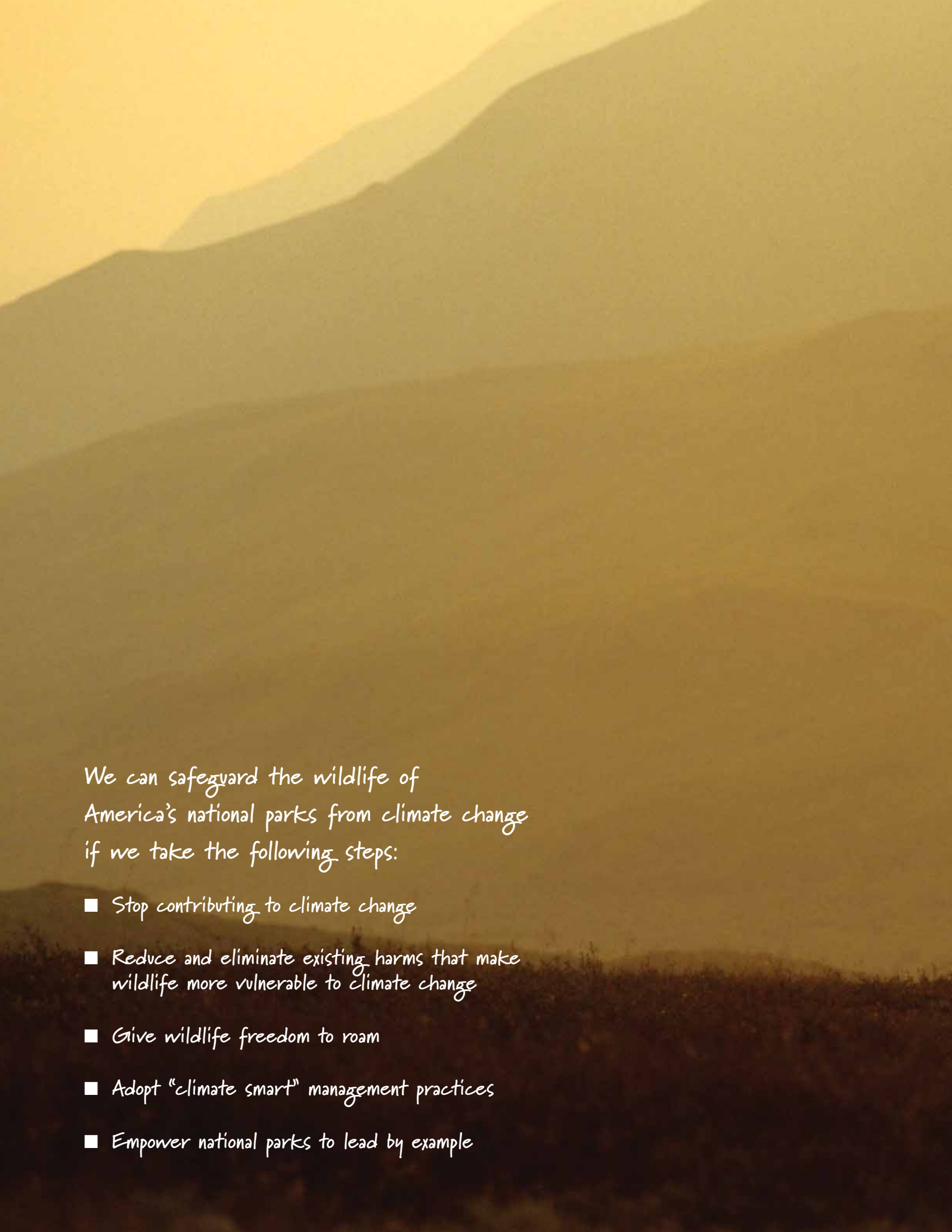

National Parks Conservation Association®
Protecting Our National Parks for Future Generations®
CLIMATE CHANGE & NATIONAL PARK
Wildlife
A Survival Guide for a Warming World
INSIDE:
Five steps for safeguarding wildlife from climate change
Eleven wildlife profiles, from migratory birds to grizzly bears
Dozens of national park stories, from the Arctic to the Caribbean



We can safeguard the wildlife of America's national parks from climate change if we take the following steps:

- Stop contributing to climate change
- Reduce and eliminate existing harms that make wildlife more vulnerable to climate change
- Give wildlife freedom to roam
- Adopt "climate smart" management practices
- Empower national parks to lead by example

CLIMATE CHANGE & NATIONAL PARK

Wildlife

A Survival Guide for a Warming World

Grizzly, Denali National Park, Alaska © Michael S. Quinton/Getty

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Chipmunk in Glacier National Park, Montana © Ian Shive/Aurora Photos

CLIMATE CHANGE AND NATIONAL PARK WILDLIFE:

Risk & Opportunity

The effects of climate change have been visible for years in our national parks. Glaciers are disappearing faster than scientists had predicted even a few years ago. Native trees and animals are losing ground because changing temperature and weather patterns are making the availability of food, water, and shelter less certain. Fish and wildlife are being driven from their national park homes by changes that are unfolding faster than the animals' ability to adapt.

Changes that harm wildlife — depriving them of food, water, or shelter — will ultimately harm us.

Climate change is here and now, affecting the coral reefs in Florida at **Biscayne** National Park, lodgepole pines in **Rocky Mountain** National Park and animals that rely on snow in Yellowstone National Park. The danger signs are a clear call to action for the National Parks Conservation Association, a nonprofit citizens' organization that works to enhance and restore America's national parks for present and future generations.

What's happening in the parks is symptomatic of changes unfolding across the larger landscapes to which they are inseparably connected, the same landscapes that contain our communities. Changes that harm wildlife — depriving them of food, water, or shelter — will ultimately harm us. Given the iconic importance of parks, and that they protect core ecoregions of this country, working to safeguard parks and their wildlife from climate change should be a central strategy in safeguarding our nation from climate change.

Solutions are neither simple nor quick and easy. It will take decisive action on the part of our federal government and all of us to meet the challenge and keep our faith with future generations. To avoid the potentially catastrophic loss of animal and plant life, it is imperative that we wean ourselves from energy sources like coal and oil that are accelerating rising temperatures and causing unnatural climate change. And it is equally imperative that we pursue new strategies to preserve functioning ecosystems and the full diversity of life they support.

Right now, no national plan exists to manage wildlife throughout their habitat, which often is a patchwork of lands managed by multiple federal agencies, states, tribes, municipalities, and private landholders.

National parks can play an important role in these strategies, preserving healthy ecosystems and their wildlife, in part by helping them to adapt to new climatic conditions. But some challenges must be addressed before the parks can fully step into this role. Right now, no national plan exists to manage wildlife throughout their habitat, which often is a patchwork of lands managed by multiple federal agencies, states, tribes, municipalities, and private landholders. Wildlife need corridors that enable them to migrate between protected lands as climate change renders their current homes inhospitable. We also need to work harder to reduce air and water pollution that compound climate change stresses on wildlife. All of these elements must be put in place as soon as possible to safeguard all living communities.

This is a unique moment in time to leverage the power of America's national parks for change. A confluence of events, including a new Ken Burns film series on the national parks, the release of the National Parks Second Century Commission's vision for the park system, the new leadership at the Department of the Interior and National Park Service who are making climate change a top priority, and the galvanizing focus of the coming Centennial of the National Park Service in 2016 can catalyze public support to safeguard our national parks from climate change.

We must act now to secure America's natural legacy before it is lost to our children and grandchildren. The National Park System can play a central role in restoring and preserving the healthy ecosystems necessary for wildlife — and indeed ourselves — to thrive.

Tom C. Kiernan, President, National Parks Conservation Association

FIVE STEPS TO SAFEGUARD AMERICA'S WILDLIFE & OURSELVES FROM

Climate Change

America's national parks are showing the signs of climate change. From Yosemite's forests in California to the Gulf Stream waters of the Florida coast, from the top of the Rocky Mountains to the shores of the Chesapeake Bay, these lands and the incredible diversity of life they support are all feeling the heat.

The choice is now ours to either chronicle their decline or take actions to make our national parks part of the climate change solution. If we fail to act, many species of fish and wildlife could disappear from the parks — or even become extinct.

That we must reduce global warming pollution to protect our natural world and human communities is now understood by many. But that is not all we must do. Unnatural climate change is already underway and will continue for decades even if we put a stop to all global warming pollution today.

Additional steps must be taken now to safeguard wildlife. We must protect the places that will help wildlife survive as the climate changes, manage wildlife anticipating the changes ahead, and improve the ecological health of the national parks and their surrounding landscapes to give fish and wildlife a fighting chance to survive unnatural climate change.

National Parks Conservation Association (NPCA) advocates five steps that, taken together, will help safeguard fish and wildlife, their homes, and our communities, from climate change. Here's what needs to be done:

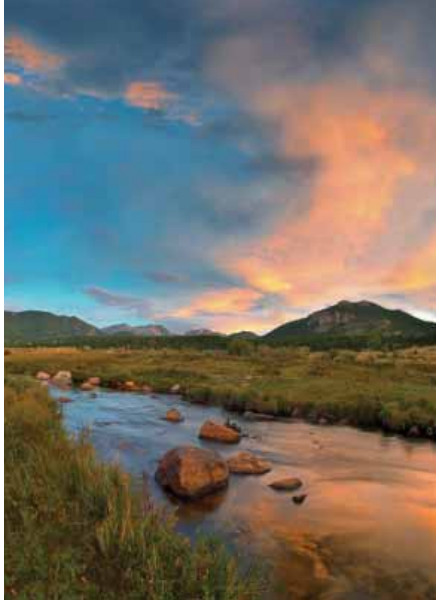
If we fail to act, many species of fish and wildlife could disappear from the parks — or even become extinct. We can safeguard the wildlife of America's national parks if we take the following ***five steps:***

We must limit the effects of climate change by rapidly reducing greenhouse gas emissions and switching to less-polluting sources of energy.

#1: Stop contributing to climate change

Many wildlife species are struggling to cope with climate changes already underway. Some will not be able to endure much more change, and could disappear from national parks and even go extinct if climate change is unchecked. We must limit its effects by rapidly reducing greenhouse gas emissions and switching to less-polluting sources of energy.

- Coral reefs protected by **Biscayne** and **Virgin Islands** national parks might not survive if we fail to reduce carbon dioxide pollution that is warming and acidifying the ocean.
- Salmon might disappear from **Olympic**, **North Cascades**, and **Mount Rainier** national parks if climate change continues to alter stream flows, increase water temperatures, and create extreme downpours that wipe out young salmon.
- Grizzly bears, birds, fish, and other animals in **Yellowstone** and **Rocky Mountain** national parks could decline if the lodgepole and whitebark pine forests that sustain them continue to be wiped out by the advance of bark beetles, drought, and other climate change-related forces.



#2: Reduce and eliminate existing harms that make wildlife more vulnerable to climate change

The damaging effects of climate change are compounded by existing stresses on wildlife. Air and water pollution, development of adjacent wild lands, logging and mining, and other forces are harming national park wildlife now, and adding climate change to the mix could be disastrous. By reducing and eliminating these environmental harms we can significantly decrease the vulnerability of plants, fish, and wildlife to climate change as well as produce rapid and tangible benefits — such as clean air and water — that both people and wildlife need to thrive.

- Water pollution and non-native species are already stressing waterfowl, shorebirds, and migratory birds that visit **Sleeping Bear Dunes National Lakeshore** and other **national parks** in the **Great Lakes** region. By cleaning up water pollution and combating invasive species, we can give birds that depend on the Great Lakes a better chance to survive climate-related changes.

- Historic overharvesting, disease, and pollution have caused a massive decline in **Chesapeake Bay** oysters. A more aggressive approach to reducing these threats would help the bay's oysters survive climate change stresses such as warmer waters and heavier floods that flush pollution in to the Bay and introduce more fresh water than the oysters can tolerate.

- Pesticides, disease, and non-native trout have nearly eliminated the mountain yellow-legged frog from **Yosemite, Sequoia,** and **Kings Canyon** national parks. Reducing these threats and restoring healthy populations of frogs throughout the parks could help them survive the loss of shallow ponds and streams expected to occur in some areas as the climate continues to warm.

By reducing and eliminating existing environmental harms we can significantly decrease the vulnerability of plants, fish, and wildlife to climate change as well as produce rapid and tangible benefits — such as clean air and water — that both people and wildlife need to thrive.

Because national parks, like all protected areas, are interconnected with surrounding landscapes, cooperation and coordination among all land owners — public and private — is essential to preserve functioning ecosystems and the wildlife they support.

#3: Give wildlife freedom to roam

Climate change will cause some wildlife to move outside the parks' protected boundaries, while other species may move in. Because national parks, like all protected areas, are interconnected with surrounding landscapes, cooperation and coordination among all land owners — public and private — is essential to preserve functioning ecosystems and the wildlife they support. National parks can play a key role in conserving wildlife across the landscape. In some cases they provide natural corridors; in other cases new corridors will be needed to connect parks and other protected lands so that wildlife can move in response to climate change.

- Thanks to the efforts of the National Park Service, there is an unbroken, 2,175-mile corridor of protection, the **Appalachian** National Scenic Trail. Stretching from Georgia, north through **Great Smoky Mountains** and **Shenandoah** national parks, to Maine, the trail and its network of parks stands ready to serve as a corridor and refuge for species that need to move in response to climate change.

- Desert bighorn sheep that frequent **Arches, Canyonlands,** and **Capitol Reef** national parks shift location in response to seasons and weather. As climate change alters precipitation and vegetation patterns, new migration patterns could emerge. Working together, wildlife managers and private landowners can ensure pathways are available for bighorn sheep to access food and water they need to thrive.

- The caribou that live in and pass through Alaska's high arctic parks — **Noatak** and **Bering Land Bridge** national preserves**, Kobuk Valley** National Park**,** and **Gates of the Arctic** National Park & Preserve — also roam across a landscape with a patchwork of federal, state, and tribal owners. As climate change renders traditional calving grounds and winter feeding areas unsuitable, wildlife managers working together can identify new habitat and ensure the path is clear for caribou to get there.

#4: Adopt "climate smart" management practices

"Climate smart" management includes four key elements: (1) training national park managers to build climate change into their work, (2) establishing guidance and policies that enable park staff to work closely and equally with other federal, state, local and private landowners, (3) providing sufficient funding and staffing for the challenge at hand, and (4) creating a political and organizational setting that facilitates appropriate, timely, and collaborative action. While research and monitoring should be a part of any park's approach to "climate smart" management, real focus needs to be placed on implementing management changes now based on what we already know.

"Climate smart" management requires real focus on implementing management changes now based on what we already know.

- For wolverines in **Yellowstone** and **Glacier** national parks, the loss of deep winter snows could mean fewer winter-killed animals that are essential to their diet. A healthy wolf population creates ample carrion. Further research could confirm that maintaining a healthy wolf population is a "climate smart" strategy for helping wolverines survive as winter snows decline.

- Nestled between its larger neighbors in the Sierra Nevada Mountains — **Yosemite** and **Sequoia** — **Devils Postpile** National Monument is home to a great diversity of wildlife. But at only 800 acres, the park cannot by itself meaningfully address climate change impacts on its wildlife. So the park superintendent is developing a plan in coordination with managers of the surrounding national forest to protect wildlife throughout the larger ecosystem.

- Northeast coastal parks like **Acadia** National Park and **Fire Island** National Seashore provide critical nesting and feeding areas along the Atlantic migratory flyway. Sea level rise threatens to swamp some bird habitat along the flyway. Working together, resource managers from the Park Service and other federal, state, and local agencies can identify and protect critical habitat, restore marshes, and take steps that allow coastal habitats the opportunity to shift inland.

National parks can help visitors understand climate change already occurring, the vulnerabilities of tomorrow, and how we can all reduce our contribution to global warming.

#5: National parks lead by example

With more than 270 million annual visitors, a core education mission, and a tradition of scientific leadership, national parks have an unparalleled ability to engage Americans in the fight against climate change. National parks can help visitors understand climate change already occurring, the vulnerabilities of tomorrow, and how we can all reduce our contribution to global warming. National parks can also serve as natural laboratories for testing innovative ways to safeguard wildlife from the effects of climate change, and to reduce greenhouse gases that are causing climate change.

- Throughout the country, national parks such as **Everglades**, the **Smokies**, **Glacier**, and **Yosemite**, have banded together as **Climate Friendly Parks**. They share common goals of reducing their own greenhouse gas emissions and demonstrate sustainable solutions to others. NPCA operates ***Do Your Part!***, a program that carries the parks' sustainability message to the general public and provides individuals with opportunities to do their part to reduce global warming pollution.

- The National Park Service is beginning to experiment with **scenario planning**, a model that identifies future scenarios that could occur with increasing climate change and explores management responses for each. The model will help managers develop action and monitoring plans that give them the information and flexibility they need to maximize the chance not of the single "best" outcome — a risky approach when uncertainty is high — but the chance of *some* positive outcome.

By safeguarding wildlife, we help secure our own future

National parks are America's national treasures. It is a uniquely American idea that each of us owns our national parks. They have been entrusted to us, and it is our responsibility to make sure that climate change does not rob the parks of their incredibly rich array of plants, fish, reptiles, birds, and mammals.

Wildlife is threatened now as perhaps never before. The Intergovernmental Panel on Climate Change warns that up to a quarter of assessed species could face extinction due to global warming by the end of this century. It's difficult to imagine that the changes leading to mass wildlife extinctions would not also profoundly threaten human life.

Decisive action now can help bring about a more hopeful future for wildlife and for ourselves. Taking the five steps recommended here will help safeguard national park wildlife by preserving and strengthening the ecosystems that support all wildlife. In turn our communities, which have always relied on healthy natural resources, will be better equipped to cope with the changes ahead.

They have been entrusted to us, and it is our responsibility to make sure that climate change does not rob the parks of their incredibly rich array of plants, fish, reptiles, birds, and mammals.

Mark Wenzler

Mark Wenzler, Director, Clean Air & Climate Programs, National Parks Conservation Association

Lara Hansen, PhD, Chief Scientist & Executive Director, EcoAdapt

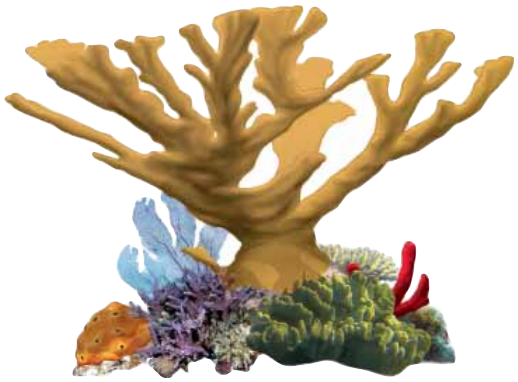
Hawksbill Turtle finning over coral reef © Richard Carey/iStockphoto

Venture beneath the surface and you'll encounter a rich, vibrant ecosystem that contains fanciful sea life ranging from sharks and sea cows to the only living tropical coral reef in the continental United States.

Coral Reefs
of Southern Florida and the Caribbean

Neon-hued parrotfish. Graceful angelfish the size of dinner platters. Delicate sponges that sway in the currents. Coral communities teeming with colorful marine life. Our fascination with the oceans and their denizens has led Congress to include within the National Park System some of the nation's most incredible and beautiful marine ecosystems.

Ninety-five percent of **Biscayne** National Park, for instance, is underwater. Venture beneath the surface and you'll encounter a rich, vibrant ecosystem that contains fanciful sea life ranging from sharks and sea cows to the only living tropical coral reef in the continental United States. Known as the Florida Reef Tract, it is the world's third-largest reef and wraps from Biscayne on Florida's eastern shore all the way to **Dry Tortugas** National Park off the state's southwestern tip. Within Dry Tortugas you will find a seascape similar to that of Biscayne, with a wide variety of marine life protected within the park's borders. You will also find a 46-square-mile research natural area that offers an added layer of protection by prohibiting anchoring of boats and fishing which can physically damage coral reefs, while providing an area for unfettered marine ecosystem research. Park managers hope that threatened staghorn corals, which have declined by 99 percent in the park's waters since 1977, will benefit from these additional protections and expanded research opportunities.



In recent decades there have been significant changes in the coral reef communities of Florida and the Caribbean.

Unfortunately, multiple problems confront coral reefs. Over-fishing can reduce fish species that are critical to coral reef health. In addition, water quality issues and physical disturbances have been long-standing problems. Now climate change threatens to exacerbate these stressors.

Both staghorn and elkhorn corals were listed as threatened species under the Endangered Species Act in May 2006, partly due to the threats posed by climate change. Two years later, in November 2008, the National Marine Fisheries Service designated part of Florida's waters and those in the U.S. Virgin Islands, including **Virgin Islands** National Park, as critical habitat for these two corals. Designations of critical habitat are important steps in protecting corals, but the human-caused stressors, as well as global stressors such as climate change, must also be addressed.

In recent decades there have been significant changes in the coral reef communities of Florida and the Caribbean. More potent and numerous hurricanes and coral "bleaching" — a phenomenon in which corals stressed by too-warm water or other stressors turn white as they expel their resident algae — are damaging, if not outright destroying, these valuable ecosystems. The most significant bleaching episode to date in the Florida Keys occurred in 1997-98. Compounding that event were Hurricane Georges and Tropical Storm Mitch, which added to the reef damage. The extent of damage varies from year to year, but declines in many coral reef habitats have been recorded throughout the Florida Keys in the last two decades. Warming ocean temperatures and disease may have been primary contributing factors to these declines. In **Virgin Islands** National Park, three months of abnormally elevated water temperatures led to extensive bleaching followed by disease outbreaks that resulted in an average decline in hard coral cover of more than 51 percent during 2005. The future seems bleak, as scientists expect bleaching episodes to become a more frequent calling card of climate change.

The latest climate-related threat to coral reef ecosystems is ocean

acidification. While the oceans' capacity to absorb atmospheric carbon dioxide makes them great "carbon sinks," they are absorbing so much that their pH is decreasing and ocean waters are becoming more acidic. If left unchecked, this acidification threatens to deprive corals of their ability to create and maintain their calcium carbonate skeletons (acid dissolves calcium carbonate). And it is these skeletons, when assembled in mass, which create the reefs.

Along with global stressors such as warming waters and hurricanes are localized man-made stressors, including overuse, sedimentation, water pollution, physical disturbance (i.e., boat groundings), and disease — all of which affect the reefs.Over-fishing takes a toll by culling beneficial fish and invertebrate species that help control algal growth on corals.

The impacts of weakened and dying corals go beyond the somewhat monochromatic and crumbling skeletons left behind by bleaching and other damage. Not only are coral reef ecosystems some of the most diverse and species-rich ecosystems on Earth, but they are huge economic drivers for nearby communities. **Biscayne** National Park alone generates more than $23 million a year in economic activity thanks to its visitors, and the entire south Florida region profits $4.4 billion annually, along with more than 70,000 full- and part-time jobs, thanks to business associated with these ecosystems. Marinas, charter boats, fishing guides, dive shops, grocery stores, motels, restaurants, and gift shops all benefit from the reefs.

SOLUTIONS

How can we help protect coral reefs, the myriad species that depend on corals, and the economies of coastal communities? Stop contributing to global warming and work to alleviate the local human-generated stressors that may be hurting our reefs' chances of recovery from bleaching and other adverse effects of global warming. This will not be simple. Some say that even if greenhouse gas emissions dropped back to pre-Industrial levels (below 300 parts per million) in the atmosphere tomorrow, it could take as long as 40 years for a return to normal temperature regimes.

While impacts of climate change, such as warmer waters and more potent storms, can't be eased overnight, working to reduce the human-related impacts can help lessen the reefs' vulnerability to climate change. Studies have shown that reef ecosystems with a rich diversity of plants, invertebrates, and fish are more resilient to bleaching and rebound more quickly after bleaching episodes. Helping maintain such diversity are healthy mangrove forests, which serve as nurseries for fish fry that later inhabit reefs as adults. Human-produced stressors include the fertilizers, pesticides, and toxic substances that stormy weather flushes from coastal areas into the oceans, where the pollution can harm reefs. Through managing healthy populations of fish and combating human impacts the resilience of coral reefs to climate change actually can be heightened.

Understanding the interconnectedness of marine systems and managing them to promote species diversity, as well as minimizing or limiting human-caused impacts (e.g., sedimentation, over-fishing, pollution, physical disturbances), could help coral reef communities cope with the effects of climate change. Altering human impacts by getting stakeholders to realize the problems and work proactively to overcome them can start to pay off almost immediately. Such an approach will require National Park Service managers to work with other governmental agencies and bring together all stakeholders to develop and implement a comprehensive strategy to protect the reefs.

We Can Safeguard Coral Reefs from Climate Change

Stop contributing to climate change

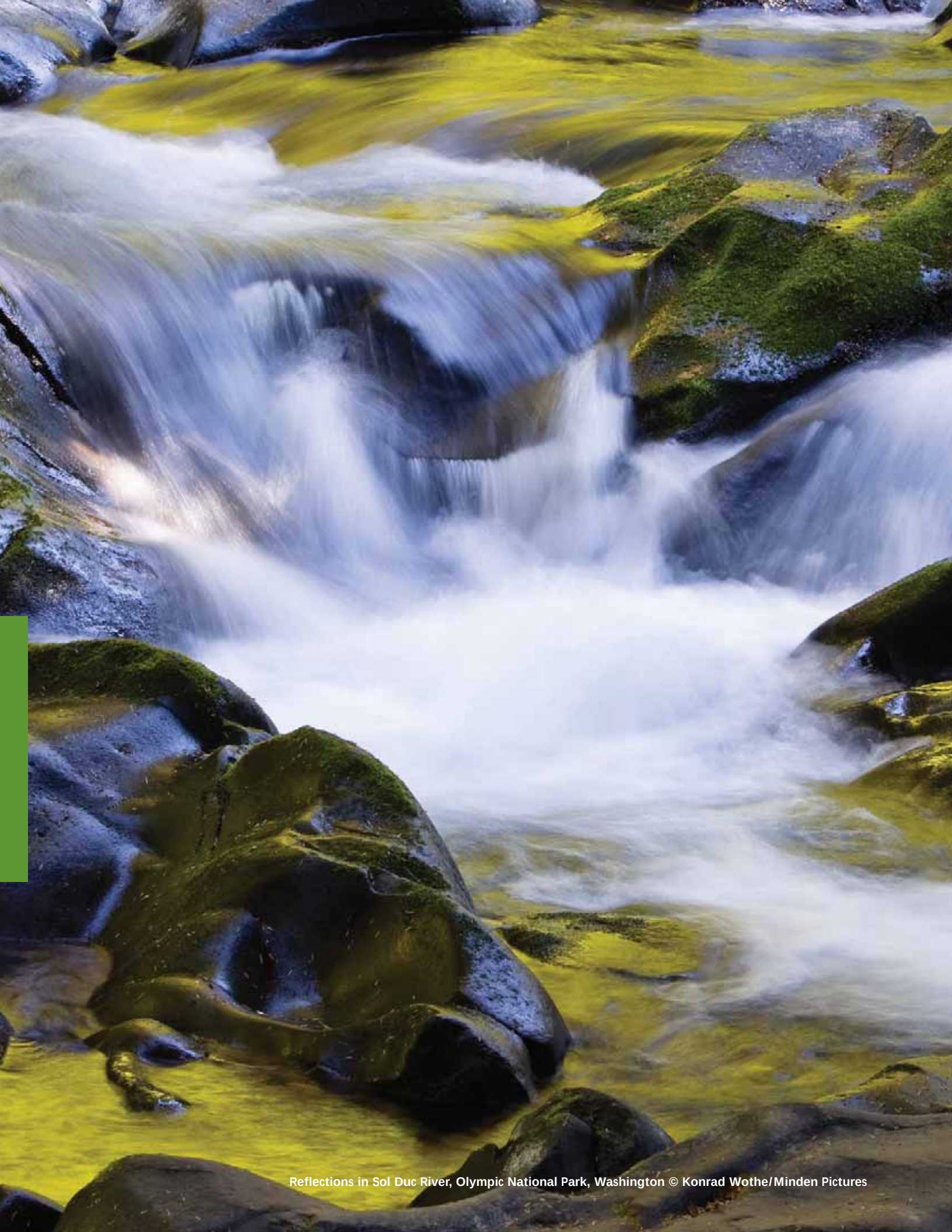
Coral reefs might not survive if we fail to reduce carbon dioxide pollution that is warming the waters and acidifying the ocean.

Reduce and eliminate existing harms that make coral more vulnerable to climate change

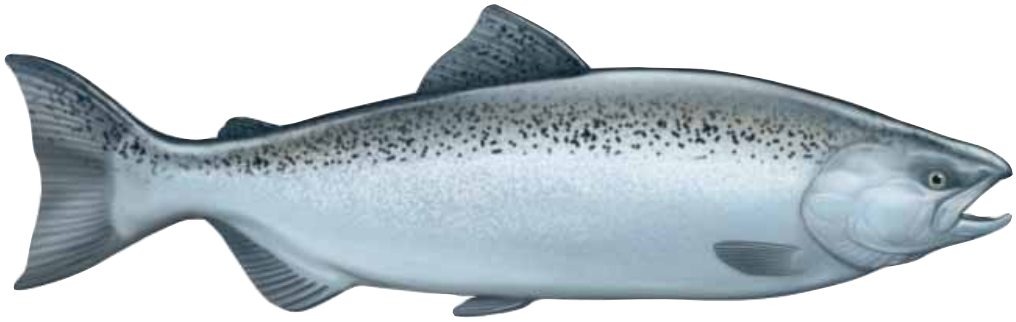
Reducing pollution runoff, sedimentation, over-fishing, and physical disturbances will help corals become healthier and better able to withstand climate change impacts.

Adopt "climate smart" management practices

National Park Service managers can bring together all stakeholders to develop and implement strategies that strengthen coral reef systems, such as restoring mangrove forests that shelter fish that help keep coals healthy, and minimizing human-caused impacts. These strategies should help coral reef communities become more resilient in the face of climate change.



Reflections in Sol Duc River, Olympic National Park, Washington © Konrad Wothe/Minden Pictures



Salmon
of the Pacific Northwest

Life is not easy for salmon in the Pacific Northwest. They're born inland, usually in a stream far from the ocean. Then, when they're old enough, they have to swim all the way to the ocean, hopefully timing it right so there will be plenty to eat when they arrive. Some years later, if they've managed to avoid the Pacific's predators, they have to retrace that journey to return to where they were born so they can mate. And then they die.

Unfortunately, that already difficult existence is likely to become even more grueling in the years to come as climate change is expected to alter stream flows, increase water temperatures, and flush fry and young smolts toward the ocean before they're ready.

Salmon in the Pacific Northwest aren't strangers to challenges posed by humans and our environmental alterations. Dams built in the early 1900s along the Elwha River, which originates in the mountains of **Olympic** National Park, have stood in the way of salmon migrations for years, as have dams throughout the Columbia River drainage. Over-fishing has strained salmon populations since the start of industrial harvest in the 19th century, as have pollution, logging, development, and agricultural demands for water. Conditions for salmon were so tough during the 20th century that by the time the 21st century rolled around salmon in the

Salmon in the Pacific Northwest aren't strangers to challenges posed by humans and our environmental alterations.

Ensuring that fisheries maintain healthy stocks of the various salmon populations, while carefully managing habitat needs, could be key in confronting climate change.

Northwest had vanished from about 40 percent of their historical range. Climate-change scenarios predict tougher times ahead.

Various predictive scenarios agree that a warming climate will result in more winter rains and fewer winter snows in the Northwest. The snow that does fall is expected to melt earlier in the year, likely leading to sooner-than-usual peak stream flows that could wash salmon fry down to the Pacific Ocean before the nutrient base (i.e., plankton blooms) the fish depend upon is in place. A review of the winter storm projections made to date shows that it also wouldn't be surprising to see more devastating downpours, such as those that raked **Olympic**, **Mount Rainier**, and **North Cascades** national parks in November 2006 and again in the fall of 2007. Those storms blew out roads, washed away campgrounds, obliterated hiking trails, and scoured out rivers and streams.

Beyond such storm scenarios, increased stream water temperatures created by a combination of higher air temperatures, shallower streams that flow more slowly, and the release of warm, stagnant waters from reservoirs behind dams could prove deadly to salmon. Studies have shown that sustained exposure to waters that are 70 degrees Fahrenheit or above is usually fatal to salmon.

Water politics in the western United States have long been contentious;

climate change and its effects promise to further complicate matters by reducing already low summertime flows. Concerns about reduced stream flows could lead to calls for more water storage facilities — projects that, if approved, would further threaten salmon.

The combination of all of these factors has led scientists to predict that suitable salmon habitat in Washington state alone could shrink by about 22 percent by 2090 due to climate change.

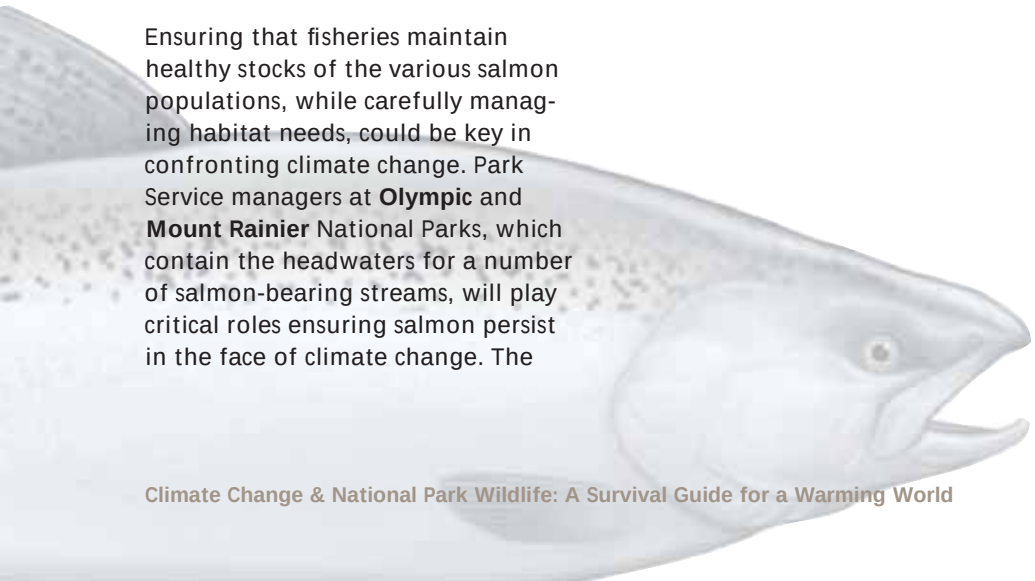
SOLUTIONS

Confronting the effects of climate change won't be easy, but it's not impossible. There are ways to mitigate the effects of climate change. In the past, land management agencies have been slow to act to address the future effects climate change will have on water resources. Now is the time to factor climate change into management policies, including recovery plans for threatened and endangered species. While many public land managers in the Pacific Northwest have had to create habitat conservation plans for one or more salmon species that have been listed as threatened or endangered under the Endangered Species Act, at present none appear to have factored climate change into their plans. Doing so could be as simple as realizing that it's necessary to sustainably manage fisheries to promote the most species diversity possible.

Ensuring that fisheries maintain healthy stocks of the various salmon populations, while carefully managing habitat needs, could be key in confronting climate change. Park Service managers at **Olympic** and **Mount Rainier** National Parks, which contain the headwaters for a number of salmon-bearing streams, will play critical roles ensuring salmon persist in the face of climate change. The National Park Service will also need to work closely with other management agencies because salmon migrate through waters that fall under various jurisdictions.

In the case of warming waters, efforts to preserve trees on stream banks could help cool rivers and streams. Dam removal also helps lower temperatures by allowing more natural stream flows, and it restores access to salmon habitat. Already, the Park Service is part of the largest dam removal project in history. The Elwha Dam and the Glines Canyon Dam, both on the Elwha River, will be removed in stages beginning in 2011. This will restore access to more than 70 miles of salmon habitat. When dam removal isn't feasible, releasing cool water from the bottom of reservoirs could help lower river and stream temperatures.

Other ways to help salmon cope with the effects of climate change include working to maintain stream flows for salmon during anticipated periods of low flow; improving existing in-stream habitat by maintaining or restoring riparian areas, decreasing pollution and sedimentation, and adding woody debris where appropriate; acquiring new habitat; protecting groundwater recharge; and removing obstacles to up- and downstream migrations. Preserving naturally occurring springs, which provide an influx of cool water to streams, is also important.



We Can Safeguard Salmon from Climate Change

Stop contributing to climate change

Salmon could decline even further if we fail to reduce carbon dioxide pollution and global warming that is causing heavier spring floods and warmer water detrimental to salmon.

Reduce and eliminate existing harms that make salmon more vulnerable to climate change

Dam removal, restoration of riparian lands, and reduction of pollution and sedimentation will help restore and improve salmon habitat and help salmon cope with the additional stresses resulting from climate change.

Adopt "climate smart" management practices

By factoring climate change into the numerous existing plans to preserve salmon and their habitat, resource managers for the Park Service and throughout the Pacific Northwest can develop and implement strategies that attempt to compensate for the damaging effects of climate change on salmon populations, including warmer water and heavier spring floods.

Sunset over river and peaks in Moraine Park, Rocky Mountain National Park, Colorado © Tim Fitzharris/Minden Pictures

Studies have shown that when there's a good whitebark pine nut crop, grizzly sows gorge on them and head into hibernation both fatter and healthier.

Grizzly Bear

and other wildlife among the Rocky Mountain pine forests

Natural events — wildfires, floods, windstorms — often leave behind obvious marks on the landscapes they touch. Charred trees and scorched meadows, washed out trails, and swaths of fallen trees are some of the reminders of these powerful forces. The impacts wrought by other naturally occurring events and cycles are not always so easy to discern. For example, mountain pine beetles, the size of grains of rice, have long played an important role in forest ecosystems, but as climate change upsets the rules that once governed the dynamics between beetles and forests, the beetles' effects on forest ecosystems are bordering on catastrophic. Even the mighty grizzly bear, denizen of the northern Rockies, is likely to suffer from the changes wrought by the tiny pine beetle.

Diminutive in size, the beetle's lifecycle revolves largely around lodge-pole pines, primary components of forests throughout the Rocky Mountain region, including the forests of **Rocky Mountain** National Park. Adult beetles bore through the trees' outer bark and into the phloem

Reversing the warming trends that are allowing the pine bark beetle to thrive could take decades, but land managers have begun discussions about how best to combat the beetles under climate change scenarios.

tissue where they burrow about eating and laying eggs. When the eggs hatch the following year, the young eat their way back out, and head off in search of another lodgepole to start the process anew. Left behind is a tree that soon dies, its flow of nutrients thought to be fatally disrupted by the beetles.

Lodgepoles are not completely defenseless against the beetles' attack. They respond to the onslaught by exuding copious amounts of resin that drown many of the beetles. Cold snaps of 40 degrees below zero for ten days or more are also capable of killing the beetles, providing a respite for the trees. Large-scale fires can also help forests deal with the beetles because they promote the release of lodgepole seeds from their cones, leading to eventual germination and growth of new trees.

Mountain pine beetles and lodgepole pine forests have long coexisted. But climate change is stacking the ecological cards against the lodgepole forests of the southern Rockies and in favor of the beetles. For starters, those deadly Rocky Mountain cold snaps are becoming few and far between. In addition, warming temperatures in recent decades have enabled the pine beetles to significantly broaden their infestations by (1) allowing them to complete their lifecycle in one year instead of two, a development that could lead to a doubling in the beetle's population growth rate, and (2) enabling the beetles to move higher in elevation

and attack not only more lodgepole pines but also whitebark pines that did not evolve with the insects and so have no natural defenses. In **Rocky Mountain** National Park, not only is climate change likely to aid pine beetles with warmer temperatures, but a dryer climate in the park's forests could further hinder the lodgepole pine's beetle defenses by reducing its resin resources. The warming and drying could also make the forests more prone to disease, further increasing their susceptibility to beetle attack. Park officials expect the predicted warming to initially make the lodgepole forests more susceptible to fire. In the long run, though, fire danger could drop due to a decrease in fuels.

Back in 2001 the U.S. Forest Service predicted that by 2017 some 21 million acres of Western forests were in danger of suffering "significant tree mortality" tied to the pine beetles. More recently, forestry officials are projecting that *all* mature lodgepole forests in Colorado will be dead by 2013. The impacts likely will be far-reaching. Fires kindled by lightning or careless humans in the tinder-dry forests of dead lodgepoles will create air-quality problems, damage watersheds, impact wildlife and possibly fisheries, affect the logging industry, threaten communities, and cost millions of dollars to fight.

The makeup of forests likely will change, too, as beetle outbreaks kill large swathes of lodgepole stands that then are susceptible to fires. Additionally, climate change is enabling this beetle to make longer and longer forays into the upper elevations of the greater **Yellowstone** ecosystem, inroads that are seriously jeopardizing another key tree species — whitebark pine — whose disappearance could have dire ramifications for the overall health of the ecosystem in general and the grizzly bear specifically.

Historically, whitebark pines have been out of reach of pine beetles. While there have been isolated infestations in this pine species, the beetles typically couldn't survive the cold winter temperatures in the highest reaches of the ecosystem. But warming has allowed the beetles to reach more and more whitebark pine stands, and to complete an entire life cycle in one, not two, years, as was the old norm. These current infestations are unprecedented and threaten the future of the ecosystem. Some whitebark pine stands in the greater Yellowstone ecosystem have lost more than 90 percent of their trees to the beetles.

Remove whitebark pines from the ecosystem and you also remove their pine nuts, which are a valuable, high-protein segment of grizzly bears' fall diets. Studies have shown that when there's a good whitebark pine nut crop, grizzly sows gorge on them and head into hibernation both fatter and healthier. A key result is that they have larger and healthier cub litters than sows that hibernate with depleted reserves.

SOLUTIONS

Reversing the warming trends that are allowing the pine bark beetle to thrive could take decades, but land managers have begun discussions about how best to combat the beetles under climate change scenarios. Initial suggestions include creating forests of different age-group trees (beetles bypass young trees and instead focus on those at least 5-6 inches in diameter at chest level); thinning forests to reduce the competition for nutrients and so produce healthier trees better equipped to combat and survive pine beetle attacks; and encouraging a diversity of tree species. Some parks and national forests also have been spraying pesticides and using pheromones to control mountain pine beetles, but these applications are controversial. Spraying pesticides in national parks runs counter to the National Park Service's mission to let nature run its course, and it is costly.

We Can Safeguard Wildlife that Depend on Healthy Forests

Stop contributing to climate change

Whitebark and lodgepole pine forests, and the wildlife that depend on them, will likely decline if we fail to reduce carbon dioxide pollution that is warming the Rocky Mountain region and aiding the spread of the pine beetle.

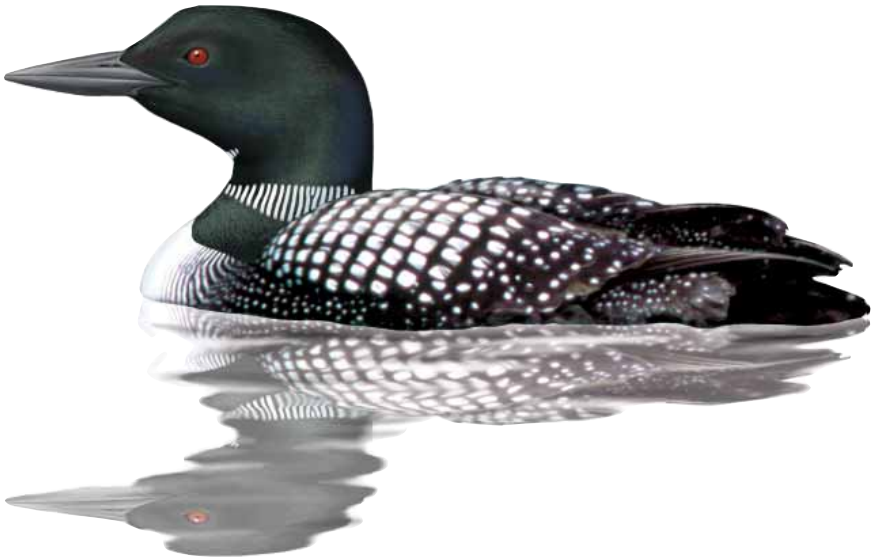
Adopt "climate smart" management practices

By identifying and implementing forest management practices that help preserve some intact whitebark and lodgepole pine forests, and by focusing their efforts on areas with the greatest concentrations of at-risk wildlife, resource managers for the Park Service and other agencies can help communities of grizzly bear and other wildlife survive as their landscape continues to change.

Give wildlife freedom to roam

Wildlife throughout the Rocky Mountain region that depend on whitebark and lodgepole pine forests need access to healthy forests as the trees in their current habitats succumb to pine beetle infestations.

Birch trees and sandstone cliffs along Lake Superior, Pictured Rocks National Lakeshore, Michigan © Carr Clifton/Minden Pictures



Loon

and other birds of the Great Lakes

Change is under way in the Great Lakes, the source of 84 percent of North America's fresh water and more than 20 percent of the world's supply. It is a progressive sweeping change that threatens to greatly transform the ecosystems of these inland seas by warming their waters and supplanting native species with harmful invasives. And it is a change that ultimately may threaten the viability of the common loon and dozens of other birds that depend on the lakes.

Many people see invasive species as the primary challenge in restoring lakes Superior, Michigan, Erie, Huron and Ontario, and the national parks of the Great Lakes experience these challenges firsthand. But equally challenging is climate change, for its impact is felt throughout the Great Lakes region on native and non-native species alike.

Many impacts of climate change — shorter winters, precipitation changes, decreasing duration of ice cover, increasing annual average temperatures that are boosting the temperature of the lakes — are already obvious. These changes affect the native fish and birds that call the Great Lakes home. Loss of winter ice jeopardizes reproduction of native whitefish by exposing eggs to the effects

Many impacts of climate change — shorter winters, precipitation changes, decreasing duration of ice cover, increasing annual average temperatures that are boosting the temperature of the lakes — are already obvious.

In recent years, tens of thousands of birds have perished from botulism that is erupting in the lakes, and which some scientists believe is partly a result of climate change.

of winter storms. Coldwater species such as coaster brook trout, found at **Pictured Rocks** and **Apostle Islands** national lakeshores and **Isle Royale** National Park in Lake Superior, are declining and will continue to do so as lake temperatures rise.

In recent years, tens of thousands of birds have perished from botulism that is erupting in the lakes, and which some scientists believe is partly a result of climate change. Species impacted include the common loon, Minnesota's state bird; mergansers, which summer and winter on portions of the lakes; Double-crested cormorants, which migrate through the region and summer on the lakes; and even the piping plover, an endangered shorebird that summers on portions of the lakes. Climate change and invasive species impact all levels of the food chain, beginning with an "invader" from Russia.

Zebra and Quagga mussels, shellfish species from Eastern Europe, arrived in the lakes via ballast water dumped by ocean-going ships. The issue with these mussels is that they multiply rapidly and act as millions of tiny water filters in the lakes. The increasing clarity of the water, combined with the lowering lake levels and warming waters, has fostered an environment that has spurred more and more *Cladophora* blooms. Although this alga is native to the Great Lakes, its recent growth spurts are highly atypical. The algae flourish, creating piles of rotting organic matter that

provide the perfect environment for Type E botulism bacteria to thrive. Mussels eat organic matter containing the toxin, concentrating it in their bodies.

Dispersing this poison are Round Gobies, yet another invasive species. These fish came to the Great Lakes from the Black and Caspian seas via ballast water in the mid-1990s. They've managed in their new home quite well, numbering in the billions in Lake Erie alone.

The gobies dine on the mussels as well as the decaying algae and become carriers for the botulism. Then waterfowl — loons, cormorants, and mergansers as well as songbirds, raptors and other fish-eating birds — feast on the dying gobies that float to the surface or wash ashore, ingest the botulism, and die. From 1999 to 2006 an estimated 70,000 birds were killed by this toxic diet. About 3,000 dead loons and cormorants washed up on the beaches at **Sleeping Bear Dunes** National Lakeshore in 2006 alone.

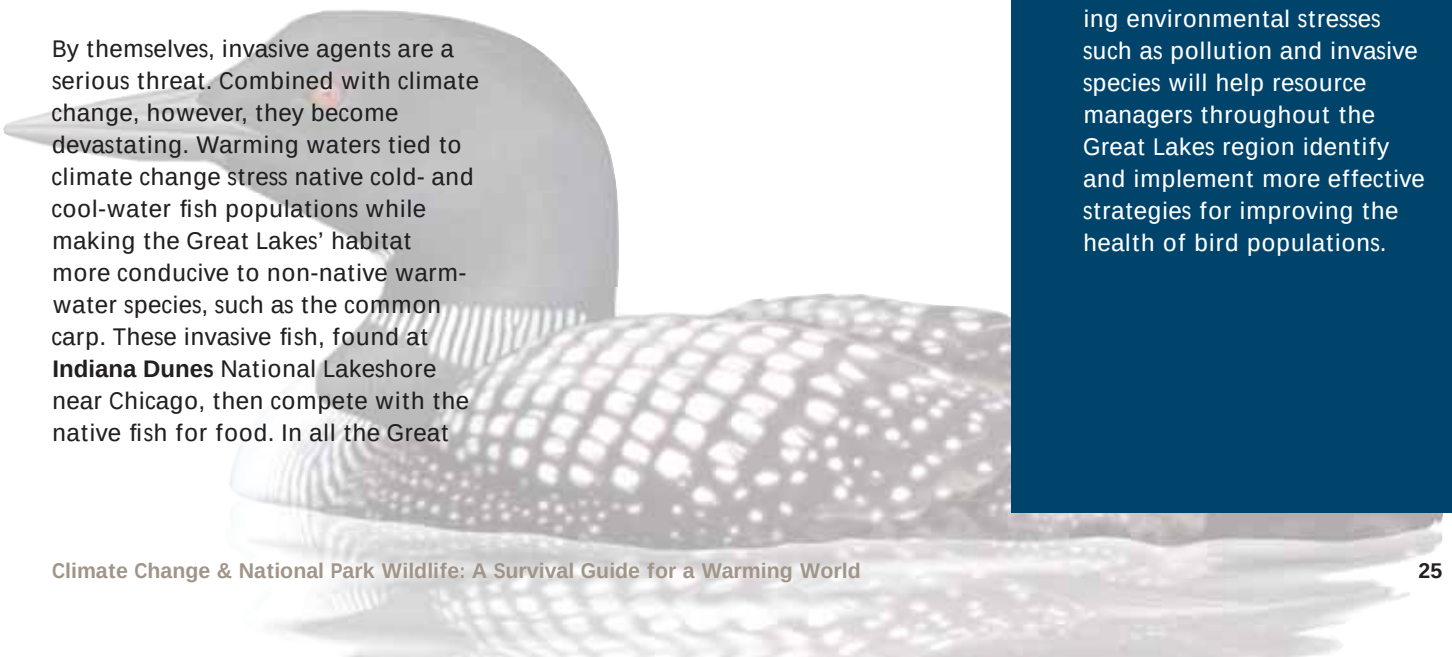
So while the invasive mussels and gobies have gotten much of the attention for their role in this massive bird die-off, climate change may be a key driver. If there were no botulism toxin, there would be no die-off, and climate change is creating conditions — warmer waters, lower lake levels, and possible seasonal increases in nutrient levels — more favorable to the bacteria that make the toxin.

By themselves, invasive agents are a serious threat. Combined with climate change, however, they become devastating. Warming waters tied to climate change stress native cold- and cool-water fish populations while making the Great Lakes' habitat more conducive to non-native warm-water species, such as the common carp. These invasive fish, found at **Indiana Dunes** National Lakeshore near Chicago, then compete with the native fish for food. In all the Great Lakes, longer duration of summer stratification will rise, increasing the risk for oxygen depletion and formation of "dead zones" for fish.

SOLUTIONS

Battling aquatic invasive species while coping with climate change will require a variety of solutions. They include further controlling phosphorous runoff that feeds algae growth, as well as tighter ballast-water regulations on ocean-going ships to control the spread of non-native species. There is also a need for physical barriers to prevent non-native species from reaching the Great Lakes via surrounding canals and waterways along with an intensive invasive species management program.

Complementing these lake-specific approaches would be an overall effort to reduce greenhouse gases that lead to global warming. The Great Lakes national parks have already shown leadership by exercising their authority to keep ballast dumping outside of park waters and by adopting "climate friendly" strategies, which include reduction of carbon-fueled park vehicles and public outreach and education.



We Can Safeguard Birds of the Great Lakes from Climate Change

Stop contributing to climate change

The ecological health of the Great Lakes and their bird populations could decline even further if we fail to reduce carbon dioxide pollution and climate change that is warming the water, aiding the spread of a toxin deadly to birds, and reducing the availability of fish.

Reduce and eliminate existing harms that make birds more vulnerable to climate change

By better controlling invasive species and polluted runoff we can retard the spread of algae and toxins, which will improve the health of the Great Lakes and help birds cope with the additional stresses wrought by climate change.

Adopt "climate smart" management practices

Understanding how climate change interacts with existing environmental stresses such as pollution and invasive species will help resource managers throughout the Great Lakes region identify and implement more effective strategies for improving the health of bird populations.

Sunset over the Chesapeake Bay, Maryland © Brian Palmer/iStockphotos

The Chesapeake once harbored oyster beds so rich and bountiful that they formed reefs.

Oysters
icon of the Chesapeake

Whether you call them Eastern oysters, American oysters, Rappahannock oysters, or simply "white gold," the iconic shellfish plucked from the Chesapeake Bay are a salty delicacy that some think is best served with a dash of horseradish and a squirt of lemon juice. Sadly, it's a delicacy that is not as abundant as it once was. The Chesapeake once harbored oyster beds so rich and bountiful that they formed reefs. That was the case in 1608 when Capt. John Smith explored the bay and found oysters so thick that ships could run aground on them. The **Chesapeake Bay Gateways Network**, administered by the National Park System, was established in 2006 to help preserve the rich cultural and natural history of the Bay, including its oystering heritage.

Today, Chesapeake Bay's oyster population is estimated to be less than one percent of what it was in the 1800s. Although natural oyster beds can still be found in the Chesapeake, their dramatic decline over the years due to pollution, over-harvesting, and disease has had a far-reaching effect on the

Warming bay waters associated with climate change, particularly in winter months, are responsible for the survival and virulence of a parasite that is killing the oysters.

overall health of Chesapeake Bay. Oysters filter water, feeding on algae and removing pollutants, sediments, and excess nutrients from the water column. Fewer oysters means less water-cleansing by these miniature filtration systems. Once there were enough oysters in the Chesapeake Bay, whose overall watershed represents the country's largest estuary, to filter all the bay water in as little as a week; these days it takes the resident oysters a year to accomplish the same task.

And now climate change has been added to the stresses affecting the oysters. Warming bay waters associated with climate change, particularly in winter months, are responsible for the survival and virulence of a parasite that is killing the oysters.

Compounding the impact of this parasite, *Perkinsus marinus* (also known as Dermo), have been wide swings in annual precipitation believed to be tied to climate change. And these swings in precipitation have become more lethal as the Chesapeake watershed has become more urbanized.

Between 1990 and 2000 there was a 60 percent increase in urbanization of the Chesapeake watershed as agricultural and forested lands were transformed into residential areas. This urbanization directly affected the amounts of phosphorous and nitrogen — usually stemming from the use of fertilizers, but also from vehicle emissions, treated wastewaters, manure, and even septic systems — flowing into the

Chesapeake. Although residential neighborhoods contribute lower flows of nutrients than agricultural lands, they contribute higher levels of nutrients than previously forested land. This nutrient flush is a prime factor in the bay's troublesome water quality. Higher nutrient levels spur booms in algal growth, which in turn can reduce the bay's oxygen levels through the buildup of decaying organic matter on the seabed.

Precipitation plays a role in determining the flow of nitrogen and phosphorus into the Chesapeake's waters. During dry years, much of the nitrogen and phosphorous is cached on shore, something that presumably would benefit the bay's waters. However, when powerful storms return they can flush these large caches of nutrients into the Chesapeake. The particularly wet year of 2003, for example, produced one of the worst instances of nutrient-loading in the bay, leading to oxygen deprivation for oysters and other sea life.

Heavy storms, which many believe are being spurred by climate change, do more than flush nutrients into the bay. Fresh water from the storms also kills oysters. When Tropical Storm Agnes swept the area in 1972, its rainfall killed an estimated 2 million bushels of marketable oysters, as well as most oyster larvae in the Chesapeake. In addition to killing oysters, fresh water runoff from storms typically doesn't blend well with salt water, so it can inhibit mixing that normally would cycle oxygen into deeper waters. This can result in low oxygen levels (hypoxia) on the bay bottom.

Oxygen levels in the bay are also affected as water temperatures warm due to climate change. Warm water holds less dissolved oxygen than colder waters and also leads to higher rates of plant decay that contribute to hypoxia.

SOLUTIONS

What's to be done? If we stop contributing to climate change we may be able to keep temperatures in the Chesapeake Bay from warming to an even greater extent, further supporting the spread of oyster-killing parasites. Keeping global warming in check might also prevent storms from growing even stronger and increasing the flow of the harmful sediments into the Bay.

We must also work to preserve remaining wetlands, marshes, and forests — they naturally filter excess nitrogen, phosphorus, and sediment from stormwater, and protect community streams and rivers, and ultimately the Chesapeake. More accurate information from EPA about the Bay's condition will help leaders at all levels of government identify key habitats to restore and preserve, and make other management decisions that benefit healthy oyster populations.

On top of preserving habitat, communities must make choices to reduce the flow of these pollutants into neighborhood streams. We can choose clean water by reducing fertilizer use throughout the watershed, replacing failing septic tanks, and ensuring all existing septic tanks can withstand sea level rise. We can take measures to slow runoff during storms. If individuals, business owners, and officials at every level of government from Cooperstown, New York to Virginia Beach choose clean water, our local streams will be healthy, and the Chesapeake Bay will once again support an abundant population of this iconic native inhabitant.

We Can Safeguard the Chesapeake Bay and its Oysters from Climate Change

Stop contributing to climate change

The ecological health of the Chesapeake Bay and its oyster populations could decline even further if we fail to reduce carbon dioxide pollution and global warming that is warming the water, aiding the spread of deadly parasites, and contributing to the runoff of harmful pollutants.

Reduce and eliminate existing harms that make oysters more vulnerable to climate change

By better controlling polluted runoff from farms and towns, and by restoring and preserving wildlife habitat surrounding the Chesapeake Bay, we can reduce existing stresses on the Bay's oyster populations, which could help them cope with changes wrought by global warming.

Adopt "climate smart" management practices

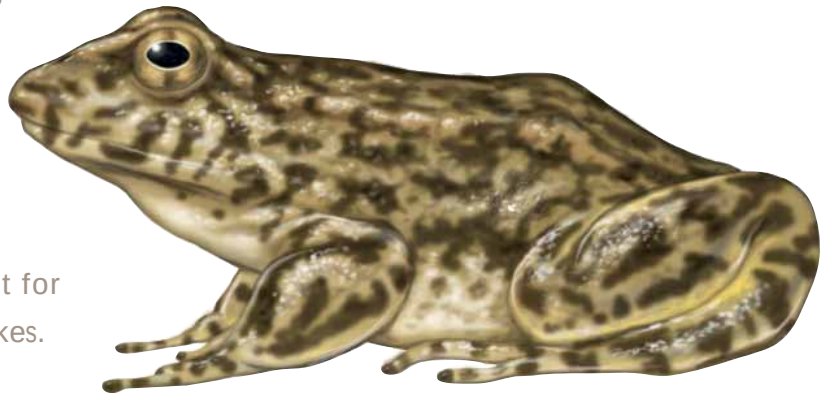
By factoring climate change into existing plans to restore the Chesapeake Bay, resource managers for the Park Service, EPA, and state and local agencies can develop and implement strategies that attempt to minimize the damaging effects of climate change on oysters, including heavier than usual floods.

Yosemite valley, river, Yosemite National Park, California © David Noton/npl/Minden Pictures

Climate change predictions for the region suggest altered precipitation patterns that will lead to less snowpack in the Sierra Nevada, a development that would be dire for the frogs.

Yellow-Legged Frogs
of the Sierra Nevada mountains

The mountain yellow-legged frog was once one of the most abundant vertebrates in the Sierra Nevada. The flash of its yellow legs could be seen and the echo of its croaking could be heard across the Sierra's alpine lakes, even those nestled at 12,000 feet that contain watery habitats typically too cold for amphibians. Unfortunately, that empire began to crumble as long ago as 1850 when non-native trout were first transplanted into some of those lakes to increase fishing opportunities. The introduced fish found the frogs and their offspring to be delectable. Fish stocking became more vigorous in the 1920s when the State of California took control of the program; in the 1950s the program was stepped up again as ground crews transplanting trout received aerial support for stocking some of the high backcountry lakes.



For "Climate Smart" Management, Bigger Isn't Necessarily Better

Nestled between its national park neighbors in the Sierra Nevada, **Devils Postpile National Monument** is demonstrating that even small parks can adopt "climate smart" management. At just 800 acres, the park is nevertheless biologically rich, with roughly 400 plant species and 100 bird species, and is a mixing point for such eastern and western Sierra vegetation as Red fir, sagebrush, and Great Basin juniper. In spite of the park's small size, Devils Postpile Superintendent Deanna Dulen is working to develop a General Management Plan designed to, in effect, turn the monument into a refuge of sorts from climate change. Working with officials from the Inyo National Forest, which surrounds the monument, Superintendent Dulen hopes to develop a plan that will guide management for the next 20 years of not just the monument's 800 acres but also for a considerable swath of the surrounding national forest that shares the canyon containing the headwaters of the Middle Fork of the San Joaquin River. Superintendent Dulen believes that the monument will be able to serve in the years ahead as a vital link for species migration as well as a living seed bank.

One of the reasons we know so much about the historic distribution of the mountain yellow-legged frog and its habitat needs was one of the most ambitious scientific explorations ever conducted, the Grinnell Survey. Launched in 1908 and led by field biologist and zoologist Joseph Grinnell, it cruised through a wide swath of California, including a good chunk of **Yosemite** National Park, in an audacious bid to document the state's natural systems. The survey ran for three decades and created an invaluable ecological database for the Sierra Nevada from the 20,000 specimens collected and the 13,000 pages of field notes. Some of those jottings, made in 1924 by Grinnell himself, noted that the mountain yellow-legged frog was a "common resident practically throughout the Yosemite region." But Grinnell also pointed to the decline of the mountain yellow-legged frog and attributed its demise to trout stocking.

Today it's thought that the frogs inhabit less than 10 percent of their historical distribution, in part because of the trout stocking. But the frog's future outlook has improved of late. In **Yosemite** and **Sequoia** national parks ecologists have been working in recent years to remove trout from dozens of lakes, and the amphibians are rapidly rebounding. In some instances, lakes that held fewer than 200 frogs in 2001 saw populations explode to 14,000 tadpoles and 3,600 adults three years later after most of the trout were removed.

However, the challenges to the mountain yellow-legged frog are more complicated than simply removing non-native trout from frog habitat. An ongoing concern comes from chemical pollutants, such as fertilizers and pesticides that could be blown from California's Central Valley into ponds and lakes inhabited by the frogs. Frogs possess permeable skins through which environmental pollutants may easily pass. Studies have shown "a strong association" between agricultural pesticides and the disappearance of populations of four species of frogs — including one population of mountain yellow-legged frogs — from historic habitats in California. Additionally, a non-native disease, the chytrid fungus, has been sweeping through parts of the Sierra Nevada and typically is fatal to the frogs.

Climate change is also likely to exert pressure on these already-stressed amphibians both because of direct effects and because it could exacerbate other stressors. Climate change predictions for the region suggest altered precipitation patterns that will lead to less snowpack in the Sierra Nevada, a development that would be dire for the frogs. Less precipitation means already shallow lakes could evaporate and streams dependent on runoff from snowmelt could shrink or perhaps vanish, leaving the amphibians high and dry. The trout make frogs even more vulnerable to shrinking and warming lakes by excluding them from many of the larger lakes that would provide a refuge during dry years. The combined effects of non-native trout and drying lakes pose a severe threat because tadpoles need a year-round water source for their first two to four years to survive, and high egg production depends on above-average snowpack.

SOLUTIONS

Together, all of the factors impacting the mountain yellow-legged frog — less snowpack, earlier runoffs, non-native trout, pollutants, and diseases — pose significant management challenges for the National Park Service as the agency strives to preserve and protect species, ecosystems, and all park resources for the future. Just as we must reduce human-caused threats like non-native trout and pollution, we must limit human-caused warming in order to help preserve lakes and streams the frogs need to survive in **Yosemite** National Park and throughout the Sierra Nevada.

Developing and implementing plans to help the mountain yellow-legged frog and other species adapt to the effects of climate change and other threats is becoming urgent. Fortunately many of the Grinnell Survey's tracks have been retraced in recent years by crews from the Museum of Vertebrate Zoology at the University of California, Berkeley, in a bid to collect contemporary data on species distributions, habitat, and community composition that can be compared to Grinnell's records. The trick, now, is to use all of this data — that from the Grinnell Survey, recent surveys, and analysis of climate change scenarios — to develop on-the-ground plans that the National Park Service and other land managers can use to guide management of Sierra Nevada species and ecosystems to ensure their survival in the face of climate change.

We Can Safeguard Mountain Yellow-Legged Frogs from Climate Change

Stop contributing to climate change

Mountain yellow-legged frogs could decline even further if we fail to reduce carbon dioxide pollution and global warming that threatens the persistence of mountain lakes and streams that young frogs need to survive.

Reduce and eliminate existing harms that make mountain yellow-legged frogs more vulnerable to climate change

Reducing non-native trout from mountain lakes and streams in the Sierra Nevada, and cutting harmful pollution that originates in the Central Valley, will speed the recovery of mountain yellow-legged frogs and help them cope with new stresses resulting from climate change.

Adopt "climate smart" management practices

Long-term monitoring and research is helping national park scientists begin to understand how climate change interacts with pollution, non-native trout, and other forces that threaten mountain yellow-legged frogs, and this in turn will help them identify and implement strategies that boost the frogs' chance of survival in the face of climate change.

Appalachian Trail and forest in fog, Great Smoky Mountains National Park, North Carolina and Tennessee © Carr Clifton/Minden Pictures

Flying Squirrel

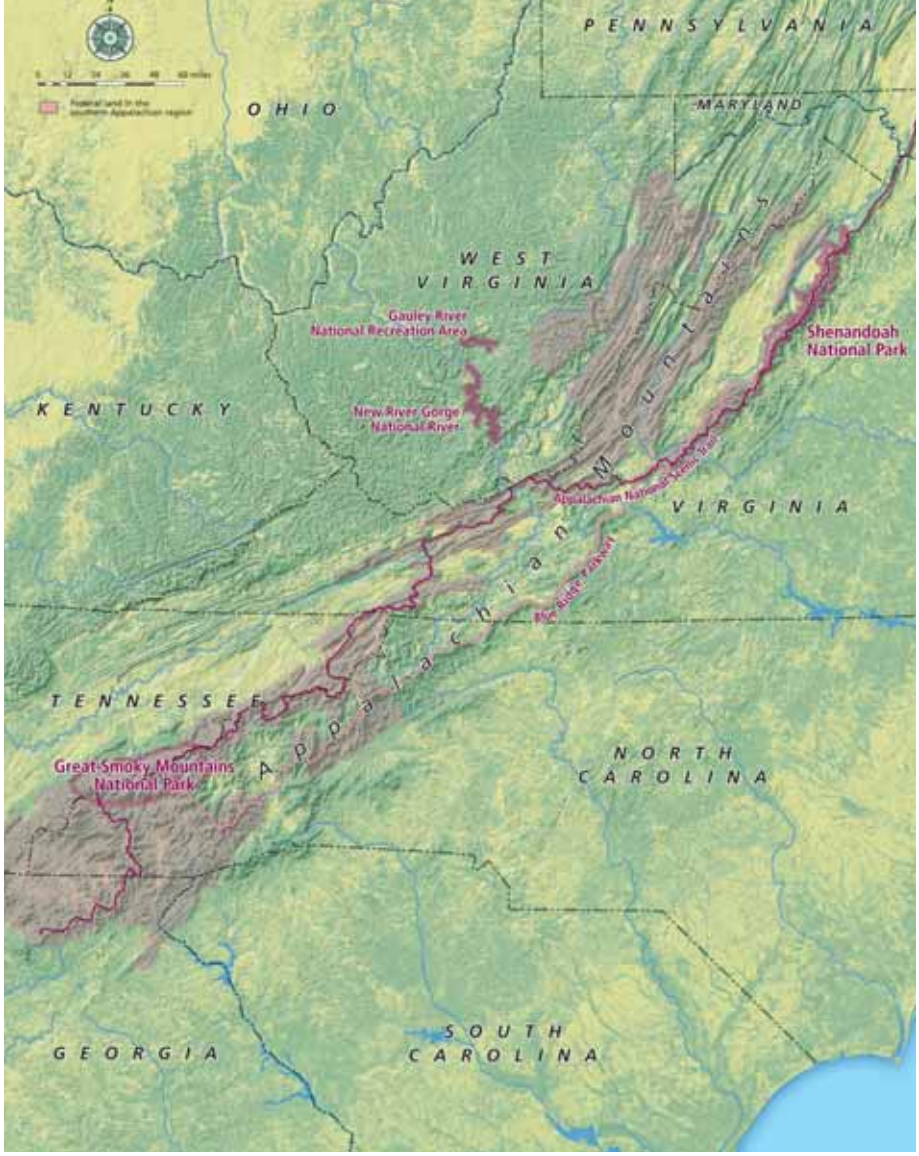
and other threatened mammals of the Appalachian mountains

The climate is not static. Ice ages come and go, pushing rivers of ice south and then pulling them back north across continents as temperatures and snowfalls rise and fall. Animal and plant species either stay ahead of these icy incursions and adapt, or perish. After the glaciers retreat, the plant and animal species that have shifted geographically sometimes remain in their new locations. But when climate change unfolds relatively quickly, as we are seeing today, many animals — like the northern flying squirrel — may not be able to stay ahead of the curve.

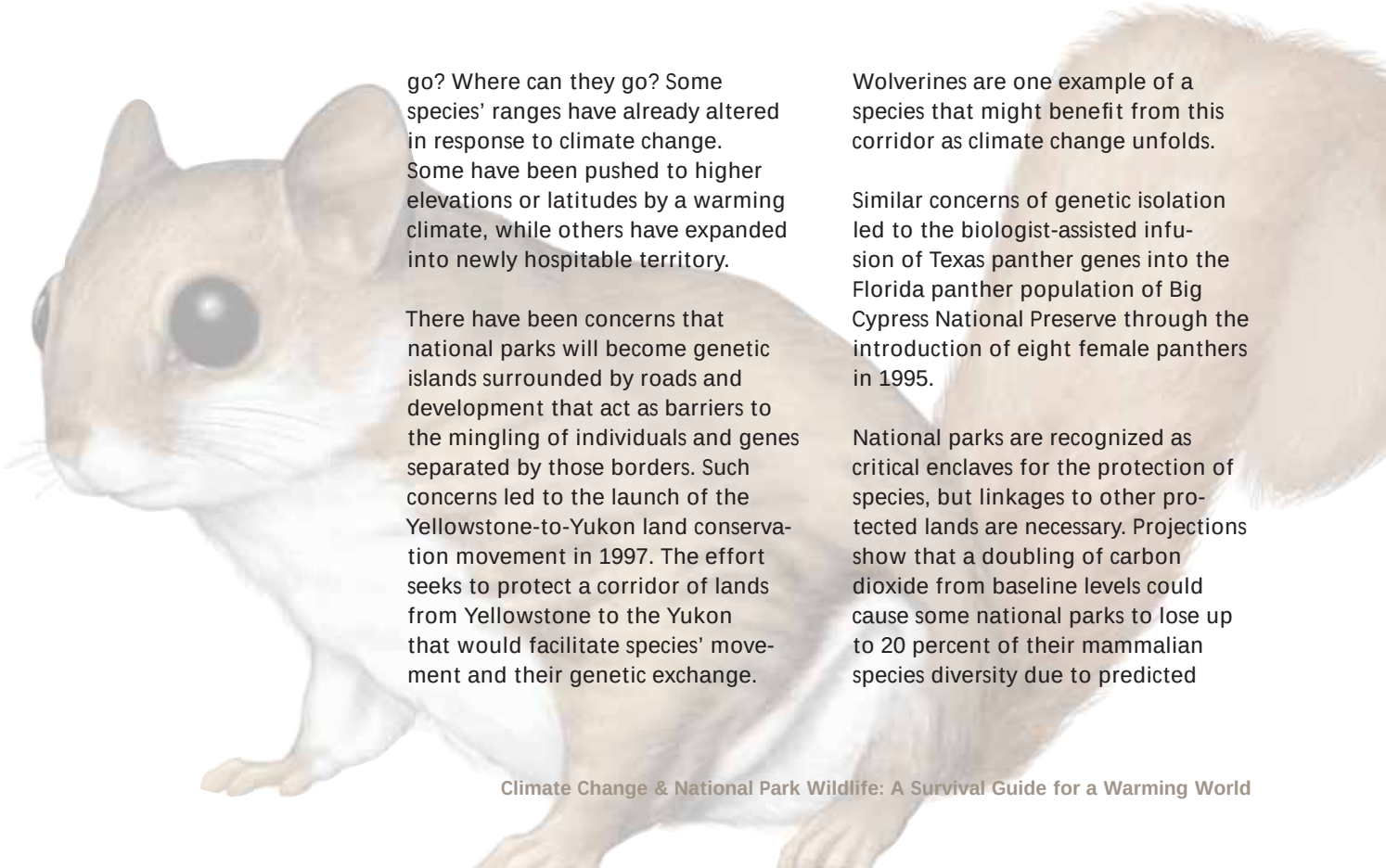
Geographic shifts of living communities can be seen at **Great Smoky Mountains** National Park along the Tennessee-North Carolina border. Hike toward the park's mountaintops and you'll find a geographically unusual spruce-fir ecosystem that took hold there about 10,000 years ago when the glaciers of the Wisconsin Ice Age retreated. In the highest and coolest of the Smokies' elevations there are many plant species that today are more commonly found nearly 1,000 miles to the north in the boreal forests of Maine and Canada.

But what will these species do in response to the prospect of higher temperatures resulting from accelerated unnatural climate change? Where will they

Hike toward the park's mountaintops and you'll find a geographically unusual spruce-fir ecosystem that took hold there about 10,000 years ago when the glaciers of the Wisconsin Ice Age retreated.



By monitoring the environmental impacts along the Appalachian Trail corridor, land managers will be better able to manage the landscape for its long-term health.



go? Where can they go? Some species' ranges have already altered in response to climate change. Some have been pushed to higher elevations or latitudes by a warming climate, while others have expanded into newly hospitable territory.

There have been concerns that national parks will become genetic islands surrounded by roads and development that act as barriers to the mingling of individuals and genes separated by those borders. Such concerns led to the launch of the Yellowstone-to-Yukon land conservation movement in 1997. The effort seeks to protect a corridor of lands from Yellowstone to the Yukon that would facilitate species' movement and their genetic exchange.

Wolverines are one example of a species that might benefit from this corridor as climate change unfolds.

Similar concerns of genetic isolation led to the biologist-assisted infusion of Texas panther genes into the Florida panther population of Big Cypress National Preserve through the introduction of eight female panthers in 1995.

National parks are recognized as critical enclaves for the protection of species, but linkages to other protected lands are necessary. Projections show that a doubling of carbon dioxide from baseline levels could cause some national parks to lose up to 20 percent of their mammalian species diversity due to predicted

shifts in distribution ranges that would move their habitat beyond a park's borders. **Great Smoky Mountains** National Park can expect to lose nearly 17 percent of its mammalian species as the park's largely temperate deciduous forest is transformed into a warmer mixed forest, similar to those found to the south. Among the species expected to be lost from the park under this change are the red squirrel, northern flying squirrel, and southern red-back vole. **Shenandoah** National Park, 469 miles to the north, and connected via the **Blue Ridge** Parkway, also stands to lose the red squirrel and the southern red-back vole.

Just as some of the species currently living in the Smokies and Shenandoah are expected to shift their ranges north as climate change effects accumulate, species currently living farther south can be expected to move north into these parks. However, these movements can occur only if there are corridors connecting suitable habitats.

Fortunately, one north-south linkage already exists: the **Appalachian National Scenic Trail**. Covering 2,175 miles and 250,000 acres from southern Georgia to northern Maine, the trail passes through **Shenandoah** National Park, **Great Smoky Mountains** National Park, and lands administered by various federal and state agencies along the way. It already serves as a vital corridor that provides habitat for flora and fauna up and down the Eastern Seaboard. Warblers, wild turkey, and once-endangered peregrine falcons are among the bird species that rely on the Appalachian Trail corridor. Overall, the corridor provides habitat for more than 2,000 rare, threatened, and endangered species, including more than 80 that are globally rare.

SOLUTIONS

Though protected from development, the Appalachian corridor is not immune from outside impacts, beginning with the estimated 4 million hikers it receives each year. With that in mind, the Appalachian Trail Conservancy, operating under an agreement with the National Park Service, is monitoring the pulse of this corridor to better understand the threats to its environment. With its vast network of volunteers, the Conservancy (through its Appalachian Trail MEGA-Transect project) is assessing how outside factors — invasive species, air pollution, and urban sprawl, for instance — are affecting the leafy corridor. Other entities, such as the Smithsonian Institution Conservation and Research Center, are also involved in projects along the trail.

By monitoring the environmental impacts along the trail corridor, land managers will be better able to manage the landscape for its long-term health. Developing monitoring programs to track climatic, biological, and ecological change will enable managers not just to see what's changing, but also evaluate the effectiveness of their management strategies and make adjustments in a timely fashion. It's expensive to conduct monitoring programs and implement management strategies; therefore, it will be critical for Congress, the Department of Interior, and other entities to provide adequate support to the National Park Service and its partners involved in this work.

However well the Appalachian mountain chain has served as a corridor in the past, there is no guarantee that it will function equally well as a corridor under rapidly changing climatic conditions. We must therefore foster cooperation and coordination among government agencies and landowners neighboring national parks to accommodate shifts in species distribution that occur in response to climate change. Cooperation is essential to ensure the preservation of species, and the preservation of functioning ecosystems.

We Can Safeguard Appalachian Wildlife from Climate Change

Stop contributing to climate change

Wildlife species like the northern flying squirrel, red squirrel, and southern red-back vole could be driven out of Great Smoky Mountains and Shenandoah national parks if we fail to reduce carbon dioxide pollution and global warming that is transforming temperate deciduous forests into warmer mixed forests.

Give Appalachian wildlife freedom to roam

Protecting the network of existing federal and state conservation lands throughout the Appalachian Mountains, continuing to monitor wildlife migration patterns, and conserving additional lands that may be needed for the region to support wildlife migration, will help the plants and animals of the Appalachian region secure suitable new habitat as the climate warms.

Reduce and eliminate existing harms that make Appalachian wildlife more vulnerable to climate change

Air and water pollution, as well as encroaching development, are major existing stresses on the forests and wildlife of the Appalachian region. By reducing pollution and keeping inappropriate development at bay, we can help wildlife better cope with the new stresses wrought by climate change.

Organ Pipe Cactus and the Ajo Range, Organ Pipe Cactus National Monument, Arizona © Carr Clifton/Minden Pictures

Though Canyonlands' bighorns are well adapted to endure harsh conditions, Canyonlands' arid climate offers little cushion for bad years.

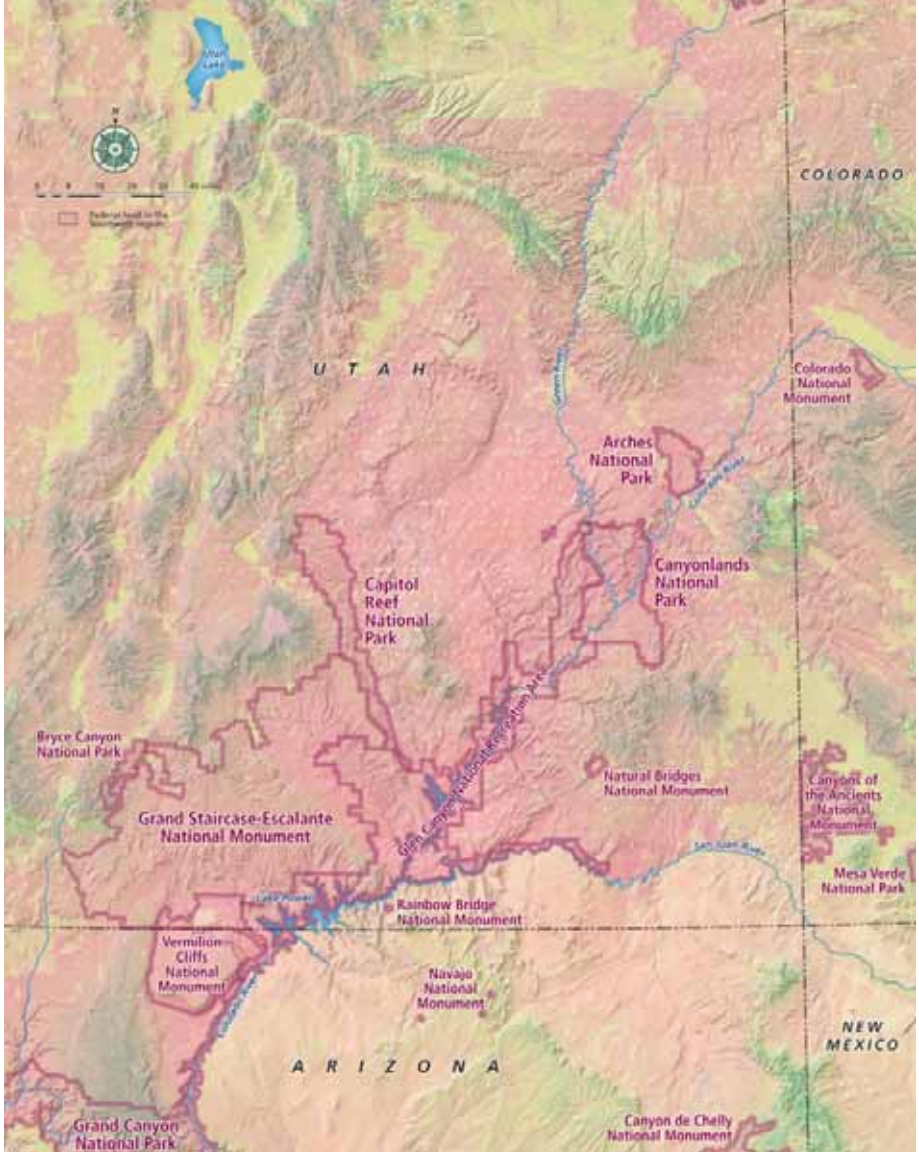
Bighorn Sheep
in the Southwest

Canyonlands National Park is one of the most rugged national parks, with a harsh summer sun that bakes the dry, canyon-riddled landscape. But those deep canyons' steep rocky slopes, which offer ample grasses and shrubs, and an openness that puts predators at a disadvantage, are an optimal environment for bighorn sheep. In fact, Canyonlands' bighorn population has been so stable that Utah's wildlife biologists long relied on it for stock to re-establish herds elsewhere in the state. Bighorn sheep range throughout the southwestern U.S. and are found in nearby **Arches** and **Capitol Reef** national parks.

Though they were once feared to be headed toward extinction due to diseases introduced by domesticated livestock, from competition with livestock for food, and hunting, today more than 300 desert bighorns live in **Canyonlands** National Park. They clatter about talus slopes in remote side canyons off the Green and Colorado Rivers, managing for the most part to avoid the park's mountain lions and coyotes. But there are other threats that bighorns might not so nimbly escape: drought, hot summers that jeopardize the survival of lambs, and years

Helping Bighorn Sheep Regain a Foothold

Big Bend National Park is a partner with Texas Parks and Wildlife Department, the Texas Bighorn Society, and Mexican wildlife managers in an international Desert Bighorn recovery program. Native to the area, bighorn sheep were wiped out of the Trans-Pecos and Northern Chihuahua/Coahuila by the mid-20th century by domestic livestock diseases and hunting. Over the past 20 years, bighorn sheep have been introduced into several sites, including Big Bend's Deadhorse Mountains, the State of Texas' adjacent Black Gap Wildlife Management Area, and Mexico's Sierra del Carmen range. While still small, the populations are slowly increasing. Desert bighorn sheep depend upon sparsely vegetated desert mountain terrain, and the few water sources scattered throughout the habitat. Climate change threatens the persistence of water sources bighorn sheep depend upon, but it's not certain which areas will be most impacted, and it's likely that impacts will shift over time. Helping sheep regain a foothold in strategic places throughout their historic range could increase their chances of survival in the face of climate change uncertainties.



with poor vegetation. As a result, relatively subtle, long-term changes in the park's climate that increase those conditions could disrupt the bighorns' habitat, food sources and reproduction enough to jeopardize their future.

Perched on the Colorado Plateau of southeastern Utah, **Canyonlands** National Park encompasses 527 square miles of demanding landscape. Temperatures on hot summer days can rise to 100 degrees Fahrenheit and beyond, while temperatures on cold, wind-whipped winter days and nights can plummet to zero degrees Fahrenheit. Though the park's bighorns are well adapted to endure these conditions, Canyonlands' arid climate offers little cushion for bad years. The park's relatively high elevation offers a shorter growing season than lower areas such as the Mojave Desert in California. As a result, how and when precipitation arrives is critically important to the bighorns.

In canyon country, water is vital to life. **Canyonlands** National Park's bighorns have adapted to the 8 inches or so of moisture that fall on the park each year. The park's two rivers are ever-flowing sources of water, while "potholes" — natural bowls in sandstone that capture rain — provide another source of water for the sheep. Moisture also is critical for the vegetation that nourishes the bighorns, particularly during the ewes' gestation and birthing periods. Changes in precipitation patterns — even relatively

minor ones — affect the bighorns' reproductive success. Proof of this relationship stands out when reviewing the park's long-term bighorn population data. Between 1976 and 1998 the park's ewes produced, on average, 44 lambs per 100 ewes each year. But during the dry year of 1984, only 15 lambs per 100 ewes were spotted, while the wet year of 1982 was notably bountiful, producing 77 lambs per 100 ewes.

Fortunately, ewes are capable of slightly altering their breeding timetables to coincide with weather conditions that produce the most nutritious forage during the last stage of gestation and on through the weaning of lambs. But sometimes conditions are beyond their adaptation.

Cold, late winters can produce a ground so frozen that spring rains don't adequately soak in to fully nourish vegetation. Droughts, late springs that are unusually wet and cold, and unusually hot springs that affect the nutritional value of forage also can adversely affect population growth. Beyond those immediate conditions, studies have shown that forage conditions two years *before* a ewe becomes pregnant can impact her productivity by depriving her of needed nutrition.

Since ewes in Canyonlands typically give birth in April and May, and since the moisture content in the park's soils usually begins to dwindle in April, a change in climate that results in fewer or less potent winter storms or hotter May weather could jeopardize the bighorns by depriving them of nutritious vegetation when they most need it.

An overall climate change that produces higher temperatures and lower precipitation in general, as is forecast for much of the West, also poses a threat to other bighorn sheep habitat in mountain ranges. During the 20th century, a noted rise in temperature that coincided with a drop in precipitation led to the extinction of 26 bighorn sheep populations in California.

SOLUTIONS

In light of these threats, providing and protecting undeveloped land between existing bighorn habitats will help bighorns cope with the impacts of climate change. Land managers will need to create safe ways for bighorns to cross barriers, such as highways, to access those areas. Finally, bighorn sheep transplant programs should consider potential climate change impacts when deciding where the sheep are introduced and how many the main herd can stand to lose.

We Can Safeguard Bighorn Sheep from Climate Change

Stop contributing to climate change

Bighorn sheep could decline if we fail to reduce carbon dioxide pollution and global warming that is altering precipitation patterns and increasing drought in the Southwest.

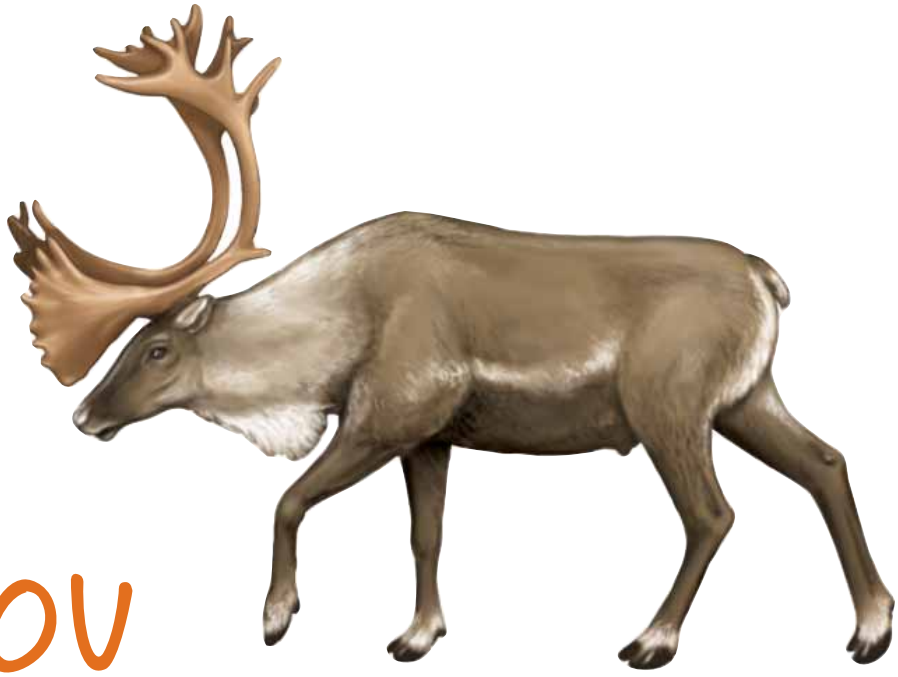
Give bighorn sheep freedom to roam

Bighorn sheep need to roam freely so they can access food and water in new areas if changing precipitation patterns and rising heat make food and water scarce in their traditional habitat.

Adopt "climate smart" management practices

By coordinating bighorn sheep reintroduction efforts, identifying potential shifts in migration corridors, and working to keep these corridors open, resource managers from national parks, forests, wildlife refuges, and state conservation areas can help bighorn sheep overcome some of the climate challenges they face.

Lupine growing along Icy Bay, Wrangell-Saint Elias National Park and Preserve, Alaska © Carr Clifton/Minden Pictures



Caribou

in Alaska's parks and preserves

Caribou have been on the landscape for more than 400,000 years. For roughly the past 12,000 years, they have been hunted by humans — first the paleo-Indians, now the First Nations' cultures along with many other Alaskans. Resilience to hunting, to weather, and to predators has enabled the caribou to remain an integral part of both the natural landscape and the human culture. The greatest test of their resilience, though, stands to be climate change.

Caribou travel great distances, in some cases traversing more than 200,000 square miles annually, in their search for adequate vegetation. For example, although the Denali Herd spends almost the entire year in **Denali** National Park and Preserve, the Porcupine Herd roams between the Arctic National Wildlife Refuge in northeast Alaska and the Northwest and Yukon territories. The Western Arctic Herd, one of three herds that visit **Gates of the Arctic** National Park and Preserve, crosses a jigsaw-puzzle mix of federal, state and tribal lands, including not just Gates of the Arctic but also **Noatak** National Preserve and **Kobuk Valley** National Park as well.

Caribou travel great distances, in some cases traversing more than 200,000 square miles annually, in their search for adequate vegetation.

With so many potential changes in store for caribou, it's crucial that the National Park Service, other federal agencies, state agencies, and tribes collaborate in monitoring the health of both caribou herds and vegetation across their ranges.

Climate change will affect all these areas. Indeed, already many impacts can be seen throughout Alaska. Ice fields are shrinking, ice sheets are breaking up, forest fires and insect outbreaks are increasing, permafrost is melting, and coastal villages are disappearing into the sea. For caribou, one of the Earth's great iconic species, these climate-related shifts are expected to bring many changes, some good, some not so good, and some unknown.

Cows and calves require lush spring vegetation for vital nutrients during the critical period around calving and early development. Climate change will affect when that spring vegetation appears, potentially putting the green-up out of sync with calving, and leaving adults and newborns without adequate nutrition. With climate-change forecasts predicting a warming of as much as 5 degrees centigrade throughout the Arctic, a trend that is likely to lead to earlier plant germination, will caribou be able to advance their biological clocks and keep calving when food is most available? Some think earlier springs could also lead to an earlier than normal vegetation die-off in the fall, which could create a lack of forage when caribou are trying to fatten up for winter. Lack of proper nutrition in the fall decreases a pregnant female's chance of successfully bringing her calf to term.

Climate change doesn't mean climate uniformity. While a trend to warmer

weather could mean less snow in some areas, it could mean heavier snows elsewhere that could force caribou out of their traditional calving grounds. Warmer temperatures also bring occasional rain to regions that used to only see snow in the winter. These thaw and refreeze events create a tough layer of ice that places forage out of reach.

Also complicating life for caribou is the prospect of more frequent tundra fires. These fires, predicted to increase in number if not in size as the climate warms, could adversely impact lichens that caribou rely on in winter. Even without fire lichen patches might shrink under current climate-change scenarios. Lichens prefer poor soils, but with permafrost thawing there is expected to be better soils, which will encourage and support different vegetation that could drive out lichens. Already there have been documented increases in shrub cover over northwestern Alaska, and some studies indicate that caribou won't eat shrubs.

All these factors — timing and types of vegetation, fires, and lichen decline — are poised to interfere with the herds' reproductive cycles and nutritional needs. More problems could arrive in the form of parasites.

SOLUTIONS

With so many potential changes in store for caribou, it's crucial that the National Park Service, other federal agencies, state agencies, and tribes collaborate in monitoring the health of both caribou herds and vegetation across their ranges. For example, a better understanding and mapping of the present-day status of caribou winter ranges can help play a role in developing fire management plans that balance active fire suppression in areas with valuable lichen resources against letting wildfires burn themselves out.

Wildlife and human life are so intertwined in Alaska, just as national park lands are so intertwined with other federal, state, and tribal lands. Climate change threatens to send shudders, if not outright shatter, some of these connections if nothing is done to slow, and hopefully reverse, its course.

We Can Safeguard Caribou from Climate Change

Stop contributing to climate change

Caribou in Alaska could decline if we fail to reduce carbon dioxide pollution and global warming that is altering the timing and variety of foods caribou need to produce healthy calves in the spring and to survive the winter.

Give caribou freedom to roam

Even with the vast territory available to Alaska's caribou herds, traditional calving grounds and winter feeding areas may become unsuitable due to climate change impacts on vegetation; identifying suitable new habitat and ensuring the path is clear for caribou to get there should help caribou cope as climate change alters their landscape.

Adopt "climate smart" management practices

By coordinating the work of resource managers from the National Park Service, other state and federal agencies, and tribes, to monitor and map caribou herds and the vegetation they depend on, we can make smarter decisions about fire management and other land management practices that will help caribou overcome the climate challenges they face.

Snow-dusted mountains, Glacier National Park, Montana © Tim Fitzharris/ Minden Pictures

The diminutive wolverine possesses a legendary reputation for toughness, resilience, and, some would say, cantankerousness.

Wolverines
of the Northern Rockies

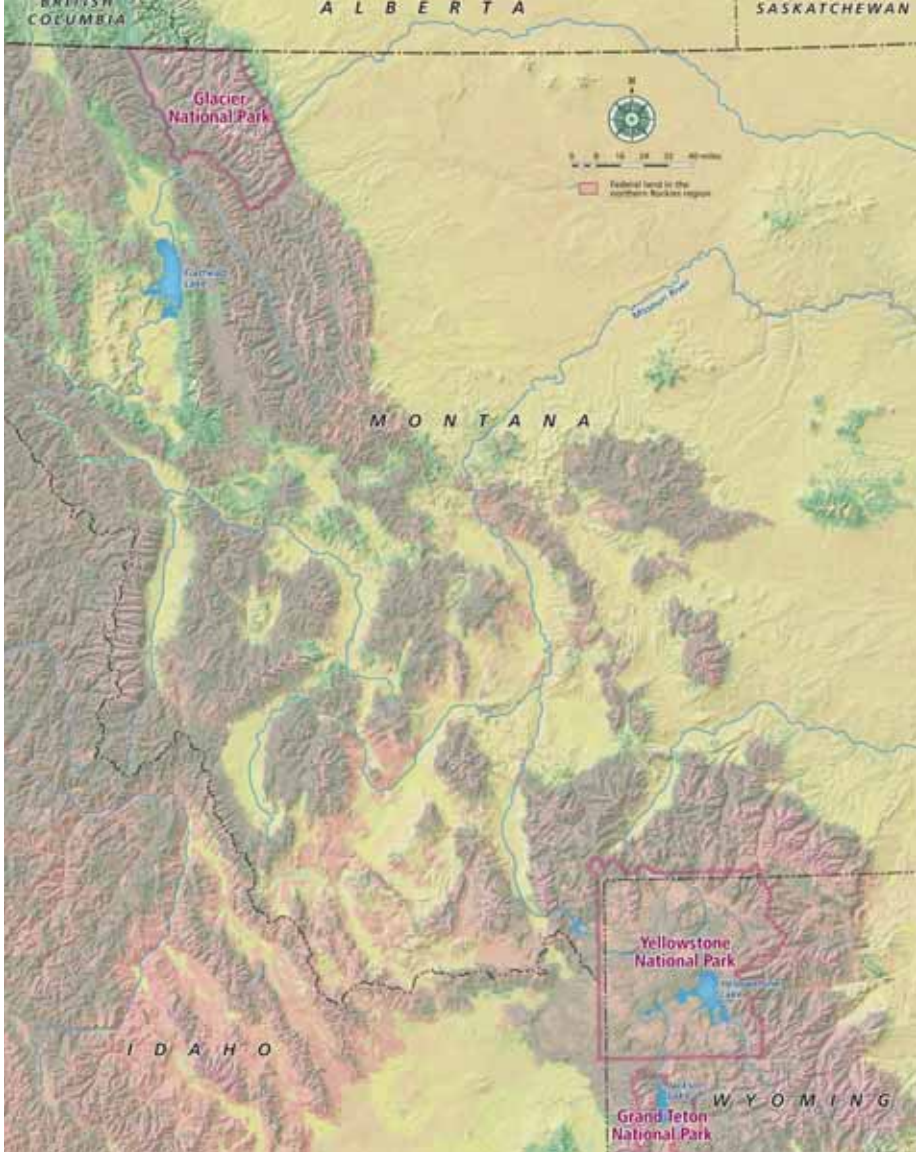
If ever there was an enduring symbol of the wildness of the Rocky Mountains, it would be the wolverine. While wolves and grizzly bears usually come to mind when talk turns to the Rockies' animals that conjure images of the wild, the diminutive wolverine possesses a legendary reputation for toughness, resilience, and, some would say, cantankerousness.

But these solitary creatures, rarely seen due to their typical travels near or above tree line in home ranges that span hundreds of miles, could very possibly be erased from the landscape by climate change.

These opportunistic carnivores once roamed wide and far across the continental United States, with historical populations noted in the coastal mountains of California, Oregon, and Washington, the Rocky Mountains from **Glacier** National Park on the Canadian border all the way south to Taos, New Mexico, east into the Great Lakes region, and even in the Northeast.

Throughout history this 30- to 40-pound ball of tenacity has been known by a smattering of names, and none very

Beyond the need for snow, the future of wolverines in the Northern Rockies is clouded, in part, by their low numbers — it is likely that there are no more than 400 wolverines left in the United States, and there could be as few as 218.



flattering. There was "skunk bear" and "Indian devil," and to 19th-century French fur trappers the animal was "carcajou." That's how the trappers' tongues stumbled through the Micmac Nation word "kwi'kwa'ju," which translates to "evil spirit." And the trappers no doubt viewed wolverines as evil spirits, for they have a long and well-deserved reputation for not only raiding trap lines but breaking into cabins to forage trappers' provisions.

And yet, admiration also flows for wolverines. "I wonder if there is another inhabitant of northern wilderness that so excites the imagination," Olaus Murie, the noted American wildlife biologist and conservationist, once wrote. "Merely seeing those tracks in the snow made it a red-letter day."

But those tracks are getting harder to find, because female wolverines den in snowfields, which are shrinking under warmer temperatures. Also, while wolverines have been known to hunt deer, elk, and even moose that founder in deep snows, they also are expert scavengers; in winter and spring they often make meals of wildlife killed by avalanches. Less snow is also reducing the opportunity for easy meals.

During the past four decades, wolverines that were found in the Lower 48 states were spotted in areas with snow cover that usually lasted through the wolverines' spring

denning season. The females would burrow into the snow, creating networks of insulated dens and tunnels that protect them from predators.

Unfortunately, snowfall not only has been on the decline, but snow that does fall has been disappearing sooner than what once was considered normal. Studies note that nearly one-third of the historical spring snowpack in existing wolverine habitat already has been lost as global temperatures continue to warm, and that that percentage could double by 2090. Without snow, these carnivores could quickly go extinct. Nowhere in the world has a female wolverine been documented to build her den anywhere else but in snow.

Beyond the need for snow, the future of wolverines in the Northern Rockies is clouded, in part, by their low numbers — it is likely that there are no more than 400 wolverines left in the United States, and there could be as few as 218. Most of these scavenger-predators are clustered in Montana, Wyoming, Idaho, and Washington. Their habitats are increasingly shrinking and becoming isolated due to development and roads.

SOLUTIONS

Agreements with private landowners and coordination among public land managers can help to protect wolverines and encourage them to move north to cooler areas as climate change forces them from their current mountain ranges. Wolverines may be able to survive in areas where snowpack remains and perhaps even colonize new territory in more northerly or higher elevation regions, but only if they are able to roam widely across the landscape. Movement corridors and larger refugia where wolverines are protected could help these wild creatures to survive.

Wolverines may also get help holding on from another predator. Studies in **Yellowstone** National Park have shown that leftovers from wolf kills are helping to replace the carrion that wolverines had been able to scavenge in the wake of avalanches. Wolves could also offset an expected reduction in bison, elk, and mule deer killed by cold, snowy winters, as winters warm and snowfalls decline. Without wolves, late-winter carrion in Yellowstone would be expected to drop off by nearly a third in March and two-thirds in April under current climate-change scenarios. However, as long as healthy populations of wolves reside in the park, the amount of carrion in March would only be expected to drop by 4 percent under climate-change scenarios, and by just 11 percent in April.

While ensuring a future for wolverines is not as simple as dropping a wolf pack or two into their neighborhood, it makes sense for public lands managers, including the National Park Service, to determine whether there are missing species that, if returned, might help reduce their ecosystem's vulnerability to climate change. Mitigation and prevention of habitat fragmentation is also necessary, ideally with the creation of protected wildlife corridors. Linking undeveloped areas to protected areas, such as national parks or officially designated wilderness, will make it easier for animals like the wolverine to find habitat and maintain healthy populations.

We Can Safeguard Wolverines from Climate Change

Stop contributing to climate change

Wolverines could be driven from the Rockies and even go extinct if we fail to reduce carbon dioxide pollution and global warming that is decreasing snowpack wolverines need to survive.

Give wolverines freedom to roam

Wolverines may be able to survive in areas where snowpack remains and perhaps even colonize new territory in more northerly or higher elevation regions, but only if they are able to roam widely across the landscape. Movement corridors and larger refugia where wolverines are protected could help these wild creatures to survive.

Adopt "climate smart" management practices

Understanding interactions among species like wolverines and wolves, and acting to restore a balance of native wildlife, could help vulnerable species like the wolverine overcome changing climatic conditions that might otherwise drive them from their ecosystem.

Eagle Lake, Acadia National Park, Maine © Tim Fitzharris/Minden Pictures

Red Knot

and other migratory birds of the Northeast

Each spring, certain areas in **Acadia** National Park in Maine are closed to visitors as peregrine falcons return to their ancestral nesting sites on seaside cliffs. With great anticipation, park visitors gather below the cliffs with binoculars, spotting scopes, and zoom lenses to watch the peregrines — — a species that in the mid-1960s was on the brink of extinction. Similarly, flocks of bird-watchers gather at Massachusetts's **Cape Cod** National Seashore and New York's **Fire Island** National Seashore in autumn to scan the skies for migrating hawks, shorebirds, and a great diversity of songbirds. Some migratory shorebirds, like the red knot, have already suffered precipitous declines, putting them at great risk as shorelines recede in response to climate change.

Plovers, pelicans, peregrines, red knots, and warblers are just a few of the more than 300 species of birds that spend time in the forests, marshes, dune systems, tidal flats, grasslands, and open waters of the national parks that dot the East Coast. They rely on these and other protected landscapes that lie within the Atlantic Flyway — a primary migration corridor — for food, nest sites, and places to rest.

Plovers, pelicans, peregrines, red knots, and warblers are just a few of the more than 300 species of birds that spend time in the forests, marshes, dune systems, tidal flats, grasslands, and open waters of the national parks that dot the East Coast.

To help these species, cooperation is critical. The National Park Service must work with other land managers — private, federal, city, and state — to protect existing habitat up and down the Atlantic Flyway, create and maintain corridors between protected areas, and build new habitat when possible.

Stretching from the coast of Greenland all the way south to the Caribbean, the core of the flyway coincides with the barrier islands stretching from Cape Cod to **Cape Hatteras** National Seashore. The national parks and refuges along the way offer key landing zones that are interwoven into the life expectancy of both individual birds and species as a whole. Critical to survival is habitat that is ready with food when exhausted birds arrive, either for a quick feeding stop or to settle in and breed. Also important are vegetation in which to elude predators and suitable habitat for nesting. Pull one brick out of this foundation and it could lead to ecological collapse.

Unfortunately, climate change threatens to pull at least a few bricks out of the massive flyway's structure, all to the detriment of various bird species. Predicted sea-level rise, coupled with more potent storm surges, could radically alter coastal wetlands if those habitats are not able to shift inland as the seas rise. Wetland-dependent species such as sora rail, common loon, and American bittern, are projected to see a 50 percent drop in abundance under most climate change scenarios. Higher temperatures in ocean surface waters could jeopardize food sources for gulls, terns, and other seabirds that spend much of their lives at sea. Some important food plants will bear fruit at dates that do not coincide with bird nesting or migration. A recent study predicted that the Northeast will be greatly affected by higher ocean levels associated with human-caused global warming, which could spell trouble for long-legged waders and seabirds that rely on the Northeast's coastal areas for nesting. The common loon is another signature species likely to suffer from climate change as the Atlantic Coast estuaries where they spend winters are affected by rising waters.

The effects of climate change aren't restricted to only those bird species that rely on coastal areas. Black-throated blue warblers and Bicknell's thrush will be affected as vegetation changes driven by global warming alter the spruce-fir forests they inhabit. Some researchers predict that warming by as little as one degree Centigrade could cut in half suitable habitat for high-elevation

species, such as Bicknell's thrush, by forcing the spruce-fir forests they inhabit to move higher in elevation. Other studies indicate that montane environments inhabited by other high-elevation bird species, including boreal chickadees, kinglets, and crossbills, will shrink by 90 percent before the end of the 21st century.

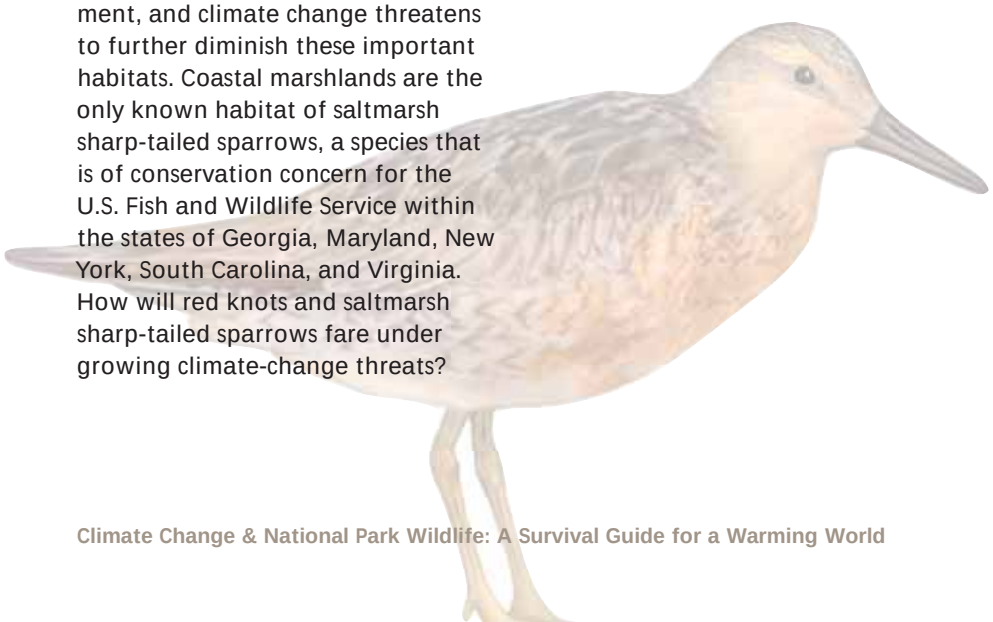
Many of our bird species are already struggling due to the combined effects of forest fragmentation, acid rain's impacts on forests and aquatic ecosystems, human disturbance at nesting sites, and over-fishing that has humans out-competing our wild friends for food. Climate change impacts will exacerbate these problems. Some birds might not have the energy needed to complete their annual migrations. Up to 85 percent of adult bird mortality that typically occurs may occur during migration, and that rate is expected to increase under climate change as conditions change at a time when migrating birds, already stressed by arduous flights, can least afford it.

Already, East Coast populations of red knots, colorful shorebirds that migrate along the Atlantic Flyway between the Arctic and Tierra del Fuego at the bottom of South America, have plummeted 82 percent. These declines are primarily due to competition for horseshoe crabs (from humans) and human disturbance (i.e., beach use) at their resting sites. Atlantic coastal marshlands have disappeared largely due to development, and climate change threatens to further diminish these important habitats. Coastal marshlands are the only known habitat of saltmarsh sharp-tailed sparrows, a species that is of conservation concern for the U.S. Fish and Wildlife Service within the states of Georgia, Maryland, New York, South Carolina, and Virginia. How will red knots and saltmarsh sharp-tailed sparrows fare under growing climate-change threats?

SOLUTIONS

To help these species, cooperation is critical. The National Park Service must work with other land managers — private, federal, city, and state — to protect existing habitat up and down the Atlantic Flyway, create and maintain corridors between protected areas, and build new habitat when possible. Remaining salt marshes need to be protected, and degraded or destroyed marshes should be restored. Colonial seabird nesting sites could be re-established with dredge spoils. Land use needs to be regulated as much as possible to allow coastal refuges to retreat inland in the face of rising seawaters. Where shoreline retreat isn't possible due to existing development, the only options are slowing seawater rise or increasing beach buildup by natural or supplemental means.

Land managers are not the only ones who can help protect birds facing threats from climate change and other human-caused problems. Academic institutions, nonprofit, and citizen-based organizations, could play a valuable role by carefully monitoring populations of at-risk species. This information would enable scientists to spot emerging trends that could be tied to subtle changes in habitat along the flyway. With this information in hand, we would all be better equipped to take appropriate actions to preserve species and habitat before it's too late.



We Can Safeguard Migrating Birds from Climate Change

Stop contributing to climate change

Migrating birds like red knots could decline even further if we fail to reduce greenhouse gas emissions and climate change that is causing sea levels to rise, threatening coastal sanctuaries that are vital flyover stops on their migration routes.

Reduce and eliminate existing harms that make migrating birds more vulnerable to climate change

By preventing further loss of critical habitat to development, and by balancing the harvest of food sources like horseshoe crabs and fish to meet the needs of human communities and migrating birds, we can help birds cope with additional loss of habitat that could result from climate change.

Give migrating birds freedom to roam

The National Park Service, working with other land managers — private, federal, city, and state — can protect existing habitat up and down the Atlantic Flyway, and can identify and protect replacement habitat for migrating birds that will be necessary as existing flyover stops are lost to sea level rise.

CLIMATE CHANGE & NATIONAL PARK WILDLIFE: A SURVIVAL GUIDE FOR A WARMING WORLD

For an electronic version of this report with full citation of authorities, please visit:
www.npca.org/survivalguide

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ADDITIONAL PHOTO CAPTIONS:

Cover: Brown bear and seagulls in Katmai National Park, Alaska © David Tipling/Getty

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Page 3, Left: A boat-tailed grackle in Everglades National Park, Florida © Ian Shive/Aurora Photos; Right: El Capitan rising over the forest, Yosemite National Park, California © Tim Fitzharris/Minden Pictures

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Page 5, Left: Sunset over river and peaks in Moraine Park, Rocky Mountain National Park, Colorado © Tim Fitzharris/Minden Pictures; Right: A crab on Santa Cruz Island, Channel Islands National Park, California © Ian Shive/Aurora Photos

Page 6, Left: Mirror Lake, Rocky Mountain National Park © Ian Shive/Aurora Photos; Right: A bullfrog sits on and under a lily pad in Acadia National Park, Maine © Ian Shive/Aurora Photos

Page 7: Eagle Lake, Acadia National Park, Maine © Tim Fitzharris/Minden Pictures

Page 8, Left: Mountain goat in the Logan Pass area, Glacier National Park, Montana © Ian Shive/Aurora Photos; Right: Lenticular clouds over Mount Dana, Mount Gibbs, and Mammoth Peak at Tuolumne Meadows, Yosemite National Park, California © Tim Fitzharris/Minden Pictures

Page 9, Left: Iconic orange Garibaldi, Catalina Marine Park, California © Ian Shive/Aurora Photos; Right: Century plant growing on canyon rim, Grand Canyon National Park, Arizona © Carr Clifton/Minden Pictures

We can safeguard the wildlife of America's national parks from climate change if we take the following steps:

- Stop contributing to climate change
- Reduce and eliminate existing harms that make wildlife more vulnerable to climate change
- Give wildlife freedom to roam
- Adopt "climate smart" management practices
- Empower national parks to lead by example

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