The Atlas of Global Conservation

CHANGES, CHALLENGES, AND OPPORTUNITIES TO MAKE A DIFFERENCE

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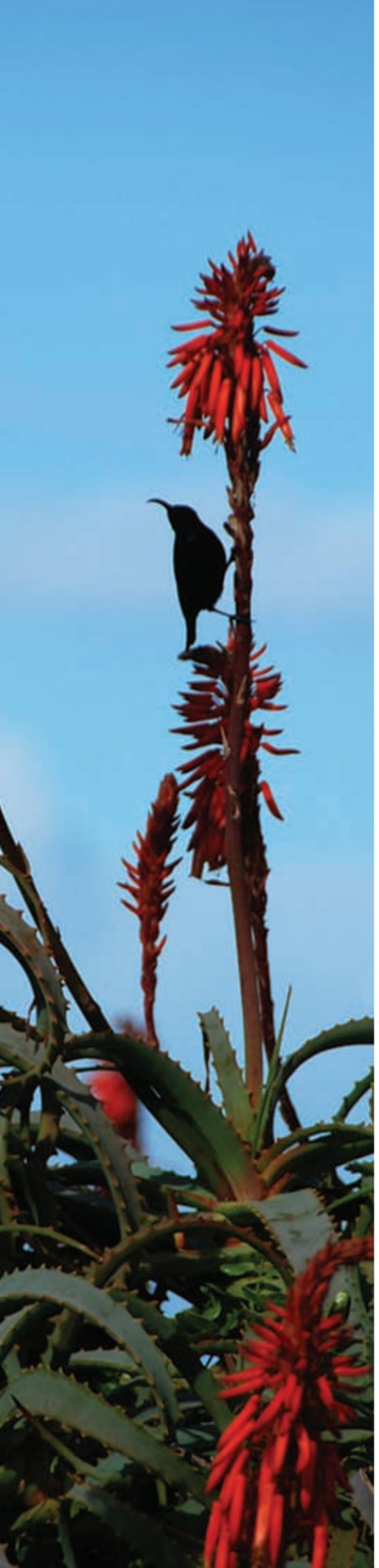

Jennifer Molnar

To future generations, and the planet they will inherit,
and in recognition of the generous support and vision of
Bill Barclay and Ofelia Miramontes

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Contents

2

Kent Mason

Habitats

FOR CHEETAHS, it is African savannas like the Serengeti. For heelsplitter mussels, it is the muddy side channels of the Mississippi River. For the bizarre parasite *Symbion pandora*, it is the lips of Norwegian lobsters.

Habitats are homes where species find their niches. They can be placid lakes, snowy mountaintops, arid deserts, or deep ocean trenches—anywhere on Earth where species can find food, shelter, and opportunities to reproduce.

As a global species, humans depend on many different habitats far beyond the towns and cities where most of us spend our lives. We rely on the oceans for fish, grasslands for farmland and pastures, and lakes and rivers for water. Forests provide wood and other natural resources, and they also help moderate changes in climate. Even if we rarely visit these habitats in person, we cannot live without them.

Some habitats, like coral reefs and grasslands, are named after the dominant species found there, but all habitats—and the vast variety of lives that they sustain—are ultimately shaped by the physical environment.

On land, climate gradients create different habitats from warm, wet tropical forests with their mind-boggling diversity of trees, orchids, birds, and insects to cold, dry tundra where only the hardiest heath plants, grouse, and caribou wait out the frigid and dark winters to revel in the midnight sun of arctic summer. In between these extremes, different combinations of temperature and precipitation sustain grasslands, evergreen and deciduous forests, and deserts.

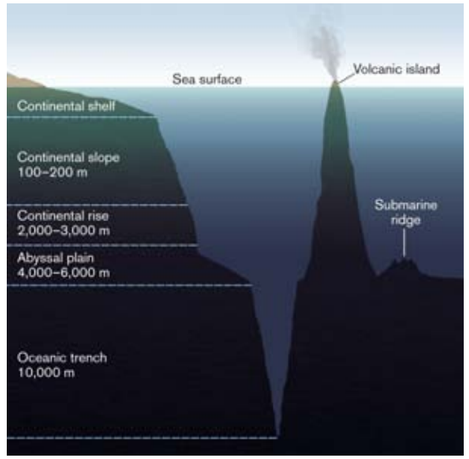
Lake and river habitats are molded by topography, geology, and climate, and they in turn can shape their environment. Steep mountains are pocked with cold, glacial lakes and cut by fast, cascading streams that provide homes for aquatic insects and trout. In lowlands, wide plains let rivers meander and fill shallow lakes and wetlands that provide habitat for larger fish and other species adapted to slower waters.

In the sea, habitats are shaped by currents and temperature, and change with water depth. Along the coasts, bays and estuaries are carved by waves, rivers, tides, and currents. Coral reefs and kelp forests grow in sunlit shallow waters. As the water deepens and darkens offshore, scallops and cod make their homes across the continental shelf, while myriad strange life-forms live in the ocean's depths.

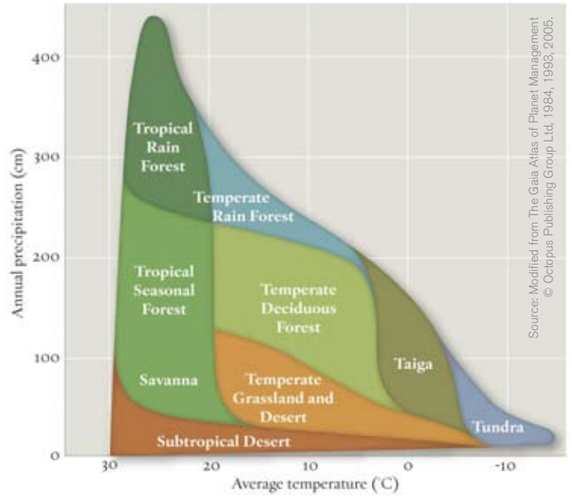
In an ever-changing world, the distribution of habitats can change with the climate and currents. But the pace of human-driven changes in land use, water management, and ocean exploitation is so great that there is a mounting risk that habitats and the species that depend on them may not be able to adjust quickly enough.

This section of the atlas explores the global variety and current distribution of major kinds of habitat. Each page highlights the uniqueness of these habitats, the benefits they provide, the dangers faced from human development, and some ways that people can act to protect them.

Shaped by, and shaping, topography. Lake and river habitats are molded by topography, geology, and climate. Mountains are pocked with cold, glacial lakes and cut by fast, cascading streams. Lowland plains let rivers meander and fill shallow lakes and wetlands.



Varied with ocean depth. Marine habitats change with water depth, temperature, and currents. Coral reefs grow in sunlit shallow waters, while deeper, darker waters are home to varied species, from tuna plying remote oceans to luminescent fish living at extreme depths.



Defined by climate. Habitats on land are shaped by the combination of temperature and precipitation that they experience. Warm, wet conditions support tropical rain forests, while cold, dry conditions support tundra.

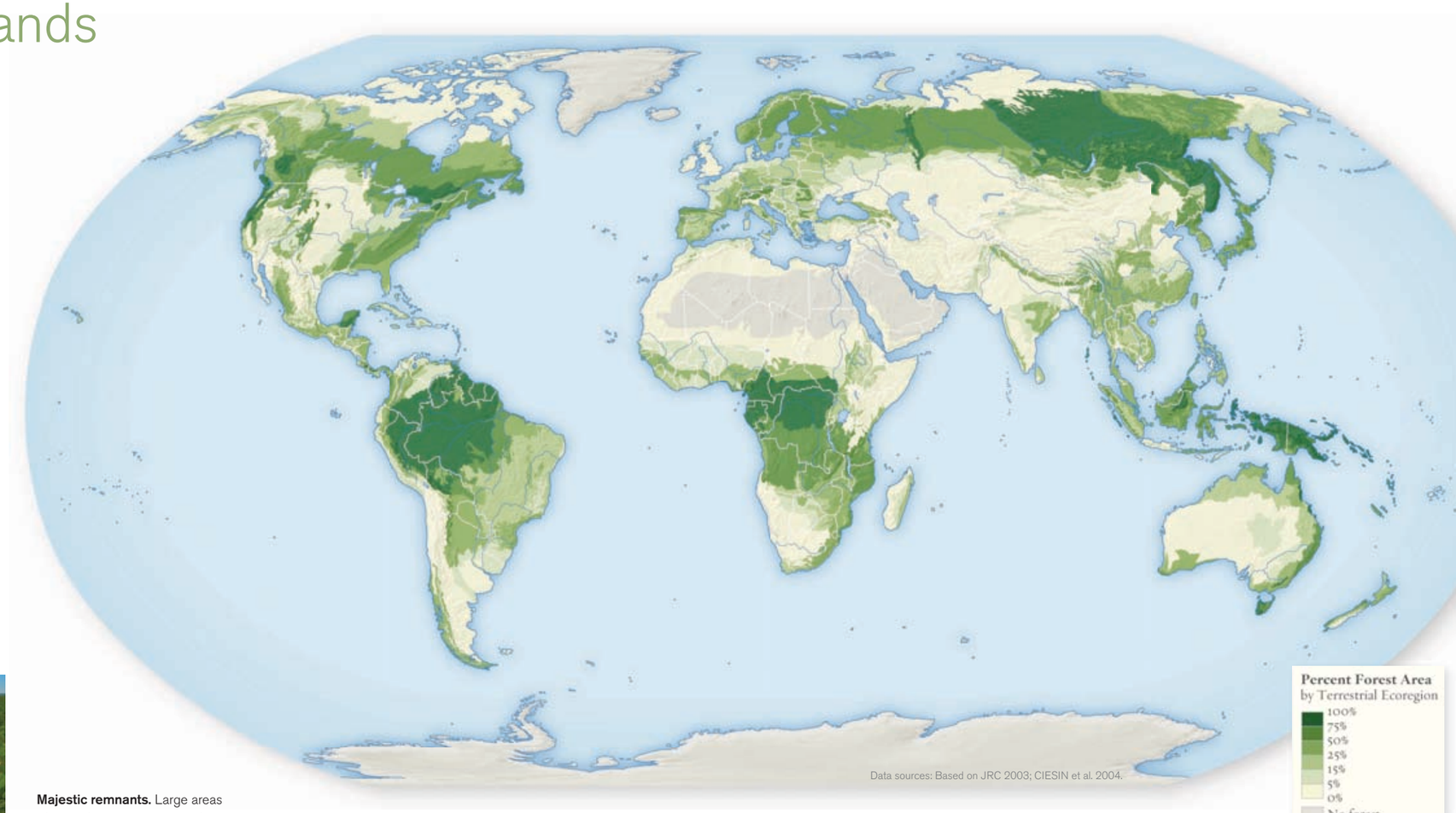
Forests and Woodlands

Giving Trees

Sergio Pucci/TNC

Scott Warren

Natural complexities. Wild forests (above) have complex structures, providing valuable habitat unmatched by plantations of trees (left) grown and harvested as a crop.



FORESTS. Forests cover one-third of Earth's land surface, with the largest remaining intact forests in the boreal regions of Asia, Europe, and North America, and the tropical Amazon and Congo basins.

Stephen Alvarez

Majestic remnants. Large areas of intact forests now cover 10 percent of Earth's land surface, but they once spread over almost half of it.

FROM THE AMAZON JUNGLES to California's oak groves, forests and woodlands are always much more than collections of trees. Rather, they are communities of interdependent plants, animals, fungi, and bacteria, which, together, support human survival as well. Woodlands differ from forests only in that they have more space between the trees, allowing a more open canopy.

Forests and woodlands produce much of the oxygen that people breathe and help stabilize the climate by absorbing carbon dioxide, a leading greenhouse gas. They also help filter rain and melting snow entering streams, and offer shade that keeps the water cool for fish and frogs. Natural forests additionally provide millions of sustainable jobs, especially in the developing world where many rural people still live off the land, whether by tapping latex from wild rubber trees; gathering medicines, food, spices, and fuelwood; or, increasingly, working as stewards or guides in protected wild places.

Forests—especially tropical forests—are some of the most diverse habitats on Earth. Nearly 1,500 species of amphibians, birds, mammals, and reptiles have been found in the southwestern Amazon rain forest—about five times the number of those species documented in forests in the eastern United States. Elsewhere, forests harbor remnants of ancient history. China's temperate broadleaf forests include plants closely related to those in the southeastern United States, echoing a time before the continents drifted apart. The evergreen "monkey puzzle" forests of South America evolved in Gondwana—the supercontinent that contained most of Earth's land mass millions of years ago. Many types of trees can live for centuries, creating old-growth forest habitats essential for the survival of many animal and plant species that have adapted there over time, such as the great apes of Indonesia and marbled murrelets, seabirds that nest only in ancient forests along the northwest coast of North America.

About 42 percent of Earth's original forests have been lost worldwide since the early 1700s—converted to human settlements and agriculture as well as timber plantations, which resemble forests yet do not provide the same range of benefits or support as many species. The modern rate of loss is accelerating, as is the degradation of what remains, due to mining, logging, road building, and clearing for cropland.

As people become more aware of the contributions of intact forests—gifts becoming ever more conspicuous in their absence—increasing efforts are being made to preserve what is left. With growing appreciation of forests' contributions to climate stability, for instance, more forests are being managed to store carbon. One of these is the Noel Kempff Mercado National Park in Bolivia, an area twice the size of New York's Long Island, which is being managed with the goal of preventing the release of 5.8 million tons of carbon to the atmosphere while conserving habitat and preserving traditional forest jobs.

Grasslands

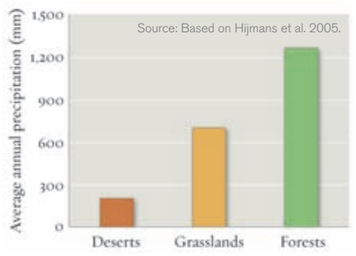
Where the Buffalo Roamed

Anup Shah/npl/Minden Pictures

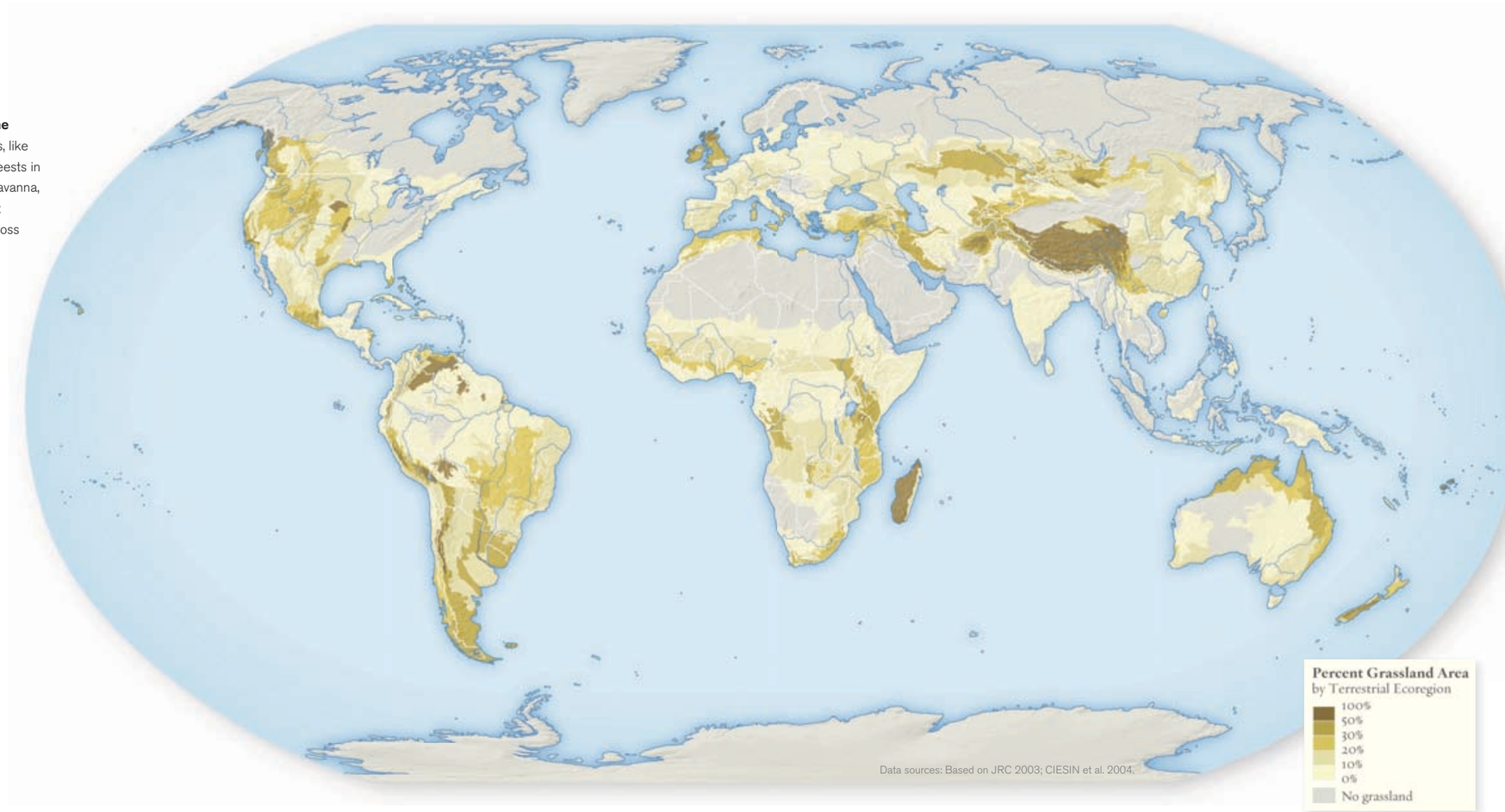
Drama on the plains. Herds, like these wildebeests in the African savanna, migrate great distances across grasslands.

Harold E. Malde

Life-sustaining fire. Fire is a recurring event in most grasslands, maintaining habitats that many grassland plants and animals depend on.



Not too wet or too dry. Grasslands occur where it is too dry to support forests yet too wet for deserts.



GRASSLANDS. Many grasslands have been plowed under or converted to pasture for livestock, yet vast intact grasslands still remain in eastern Africa, central Asia, and northern South America.

GRASSLANDS THROUGHOUT HISTORY have been open-air theaters of violent drama, as migrating, meat-eating predators have stalked their migrating, grass-eating prey. On the hot, rolling African savannas—grasslands dotted by acacia trees—lions and hyenas today still chase herds of wildebeest, zebras, and antelopes. Such scenes of pursuit and flight were once also common on the prairies of North America, where wolves and grizzlies chased bison and elk over land now covered with farms, cities, and towns.

Grasslands occur in climates too dry to sustain forests but too wet for deserts. They are found on every continent except Antarctica. In the heart of South America, savannas occupy an area about one-fourth the size of Canada, offering homes for the large capybara rodent and marsh deer. On the remote high plains of the Tibetan Plateau, grasslands cover an area almost as large as the U.S. state of Montana.

Many different animals have evolved to make the most of life in these wide open spaces. Creatures native to grasslands tend to have long legs or large wings, which help them travel great distances. Grasslands similarly have played a role in human evolution: transitioning from a four-footed life in the jungles, humans learned to walk and run and scan the horizon for prey.

The grassland drama of carnivore and herbivore is mirrored in the struggles between herbivore and plant. Grassland flora is specialized for survival, whether with long roots that can reach a deep water table, thick bark to resist the frequent fires, or thorns to ward off hungry animals.

Yet despite their adaptive arsenal, grasslands and the life they support are succumbing rapidly to human development. The features that make them most hospitable to life—their flatness and fertility—put them most at risk. Ideally suited for ranching and agriculture, in many regions they have been overgrazed and overfarmed. A more indirect danger is that increased human settlements have led to suppression of the fires on which some grasses rely to release seeds from their tough husks. By the early twenty-first century, up to one-half of the world's original grasslands had vanished, with most remnants sliced up by roads.

The ancient dramas of grassland life might seem to be in their final season, were it not for new conservation efforts by scientists, activists, and governments. Over the past fifteen years, conservationists have shown that managing grazing and fires can help restore native communities of grassland plants and even support the reintroduction of large mammals, such as the American bison.

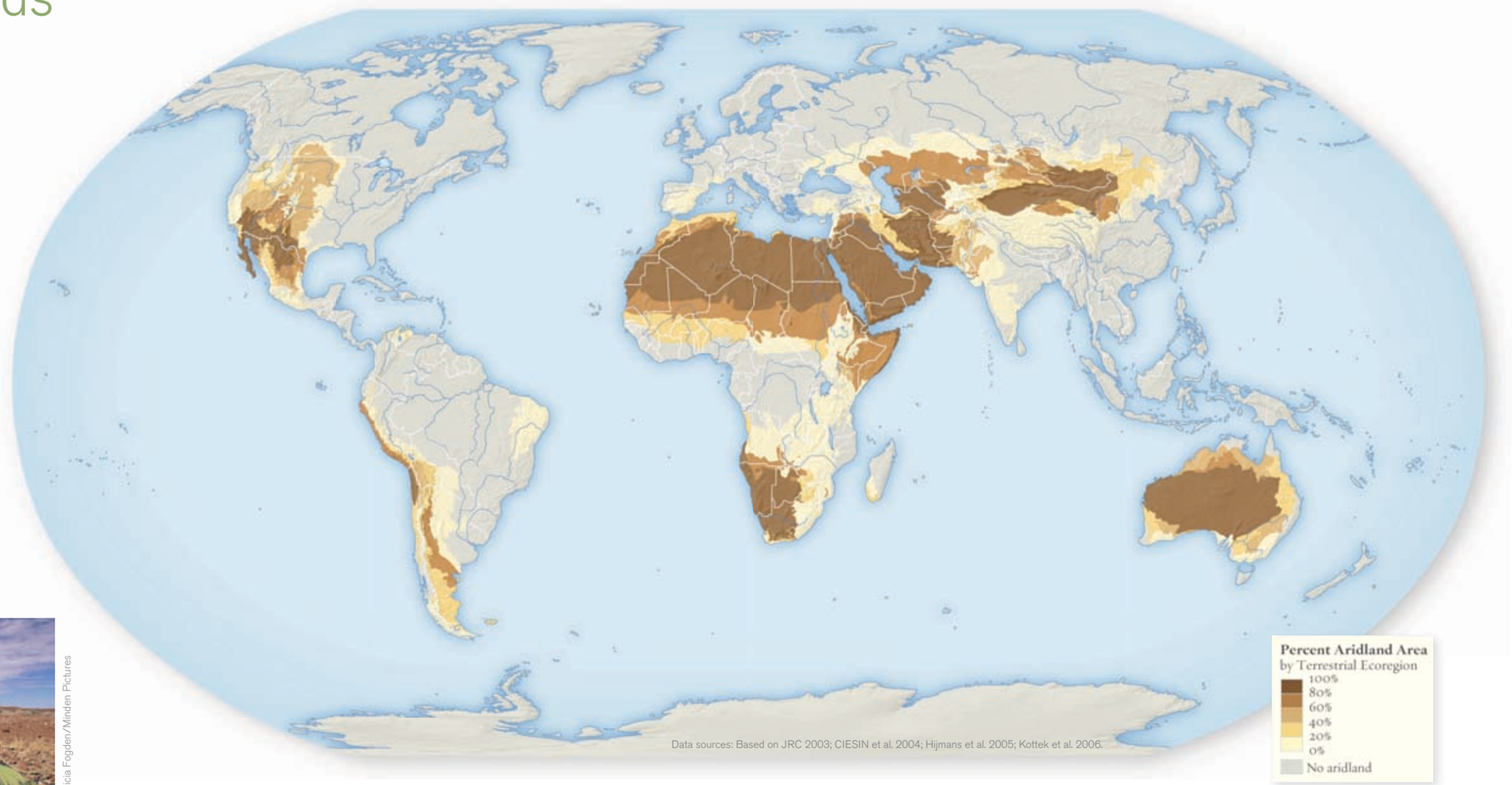
In Mongolia, private and government groups have helped conserve twenty-eight thousand square kilometers of the world's largest intact temperate grassland, an area threatened by nearby development of roads, mines, and oilfields yet still home to migrating nomads with their yaks.

Deserts and Aridlands

Hardy Life under Harsh Conditions

Henner Frankenfeld/Redux Pictures

Man-made deserts. While natural deserts can be vibrant and full of life, vast regions are being converted from dry grasslands to barren deserts. This human-induced *desertification*—the loss of vegetation and the degradation and drying of the soil—is a product of deforestation, overgrazing, and wasteful irrigation practices, aggravated by climate change. Desertification threatens the survival of more than 250 million people, like this Tanzanian herder, who depend on drylands for crops and grazing of livestock.



DESERTS AND ARIDLANDS. The world's major deserts include the Sahara, Arabian, Gobi, and Great Basin in western North America.

Quenched by fog and dew. In the Namib Desert, *Welwitschia mirabilis*, also known as "tumboa," absorbs moisture through its leaves. The tumboa grows very slowly and can live for over a thousand years.

Michael & Patricia Fogden/Minden Pictures

LOW, UNPREDICTABLE RAINFALL, high evaporation rates, and, in most cases, an abundance of paradoxes are common denominators of the world's aridlands, which cover about 40 percent of the world's total land surface. While deserts seem empty, they are usually full of life.

Look closer at the seemingly bare landscapes beyond the scraggly foliage of the world's driest places. It turns out many are not really bare but are covered by algae and lichens called *cryptogams*. Combined with bacteria and fungi, cryptogams form a living crust that holds scarce water in place and keeps soil from blowing away. But cryptogamic crusts can crumble under the weight of just a footstep, making deserts some of Earth's most fragile landscapes.

Resident animals are characterized by extraordinary adaptations that allow them to survive in these all but inhospitable terrains. The endangered Arabian oryx, which resembles a long-horned antelope, has thick, bright white fur that reflects the sun's rays in summer but absorbs the warmth in winter. Gila monsters store water in their tails. The Namibian tumboa plant absorbs fog and dew through its leaves. Australia's Eyrean grasswren, a small bird, has such efficient kidneys that it does not need to drink water—it gets all the moisture it needs from the seeds and insects it eats. Plants have similarly evolved to fit their habitat: many of them grow, flower, make seeds, and die in just the few days of rain during the year.

Apparently timeless and unchanging, deserts are increasingly being transformed by human activities. Eight percent of the world's human population live in deserts and the aridlands on their margins, eking out incomes from livestock, mining, and minimal farming. Desert and aridland habitats throughout the world have also been lost to irrigated farming and urbanization, while the introduction of invasive plant species and the suppression of fires have transformed immense expanses of these habitats.

Throughout the ages, travelers in search of solitude and inspiration have also been drawn to desert wilderness. These incursions have damaged the fragile environments. Cryptogamic crusts and other fragile flora have been destroyed by off-road vehicles and other means.

Many opportunities do remain to protect desert habitats with improved fire management, careful grazing practices, and control of invasive plants. Invasive yellow star thistle and cheatgrass, for example, have taken over and devastated huge areas of North America's Great Basin Desert. However, in at least one area, Hells Canyon of Idaho, conservation groups and state agencies have been tracking the plants' progress by flying over the area in small planes and helicopters, returning by land to remove the invasives, whether with fire or grazing animals, or by pulling the plants out by hand.

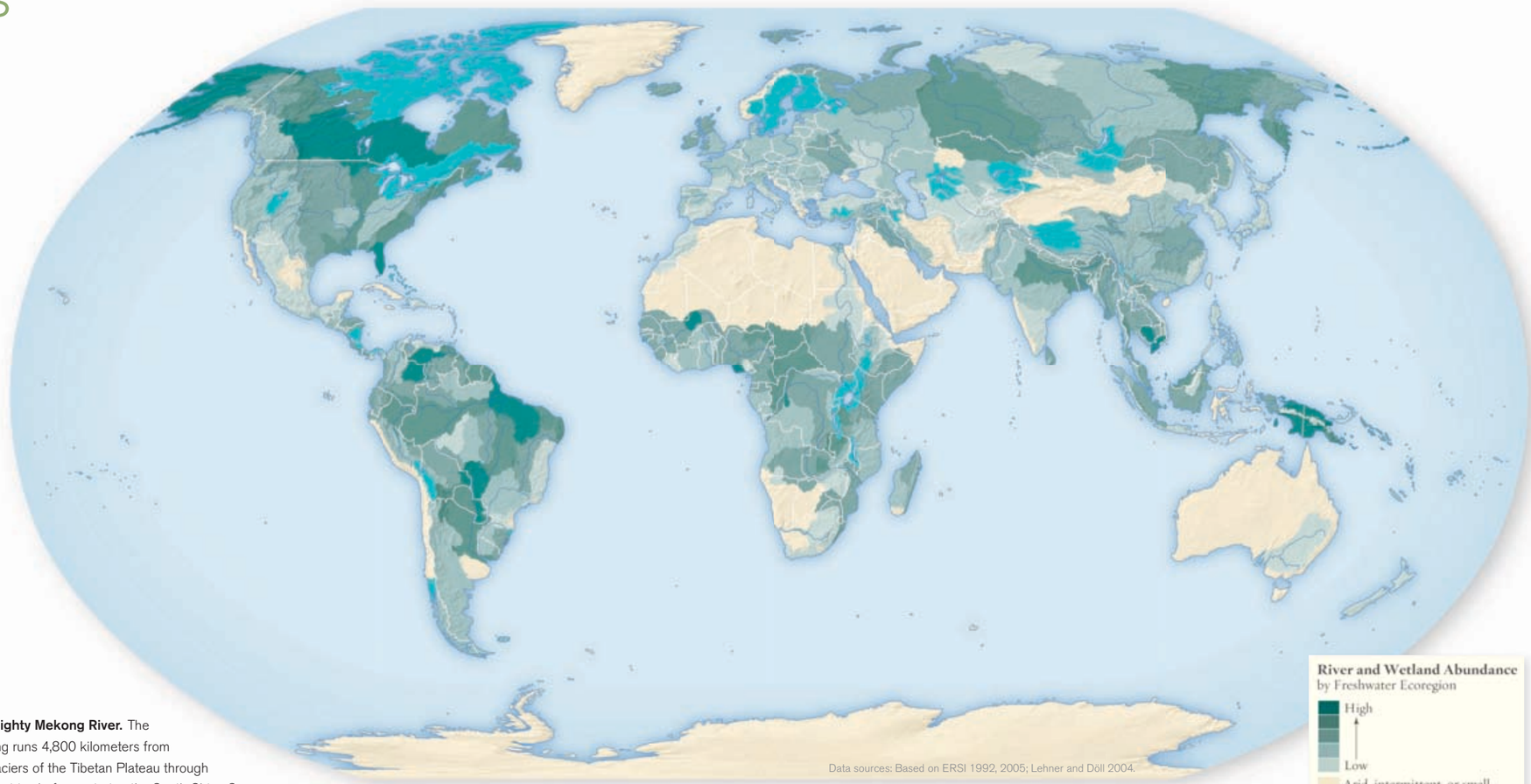
Rivers and Wetlands

The Planet's Lifeblood

Brian Richter/TNC

Life-giving floods. The annual rainy season brings essential water and nutrients to the Okavango Delta. Hundreds of species, from Cape buffaloes and lechwe antelope to tiny invertebrates, could not survive without this seasonal flooding.

Richard Du Toit/Minden Pictures



RIVERS AND WETLANDS. Climate, topography, and geological events such as the advancing and retreating of glaciers have shaped the distribution of rivers and wetlands throughout the world.

Zeb Hogan

The Mighty Mekong River. The Mekong runs 4,800 kilometers from the glaciers of the Tibetan Plateau through six countries before entering the South China Sea. It is home to the Mekong giant catfish, which can grow up to three meters in length and weigh three hundred kilograms and is now close to extinction because of overfishing and habitat loss. The lower Mekong Basin waters contain the world's most productive inland fisheries, providing protein and incomes to forty million rural dwellers.

RIVERS HAVE ALWAYS BEEN POTENT symbols of time and change, shifting shape as they travel from the mountains to the sea. Fast-flowing streams dominate their upper reaches, growing larger and slower as they descend toward wetlands and the coast.

No two rivers are exactly alike. Climate, geology, the chemistry of the water, and the contours of the land all determine a river's characteristics and the varieties of life that it supports. As a rule, large fish such as the Mekong giant catfish can be found in the deep, slow-moving waters of main river channels. Smaller species, such as Australia's climbing galaxids, which got their name for their ability to wriggle up waterfalls, inhabit the shallower headwater streams. Other species, native to arid regions, have adapted to periods when rivers run dry or are reduced to a few standing pools until the next rainy season. The Australian salamanderfish, for example, clings to life during the annual dry period by burrowing in the mud and covering itself with a thick layer of mucus.

Floodplains and wetlands typically harbor the greatest number of species. Renewed each year with river-borne nutrients, these habitats are sprawling nurseries for aquatic plants, insects, worms, and other invertebrates, which in turn attract large numbers of fish, mammals, and birds to feed and breed. One of the world's most magnificent wetlands is Africa's Okavango Delta in the margins of the Kalahari Desert, an alluvial fan of fifteen thousand square kilometers that floods every rainy season as the Okavango River flows down from the highlands of Angola. The Okavango offers habitat for a large array of plants and animals that would otherwise succumb to the desert heat. It also provides food for more than a hundred thousand indigenous people, and spectacular views for visitors supporting Botswana's lucrative tourism industry.

Throughout the world, rivers and wetlands play similarly vital roles in people's lives, providing shipping routes, hydropower, recreation, jobs, and food and drinking water. Indeed, river and wetland fisheries often provide the only source of animal protein for people in much of the developing world, particularly the rural poor who turn to fishing when they cannot find other jobs. In Laos, over 70 percent of farmers are also involved, at least part-time, in fishing activities to augment their family food supplies and incomes.

Over time, we have heavily altered waterways to fit our needs by building dams, levees, and canals. Other harmful practices, which today are unfortunately widespread, include draining wetlands, withdrawing too much water for agriculture, polluting rivers with fertilizer, dumping waste, overharvesting fish, and introducing non-native species. All these threats pose major challenges to conservationists, who nonetheless are making progress. A case in point in the United States is the Connecticut River and its tributaries, which are reviving today after forty years of efforts to protect land, restore shoreline vegetation, improve sewage treatment, and manage fish and recreation.

Lakes

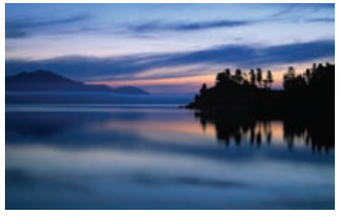
Fragile Pools of Life

Broudy/Donohue Photography/Corbis

Saving Himalaya's lakes. Lake Gokyo was one of the four glacial lakes protected by Nepal in 2007 under the Convention on Wetlands. This system of lakes near Mount Everest is a vital water source for local communities and is home to threatened species, including the reclusive snow leopard.

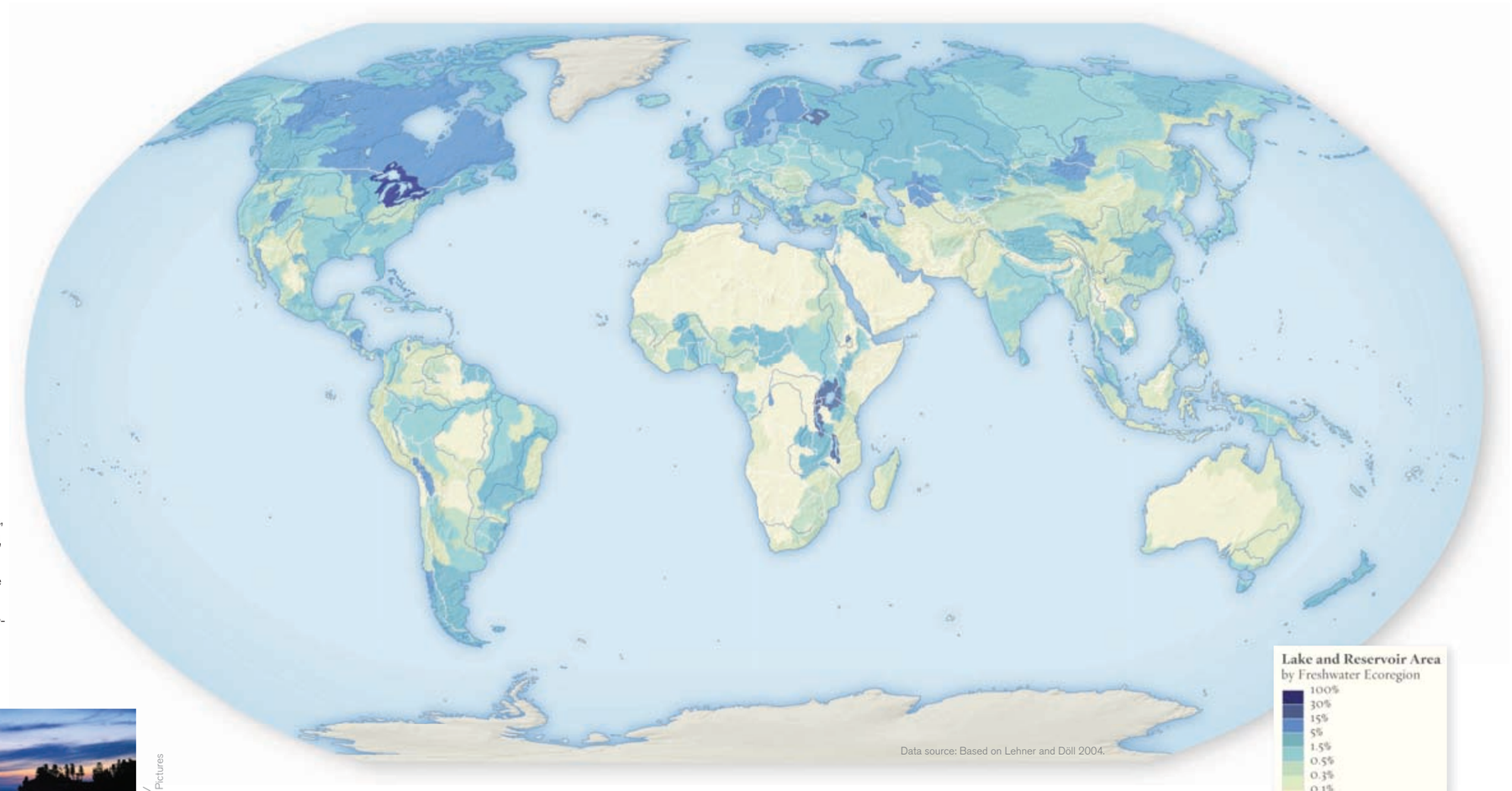
Konrad Wothe/Minden Pictures

The unique freshwater seal of Baikal. The nerpa, found only in Lake Baikal, is the world's only strictly freshwater seal. It can live over fifty years and stay underwater for up to forty-three minutes.



Konstantin Mikhailov/ Foto Natura/Minden Pictures

World's largest lake. Lake Baikal holds one-fifth of the world's freshwater. More than 330 streams flow into the lake, but only the Angara River flows out toward the sea.



LAKES AND MAN-MADE RESERVOIRS. Lakes are most prevalent in the northern latitudes, where many were formed by glaciers of the last ice age. Dam building has produced more man-made reservoirs in developed countries, although less developed nations are quickly catching up.

FROM THE VAST Great Lakes of North America to tiny Gokyo Lake, nestled high in the Himalayas, lakes in their many different forms sustain a wide variety of natural life. Much like islands, they provide habitats in which freshwater plants and animals can evolve in isolation.

Lakes are formed after glaciers, volcanoes, or earthquakes leave craters that fill with water. Next, species from surrounding waters, as well as seeds carried by wind and wildlife, colonize these new environments and gradually adapt to their conditions.

Lake Baikal in southern Siberia is the world's oldest and deepest freshwater lake. Formed by a deep crack in Earth's crust more than twenty-five million years ago, it holds nearly one-fifth of all the world's freshwater, roughly equal to the volume of all the North American Great Lakes combined. And just as outstanding as its size is the quantity and variety of plants and animals that it sustains: in all, 2,630 species, three-quarters of which are found nowhere else on Earth. In comparison with Lake Baikal, most other lakes in the world are relatively young, having formed within the last ten to twenty thousand years. Younger lakes generally have many fewer species, but these species continue evolving today.

Reservoirs look like lakes and are often mistaken for them. Yet they are different in important ways. Reservoirs are artificial environments, formed by a dam that interrupts a river's flow and floods the land behind it. Reservoirs transform flowing river water into standing water, with the result that native river fauna often cannot adapt and survive. Many reservoirs are also intentionally stocked with non-native fish species, such as trout or bass, which can end up competing with native species. While there are still many more lakes than reservoirs, there are now reservoirs on nearly every river system on Earth.

People use lakes and reservoirs in all sorts of ways—they are fish tanks, sources of irrigation water, and fields for Jet Skis. And as with other elements of nature, we often love our lakes to death. The most prevalent threats to lakes today are pollution from sewage, industrial effluents, and fertilizers running off farmland. Nutrients in sewage and fertilizer end up feeding algae and plant life that then rob the water of its oxygen as they die and decay. This process—called *eutrophication*—results in the suffocation of fish and other species. Other pressures on lakes include overharvesting of fish, the proliferation of invasive species, and the lowering of water levels from excessive water use.

Some of these threats can be abated through sound management and conservation. Back in the 1960s, Lake Washington in the U.S. Pacific Northwest was dominated by toxic algae and unfondly called "Lake Stinko" by locals, as a result of many years of dumping of raw sewage from Seattle and surrounding areas. The lake has since recovered, however, as managers have built sewage treatment plants, and is now a popular place for recreation and home to nearly thirty species of fish.

Caves and Karst

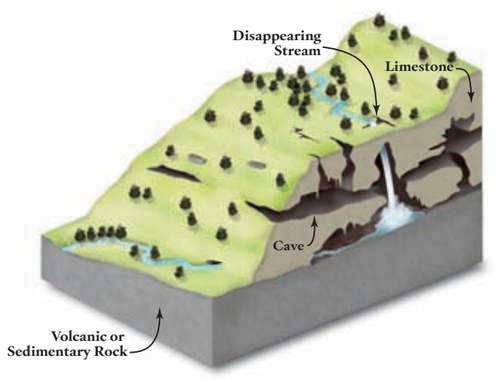
Troves of Subterranean Species

Henry Watkins & Yibran Aragon/Reuters/Corbis

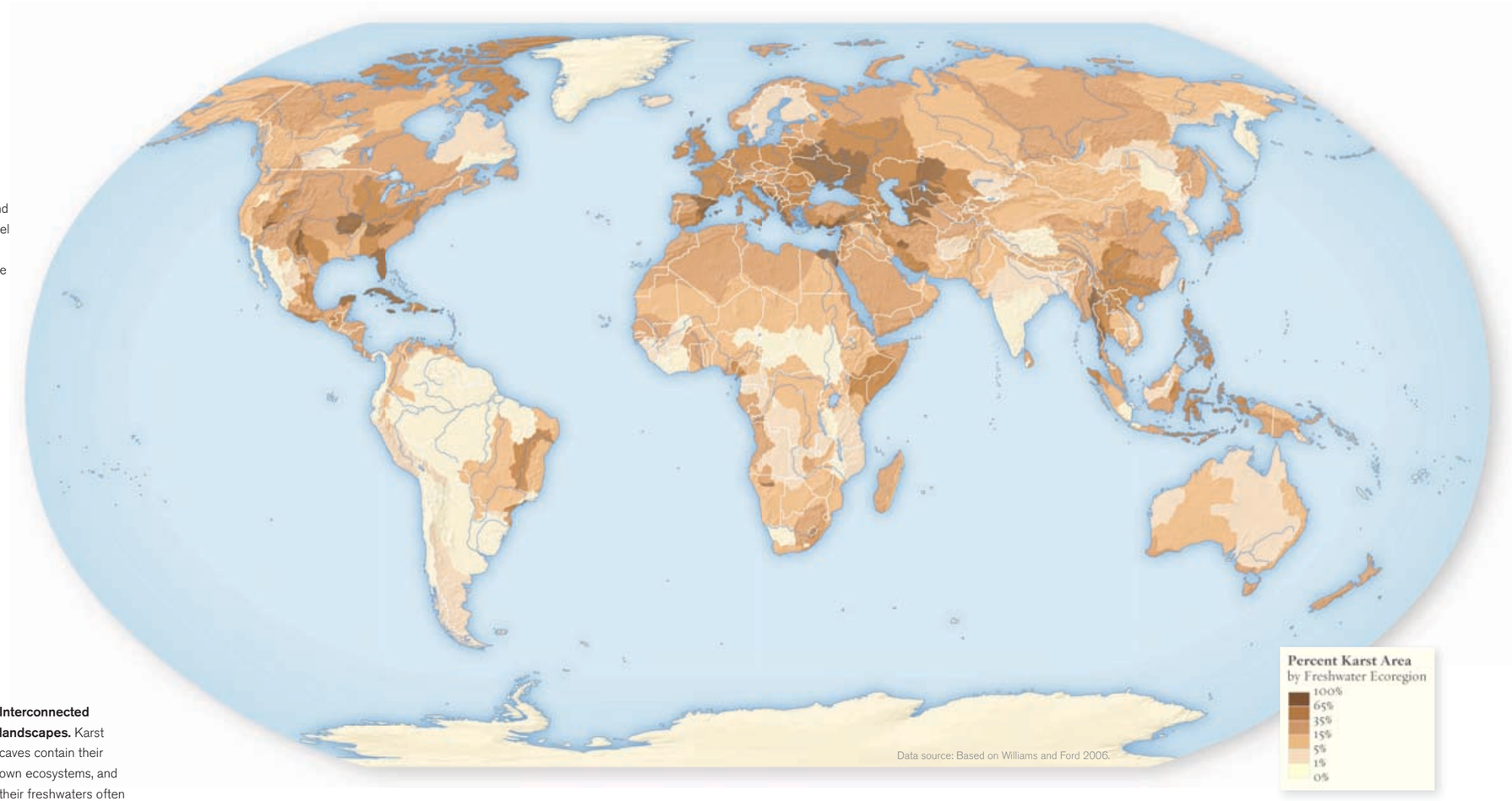
An underground blue world. The Quintana Roo province in Mexico contains more than 685 kilometers of underground rivers, including the Ox Bel Ha, the world's longest surveyed underwater cave system.

Rare and out of sight. The endangered Benton Cave crayfish is found in just four sites within the Ozark karst system of the U.S. state of Arkansas, with only forty individuals known to exist.

Stephen Alvarez



Interconnected landscapes. Karst caves contain their own ecosystems, and their freshwaters often nourish aboveground rivers and streams.



KARST TERRAIN. Many caves remain unexplored or even still undiscovered, but karst terrain—limestone or other soluble rock formations—illustrates where karst caves, and thusly cave species, are likely to exist.

HIDDEN AWAY BELOW OUR FEET, some of the world's rarest and weirdest creatures dwell in underground caverns, tunnels, and caves. These mysterious abodes have been created in various ways: from cooled tubes of lava, the force of waves battering rocky coasts, or, most often, from the formation of karst. Karst caves form when water percolates through soluble portions of Earth's crust, dissolving rocks such as limestone and dolomite. Small spaces over time become vast subterranean tunnels and grottoes, often traversed by streams, rivers, and lakes.

The darkest reaches of this cavernous world are home to a class of specially adapted creatures: troglobites, which, having evolved without light, rely on highly developed other senses, including smell, taste, and vibration detection. Usually these species have little or no pigmentation and either rudimentary eyes or no eyes at all. Troglobites also tend to have remarkably slow metabolisms, allowing them to thrive in environments with little food to spare.

Cave habitats are usually so isolated from one another that they are high in endemism, with many troglobite species unique to a single location. The endangered Benton Cave crayfish—a blind, transparent crustacean that can live as long as a human—is found only in a handful of sites within the U.S. state of Arkansas's Ozarks karst system. Other, more common species come and go as they please. Bats may roost within caves, leaving them to feed and, in the process, routinely importing nutrients back home. Other animals, such as frogs and bobcats, spend most of their time aboveground but use caves for water and shelter during droughts or cold spells.

Scientists estimate that karst terrain occupies nearly 15 percent of Earth's surface—a vast area that nonetheless remains largely unexplored, with many still-unknown species. Once documented, these permanent cave dwellers are ideal indicators of the health of a given environment, since they are extraordinarily sensitive to changes in the quantity and quality of the water seeping in from above. Unfortunately, many of them are not faring well.

As increasing human populations aboveground use water for irrigation and drinking, and pollute water with pesticides and fertilizers, sensitive cave species suffer. The blind Aigamas Cave catfish found only in the Aigamas Cave in Namibia, has arrived at the brink of extinction as karst water supplies have dwindled. Similarly, water pollution and diversion to reservoirs has damaged Central Europe's vast Dinaric karst, threatening such unique species as the "human fish" salamander.

Yet together with the new threats to cave species has come new interest in understanding and preserving them. Between 1980 and 2005, the rate of discovery of new subterranean fish species quadrupled in comparison with findings from the preceding sixty years. And recently, an ad hoc coalition of conservationists, landowners, and public officials has worked to protect sensitive habitats in the Ozark karst system by improving groundwater quality, regulating disposal of hazardous materials, conducting volunteer cleanups and restricting access to important cave sites. Other countries such as Brazil, Australia, Mexico, and Croatia have recently taken measures to protect cave habitats as well.

Hope in Habitats

STEVEN J. McCORMICK

I FIRST BECAME ENRAPTURED with the natural world in the late 1950s, playing with a band of friends in the woods—or, should I say, "the jungle." For that was the name we gave to the mixed oak woodland (not a phrase that was in the lexicon of eight-year-old boys) behind our neighborhood in Northern California.

Many weekends we'd march off to the jungle for a long day of climbing the burly, gnarled limbs of coast live oaks and exploring the dark, spicy interiors of dense bay forests. Those boyhood experiences, pursued solely for the sheer joy of unconstrained, unstructured adventure, profoundly influenced and shaped my growth to adulthood.

We didn't think of the jungle as a "habitat type," but we did appreciate the forest as more than just a bunch of trees. The creeks were full of "water skeeters" and other bugs; salamanders were abundant in early spring; gopher snakes prowled the open areas; quail erupted from underbrush; deer were almost always browsing early in the morning.

I can't say that my experiences in the jungle launched a career in conservation, but they were certainly a powerful influence on my life. When I first started working for The Nature Conservancy in 1977, I was convinced that we should focus more on conserving "natural communities" (a synonym for "habitat types") than on individual species, because—as I knew from my days in the jungle—not only was the whole system more than the sum of the parts, but the parts required the whole system (a pretty sophisticated ecological awareness for someone trained as a lawyer).

When I became president of The Nature Conservancy in 2001, I wanted to make this the guiding principle for the whole organization. And, inasmuch as the mission of the Conservancy compels a global vision ("to preserve the … diversity of life *on Earth*"—my emphasis), I was committed to undertaking a global assessment of all habitat types to determine conservation priorities based on considerations such as threat, and the extent to which habitat types are currently protected in different regions of the world.

This atlas is a culmination of that commitment. And what a wonderful, insightful resource it is! While no major habitat types are sufficiently conserved on a global scale, what this atlas reveals is that some are alarmingly overlooked. Temperate grasslands, for example, do not have the glamour or drama, say, of an African savanna or the abundance of species of a so-called tropical rain forest hotspot, but as an element of biological diversity, these grasslands are no less significant. Yet less than 5 percent of the world's temperate grasslands are represented in protected areas, and most are heavily altered by a long history of human agricultural use.

Focus on habitats also requires us to think in terms of what it will take to assure conservation of functioning natural systems, and to go beyond the convention of thinking of protected areas as the only approach for conservation. At the enormous scale required to assure meaningful conservation, we'll need to act with a commitment to assuring legitimate human needs and desires. Those of us who've had the luxury of coming to a conservation ethic in a prosperous nation must understand that the terminology we use—*protect*, *preserve*, *save*, *set aside*—is taken as arrogant at best, and confiscatory at worst, to those struggling for survival. The term *habitat* should be appreciated for its imperative for human well-being, not just for the preservation of the other species that reside there. After all, we humans also live in virtually every habitat on the planet. This realization suggests a whole new precept: conservation of habitats *for* people; not protection of nature *from* people. We also need to collaborate with many partners to develop creative solutions. It is clear that no one approach or one group can single-handedly reverse the current extinction crisis, tackle climate change, or prevent ecosystem degradation.

Last year I returned to live in Northern California. The jungle is still there, intact.

Mark Godfrey/TNC

Mediterranean woodlands, California, United States

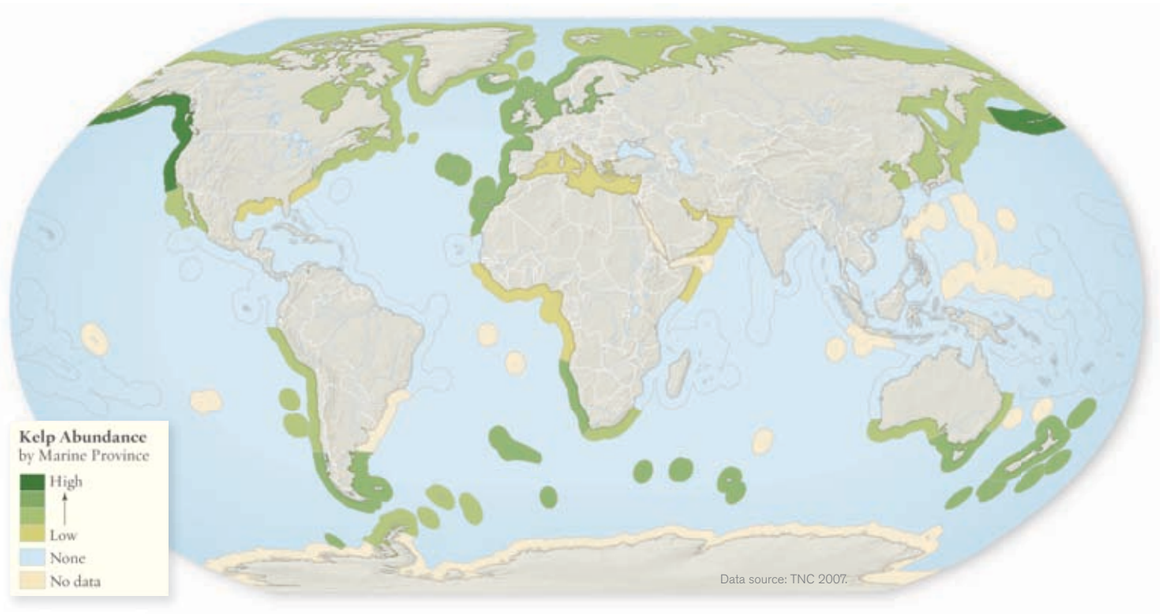
It's smaller and less exotic than I recall it. But the forest, redolent of bay and tanbark oak—what I now know is Mediterranean, a habitat type that has been heavily impacted by people here and elsewhere around the world—not only brought back powerful, and immediate, memories of a wondrous boyhood but also kindled a profound sense of hope for the future. This small but enduring habitat, surrounded by development, was alive with small children, doing exactly what I did at their age.

STEVEN J. MCCORMICK IS PRESIDENT OF THE GORDON AND BETTY MOORE FOUNDATION.

Coasts and Shelves

The Sea's Sunlit Margins

UPWELLINGS. In many regions, currents bring cool, nutrient-rich waters from the deep sea onto the continental shelf, feeding diverse forms of life. Upwellings off Peru and Chile are the richest, supporting over 15 percent of the world's marine fish catch.



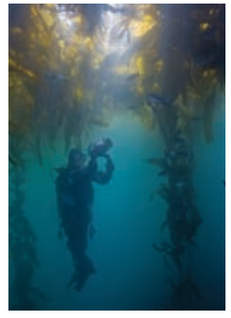
KELP FORESTS. Though not a dominant coastal feature in much of the world, kelp forests are abundant and diverse in the temperate waters of the northern Pacific Ocean.

Mark D. Spalding

Above the tides. Though scoured by wind and doused by sea spray, marine turtles and seabirds like the red-footed booby shown here find coastlines inviting places to rest, nest, and rear their young.

Jennifer Molnar

Intertidal. Salt marshes, mangroves, and shellfish reefs thrive in dynamic zones that are covered and uncovered by the tides.



Richard Herrmann

Beyond the waves. The continental shelf is home to plants, invertebrates, and in some regions even underwater forests of kelp that form three-dimensional habitats.

WHEREVER LAND TILTS into the sea there is a complex transition of worlds. First comes the intertidal zone, a place of constant motion, swept by currents, waves, and tides, yet sustaining myriad creatures and plants. Below the tides' play, shallow sunlit waters teem with life. The seafloor slopes gently away from the land, and as the waters deepen, the flow of nutrients from land diminishes, sunlight is filtered, and the seabed becomes more sparsely populated.

The intertidal zone is a strand of sometimes-water, sometimes-land that harbors communities of life that vary according to the nature of the seabed and the force of the waves. Salt marshes and mangroves grow in fine silt or mud where waters are calm. Below these, mudflats often stretch out in wide expanses, providing habitat for bacteria, algae, and burrowing animals such as razor clams, which in turn attract masses of wading birds, foraging fish, and crabs.

Different types of coastlines are home to distinct assortments of life. Rocky shores host a suite of flora and fauna that includes seaweeds (macroalgae), mollusks, anemones, crustaceans, and tiny bryozoans, which cling to the rocks, competing for space where sunlight and oxygen are plentiful. Sandy shores, by contrast, are not so densely populated but provide resting areas for turtles and seals. Estuaries and deltas are more complex places, forming the nexus of land, freshwater wetlands, and the ocean. Here, insect larvae and crustaceans scurry together, and schools of fish congregate to spawn, leaving billions of eggs and fish larvae. Mud crabs filter the sediment, while, in the tropics, large crocodiles hide in ambush.

The continental shelf is a shallow coastal region stretching as far as hundreds of kilometers from the coast, dominated by sand and mud. Scientific convention holds that the continental shelf stops when it reaches a depth of about two hundred meters, after which there is often a steep drop to the inky depths of the deep sea, a place still rarely visited and poorly understood. Areas reached by sunlight may be colonized by plants, including seagrasses and algae, and by invertebrates such as worms, mollusks, and starfish. Rocks rising from the seabed support larger life-forms, including corals, sponges, sea fans, and large seaweeds known as kelp. Found throughout the world's oceans, kelp are most widespread in cooler, nutrient-rich waters, such as the Pacific Ocean coast of Canada and the United States. There, rich kelp forests grow up from the seafloor to heights of twenty meters or more.

Living reefs are another common feature of the continental shelf. Best known, and home to the greatest diversity of species, are the coral reefs found in tropical zones. But other large reefs formed from the skeletons of animals and plants, including worms, mollusks, and even a red-colored algae, called *maerl*, are found in cooler waters, providing homes to many species of fish and crustaceans.

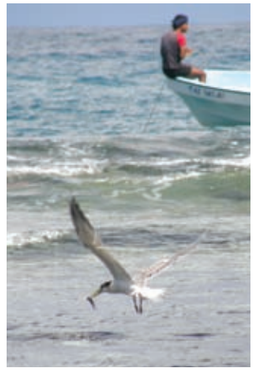
Marine life is most varied and abundant in coastal waters—and human activities such as fishing and boating are also most intense here. In addition, human development along the coasts has had a tremendous and mounting impact on adjacent waters. In contrast to efforts on land, however, conservation efforts in coastal waters have been much more limited, with fewer areas protected and fewer regulations to prevent pollution or over-exploitation.

Coral Reefs

Crown Jewels of the Ocean

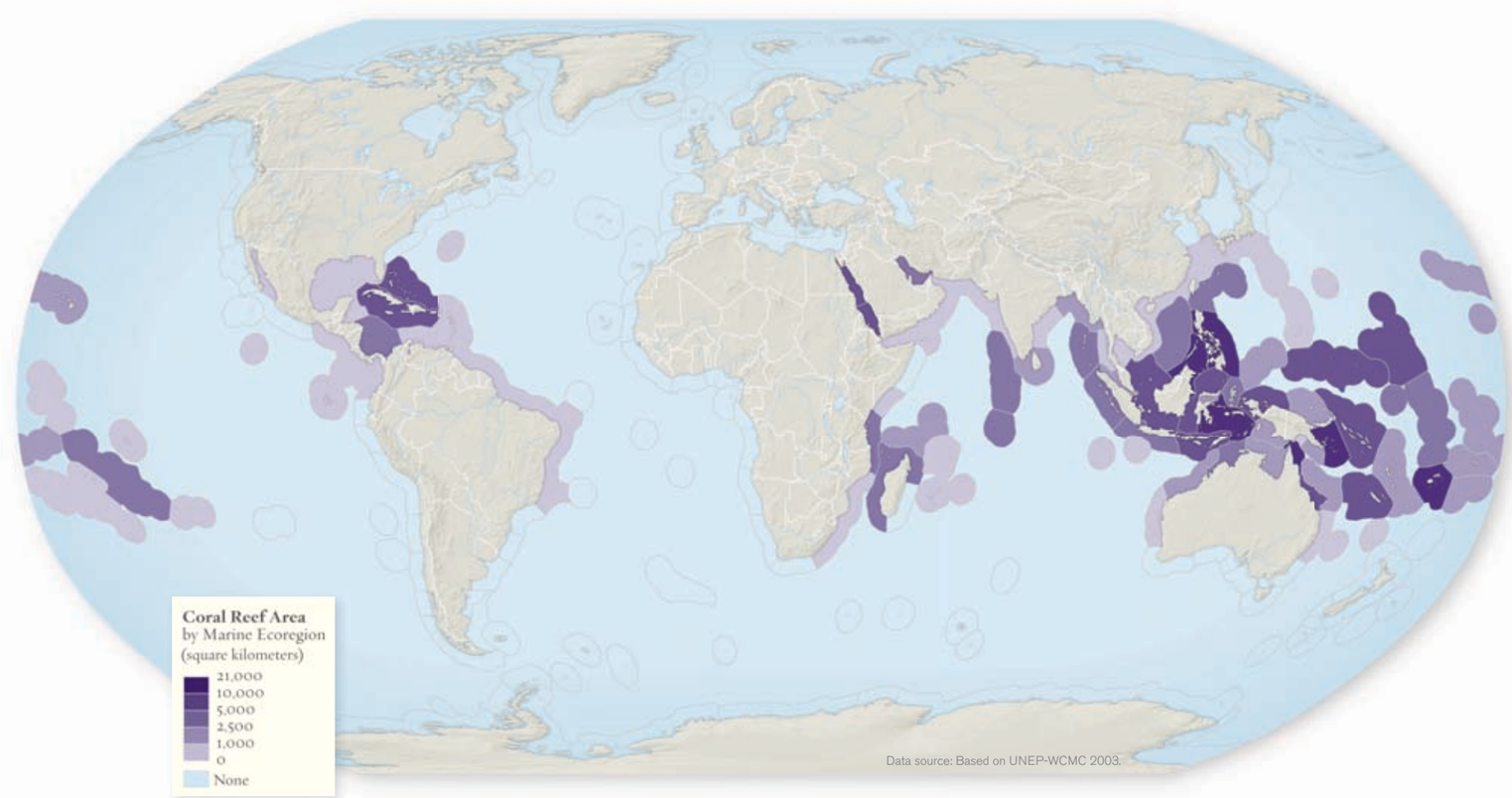
Steve Allen/Getty Images

Tiny builders, big results. Tiny coral animals form colonies that provide shelter for fish and the raw materials that have built great coral reefs and even islands, such as here in the Cook Islands.



Mark D. Spalding

Providing crucial resources. The rich resources of coral reefs are widely utilized, not only by birds, but by millions of fishers in over one hundred countries.



CORAL REEFS. Coral reefs are abundant throughout the Indo-Pacific ocean region, from East Africa and the Red Sea to the central Pacific Ocean, where many of the islands are built entirely by coral reefs. Reefs are also abundant through the Caribbean.

CORAL REEFS are undersea monuments, built up over thousands of years by billions of stony coral polyps. The polyps are tiny creatures, each consisting of little more than stinging tentacles, a mouth, and a stomach. They live in close-packed colonies, and as they die, they leave behind limestone skeletons to which new polyps attach. Over time, the skeletons become reefs, which can extend for hundreds of kilometers, growing up toward the surface of the sea. The still-living polyps are what give the reefs their jewel-like colors. The Great Barrier Reef, the largest geological structure ever built by living things, stretches almost two thousand kilometers along the northern coast of Australia, covering an area the size of Finland.

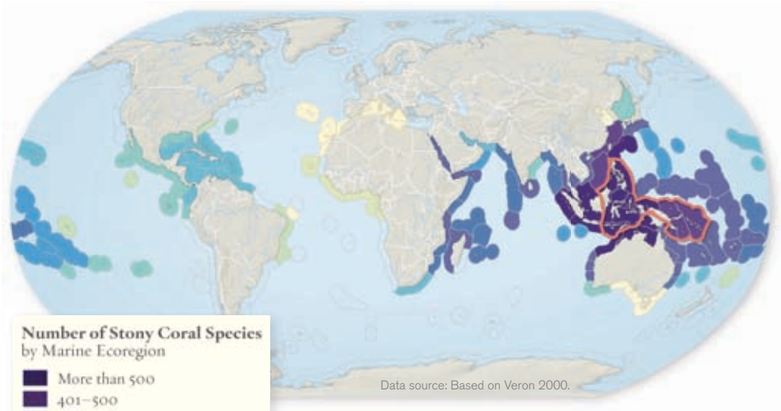
Coral reefs have long been famous for the diversity of life that they support, vying even with tropical rain forests in that regard. Yet even reef experts were surprised after one marine biologist identified 284 different fish species during a single dive along the reefs of the Raja Ampat Islands, Indonesia. In subsequent expeditions, scientists have tallied a total of 1,149 different fish, 537 different coral species, and more than 700 mollusks from these islands, which lie in the Coral Triangle, home to the richest variety of all marine life.

Coral reef scientists recognize two major regions of coral reefs in the world. The vast Indo-Pacific region, stretching from East Africa and the Red Sea to the central Pacific Ocean, has the greatest extent of reefs and highest diversity of species. By contrast, the Atlantic coral reefs, most abundant around the Caribbean and the Bahamas Archipelago, have lower diversity, but their corals and fish are unique to this region, having evolved in isolation for hundreds of thousands of years.

People living on tropical islands depend on the reefs for their diets and incomes. Inhabitants of tiny atolls, such as the Maldives and Marshall Islands, actually live on land made of coral and sand, piled up by storms, or sometimes uplifted by ancient earthquakes. In many countries, reefs are a lucrative tourist attraction, since visitors will travel far to snorkel and scuba dive among healthy, diverse coral gardens. Reefs also reduce the impacts of waves, providing protection from storms.

Despite this immense value, many coral reefs are in decline. They are highly vulnerable to overfishing; in parts of Southeast Asia, they are being destroyed by fishers who use explosives to guarantee a maximum catch. Pollution and silt from inland agriculture and coastal development are also degrading the reefs. The greatest long-term threat may be the warming of the oceans due to climate change. Corals are highly sensitive to fluctuations in sea temperature, and since the mid-1990s, warm summers in the Caribbean, the Western Indian Ocean, and the Great Barrier Reef have caused widespread coral death.

Hope rests in a combination of science, common sense, and concerted efforts. Scientists have realized that small areas of reef often survive the more widespread coral death that has occurred in recent warm summers, and that reef recovery more generally is enhanced where reefs are free from other human impacts such as overfishing. Working with expert knowledge of both scientists and local fishers, conservationists have created a plan for the communities around Kimbe Bay, Papua New Guinea, to safeguard these resilient coral reefs and to foster rapid recovery from future impacts, using traditional management approaches but ensuring that critical areas are safeguarded for the future.



STONY CORAL SPECIES. The Coral Triangle hosts the greatest diversity of coral species, in addition to other types of life such as fish and mollusks. In comparison, the Caribbean is much less diverse yet hosts species unique to its region. Stony corals are also found in regions—including the Mediterranean Sea and West Africa—where their numbers are insufficient to build reefs.

Mangrove Forests

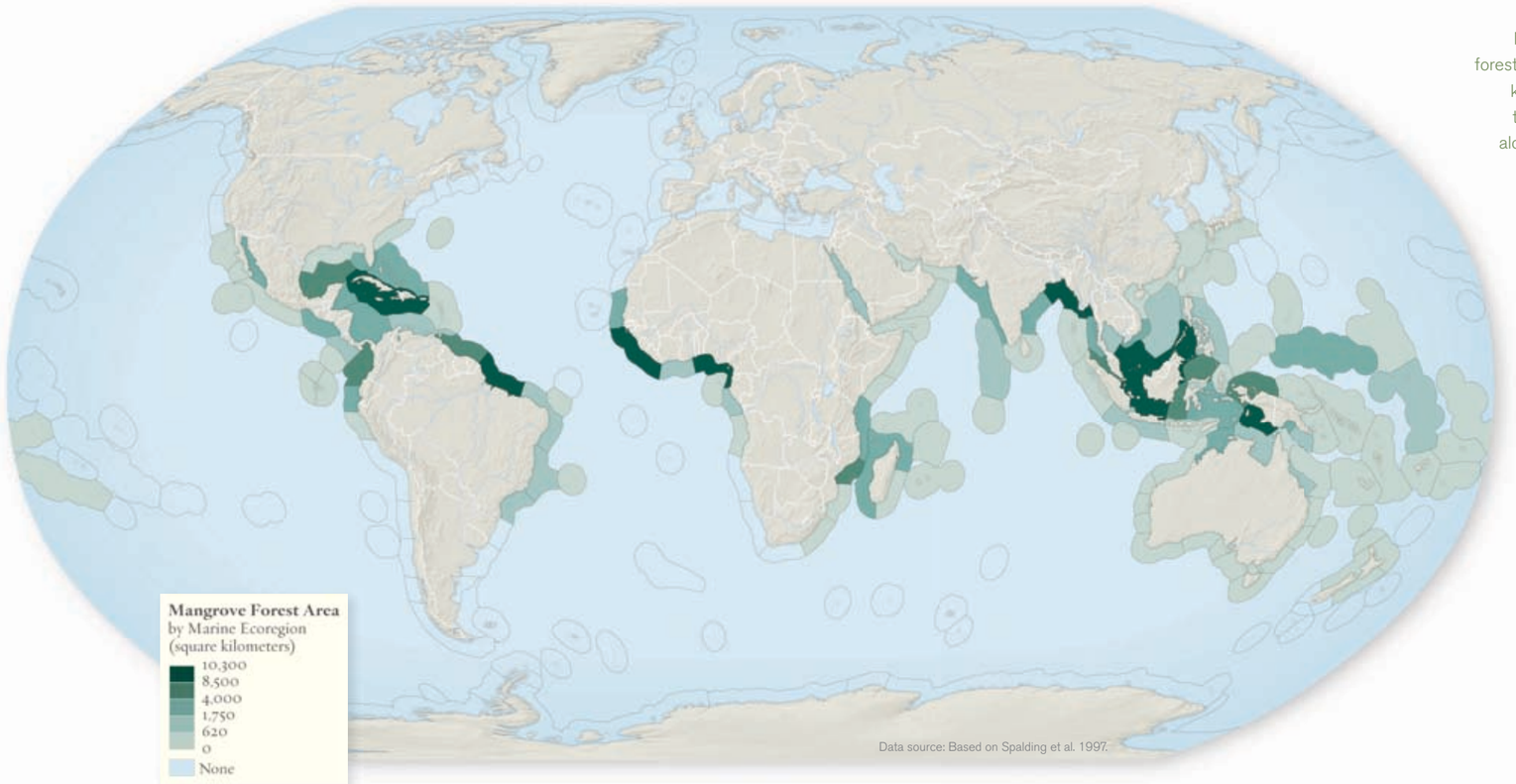
Bridging Land and Sea

Courtesy of AsiaExplorers/www.asiaexplorers.com

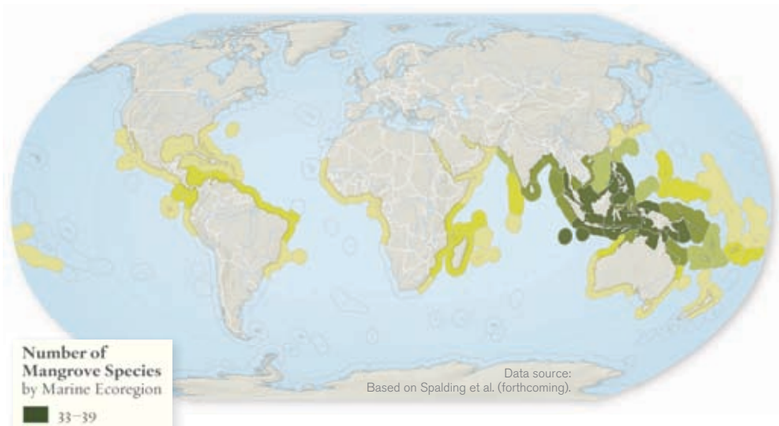
A tended forest provides. The Matang forest of Malaysia is likely the longest continuously harvested tropical forest in the world. Beginning in 1902, Matang's stewards have carefully tended the four hundred square kilometer forest and have been richly rewarded. Today, some 2,200 people are employed in timber extraction and processing, while the associated fishing industries provide livelihoods for over 10,000 people.

A rare sight. Found only on the island of Borneo, the proboscis monkey dines on mangrove leaves and unlike other monkeys it is an excellent swimmer.

Thomas Marent/Minden Pictures



MANGROVE FORESTS. Mangrove forests today cover about 150,000 square kilometers. They are widespread in all tropical realms but are most common along low-lying coastlines in areas with generous rainfall.



MANGROVE SPECIES. The vast majority of the world's sixty five mangrove tree species are found in the Central Indo-Pacific, which is also a center of diversity for corals and seagrasses. Far fewer species are in the Atlantic and the Tropical Eastern Pacific.

MANGROVES TREES inhabit a world midway between land and sea. They thrive in swamps, their roots sometimes inundated by the rising tide. Scientists have catalogued some sixty-five species of these trees, all uniquely adapted to survive in the intertidal zone, sometimes in salty water, always in waterlogged earth. Mangroves' most distinctive features are their strange, adaptive root structures, all exposed to air at least part of the day so as to sip precious oxygen from an otherwise anaerobic terrain. These include pneumatophores, root extensions growing upright from the mud; "prop roots," looping from branches and trunks; and "knee roots," resembling strange knobby knees that poke up through the mud from the web of roots below.

In and among the great forests formed by these trees dwells an equally distinct mix of animals. Hordes of fiddler crabs march across the mud as the tide falls, the males waving a specialized giant pincer—attracting mates and deterring rivals. Mudskippers, an amphibious fish, climb up tree roots to graze on algae in the open air. Archerfish stay submerged but squirt jets of water from their mouths to dislodge insects from the leaves above. In the vast Sundarbans mangrove of Bangladesh and India, tigers stalk their prey. Hippos rest in the mangroves of West Africa, while the extraordinary, long-nosed proboscis monkey, which feasts on mangrove leaves, is found only on the island of Borneo.

Mangroves also support millions of people by providing timber, fuelwood, and food. The mud crabs and oysters, prawns and finfish nurtured among their roots add protein to the diets of nearby villages and provide income as valuable exports. They are an important nursery for many coral reef and seagrass fish. Even far offshore, species such as the prawns taken in northern Australia's massive prawn capture fishery rely on mangroves for part of their lives.

In many parts of the world, mangrove forests are living sea walls. They baffle waves, prevent erosion, and protect coastal settlements from devastation by storms. News reports in the wake of the 2004 Indian Ocean tsunami said mangroves helped shield some villages from the worst ravages of that disaster. Their complex roots and meandering channels also filter water and help consolidate the shore by capturing sediment carried by rivers or swept along the coast.

Mangrove forests are disappearing faster than any other forest type. Between 1980 and 2005, they lost thirty-five thousand square kilometers, almost one-fifth of their total extent. This was mostly through overharvesting of wood or to make way for aquaculture ponds, agricultural land, and urban or tourist resort development. And now, as their gifts are being recognized, many mangrove forests are receiving increasing levels of protection, while others are being managed sustainably for forestry and fisheries. Countries such as Cuba, Bangladesh, Vietnam, and the Philippines have each planted hundreds of square kilometers of mangroves to replace lost forests and to safeguard coastlines and fish stocks.

Seagrass Beds

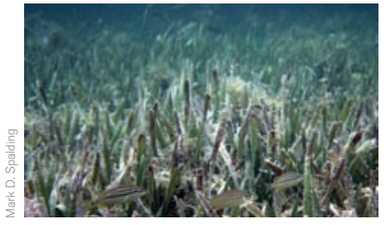
Marine Meadows

Fred Bavendam/Minden Pictures

In cold waters. Unlike corals and mangroves, seagrasses grow in temperate and even polar waters. Here a giant Pacific octopus is foraging the waters off British Columbia, Canada.

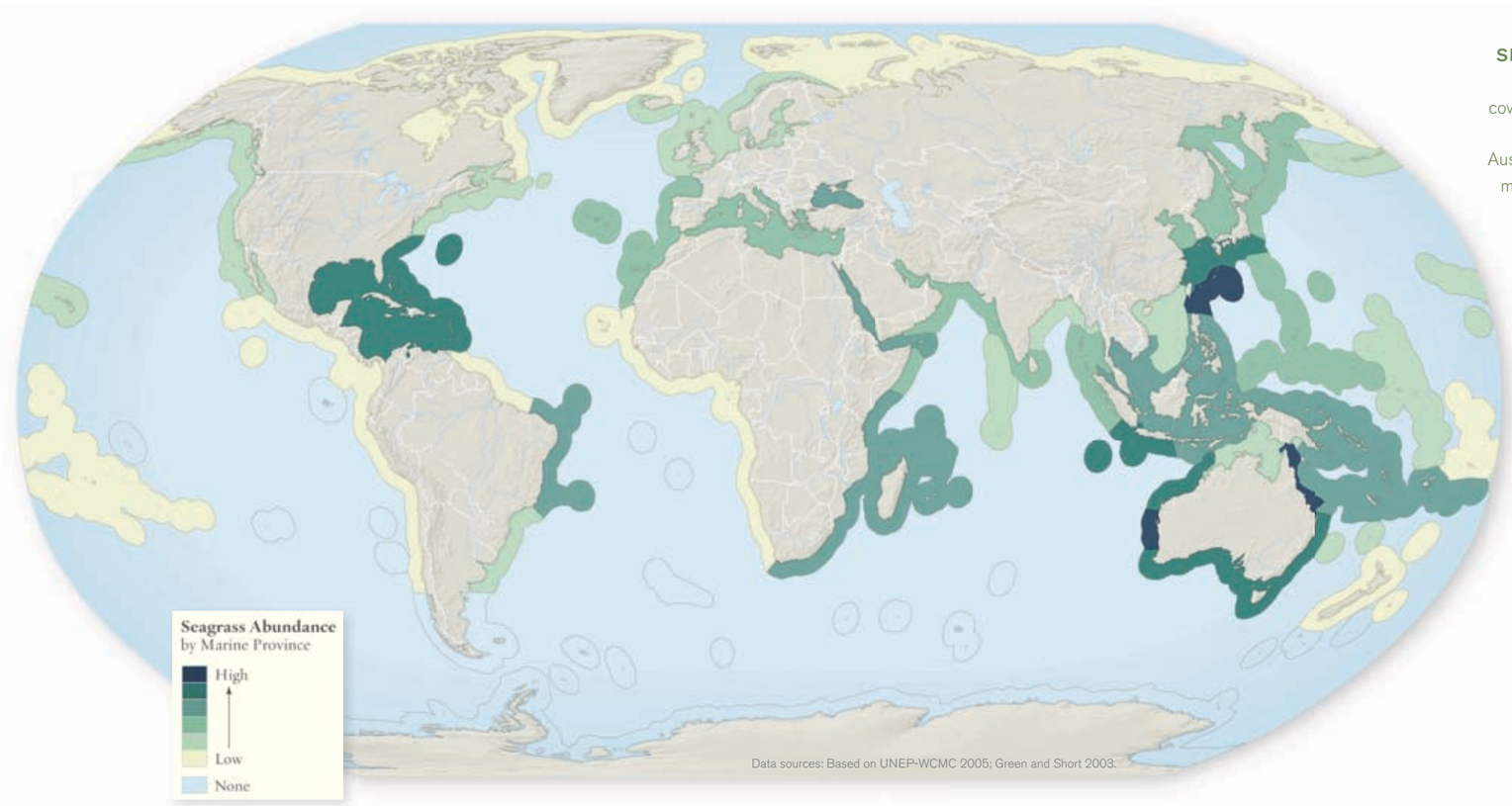
Mike Parry/Minden Pictures

Gentle giant. The dugong is a marine mammal that feeds on seagrasses, here in Vanuatu, Pacific Ocean.

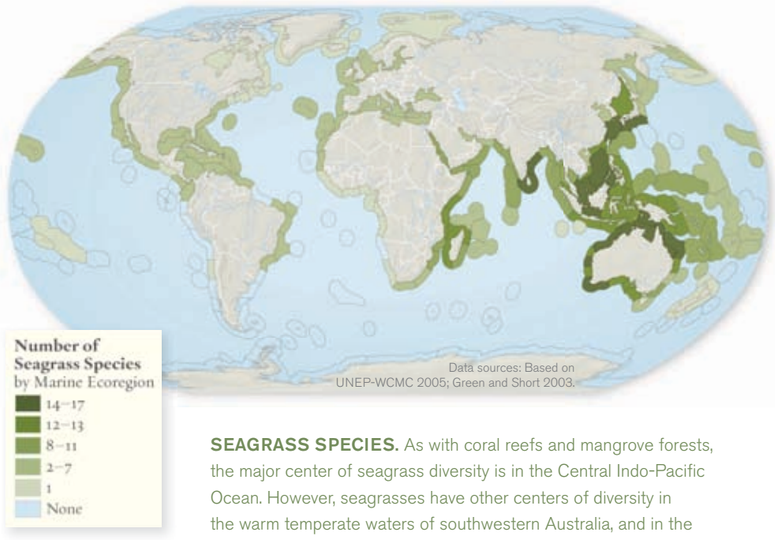


Mark D. Spalding

Protecting the young. Seagrasses can form dense beds over sands and silts and provide important shelter for juvenile fish.



SEAGRASS HABITAT. Seagrasses are most extensive in the tropics but also cover large areas in the Northern Atlantic, Mediterranean Sea, and temperate Australasia. Scientists estimate that these meadows cover at least 177,000 square kilometers of seafloor.



SEAGRASS SPECIES. As with coral reefs and mangrove forests, the major center of seagrass diversity is in the Central Indo-Pacific Ocean. However, seagrasses have other centers of diversity in the warm temperate waters of southwestern Australia, and in the northwestern Pacific Ocean.

PICTURE A MEADOW where turtles and manatees graze. The ebb and flow of water ruffles the foliage like a breeze, while millions of crustaceans, mollusks, and starfish stand in for scurrying insects and rodents.

This underwater field is made of seagrasses, the world's only fully submerged plants with roots in marine and tidal zones. Scientists to date have identified some sixty of these strange and highly specialized plants, originating from a variety of different plant families. None are in fact true grasses, but many have grasslike blades. Given sufficient bright sunlight and a soft bed for their roots, they will spread over vast expanses of the shallow seafloor.

At first glance, these uniform underwater meadows might not seem capable of supporting rich and diverse species. Yet just like grassy fields on land, they are fast growing and highly productive, while the complex network of roots and leaves creates a three-dimensional habitat. Algae and small invertebrates settle and grow on the seagrasses themselves, accompanied by hundreds of species of fish and large invertebrates such as shrimps and crabs. A study of seagrass bed inhabitants in just one bay in temperate Australia found 631 invertebrate species, while in the U.S. state of Florida 113 different kinds of algae were found growing on and among the plants.

Hidden just beyond our crowded shores, seagrass beds are an often-undervalued part of nature. Yet they do much to support other life, including humans. The great range of biodiversity they sustain includes important fishery species, among them crustaceans, mollusks, and fish such as snappers and seahorses. The conch and lobster fisheries from undamaged seagrass areas in countries such as Belize and the Bahamas are worth many millions of dollars in exports every year.

Seagrass beds also improve water quality, by filtering out nutrients and contaminants and trapping sediments. The complex networks formed by their roots help stabilize the seafloor and soften the impacts of waves, preventing erosion not only underwater but also on adjacent shores, and reducing property damage from storms.

With all these benefits largely unknown or ignored, seagrasses around the world are diminishing. Pollution has spurred increased growth of algae and phytoplankton that block vital sunlight from the seabed; coastal development has smothered wide areas with sand and rubble; and in many areas, these underwater meadows are being plowed under by trawling and dredging. While there are no accurate measures for the overall loss, one conservative estimate suggested that some twelve thousand square kilometers of seagrasses vanished from the mid-1980s to the mid-1990s.

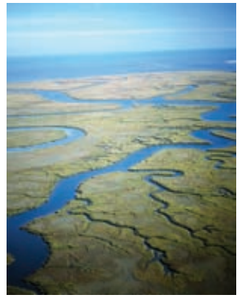
The extraordinary-looking giant dugong, typically weighing in at one-quarter of a metric ton, seems an unlikely savior for the seagrasses, but in Had Chao Mai, Thailand, the appearance of these rare creatures led to a mass media campaign, with local conservation organizations persuading villagers to stop using fishing methods that were damaging the dugong's seagrass food, and to use fish traps instead. Since then the seagrasses have expanded, and, to the delight of the fishers, the recovering environment also led to higher and more profitable fish catches.

Salt Marshes

Living Filters along Our Coasts

Mark D. Spalding

Remaining European wilderness. Salt marshes are among the only truly natural remaining habitats around the North Sea. One hundred thousand waterfowl overwinter on the north Norfolk coast every year.



James Randklev/Getty Images

Filtering and sheltering. The complex array of tidal creeks and salt marshes (here in Georgia, United States) filters pollutants and provides safe haven for many species.

Barry Truitt/TNC

A smorgasbord for birds and fish. Salt marshes provide rich feeding grounds for wading birds (here whimbrels in Virginia, United States) and fish.

SALT MARSH HABITAT. Salt marshes are a major coastal habitat in many low-lying, sheltered areas in temperate and northern polar regions. In the tropics, they often mingle with mangroves, but they can also survive in harsher conditions.

NORTHERN EUROPE has some of Earth's most altered landscapes. Its few remaining forest patches have been managed since record keeping began, while the vast, low-lying wetlands of the Netherlands and eastern England were drained several centuries ago. Even so, you can still see traces of a natural wilderness fringing the edges of these lands: dense pastures of grasses, herbs, and shrubs fringing the sea. These are salt marshes: muddy expanses where land plants have put down their roots. They occur along the world's calmest coastlines, behind barrier islands or in the sheltering arms of estuaries, protected from waves that would otherwise stir the sediments. With each rising tide, parts of these marshlands are inundated with saltwater that the plants have adapted to withstand. Then the receding waters drain into convoluted networks of channels carving deep into the mud, twisting and turning on their way out to sea.

Salt marshes can be found throughout the world, from the poles to the tropics. Able to tolerate dry and saline settings, they thrive in desert regions such as the edges of the Arabian Peninsula, Mexico, and parts of northern and western Australia. In contrast with coral reefs, mangroves, and seagrasses, however, they are most abundant in the world's more temperate realms, and it is in the North Atlantic region that they are most diverse in terms of species.

Coastal salt marshes are among the planet's most productive natural factories of food for a great web of life. Birds gather in vast numbers as permanent residents or as seasonal migrants. Some species, such as geese, graze directly on the salt marsh plants, while others feast on the numerous invertebrates found in their muddy pastures. Crustaceans and juvenile fish shelter in the complex maze of channels.

Humans greatly benefit from this abundance, from the wealth of fish, mollusks, and invertebrates that we capture in their vicinity. In addition, wetland plants serve as filters, holding back nutrients and toxic pollutants that would otherwise enter the ocean from coastal settlements. Their leaves, stems, and roots also help capture drifting sand and silt and hold it together, reducing erosion and often helping build out new land into the sea and lessen the impacts of storms by buffering waves. Yet like wetlands all over the world, salt marshes are highly threatened, and vast areas have already been damaged by marine pollution or converted to agricultural land and urban or industrial development.

But on the Blackwater Estuary in southern England, an alternative future is being tested. Here, since the mid-1990s, the sea has been allowed back into several former marshes. Seawalls protecting agricultural land have been breached, and salt marshes have returned. The now-regular flow of tides has deposited new sediments, raising the elevation of the newly flooded land. Such "managed realignment" of coastlines offers a much cheaper alternative to maintaining sea defenses. It offers a better future for salt marshes and for the people who live nearby, particularly in an era where sea levels are starting to rise.

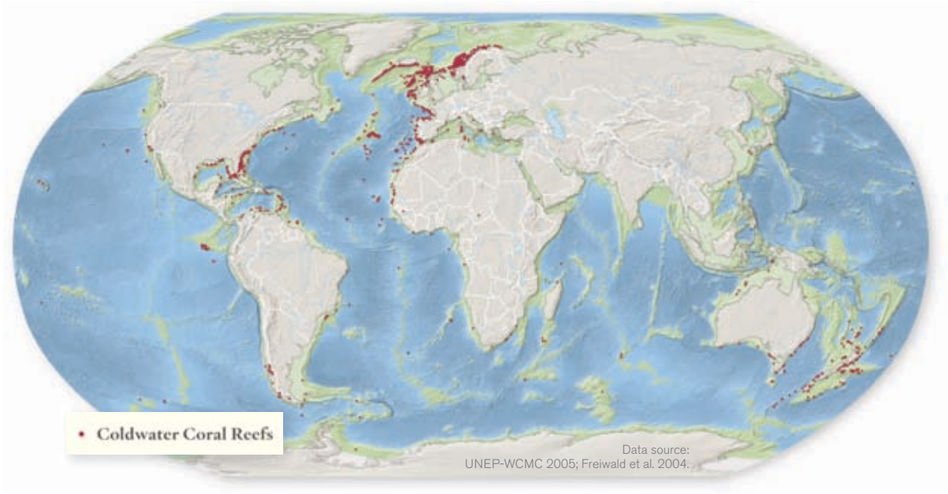
High Seas and Deep Oceans

Earth's Uncharted "Inner Space"

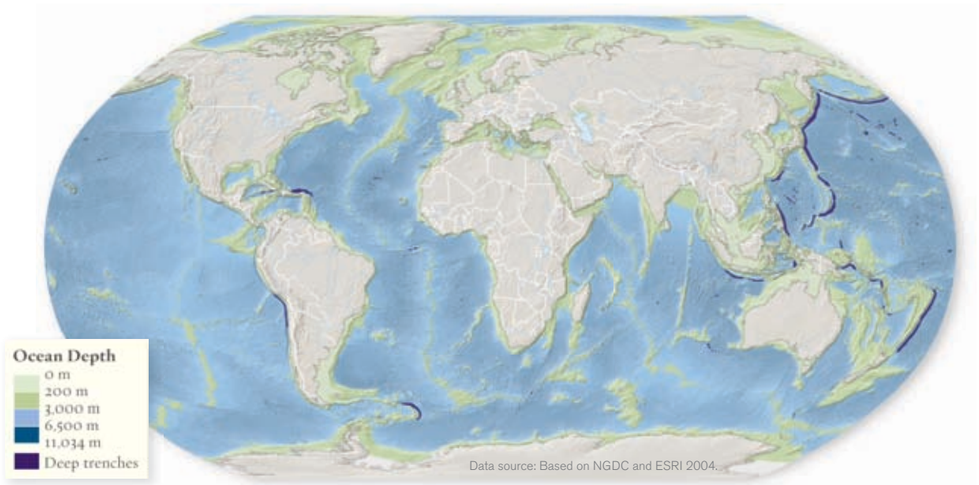
SEAMOUNTS, VENTS, AND SEEPS. By interrupting the flow of currents, seamounts receive a rich food supply and offer safe harbor to plants and animals—many of which are found only at one or a few adjacent seamounts. Large fishing vessels have begun to exploit the life seamounts nurture and are destroying these isolated communities. On the seafloor, superheated and mineral-rich waters of hydrothermal vents and the methane and sulfide-rich waters that leak out as cold seeps support life as well.

Dr. Bob Embley, NOAA PMEL

Nourishing flows. In deep dark waters, far from the life-giving rays of the sun, the rich mineral nutrients of vents and seeps nourish great densities of bacteria. These in turn feed expansive colonies of clams, worms, and mussels.



COLD-WATER CORAL REEFS. Less famous than their closely related tropical cousins, cold-water reefs harbor extraordinary communities of life. Most have been found in the North Atlantic, where research has concentrated. The largest, Rost Reef, covers one hundred square kilometers off the coast of Norway. Trawl fishing is a major and increasing threat to these reefs.



DEEP-OCEAN TRENCHES. Two kilometers deeper than Mount Everest is tall, the Mariana Trench is the world's deepest known point. Such exceptionally deep trenches occupy less than 1 percent of the ocean floor, mostly in long narrow channels where one continental plate is being subducted under another. They are exotic worlds dominated by sea cucumbers, mollusks, crustaceans, and worms.

OF ALL OF EARTH'S HABITATS, the largest is liquid—the vast open space of the oceans and seas. Oceans cover two-thirds of the planet, yet they remain mostly foreign to humanity. Many more people have journeyed to outer space than have visited even the average depths of the world's oceans, a distance of some 3,800 meters.

Facing recent evidence suggesting that some 40 percent of oceans have been strongly affected by human activities, scientists have joined in a race to understand the open seas—the pelagic ocean—and the seabed before they are irrevocably changed.

Staying still is never an option in the open sea. Throughout its depths, hunters and hunted play their parts in constant motion, shifting with the winds and currents. At the bottom of the food chain are microscopic algae and phytoplankton, which convert solar energy to sugars and nutrients, the stuff of life. They in turn provide meals for plankton, such as crustaceans and jellyfish, which subsequently feed ocean-faring hunters, including tuna, billfish, sharks, whales, and even giant squid, as well as large ocean-roving seabirds such as the albatross.

Scientists continue to identify new ocean species. A few smaller whales are known from just a handful of sightings or from skulls washed onto remote shores. But even as species are still being discovered, they are facing mounting dangers from human development. Fishing vessels have scoured the high seas for centuries, first targeting the great whales, but now tuna, billfish, sharks, and even tiny krill. Whale stocks have collapsed, tuna are being overexploited, and many shark species are threatened with extinction.

Spreading over twice the area of all the continents combined, the deep seabed is dark, cold, and crushed by immense water pressure. Until the late nineteenth century, scientists assumed these conditions could not possibly sustain life. But then small samples of the seabed were hauled up, containing previously unknown sea cucumbers, worms, and crustaceans. Modern evidence has revealed there could be as many as ten million still-unidentified types of animals living in the ocean's muddy depths, primarily concentrated on the undersea mountains known as seamounts and in the communities around hot volcanic vents and cold seeps.

Reports of the declining state of the oceans have prompted efforts to manage them better. There are regulations controlling fishing in deep waters adjacent to many countries, but the "high seas," outside any national jurisdiction, are by nature a much greater challenge. Making up half the total area of Earth, it will take concerted international collaboration to protect their biodiversity. At this writing, there was not a single protected area in all their expanse. But there have been some victories. A 1986 moratorium on commercial whaling saved a number of whale species from extinction, while bans by several nations in the early 1990s curbed the use of large-scale drift nets in the high seas. The nets—dubbed "walls of death" by some environmentalists—were up to fifty kilometers long. Aimed at tuna and billfish, they caught everything in their path, including dolphins, turtles, and seabirds.