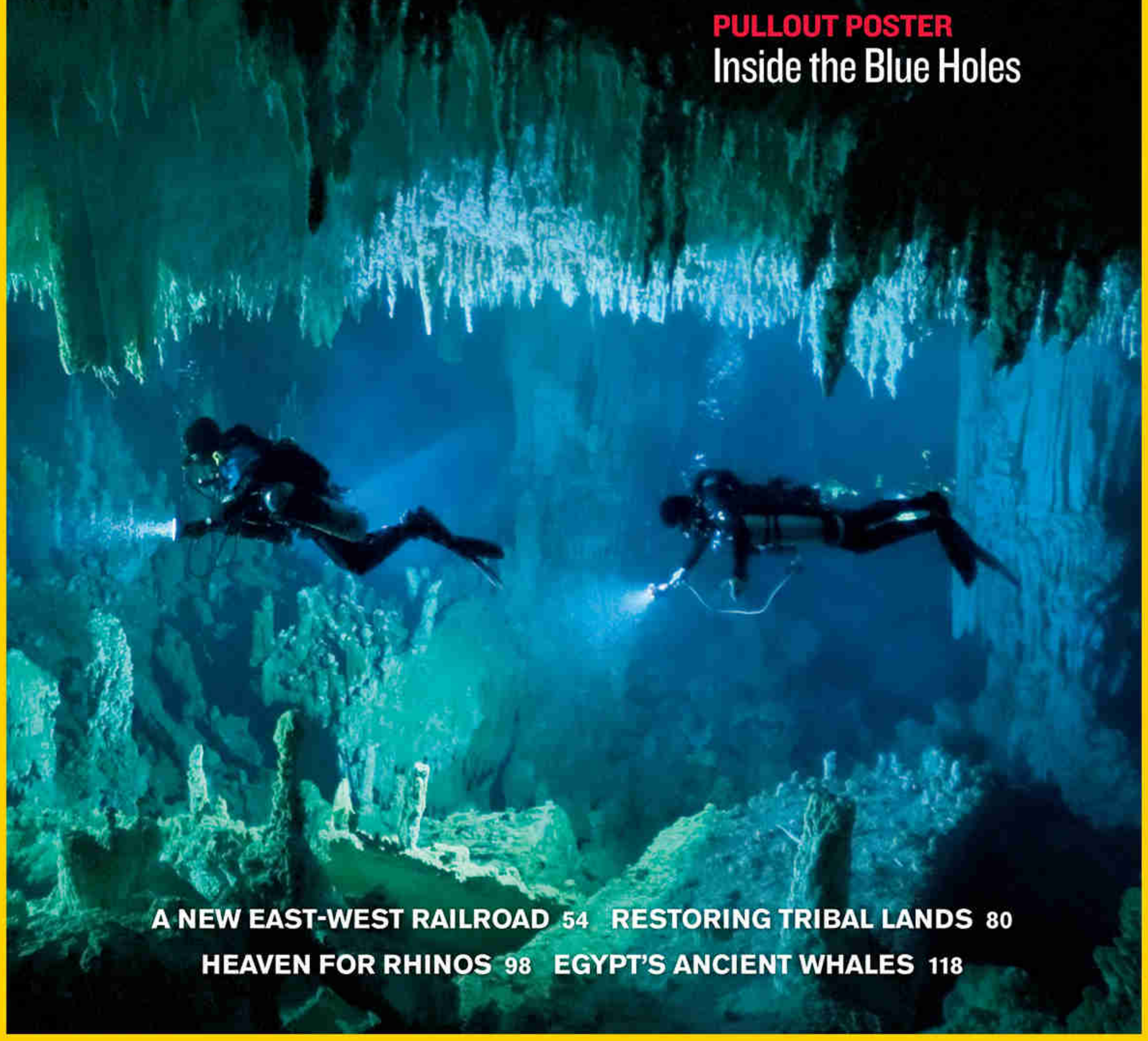
NGM.COM AUGUST 2010

NATIONAL GEOGRAPHIC

Bahamas Blue Holes

DIVE INTO BEAUTY, DANGER, AND DISCOVERY

PULLOUT POSTER
Inside the Blue Holes



A NEW EAST-WEST RAILROAD 54 RESTORING TRIBAL LANDS 80
HEAVEN FOR RHINOS 98 EGYPT'S ANCIENT WHALES 118

2010 Toyota Camry LE

MPG: 32 – EPA est hwy

2010 IIHS Top Safety Pick: no*

Powertrain Warranty: 5 years/60,000 miles**

Automatic Crash Response: not available

Turn-by-Turn Navigation: optional

*Malibu models built after November 11, 2009. Visit IIHS.org for complete details on IIHS segmentation and testing results.
**Whichever comes first. See dealer for limited warranty details. †Visit onstar.com for details and system limitations.

2010 Chevrolet Malibu LTZ

MPG: 33 – EPA est hwy

2010 IIHS Top Safety Pick: yes*

Powertrain Warranty: 5 years/100,000 miles**

Automatic Crash Response: OnStar®/1 year standard†

Turn-by-Turn Navigation: OnStar/1 year standard

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Cuban Iguana *(Cyclura nubila nubila)*
Size: Head and body length, 30.5 - 74.5 cm (12 - 29.3 inches); tail, 32 - 73 cm (12.6 - 28.7 inches) **Weight:** 1.1 - 8.5 kg (2.4 - 18.7 lbs) **Habitat:** Arid coastal areas with xerophytic vegetation and some dry areas farther inland; needs areas of limestone for hiding and soil patches for nesting sites **Surviving number:** Estimated at 40,000 - 60,000

Photographed by Andy Phillips

WILDLIFE AS CANON SEES IT

Hurricane-proof? The Cuban iguana is well suited to weather the calamitous storms that batter the islands. It wedges itself into rock holes so it doesn't get blown out to sea, and its metabolism allows it to survive in the storm's aftermath until plants regenerate leaves, fruits and flowers. The big herbivore plays a major role in seed dispersal, contributing significantly to the health of the ecosystem. Aggressively territorial, males resist intruders whenever possible, but they are powerless to fight habitat loss and disturbance. Already among the most endangered lizards in the world, this iguana is facing a decidedly cloudy future.

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.

Canon

NATIONAL GEOGRAPHIC

AUGUST 2010 · VOL. 218 · NO. 2

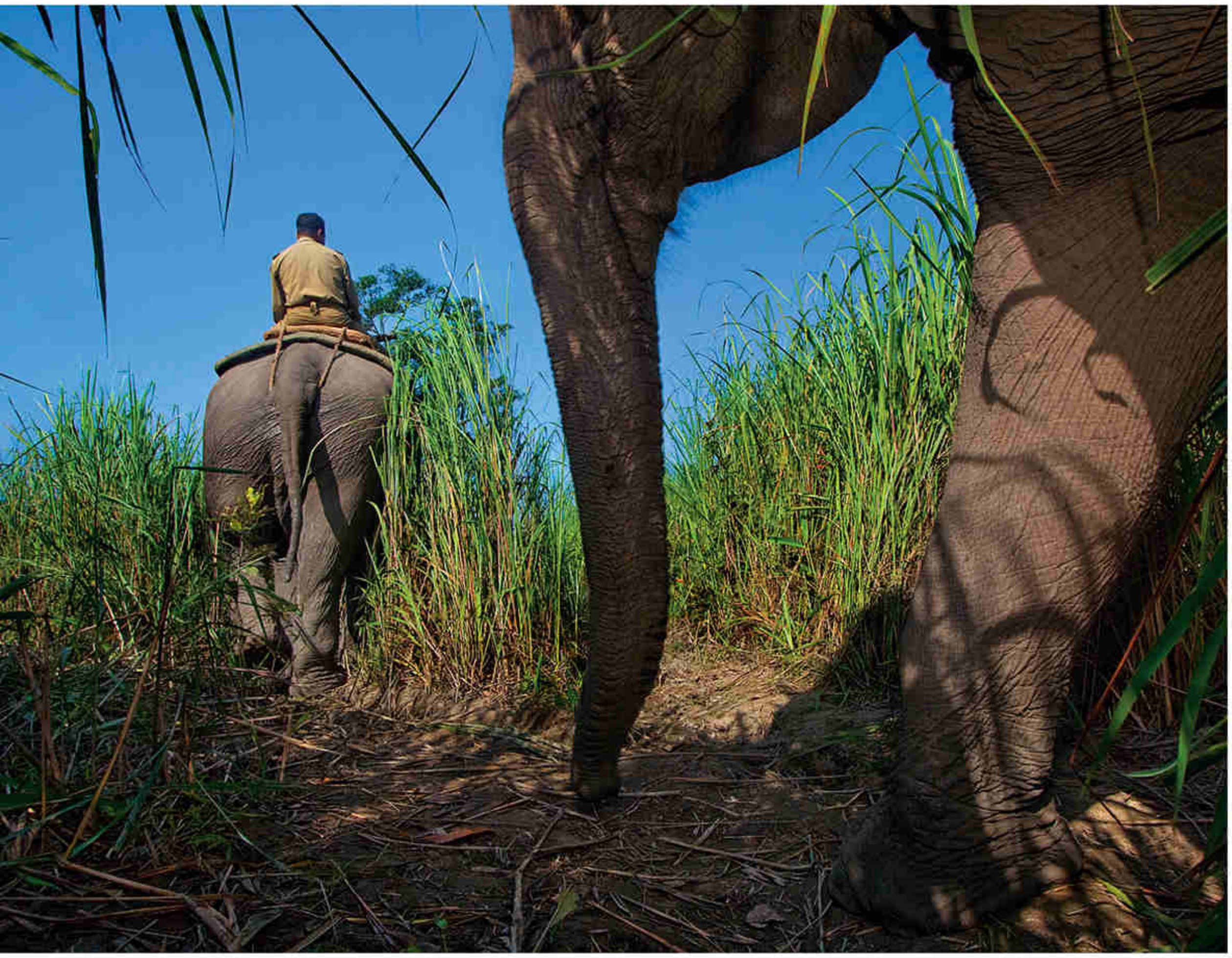
Deep Dark Secrets 34 Scientists dive into the deadly blue holes of the Bahamas.
By Andrew Todhunter Photographs by Wes C. Skiles

The Iron Silk Road 54 A new Europe-to-Asia railway fuels trade—and tensions.
By Brett Forrest Photographs by Alex Webb

Reviving Native Lands 80 U.S. tribes strive to undo years of environmental abuse.
By Charles Bowden Photographs by Jack Dykinga

A Grassland Kingdom 98 India's Kaziranga park shelters tigers, buffalo, and rhinos.
By Douglas H. Chadwick Photographs by Steve Winter

Valley of the Whales 118 The origins of the marine mammal lie buried in Egyptian sand.
By Tom Mueller Photographs by Richard Barnes

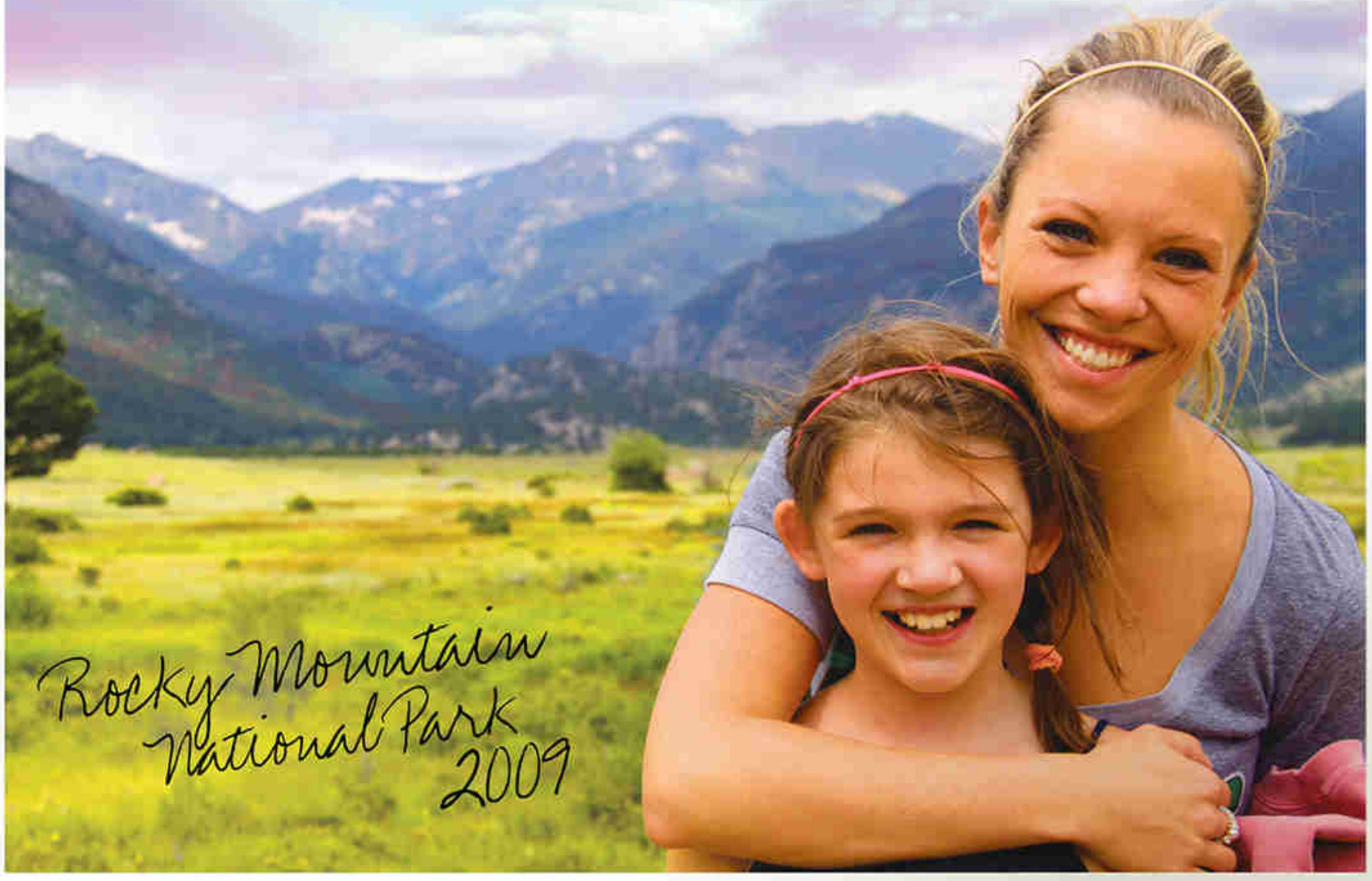


STEVE WINTER

In Kaziranga, poachers have killed hundreds of endangered animals. The park's 600 guards patrol by foot, boat—and elephant. Story on page 98.

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY

Moments like these
are worth saving.



Nature Valley will make a 10¢ donation* to the National Parks Conservation Association for each Nature Valley wrapper you mail to us from specially marked packages, through August 31, 2010.

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*Guaranteed minimum donation of $250,000 maximum donation of $500,000. ©2010 General Mills A20589D

Long before visitors flocked to the Grand Canyon, native plant species were on the scene, hard at work preventing erosion and flooding, sustaining wildlife, and keeping complex ecosystems in perfect balance. Today, the canyon's spectacular landscape is under attack from exotic invasive plant species.

Saving the green in GRAND CANYON'S *red*

A PLANT FOUND ONLY ONE PLACE ON EARTH

The tiny rock-hugging sentry milk-vetch grows only on the Grand Canyon's rim; in fact, its scientific name literally means "gorge watchman." Trampled for years, the endangered plant is now on the verge of extinction. Meanwhile water-hungry tamarisk, an extremely invasive non-native tree, chokes out natural plant communities in the rarest of all canyon habitats, the Colorado River tributary wetlands. These and other changes in park plant life threaten biological diversity, deplete groundwater, and increase flooding.

FIGHTING A GROWING PROBLEM

The innovative Grand Canyon Vegetation Program works to help fragile Grand Canyon habitats flourish once again. Nature Valley is partnering with the National Parks Conservation Association in these efforts. Hundreds of volunteers work with park specialists to collect native seeds by hand, care for seedlings in a greenhouse nursery, reestablish native species, and comb critical areas to locate and remove unwanted invasive plants. From the depths of the canyon floor to its rocky red rim, Nature Valley's hands-on mission preserves the plants that protect an unparalleled wonder.

Nature Valley is helping and so can you. Donate to the National Parks Conservation Association, learn more, and track project progress at **PreserveTheParks.com**

NATIONAL GEOGRAPHIC

DEPARTMENTS

Editor's Note 4

Letters 8

Your Shot 12

Visions of Earth 14

WILD

Coyote Savvy, Wolf Skills

The hybrid eastern coyote hunts deer and rabbits. Should your Chihuahua be worried too?

GEOGRAPHY

Ready, Set…Map

Senator Al Franken can draw the U.S. in minutes. It's a parlor trick—but also a useful skill.

FOSSILS

Tail Power

The glyptodont, an ancient armadillo kin, deftly swung its spiked hind part.

OCEANS

Squid on the Fly

The jumbo flying squid lives a fast and furious life—and it's heading up the California coast.

ARCHAEOLOGY

A Round Ark

A Babylonian tablet offers a different shape for the animal-filled vessel in Flood lore.

THE BIG IDEA

Carbon Capture 30

"Artificial trees" might suck planet-warming CO_2 out of the air faster than real ones.

Inside Geographic 138

Flashback

GeoPuzzle

ngm.com

Down a Blue Hole

Our interactive graphic draws you into the underwater caves of the Bahamas and tells how they came to be.

On the Cover

Extreme climate shifts forged this ancient Bahamian cave as seas rose and fell. Extreme danger awaits divers who explore it.
Photo by Wes C. Skiles

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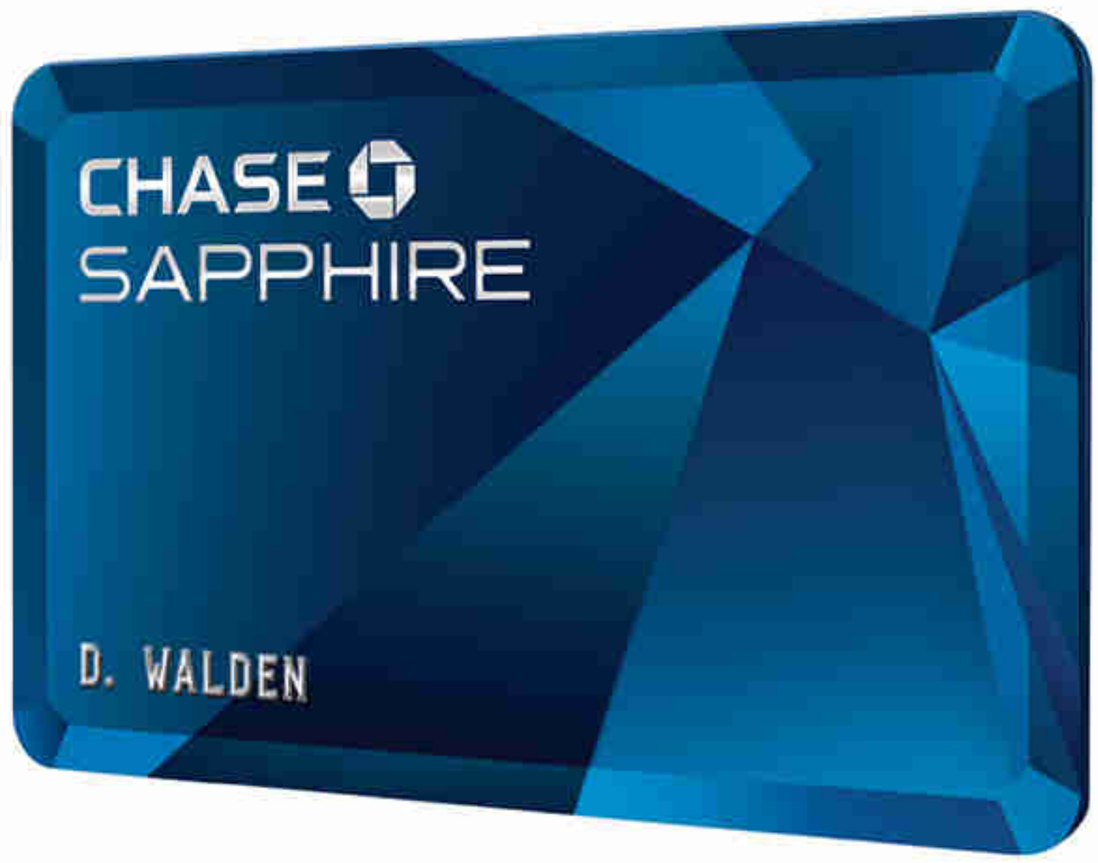

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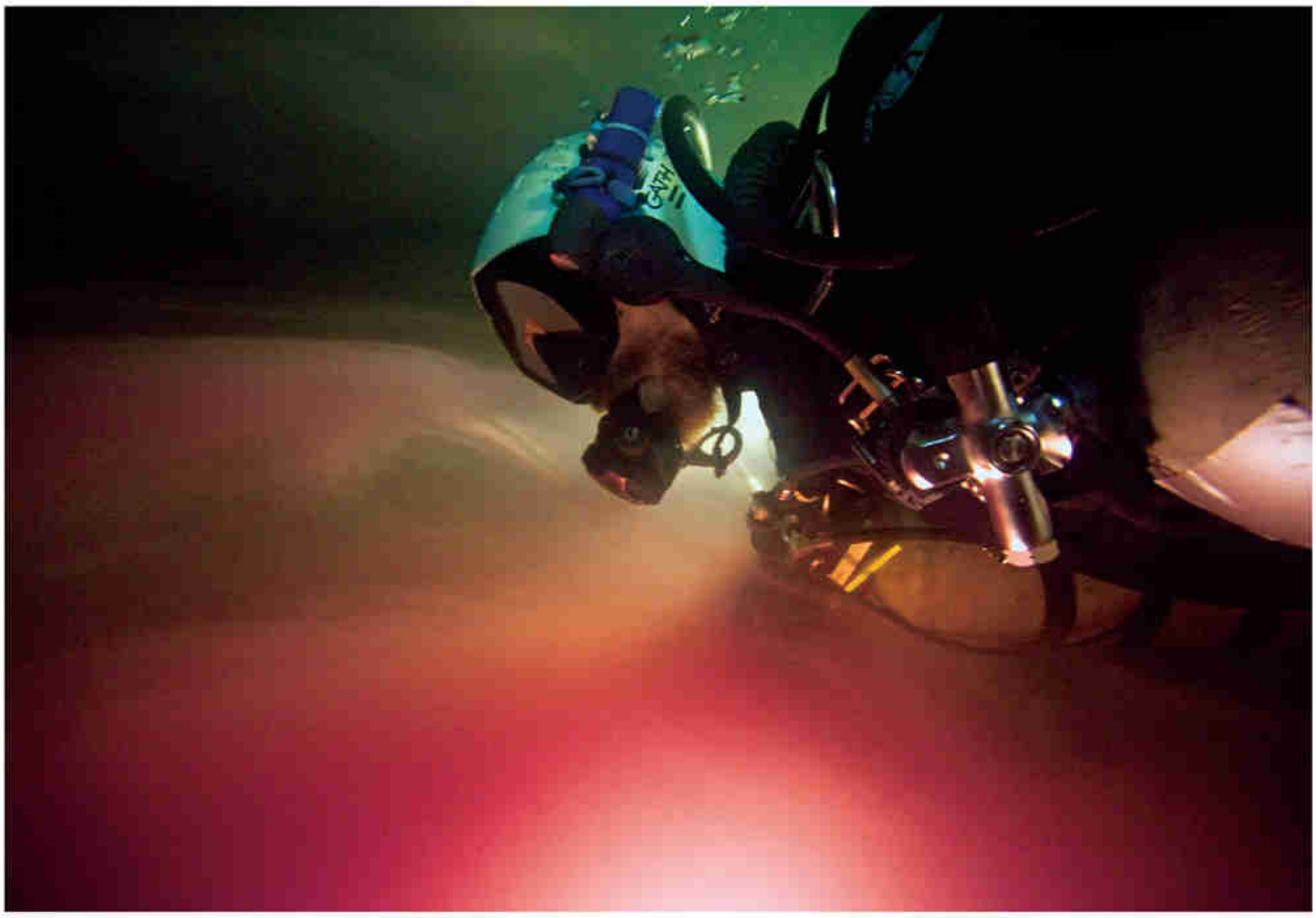
EDITOR'S NOTE



Wes Skiles took this photo of veteran diver Kenny Broad as they began their descent into the hydrogen sulfide zone of a Bahamas blue hole.

Photographer Wes Skiles descends through 30 feet of fresh water and encounters a pink, murky haze. The color indicates the presence of hydrogen sulfide gas—produced by decaying organic material in environments where oxygen is scarce—and it's dangerous. Skiles has little time to traverse this 20-foot-thick, toxic layer. The longer he lingers in this sulfurous hell, the more the risk. His head will begin to throb. He'll get a tingling sensation in his lips. He'll feel nauseous from oxygen deprivation. He must reach the saltwater layer below before he collapses. Skiles, writer Andrew Todhunter, and a team led by Kenny Broad, an anthropologist and veteran cave diver, are on a National Geographic–funded expedition to explore the flooded limestone caves of the Bahamas. These blue holes, the subject of this month's cover story, are an environment like no other. Their dangers are also like no other. Many caves produce violent whirlpools that can rip off a face mask and suddenly suck a diver down hundreds of feet. The risk is worth it.

To study blue holes is to deepen our understanding of the Earth's biology, chemistry, and geology. Some of the caves, Todhunter writes, are the scientific equivalent of Tut's tomb. "It's true exploration," Skiles says. Explorers, like Broad's team of scientists and divers, open doors. They lift the curtain on hidden, sometimes dangerous, worlds. That's their nature, and our world is richer for it.

PHOTO: WES C. SKILES

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NATIONAL GEOGRAPHIC

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Paul Fredrick

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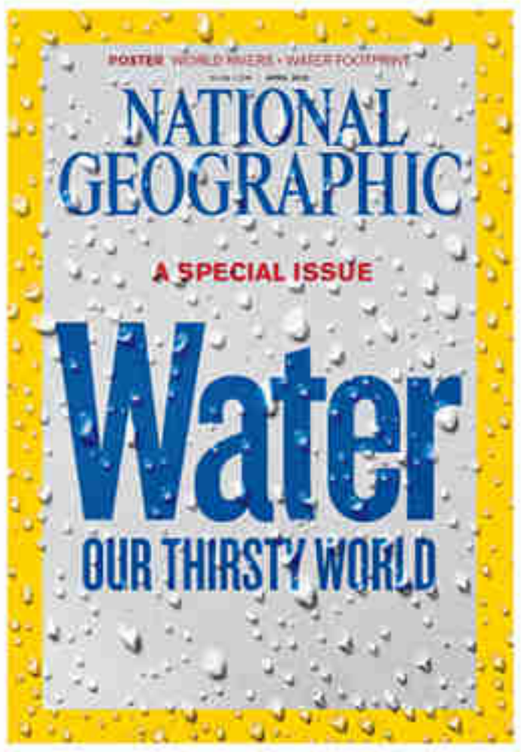
LETTERS



April 2010

The Water Issue

I wanted to share my thoughts on your water issue. Most articles talk of technology to improve what we have so it will continually support life on the planet. The one major issue that is always tap-danced around is our exponentially growing population. I believe the planet has sufficient resources to support humans, as long as population growth is managed in a way so that we don't eat, drink, burn, and trash our way into oblivion. We have to take steps to make sure we don't use up all the planet can provide.

WES WHEADON
Los Angeles, California

I did not notice any mention of the big industrial water users. I wonder if they are paying their fair share of the value of water? I used to be in charge of the water required by a pulp mill on Vancouver Island in Canada. The daily usage was 60 million gallons. This was more than was required by the capital of British Columbia, also on Vancouver Island. I have recently studied the tar sands in northern Alberta. Industry there takes on average three barrels of fresh water for every barrel of oil extracted. And they want to extract oil from shale: more water requirements?

J. G. HANS DUERICHEN
Smithers, British Columbia

This issue was the single most terrifying *National Geographic* I have ever read.

PETRINA VECCHIO
Ashford, Washington

My family lives on the banks of Lake Erie, part of one of the largest clear water systems on Earth, the Great Lakes. We don't take this abundance for granted. This is a resource to be carefully protected. When the public library in our small town built an addition this year, it also added a cistern that catches and stores rainwater. All the toilets in the building are flushed with this water that would otherwise be lost. This avoids tapping into the lake supply, which is the source of our drinking water. We all need to remember that the most important liquid on Earth is not oil. It is water.

JOETTE McDONALD
Vermilion, Ohio

Visions of Earth

The seemingly pristine pool under the Laotian boy on the rope swing on pages 14-15 dredged up mixed emotions from my recent trip to watery Cambodia. My tour guide was also the administrator of the Children's Sanctuary, an orphanage in Siem Reap. Each time I would remark on how beautiful or happy the children in the countryside appeared, he would caution: "Maybe dead soon. Bad water." I did not understand fully what he meant until I read your water issue.

RICK NORMAN
Lake Charles, Louisiana

The Burden of Thirst

I had the privilege of visiting Ethiopia with an international development agency that has been working in that country to bring water to its residents. Water is always the entry point for the development of a suffering community, but it is more than that. Your article spoke of health and education from these water-development projects. What was missing was mention of how freeing a girl from walking through forests for hours on end might free her from the chance that she'll be raped before she's 14 or kidnapped by members of neighboring villages. When development is done well, a community is empowered. The villagers I met didn't need my expertise, my sympathy, or even my help. They simply needed a few resources—steel pipes, trucks to haul said pipes up the mountain, and a bit of concrete to encase their spring. Your article also failed to mention the obstacle met by development workers who, after water comes to a village, try to convince parents to allow their daughters to go to school. Often sons are encouraged to get an education. Girls, however, are a valuable resource put to other tasks of survival, if not water collection.

JOLINE OLSON
Calgary, Alberta

Contact Us

Email ngsforum@ngm.com
Write National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199. Include name, address, and daytime telephone. Letters may be edited for clarity and length.

Brazil Expedition Uncovers Thousands of Carats of Exquisite Natural Emeralds

Brandish a whopping 50 carats of genuine South American emeralds in a handcrafted new necklace design for less than $200.....

and get a $100 Stauer Gift Coupon!

Halfway into our ambitious trek through the rain forest I had to remind myself that "Nothing good comes easy." These days it seems that every business trip to Brazil includes a sweltering hike through overgrown jungles, around cascading waterfalls and down steep rock cliffs. But our gem broker insisted it was worth the trouble. To tell you the truth, for the dazzling emeralds he delivered, I'd gladly go back to stomping through jaguar country.

Now our good fortune is your great reward. Don't miss this rare opportunity to own an impressive 50 carat strand of genuine South American emeralds for under $200. And for a limited time, we'll sweeten every necklace order with **a $100 Stauer Gift Coupon!**

Faced with this embarrassment of riches, our designer transformed this spectacular cache of large stones (each is over 8 carats average weight) into a stunning 50 ctw necklace of faceted emeralds set into .925 sterling silver. Each emerald is surrounded by delicate sterling silver rope work and filigree in the Bali-style. The 18" necklace dangles from a sterling silver chain that fastens with a secure double-sided shepherd's hook clasp.

What is the source of our emerald's timeless appeal?

The enchanting color of the Stauer ***Carnaval*** **Faceted Emerald Necklace** comes from nature's chemistry. Our polished and faceted, well-formed natural emeralds are immediately recognized as something special. Indeed, when we evaluated these emeralds, color was the most important quality factor. Today, scientists tell us that the human eye is more sensitive to the color green than to any other. Perhaps that is why green is so soothing to the eye, and why the color green complements every other color in your wardrobe.

Emeralds are, by weight, the most valuable gemstone in the world.

Now you can wear genuine emeralds and feel great about knowing that you were able to treat yourself to precious gems without paying a precious price. A 50+ carat emerald necklace found on Rodeo Drive or 5th Avenue could cost well over $100,000...but not from Stauer. Wear and admire the exquisite Stauer ***Carnaval*** **Faceted Emerald Necklace** for 30 days.

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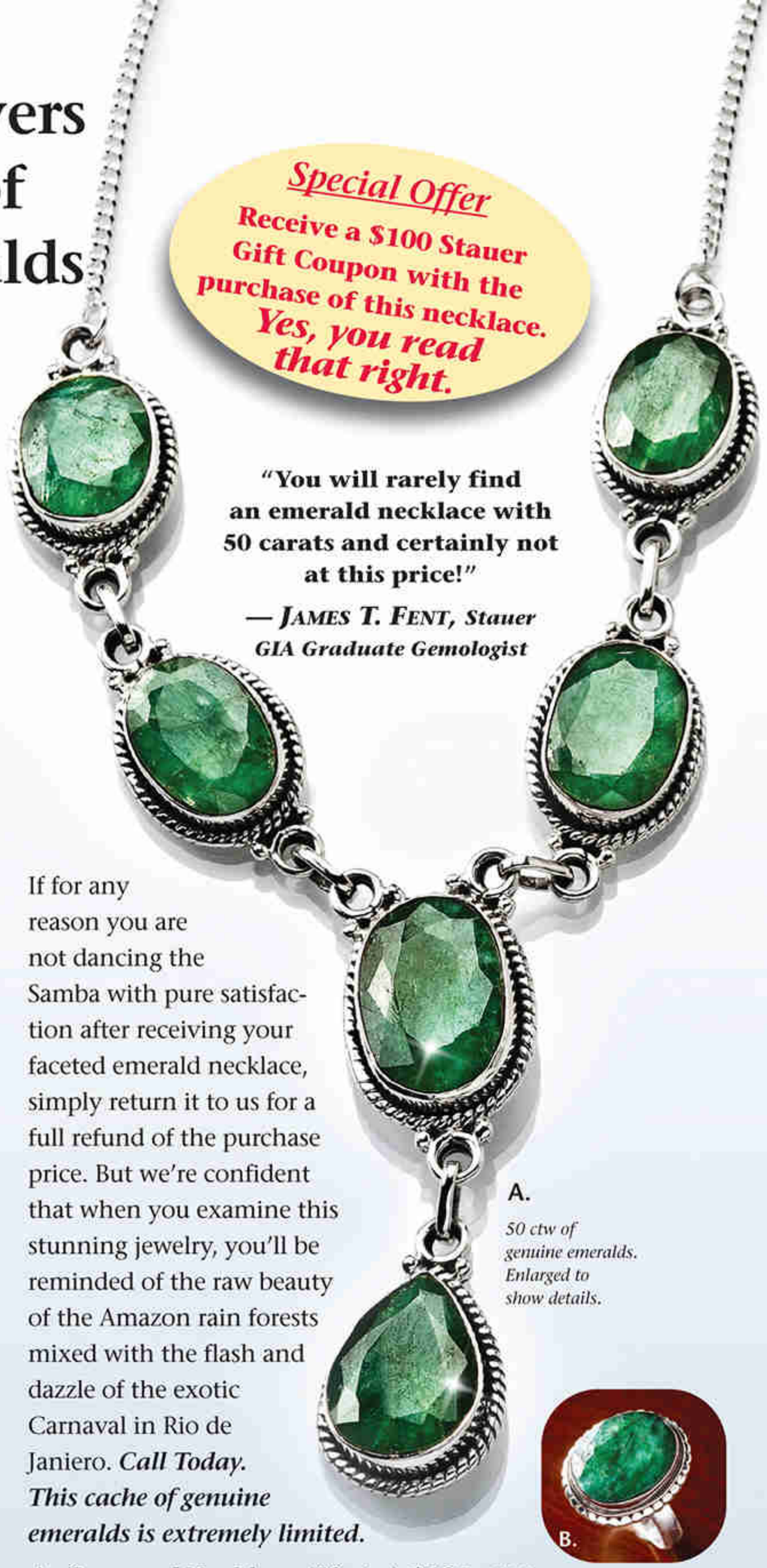
— *James T. Fent, Stauer*
GIA Graduate Gemologist



If for any reason you are not dancing the Samba with pure satisfaction after receiving your faceted emerald necklace, simply return it to us for a full refund of the purchase price. But we're confident that when you examine this stunning jewelry, you'll be reminded of the raw beauty of the Amazon rain forests mixed with the flash and dazzle of the exotic Carnaval in Rio de Janiero. ***Call Today. This cache of genuine emeralds is extremely limited.***

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B.


C.


D.

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EDITORS' CHOICE

Brenda Rusnak Toronto, Ontario

On safari in Tanzania's Serengeti National Park, Rusnak, 50, captured a scene her guide said he'd never seen in 25 years: a treebound leopard leaping far away from a lion. The bigger cat had climbed up to take away the smaller one's freshly killed prey.

Mike Quinn Colts Neck, New Jersey

"I woke up early one morning after a night of snow," says carpenter Quinn, 25, whose father manages a Thoroughbred breeding farm. Seeing 15 inches of accumulation, "I captured one of our horses plowing through a drift and exploding out the other side."

READERS' CHOICE

A proud history of savings and reliability, backed by the strength of Warren Buffett's Berkshire Hathaway Inc. (Note: the above portrait is not Mr. Buffett.)

Nearly 15 years ago, GEICO became a proud part of Warren Buffett's famed holding company. Back then, the Gecko® was one of the hardworking people — sorry, reptiles — in our GEICO offices. Now he's helped GEICO become not only the third-largest car insurance company in the country, but also the fastest growing. Which is no surprise. For over 70 years, GEICO has worked hard to save people hundreds on car insurance. So why not give the Gecko a call to see how much you could save? You'll find he's easier to reach than Mr. Buffett.

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I CHOSE

- [x] To work on controlling my blood sugar.
- [x] To talk to my doctor about insulin.
- [x] To add insulin to my treatment plan.

If you have type 2 diabetes, and pills alone aren't controlling your blood sugar anymore, this could be the right time to consider adding insulin. Insulin is an effective way to lower blood sugar. Controlling blood sugar is important because, over time, high blood sugar can lead to serious complications.

Today, insulin comes in an easy-to-use pen. Insulin should be used as part of an overall diabetes treatment plan, which includes diet, exercise, and other diabetes medications. Make the choice to talk to your doctor about whether insulin is right for you.

Important Safety Information for Lantus® (insulin glargine [rDNA origin] injection)

Do not take Lantus® if you are allergic to insulin or any of the inactive ingredients in Lantus.®

You must test your blood sugar levels while using insulin, such as Lantus.® Do not make any changes to your dose or type of insulin without talking to your healthcare provider. Any change of insulin should be made cautiously and only under medical supervision.

Do NOT dilute or mix Lantus® with any other insulin or solution. It will not work as intended and you may lose blood sugar control, which could be serious. Lantus® must only be used if the solution is clear and colorless with no particles visible. **Do not share needles, insulin pens or syringes with others.**

The most common side effect of insulin, including Lantus,® is low blood sugar (hypoglycemia), which may be serious. Other possible side effects may include injection site reactions, including changes in fat tissue at the injection site, and allergic reactions, including itching and rash. In rare cases, some allergic reactions may be life threatening.

Tell your doctor about other medicines and supplements you are taking because they can change the way insulin works. Before starting Lantus,® tell your doctor about all your medical conditions including if you have liver or kidney problems, are pregnant or planning to become pregnant, or are breast-feeding or planning to breast-feed.

Indications and Usage

Prescription Lantus® is a long-acting insulin used to treat adults with type 2 diabetes and adults and children (6 years and older) with type 1 diabetes for the control of high blood sugar. It should be taken once a day at the same time each day to lower blood glucose.

Do not use Lantus® to treat diabetic ketoacidosis.

Lantus® SoloSTAR® is a disposable prefilled insulin pen.

Please see additional important information on the next page.

WhyInsulin.com
1-877-665-9334

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.

From the maker of Lantus® SoloSTAR.®

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US.GLA.10.04.078

BRIEF SUMMARY OF PRESCRIBING INFORMATION

HIGHLIGHTS OF PRESCRIBING INFORMATION

These highlights do not include all the information needed to use LANTUS safely and effectively. See full prescribing information for LANTUS.

LANTUS® (insulin glargine [rDNA origin] injection) solution for subcutaneous injection

Initial U.S. Approval: 2000

INDICATIONS AND USAGE

LANTUS is a long- acting human insulin analog indicated to improve glycemic control in adults and children with type 1 diabetes mellitus and in adults with type 2 diabetes mellitus. (1)

Important Limitations of Use:

- Not recommended for treating diabetic ketoacidosis. Use intravenous, short-acting insulin instead.

DOSAGE AND ADMINISTRATION

- The starting dose should be individualized based on the type of diabetes and whether the patient is insulin-naïve (2.1, 2.2, 2.3)
- Administer subcutaneously once daily at any time of day, but at the same time every day. (2.1)
- Rotate injection sites within an injection area (abdomen, thigh, or deltoid) to reduce the risk of lipodystrophy. (2.1)
- Converting from other insulin therapies may require adjustment of timing and dose of LANTUS. Closely monitor glucoses especially upon converting to LANTUS and during the initial weeks thereafter. (2.3)

DOSAGE FORMS AND STRENGTHS

Solution for injection 100 units/mL (U-100) in

- 10 mL vials
- 3 mL cartridge system for use in OptiClik (Insulin Delivery Device)
- 3 mL SoloStar disposable insulin device (3)

CONTRAINDICATIONS

Do not use in patients with hypersensitivity to LANTUS or one of its excipients (4)

WARNINGS AND PRECAUTIONS

- Dose adjustment and monitoring: Monitor blood glucose in all patients treated with insulin. Insulin regimens should be modified cautiously and only under medical supervision (5.1)
- Administration: Do not dilute or mix with any other insulin or solution. Do not administer subcutaneously via an insulin pump or intravenously because severe hypoglycemia can occur (5.2)
- Do not share reusable or disposable insulin devices or needles between patients (5.2)
- Hypoglycemia: Most common adverse reaction of insulin therapy and may be life-threatening (5.3, 6.1)
- Allergic reactions: Severe, life-threatening, generalized allergy, including anaphylaxis, can occur (5.4, 6.1)
- Renal or hepatic impairment: May require a reduction in the LANTUS dose (5.5, 5.6)

ADVERSE REACTIONS

Adverse reactions commonly associated with Lantus are:

- Hypoglycemia, allergic reactions, injection site reaction, lipodystrophy, pruritus, and rash. (6.1)

To report SUSPECTED ADVERSE REACTIONS, contact sanofi-aventis at 1-800-633-1610 or FDA at 1-800-FDA-1088 or *www.fda.gov/medwatch.*

DRUG INTERACTIONS

- Certain drugs may affect glucose metabolism, requiring insulin dose adjustment and close monitoring of blood glucose. (7)
- The signs of hypoglycemia may be reduced or absent in patients taking anti-adrenergic drugs (e.g., beta-blockers, clonidine, guanethidine, and reserpine). (7)

USE IN SPECIFIC POPULATIONS

- Pregnancy category C: Use during pregnancy only if the potential benefit justifies the potential risk to the fetus (8.1)
- Pediatric: Has not been studied in children with type 2 diabetes. Has not been studied in children with type 1 diabetes <6 years of age (8.4)

See Full Prescribing Information for PATIENT COUNSELING INFORMATION and FDA-approved patient labeling

Revised: 09/2009

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—George Thomas
Towson Watch Company

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Eighty-six years ago, a watchmaker in Paris famous for building the magnificent clocks at Versailles created a legendary timepiece. He invented the first watch with an automatic mechanical drive. These innovative movements required no batteries and never needed to be manually wound. Only seven of these ultra-rare watches were ever made and we've studied the one surviving masterpiece in a watch history museum. Inspired by history, classic design and technology, our Stauer ***Meisterzeit*** has been painstakingly handcrafted to meet the demanding standards of vintage watch collectors.

Why the new "antique" is better than the original. The original timepiece was truly innovative, but, as we studied it closely, we realized that we could engineer ours with a much higher level of precision. The 27-ruby-jewel movement utilizes an automatic self-winding mechanism inspired by a patent from 1923, but built on $31 million in state-of-the-art Swiss-made machinery. With an exhibition back, you can see into the heart of the engineering and view the rotor spin—it's powered by the movement of your body.

This limited edition Stauer ***Meisterzeit*** allows you to wear a watch far more exclusive than most new "upscale" models. Here is your chance to claim a piece of watchmaking history in a rare design that is priced to wear everyday.

Elegant and accurate. This refined beauty has a fastidious side. Each movement and engine-turned rotor is tested for 15 days and then certified before it leaves the factory.

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View the precision movement of the *Meisterzeit* through the rear exhibition port.

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VISIONS OF EARTH

United Arab Emirates From the top of the world's tallest building—the 164-story, 2,717-foot Burj Khalifa—an economic history of Dubai is visible. Dense development reflects the recent boom; open spaces are remnants of an earlier era.

PHOTO: SAMAR JODHA

France Late afternoon finds the shallows of Lac de la Motte awash in amphibian life. As a mature common toad ascends to the sunlit surface, a clutch of frog eggs—set to hatch in a few days—piles the reed-lined bottom.

PHOTO: MICHEL LOUP, BIOSPHOTO

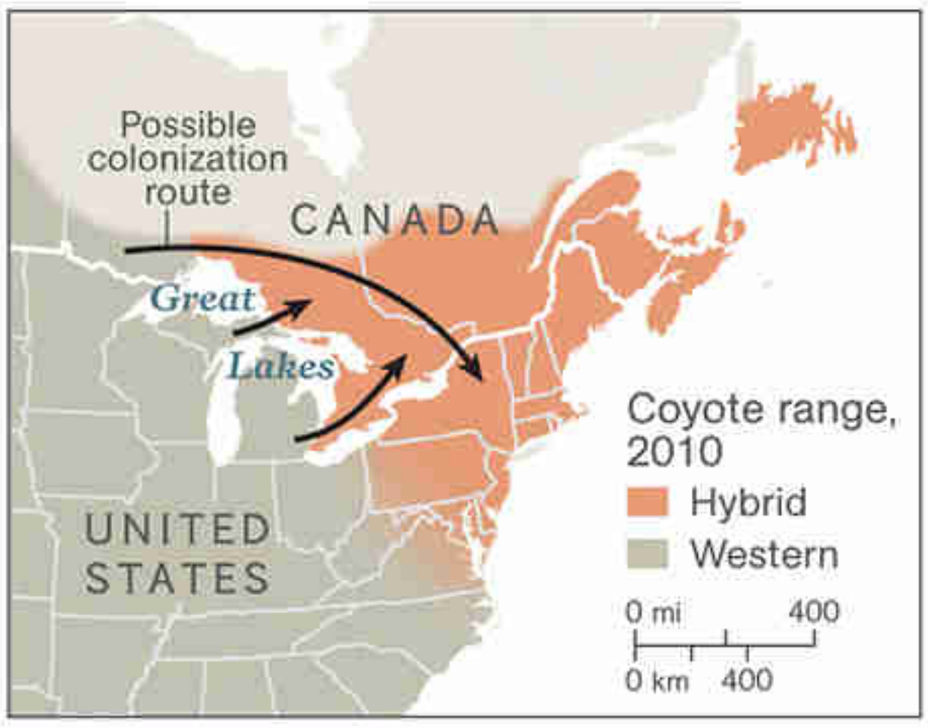
Afghanistan In a private shop in Kandahar, where images of modern beauty adorn the walls, a seated woman primps for a Persian New Year party. In public she will honor custom and veil her makeup beneath a burka.

PHOTO: PAULA LERNER, AURORA PHOTOS

New Beasts in the East Hiking in a Nova Scotia park last fall, a young woman was killed by two canids. They were bigger than coyotes and smaller than wolves, with skulls and jaws unlike either species'. Some eastern Canadians and Americans had glimpsed "coywolves" before, but the grisly incident conjured fresh questions. What exactly are they? And should we be worried?

Roland Kays of New York State Museum can answer the first one. In the 1920s, he says, coyotes from the west pushed into the Great Lakes region and mated with wolves from the east. The result wasn't a new species but, according to recent DNA analysis, a hybrid that's more coyote than wolf, with the street smarts of the former and the hunting capabilities of the latter. No one knows their current numbers, but eastern coyotes (the favored term) form families, seek food at night, and can prey on pets and livestock—the main reason for their recent run-ins with humans.

As for worrying, Cape Cod wildlife specialist Peter Trull says there's no need to; the Nova Scotia case was an anomaly. "Coyotes are wild animals, and people have been bitten by them," he says. "But generally they avoid humans." —*Jeremy Berlin*



Western coyote

Eastern coyote (hybrid)

Wolf genes give eastern coyotes bigger skulls and wider jaws—capable of taking down large prey like deer—than their western predecessors.

Adult eastern coyotes, like this one snapped by a camera trap in upstate New York, weigh 32 to 44 pounds.

PHOTOS: NEW YORK STATE MUSEUM, ALBANY
NGM MAPS. SOURCES: ROLAND KAYS, NEW YORK STATE MUSEUM; BRADLEY N. WHITE, TRENT UNIVERSITY, ONTARIO

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GEOGRAPHY

A designer at *National Geographic* drew this map from memory in under five minutes.

Ready, Set…Map Senator Al Franken can draw the U.S., state by state, in a matter of minutes—check him out on YouTube. Is it a parlor trick or a skill students should learn?

It's a bit of both. Sure, you've got to memorize trivia. But you'll also learn a lot of useful information. To wit: "Texas has Louisiana to the east and goes all the way to New Mexico and is huge," says Paul Blank, chair of the geography department at California's Humboldt State University.

Then again, some kids just aren't good at drawing. Even if they are, mimicking maps isn't enough. "Geography is the why of where," says Blank. Lessons should help kids see how geography can cause wars and shape cultures. To that end, teachers should aim to build mental maps, says Phil Gersmehl of the New York Center for Geographic Learning and the Michigan Geographic Alliance. The goal is to fill the brain with instructive landmarks, like the 20-inch rainfall line. Heading up the 100th meridian from Texas to North Dakota, it marks the divide between wet and semiarid climes. Crops thrive to its east; people grow scarce to its west. *—Marc Silver*

NAPKIN MAP TIPS

Think of a rectangle of dough. Pull up Maine, pull out Massachusetts, pull down Texas and Florida, push in the Great Lakes. And then…

1 **The 49th parallel sets up five states:** Washington, Idaho, Montana, North Dakota, and Minnesota.

2 **Sketch the Four Corners.** That's the intersection of Arizona, New Mexico, Colorado, and Utah.

3 **Draw two boxing gloves.** One is the Lower Peninsula of Michigan; two is Wisconsin, punching Minnesota in the gut.

4 **Look for shapes.** New Jersey? A peanut.

ART: OLIVER UBERTI, NGM STAFF. PHOTO: TIM HUSSIN

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Hard Hit Every batter and tennis pro knows the best *thwack* comes when the ball hits the equipment's sweet spot. Turns out glyptodonts, giant armored mammals that lived from about 30 million to 10,000 years ago, were using that center of percussion, as the spot is known, to strike hard blows with their battle-ready tails.

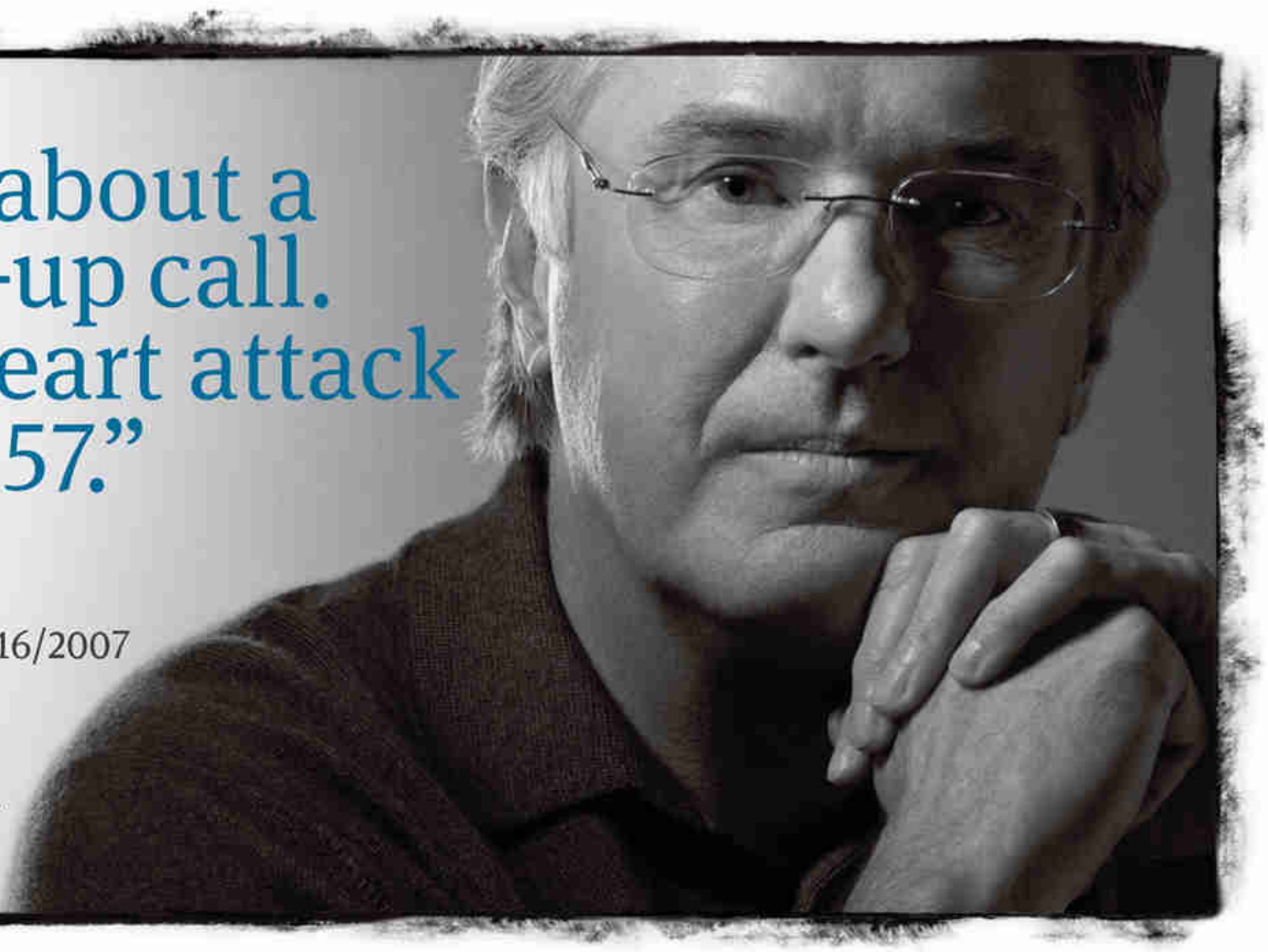
Fossil evidence tells us that some of the largest of these armadillo kin wielded spiked clubs weighing up to 140 pounds, joined to the body by a series of bony rings. Now biomechanical studies by Uruguayan scientist R. Ernesto Blanco and colleagues suggest that glyptodont fights didn't involve random swinging of arms. While smaller species had mobile tails for quick swipes at predators like carnivorous birds, the largest ones had stiffer tails with a sweet spot at or near their prime spike. This morphology allowed the beasts to nail foes while minimizing harmful vibrations to the body joint from the force of impact. The big guys could afford this adaptation, which limited the tail's speed and range of motion but, Blanco theorizes, offered a particular advantage during slow, ritualized courtship battles over favored females. How sweet is that? *—Jennifer S. Holland*

At up to two tons, the largest glyptodonts weighed more than a Volkswagen Beetle.

The tail's sweet spot minimized joint injuries from the impact of blows.

ART: RAÚL MARTÍN

"Talk about a wake-up call. I had a heart attack at 57."



~John E.
Lafayette, CA
Heart attack: 8/16/2007

a LIPITOR heart to heart

"I should have been doing more for my high cholesterol. I learned the hard way. Now I trust my heart to Lipitor." Talk to your doctor about your risk and about Lipitor.

- When diet and exercise are not enough, adding Lipitor may help. Lipitor is FDA-approved to reduce the risk of heart attack and stroke in patients who have heart disease or risk factors for heart disease, including family history of early heart disease, high blood pressure, low good cholesterol, age and smoking.
- Lipitor has been extensively studied with over 18 years of research. And Lipitor is backed by over 400 ongoing or completed clinical studies.

IMPORTANT SAFETY INFORMATION:
LIPITOR is not for everyone. It is not for those with liver problems. And it is not for women who are nursing, pregnant or may become pregnant.

If you take LIPITOR, tell your doctor if you feel any new muscle pain or weakness. This could be a sign of rare but serious muscle side effects. Tell your doctor about all medications you take. This may help avoid serious drug interactions. Your doctor should do blood tests to check your liver function before and during treatment and may adjust your dose.

Common side effects are diarrhea, upset stomach, muscle and joint pain, and changes in some blood tests.

INDICATION:
LIPITOR is a prescription medicine that is used along with a low-fat diet. It lowers the LDL ("bad" cholesterol) and triglycerides in your blood. It can raise your HDL ("good" cholesterol) as well. LIPITOR can lower the risk for heart attack, stroke, certain types of heart surgery, and chest pain in patients who have heart disease or risk factors for heart disease such as age, smoking, high blood pressure, low HDL, or family history of early heart disease.

LIPITOR can lower the risk for heart attack or stroke in patients with diabetes and risk factors such as diabetic eye or kidney problems, smoking, or high blood pressure.

Please see additional important information on next page.

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(LIP-ih-tore)

LOWERING YOUR HIGH CHOLESTEROL

High cholesterol is more than just a number, it's a risk factor that should not be ignored. If your doctor said you have high cholesterol, you may be at an increased risk for heart attack and stroke. But the good news is, you can take steps to lower your cholesterol.

With the help of your doctor and a cholesterol-lowering medicine like LIPITOR, along with diet and exercise, you could be on your way to lowering your cholesterol.

Ready to start eating right and exercising more? Talk to your doctor and visit the American Heart Association at www.americanheart.org.

WHO IS LIPITOR FOR?

Who can take LIPITOR:

- People who cannot lower their cholesterol enough with diet and exercise
- Adults and children over 10

Who should NOT take LIPITOR:

- Women who are pregnant, may be pregnant, or may become pregnant. LIPITOR may harm your unborn baby. If you become pregnant, stop LIPITOR and call your doctor right away.
- Women who are breast-feeding. LIPITOR can pass into your breast milk and may harm your baby.
- People with liver problems
- People allergic to anything in LIPITOR

BEFORE YOU START LIPITOR

Tell your doctor:

- About all medications you take, including prescriptions, over-the-counter medications, vitamins, and herbal supplements
- If you have muscle aches or weakness
- If you drink more than 2 alcoholic drinks a day
- If you have diabetes or kidney problems
- If you have a thyroid problem

ABOUT LIPITOR

LIPITOR is a prescription medicine. Along with diet and exercise, it lowers "bad" cholesterol in your blood. It can also raise "good" cholesterol (HDL-C).

LIPITOR can lower the risk of heart attack, stroke, certain types of heart surgery, and chest pain in patients who have heart disease or risk factors for heart disease such as:

- age, smoking, high blood pressure, low HDL-C, family history of early heart disease

LIPITOR can lower the risk of heart attack or stroke in patients with diabetes and risk factors such as diabetic eye or kidney problems, smoking, or high blood pressure.

POSSIBLE SIDE EFFECTS OF LIPITOR

Serious side effects in a small number of people:

- **Muscle problems** that can lead to kidney problems, including kidney failure. Your chance for muscle problems is higher if you take certain other medicines with LIPITOR.
- **Liver problems**. Your doctor may do blood tests to check your liver before you start LIPITOR and while you are taking it.

Call your doctor right away if you have:

- Unexplained muscle weakness or pain, especially if you have a fever or feel very tired
- Allergic reactions including swelling of the face, lips, tongue, and/or throat that may cause difficulty in breathing or swallowing which may require treatment right away
- Nausea, vomiting, or stomach pain
- Brown or dark-colored urine
- Feeling more tired than usual
- Your skin and the whites of your eyes turn yellow
- Allergic skin reactions

Common side effects of LIPITOR are:

- Diarrhea
- Upset stomach
- Muscle and joint pain
- Changes in some blood tests

HOW TO TAKE LIPITOR

Do:

- Take LIPITOR as prescribed by your doctor.
- Try to eat heart-healthy foods while you take LIPITOR.
- Take LIPITOR at any time of day, with or without food.
- If you miss a dose, take it as soon as you remember. But if it has been more than 12 hours since your missed dose, wait. Take the next dose at your regular time.

Don't:

- Do not change or stop your dose before talking to your doctor.
- Do not start new medicines before talking to your doctor.
- Do not give your LIPITOR to other people. It may harm them even if your problems are the same.
- Do not break the tablet.

NEED MORE INFORMATION?

- Ask your doctor or health care provider.
- Talk to your pharmacist.
- Go to **www.lipitor.com** or call **1-888-LIPITOR**.

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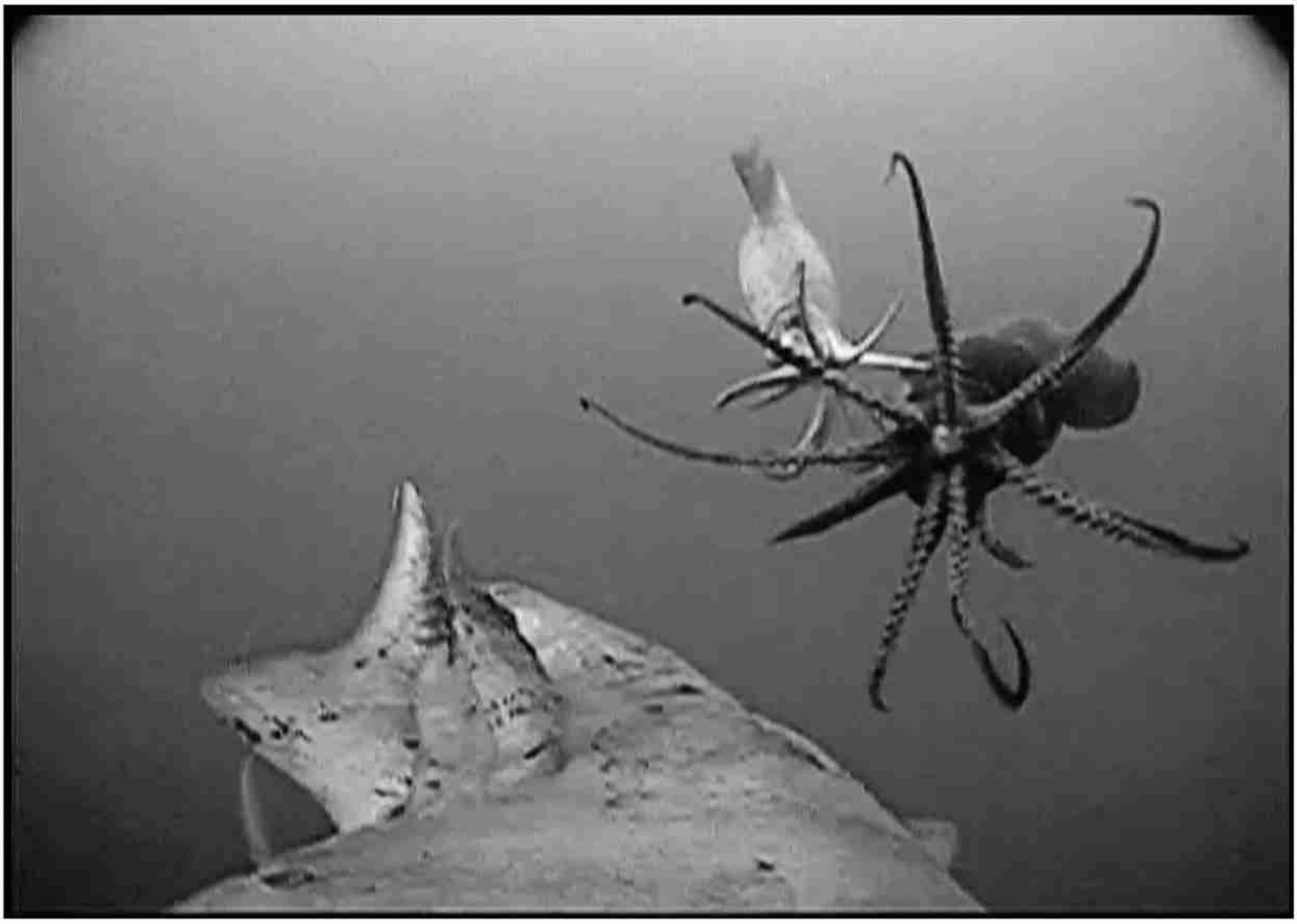
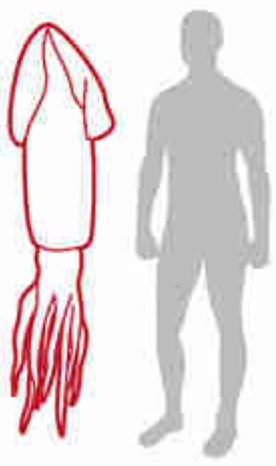
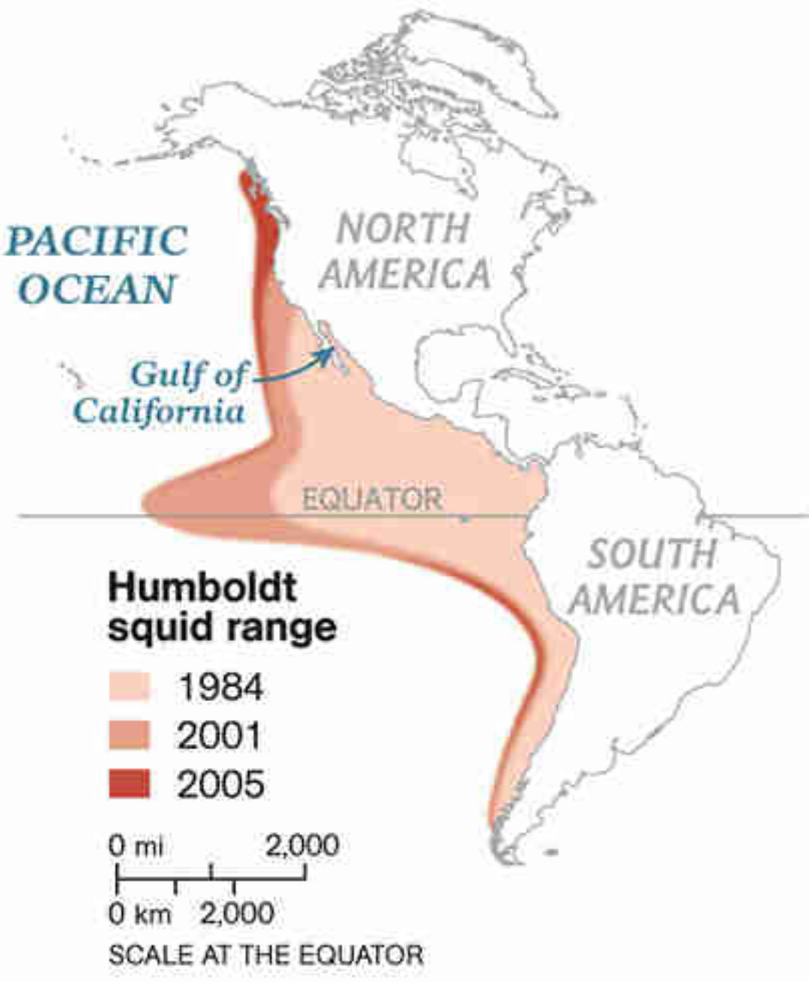


Wearing a Crittercam that later detached, a Humboldt squid, 140 feet down in the Gulf of California, films its cohorts.

Squid on the Fly The millions of Humboldt squid, aka jumbo flying squid, live "fast and furious" lives, says NOAA Fisheries oceanographer Ken Baltz. "They hunt and eat and hunt and eat" for a year or two, then expire. Their diet is mainly fish, an occasional floating seabird—and sometimes each other. Once in a great while they "fly" by ejecting themselves from the water. Given that a squid's body plus tentacles can run six feet and top the scales at 80 pounds, that's quite a feat. Flight might be a way to evade predators, although scientists don't know exactly why squids soar. Nor do they understand why the squid can quickly change from red to pink to maroon: maybe to confuse prey, maybe to signal each other.



Now this warm-water denizen is in the news because of an unexpected incursion into the northern Pacific. Its big appetite will surely affect the ecosystem. If salmon are also on the menu, adds William Gilly, a biologist at Hopkins Marine Station of Stanford University, Northwest fisheries will suffer. But he doesn't buy reports of summer 2009 attacks on San Diego scuba divers. A squid might nudge with a toothed appendage to assess edibility, he says. "They're smart and curious and really tactile." Anyone in a wet suit would be deemed unfit for cephalopod consumption. *—Marc Silver*



Warming oceans could be causing this ace predator, which thrives in tropical waters, to head as far north as Alaska.

Watch *Dangerous Encounters: Cannibal Squid*, airing July 30 at 9 p.m. on the National Geographic Channel.

PHOTO: KYLER ABERNATHY, REMOTE IMAGING, AND SIMON BOYCE, *DANGEROUS ENCOUNTERS WITH BRADY BARR*. NGM MAPS
SOURCES: ASHLEY BOOTH AND WILLIAM F. GILLY, STANFORD UNIVERSITY

"Atram-Hasis, pay heed to my advice, that you may live forever! ... Draw out the boat that you will build with a circular design; let its length and breadth be the same."

—ENKI, A BABYLONIAN GOD

A Babylonian text has specs for a round ark meant to ride out the Flood.

Actual size

Hark the Round Ark "Make thee an ark," the Lord told Noah in the Book of Genesis, and forever after the ark has been pictured as an animal-filled boat with a conventional prow and stern. Now a recently translated Babylonian tablet (above), related to the *Epic of Gilgamesh,* floats an intriguing alternative in which the archetypal ark was round and made of pitch-covered reeds, much like a coracle, a craft still used today on the Euphrates and Tigris Rivers.

"The ark wasn't going anywhere," explains Irving Finkel, assistant keeper of cuneiform at the British Museum, who did the translation. "It simply had to bob along the surface until the waters went down." The author of the 4,000-year-old clay tablet might have glanced out his window at the vessels on the river and adapted the detail to his story.

Flood myths appear in many cultures, and this one had circulated for eons before it was incorporated into the Bible. Finkel thinks the Babylonian version may have been a precursor to the familiar Hebraic one. While the shape of the ark may vary according to the teller, a basic narrative thread holds: Man was flawed. Revision was required. Best to wipe the slate clean and start again. *—Cathy Newman*

PHOTO: ROLF MARRIOTT

David LaChapelle *for* Rolling Stone

Young people do everything online. Like order millions of magazines.

Somehow, amidst their infatuation with Facebook, YouTube, Twitter and the like, young adults are still making time for another one of their favorite pursuits: reading magazines.

Contrary to popular misperception, the phenomenal popularity of the Internet has not come at the expense of magazines. Readership is actually increasing, and adults between 18 and 34 are among the most dedicated readers. They equal or surpass their over-34 counterparts in issues read per month and time spent per issue.

What's changed isn't people's affinity for magazines but the means by which they acquire them. Last year, nearly 22 percent of all new paid subscriptions were ordered online.

And just as the Internet drives magazine subscriptions, magazines drive Web searches – with nearly double the effectiveness of the Internet itself. Some might call it ironic.

The medium that some predicted would vanquish magazines is actually helping fuel their growth. And vice versa.

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Scrubbing the Skies

Pulling CO_2 back out of the air might be easier than building jets and cars that don't emit it.

EVERY TIME YOU DRIVE TO WORK, or worse yet, fly on a plane, the vehicle emits carbon dioxide that will stay in the atmosphere, warming the planet for thousands of years. Does it have to? Trees can take CO_2 back out again—but even covering the planet with forests wouldn't solve our problem, and there would be an awful lot of wood to preserve. (If allowed to rot or burn, trees release their carbon again.) Physicist Klaus Lackner thinks he has a better idea: Suck CO_2 out of the air with "artificial trees" that operate a thousand times faster than real ones.

They don't exist yet, and when they do, they probably won't look like real trees. But in Lackner's lab at Columbia University he and colleague Allen Wright are experimenting with bits of whitish-beige plastic that you might call artificial leaves. The plastic is a resin of the kind used to pull calcium out of water in a water softener. When Lackner and Wright impregnate that resin with sodium carbonate, it pulls carbon dioxide out of the air. The extra carbon converts the sodium carbonate to bicarbonate, or baking soda.

CO_2 scrubbers that rely on similarly simple chemistry already recycle human exhalations in submarines and space shuttles. Devising an economic way of scrubbing the outside air, though, is harder. Lackner's plastic offers two advantages, he says, over schemes that other labs are working on. It sponges up CO_2 quickly—the porous material has lots of surface area to contact the air—and holds on *(Continued)*

THE CO_2 SITUATION
Roughly a third of carbon dioxide emissions come from cars, planes, and other vehicles. Scientists are developing scrubbers to capture colorless CO_2 from the outside air.

THE SOLUTION
In physicist Klaus Lackner's plan, a single scrubber, small enough to fit in a shipping container, could capture a ton of CO_2 a day—the output of 75 average U.S. cars. CO_2 spreads quickly, so scrubbing it out anywhere benefits everyone.

HOW IT WORKS

1 Wind blows air through a carousel's plastic filters, which are laced with an absorbing agent that extracts CO_2. When the air reemerges, it contains less CO_2.

2 As filters become saturated, they are lowered into vacuum chambers and rinsed with water vapor, which removes the lightly bound CO_2 from the filters.

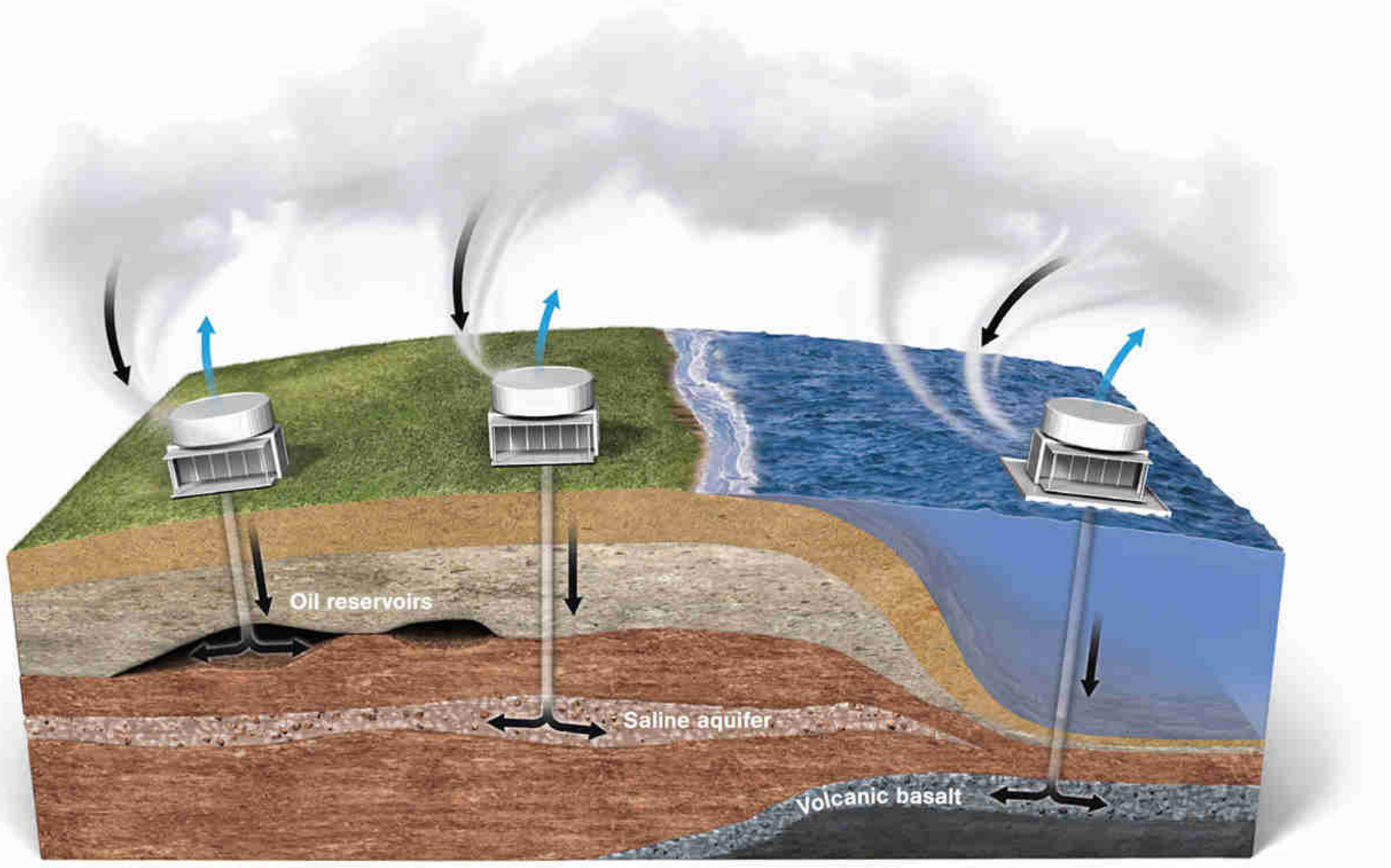
3 The filters return to the carousel. The CO_2 is separated from the water, compressed to a liquid, and pumped underground (see following page).

ART: SPLASHLIGHT. SOURCE: KLAUS LACKNER, LENFEST CENTER FOR SUSTAINABLE ENERGY, COLUMBIA UNIVERSITY

LET'S HELP TO KEEP THE SKIES BLUE.
LET'S GO.

We all need clean air. Not just for today's kite-flying trip, but for future generations who want to live and play under clearer blue skies. That's why, for example, at Shell Brazil, we've created a fuel oil for factories that can cut soot emissions by 30-76%. It should help Raul and his friends breathe a little easier. Just one of the many things we're doing to help build a better energy future. Let's go.

www.shell.us/letsgo



Where the Carbon Goes Government studies suggest there is room underground for many decades' worth of CO_2—though the idea has not been tested on the massive scale required.

OIL RESERVOIRS
Captured CO_2 could be used to flush oil out of old reservoirs; oil companies today buy CO_2 for that. But such cavities could store only a small fraction of our CO_2 emissions.

SALINE AQUIFERS
Briny aquifers a half mile down or more, widely distributed on all continents, might store vast amounts of CO_2. The pressure at those depths would keep it liquid and unlikely to escape.

DEEP OCEAN BASALT
Injecting liquefied CO_2 into volcanic basalt, which underlies all oceans and some areas on land, might secure it permanently as an inert carbonate mineral. The idea is being tested in Iceland.

to it lightly. The latter is crucial. The CO_2 must be separated from the sponge for disposal, and in most schemes that step takes a lot of energy. But Lackner and Wright just rinse their plastic with water in a vacuum chamber, and the CO_2 comes off.

What to do with it? Most likely, compress it to a liquid and pump it underground—the same option being studied for coal-fired power plants, which could capture CO_2 at the smokestack. That's not practical for cars and planes; there wouldn't be room on board to store the gaseous stuff until you got to the CO_2 dump. A scrubber that pulled CO_2 out of the air, on the other hand, could be located anywhere—right above the most convenient dump site, say.

Another option would be to add hydrogen to the CO_2 and convert it back into liquid hydrocarbons. If the energy for that came from renewable sources, engines that burned the fuel would emit no new carbon. Jet travel would become guilt free again. We could keep our cars and gas stations—no need for a whole new hydrogen- or electric-powered infrastructure. Subversive thought: We could keep our lifestyles. "That's historically what we've done," Lackner says. "We've run into environmental issues that seemed insurmountable—and we've found a solution." One day, he says, when we've finally stopped the rise of CO_2, we might even be able to reduce its concentration in the atmosphere, back to a level that won't melt glaciers. *—Robert Kunzig*

ART: JOE ZEFF DESIGN. SOURCE: DAVID GOLDBERG, LAMONT-DOHERTY EARTH OBSERVATORY, COLUMBIA UNIVERSITY

Deep Dark Secrets

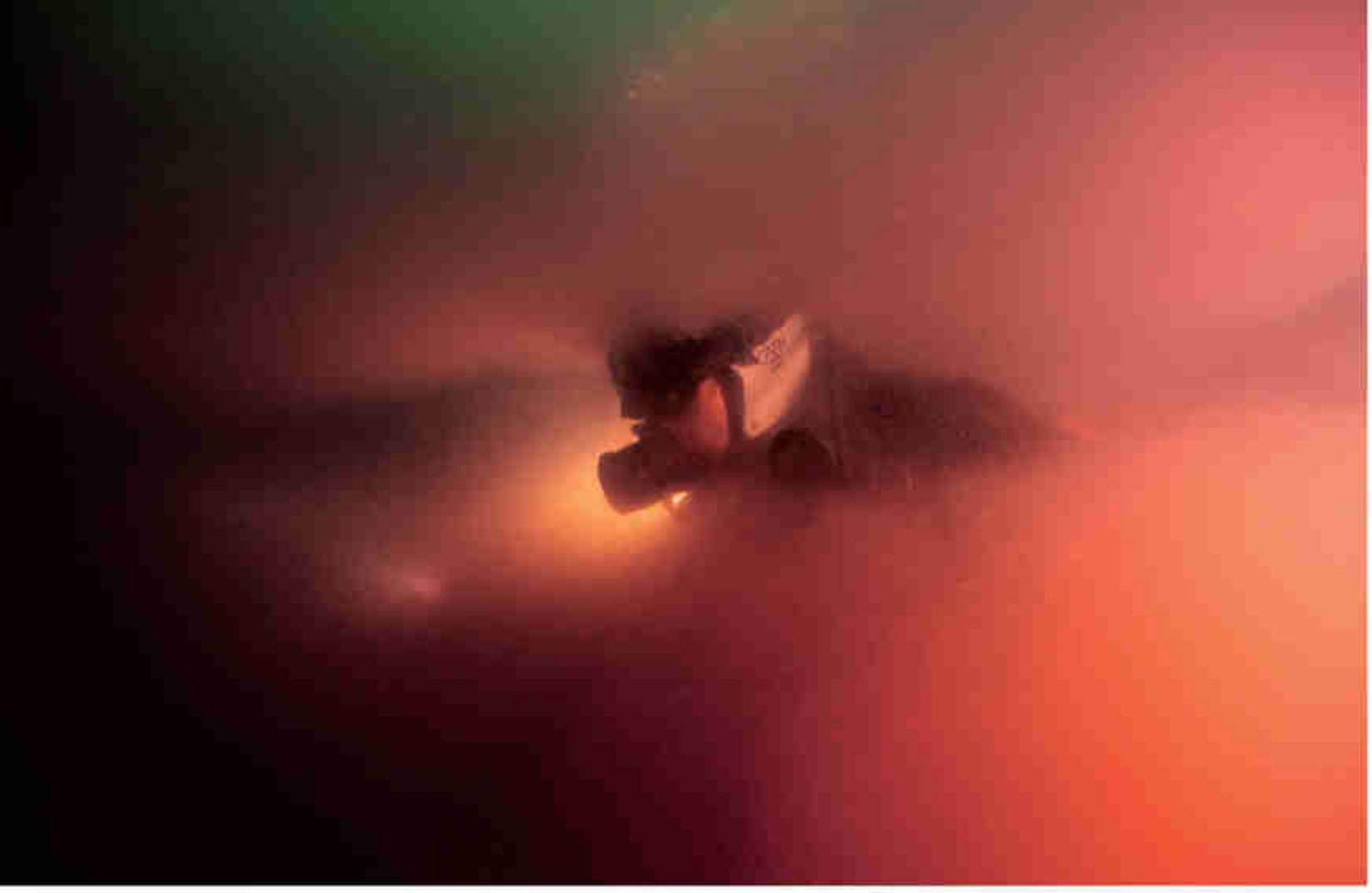
The blue holes of the Bahamas yield a scientific trove that may even shed light on life beyond Earth. If only they weren't so dangerous to explore.

Following the guideline her life depends on, a diver threads the needle through a stalagmite forest in Dan's Cave on Abaco Island. A single, misplaced fin kick can shatter mineral formations tens of thousands of years old.

Bacteria color the water at a depth of 30 to 36 feet in Sawmill Sink on Abaco. Here and in a colorless layer below, poisonous hydrogen sulfide gas is present. Divers move through it with all deliberate speed.

Veteran cave diver Brian Kakuk lifts a more than 3,000-year-old Cuban crocodile skull—an animal no longer found in the Bahamas—from sediment in Sawmill Sink. Nearly oxygen free, blue holes preserve bones intact.


Dive Rite



BY ANDREW TODHUNTER PHOTOGRAPHS BY WES C. SKILES

We sink into Stargate, sweeping the void with our dive lights. Fifty feet from the surface looms a pale haze, less smoky than fibrous, like a silvery net of faint, swirling cobwebs hovering motionless in the darkness. It's a layer of hydrogen sulfide, a toxic gas created by bacterial colonies and decaying organic matter. Divers entering the gas may experience itching skin, tingling, or dizziness; some smell rotten eggs as it penetrates their skin and metabolizes through their lungs. The gas density in Stargate is relatively low, but I'm struck by a wave of nausea as we descend. I glance at my guide, Brian Kakuk—one of the world's foremost cave divers. He appears unfazed. My head begins to throb; clearly, I'm unusually sensitive to the toxin. In the epic poem *Beowulf,* "dim serpent shapes" in the depths guard the lake of Grendel and his mother, shielding their lair. The otherworldly mist in Stargate appears to serve a similar role—a poisonous curtain that protects the deeper reaches of the cave.

Offshore flooded caves, so-called ocean blue holes, are extensions of the sea, subject to the same heavy tides and host to many of the same species found in the surrounding waters. Inland blue holes, however, are unlike any other environment on Earth, thanks largely to their geology and water chemistry. In these flooded caves, such as Stargate on Andros Island, the reduced tidal flow results in a sharp stratification of water chemistry. A thin lens of fresh water—supplied by rainfall—lies atop a denser layer of salt water. The freshwater lens acts as a lid, isolating the salt water from atmospheric oxygen and inhibiting bacteria from causing organic matter to decay. Bacteria in the zone just below the fresh water survive by exploiting sulfate (one of the salts in the water), generating hydrogen sulfide as a by-product. Known on land as swamp or sewer gas, hydrogen sulfide in higher doses can cause delirium and death.

As living laboratories, inland blue holes are the scientific equivalent of Tut's tomb. From a diver's perspective, they're on par with Everest or K2, requiring highly specialized training, equipment, and experience. Even more than high-altitude mountaineers, cave divers work under tremendous time pressure. When something goes wrong, if they don't solve the problem and make it back to the cave entrance before their gas runs out, they're doomed.

In Stargate, a blue hole on Andros Island, divers illuminate North Passage (right). In Sawmill Sink (above), expedition leader and anthropologist Kenny Broad descends through the bacterial layer on an exploratory dive.

REMOVE POSTER HERE

NATIONAL GEOGRAPHIC

The Cascade Room, some 80 feet beneath the surface, leads divers deeper into Dan's Cave on Abaco Island. Nearly seven miles of the cave have been explored since the mid-1990s.

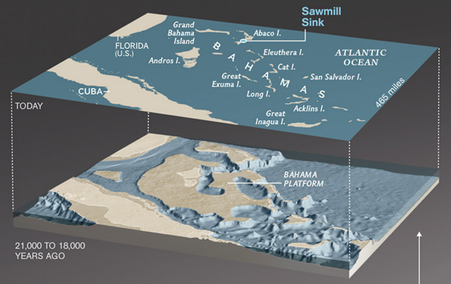
WES C. SKILES. PANORAMA COMPOSED OF THREE IMAGES

Blue Holes of the Bahamas

A blue hole is a flooded cavern with an eye to the sky, a sinkhole with a twist. Its opening, created by a cave-in, leads to a deep void and side passages filled with seawater. The Bahamas may hold more than a thousand blue holes, on land and offshore. About 200 have been explored.

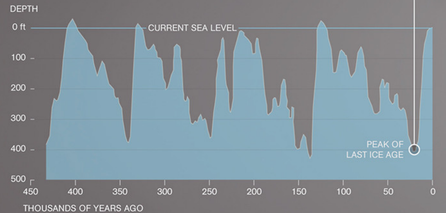
What lies beneath

The Bahamas are visible slivers of a great limestone platform. It was most fully exposed when seas were some 400 feet lower, 21,000 to 18,000 years ago.



Sea-level changes sculpt caverns

Sea levels fell when Pleistocene ice sheets far to the north expanded, then rose as the ice melted. When the Bahamas limestone was exposed, rain seeped into the rock and carved passages. When rising seawater penetrated the limestone, a chemical reaction between fresh and salt water further dissolved the rock.



Climate clues

Sawed lengthwise to reveal its core, a blue hole stalagmite, 14.5 inches tall, holds 36,000 years of climate history. Growing drop by drop as rainwater leaches calcite from limestone, a stalagmite becomes a climate time line.

Colors may reflect the rate of formation.

HIGH LEVEL OF IRON

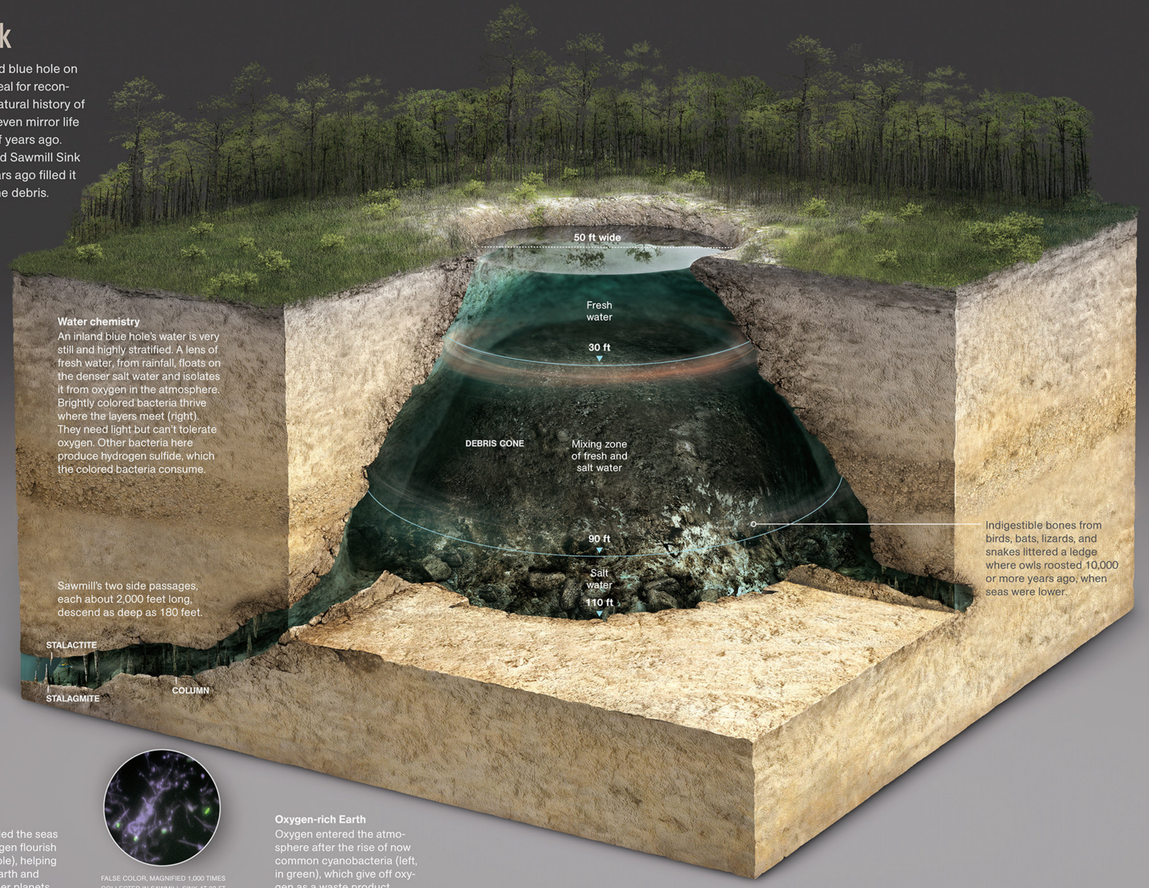
Chemical analysis shows high levels of iron at five intervals, evidence of dust blown from the Sahara. Their dates match episodes of rapid climate change (from drier to wetter in the Bahamas) previously detected in ice cores and ocean-floor sediments.

Scientists have only begun to study blue hole stalagmites, including one dating back 350,000 years. These rare records from the tropics help build a global picture of when and why climate changes.

HEIGHT: 14.5 in
FROM DAN'S CAVE, ABACO

Sawmill Sink

Conditions in this inland blue hole on Abaco Island make it ideal for reconstructing the ancient natural history of the Bahamas and can even mirror life on the planet billions of years ago. The cave-in that opened Sawmill Sink as early as 120,000 years ago filled it with a cone of limestone debris.



Water chemistry
An inland blue hole's water is very still and highly stratified. A lens of fresh water, from rainfall, floats on the denser salt water and isolates it from oxygen in the atmosphere. Brightly colored bacteria thrive where the layers meet (right). They need light but can't tolerate oxygen. Other bacteria here produce hydrogen sulfide, which the colored bacteria consume.

Cave formations
Stalagmites and stalactites grow only when sea level is too low to flood the caves. Some formations merge into massive columns.

FALSE COLOR, MAGNIFIED 1,000 TIMES
COLLECTED IN SAWMILL SINK AT 33 FT

Oxygen-free Earth
Bacteria like those that ruled the seas when Earth had scant oxygen flourish in blue holes (right, in purple), helping scientists envision early Earth and how life might exist on other planets.

Oxygen-rich Earth
Oxygen entered the atmosphere after the rise of now common cyanobacteria (left, in green), which give off oxygen as a waste product.

BILLIONS OF YEARS AGO

4.5 Origin of Earth | 4.0 Single-cell organisms | 3.5 Light-harvesting bacteria | 3.0 | 2.5 Oxygen revolution | 2.0 Multi-cell organisms | 1.5 | 1.0 | 0.5 Vascular plants | 0 Mammals

Remains of a lost world

The best preserved fossils in the Bahamas lie in the low-oxygen depths of blue holes. Sawmill Sink is a natural trap, where prey and their predators tumbled in. Peat from decaying vegetation covered the bones.

Crocodylus rhombifer *4,000-3,000 years old*
The Cuban crocodile, a freshwater species, now survives only in Cuba; the most recent bones in the Bahamas are 2,800 years old. Human predation and environmental change may have killed it off.

7 ft long

Caracara creightoni *Undated*
Known only from a few fossils in the Bahamas and Cuba, this extinct short-winged caracara was likely a poor flier. It's among 35 bird species found in Sawmill Sink, some new to science.

23 in tall

Human sacrum *ca 1,040 years old*
Lucayan Indians, whom Columbus met on his first New World landing in 1492, vanished from the islands soon afterward. This sacrum, a bone near the base of the spine, belonged to a juvenile about age 13.

ALEJANDRO TUMAS, AMANDA HOBBS, NGM STAFF. ART: HERNÁN CAÑELLAS. MAPS: VICKIE TAYLOR, INTERNATIONAL MAPPING. TEXT: JANE VESSELS, NGM STAFF.

SOURCES: NANCY ALBURY AND MICHAEL PATEMAN, NATIONAL MUSEUM OF THE BAHAMAS; KENNETH BROAD, PETER SWART, AND MONICA ARIENZO, UNIVERSITY OF MIAMI; BRIAN KAKUK, BAHAMAS CAVES RESEARCH FOUNDATION; THOMAS ILIFFE, TEXAS A&M UNIVERSITY; JENNIFER MACALADY, PENNSYLVANIA STATE UNIVERSITY; JOHN MYLROIE, MISSISSIPPI STATE UNIVERSITY; DAVID STEADMAN, FLORIDA MUSEUM OF NATURAL HISTORY. PHOTOS: NANCY ALBURY (FOSSILS), JENNIFER MACALADY (BACTERIA), AND PETER SWART (STALAGMITE).

"All of a sudden, it's got you," says photographer Wes Skiles of the "insanely dangerous" vortex in Chimney Blue Hole (left) off Grand Bahama. Like a giant bathtub drain, it sucks down millions of gallons when the tide comes in. "It's like going over a waterfall—there's no escape." Keeping his distance, a diver sets up equipment to measure the whirlpool's flow rate. From a protected cove on Long Island, Dean's Blue Hole (above)—Earth's deepest known underwater cave—plunges more than 600 feet into darkness.

Until now, only a handful of scientists have ventured into blue holes, but in the summer and fall of 2009, a multidisciplinary cave-diving and scientific team spent two months studying them on Andros, Abaco, and five other Bahamian islands. Funded by the National Geographic Society in collaboration with the National Museum of the Bahamas, headed by Keith Tinker, the Bahamas Blue Hole Expedition was conceived by Kenny Broad, a veteran cave explorer and an anthropologist at the University of Miami. Under Broad's wisecracking, driven leadership, with Brian Kakuk as dive safety officer and preeminent cave explorer Wes Skiles shooting film and stills, team members made around 150 dives in dozens of blue holes. They gathered data that promise to deepen our understanding of everything from geology and water chemistry to biology, paleontology, archaeology, and even astrobiology—the study of life in the universe.

They worked with urgency. At the current rate of sea-level rise (possibly several feet over the next century), many inland caves will flood with seawater in the coming decades, disrupting their delicate chemistry and destroying the very conditions that make them so valuable to science. Meanwhile, blue holes are often used as dumping grounds, polluting the islands' primary source of natural fresh water. "Look at the damage we're doing to highly visible and beautiful resources like redwoods, whales, and coral reefs," Broad says. For all its importance, he explains, the invisibility of the underground world leaves it off the conservation priority list. So the expedition also made it a goal to publicize the importance of blue holes and the threats they face.

Andrew Todhunter's latest book is the award-winning A Meal Observed. *Explorer Wes Skiles is a pioneer in underwater cave photography.*

WE INSTINCTIVELY ASSOCIATE LIFE with oxygen, but living things existed on Earth for more than a billion years in the absence of the one gas divers can't last minutes without. Ironically, the oxygen revolution came about through the rise of bacteria that created oxygen as a waste product. Jenn Macalady, an astrobiologist at Pennsylvania State University's Department of Geosciences, is studying the water chemistry of Bahamian blue holes to understand the conditions most similar to the earliest, oxygen-free environments that supported life. She's especially interested in the period from about four billion years ago—when life first appeared on Earth—to what scientists call the oxygen revolution, some 2.5 billion years ago. By investigating bacteria that thrive in the anoxic waters of blue holes, she can postulate what may exist in the oxygen-free, liquid-water environments of distant planets and moons. "The universe is made of the same elements," Macalady says, "and habitable planets are likely to share many of the same characteristics, like a temperature range conducive to life and the presence of water." Many astrobiologists believe such conditions may exist in pockets of liquid water deep beneath the surface of Mars or in a sea under the frozen crust of Jupiter's moon Europa—to say nothing of far distant worlds potentially much more like our own.

Macalady doesn't dive, but she's an active dry caver who hauls tanks, coils ropes, and chats with young Bahamians about cave slime and the possibility of life in the universe. At her direction, divers take water, bacteria, and hydrogen sulfide samples at depths ranging from the surface to 270 feet. Most of her studies—including DNA testing, bacterial culturing, and the search for molecular fossils—must wait until she gets back to the equipment in her lab. But hydrogen sulfide is too unstable to transport, so

VICKIE TAYLOR, INTERNATIONAL MAPPING; NGM MAPS

she analyzes water samples for gas levels with a portable spectrophotometer at the dive site. By comparing sulfide densities with water depth, she's learning where different species of bacteria are likely to concentrate in a given blue hole and which mechanisms they use to survive. She is aided by Nikita Shiel-Rolle, a Bahamian cave diver and marine science graduate student at the University of Miami. Stargate's entrance lies on land that's been in her family for generations.

"To give an idea of just how unique each hole is," Macalady says, "we analyzed the DNA of microbes from five inland blue holes and didn't find any shared species." She is continually surprised by the variety of ways cave organisms harvest energy. "Some of these organisms use tricks we used to think were chemically impossible," she says. "If we can understand precisely how these microbes are making a living, we know what to look for on oxygen-free worlds."

AS KAKUK AND I emerge from the hydrogen sulfide into the black water below, my nausea and headache quickly pass. I'm relieved not to have to put into practice the suggested method for vomiting underwater, to say nothing of the impact my breakfast—a biological mushroom cloud—would have on the fragile environment. We descend slowly along the cave's east wall until a triangular portal appears in our lights: the entrance to a 2,500-foot-long tunnel known as South Passage.

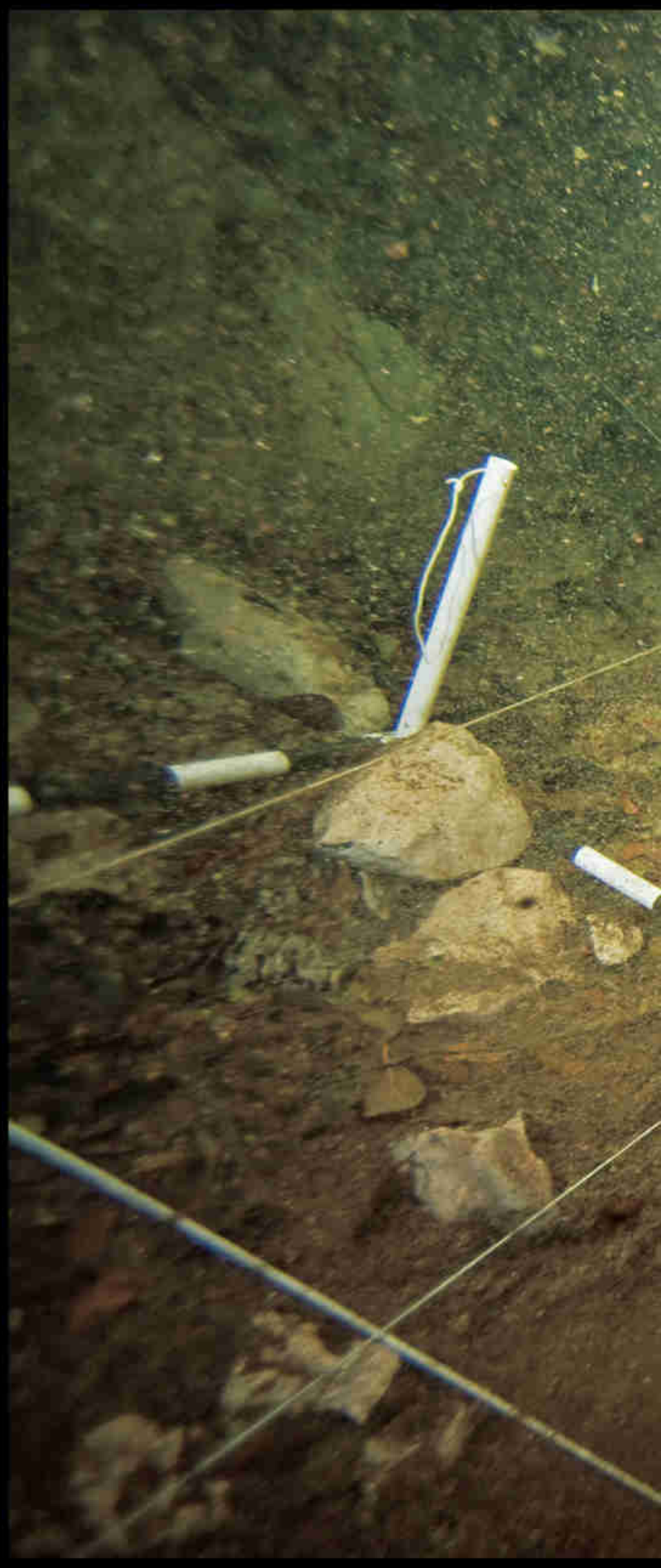
Stargate consists of a central shaft some 340 feet deep, with passages extending north and south. Kakuk has explored North Passage about 1,300 feet out from the central shaft, edging ever closer to the next blue hole to the north, and he's pushed even farther into South Passage. Of the more than one thousand blue holes believed to be in the Bahamas, less than 20 percent have been probed, and Kakuk estimates that three-quarters of those offer passages never seen before. The great age of Bahamian blue hole exploration lies ahead.

The entry to South Passage is decorated by spectacular calcite formations, or speleothems, from drapery (thin, curtain-like formations) and straws (fine, cylindrical deposits like soda straws)

In lightless blue holes, animals like this inch-long *Agostocaris* cave shrimp don't need surface pigmentation. Only part of the shrimp's digestive system has color.

As living laboratories, blue holes are the scientific equivalent of Tut's tomb. From a diver's perspective, they're on par with Everest or K2.

to the more familiar stalactites and stalagmites. (Remember, stalac*tites* need to cling *tightly* to the ceiling above.) They built up during ice ages, when the sea level dropped dramatically, leaving the caves dry. For Peter Swart, professor of marine geology and geophysics at the University of Miami, speleothems hold a priceless record of climate change in every year of their growth—at the inexorable rate of one to five centimeters every thousand years. By studying speleothems in detail, Swart, Broad, and Amy Clement, a climate modeler at the University of Miami, will gain valuable information about sudden climate shifts of the past. These include prolonged storms that blew Saharan dust across the Atlantic from Africa thousands of years ago, leaving high concentrations of iron in the stalagmites and red stripes visible in the sediment of cave walls. Information



Archaeologist Michael Pateman lifts a centuries-old Lucayan Indian skull (above) from a gridded site 110 feet down in Sanctuary Blue Hole on Andros Island. Brian Kakuk (left, both) has an arsenal of offbeat tools for gathering samples. His turkey baster collects red dust blown from the Sahara in ancient times, and the inflatable lift bag brings a stalagmite to the surface to be studied for evidence of abrupt climate changes in the past.

His air bubbles forced down by the current in a blue hole on Abaco, Kenny Broad fights to the surface, a stalagmite under his arm. Divers must bring extra breathing gas when they'll have to struggle against a siphoning tide.


ULTRACLEAR

from speleothems will shed light on today's rapid warming and the associated rise of sea level. "The better we understand how the natural climate system works," Swart says, "the better we can understand the nature and degree of our own impact."

AT KAKUK'S DIRECTION, I tie off our safety reel to the line at the entrance of South Passage and follow him inside. In the play of our lights, the natural geometry of the corridor is breathtaking. Above soars a vaulted, triangular ceiling; below, a floor of impenetrable darkness. There is an eerie quality of intention—the vaulted corridor seems more designed than randomly occurring—and I'm reminded simultaneously of the outer walls of Mycenae and the gallery in Khufu's Great Pyramid. Covering my light with my palm, I hover and watch Kakuk's single lamp move steadily forward as the walls' steep angles come into view. I had expected a measure of anxiety in such an alien environment, but for all its unearthly surrealism, this motionless, lightless place is profoundly calming. For a moment I relax completely, releasing an attenuated breath and swinging my light upward through the swarm of ascending bubbles.

Two hundred lateral feet into South Passage, Kakuk collects a water sample for Macalady in a plastic tube. He points out a fish with a shimmering, translucent tail that flickers like a candle flame—a *Lucifuga,* about five inches long. Like most life-forms in these lightless depths, the fish is blind. Then Kakuk directs my attention to a *Barbouria* shrimp, a reddish, two-inch crustacean with long, bowed antennae for sensing prey in the darkness. Minutes later, he pauses and shines his headlamp on his fingertip—his signal for the presence of the tiniest creatures. It's an ostracod, a crustacean no bigger than a sesame seed, its brilliant pink interior sheathed in a transparent, clamlike shell. High on its round body, a pair of antennae flutter like fairy wings, propelling the animal through the water.

Kakuk is known for his ability to spot things most other divers—including trained scientists—never see. During his 21-year career diving in blue holes, he has discovered more than a dozen new animal species, four of which expedition scientist Tom Iliffe, himself an expert cave explorer and a professor of marine biology at Texas A&M University, has named after Kakuk. In recent decades Iliffe and other scientists have discovered an astonishing abundance of previously unknown organisms in these and other flooded caves around the world: more than 300 new species, 75 new genera, nine new families, three new orders, and a new class, Remipedia, first documented in 1981 in the Bahamas.

Most cave-adapted species are crustaceans, and many, like the remipedes, are "living fossils"—live species closely resembling those preserved in the fossil record. Iliffe says that the greatest percentage of saltwater cave species come from blue holes in the Bahamas, including 18 of the 24 known species of remipedes. Remipedes emerged 300 million years ago and give scientists a rare look at life in the Carboniferous period—tens of millions of years before dinosaurs appeared. With slender, segmented bodies less than two inches long and usually colorless and blind, remipedes are, nonetheless, at the top of the food chain in their habitats, using hollow, venom-injecting fangs to kill shrimp and other crustaceans.

AS WE FIN DEEPER into South Passage, the only sound is the rhythmic hiss of our regulators and the rumble of our exhaled breaths. Kakuk occasionally traces a broad circle with his light on the passage wall, signaling the question, "OK?" I return the signal as an affirmative response. I've known Kakuk less than two months, but my life depends on his judgment, and his, to some degree, on mine.

In cave diving, redundancy is critical. If one of my lights goes out, I have three in reserve. Our gas supplies—in this case oxygen-enriched nitrox, a combination of oxygen and nitrogen—are backed up with two independent tanks and regulator systems. As long as we follow the rule of thirds (one-third of your total gas going in, one-third coming out, and one-third in reserve

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

for emergencies), we should always have enough to get home—even if one of our tanks or regulators fails. That's assuming we don't lose our guideline. In the labyrinth of passages, separation from the line can be fatal. In my training, Kakuk had spun me around with my eyes closed and towed me away from the line to simulate disorientation. Groping blindly and using my safety reel to search in a spoke pattern, it took me 12 interminable minutes to find the line. One of Kakuk's students was so traumatized by this drill that he bloodied his hands clawing for the line along a cavern roof. For his part, Kakuk has logged some 3,000 cave dives without serious injury. Given the risks, the lighthearted mood of Broad's team belied this fact: Combined, these divers have participated in dozens of body recoveries from submerged caves.

Some 500 feet into South Passage, we reach the end of the main line, tied off to a bollard of calcite at a depth of 130 feet. Here the tunnel narrows and plunges to below 230 feet. On previous dives, Kakuk had extended the line 2,000 feet farther, but at my level of experience, we've come as far as he'll allow. We check our air—the first of our thirds is nearly depleted—and turn for home.

At the portal separating South Passage from Stargate's central shaft, Kakuk covers his lights and stops. The faint green of daylight in the shaft beyond is just strong enough to cast the walls of the passage entry into silhouette. I allow my limbs to hang freely, my body rising and sinking almost imperceptibly with each breath. Time appears to stop. I'd like to float here for hours, weightless and relaxed, suspended in the void, all thoughts draining from my mind.

ASCENDING SLOWLY to a depth of 60 feet, we pause at a sloping ledge directly below the cave mouth. In the middle of the ledge is a long trough packed with silt. Kakuk spotted this promising feature on an earlier dive and now reaches into the mud. He gropes gently back and forth and—so quickly it seems miraculous—extracts a long bone the color of mahogany: a human femur. Two smaller bones follow. Then he extends his arm deeper, working the silt, and draws out the

The remipede is a "living fossil" nearly unchanged for 300 million years. It kills its prey, primarily other crustaceans such as cave shrimps, with venom-injecting fangs.

The lighthearted mood of Broad's team belied this fact: Combined, these divers have participated in dozens of body recoveries from submerged caves.

domed pate of a human skull. Although lacking a lower jaw, the yellowed skull has molars on both sides and a single front tooth. The forehead slopes dramatically, a sign that its owner was a member of the native Lucayan tribe that thrived in the Bahamas from the sixth through the 15th centuries. To create a sloping brow, Lucayans bound boards to their children's foreheads. Some archaeologists think the practice was intended to make the front of the skull better able to withstand blows in battle; others believe it was purely aesthetic.

Kakuk hands me the skull. Silt and leaf fragments clog the eye sockets and nasal cavity. I try to imagine—from the brow, eye sockets, and cheekbones alone—how this individual appeared in life. In its breadth and solidity, the skull strikes me as distinctly male. Was he a warrior? A

shaman? I return the precious object to Kakuk, who reburies it in the silt to await later study.

In 1991 Rob Palmer (the cave-diving pioneer who named Stargate) and his team discovered and excavated 17 sets of Lucayan remains from a cave on Andros called Sanctuary: 11 adult males, five adult females, and a child. On the 2009 expedition, Michael Pateman, an archaeologist and cave diver with the National Museum of the Bahamas, recovered the remains of two more Lucayans. He will carbon-date and study the bones (and those Kakuk found on our dive), seeking information about the age, sex, stature, diet, and life stresses of these individuals as well as how they died.

"One of the things we know about the Lucayans is that they were tremendous divers," Pateman tells me. "They were sought out by the Spaniards to dive for pearls. And we've found evidence of deep diving on some of the skulls—over time, in response to the pressure, bone builds up around the ears." As with so much in the scientific study of blue holes, Pateman's work has barely begun. Foremost on his mind is the question: How and why did Lucayans end up in blue holes? He suspects that the submerged caves were burial sites, but the discovery of a bound Lucayan body in a dry cave on one island suggests other, more violent practices. Were they murder victims? Were they victims of feuding, warfare, or religious sacrifice?

Lucayan bones are just part of the tapestry of blue holes, says Nancy Albury, project coordinator at the National Museum of the Bahamas, whose passion for blue holes centers on the animal remains they contain—the remarkably preserved fossils and bones of crocodiles, tortoises, bats, owls, beetles, and other species that thrived in the Bahamas before the Lucayan occupation. "In some blue holes," Albury says, "we've found complete skeletons and soft tissues preserved on tortoise shells thousands of years old. Leaves still have their structure and pigments, and insect wings are still iridescent blue and green." As expedition paleontologist Dave Steadman explains, the anoxic, sheltered environments of blue holes are perfect for preserving organic material. Were it not for blue holes, Steadman says, much of the fossil record for Bahamian animals going back thousands of years would not exist.

ONE OF THE REWARDS of the expedition's multidisciplinary approach is the constant exchange of ideas and enthusiasm among scientists with wholly different backgrounds. Swart's work on speleothems will shed light on ancient climates, which in turn may explain how and when some Bahamian animal species went extinct—Steadman's and Albury's domain. Pateman's work on human remains may reveal as yet unknown connections between Lucayans and animal bones found in blue holes. Without the unique geologic structure of the inland blue holes—deep, dark, sheltered, with little tidal flow—specialized bacteria studied by Macalady would never have gained a foothold. And if the bacteria hadn't created an anoxic environment, many of Iliffe's species wouldn't have flourished in the caves and much of the biological evidence would have vanished. As Broad puts it, "I can think of no other environment on Earth that is so challenging to explore and gives us back so much scientifically."

Rising slowly toward the surface, Kakuk and I pass again through the veils of hydrogen sulfide to our decompression bottles: tanks of pure oxygen hanging from a length of plastic piping at a depth of 20 feet. We switch to these tanks and hover, breathing easily. Time and oxygen at this depth will eliminate the nitrogen that has built up in our bloodstreams during the dive, preventing decompression sickness—the bends—that in extreme cases can cripple or kill a diver. After 18 minutes of decompression and a total dive time of 65 minutes, we emerge into the warm Bahamian air. Even here, as I float on my back for a moment, resting on its liquid skin, Stargate feels like a benign and alien world. □

Kenny Broad and Brian Kakuk surface at dusk after multiple dives in Sawmill Sink, where they collected bacteria samples and fossils. "It's an alien world down there," says Broad, "that keeps pushing us beyond our dreams."

THE NEW SILK ROAD

A railroad through the southern Caucasus will soon connect Europe and Asia, fueling dreams and discord in the region.

GEORGIA *A bustling trackside market in Tbilisi offers a taste of what Georgians hope soon to gain: an economic boost as trains pass through their country en route from oil-rich Azerbaijan to trade partner Turkey and beyond.*

TURKEY *A ten-foot concrete hand stands above the eastern Turkish town of Kars, part of a monument of goodwill toward nearby Armenia that may never be completed. Construction stopped partly because of protests by residents opposed to improved relations with Armenia.*


Love

AZERBAIJAN *A promenade along the Caspian Sea attracts residents of Baku, capital of Azerbaijan, for an afternoon stroll. Increased oil production has enriched the nation; Azerbaijan hopes the completion of the new railroad will spur energy exports.*

By Brett Forrest

Photographs by Alex Webb

THE DYNAMITE COMES FROM ANKARA. TEN TONS, AND IT TAKES TWO DAYS. THE TRUCK CLIMBS CAREFULLY, SCREWING 2,500 FEET UP THE MOUNTAINS OF NORTH-EASTERN TURKEY, WHERE THE CLOUDED SUN MAKES FARAWAY ICE FIELDS ROLL LIKE A DISTANT SEA. THIS IS BEAUTIFUL, FORBIDDING COUNTRY, THROUGH WHICH A NEW RAILROAD WILL SOON RUN.

Arslan Ustael awaits the dynamite in the snow, with night temperatures reaching 40 below. Standing before the rail tunnel, Ustael says that in this weather your spit freezes before it hits the ground. He is a young man still, 30, and free with Turkish good humor, even up here in the cold clouds waiting for the dynamite that will make the volcanic mountain agreeable to his demand to bore a tunnel through it. Free with good humor because he knows this is an undertaking that could make a young engineer's career: building the Baku-Tbilisi-Kars (BTK) railway, an "Iron Silk Road" that will connect the oil-rich Caspian Sea region to Turkey—and beyond to Europe.

The travels of antiquity are tiring to contemplate. The 750-mile stretch of land between the Black Sea and the Caspian Sea is known as the Caucasus, named for the mountain range through which Ustael is digging his tunnel. Before the region got swallowed up by the Russian Empire, the Caucasus served as a transit point between Europe and Asia; the old Silk Road passed through it. Yet transport between West

Brett Forrest reports frequently from the former Soviet Union. Photographer Alex Webb's most recent book is Istanbul: City of a Hundred Names.

TURKEY *Crossing cultures and connecting faiths, the newest section of the planned rail route stitches Christian Georgia to Muslim Turkey. Gönülalan is one of the Turkish villages on the train's path; nomadic Kurds like this man and boy find temporary housing in tents while they tend livestock.*

and East has never been easy. For centuries, to get from one sea to the other, you had to paddle north up the Don River from the Sea of Azov, portage over the steppe, then drift down the Volga to the Caspian. Only when the Russians began building railroads over the Caucasus in the 19th century could you travel more directly across the region.

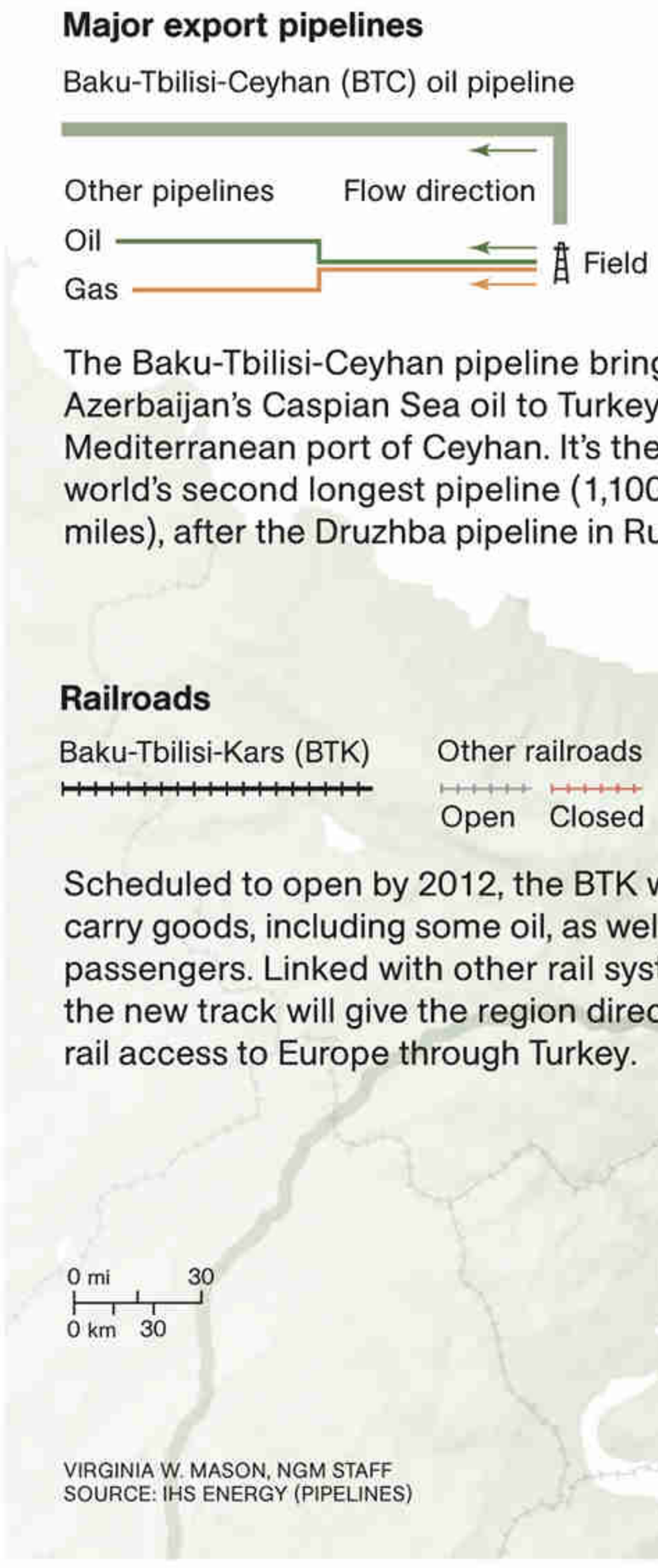
The Iron Silk Road will launch a new chapter in the history of the Caucasus. After the Soviet Union collapsed in 1991, the newly independent republics of the southern Caucasus—Georgia, Armenia, and Azerbaijan—regained strategic importance. A realization of the enormity of the oil and natural gas reserves lying beneath and along the Caspian Sea ignited a scramble to lay pipelines across the southern Caucasus to bring those resources to the European market. Today the pipelines are operational, and the BTK is being built to grease a trade boom, transporting European goods east and petroleum products west across the southern Caucasus. Once completed, by 2012, the railway will begin at the Azerbaijani capital of Baku and travel through the Georgian city of Tbilisi, before carrying on to Kars, a Turkish post town on the southwestern lip of the Caucasus region.

The participation of Turkey signals a new alignment in a region often viewed as Russia's backyard. Like the Baku-Tbilisi-Ceyhan (BTC) pipeline—which opened in 2005 to bring oil from Baku to the Turkish port city of Ceyhan, on the Mediterranean—the BTK railway is the result of an alliance between Turkey, Georgia, and Azerbaijan; neighboring Armenia was deliberately left out of the party. And like the pipeline, this east-west corridor will provide an alternative to going through Russia to the north or Iran to the south. It is a more than $600-million project of economic development, social engineering, or shrewd geopolitics, depending on your point of view, which in the southern Caucasus shifts as quickly as the snow that obscures the mountain road.

For Ustael, chief of the tunnel operation on the Turkish-Georgian border, this railroad has become something else: a road to loneliness. Back

CONTINENTAL CROSSROADS

The Iron Silk Road, as promoters call the Baku-Tbilisi-Kars railroad, will make the southern Caucasus a greater corridor for East-West trade (right). Financed largely by Azerbaijan, whose oil dominates the area's economy, the railroad breaks a long dependence on transporting goods through Russia—and reflects the region's hostility toward Armenia, which it pointedly bypasses.



60°N
30°
90°E
30°
U.K.
London
EUROPE
FRANCE
ITALY
UKRAINE
Moscow
Volga
Don
Sea of Azov
Novorossiysk
RUSSIA
Bosporus
Black Sea
MARMARAY TUNNEL
Istanbul
Ankara
Trabzon
Ceyhan
Mediterranean Sea
To Europe
To Europe
ASIA
Flow of commerce through the southern Caucasus
KAZAKHSTAN
Caspian Sea
Tbilisi
Baku
UZBEKISTAN
TURKMENISTAN
KYRGYZSTAN
TAJIKISTAN
CHINA
AREA ENLARGED
SYRIA
IRAQ
IRAN
AFGHANISTAN
PAKISTAN
Khyber Pass
AFRICA
To Novorossiysk
Groznyy
ABKHAZIA
Sokhumi
CAUCASUS
NORTH OSSETIA
INGUSHETIYA
CHECHNYA
RUSSIA
Caspian Sea
Georgia maintains relations with Armenia.
Black Sea
MOUNTAINS
SOUTH OSSETIA
Georgia, Armenia, and Azerbaijan declared independence from the Soviet Union in 1991.
Poti
Supsa
GEORGIA
DAGESTAN
Oil shipped from Kazakhstan also moves through the BTC pipeline.
Batumi
AJARIA
Tbilisi
Rustavi
Akhalkalaki
Kartsakhi
TURKEY
Akhuryan River
Mingəçevir Res.
AZERBAIJAN
Gönülalan
Section of BTK railroad under construction
Kars
Ani
Gyumri
ARMENIA
Lake Sevan
Cease-fire line
Şüvälän
Baku
BTC pipeline
To Ceyhan
Erzurum
★ Yerevan
Vank
Turkey closed its border with Armenia in 1993 in support of Azerbaijan.
NAGORNO-KARABAKH
The Armenian enclave Nagorno-Karabakh broke away from Azerbaijan in a war that ended in 1994.
NAXÇIVAN (Azerbaijan)
Lake Van
IRAN

in Trabzon, a temperate, Turkish Black Sea coastal town, his girlfriend's face clouded when she imagined two years in the Caucasus Mountains, for that is how long it will take to build this tunnel. She just couldn't do it. Ustael exhales, stirs the sugar through his tea. A man must make choices. Smoke hangs over the canteen. Workers chalky with tunnel dust stare distantly at the men in sun and shorts chasing a ball across the TV. Through the windows, another blizzard is mixing up the air. In World War I, 90,000 Ottoman soldiers waited in these mountains for the Russians to come. "Some froze to death without firing a shot," Ustael says. He grabs a hard hat and walks to the door. Tunnel work progresses in round-the-clock, three-hour shifts.

Work is likewise endless for the Turkish state, toiling to gain acceptance into the European Union (EU). Turks look indignantly at countries like Bulgaria and Romania that have already been accepted, places with much less developed economies and greater corruption. Turkey, the Cold War NATO ally, meanwhile, waits for an invitation that may never come. This "raises questions of fairness, at least," says N. Ahmet Kuşhanoğlu, the Turkish deputy director of transport in charge of railways. "Turkey's face is turned westward since two centuries." Now Turkey is looking east in order to make itself indispensable to the West. Once the Marmaray rail tunnel opens in 2013 beneath the Bosporus in Istanbul, trains from Baku will reach all the way to London. "It is easy to see that this railway shall serve Europe also," says Kuşhanoğlu.

Looking directly east, Turkey has lately sought to repair relations with its neighbor Armenia. In 1993 it had closed the border and shut down its rail service with Armenia as a sign of loyalty to Azerbaijan—a close Turkish ally with the same Muslim religion—after Christian Armenia helped ethnic Armenians in the Azerbaijan enclave of Nagorno-Karabakh wage a bloody war to secede. Last year in Zurich, under the watchful eyes of the EU and the U.S., Turkey signed an agreement with Armenia to mend diplomatic ties and reopen the border. But the Armenians then demanded that Turkey acknowledge that the 1915 massacres of its people constituted genocide, which Turkey is loath to do. For their part, the Turks began insisting on some resolution to the Nagorno-Karabakh conflict. Since neither is likely to happen anytime soon, the

GEORGIA *The railway provides work for many, including these men digging a drainage ditch along a freshly cleared railbed between Akhalkalaki and the Turkish border. Georgians (left) make the morning commute from the capital, Tbilisi, to jobs in nearby Rustavi in the existing railway's faded cars.*

deal—and the opportunity for a rapprochement—collapsed last spring.

A bridge between Turkey and Armenia actually does exist, though most of it has crumbled into the Akhuryan River, which cuts deeply through a gorge that serves as the border between the two countries. The Silk Road city of Ani stands abandoned along this part of the border, its mosques and churches intact after a thousand years, its bazaars echoing in a winter wind. Beyond an electric fence and across the river, Armenian guard towers keep watch over the ruins.

Some 50 miles north of Ani, Ustael's workers continue to dig 13 feet every day. Once completed, the tunnel will run for a mile and a half, 1,300 feet beneath the surface. It will be one of the longest in Turkey, Ustael says, and everyone will know his name. "Maybe then I can go work someplace warm."

Ustael spends his downtime in Kars, 42 miles south of the border, the two-hour drive made eventful by the slippery fact of coming down the mountain. Along icy roads, the car twists through slopeside villages, past minarets and the mud roofs of stone huts overgrown with grass. A vast westward migration of people in search of jobs has robbed these villages of all but the least mobile. Foxes forage at the roadside, headlights igniting their eyes.

In Kars, the site of great 19th-century battles between Ottoman Turks and Russians, the hilltop citadel remains. The women stay indoors. The men walk arm in arm down the streets, savoring a drink of raki in the saloons that exist in this region of lax Islam. Raki tastes like the anise-flavored pastis of France, but there is little European refinement in Kars. That could change when the BTK links this city to Baku, its wealthy antipode on the Caspian, injecting new revenue into the local economy. The governor of Kars, Ahmet Kara, talks of how the railroad will transform Kars into a city "important in the world's eyes." Behind Kara hangs a photo of Mustafa Kemal, or Atatürk, the first president of Turkey, who turned the Ottoman Empire into a modern, secular state,


D&GABBANNA

GEORGIA *Spring warmth draws a crowd to a lake on the outskirts of Tbilisi. Georgia seeks greater ties with western Europe—and security in the shadow of Russia, the giant to its north. In 2008 Russia routed Georgian forces from South Ossetia and Abkhazia in a short-lived war.*

AZERBAIJAN *Makeshift slaughterhouses line the road to the mosque in Şüvälän during the Kurban Bayram holiday, when sheep are killed to commemorate Abraham's willingness to sacrifice his son to God. The meat is shared with the poor.*

encouraging Western ways and outlawing the fez.

With a knit cap on his head and bundled in a thick anorak, Ustael watches a drill needle the far wall of the tunnel, making small stones out of solid rock. A front loader strains up the tunnel's incline, its bucket carrying a ton of freshly dislodged stone. It emerges from the tunnel and rolls into the blizzard, driving past Ustael toward a waiting truck. He says he wants to contribute to modern Turkey, to help bridge East and West. When the dynamite arrives, he laughs when he sees that it was made in China; it has already crossed this border once before.

There will be no explosions today. The mountain rock is soft enough for the drill to do its work without dynamite. Ustael looks down the tunnel toward Georgia. "We haven't found gold yet," he jokes. The stones tumble from the front loader into the truck, the crash almost drowning out his voice. "The Silk Road will live again."

THEY'RE NOT HIRING in Akhalkalaki. There's no gold here either. Not much glitters in the hardscrabble hills near this town in the Georgian south. This is where the old railroad from Georgia's capital city of Tbilisi terminates. Beginning here, 60 miles of new rail will be laid, running south through Ustael's mountain tunnel to Kars. Another 75 miles of existing rail will be rehabilitated. Work begins with the thaw.

Akhalkalaki is in Georgia, but most of its residents are ethnically Armenian—and desperately poor. The factories in Akhalkalaki were dismantled after the Soviet collapse, their components sold off in the new capitalism. Since the agricultural collectives shut down, once fertile lands have overgrown with weeds. Bandits clipped the aluminum wires and copper connectors that helped propel rail cars, selling the metal in Iran and Turkey. The economy took a big hit in 2007, when the Russians closed a military base here.

There is no work, so the men go to Moscow, where they step into the orange jumpsuits of the street cleaner, sending money back home. Many who have stayed feel neglected by the central Georgian government. Protests have been frequent. Very few people in Akhalkalaki and the surrounding Javakheti region speak Georgian, and in the schools there is no one to teach the language. During the 1990s the prospect loomed that Javakheti could be Georgia's next breakaway region, like Abkhazia and South Ossetia in the north, which declared independence in the early 1990s but remain largely unrecognized.

Now Georgia is counting on the BTK railway to boost economic activity and help integrate this turbulent Armenian enclave into the rest of the country. When plans to open the railway were first announced, Georgia's Armenians opposed its construction, citing the unfairness of its bypassing Armenia. But today in Akhalkalaki there is a small hope that the new railroad will alleviate this long postcommunist endurance.

Grigoriy Lazarev stands guard at Akhalkalaki's outdoor bazaar. He takes potatoes on consignment from a local farmer, barters them for mandarins, then sells the fruit at the bazaar for 40 tetri a kilo, or about ten cents a pound. He would like to work on the railroad. "I am a mechanic, a welder, a master engineer," he says. "Selling mandarins is not good for my psyche." He stands before a pile of fruit in the trunk of his green Moskvitch, looking left and right at the many others who also sell mandarins here. In Soviet days this street had order, Lazarev says. "But everybody became sellers." He is 58 years old, has only enough teeth to chew soft food like citrus fruit. He has two young children, and a few tetri jangle in his coat pocket.

When Lazarev drove two hours to the town of Kartsakhi to apply for work on the railroad, the contractors turned him away. He visited the camp forming on the outskirts of Akhalkalaki, where Turkish and Azerbaijani skilled workers will soon congregate. You cannot operate a Komatsu excavator, they said. You do not speak Georgian.

The ministers in Tbilisi say Akhalkalaki will be the site of a critical station on the Iron Silk Road, where trains will switch between European and Russian rail gauges. For people in Akhalkalaki, it is difficult to imagine how they will benefit. Like Lazarev, many hundreds of locals have petitioned for railroad work, yet such work remains elusive.

opposed its construction, citing the unfairness of bypassing Armenia.

Conditions have improved since Mikheil Saakashvili assumed the Georgian presidency—people in Akhalkalaki will admit that. Under Eduard Shevardnadze, they had electricity only five hours a day—while they slept—long enough for bread to bake in time for morning. It was subsistence living: no TV, poor roads, little interaction with Tbilisi, and a rationing of the wood that fueled the house stoves that kept people from freezing in their beds. Now there are a few good roads and electricity all day, if not running water in every home. It is often cold in Akhalkalaki, even indoors, and the abiding stress makes the people wander these streets weakly, nothing like the powerful Narts, the fabled giants that inhabited the Caucasus before humans arrived and that inspired them to carve mountains into kingdoms and then into nations.

Just 19 years old as a nation, Georgia is struggling through its adolescence. Seven years ago the Rose Revolution engendered all manner of youthful aspiration. Membership in NATO. Inclusion in the European Union. Bringing the breakaway regions of Abkhazia and South Ossetia under firm federal control. Reworking relations with Russia. Saakashvili wanted it all, wanted it quickly. If not for Georgia's northerly neighbor, he might have gotten it all.

The Russians have long felt a sense of entitlement toward Georgia, for they were the ones who folded Georgian nobility into their ranks during the 19th century, forming many principalities into a single governable entity, a Christian fortification in a region otherwise allied with the Ottomans or Persians. Russia also feels a deep emotional attachment to a land romanticized by Aleksandr Pushkin and Leo Tolstoy. But benevolence is a matter of perspective. Soon after Alexander I attempted to adopt Georgia in 1801, the widowed Georgian queen greeted the tsar's envoy with a dagger in the side, killing him.

More recently tensions spiked as Russia, fed up with Georgia's Western desires, closed the border between the two countries in 2006. Russia worries that if Georgia gains entry to the Western institutions it so esteems, this could inspire similar freethinking in the northern Caucasus—including the Russian regions of Dagestan, Ingushetiya, and Chechnya—which continues to shudder with explosions and assassinations that threaten Moscow's territorial hold.

The long-running tensions between Russia and Georgia escalated into war in the summer of 2008. Russia moved to assert control over the breakaway regions. Its troops routed Georgia's army, and Russia recognized South Ossetia and Abkhazia as new nations. It was a reminder that a small skirmish in these borderlands could spark a global showdown. Yet the EU and the U.S. were notably indisposed to intervene. Since the war, Georgia's pro-Western policy has stalled. Though the border between the two countries reopened last March, tensions are still high.

Like Prometheus, whom the gods chained to the Caucasus as punishment for giving humanity the power of fire, Georgia cannot escape its coordinates. Yet its position on the map may be its strongest asset. For NATO, the southern Caucasus is now viewed as a needed route for supplying the war in Afghanistan, ever since terrorist attacks in November 2008 began threatening the supply route through Pakistan's Khyber Pass. For Turkey, an important trade partner, Georgia is the gate to Central Asia. Armenia and Russia cannot trade with each other without going through Georgia. And Azerbaijani oil cannot reach the Mediterranean without passing through Georgia, earning the country $65 million in annual transit fees.

Georgia is a small player at the table, left to stack small chips. Indeed, the most significant impact of the Iron Silk Road on Georgia may prove to be the dismay it will create in the Black Sea ports of Batumi and Poti, the country's most dynamic economic centers, once freight can be diverted to Turkey instead. Still, Georgia can hope that if there's another conflict with Russia, European countries will cry foul if their trade through the southern Caucasus is disrupted.

In Akhalkalaki, Grigoriy Lazarev packs up his scale and its rusted one- and five-kilogram weights, and slowly walks away from the bazaar. He passes a funeral procession running along the main thoroughfare, a photo of the deceased

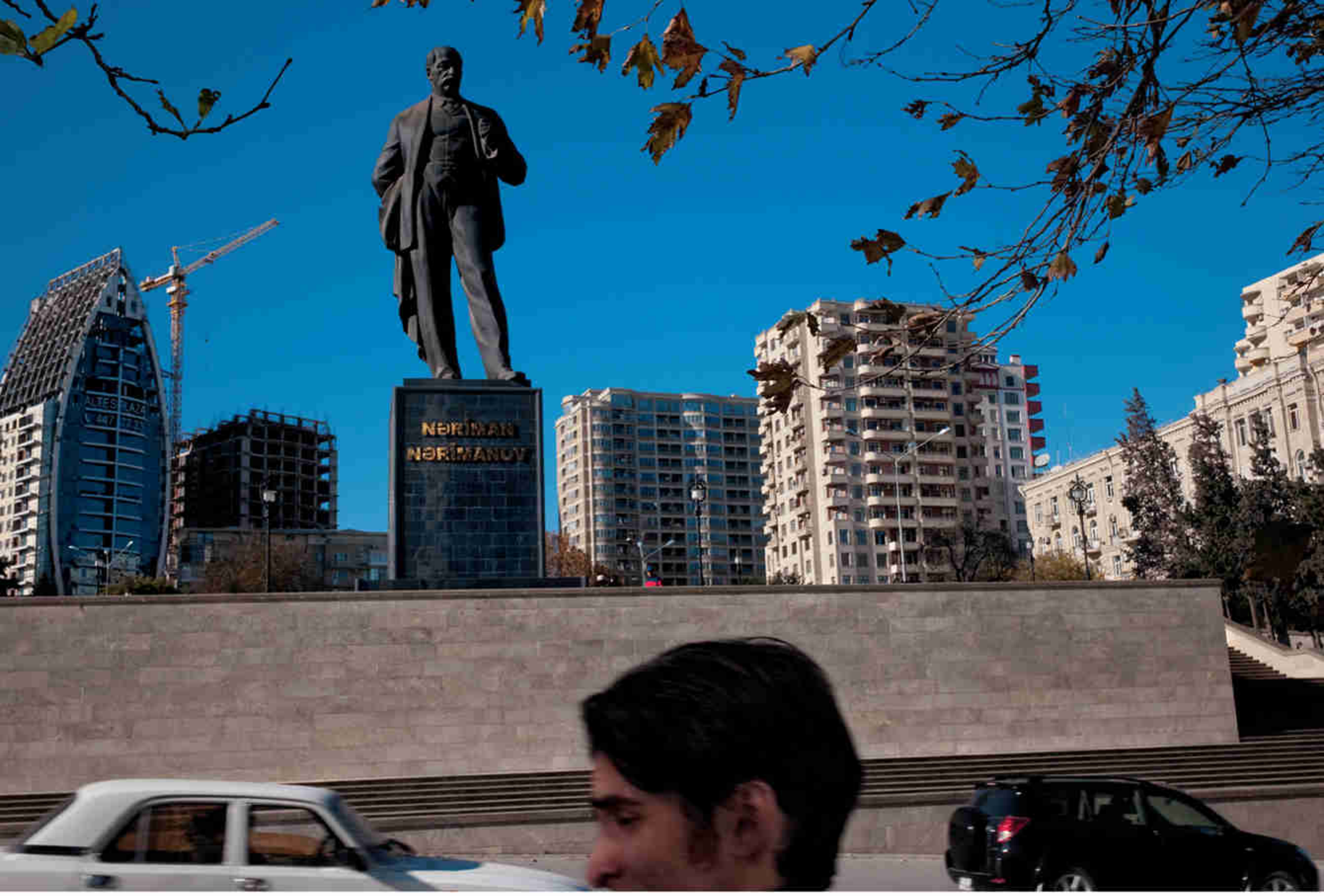
man affixed to the windshield of a sedan. Arms linked, men walk up the mud of the street, women up the mud of the sidewalk.

Lazarev's small house was built in 1850, in the time of hard-willed Nicholas I. The roof leans severely, threatening to cave. Lazarev cannot pay to fix it. He and his family live off his mother's 90-lari (about $50) monthly pension. Still, when they have guests, Lazarev's wife, Liza, busies herself setting the table with what food they possess. A daughter, Gohar, sits at an old upright piano and practices her lessons, filling the small room with music and missteps. Lazarev grieves over his bad luck with the railroad and more generally, but not so loudly that his family will hear.

He rummages through a wardrobe and returns to the table. In his hand is a felt-backed shoulder board, its green fabric faded nearly to gray. It is the emblem of a lieutenant, an engineer with the Russian border service. "My grandfather served under Nicholas II," Lazarev says. "He built roads to Akhaltsikhe and Batumi." Lazarev smiles, a rare incident, and then the room goes dark. The electricity has gone out in Akhalkalaki, and the Lazarevs fall silent, but for the sound of the old piano.

IT IS ELECTRICITY that initially impresses in Baku, its roadway lamps gilding the new asphalt from airport to city. Baku no longer supplies half the world's petroleum needs, as it did at the opening of the 20th century. But it feels like it does. In the past three years all manner of luxe stores have opened along the boulevard Neftchiler Prospekti, their windows reflecting the Caspian waters. Plans are progressing on a $4.5-billion, carbon-neutral resort on Zira Island, in the bay beyond the city. A Four Seasons Hotel will open shortly to house the guests drawn to Baku by the wealth of the state oil monopoly, located across the street. In the five years since the BTC pipeline began pumping oil out of the Caspian and money into Baku, Azerbaijan's economy has grown by more than 100 percent.

In the years after the former Turkish president, Süleyman Demirel, broached the topic of the Iron Silk Road in a Tbilisi speech in the late 1990s, the parties involved attempted to secure international funding for its construction. But the Armenian diaspora blocked all financing efforts, arguing convincingly that the routing of the railroad, like that of the oil pipeline before it, was a punitive gesture linked to Nagorno-Karabakh.



AZERBAIJAN *In the capital of Baku modern construction dwarfs a figure from the past—the father of Azerbaijani communism, Nariman Narimanov. Rusting oil pumps (left) from the Soviet era fill the horizon outside the city, where obsolete equipment and poor extraction techniques pollute the landscape.*

Washington, the EU, and the World Bank stayed away. When the oil spigot turned on in 2005, briefly making Azerbaijan the world's fastest growing economy, the hesitance of international financiers no longer mattered. Azerbaijan can now afford its own portion of the railroad, upgrading 313 miles of outdated lines to the Georgian border. It is also loaning Georgia a few hundred million dollars for its section on neighborly terms—25 years at one percent annually. Magnanimity is a pleasure of abundance.

No train passed through Musa Panahov's hometown in the Azerbaijani west, so he went out looking for one. He graduated from the Moscow Transportation Institute during the time of Leonid Brezhnev, then joined the Soviet railroad fraternity. The Soviet Union administered the world's largest, by volume, rail system; all strategic goods were transported by train. This centrally commanded network was a key part of the national security infrastructure, protected and privileged. Train employees had their own separate hospitals, their own schools, even their own militia. "We had everything except a foreign ministry," says Panahov, now Azerbaijan's deputy minister of transport.

Railroads are less important in Azerbaijan today. Oil and gas predominate, according to the plan of the late Heydar Aliyev, the country's third president and primary citizen, who by force of will forged Azerbaijan into what it is today: the relatively secure, relatively independent economic dictator of the region. Aliyev possessed the foresight to invite foreign firms to cooperate in Caspian development, and he understood the importance of the Iron Silk Road. Panahov is the man laying another plank in Aliyev's plan for Azerbaijanis' continued independence.

Panahov, 51, unrolls a map of the southern Caucasus across a table in his office and slowly runs his fingers from east to west, from sea to sea. At this table he negotiated with transport ministers from Georgia and Turkey in discussions that lasted until early in the morning. Cherubic but with graying hair, he speaks in a soft

AZERBAIJAN *An Azerbaijani refugee from Nagorno-Karabakh huddles in his Baku home beneath a picture of his wife, now dead. When ethnic Armenians won control of the enclave in the early 1990s, some 800,000 Azerbaijanis fled the region.*

ARMENIA *A couple waits to be married in a hilltop church above Lake Sevan. Isolated and land-locked, Armenia has been left out of the regional railroad plan because of political tensions with Turkey and Azerbaijan.*

BAKU NO LONGER SUPPLIES *half the world's petroleum, as it did*

NAGORNO-KARABAKH *The license plates were taken from cars abandoned by Azerbaijanis fleeing their homes as Armenia and Azerbaijan fought over control of the region in the early 1990s. Now they line roadside walls in the town of Vank and are seen as trophies of victory.*

at the opening of the 20th century. But it feels like it does.

voice as he delineates the numbers. Total length of the Iron Silk Road: 500 miles. Total annual cargo capacity: 25 million tons. He speaks of the Azerbaijanis who fled to Turkey to escape communism. "It gives me a sense of happiness to connect brothers again," he says.

Azerbaijan became a Muslim parliamentary republic in 1918 and enjoyed that status for a couple of years. Since the breakup of the Soviet Union, however, little about Azerbaijan is visibly Muslim or parliamentarian. It is difficult to locate a minaret or an honest vote in Baku, less so a Bentley. Prosperity and social equality need not be strangers, but when a country has oil, it is tempting to focus on the former at the expense of the latter. More tempting still when the world needs what it has to give. The BTC is the only pipeline that delivers non-Russian, non-OPEC, non-Arabic oil to Mediterranean tankers. With the global oil supply diminishing, Azerbaijani influence has only risen.

Social justice is not a topic of public debate in Azerbaijan. More important to those in power is the fact that this small nation has managed to survive—and now thrive—in a difficult neighborhood. As one official said, "The optimists live in Georgia, the people who are complaining all the time live in Armenia, but the realists live in Azerbaijan."

Or rather in Baku. A short ride on the existing rail leading northwest from the capital reveals not political realists but reality itself, the hovels that house those who have not felt the benefits of Baku's oil boom. A quarter of Azerbaijanis live below the poverty line.

These train cars retain the cracked gloss of Soviet adornment, frills and curtains that are rough to the touch, landscape paintings that hang in the spaces between the windows. A sorority of railway workers in starched uniforms tends to the train as it rolls through a world cleanly separated from Bakuvian luxury. One woman shovels coal into a furnace that heats the car's interior.

Musa Panahov knows these trains, knows they do not rival their German, Japanese, or American counterparts. He is a railway man in an oil country. "But oil and gas will end someday," he says, smiling. "The railroad will live always." □

Native

Santa Clara Pueblo

When drought dried the land around 1580, New Mexico's Puye Cliff dwellers abandoned their homes. Their descendants, the Santa Clara Pueblo, are restoring the nearby watershed.

Lands

Something remarkable is happening in Indian country: Tribes whose lands were once taken from them are setting an example for how to restore the environment.

Big Cypress Reservation

In the green firmament of a slough, galaxies of duckweed are stirred by slow moving waters. Florida's Seminole call this section of swamp the Jurassic.

By Charles Bowden

Photographs by Jack Dykinga

Between the city that gave birth to the atomic bomb and a Rio Grande Valley now studded with Indian casinos, something new is appearing under the sun: the way things were. Here in New Mexico's Santa Clara Canyon, a Native American tribe is restoring its ancestral land. On a volcanic bluff 200 feet above Santa Clara Creek sit the Puye Cliff Dwellings, with hundreds of rooms in buildings fashioned from cut stone and at least 700 more homes incised into the soft tuff of the cliffs below. No one has been home for five centuries. The settlement was probably created during a time of good rain. Then deep drought emptied out this pueblo around 1580. The descendants of its former inhabitants are the current residents of Santa Clara Pueblo, an Indian reservation eight miles downstream on the Rio Grande. The tribe is working to restore the entire watershed along Santa Clara Creek to its natural state after decades of neglect. Eventually thousands of acres will once again be thick with native plants, beaver, and cutthroat trout.

The Santa Clara Pueblo is among a growing number of tribes across the United States—of 564 recognized by the Bureau of Indian Affairs (BIA)—making moves to bring back land crushed over generations of human use. Native American reservations cover 55 million acres of land (compared with 84 million acres controlled by the National Park Service), though most of these acres are not managed as wilderness or wildlife preserves. But something remarkable is emerging in Indian country. Those whose lands were once taken from them, those once dominated, often brutally, by the U.S. government, are setting an example for how to steward the environment.

In 1979 the Confederated Salish and Kootenai Tribes of Montana became the first in the nation to set aside tribal land—92,000 acres of the Flathead Reservation's mountains and meadows—as wilderness. Since then, the Nez Perce have acquired 16,286 acres of ancestral lands in northeast Oregon that they will manage solely to benefit fish and wildlife. The Assiniboine and Sioux tribes in northeastern Montana are working to bring back bison on the Fort Peck Reservation. In Minnesota the Chippewa, or Ojibwa, have restored a ravaged walleye population at Red Lake. And on the Fort Apache Reservation in Arizona the threatened Apache trout is finding a new home, and the forest is now managed with ecology, not just lumber, in mind.

Santa Clara Pueblo's conservation program had an unlikely beginning. Late one evening in May 2000 a controlled burn to remove

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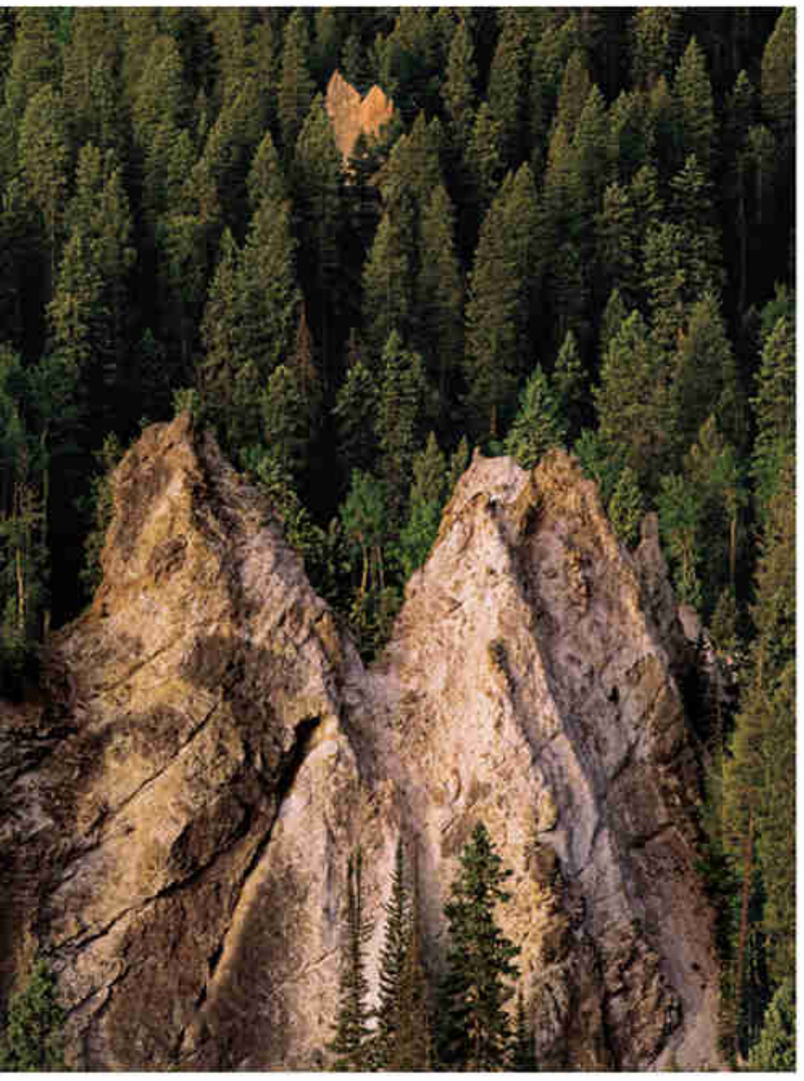
Charles Bowden wrote about Libya's Fezzan region in the October 2009 issue. Jack Dykinga photographed the Big Bend of Texas and Mexico in 2007.

Wind River Roadless Area

No signs point the way here, only the arthritic limbs of a pine gesturing to an endless sky. It is the wildest of the wild, a glacier-scoured terrain unmarred by roads, tugged at by wind, on the shoulder of the Continental Divide. This preserve of the Eastern Shoshone and Northern Arapaho dates back to 1937, decades before the United States passed the Wilderness Act, in 1964.

NGM MAPS



Goat Rock, Santa Clara Pueblo

underbrush in nearby Bandelier National Monument went awry. The so-called Cerro Grande fire wound up devouring 235 buildings in the towns of Los Alamos and White Rock and eating more than 47,000 acres, including the upper part of Santa Clara Canyon. The fire even spread to the Los Alamos National Laboratory, though no radiation was reported to have been released from its nuclear facilities. When the smoke cleared, the Santa Clara Pueblo closed the canyon, long a tourist attraction, and announced that it would take over management of its land from the BIA.

Today the scent of pine and juniper floats in the morning air under a blue sky. The valley rolls out a green tongue of trees in the slot canyon, tracing a path toward the Valles Caldera. The tribe has removed the invasive, exotic tamarisk and Siberian elm and Russian olive from 650 acres along the Rio Grande and restored 75 acres of wetland. In the burn area above the canyon 1.7 million seedlings have been planted, including ponderosa pine, Douglas fir, blue spruce, Engelmann spruce, and white fir. Where Turkey Creek joins the main stream, the signs of elk are everywhere—gnawed bark on wind-felled aspen, droppings in the snow—and ancient beaver dams molder under recent growth. Fifteen years ago the last beaver left this canyon. Now the tribe hopes that with the restoration of streamside growth, the beaver will return and once again start the cycle of dams, ponds, and eventually, as silt fills the impoundments, meadows—a rhythm as old as the mountains.

The pueblo's recreation director, Stanley Tafoya, says simply, "What we are trying to do is restore our resources. The older people want their grandkids to enjoy the canyon we once knew."

That said, there is no Eden to restore. The North American landscape encountered by European invaders was hardly a pristine wilderness. Early human hunters may have helped wipe out mammoths and other megafauna at the end of the Ice Age. For thousands of years after that, Native Americans manipulated the land for their own needs with dams, canals, and fields. They regularly cut and burned the forests to clear land for farming and hunting.

In modern times, some tribal lands became littered with junk, and a few tribes opened solid-waste dumps to bolster their income. In Santa Clara Canyon the disappearance of the beaver was almost certainly hastened by tribal members. Even today, the land is grazed by the tribe's cattle. But in the hope of restoring the streamside vegetation and the beaver, the tribe has begun fencing livestock out of wetland areas and adopted a grazing management plan.

Where conservation efforts are gaining ground, they're often funded by cash from gambling and other enterprises. The Santa Clara Pueblo, for instance, owns and operates a hotel-casino, the Black Mesa Golf Club, and the Dreamcatcher Cinema in nearby Espanola. And of course some native people are as disconnected from the land as the typical American suburbanite, driving giant pickup trucks and killing

the dark hours watching DVDs. Yet this is a culture that has lived close to the land for centuries and whose elders tell stories that reach into a time beyond the imagination of industrial civilization. There remains a faith among Native Americans that they can rediscover the ground where their ancestors knew how to talk to gods.

ON A STRETCH OF FOGGY COAST 200 miles north of San Francisco, less than 2 percent of the original old-growth redwoods survived the relentless logging of a few decades ago. The trees did better than the native people, who were hunted and slaughtered in the exuberance following the mid-19th-century gold rush. Their land was eventually claimed by timber companies. Now the tribes that formed a consortium to protect the land are working together to steward and restore 3,900 acres of the Sinkyone wilderness along the Lost Coast—lost because Highway 1 is forced inland here by the rugged terrain. At Sinkyone they have established a precedent—an intertribal wilderness area where trees will never be commercially harvested again.

The ground underfoot is brown litter. The trees tower, and everything is shadow. For a long time the Lost Coast was lost to Europeans. Early Spaniards couldn't find a decent harbor and were beaten back by storms. Before settlers arrived, the Sinkyone Indians lined the valleys with villages, made redwood dugout canoes that featured carved lungs and hearts, and rode the waters hunting sea lions and other beasts. They saw the giant trees as fellow members of the community, the condor as a messenger from on high. The Sinkyone are a people who "fix the world" every year through a series of ceremonies. One of their stories is that the creator made the world and patted everything down, and then "bad men were not satisfied and tore it down, tore up the ocean banks, tore up the trees, tore down the mountains. Since that time we have had to sing and dance every year to make it right again," according to tribal beliefs.

Sally Bell was ten years old on the morning 150 years ago when white men came to her home near Needle Rock. They wiped out her family and cut out her baby sister's heart, which they tossed into the brush where Sally hid. "I didn't know what to do. I was so scared that I guess I just hid there a long time with my little sister's heart in my hands." When Sally's words were finally taken down in the late 1920s, the visiting anthropologist described her as "blind, senile, sees spirits in rafters."

Sally Bell's name became a rallying cry in the 1980s, when the Georgia-Pacific lumber company sought to topple some of the last surviving old redwoods in a 90-acre grove that now memorializes her. Environmentalists chained themselves to trees, the cutting stopped, and then something like change came to the Lost Coast. In 1985 a court ruling put an end to clear-cutting on 7,100 acres of timberland, about half of which was added to Sinkyone Wilderness State Park. Native people, loggers, and environmentalists sat down

Fifteen years ago the last beaver left Santa Clara Canyon. Now the tribe hopes that with the restoration of streamside growth, the beaver will return and start a new cycle of dams and ponds.

InterTribal Sinkyone Wilderness

The ten tribes of the wilderness council are careful custodians of a temperate rain forest rich in moss-covered tan oak (above) and redwood and closed to commercial logging. The "sacred ecosystem," as executive director Hawk Rosales calls it, is threaded by waters like Wolf Creek (right), focus of a project to restore salmon habitat.

Saw palmetto, Big Cypress Reservation

to help thrash out a plan for the other half. The original agreement set aside some areas as reserves, with the remainder to be harvested after a few decades of rest. But the tribes held out for a different plan.

Priscilla Hunter, one of the founders of the InterTribal Sinkyone Wilderness Council, put her foot down and insisted that the land simply not be exploited again—a stance that almost destroyed the agreement and led to ill feeling. After years of meetings and with a heavy dose of obstinacy, the council became the leading force in the efforts of various state parks and nonprofits to retire patches of woodland so that the historic forests could return.

In 1997, after more than a century of dispossession, the council acquired the 3,900 acres of Sinkyone land and turned it into the country's first intertribal wilderness area. "It was time for our people to get land back so that we could protect it," Hunter says. "The coastline and the redwood forests are sacred to the tribes. That's where our people gather food and medicines, and the mountains are a place of ceremony where we can go and feel the power of our Mother Earth. The elder redwood trees are very powerful to us in a spiritual way."

In cooperation with California State Parks, the council is restoring a stream known as Wolf Creek, which runs through nearby Wheeler, an abandoned logging town, in hopes of beckoning back a salmon run. Old logging roads have been removed by the council and the state parks, and the land is beginning to heal. Upon a low ridge, redwoods twist and writhe, their limbs shaped by winds off the sea, almost a chorus of wood singing songs that modern humans are only slowly learning to hear.

ACROSS THE CONTINENT in southern Florida, another tribe once pegged for extermination is trying something similar. During the 20th century about half of the Big Cypress Swamp and the neighboring Everglades was destroyed for cities and farms. Invasive trees such as the melaleuca and the Brazilian pepper threaten what remains. A federal and state plan signed into law in 2000 promised a massive effort to revive the wetlands by restoring more natural water patterns, but until recently the plan remained stalled for lack of funding. So the Seminole Indians developed their own Everglades initiative, electing to take 2,100 acres of Big Cypress Reservation land, systematically remove the invaders, flood it to approximate what were once normal flows, and bring back some of the wild ground.

For tribal members, the Big Cypress Swamp and the Everglades are rare relics of the very earth that once saved them from genocide. When the Spanish first landed in Florida during the expedition of Juan Ponce de León in 1513, the area was home to 250,000 natives, whom the Spanish came to call *cimarrones,* meaning "wild ones." By the 18th century the Indians were known as the Seminole, and they stuck like a fish bone in the throat of American might. In 1819 the U.S. acquired Florida from Spain for five million dollars, then

dropped more than $30 million on the Seminole Wars. When the gore ended, about 4,000 had been exiled to what is now Oklahoma, and maybe 300 remained hiding in the swamp. For most of the 20th century their descendants eked out a living as tourist attractions around Miami or in the Everglades, wrestling alligators, performing dances, and making trinkets for visitors.

The big turnaround came in 1988, when Indian gambling was sanctioned. Today every man, woman, and child in the tribe of 3,500 members receives a healthy percentage of casino profits. In December 2006 the tribe cut a $965-million deal that bought up almost all of the Hard Rock Cafes and casinos in the world.

This prosperity is allowing them to save a fragment of the Big Cypress that was never developed because it was unsuitable for agriculture; citrus groves, cattle farms, and vegetable fields cover the rest of the reservation. "That means bringing back more of the animals, giving it the traditional look of the land," says Brian Zepeda, director of Florida Seminole Tourism. "The cypress trees were once so large and dense they formed like a fort created by nature."

Zepeda leads the way through the swamp, carrying a machete to help clear a path. Sabal palms, pop ashes, and willows share the space with the cypresses. It is early in the dry season, and the ground underfoot feels firm, though it buckles in the low, wet spots. Deer dart on the edge of the forest, and a remnant of the endangered Florida panthers—maybe 20 of a possible state population of a hundred—holds out on the Big Cypress Reservation.

Wild sour oranges, introduced by the Spaniards, persist as well. The Seminoles roast them to bring out their sweetness. In one part of the reservation that's under restoration is a raised spot in the marsh, a former settlement where natives hid from soldiers in the safety of trees at the end of the last Seminole War.

Zepeda says he used to wrestle alligators. "But I got older, and the alligators still stayed young," he says.

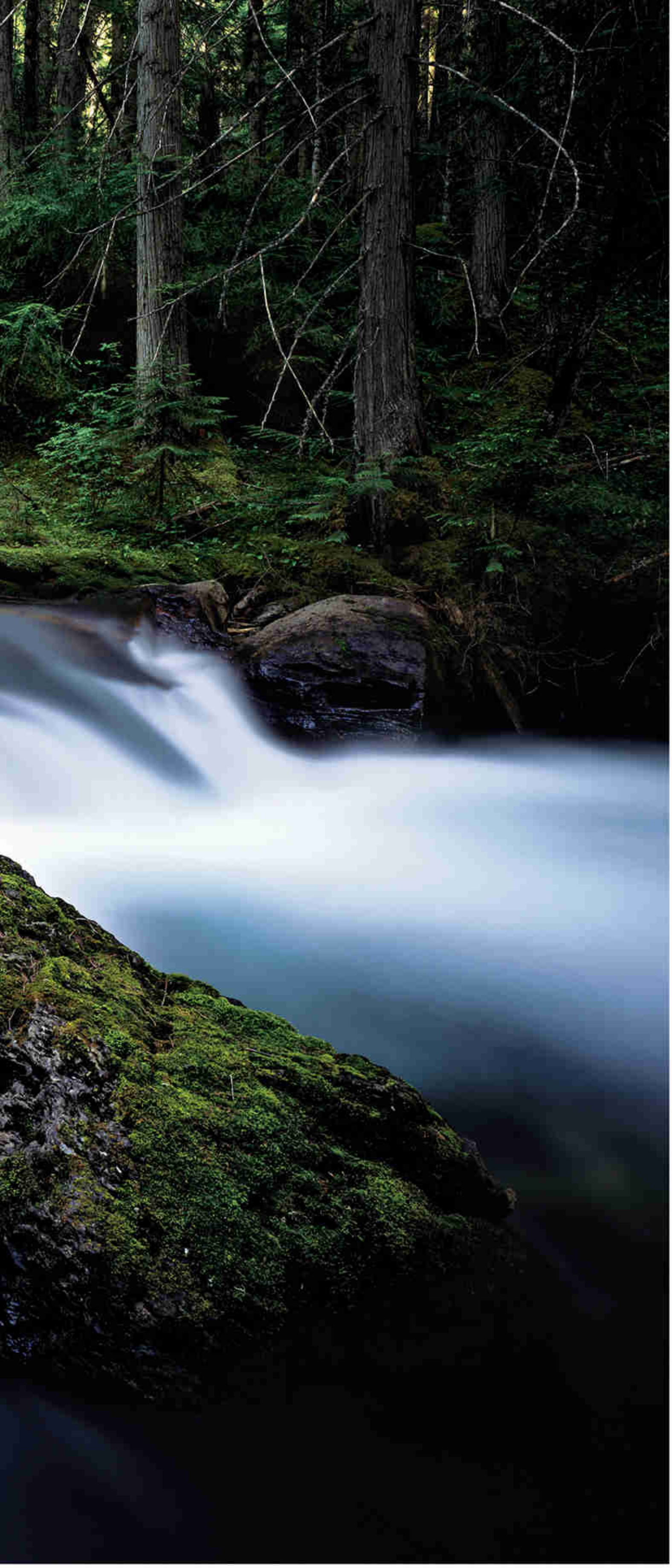
And that is the song of the Big Cypress and the Everglades—the nation got older, and this land, now coming back around the abandoned village, recalls a world that was newer and fresher.

The project covers little more than 2,000 acres, compared with the entire Everglades, which comprise more than four million. And it is migrant laborers, not Seminoles themselves, who have been hired to remove the exotic species. (This is also true at Santa Clara Pueblo.) It would be easy to dismiss the effort as a tiny gesture.

But this would hardly be the attitude of an alligator or a cypress.

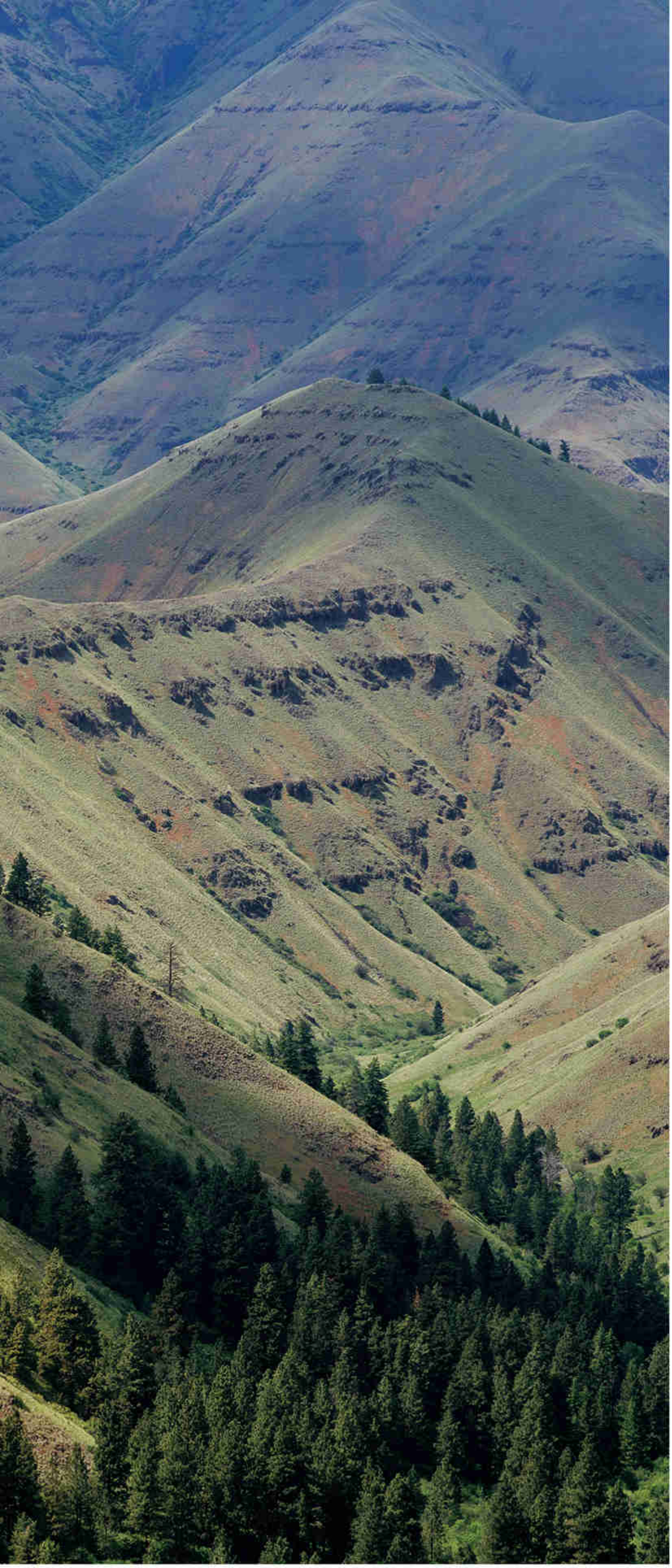
In a canal snaking around the area under restoration, an alligator leaps from the water in the sunlight and snatches a fish. The canal, part of the huge water-drainage effort that destroyed much of the Everglades, is little more than an industrial ditch. And yet the alligator lives here, beautiful as it arcs in the light—wild, throbbing life in a world going to concrete, condos, and freeways. □

The Big Cypress Swamp is a rare relic of the very earth that once saved tribal members from genocide. After the Seminole Wars, those not exiled remained hiding in the swamp.



Mission Mountains Tribal Wilderness

Post Creek stairsteps down through the Grizzly Bear Management Zone, an 11,000-acre section of the Mission Mountains Tribal Wilderness closed to humans in summer so bears can feed on army cutworm moths. The Confederated Salish and Kootenai Tribes designated 92,000 acres as wilderness in 1979, but the way had been paved earlier. In 1974 a pending timber sale threatened old-growth trees. Three grandmother elders, or yayas, ***appeared at a tribal council meeting. "They straightened their scarves, spoke of their concern for generations to come, and refused to leave until the council banned logging," said a witness. It did.***



Nez Perce
Precious Lands

"For a short time we lived quietly. But this could not last," Chief Joseph of the Nez Perce said. In 1877 the federal government forced the Nez Perce from the fir-clad mountains of Oregon's Wallowa Valley. Joseph spent his last days in exile, dying, his doctor said, of heartbreak. With assistance from the Trust for Public Land, the tribe has regained 16,286 acres of its Precious Lands, as they are rightly called. Native grasses are being replanted. The graceful flight of a white-throated swift has been noted. The green-banded mariposa lily unfurls its lavender petals. Renewal is in the air; it is not just restoration of land but of spirit.

Red Lake Reservation

Sunset flares over Thunder Lake, one of 14 small lakes on the Red Lake Reservation managed by the tribal fisheries department. It feeds Red Lake, sacred to the Chippewa and once again thick with walleyes—fish with a glassy stare revered for their sweet, snowy flesh. By 1996 decades of overfishing had decimated the Red Lake fishery. Tribal, state, and federal agencies, along with the University of Minnesota, cooperated to set up a management plan. Fishing was suspended. Walleye fry were stocked. In less than ten years the fish population exploded from 200,000 to eight million, and tribal members were allowed to resume commercial fishing.

100 tigers,
2,000 one-horned rhinos,
1,800 wild buffalo…
Kaziranga National
Park is

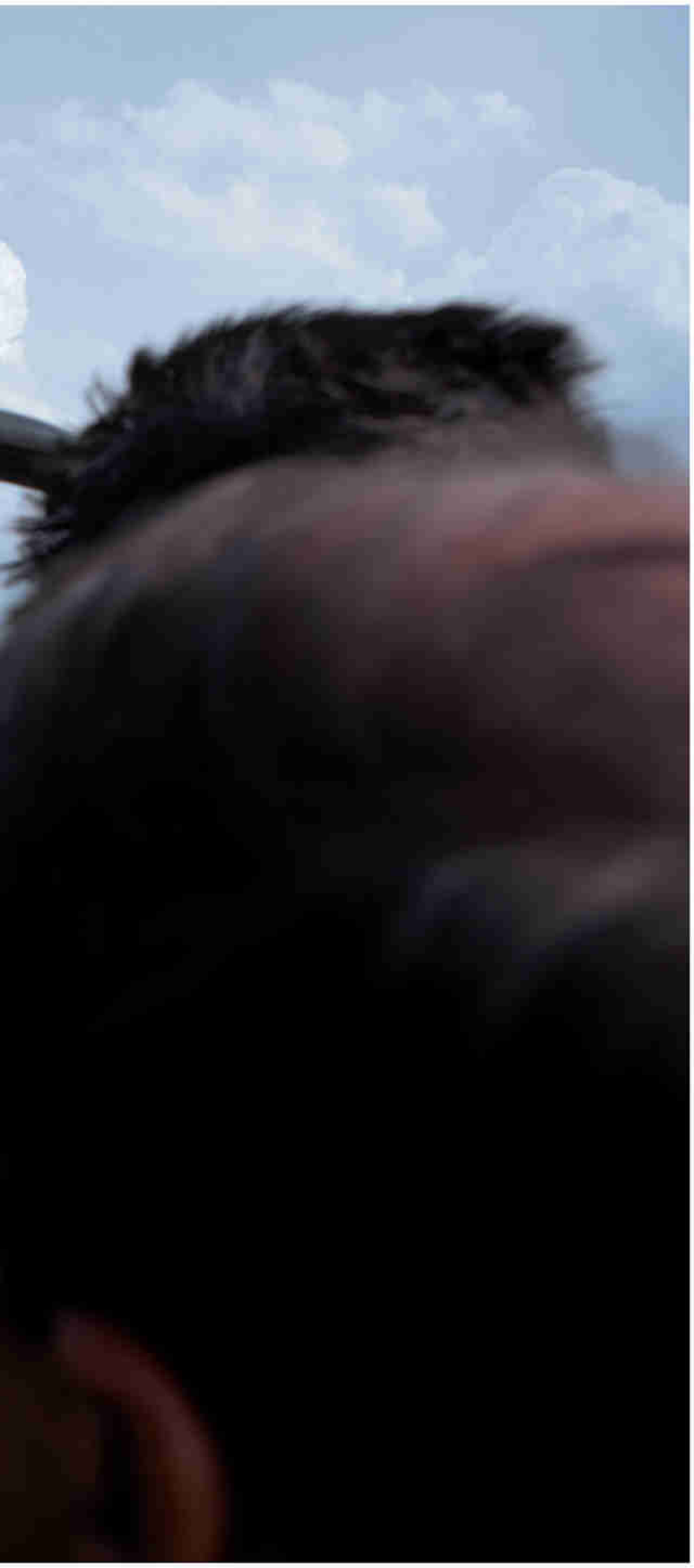
India's Grassland Kingdom

98 Hunted to death in much of India, tigers survive in Kaziranga.

Each of Kaziranga's 1,300 elephants downs an average 300 pounds of forage and 50 gallons of water a day—more than the park can provide at times. Upland forest reserves are vital for these and other species, but expanding human settlement could sever access.

The rhino charged. A park guard, riding with the *Geographic* team, tried a warning shot, but his rifle jammed. A rhino can run 25 miles an hour, and cars can get rammed—or worse. The driver of this one managed to speed away.

By Douglas H. Chadwick
Photographs by Steve Winter



An Indian one-horned rhino

—*Rhinoceros unicornis,* the kind that looks like it has shields bolted to its butt—weighs as much as an SUV. Only Africa's white rhino is larger. Only the Sumatran rhino (population 350 or fewer) and Javan rhino (50 or fewer) are more imperiled. Once common from Pakistan to Myanmar, *R. unicornis* is represented today by fewer than 2,700 animals. A quarter are confined to ten little reserves in northern India and neighboring Nepal. Virtually all the rest—about 2,000 at the latest count—live in Kaziranga National Park, a 332-square-mile reserve that takes in 50 miles of the Brahmaputra River with its sand islands, a few areas to the north, and a much larger portion of the floodplain to the south. Excluding the river, that's an average of 11 ancient, armored, irritable unicorns for every square mile of the park.

Fewer than 200 were left in the north Indian state of Assam a century ago. Agriculture had taken over most of the fertile river valleys that the species depends on, and the survivors were under relentless assault by trophy hunters and poachers. Kaziranga was set aside in 1908 primarily to save the rhinos. It held maybe a dozen. But the reserve was expanded over the years, given national park status in 1974, and named a World Heritage site in 1985. During the late 1990s it grew again, doubling in size (although legal issues remain to be settled). Now Asia's premier rhino sanctuary and a reservoir for seeding other reserves, Kaziranga is the key to *R. unicornis*'s future.

A thundering conservation success story, the park also harbors almost 1,300 wild elephants; 1,800 Asiatic wild water buffalo, the largest remaining population anywhere; perhaps 9,000 hog deer; 800 barasinghs, or swamp deer (it's a

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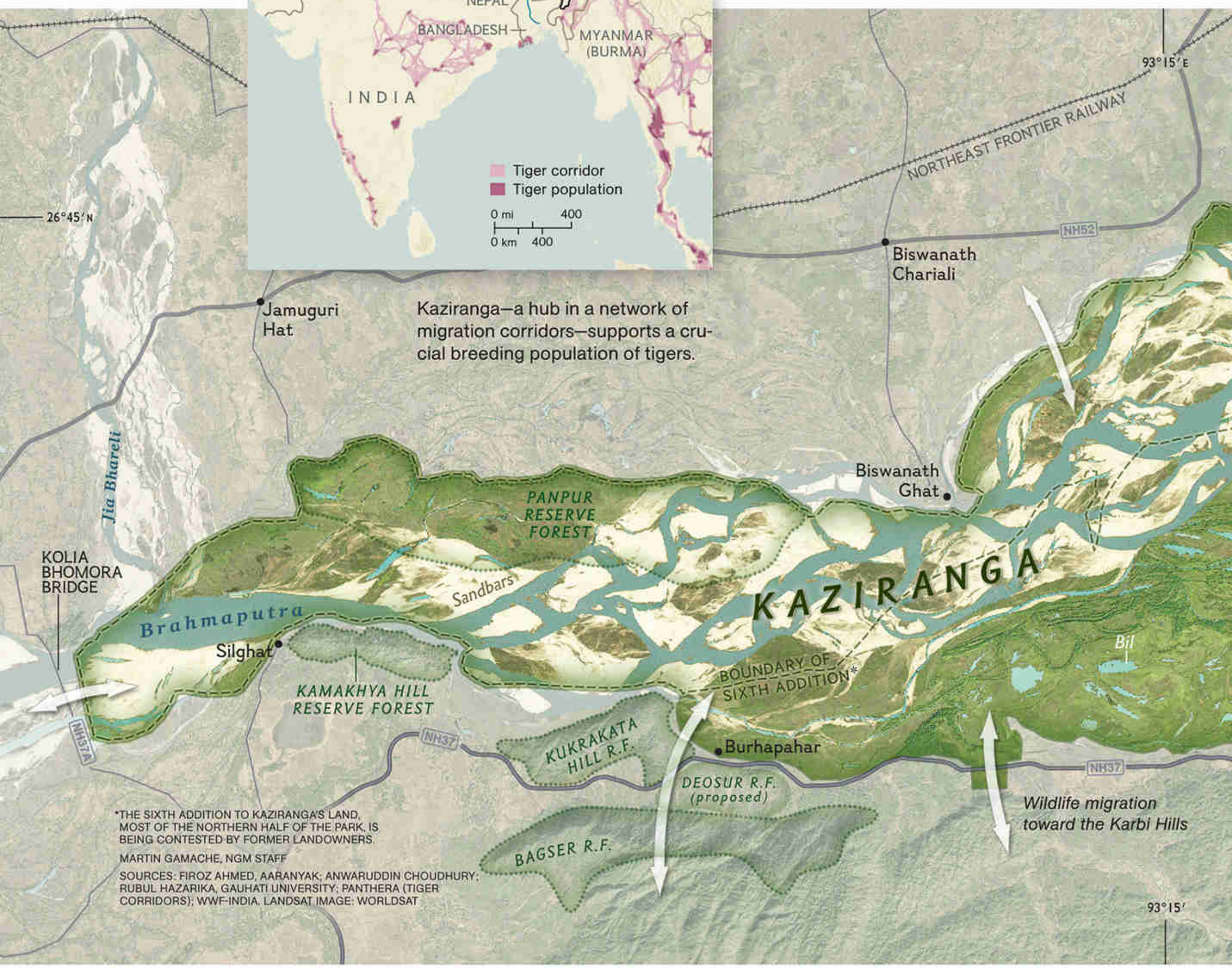
Douglas Chadwick and Steve Winter last worked as a team tracking snow leopards in Central Asia for the June 2008 issue. Both are regular contributors.



*THE SIXTH ADDITION TO KAZIRANGA'S LAND, MOST OF THE NORTHERN HALF OF THE PARK, IS BEING CONTESTED BY FORMER LANDOWNERS.

MARTIN GAMACHE, NGM STAFF

SOURCES: FIROZ AHMED, AARANYAK; ANWARUDDIN CHOUDHURY; RUBUL HAZARIKA, GAUHATI UNIVERSITY; PANTHERA (TIGER CORRIDORS); WWF-INDIA. LANDSAT IMAGE: WORLDSAT

main enclave of this vanishing species); scores of elk-like sambars; and hundreds of wild hogs.

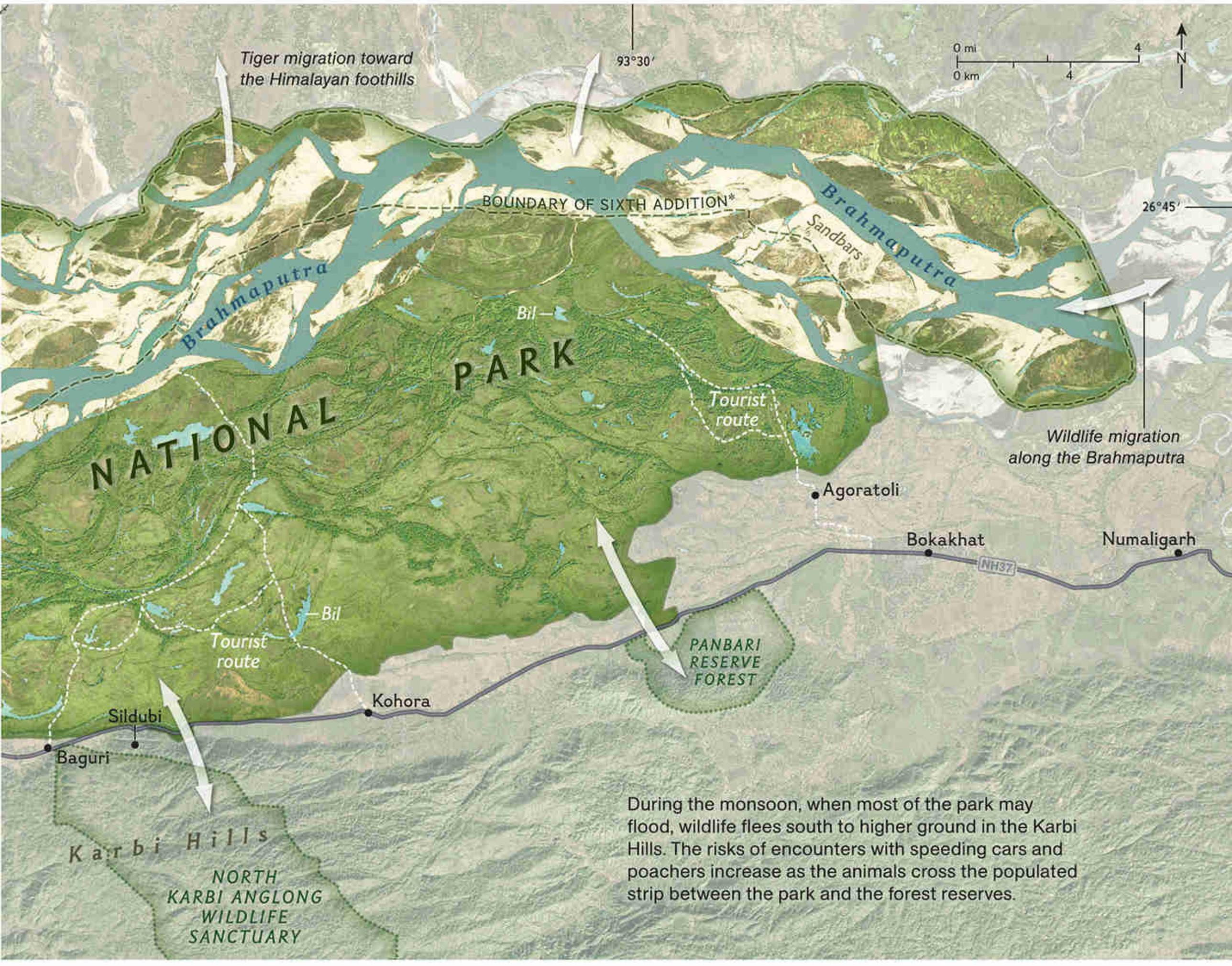
That's millions of pounds of prey. Yet neither wolves nor Indian wild dogs roam here. The resident sloth bears dine on termites and vegetation, while leopards favor the surrounding hillside forests for hunting. When the hog deer snort in alarm or the buffalo all swing their crescent-horned heads to stare toward the same patch of grass, what's coming is most likely striped and orange with paws the size of plates.

It was the deer's suddenly raised tails that tipped me off: tiger time. One had moved into the opening around a drying lake just a stone's throw from me, but I couldn't find it. I was looking too low to the ground. The first thing I saw were legs. Then I was staring at a cat that loomed over the tallest deer, weighed 500 pounds, and looked made of flames. Then the hunter and the hunted vanished, leaving me to stare again into the sun-dappled stalks that had framed the tiger's silhouette for just a moment.

In the face of widespread deforestation and poaching, coupled with weak protection at many

A river's riches

Pouring from the Himalaya, the Brahmaputra leaps its banks yearly, depositing nutrient-laden silt that grows towering grasses, which support megatons of wild grazers. But such fertility is a magnet for agriculture, making natural floodplain habitats like Kaziranga's extremely rare today.



During the monsoon, when most of the park may flood, wildlife flees south to higher ground in the Karbi Hills. The risks of encounters with speeding cars and poachers increase as the animals cross the populated strip between the park and the forest reserves.

reserves, the majority of India's tigers have disappeared over the past 25 years. Yet they seem to be thriving within Kaziranga. The official estimate is now 90 to a hundred, composing what may be the densest concentration in the world today.

What's so right about the park that it can pack this many big animals into a modest-size area? The answer flows from the river. Beginning high in Tibet, the Brahmaputra runs east for about 700 miles, draining the north side of the Himalaya before making a U-turn to continue 500 miles through India and Bangladesh. When the summer monsoon adds torrential rains to the watershed, the river spills out over the valley. By the time the surge recedes, it will have coated the floodplain with a fresh layer of nutrient-charged silt. Sedges and a variety of tallgrasses arise from the muck in luxuriant profusion. Their specialty is converting sunlight into nonwoody tissues loaded with starch; that is, into vast fields of high-energy food—fields that grow 20 feet high.

We think of forests as the places in the subtropics with the most wildlife and the greatest

What bloodied this rhino? Maybe a clash with a male rival, maybe a courting session with the departing female in the background. The park harbors three-quarters of the world's Indian one-horned rhinos—11 per square mile. The crowding could lead to more battles and more wounds, which are a frequent sight.

Tourists atop elephants are safe from rhinos—and well positioned for a trek through Kaziranga. Swamp deer graze in an area of new growth stimulated by a fire set by park staff (right). Burns keep the grassland fertile and prevent woody plants from encroaching on the savanna.

need for conservation. But the tallgrass habitats of alluvial plains are richer in large native animals and far more rare. The park has meadows of naturally short grasses too, and the throngs of creatures visible on those open savannas rival scenes from the most famous African parks.

On slightly higher ground, trees such as Indian lilac form airy forest canopies roped with vines. Rhesus macaques troop past the buttressed trunks. Parakeets and great hornbills decorate the branches. Cup your ears, and the voices of hundreds of other bird species swell from the shadows like a distant crowd cheering.

Overflow channels that have become shallow lakes, periodically recharged with water and fish by the floods, pattern the landscape. Migratory waterbirds, from bar-headed geese to ruddy shelducks, crowd into Kaziranga wetlands over the winter with spot-billed pelicans and black-necked storks. While rare Pallas's fish-eagles scoop prey from ponds, or *bils*, otters on the hunt sometimes arc from the water like dolphins. I even saw seven-foot-long Ganges River dolphins rising from the surface in the Brahmaputra. Endangered over most of their range, these mammals appear to be holding their own along the park's length of the river, free from fishing pressures and entangling nets.

BUDHESWAR KONWAR, my guide, stopped our open-topped jeep so he could move another aquatic creature—an Indian tent turtle—off a back road on a hot afternoon. The rest of us got out to stretch and watch. When I turned to check in the opposite direction, the view was terrible.

"Rhino!" Close and churning toward us.

These organic tanks can sprint at more than 25 miles an hour. Visitors (Kaziranga hosts about 70,000 Indian tourists and 4,000 foreign tourists annually) must have an armed park guard travel with them, and the requirement is not an idle formality. We didn't have time to

My guide had made a rule: "No allowed for scared." I was breaking it as the rhino butted our rig up onto two wheels.

leap in the vehicle and race away, so Ajit Hazarika fired a round. It was a snap shot but perfectly placed. The bullet kicked up a stinging spray of dirt inches from the attacker's front foot. Combined with the crack of the rifle, it was enough to make the rhino veer aside two seconds from us.

Ten minutes later we were driving through forest along a raised dirt track when a rhino fresh from a wallow climbed onto the road, followed by an equally muddy juvenile two-thirds her size. Walking in leaf-softened light on the red blossoms fallen from a silk-cotton tree, the pair slowed and exchanged a sniff. A second subadult appeared behind. All three then dropped out of sight down the other side.

We drove on after waiting a bit, only to discover mother rhino charging through the trees on a course aimed to collide with ours. No chance to back up, no hope of accelerating out of trouble on the rough track. Hazarika, in the passenger seat, couldn't even get off a shot before the earth-glazed female clobbered the jeep, which she far outweighed. His door caved in. I realized the rhino was shoving us toward the road's edge and butting our rig up onto two wheels, and I'd better get ready to jump before she rolled us.

Unlike African rhinos, Indian rhinos don't gore an enemy with the spike on their heads. They bite with large, sharp lower incisors. The female's teeth were gouging deep grooves into the jeep's steel. Damn.

Konwar had laid down a rule for Kaziranga—"No allowed for scared." I was breaking it while he gunned the engine, fighting for traction. At last the vehicle leveled out and skidded free. But she instantly gave chase, and it was still touch and go in a cloud of dust for several hundred feet.

Our destination was a site where the tracks of two tigers had been seen around a fresh rhino carcass. Tigers claim as many as 15 percent of the rhino calves in Kaziranga. This carcass spoke of

Shouting villagers chase elephants from private land near the park border. The elephants were bound for Kaziranga's rich natural pastures from forested range outside the park. Keeping babies in the middle to protect them, the herd evaded mobs all day, escaping into the reserve after dark.

Villagers honor a fallen elephant with incense and prayers, reflecting the Hindu belief that these pachyderms are sacred. This animal was shot—an illegal act—while it was raiding a rice field near the park. It died of its wounds a few days later.

Suspects in a rhino-poaching deal are blindfolded for interrogation at the Baguri ranger station; they were later released. At right, a female rhino was killed by a pair of tigers while she was having difficulty birthing a calf. Park staff removed her horn after she died to prevent poachers from taking it.

tigers taking down an adult—a risky enterprise rarely reported.

The most serious threat to rhinos still comes from predatory humans, just as it did a century ago. Which is why Kaziranga has nearly 600 guards in the field, stationed between the unruly big animals and the poachers. Squads operate out of 130 camps, some built of concrete, the rest of logs and thatch, all standing on stilts. Guards mark the posts to show the levels of floods; some years, it's a post on the upper story. The men move in pairs or trios on foot and elephant-back—or by boat. Afternoon patrols finish after dark. The guards wake to begin another sortie long before dawn, pausing first at a humble shrine to the goddess Kakoma to ask once again for safe passage. When the moon grows big, teams stay out all night.

The mission never ceases. People caught taking fish from the river or bils have their nets confiscated and are subject to fines. Cattle and goats grazing inside the park have to be shooed home to village pastures. More often, guards are called on to drive wildlife from the villages and fields back to Kaziranga.

That's all routine work compared with dealing with armed men stalking rhinos. The animals' horns—made of agglutinated keratin fibers, the same substance as in hooves and hair—are prized for dagger handles in the Middle East and valued even more highly throughout Asia for their purported medicinal powers. With a single horn fetching over $30,000 on the black market, this is a lethal commodity.

From 1985 through 2005, illegal hunters shot 447 Kaziranga rhinos and several guards; guards killed 90 poachers and arrested 663. The number of rhinos poached annually dropped below nine starting in 1998—then in 2007 it rose to 18. By the fifth week of 2008, when I arrived, five more had been felled. One was a calf, slaughtered for a tiny nub of horn. The wounded mother's horn

Kaziranga has nearly 600 guards in the field, stationed between the unruly big animals and the poachers.

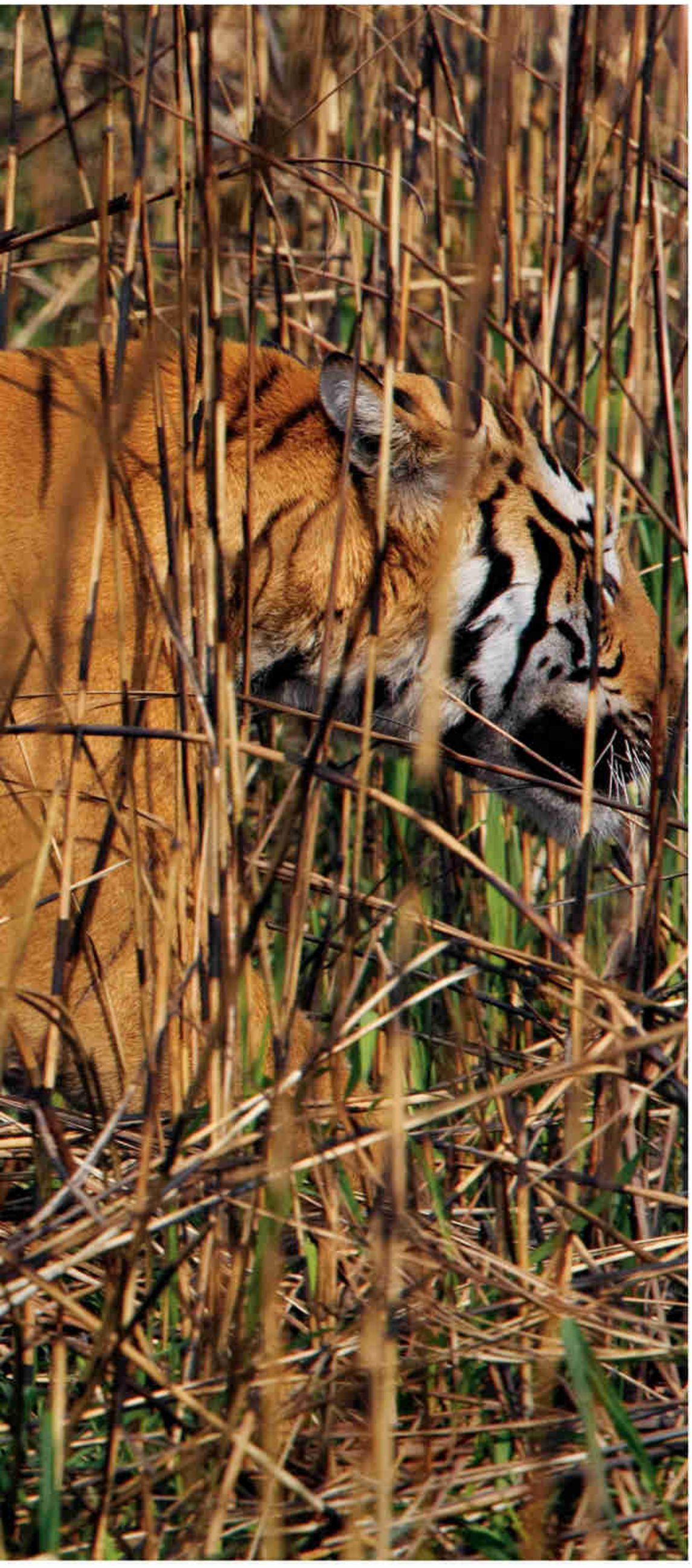
was hacked off her face while she was still alive. It took her two days to die.

A series of arrests squelched the flurry of rhino poaching, although judging by past experience, more bad guys will show up sooner or later. But the park has another major problem—one nobody can suppress.

Kaziranga depends upon a much larger landscape to maintain its spectacular wildlife. In times of heavy flood, when the land vanishes beneath the Brahmaputra's brown currents, wildlife flees the reserve. It always has. Yet wherever the animals go these days, they encounter a rising flood of humankind. You can get lost in the tallgrass right up to Kaziranga's southern edge, but just beyond you're among kids, dogs, chickens, milk goats, and miles of rice fields. A little farther on, you might reach a shed where a listless cow lies oozing fluids from the tiger wound on her neck, while Nijara Nath tells of discovering the cat at night in the cattle pen by the house. When crops begin to ripen, her husband, Indeswar, spends many nights at the edge of their field trying to scare away vegetarians, from dainty-hoofed deer to rhinos that pothole a paddy with every step. The Naths don't resent the park—Indeswar's cousin makes good wages cooking at a tourist lodge—but they wish that the bureaucracy supposed to compensate folks for wildlife damage worked more efficiently. "Some years we have a big loss, some years small," Indeswar said, "but there is a loss every year."

DEVELOPMENT CROWDS even closer on the park's north side. From high in a lookout tower at a camp there, I could see only tame life—dairy herds of domestic buffalo and cattle—feeding across wetlands inside the park. Since livestock grazed in this area before it was appended to the reserve in the 1990s, authorities allow the practice to continue. But the area as a whole experiences more elephant conflicts than almost any place in

Amid tallgrass the coat of a tiger becomes a cloak of invisibility, the camouflage raising the odds for a successful kill. Tigers in the park hunt, with no competition, millions of pounds of deer, buffalo, and wild hog.



Assam, for it lies on a migratory route of herds following the last tatters of forest between Kaziranga and the Himalayan foothills to the north.

During high water, animals also migrate southward toward the Karbi Hills. Five small but absolutely vital habitat bridges were recently added to the park to ease the journey. Along the way the animals confront National Highway 37, Assam's main east-west transportation route. Guards set up a slalom course of barriers to slow truck traffic at the most heavily used crossing sites. Nevertheless, elephants, rhinos, pythons, and deer on the move become roadkill most every year. A proposal to widen the route to four lanes has had India's conservation community in a sweat.

"If Highway 37 is made a freeway, it's a death knell for Kaziranga," declared Asad Rahmani, director of the Bombay Natural History Society. Officials are considering backing off the four-lane plan in favor of upgrading a parallel road north of the river. "We still need to control the encroachment of other development," he said. "The government should buy land for more corridors before Kaziranga becomes cut off."

Even if links to the Karbi Hills are strengthened, what of the hills themselves? And the uplands sloping toward the Himalaya? Woodcutters, stone-quarry operators, herders, and squatters populate more of the state's forest reserves in those places every year, changing a continuous tree cover into a weedy patchwork of cutover, eroding slopes. It helps that India has declared a Kaziranga–Karbi Anglong Elephant Reserve that extends far to the south and a Kaziranga Tiger Reserve that reaches many miles north. But they are little more than hopeful lines on a map at this stage, and the nonpark portions keep filling with land-hungry people.

The challenge is to connect the remnants as much as possible. If the obstacles start to look overwhelming, think about the dedicated guards at lonely outposts and about Budheswar Konwar and the rhino-country rule. Remember? No allowed for scared. □

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

VALLEY OF THE

WHALES

An Egyptian desert,

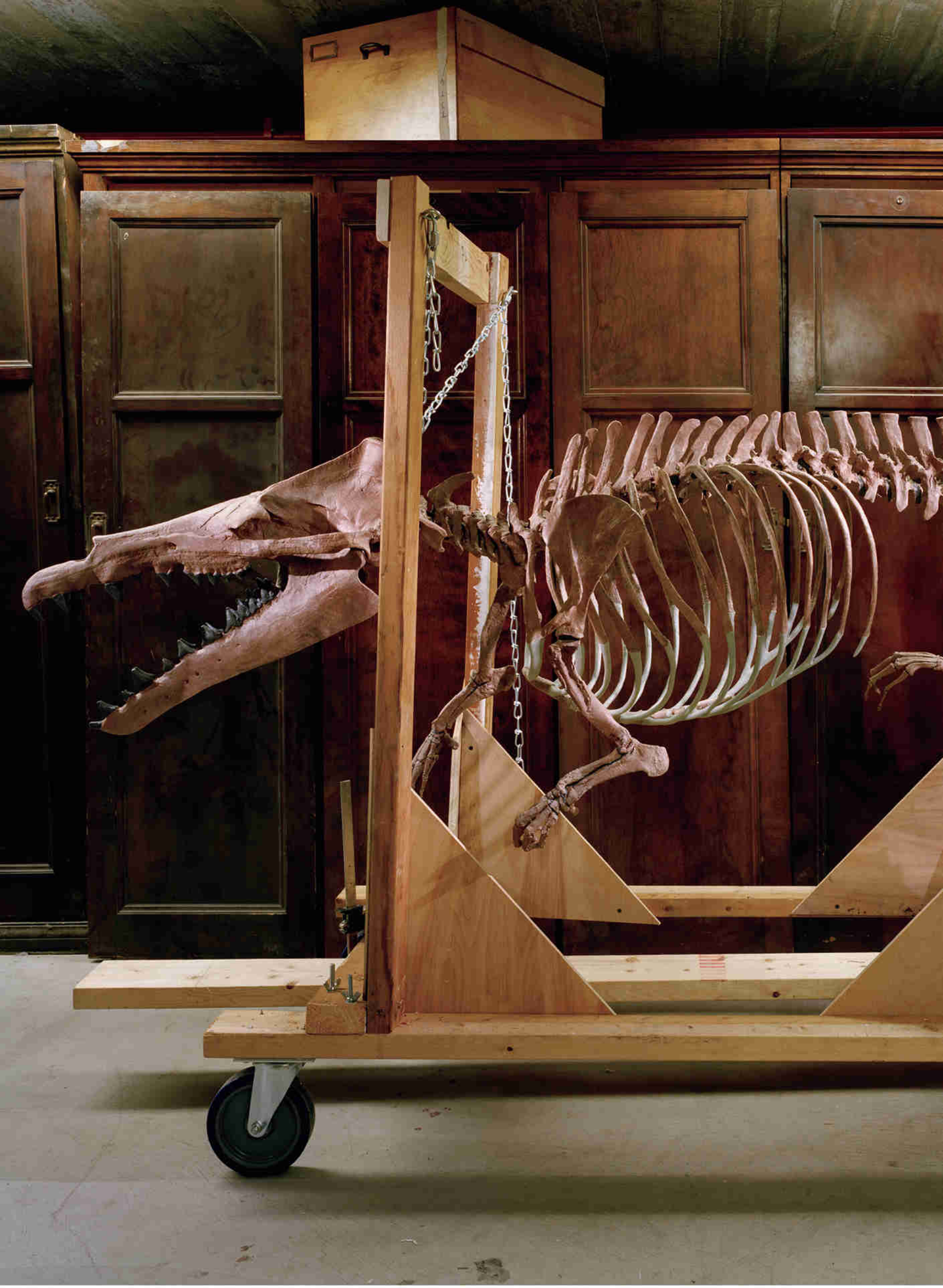
ONCE AN OCEAN,

HOLDS THE SECRET TO ONE OF

EVOLUTION'S MOST REMARKABLE

TRANSFORMATIONS.

Imagine this dry expanse underwater, with whales hunting and diving. Today visitors to Wadi Hitan walk a stone-lined path to see rocks that hold the fossils of the long-gone sea creatures.



Egypt isn't the only country with traces of early whales. Found in Pakistan, this 47-million-year-old *Maiacetus* now stands in the basement of the University of Michigan Museum of Paleontology. With robust legs and webbed feet, it propelled itself on land like a sea lion. The limbs also provided thrust for swimming; its tail served mainly as a rudder. Later whales swam more efficiently with tail power; their hind legs dwindled, and their front legs morphed into flippers.

A whale's jaws (far left) protrude from a cliff in Wadi Hitan, less than a hundred miles from the Pyramids at Giza. "An Egyptian folktale in hieroglyphics mentions a sea serpent," says paleontologist Philip Gingerich (left). "It could have been inspired by these animals."

BY TOM MUELLER PHOTOGRAPHS BY RICHARD BARNES

Thirty-seven million years ago,

IN THE WATERS OF THE

PREHISTORIC TETHYS OCEAN,

A SINUOUS, 50-FOOT-LONG BEAST

WITH GAPING JAWS AND

JAGGED TEETH DIED AND SANK

TO THE SEAFLOOR.

Over thousands of millennia a mantle of sediment built up over its bones. The sea receded, and as the former seabed became a desert, the wind began to plane away the sandstone and shale above the bones. Slowly the world changed. Shifts in the Earth's crust pushed India into Asia, heaving up the Himalaya. In Africa, the first human ancestors stood up on their hind legs to walk. The pharaohs built their pyramids. Rome rose, Rome fell. And all the while the wind continued its patient excavation. Then one day Philip Gingerich showed up to finish the job.

At sunset one evening last November, Gingerich, a vertebrate paleontologist at the University of Michigan, lay full length beside the spinal column of the creature, called *Basilosaurus,* at a place in the Egyptian desert known as Wadi Hitan. The sand around him was strewn with fossil shark teeth, sea urchin spines, and the bones of giant catfish. "I spend so much time surrounded by these underwater creatures that pretty soon I'm living in their world," he said, prodding a log-size vertebra with his brush. "When I look at this desert, I see the ocean." Gingerich was searching for a key bit of the creature's anatomy, and he was in a hurry. The light was failing, and he needed to return to camp before his colleagues started to worry. Wadi Hitan is a beautiful but unforgiving place. Along with the bones of prehistoric sea monsters, Gingerich has found the remains of unlucky humans.

He moved down the spine toward the tail, probing around each vertebra with the handle of his brush. Then he stopped and set down the tool. "Here's the mother lode," he said. Clearing the sand delicately with his fingers, he laid bare a slender baton of bone, barely eight inches long. "It isn't every day that you see a whale's leg," he said, lifting the bone reverently in both hands.

Basilosaurus was indeed a whale, but one with two delicate hind legs, each the size of a three-year-old girl's leg, protruding from its flanks. These winsome little limbs—perfectly formed yet useless, at least for walking—are a crucial clue to understanding how modern

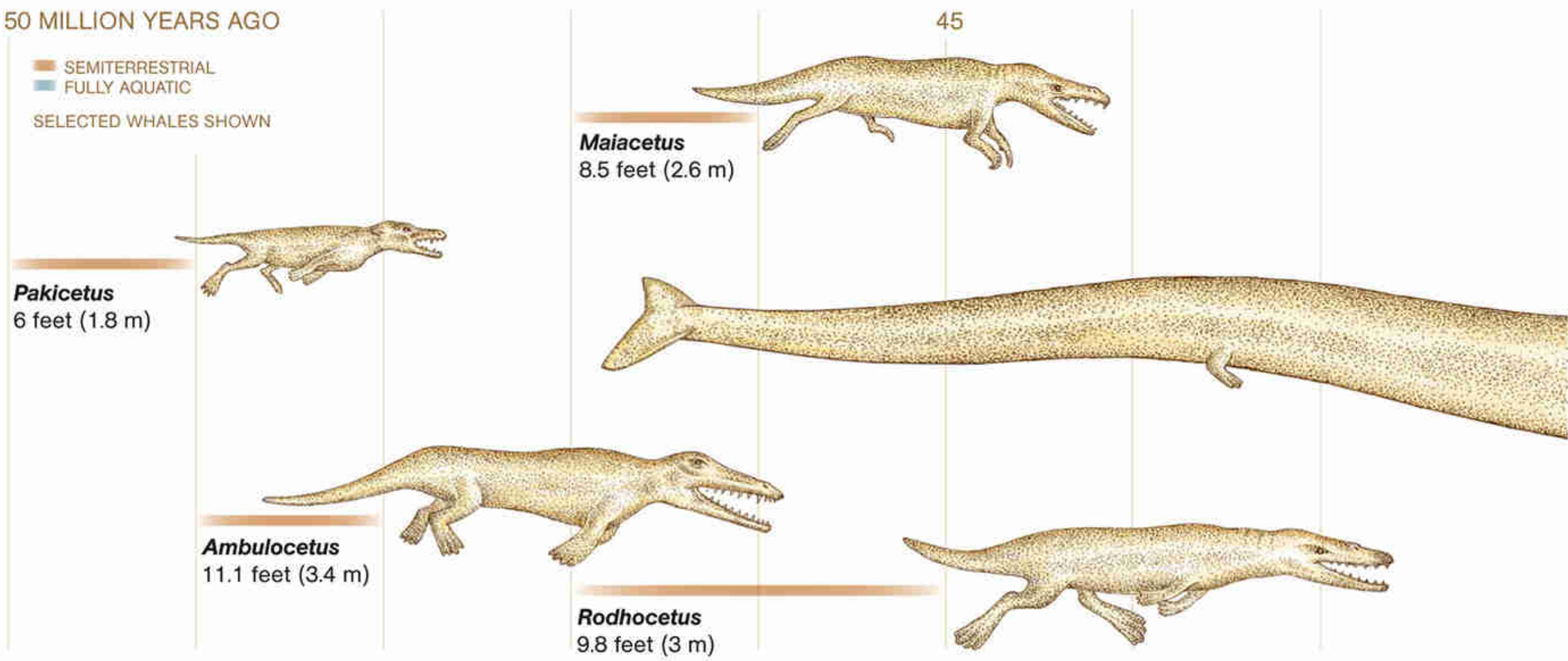
CT scans of *Basilosaurus* bones, including this long, slender jaw, will be used for a digital model showing how the whale moved, swam—and chewed.

whales, supremely adapted swimming machines, descended from land mammals that once walked on all fours. Gingerich has devoted much of his career to explaining this metamorphosis, arguably the most profound in the animal kingdom. In the process he has shown that whales, once celebrated by creationists as the best evidence against evolution, may be evolution's most elegant proof.

"Complete specimens like that *Basilosaurus* are Rosetta stones," Gingerich told me as we drove back to his field camp. "They tell us vastly more about how the animal lived than fragmentary remains."

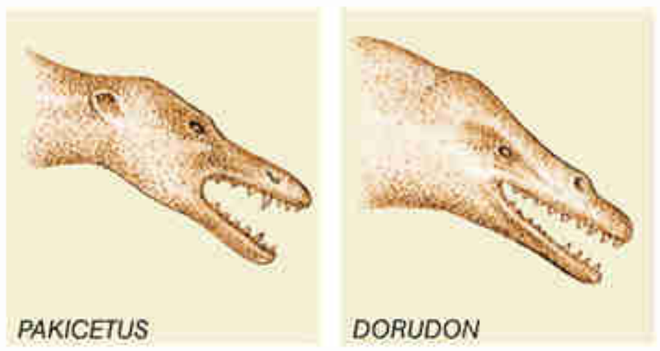
Wadi Hitan—literally "valley of whales"—has proved phenomenally rich in such Rosetta stones. Over the past 27 years Gingerich and his colleagues have located the remains of more than a thousand whales here, and countless more are left to be discovered. When we pulled into camp, we met several of Gingerich's team members just back from their own fieldwork. We were soon discussing their results over a dinner of roast goat meat, *foul mudamas* (fava bean puree), and flatbread. Mohammed Sameh, chief ranger of the Wadi Hitan protected area, had been prospecting for whales farther to the east and reported several new bone piles—fresh clues to one of natural history's great puzzles. Jordanian postdoc Iyad Zalmout and grad student Ryan Bebej had been excavating a whale rostrum poking out of a cliff face. "We think the rest of the body is inside," said Zalmout.

THE COMMON ANCESTOR of whales and of all other land animals was a flatheaded, salamander-shaped tetrapod that hauled itself out of the sea onto some muddy bank about 360 million years ago. Its descendants gradually improved the function of their primitive lungs, morphed their lobe fins into legs, and jury-rigged their jaw joints to hear in the air instead of water. Mammals turned out to be among the most successful of these land lovers; by 60 million years ago they dominated the Earth. Whales were among a tiny handful of mammals to make an



WHALES: FROM LAND TO SEA

Early whales plied the shallows but still hauled themselves onto shore, probably to rest and to give birth. The fossil record tracks anatomical changes (right) as whales adapted to conditions that favored a fully marine mammal. Modern whales appeared about 34 million years ago.



Nose, eyes, and ears
Nostrils move farther up the skull for easier breathing at the ocean surface. Eyes migrate toward the sides of the head; ears adapt to underwater hearing.

Feet to flippers
For foot-powered swimming, toes lengthen and grow webbing. As tail-powered swimming evolves, foot bones become encased in flippers.

evolutionary U-turn, retrofitting their terrestrial body plan to sense, eat, move, and mate underwater.

How whales accomplished such an enormous transformation has baffled even the greatest scientific intellects. Recognizing the conundrum as one of the great challenges to his theory of evolution by natural selection, Charles Darwin took a stab at accounting for whales in the first edition of *Origin of Species*. He noted that black bears had been seen swimming with their mouths open for hours at a time on the surface of a lake, feeding on floating insects. "I can see no difficulty in a race of bears being rendered, by natural selection, more and more aquatic in their structure and habits, with larger and larger mouths," Darwin concluded, "till a creature was produced as monstrous as a whale." His critics poked such loud and gleeful fun at this image, however, that he eventually omitted it from later editions of his book.

Nearly a century later George Gaylord Simpson, the preeminent paleontologist of the 20th century, was still at a loss to explain where whales fit in his otherwise orderly evolutionary tree of mammals. "The cetaceans are on the whole the most peculiar and aberrant of mammals," he remarked peevishly. "There is no proper place for them in a *scala naturae*. They may be imagined as extending into a different dimension from any of the surrounding orders or cohorts."

If science could not account for the transformation of whales, antievolutionists argued, perhaps it never happened. They contended that land animals that began to adapt to aquatic life would soon be neither fowl nor fish, incapable of surviving in either medium. And if whales really had made this huge transition, where were the fossils to prove it? "The anatomical differences between whales and terrestrial mammals are so great that innumerable in-between stages must have paddled and swam the ancient

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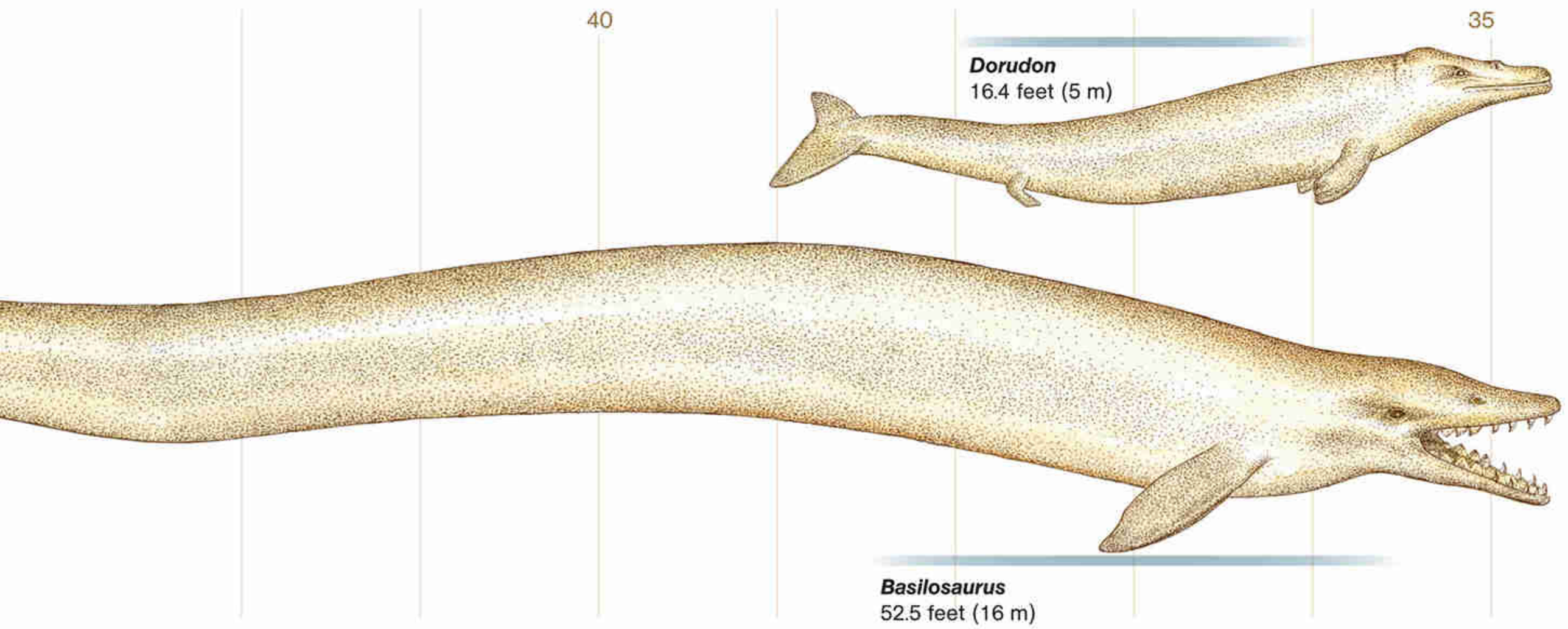
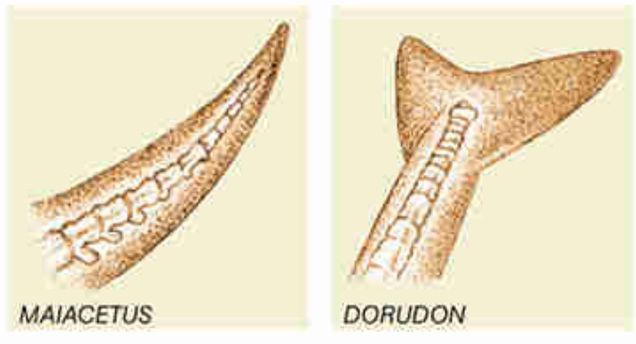
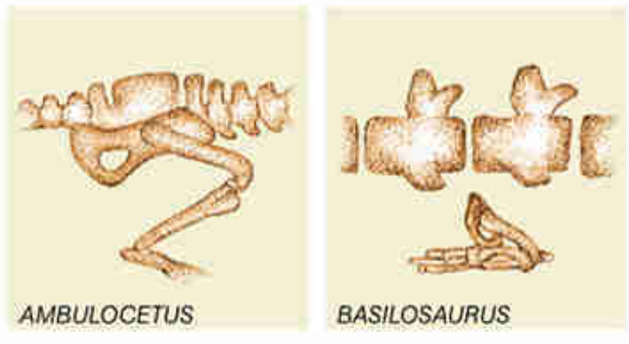
Tom Mueller wrote about mammoths in the May 2009 issue of National Geographic. *More of Richard Barnes's photos can be seen in his book* Animal Logic.





Tail transformation
Tail-powered swimming develops as tails flatten into flukes. Backbones adapt to support the more powerful muscles that tail propulsion requires.



Pelvis and spine
No longer needed to hold hind limbs that support a body, the pelvis becomes detached from the spine, enhancing the whale's range of motion.

MARIEL FURLONG AND AMANDA HOBBS, NGM STAFF
ART: JOHN BURGOYNE
SOURCE: PHILIP D. GINGERICH, UNIVERSITY OF MICHIGAN

seas before a whale as we know it appeared," wrote the authors of *Of Pandas and People*, a popular creationist textbook first published in 1989. "So far these transitional forms have not been found."

Philip Gingerich had unintentionally taken up this challenge in the mid-1970s. After earning his Ph.D. at Yale, he began excavating in Wyoming's Clarks Fork Basin, documenting the meteoric rise of mammals at the beginning of the Eocene, after the extinction of the dinosaurs ten million years earlier. In 1975, hoping to trace migrations of mammals from Asia to North America, he started fieldwork in middle Eocene formations in the Punjab and North-West Frontier (now called Khyber Pakhtunkhwa Province) Provinces of Pakistan. He was disappointed to discover that the 50-million-year-old sediments he had targeted were not dry land but marine beds on the eastern edge of the Tethys Ocean. When his team uncovered some pelvic bones in 1977, they jokingly attributed them to "walking whales"—a preposterous notion. At that time the best known fossil whales were thought to be similar to modern whales, with sophisticated mechanisms for underwater hearing, powerful tails with broad flukes, and no external hind limbs.

Then in 1979, a member of Gingerich's team in Pakistan found a skull about the size of a wolf's but with prominent—and very unwolflike—sails of bone at the top and sides of the skull to secure robust jaw and neck muscles. Stranger still, the braincase was little bigger than a walnut. Later the same month Gingerich came across some archaic whale specimens in museums in Lucknow and Kolkata (Calcutta), India. "That's when the tiny braincase started to make sense, because early whales have big skulls and relatively small brains," Gingerich remembers. "I began to think that this small-brained thing might be a very early whale."

WHEN GINGERICH freed the skull from its matrix of hard red stone back in his lab in Michigan, he found a grape-size nugget of dense bone at its

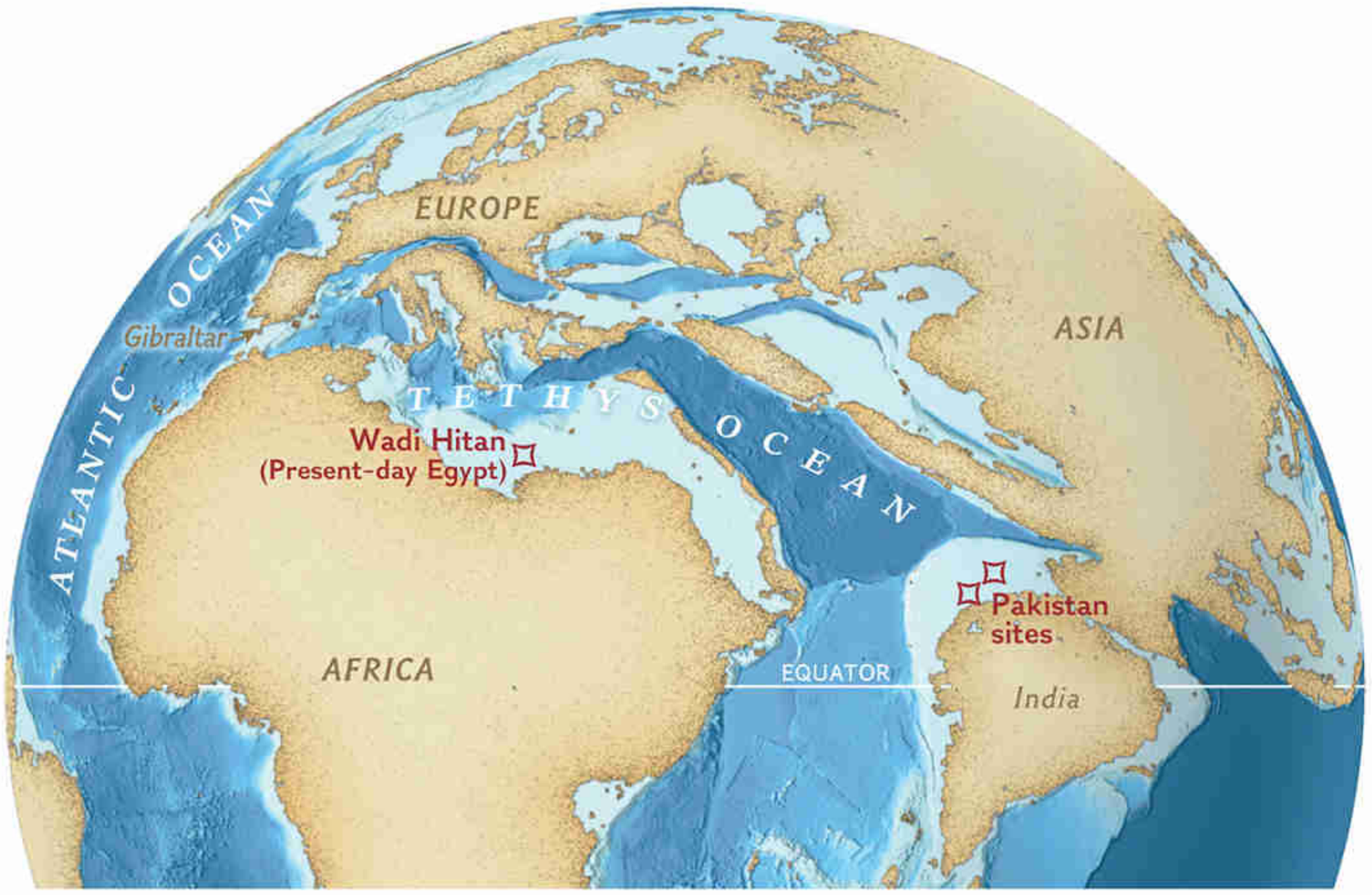
base called the auditory bulla, with an S-shaped bony crest on it known as the sigmoid process—two anatomical features that are characteristic of whales and help them hear underwater. Yet the skull lacked several other adaptations that living whales use to hear directionally beneath the waves. He concluded that the animal had probably been semiaquatic, spending significant time in shallow water but returning to land to rest and reproduce.

Discovering this most primitive known whale, which Gingerich named *Pakicetus,* made him see whales in a new light. "I started thinking more and more about the huge environmental transition that whales had made," he remembers. "This was a creature starting out as a terrestrial animal and literally turning into an extraterrestrial. Since then, I've been consumed by the search for the many transitional forms in this huge leap from land back into the sea. I want to find them all."

IN THE 1980S GINGERICH turned his attention to Wadi Hitan. Along with his wife, paleontologist B. Holly Smith, and their Michigan colleague William Sanders, he began looking for whales in formations some ten million years younger than the beds where he'd found *Pakicetus.* The trio excavated partial skeletons of fully aquatic whales like *Basilosaurus* and the smaller, 16-foot *Dorudon.* These had large, dense auditory bullae and other adaptations for underwater hearing; long, streamlined bodies with elongated spinal columns; and muscular tails to drive them through the water with powerful vertical strokes. The area was teeming with their skeletons. "After a short time in Wadi Hitan you think you're seeing whales everywhere," Smith says. "And after a little more time you realize you really are. We soon understood that we'd never be able to collect all the whales, so we started mapping them and excavating only the most promising specimens."

CRADLE OF WHALES

Fifty million years ago the Tethys Ocean stretched from modern Gibraltar to what is now India. Land-living whale ancestors entered shallow water on the western edge of modern Pakistan and flourished throughout the Tethys until a sharp cooling of the climate 34 million years ago.



JEROME N. COOKSON, NGM STAFF. SOURCE: C. R. SCOTESE, PALEOMAP PROJECT

"Fossil whales are one of God's miracles," says Mohammed Sameh (at left), Wadi Hitan's head ranger, reassembling a *Dorudon* skeleton with University of Michigan postdoc Iyad Zalmout. The site's rare prehistoric whales helped earn it UNESCO World Heritage status.

It wasn't until 1989, however, that the team found the link they were seeking to the whales' terrestrial ancestors, almost by accident. Near the end of the expedition Gingerich was working on a *Basilosaurus* skeleton when he uncovered the first known whale knee, on a leg positioned much farther down the animal's spinal column than he had expected. Now that the researchers knew where to look for legs, they revisited a number of previously mapped whales and rapidly uncovered a femur, a tibia and fibula, and a lump of bone that formed a whale's foot and ankle. On the last day of the expedition Smith found a complete set of slender, inch-long toes. Seeing those tiny bones brought her to tears. "Knowing that such massive, fully aquatic animals still had functional legs, feet, and toes, realizing what this meant for the evolution of whales—it was overwhelming," she remembers.

Though unable to support a *Basilosaurus*'s weight on land, these legs weren't completely vestigial. They had attachments for powerful muscles, as well as functional ankle joints and complex locking mechanisms in the knee. Gingerich speculates that they served as stimulators or guides during copulation. "It must have been hard to control what was going on down there on that long, snakelike body, so far from the brain," he says.

Whatever *Basilosaurus* actually did with its little legs, finding them confirmed that the ancestors of whales had once walked, trotted, and galloped on land. But the identity of these ancestors remained unclear. Certain skeletal features of archaic whales, particularly their large, triangular cheek teeth, strongly resembled those of mesonychids, a group of hoofed Eocene carnivores. (The massive, hyena-like *Andrewsarchus,* probably the largest carnivorous mammal that has ever lived on land, may have been a mesonychid.) In the 1950s immunologists had discovered characteristics in whale blood that suggested a descent from artiodactyls, the mammalian order that includes pigs, deer, camels, and other even-toed ungulates. By the 1990s

"Molding, casting, and assembling a 50-foot whale is a puzzler's dream—or nightmare," says head restorer William Sanders of the University of Michigan Museum of Paleontology. His team spent a year making casts of a *Basilosaurus*'s fossil bones, shown here with ribs in the foreground, vertebrae behind. The white casts will be painted to match the rust-hued originals. The complete whale will look like the skeleton on pages 134-5.

Sand-laden winds sculpt Wadi Hitan's stone outcroppings into exotic shapes that Egyptians call mud lions and sitting sphinxes. Ornate struts of bone on *Basilosaurus* vertebrae (right) secured huge muscles used to lift and lower the whale's tail and back as it swam.

molecular biologists studying the cetacean genetic code concluded that the whale's closest living relative was one specific ungulate, the hippopotamus.

Gingerich and many other paleontologists trusted the hard evidence of the bones more than the molecular comparisons of living animals. They believed whales had descended from mesonychids. But to test this theory, Gingerich needed to find one bone in particular. The astragalus, or anklebone, is the most distinctive element of the artiodactyl skeleton, because it has an unusual double-pulley shape, with clearly defined grooves at the top and bottom of the bone like the grooves on a pulley wheel that holds a rope. The shape gives artiodactyls greater spring and flexibility than the single-pulley form found in other quadrupeds. (Living whales were of no help, of course, because they have no anklebones at all.)

Back in Pakistan in 2000, Gingerich finally saw his first whale ankle. His graduate student Iyad Zalmout found a grooved piece of bone among the remains of a new 47-million-year-old whale, later named *Artiocetus*. Minutes later Pakistani geologist Munir ul-Haq found a similar bone at the same site. At first Gingerich thought the two bones were the single-pulley astragali from the animal's left and right legs—proof that he'd been right about the origin of whales. But when he held them side by side, he was troubled to see that they were slightly asymmetrical. As he pondered this, manipulating the two bones as a puzzler maneuvers two troublesome puzzle pieces, they suddenly snapped together to form a perfect double-pulley astragalus. The lab scientists had been right after all.

Walking back to camp that evening, Gingerich and his team passed a group of village children playing dice with the astragali of a goat. (People in various cultures have used the anklebones of domestic artiodactyls in games and fortune-telling for millennia.) Zalmout borrowed one and gave it to Gingerich, then watched in amusement as his professor spent

the rest of the evening alternately staring at the whale ankle in one hand and the goat ankle in the other, noting the unmistakable similarities. "That was a major find, but it upset my apple-cart," Gingerich says with a wry smile. "Still, now we knew for sure where whales came from and that the hippopotamus theory wasn't complete science fiction."

SINCE THEN GINGERICH and a handful of other paleontologists have filled in the story of early whales, tooth by tooth, toe by toe. Gingerich believes the first cetaceans probably resembled anthracotheres, svelte hippo-like browsers that inhabited swampy lowlands in Eocene times. (An alternative theory, advanced by paleontologist Hans Thewissen, is that whales descended from an animal similar to *Indohyus,* a prehistoric deerlike artiodactyl the size of a raccoon that was partly aquatic.) Whatever their shape and size, the earliest whales appeared about 55 million years ago, like all other modern mammalian orders, during the spike in global temperatures at the beginning of the Eocene. They lived along the eastern shores of the Tethys, where the waters exerted a strong evolutionary pull: warm, salty, rich in marine life, and free of aquatic dinosaurs, which had gone extinct ten million years earlier. Chasing new kinds of food sources deeper into the water, these early waders gradually developed longer snouts and sharper teeth better suited for snapping up fish. By about 50 million years ago, they'd reached the stage exemplified by *Pakicetus:* proficient four-legged swimmers that still moved about on land.

By adapting to water, early whales gained access to an environment closed to most other mammals, rich in food and shelter, and short on competitors and predators—perfect conditions for an evolutionary explosion. What followed was a starburst of idiosyncratic experiments in being a whale, most of which ended in extinction long before modern times. There was the hulking, 1,600-pound *Ambulocetus,* an ambush hunter with squat legs and

Found in Wadi Hitan with its nose protruding from one side of a hill and its tail from the other, this 37-million-year-old *Basilosaurus* was perfectly preserved by the rock that entombed it. This year it will return to Egypt to become the centerpiece of a new museum on whale evolution.

Shiny as a mudflat, dry as the Sahara, nummulite basins (above) are named for the coin-shaped fossils that litter their soil (right). Nummulites and other tiny desert relics provide vital clues to how early whales lived and died.

huge snapping jaws, like a hairy saltwater croc; *Dalanistes,* with a long neck and head like a heron; and *Makaracetus,* with a short, curved, muscular proboscis that it may have used for eating mollusks.

Around 45 million years ago, as the advantages of a water environment drew whales farther out to sea, their necks compressed and stiffened to push more efficiently through the water, behind faces lengthening and sharpening like a ship's prow. Hind legs thickened into pistons; toes stretched and grew webbing, so they resembled enormous ducks' feet tipped with tiny hooves inherited from their ungulate ancestors. Swimming methods improved: Some whales developed thick, powerful tails, bulleting ahead with vigorous up-and-down undulations of their lower bodies. Selection pressure for this efficient style of locomotion favored longer and more flexible spinal columns. Nostrils slid back up the snout toward the crown of the head, becoming blowholes. Over time, as the animals dived deeper, their eyes began to migrate from the top toward the sides of the head, the better to see laterally in the water. And whale ears grew ever more sensitive to underwater sound, aided by pads of fat that ran in channels the length of their jaws, gathering vibrations like underwater antennae and funneling them to the middle ear.

Though finely tuned to water, these 45-million-year-old whales still had to hitch themselves ashore on webbed fingers and toes, in search of fresh water to drink, a mate, or a safe place to bear their young. But within a few million years whales had passed the point of no return: *Basilosaurus, Dorudon,* and their relatives never set foot on land, swimming confidently on the high seas and even crossing the Atlantic to reach the shores of what is now Peru and the southern United States. Their bodies adjusted to their exclusively aquatic lifestyle, forelimbs shortening and stiffening to serve as flippers for planing, tails broadening at the tip in horizontal flukes to create a hydrofoil. The pelvis decoupled from the spine, allowing the tail a broader range of vertical motion. Yet like talismans from

a long-forgotten life ashore, their hind legs remained, complete with tiny knees, feet, ankles, and toes, useless now for walking but good perhaps for sex.

The final transition from basilosaurids to modern whales began 34 million years ago, during the sudden phase of cooling climate that ended the Eocene epoch. A drop in water temperatures near the Poles, shifts in ocean currents, and an upwelling of nutrient-rich seawater along the western shores of Africa and Europe drew whales into entirely new environmental niches and drove the remaining adaptations—big brains, echolocation, insulating blubber, and in some species, baleen in place of teeth for straining krill—present in cetaceans today.

Thanks in large part to Philip Gingerich, the fossil record of whales now offers one of the most stunning demonstrations of Darwinian evolution rather than a refutation of it. Ironically, Gingerich himself grew up in a strictly principled Christian environment, in a family of Amish Mennonites in eastern Iowa. (His grandfather was a farmer and lay preacher.) Yet at the time, he felt no clash between faith and science. "My grandfather had an open mind about the age of the Earth," he says, "and never mentioned evolution. Remember, these were people of great humility, who only expressed an opinion on something when they knew a lot about it."

Gingerich is still baffled by the conflict that many people feel between religion and science. On my last night in Wadi Hitan, we walked a little distance from camp under a dome of brilliant stars. "I guess I've never been particularly devout," he said. "But I consider my work to be very spiritual. Just imagining those whales swimming around here, how they lived and died, how the world has changed—all this puts you in touch with something much bigger than yourself, your community, or your everyday existence." He spread his arms, taking in the dark horizon and the desert with its sandstone wind sculptures and its countless silent whales. "There's room here for all the religion you could possibly want." □

Park guard Siba Sakia watches as Steve Winter sets up a camera trap.

ON ASSIGNMENT **Kaziranga Recap** Taking pictures of Indian wildlife can be dangerous work. "It's an intense challenge," recalls photographer Steve Winter (above, at left). During the 14 weeks he spent in Assam, India, in Kaziranga National Park, he was never without armed guards, who would occasionally fire shots to chase away (not injure) charging rhinos. He captured this story's lead photo with a camera trap; other shots—like the one on page 102—were closer encounters. Still, Winter didn't get hurt, a fate he credits largely to the guards. *"Jeng-jeng* means 'trouble' in Assamese," he explains. "I learned that phrase pretty quickly."

NG FILMS **The Wildest Dream** Why climb Everest? "Because it's there," is what English mountaineer George Mallory said before setting out in 1924 to be the first to reach its summit.

Mallory disappeared somewhere near the top, and his body was lost for years—until 1999, when Conrad Anker discovered it. What befell Mallory? Anker embarks on his own treacherous climb to find out in *The Wildest Dream,* a new film by National Geographic Entertainment featuring recently found Mallory footage. For theater listings, go to *nationalgeographic.com/movies.*

Society Updates

NAT GEO CHANNEL
On August 22 at 9 p.m. tune in to the National Geographic Channel's *Dawn of the Oceans,* a two-hour journey that explores the history and future of our mighty seas.

NG BOOKS
Set in Renaissance Italy, *The Professor of Secrets* tells the little-known story of a brilliant, unconventional doctor named Leonardo Fioravanti. Find it in bookstores now ($26).

GeoPuzzle Answers

R	E	H	C	■	Y	S	A	E	■	R	E	E	N	S
E	C	A	L	■	R	A	E	P	■	E	C	N	E	P
T	U	R	T	S	A	C	R	O	■	T	R	A	P	O
A	R	A	■	E	G	N	A	R	■	S	O	Z	O	B
E	T	S	A	T	N	I	■	■	N	I	F	■	■	■
■	■	■	I	N	U	■	F	L	O	W	■	T	N	A
■	S	E	L	A	H	W	F	O	S	T	N	I	R	P
N	O	R	I	■	■	O	O	W	■	■	A	D	O	S
N	A	E	C	A	T	E	C	A	T	O	G	E	H	■
I	K	S	■	T	U	S	M	■	U	S	O	■	■	■
■	■	■	B	A	C	■	■	N	O	T	L	E	K	S
D	E	E	R	T	■	D	E	I	S	A	■	K	C	I
E	S	R	U	N	■	I	T	A	G	R	E	T	A	W
L	A	I	X	A	■	R	A	M	O	■	Y	A	L	I
S	L	L	E	C	■	E	M	A	L	■	E	L	A	K

PHOTOS: SHARON GUYNUP (TOP); JIMMY CHIN

NATIONAL GEOGRAPHIC

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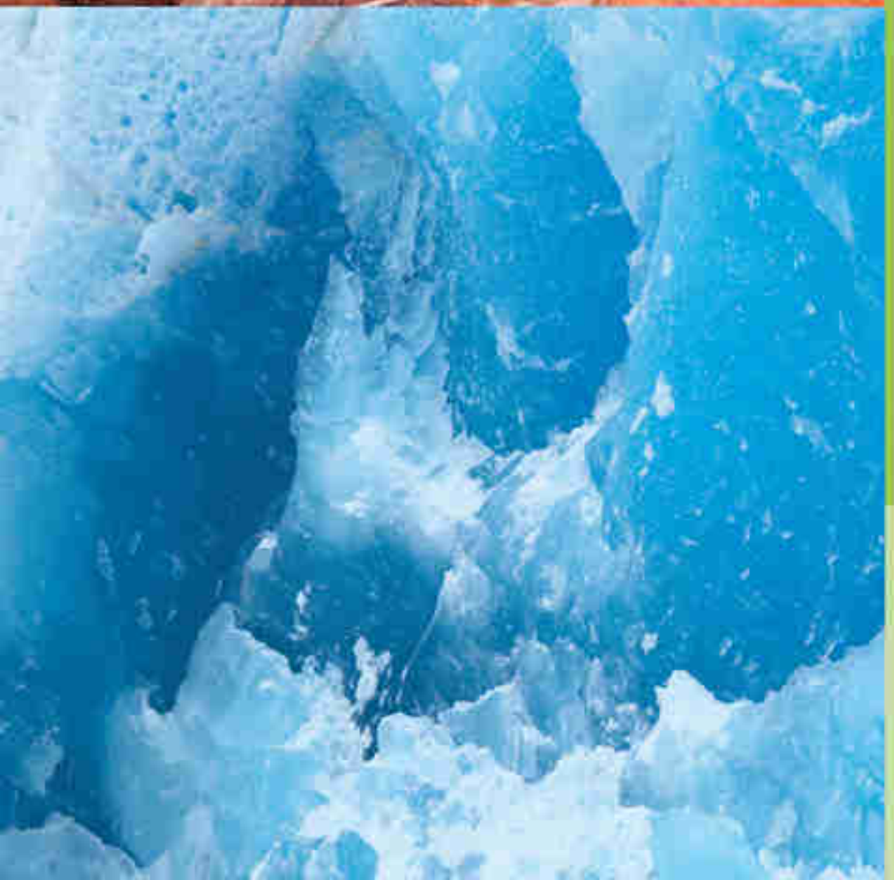

CHEVROLET Duke Energy® Shell

FLASHBACK

Deep Cover Peering through a 55-pound brass helmet, marine biologist Roy Waldo Miner "prepares to make movie actors of the rainbow-hued residents of a coral reef" off Andros Island, Bahamas. Miner's expedition, which he wrote about in the June 1934 issue of *National Geographic,* also harvested some 40 tons of coral from the site. Specimens were hoisted from the sea bottom, bleached and dried, then shipped to New York City's American Museum of Natural History, where they were coated with beeswax and painted to resemble a colorful living reef. That coral is still on display, part of a two-story-tall diorama in that museum. *—Margaret G. Zackowitz*

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

PHOTO: ROY WALDO MINER, NATIONAL GEOGRAPHIC STOCK

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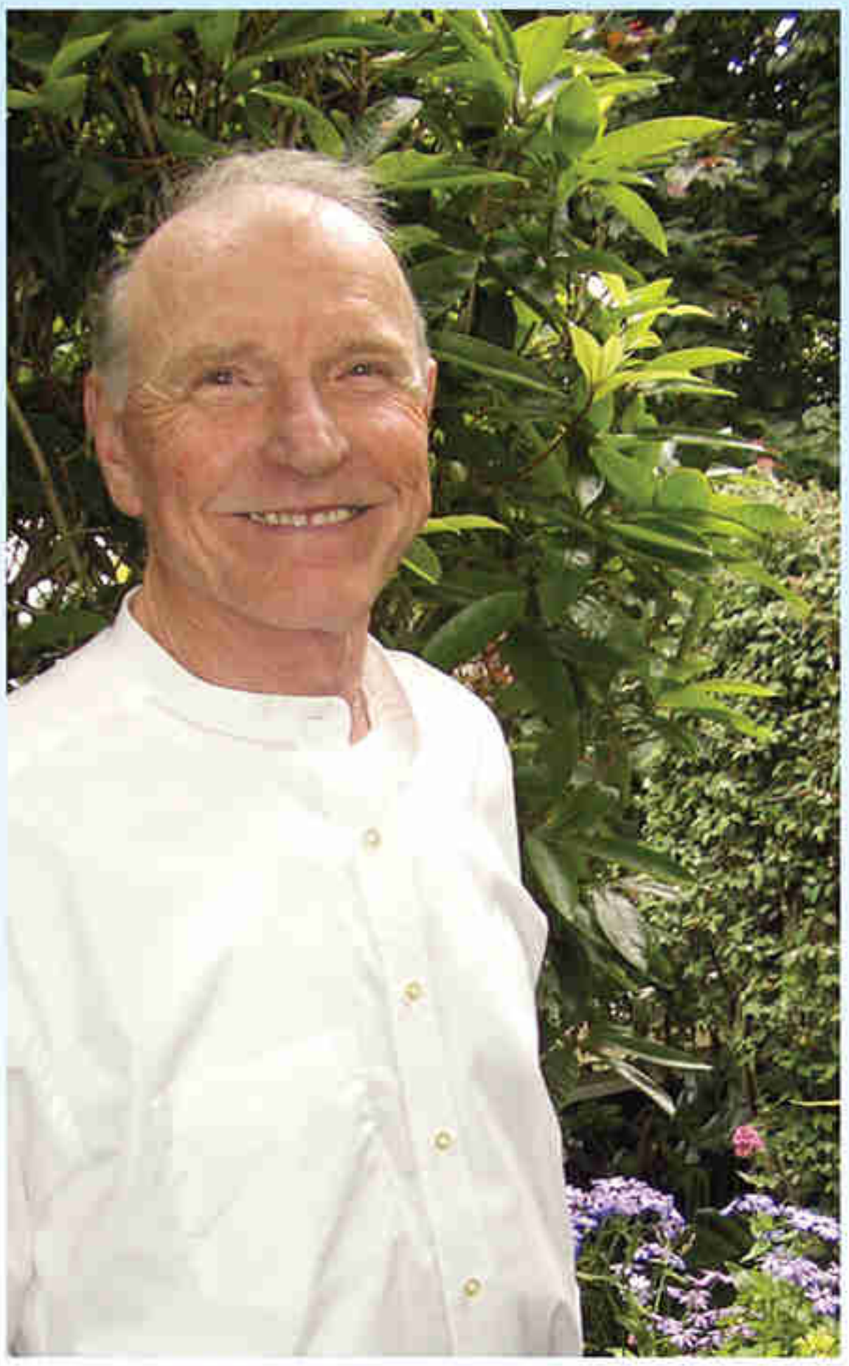

John-Joseph van Haelewyn

John McCallister included National Geographic in his estate plans.

Inspire Future Generations

An avid traveler and horticulturist, John McCallister was introduced to National Geographic when his aunt sent him a gift subscription to the magazine in the 1940s. "I like everything about National Geographic, what it stands for, and what it accomplishes," John says.

Now retired, John spends his time taking continuing education classes, landscaping his garden, and frequenting art museums, theatre performances, and concerts. John made a bequest gift as a way to support the things he holds dear. "I included National Geographic in my will because I want the Society to be around for future generations," he says.

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GEOPUZZLE

Sea Legs

Puzzle by Cathy Allis

About 55 million years ago whales had functional legs. As they spent less time on land and more at sea, the limbs morphed into flippers. The story on page 118 probes these ancient whales (left, a cast of one's skull) and could prove helpful for the tinted clues below.

ACROSS

1 Cabbage-family member
5 Weak, as excuses go
9 Brig digs
14 "Now __ me down to sleep"
15 Gen. Bradley, George S. Patton colleague
16 Along the line of rotation
17 Stride of an *Ambulocetus*?
19 Margaret Sanger was one
20 "That's gross!"
21 Parenthetical remark
22 Like a kitty cornered, maybe
23 Kadiddlehopper portrayer Red
25 Designated driver alternative
26 Columbus sch.
27 Dirty reading
29 Avail oneself of Vail
32 What happened when a policeman caught a beluga jaywalking?
36 Float ingredient
37 Court
38 Its use is decreasing?
39 What hiking humpbacks might leave behind?
44 Tiny toiler
45 "Three Little Pigs" baddie
46 Prefix with lateral
47 What a tetrapod's leg evolved from
48 Aesthetically appropriate
52 Buffoons
55 Cascades and such
57 Parseghian of Notre Dame fame
58 Dizzying gallery pieces
59 Shamu's showing-off step?
61 Cheshire change
62 Bottom-heavy fruit
63 Holey material
64 Express scorn
65 A piece of cake
66 *Moonstruck* star

DOWN

1 Nickname for New Zealanders
2 Shakespearean "Shucks!"
3 Potato pancake
4 Kind of candy or tooth
5 Closes a computer system
6 At full throttle
7 Hotel staffer
8 One-named *Harper's Bazaar* illustrator
9 Many a Bach work
10 Bedroom community
11 Pisa dough of yore
12 Use beams surgically
13 Malamute's tow
18 Dustin, in *Midnight Cowboy*
24 New England hub
25 Piece of the pie
27 Express scorn
28 Siamese "please"
29 Dried and withered
30 The enemy organization in *Get Smart*
31 Wayside stopover
32 __ in (intrude)
33 Menu-bar word
34 Truant GI
35 Lashes
36 Curative locale
40 Tornado
41 Ishmael, to Abraham
42 Rubik's Cube birthplace
43 Starting stakes
47 Coerce
48 Pizarro's victims
49 Fergie, formally
50 Cease-fire
51 One digging in
52 Conks
53 Candid
54 Westerns writer Grey
55 Dogie catcher
56 Neighborhood
60 Patient's pampering, briefly

Answers in Inside Geographic

PHOTO: RICHARD BARNES

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†Comparison to Extra Strength Tylenol based on minimum label dosing for 24 hours.

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