THE **HEAT** IS **ON**

Species feeling the effects of climate change

Polar Bear

Ursus maritimus

Region:
Arctic

Area affected:
Alaska, Canada

Climatic change:
Warming temperatures

Impact:
Loss of sea ice

ABOUT THIS SPECIES

Polar bears are among the largest carnivores on the planet. They are classified as marine mammals because they spend more time on ice than on land. With a body built for swimming and fur and blubber to help them withstand extreme cold, they are uniquely adapted to life on the sea ice, which is a surprisingly bountiful habitat. Each spring long trains of algae grow beneath the ice, anchored to its edges and taking advantage of the long periods of sunlight through the Arctic summer. The abundant algae form the base of a food chain that includes krill, pteropods, fish and—most important for polar bears—seals. The bears primarily eat ringed seals and bearded seals, which they hunt at airholes in the ice surface. Although they are excellent swimmers, polar bears have trouble catching and eating seals in open water, so they need the ice as a platform for hunting. Female polar bears also frequently give birth in snow dens on thick, stable pack ice.

DESCRIPTION OF IMPACT

The polar bear is rightly considered the "poster child" of climate change. With rising temperatures melting its icy habitat, the bear was among the first species listed under the Endangered Species Act due to the threat of climate change. Since the late 1990s, the extent of Arctic sea ice has been below the long-term average nearly every year, with a record low in 2012 and second-lowest in 2016. In recent years, harrowing stories have emerged of bears drowning in the open ocean miles from the ice edge, or starving to death while trying to subsist on land, eating birds and carrion. The extremes of Arctic habitat make it difficult to track polar bear population responses to climate change, **but declines have been observed in many of the better-studied populations, including a 22 percent drop in Canada's Western Hudson Bay population and a decline in cub survival in Alaska's southern Beaufort Sea population.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

ALASKA DEPARTMENT OF FISH AND GAME

Caribou

Rangifer tarandus

Region:
Arctic

Area affected:
Alaska and Canada

Climatic change:
Warming temperatures, precipitation changes

Impact:
Altered food availability, insect harassment

ABOUT THIS SPECIES

Caribou are the nomads of the Arctic, tracing migration routes across hundreds or thousands of miles in search of lichens, moss, shrubs and grass to eat. As the northernmost-ranging member of the deer family, caribou have a number of adaptations for tundra life, including a thick coat of two layers of fur; large, broad hooves that provide traction and aid in cratering (digging) through snow to reach food; and a muzzle specialized to help warm the air before it reaches their lungs. In Canada and Alaska, caribou amass in huge herds in spring and fall to migrate south to wintering areas and north to summer feeding grounds. Mating occurs during the autumn merger, and calving during the spring. Calves can walk within an hour of birth and run within a day.

DESCRIPTION OF IMPACT

The Arctic is warming faster than any other part of the world, affecting caribou in all seasons. Warmer autumn and winter temperatures are leading to more freezing rain events that cover the ground with a thick, icy crust that requires the animals to use considerably more effort to break through to reach food. The "green-up" of the most nutritious plants is also occurring earlier in spring, and in some places the migrating herds arriving to give birth and raise their calves are missing the best growth. And in summer, warmer temperatures are increasing the survival rates of biting flies and mosquitoes to the point that the scourge of biting insects is enough to interfere with feeding. The combined effects have been disastrous: **caribou have experienced a nearly 60 percent decline worldwide over the past three decades**. Alaska's Western Arctic Herd declined 30 percent from 2003 to 2011. Nine of the 11 major Canadian herds have also declined precipitously, down 50 to 90 percent since the early 1990s.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Alpine Chipmunk

Tamias alpinus

Region:
Sierra Nevada

Area affected:
Yosemite National Park

Climatic change:
Warmer temperatures

Impact:
Habitat fragmentation, loss of genetic diversity

ABOUT THIS SPECIES

Weighing in at just one to two ounces, the alpine chipmunk is one of the smallest varieties of this familiar rodent. They are striped like other chipmunk species, but generally paler in color and found only in the high-elevation regions of California's Sierra Nevada Mountains. Like pikas, they tend to live in sheltered crevices in rocky talus fields adjacent to alpine meadows where they feed on a variety of seeds, berries, mushrooms and sometimes bird eggs. From late October to June, alpine chipmunks hibernate in nests under rocks or soil. Females give birth to four or five young in early July, and the young reach adult size by October.

DESCRIPTION OF IMPACT

Yosemite National Park has a unique advantage when it comes to studying how species react to a changing climate: a set of baseline information collected during an exhaustive 1914 survey of the distribution of the park's fauna by zoologist Joseph Grinnell. Nearly 100 years later, the "Grinnell Resurvey Project" used the same methodology and observed that many of the park's mammals—including the alpine chipmunk—are now found at higher elevations, a response to the 5.4-degree F temperature increase in the park over that time. **Once found at elevations above 7,800 feet, alpine chipmunks now only occur above about 9,400 feet.** Unfortunately, as the chipmunks move upward, the amount of available habitat shrinks, and populations become stranded on isolated mountain top "islands." A recent survey of chipmunk genetics confirmed that populations are becoming fragmented and less genetically diverse, leaving them more likely to suffer from inbreeding and disease.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change


USFS

Snowshoe Hare

Lepus americanus

Region:
Northern United States and Canada

Area affected:
Northern forests

Climatic change:
Shorter snow season

Impact:
Phenologic mismatch

ABOUT THIS SPECIES

Snowshoe hares are the primary northern rabbit species, ranging throughout the boreal forests of Alaska and Canada and into the northern and mountainous regions of the Lower 48. They eat grasses, clover and the twigs and branches of maple, pine, willows and other trees and shrubs. The young are born with a full coat of brown fur and are capable of hopping and feeding on their own almost immediately. Their main habitat requirement is lots of dense undergrowth for feeding and cover from predators, which include coyotes, bobcats, foxes, lynx, raptors and owls. They also rely on camouflage for protection from predators. Depending on the season their coats are either brown to blend in with the bare ground or white for camouflage against the snow.

DESCRIPTION OF IMPACT

The snowshoe hare is a poster child for "phenological mismatch," a phenomenon that occurs when the timing of important events in nature is not in sync. For the hare these events are day length and season. The hares change coat color in response to a release of hormones triggered by changes in seasonal daylight, which historically reliably correlated to the onset of snow cover in the fall and snow melt in the spring. Now temperatures are shortening the snowy season on both ends, while the day-length cycle that triggers color change remains the same. In both fall and spring, researchers are seeing more hares that no longer match their background habitat and, as a result, increasing mortality from predation. **One study found that for each week of color mismatch, the chance of a hare being preyed on rises 7 percent.** Hares in a few locations remain brown year-round, but no flexibility in the timing of autumn molt has been observed in populations that do change color. It might not all be bad news for the hares, however. Recent research indicates their range may be expanding in the far north as Arctic shrubs grow larger due to higher temperatures, creating new habitat and cover for the species.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Moose

Alces americanus

Region:
Northern United States and Canada

Area affected:
New Hampshire and Minnesota

Climatic change:
Warming temperatures

Impact:
Parasite infestation

ABOUT THIS SPECIES

With their long legs, large heads and the males' palm-shaped antlers, moose are one of our most distinctive mammal species. They are also the largest members of the deer family, ranging in size from 800 to 1,600 pounds. Moose live in boreal forest regions and are most common in Alaska and Canada, but their range also extends through the northern tier of the Lower 48, particularly in New England, Minnesota and the Northern Rockies. They feed on a wide variety of terrestrial vegetation, including the branches and leaves of willow, birch and aspen and other plants. They also forage in small ponds and streams for aquatic vegetation, particularly in summer. They are mostly solitary and range over short distances rather than undertaking long migrations.

DESCRIPTION OF IMPACT

After making a comeback in the 20th century from losses due to overhunting and habitat loss, moose are once again in alarming decline across the southern part of their range. Numbers have dropped by 75 percent in Minnesota, 30 percent in New Hampshire and 50 percent in parts of southern Canada. Some of this decline may be attributable to hunting or predation, but climate change is emerging as a major problem. Moose are susceptible to heat stress in warm summers, but the bigger problem seems to be that tick populations explode when winters are warmer and the period of snow cover is shorter. **Individual moose have been found with 100,000 ticks attached and sucking their blood.** In addition to causing anemia, tick infestation causes moose to scratch obsessively and wear off fur to the point of losing the insulation they need for cold weather.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

American Pika

Ochotona princeps

Region:
Southwest

Area affected:
Great Basin

Climatic change:
Rising temperatures

Impact:
Heat stress

ABOUT THIS SPECIES

Related to rabbits but appearing more like oversize hamsters, pikas live on the rocky slopes of high mountains in the West. They do not dig burrows, but shelter instead under large piles of rocks, known as talus, adjacent to patches of grass and other vegetation. Pikas are active in the daytime year-round. Since they do not hibernate, they must store food to see them through the long winters. They harvest plants and stack them in "haypiles" to dry, before storing them under talus in piles that can weigh as much as 50 pounds. Pikas live in colonies, with individual territories of 0.1 to 0.2 acres. They communicate with each other extensively through whistles, bleats and sharp alarm calls that send the animals scurrying for cover when a predator nears. They mate in April and have litters of about three young in May.

DESCRIPTION OF IMPACT

Suitable pika habitat is restricted to regions with fewer than 30 days per year above 95 degrees F. Pikas keep their warm winter coats year-round and are thus very sensitive to high ambient temperatures—in fact, long exposure to excessive warmth can kill the animals outright. Climate warming is already affecting them: Long-term research has shown that pika populations are moving up to higher elevations, where cooler temperatures still prevail, at rates averaging more than 450 feet per decade. As climate change continues to heat up their mountain homes, pikas will be pushed farther and farther upslope. Once they reach the top, they will have nowhere to go. This may already be happening in California, Nevada, New Mexico and Utah, the southern part of their range. **In the Great Basin, 40 percent of pika populations have vanished in recent years.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change


MIKE BAIRD/NOAA

California Sea Lion

Zalophus californianus

Region:
West Coast

Area affected:
California

Climatic change:
Warming oceans

Impact:
Diet changes

ABOUT THIS SPECIES

California sea lions are one of our most visible marine mammal species, gathering by the hundreds on beaches and rocky shorelines in California and up and down the West Coast. They are large seals—females reach up to six feet and males over seven feet long—and solid brown in color, sometimes with tan across the front. Sea lions feed on the schools of anchovies, mackerel, sardines and other small fish that abound in areas where currents and wind patterns allow for upwellings of cold, nutrient-rich water. One such area, around the Channel Islands near Santa Barbara, is a key breeding ground for the sea lions. Pups are born from May to July and are weaned after about 10 months.

DESCRIPTION OF IMPACT

In January 2015, sick and starving sea lion pups began stranding in alarming numbers on California's beaches. These pups, born the previous summer, should have still been with their mothers, nursing and fattening up to a weight of 70 pounds or more. **Instead, many were closer to the weight of a newborn (20 pounds), dehydrated and suffering from ulcers and respiratory infections, indicative of stress and malnourishment.** All told, nearly 4,000 sea lion pups stranded in 2015, and above-average pup mortality continued into 2016. The likely cause was a vast "blob" of exceptionally warm waters that played havoc with the food chain off the California coast. Persistent high pressure weakened the winds that normally drive the cold-water upwelling, and the fish that are normally abundant near the sea lions' breeding grounds withdrew to deeper, colder water farther offshore. Female sea lions, in turn, had to abandon their pups for long periods of time and venture much farther afield to forage, leaving the pups undernourished.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Gray Seal

Halichoerus grypus

Region:
Atlantic Ocean

Area affected:
Nova Scotia coast

Climatic change:
Sea ice loss

Impact:
Disease

ABOUT THIS SPECIES

Gray seals are a temperate to subarctic species found off the coasts of Scandinavia, the British Isles and Iceland, New England and eastern Canada. Males grow to eight to 10 feet long and more than 800 pounds and have a distinct "roman nose" when viewed in profile. Females average around six feet long and 400 pounds. Coat color varies from light to dark gray, with variable spotting. Gray seals can dive up to 1,500 feet to forage for fish, squid and crustaceans in waters just off the coast. They rest and give birth on small, rocky islands.

DESCRIPTION OF IMPACT

As sea ice retreats and key cold-loving prey species like cod move northward, gray seals are also ranging farther north than traditionally found. This means that for the first time, gray seals are encountering ringed seals, and being exposed to a parasite that the ringed seals carry. The parasite, *Sarcocystis pinnipedi*, is relatively benign in ringed seals, replicating within tissues for a while, then forming a cyst and moving to another host. When the parasite infects a gray seal, however, it does not form a cyst; it just continues replicating in the animal's liver like a cancer, until it destroys the organ and kills the host seal. **On one island off the coast of Nova Scotia, the parasite killed more than 400 young seals in 2012, nearly 20 percent of the island's population.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Harp Seal

Pagophilus groenlandicus

Region:
Arctic

Area affected:
Eastern Canada

Climatic change:
Loss of ice

Impact:
Pup mortality

ABOUT THIS SPECIES

The harp seal's scientific name means "ice-lover from Greenland," a name that attests to its fidelity to sea ice. The young are famous for their snow-white fur, although they only sport white coats for a brief period before beginning the "molting" process, making the transition to mottled gray with a dark "saddle" across the back. Females give birth on the southern edge of the ice in February or March, shortly before the spring ice breakup begins. Pups nurse for just 12 days, gaining about five pounds per day. They are then left alone on the ice, during which time they are highly vulnerable to predators and early ice breakup. They are finally able to swim six weeks after their mothers leave them. As the weather warms, the animals migrate toward the Arctic. Harp seals feed on a wide variety of fish and invertebrates. While foraging, they can make dives up to 1,200 feet for up to 16 minutes.

DESCRIPTION OF IMPACT

As the pups are left alone on the ice for weeks, harp seal breeding success is strongly tied to ice cover. Fluctuations in ice cover due to a natural climatic phenomenon known as the North Atlantic Oscillation (NAO) have a strong effect on pup mortality. In some years, the NAO leaves plenty of ice in the harbor seal's northernmost breeding areas east of Greenland and north of Finland, and produces less ice in the species' more southerly breeding areas off the east coast of Canada. In other years the NAO has the reverse effect, hence the term "oscillation." However, imposed on these natural fluctuations is the ominous reality of the overall decline of annual ice cover at a rate of about 5 percent per year due to warming in the northern latitudes. In most of the years since 1996, the NAO pattern has been unfavorable for ice off the Canadian coast. Combined with the overall ice decline, the situation has been particularly bad for harp seals: **As sea ice melts faster, more pups lose their ice platform before they are able to swim. In some years, like 2010, none of the pups born have survived.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Hawaiian Monk Seal

Monachus schauinslandi

Region:
Pacific Ocean

Area affected:
Northwest Hawaiian Islands

Climatic change:
Sea-level rise

Impact:
Habitat loss

ABOUT THIS SPECIES

Their Hawaiian name translates to "dog running in rough seas," and Hawaiian monk seals are indeed having a rough time right now. Although it has been protected under the Endangered Species Act since 1976, the Hawaiian monk seal population continues to decline at a rate of about 3 percent per year. With only about 1,100 remaining in the wild, these seals are one of our most endangered marine mammals. Most are found in the Northwest Hawaiian Islands, a series of small, low, coral atolls built on the remnants of the oldest volcanically formed islands, which extend for hundreds of miles northwest of the inhabited Hawaiian Islands. The seals forage in the waters surrounding these islands, diving to pursue fish, squid, octopus and eels. Several of these atolls, particularly the French Frigate Shoals, are critically important to the seals for giving birth and nursing their pups, and resting during molt periods.

DESCRIPTION OF IMPACT

The Northwest Hawaiian Islands are part of a national wildlife refuge, surrounded by the enormous Papahānaumokuākea Marine National Monument, which protects the reefs and the seabirds, fish and other marine wildlife that depend on this environment. However, that designation is not sufficient to protect the low-lying atolls from the effects of sea-level rise, which is compounding the natural effects of erosion common there. For instance, **from 1985 to 1996, nearly 35 percent of the region's monk seal pups were born on Whaleskate Island in the French Frigate Shoals, but by the late 1990s this island—once the second most important breeding site in the area—was completely submerged.** A large number of mother seals crowded onto nearby Trig Island, where pup survival was much lower, possibly due to an increase in shark predation facilitated by overcrowding. There is also evidence that young monk seals have higher survival rates when regional ocean temperatures are cooler, which means they may face additional problems as the oceans warm.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

SHAWN DAHLE/NOAA

Ringed Seal

Pusa hispida

Region:
Arctic

Area affected:
Western Hudson Bay

Climatic change:
Ice loss

Impact:
Pup mortality

ABOUT THIS SPECIES

Ringed seals, the smallest of the Arctic seals, are distributed around the entire North Polar region. They are generally a dark gray in color, with lighter, ring-shaped markings that give them their name. Unlike most seals, they can maintain breathing holes in the polar ice sheets, so they aren't limited to the zones near the ice edge. In fact, they prefer areas with the thickest ice, because females nurse their pups for over a month—much longer than other species—so they require ice that remains stable well into the late spring. They also need a thick snowpack on top of the ice where they can dig a den to keep the pups warm and protected from predation by polar bears, arctic foxes and even glaucous gulls.

DESCRIPTION OF IMPACT

Given the wide and northerly distribution of ringed seals, it is difficult to assess whether climate change is affecting the overall population. However, in the more accessible Hudson Bay region, researchers have detected a strong correlation between climate changes and a decline in pup survival. The data from the 1970s to 2001 show that the period since 1990 was characterized by warmer spring temperatures, earlier break-up of sea ice in the spring, and less snow cover. **In particular, the researchers found that when the snow layer atop the ice measured less than one foot deep, far fewer pups survived to maturity.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change


USF WS

Sonoran Pronghorn

Antilocapra americana sonoriensis

Region:
Southwest

Area affected:
Southern Arizona

Climatic change:
Drought

Impact:
Mortality

ABOUT THIS SPECIES

The Sonoran pronghorn is a critically endangered subspecies of America's fastest land animal. Pronghorn—sometimes mistakenly called "antelope"—range across much of the West and have a top speed of almost 60 miles per hour, fast enough to outrun their long-extinct predator, the American cheetah. Pronghorn are distinct in appearance, with their black noses and horns and "collared" markings on the upper chest. They range across the West, often undertaking long migrations. Sonoran pronghorn are uniquely adapted to desert life: they are smaller-bodied and lighter-colored than other pronghorn, which helps them stay cooler, and they can eat cactus and other tough desert vegetation in addition to grasses and broad-leaved plants. The last remaining populations of the Sonoran subspecies occur in southern Arizona and Mexico.

DESCRIPTION OF IMPACT

The U.S. population of Sonoran pronghorn has the distinction of having very nearly been driven to extinction by a severe climate event: a 13-month drought in Arizona in 2001 to 2002. This intensely dry period devastated pronghorn habitat. Vegetation dried up and already scarce water sources vanished. **Every single Sonoran pronghorn fawn born in 2002 died, as did most of the adults, and the population plunged from about 140 animals to just 19.** Wildlife managers had to resort to emergency measures to save the species, initiating a captive-breeding program and embarking on an ambitious project to create artificial water sources and forage plots in wildlife refuges within core Sonoran pronghorn habitat.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Desert Bighorn Sheep

Ovis canadensis nelsoni

Region:
Southwest

Area affected:
Southern California

Climatic change:
Drought

Impact:
Reproductive failure, local extinction

ABOUT THIS SPECIES

Bighorn sheep are the native wild sheep of the mountainous areas of the West. "Desert" bighorns are those populations found at higher elevations in the Southwest. They prefer steep terrain, where their outstanding agility helps them avoid predators, which is particularly important for ewes and young. Due to the isolation of their preferred habitats, the sheep are often found in small and fragmented populations. One population, found in southern California and Baja, is federally protected as "endangered." Bighorns graze on a wide range of grasses, broad-leaved plants and even cacti. Both males and females have horns that grow throughout their lives, although the rams' horns are much larger and more curved than the ewes'.

DESCRIPTION OF IMPACT

Although bighorn sheep are very well adapted to the desert, they are still sensitive to the range of moisture within that arid environment. Adults can survive extended periods on only the water contained in vegetation or rainwater collected in depressions in rocks. However, for lambs to survive, nursing ewes need both regular access to water and high-quality forage. Both of these resources are in short supply during extended drought, which is becoming more common in the southwestern United States. In Canyonlands National Park, which has recorded long-term population data, breeding success is 44 percent on average, but rises to 77 percent in wet years and plummets to 15 percent in dry years. **In California, 26 bighorn sheep populations have vanished over the course of the 20th century, mostly from lower elevation sites, which tend to be hotter and drier than higher areas.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Pacific Walrus

Odobenus rosamarus divergens

Region:
Arctic

Area affected:
Bering, Chukchi Seas

Climatic change:
Melting sea ice

Impact:
Habitat loss

ABOUT THIS SPECIES

Like their relatives the seals and sea lions, walruses are marine mammals adapted for swimming and diving. They feed in the relatively shallow waters of the continental shelf, where enough sunlight reaches the ocean floor to support a rich bounty of invertebrates. Dragging their tusks along the ocean bottom and rooting through the sediments with the sensitive bristles of their "mustaches," walruses find clams, mussels and marine worms to eat. Between foraging dives, they haul out and rest on sea ice. Females also give birth on the ice, and leave their calves there, safe from predation by orcas and polar bears, returning regularly to feed them between dives.

DESCRIPTION OF IMPACT

In order to rest and regularly feed their young, walruses need stable and predictable sea ice near the shallow waters where they forage. The accelerating loss of Arctic sea ice means the ice edge is retreating faster in the spring, moving away from shallow, nearshore feeding areas and out over waters too deep for walruses to reach the ocean bottom. That leaves them with two options: undertake a marathon swim to reach their calves on the more-distant ice, or congregate on the coast. In 2014, an astonishing 35,000 walruses were spotted on a single island. With two sets of flippers and weighing in at 4,000 pounds for males and 2,500 for females, they are ungainly on land, so when amassed in such large numbers, walruses are vulnerable to stampeding if they are disturbed. **In 2007, a year that set a record for Arctic sea ice loss, 3,000 walruses, mostly calves, were crushed to death in stampedes along the coast of Russia.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

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Red Wolf

Canis rufus

Region:
Southeast

Area affected:
Coastal North Carolina

Climatic change:
Sea-level rise

Impact:
Habitat loss

ABOUT THIS SPECIES

The red wolf is the largest native canid in the southeastern United States and one of the most imperiled mammals in North America. Hunted nearly to extinction, red wolves were included on the original federal endangered species list in 1967 and rescued through an intensive captive-breeding program. Reintroduction has been challenging, however, and fewer than 45 red wolves exist in the wild today. The species faces continued threats from habitat loss, vehicle collisions and conflicts with local communities that can lead to wolf mortality, which increases the possibility of the remaining wolves hybridizing with the much more common coyote. Red wolves are primarily nocturnal and hunt alone or in small packs for rabbits, rodents and occasionally deer. Each pack consists of a breeding pair and its offspring. Wolf pairs generally mate for life and produce litters of two to eight pups each year.

DESCRIPTION OF IMPACT

Like gray wolves, red wolves are tremendously adaptable and can live in a wide range of habitat and climate conditions. They once occurred over an extensive area stretching from Texas to Florida to Pennsylvania, which would imply a greater tolerance to climate change than other species that depend on a narrower range of suitable habitat conditions. The problem for red wolves is that their current range in the wild is severely restricted. Still misunderstood by many and hemmed in by development and agriculture to the west, the tiny population is found only in a low-lying, 1.7 million-acre coastal zone in northeastern North Carolina. This area, which includes Alligator River National Wildlife Refuge and Pocosin Lakes National Wildlife Refuge, is already showing the effects of climate change-induced sea-level rise, evinced by storm surges from hurricanes, saltwater intrusion and the transition of forest habitats to marsh. **Red wolves are now facing the inundation of their habitat: Within the next 150 years, 80 percent of Alligator River National Wildlife Refuge is projected to be submerged by rising seas.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

USFS

Cassin's Auklet

Ptychoramphus aleuticus

Region:
West Coast

Area affected:
California

Climatic change:
Warming oceans

Impact:
Food web changes

ABOUT THIS SPECIES

Cassin's auklets are robin-size seabirds, gray in color with a white "eyebrow." They range along the Pacific Coast, from the Aleutian Islands to Baja California. Colonies nest on small islands in large groups of up to 100,000 pairs. Each pair lays a single egg in a small burrow or protected site under a fallen tree. Both parents incubate the egg and care for the young. Cassin's auklets also forage at sea in large groups, often congregating at upwelling zones where cold, nutrient-rich water rises to the surface from the deep ocean. The nutrients brought to the surface fertilize the phytoplankton that are the basis of a food chain that supports huge concentrations of marine life. Cassin's auklets can dive up to 100 feet to feed on juvenile squid, crabs, krill and small fish.

DESCRIPTION OF IMPACT

The auklet's fidelity to areas with high concentrations of prey makes them vulnerable to changes in ocean productivity associated with warmer water temperatures. This has been demonstrated more than once in El Niño years, when the eastern Pacific Ocean becomes unusually warm. In 2005 to 2006, for instance, Cassin's auklets in the Farallon Islands near San Francisco suffered near total breeding failure, and hundreds of Cassin's and other seabirds began washing up dead—apparently from starvation—on the coasts of California and Oregon. The culprit appears to have been a "switching-off" of the critically important currents that govern nutrient upwelling. The cold-water currents arrived two months after the auklets' breeding season, leaving nesting birds with no nearby source of food for their chicks. **An even worse die-off of seabirds occurred in 2014, when an estimated total of 50,000 to 100,000 washed ashore.** Again, the birds appeared to have died from starvation rather than illness or exposure to toxins. Scientists studying the birds suspect that a "warm blob" of unusually high-temperature water off the Pacific Coast kept vital nutrients out of reach at the bottom of the ocean, causing a dramatic reduction in plankton, with reverberating effects throughout the food chain.

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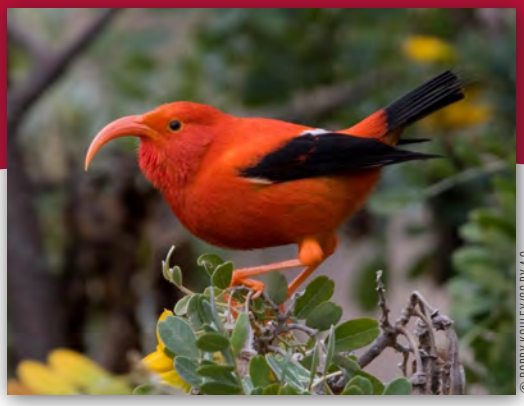
Species feeling the effects of climate change



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Hawaiian Honeycreepers

Multiple species

Region:
Pacific

Area affected:
Hawaiian Islands

Climatic change:
Warmer temperatures

Impact:
Disease spread

ABOUT THESE SPECIES

Hawaiian honeycreepers belong to a group of bird species descended from one or more flocks of Asian finches that colonized the Hawaiian Islands about 6 million years ago. Finding a wide array of unoccupied habitats, these finches, much like the ones described by Darwin in the Galapagos, eventually diversified into more than 50 species across the various islands, with bills adapted for eating nectar, insects or seeds. Unfortunately, the birds' isolation, specialization and lack of predators made them highly susceptible to the threats that accompanied human colonization of the islands—particularly habitat loss and the introduction of predators and diseases. Of the 41 Hawaiian honeycreeper species that have been described scientifically, 17 are extinct, six are likely extinct, and 18 are imperiled (ranging from vulnerable to critically endangered). Only three species are considered secure.

DESCRIPTION OF IMPACT

One of the introduced diseases that has hit Hawaiian honeycreepers particularly hard is avian malaria, which is transmitted by mosquitoes. Development and transmission of this deadly parasite are temperature-dependent, and the disease has already wiped out many birds at lower elevations where temperatures are warmest. Historically, forests above about 5,000 feet in elevation were cool enough to provide a mosquito-free refuge, but **climate change is shrinking this safe haven from avian malaria with devastating results for honeycreepers.** On the Big Island, warmer temperatures contributed to a spike in malaria prevalence at elevations up to 6,000 feet in 2001 to 2002. Similarly, on Kauai, warming temperatures and changes in stream flow have led to an increase in malaria transmission at medium- and high-elevation sites over the past 20 years.

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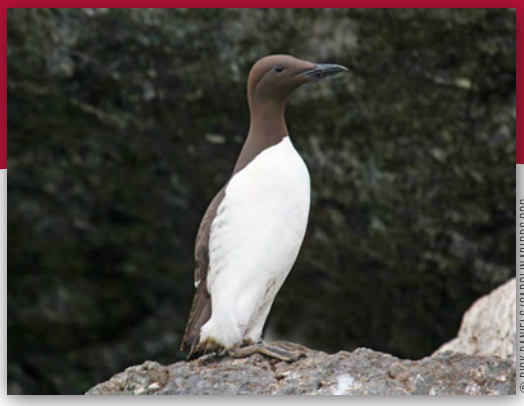

Common Murre

Uria aalge

Region:
Alaska

Area affected:
Prince William Sound

Climatic change:
Warming oceans

Impact:
Starvation due to food web changes

ABOUT THIS SPECIES

Common murres are widespread seabirds, with populations occurring along the north Atlantic and Pacific coasts of the United States and in northern Europe and northeastern Asia. Related to puffins and auks, they are the size of a small duck, with a large, pointed bill, dark gray-brown upperparts and white below. They nest in dense colonies on sea cliffs, laying their eggs directly on rocky ledges. The eggs have two special adaptations to these crowded, high-elevation conditions: They are elongated almost to a point on one end to limit rolling if jostled and have shells with highly variable speckled patterns that help parents identify their own eggs. Murres are more agile underwater than in flight, using their wings to "swim" as they dive to about 100 feet deep to feed on schools of small fish like herring, cod and capelin.

DESCRIPTION OF IMPACT

In late 2015, a biologist in Whittier, Alaska, made a grim discovery: nearly 8,000 dead birds washed up on the beach that borders the Chugach National Forest, a die-off described as "unprecedented" for a single location. **By late January 2016, over 22,000 dead murres—more than were killed in the Exxon Valdez disaster—had been found in the Prince William Sound area.** The dead birds—and the birds still living—showed signs of starvation, but no evidence of disease or parasites. Researchers suspect that a combination of climate change and El Niño conditions were to blame. The schools of small fish that the murres depend on prefer cold water, and the waters of the Gulf of Alaska were more than 5 degrees warmer than normal for months on end in 2014 and 2015. No one is certain whether the prey fish populations are also declining or have moved to cooler waters out of reach of the birds. The warm waters may also have triggered harmful algal blooms that exposed the birds to deadly toxins.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

California Brown Pelican

Pelecanus occidentalis californicus

Region:
West Coast

Area affected:
Channel Islands, Gulf of California, Columbia River

Climatic change:
Higher ocean temperatures

Impact:
Food web changes, breeding failure

ABOUT THIS SPECIES

With its pouched bill and seven-foot wingspan, the brown pelican is one of our most readily recognizable birds, as well as one of conservation's best success stories. Like bald eagles, pelicans feed almost entirely on fish and consequently once faced the same threat of extinction: reproductive failure due to the thinning of their eggshells caused by DDT and other pesticides that concentrate at the top of the food chain. The federal ban on these chemicals, along with protection of some of the coastal islands where colonies nest has led to a remarkable recovery, and the brown pelican was removed from the threatened and endangered species list in 2009. California brown pelicans feed mainly on schools of small marine fish and nest colonially on islands from southern California to central Mexico.

DESCRIPTION OF IMPACT

Unusually warm temperatures in the Pacific Ocean appear to be leading California brown pelicans astray. For the last several years, thousands of birds have been appearing in the Columbia River, 900 miles north of their traditional breeding grounds. Unfortunately, while the birds have exhibited courtship and nest-building behaviors, none have laid eggs in this northerly location, indicating that the area might not be suitable habitat. Consequently, a substantial portion of the population may fail to breed due to their northerly wanderings. **Even worse, the birds that continued using breeding habitat in the Gulf of California in 2014 and 2015 experienced some of their worst nesting failures on record: Islands that usually have hundreds or thousands of nests produced only a handful of young and some none at all.** This failure has been blamed on particularly warm ocean waters shifting food supplies away from nesting grounds. It is not yet known whether these changes are a temporary effect due to the strong El Niño or the start of a downward trend.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

White-tailed Ptarmigan

Lagopus leucura

Region:
Rocky Mountains

Area affected:
Rocky Mountain National Park

Climatic change:
Temperature increase

Impact:
Habitat loss, chick mortality

ABOUT THIS SPECIES

White-tailed ptarmigan are the smallest members of the grouse family and one of only a handful of birds that spend their entire lives in alpine tundra. They are pure white in the winter and molt to a mottled brown in the summer for camouflage. Widely distributed across Alaska and western Canada, they are found in isolated populations in the highest mountains of the Lower 48, particularly in the Cascades Range and Colorado Rockies, the southernmost extent of their range. They breed in high-elevation alpine meadows and move downslope in winter for the protection offered by stunted spruce trees just below the tree line. They are most active at dawn and dusk, feeding in small flocks on willows and other vegetation before roosting under protective vegetation or in burrows under the snow. Nests consist of a clutch of about six eggs laid in a depression lined with vegetation and feathers.

DESCRIPTION OF IMPACT

White-tailed ptarmigan populations in Colorado have been monitored regularly since the 1960s and have declined sharply to densities of about one-quarter of those recorded in the late-1970s. Several different climate factors may be contributing to the decline. Warmer winter conditions are associated with reduced population growth, possibly due to reduction in snow cover, which ptarmigan rely on for insulation while roosting overnight. Early spring temperature increases that shift precipitation from snow to rain are also a problem. **Young chicks are vulnerable to freezing to death if conditions are rainy in the first days after hatching.** And warm, dry summers also negatively impact ptarmigan both directly, because they cannot tolerate high temperatures, and indirectly by drying out the wet meadows where they forage.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Atlantic Puffin

Fratercula arctica

Region:
Northeast

Area affected:
Gulf of Maine

Climatic change:
Warming oceans

Impact:
Food web changes

ABOUT THIS SPECIES

With their brightly colored bills and penguin-like appearance, Atlantic puffins are one of the most readily recognized and beloved of seabirds. They can dive up to 200 feet deep into the ocean to prey on schools of small fish and marine invertebrates. Puffins breed in colonies on cliffs and islands along the coasts of Canada, Greenland, Iceland and Scandinavia and were recently reintroduced to former strongholds along the coast of Maine. Pairs are monogamous and will often return repeatedly to the same nest site, usually a burrow that they dig in a grassy spot or a natural crevice in rocky areas. Each season they a lay a single egg, and both parents share incubation and feeding duties. Atlantic puffins reach breeding age at around four or five years and can live up to three decades.

DESCRIPTION OF IMPACT

In the Gulf of Maine, the southern extent of their breeding range, puffins rely on a food web characterized by phytoplankton specialized to live in the Gulf's very cold, nutrient-rich waters. These plankton feed an assortment of puffin prey—herring, hake, capelin, sand lance and other small, slender fish that thrive in cold water. In 2012, an exceptionally warm period heated the Gulf of Maine early in the spring, and most of these prey species responded by moving northward to colder waters, leaving only rounder-bodied butterfish for puffins to offer their chicks. The warm spring also triggered a plankton "bloom" very early in the season, so the butterfish were larger than usual by the time the puffins hatched—too wide for the young birds to swallow. Thus only 31 percent of pairs successfully raised a chick in 2012 (in cooler years the rate is closer to 77 percent). **2013 was almost as warm, and the numbers were even worse: Only 10 percent of puffin chicks survived, causing the population in the Gulf of Maine to drop by a third.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Cape Sable Seaside Sparrow

Ammodramus maritimus mirabilis

Region:
Southeast

Area affected:
Everglades National Park

Climatic change:
Strong storms, change in fire regime

Impact:
Habitat loss, mortality

ABOUT THIS SPECIES

Seaside sparrows are found exclusively in grassy marshes along the Atlantic and Gulf coasts. Most live in salt to brackish marshes, but the endangered Cape Sable subspecies, endemic to the Everglades, requires a particular freshwater marsh habitat called "marl prairie." This habitat is flooded with a few inches of water from late summer to early winter, but dries out from late winter through much of the summer. The habitat also requires fire at roughly 10-year intervals to prevent shrubs and trees from overtaking the grasses. The sparrows breed in the dry season, building nests in the grasses about six inches above the ground. They eat a wide variety of insects and other small invertebrates.

DESCRIPTION OF IMPACT

The seaside sparrow has the distinction of having been driven from its namesake location by a severe weather event. Originally discovered on Cape Sable in the southwest tip of Florida, the species has not had a stronghold there since the Labor Day Hurricane of 1935 caused major changes in the vegetation and hydrology, which transitioned the area to salt marsh and mangrove. Unfortunately, the climate-related blows have kept coming. A population in Big Cypress National Preserve was extirpated following a series of wildfires in the 1960s. **The remaining population in the Everglades declined by half—from 6,600 to 3,300 birds—following the direct hit from Hurricane Andrew in 1992 and has remained at or below that level ever since.** Ongoing water management activities have probably impeded recovery, and although their habitat needs some fire, the birds have taken a hit from uncharacteristically severe fires in recent years. Populations declined by a further 80 percent in 2008, when unusually large wildfires struck critical habitat in the Everglades, and 2009 surveys found that three of the six subpopulations contained no female birds.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

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Wood Stork

Mycteria americana

Region:
Southeast

Area affected:
South Florida

Climatic change:
Precipitation change

Impact:
Loss of food source

ABOUT THIS SPECIES

Measuring 40 inches tall with a five-foot wingspan, wood storks are one of the largest wading birds in North America. They are also a notable Endangered Species Act success story. Listed as "endangered" in 1984 after loss of wetland habitat caused an 85 percent drop in nesting populations over the 20th century, by 2014 the birds had rebounded and were downlisted to "threatened." In the United States, wood storks are found in coastal regions in the Southeast and throughout Florida. Populations also range across the Gulf Coast regions of Mexico and Central America and throughout much of South America. Wood storks are colonial birds that feed in large flocks and cluster their nests in groups, or "rookeries," built in clumps of large cypress or mangrove trees. They use their long, slightly curved bills, which can snap shut on prey in a fraction of a second, to forage in shallow wetlands for small fish.

DESCRIPTION OF IMPACT

Wood storks depend on a specific set of seasonally fluctuating wetland conditions that provide their prey: high water periods during which fish populations increase, alternating with drier periods when the water level drops to six to 10 inches deep, concentrating fish at depths storks can reach with their bills. Raising a pair of stork chicks requires about 400 pounds of fish, so the birds depend on the seasonal dry period, when fish are easier to catch, to correspond with the stork nesting season, which runs from October to March. This pattern has been broken in South Florida in recent years, and wood stork numbers may be declining as a result. In autumn 2014, for instance, the months leading up to the breeding season were dry rather than wet, so fish populations were smaller than usual. Then in spring 2015, conditions abruptly shifted to an unusually wet period, making available fish more difficult to catch. **Consequently, in 2015 wood stork nesting was down 36 percent from the 10-year average.** In 2016, an extremely wet winter left many of the breeding areas so flooded that foraging became difficult, and biologists reported finding adult storks that apparently starved to death.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Leatherback Sea Turtle

Dermochelys coriacea

Region:
Oceans

Area affected:
Eastern Pacific

Climatic change:
Higher temperatures

Impact:
Reproductive changes

ABOUT THIS SPECIES

Leatherback sea turtles are found throughout the tropical and temperate oceans of the world. They get their name from their top shells, which are leathery and have several parallel ridges. (The shells of other sea turtle species consist of hard, bony plates.) Leatherbacks are also the largest turtle in the world, capable of growing to 6.5 feet long and a weight of 2,000 pounds. Leatherbacks spend most of their lives in the open ocean, migrating long distances and feeding mainly on soft-bodied prey, like jellyfish, which they grasp and swallow using the many tooth-like projections that line their jaws and esophagus. They nest on sandy beaches in tropical regions around the world. The largest nesting areas are in northern South America and West Africa, but they also nest on the West Coast of the United States and in the Caribbean Islands. Females lay about 100 eggs at a time in shallow, covered depressions, from which the hatchlings emerge about two months later.

DESCRIPTION OF IMPACT

All sea turtles have temperature-dependent sex determination, meaning that the incubation temperature of the nest determines the sex of each hatchling. Eggs exposed to higher temperatures at the top of the nest or in darker sand produce females; cooler incubation temperatures produce males. Climate warming poses a threat to sea turtles because it can skew sex ratios toward more females and fewer males. **Higher temperatures at leatherback nesting grounds have also been linked to increased mortality in eggs and hatchlings.** On beaches in Costa Rica, fewer eggs developed and fewer hatchlings successfully dug out of the nest in years with warmer temperatures and less precipitation than in years with cooler temperatures and more moisture.

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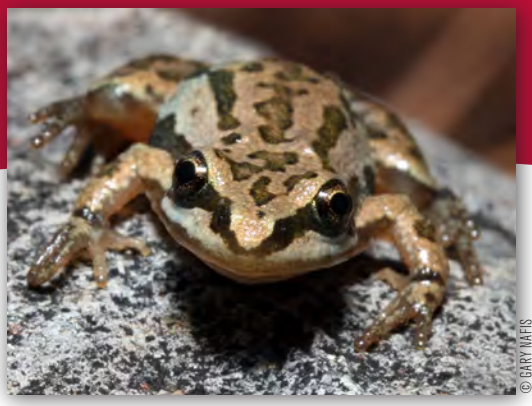
Species feeling the effects of climate change



Boreal Chorus Frog

Pseudacris triseriata maculata

Region:
Rocky Mountains

Area affected:
Yellowstone National Park

Climatic change:
Increased incidence of drought

Impact:
Loss of breeding habitat

ABOUT THIS SPECIES

The boreal chorus frog is found throughout much of the upper Midwest and Rocky Mountain states. One of the smallest frog species, adults range in size from 0.5 to 1.5 inches. They are variable in color, but usually have two sets of blotches running down their back. In early spring they congregate near small ponds and lakes, where males give their signature "chorus" calls to attract females, which lay their eggs in the water after breeding. Of particular importance to the species are small temporary ponds, called vernal pools, which form in spring when rain and snowmelt collect in low areas and dry out in late summer. The late-summer disappearance keeps the pools free of fish that would prey on eggs and tadpoles, which require about two months to complete metamorphosis into adult frogs. It is important that the vernal pools and ponds retain water for that full period: if they dry out before the tadpoles complete their development and can breathe air, the young will die. Outside of the breeding season, these frogs range relatively far upland (up to a quarter-mile from water), eating small insects.

DESCRIPTION OF IMPACT

Yellowstone National Park is one of the nation's largest and oldest nature preserves, and thus protected from many threats to boreal chorus frogs, such as habitat conversion and water diversion. But even Yellowstone cannot escape the effects of climate change. The region has been subject to a warming and drying trend in recent decades, including the most prolonged severe drought of the past century between 2000 and 2007. Researchers observed that 19 out of 49 ponds that had been present in the park in 1992 dried out during the drought, and that eight of these remained dry even after a wet year in 2008. **The number of boreal chorus frog populations declined by 75 percent from 1992 to 2008: In 1992 to 1993 they were found in 20 of 42 ponds surveyed, but only in five over the period of 2006 to 2008.**

References

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SEAN NEILSEN/NPS

Columbia Spotted Frog

Rana luteiventris

Region:
Rocky Mountains

Area affected:
Yellowstone National Park

Climatic change:
Increased incidence of drought

Impact:
Loss of breeding habitat

ABOUT THIS SPECIES

Found throughout much of the Pacific Northwest, the Columbia spotted frog is also the most abundant amphibian in Yellowstone National Park. Roughly three inches in length, their spots give these frogs a "warty," toad-like appearance. Adults feed on terrestrial insects, rarely venturing more than 50 feet from water and preferring areas with sheltering vegetation at the water's edge. They breed in late spring and lay their eggs in water bodies ranging from small pools to lakes, but seasonal ponds without fish that prey on frog eggs and larva are particularly important. Although tadpoles can metamorphose in as little as 60 days, the frogs don't reach reproductive maturity until four to six years of age.

DESCRIPTION OF IMPACT

Yellowstone National Park is one of the nation's largest and oldest nature preserves, and thus has long been free from threats like habitat conversion and water diversion. But even Yellowstone cannot escape the effects of climate change. The region has been subject to a warming and drying trend in recent decades, including the most prolonged severe drought of the past century between 2000 and 2007. Researchers observed that 19 out of 49 seasonal ponds that had been present in 1992 dried out during this period, and that eight of these remained dry even after a wet year in 2008. **The number of spotted frog populations declined by 68 percent from 1992 to 2008.** In 1992 to 1993, they were found in 22 of 42 ponds surveyed, but only in seven over the period of 2006 to 2008.

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Species feeling the effects of climate change

Blotched Tiger Salamander

Ambystoma mavortium melanostictum

Region:
Rocky Mountains

Area affected:
Yellowstone National Park

Climatic change:
Increased incidence of drought

Impact:
Loss of breeding habitat

ABOUT THIS SPECIES

The blotched tiger salamander, a subspecies of the western tiger salamander, is the only salamander found in Yellowstone National Park. These salamanders are olive in color with dark blotches across their backs. Adults are terrestrial, living beneath fallen logs or rocks, and feeding on a variety of insects and other small invertebrates. In late spring, adults migrate to small seasonal ponds to breed and lay their eggs. These small temporary ponds, called vernal pools, form in spring when rain and snowmelt collect in low areas and dry out in late summer. The salamanders evolved to use these provisional habitats rather than perennial ponds and lakes that support populations of fish that would devour salamander eggs and larvae. However, if the vernal pools dry out too quickly—before the larvae complete their development and can breathe air—the young salamanders will die.

DESCRIPTION OF IMPACT

Yellowstone National Park is one of the nation's largest and oldest nature preserves, and thus protected from many threats to salamanders, like habitat conversion and water diversion. But even Yellowstone cannot escape the effects of climate change. The region has been subject to a warming and drying trend in recent decades, including the most prolonged severe drought of the past century between 2000 and 2007. Researchers observed that 19 out of 49 vernal pools that had been present in 1992 dried out in this time period, and that eight of these remained dry even after a wet year in 2008. **The number of salamander populations declined by nearly half during this period: In 1992 to 1993, salamanders were found in 26 of 42 vernal pools surveyed, but in only 14 between 2006 and 2008.** Worse, the researchers found hundreds of dead salamanders at several of the pools that had dried out over the course of the study, indicating that drying had outpaced the larval development.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Atlantic Cod

Gadus morhua

Region:
Atlantic Ocean

Area affected:
North Atlantic

Climatic change:
Warmer oceans

Impact:
Food web changes

ABOUT THIS SPECIES

The Atlantic cod has been a staple in American diets and commerce since colonial times and was an important resource for native peoples for thousands of years before that. Although its range in the western Atlantic stretches as far south as Virginia, its population strongholds have historically been off the coasts of Maine and Massachusetts. Indeed, early explorers named Cape Cod for the bounty found in the area. Atlantic cod can grow to over four feet long and up to nearly 80 pounds, although fish of such size are rarely seen today. Adults prefer cold water and live primarily along the ocean bottom at depths of about 500 feet. Schools of cod undertake complex seasonal migrations, moving to shallower or more southerly waters in the winter and northward or to deeper waters in spring. The cod feed on a wide variety of other fish and marine invertebrates. Females spawn near the ocean bottom, but the eggs float up to the upper reaches of the water column, where larval cod live and feed on tiny organisms called zooplankton for the first three months of their lives.

DESCRIPTION OF IMPACT

Sustained fishing pressure led to the near collapse of the Atlantic cod population off the coast of New England in the mid-1990s. Fishery managers slashed harvest quotas in an effort to rebuild population levels, but, as of 2012, the fisheries in both Georges Bank and the Gulf of Maine were still considered seriously depleted. **The failure of Atlantic cod stocks to rebound over the past 20 years is probably due at least in part to major ocean changes associated with climate warming.** An examination of decades' worth of survey data showed that warm water habitats have been increasing at the expense of colder habitats in the region. These temperature changes are affecting ocean circulation patterns, leading to a decline in two types of zooplankton that are a critical food source for larval cod, which consequently have also decreased in abundance.

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Species feeling the effects of climate change

DON FEDERBACHER/FWS

Devils Hole Pupfish

Cyprinodon diabolis

Region:
Southwest

Area affected:
Ash Meadows National Wildlife Refuge

Climatic change:
Warming waters

Impact:
Decreased oxygen supply

ABOUT THIS SPECIES

Just an inch long and brilliant blue in color, the Devils Hole pupfish is one of our most imperiled species. They are found in only one place on Earth, a geothermal spring called Devils Hole in the Mojave Desert east of Death Valley National Park. Devils Hole is a limestone cavern about 400 feet deep, and only six by 18 feet wide at the surface, aquifer-fed and about 92 degrees F year-round. The fish live in the top 80 feet of the pool, where they feed on diatoms that grow on an underwater ledge that sunlight reaches. The Devils Hole pupfish has been listed as "endangered" since 1973 when there were about 500 individuals; today there are fewer than 100.

DESCRIPTION OF IMPACT

Due to the geothermal nature of Devils Hole, the pupfish is already living near the metabolic extreme at which fish can survive, because water at that temperature holds very little oxygen. Living so near the edge of their tolerance leaves very little margin for change, but over the past few years, water temperatures in the top part of the pool have risen about one degree. Though this amount of warming may seem negligible, it reduces the optimal development period for pupfish larvae by 10 percent, which means the period when temperature and food availability are just right for egg hatching and development of young has decreased from ten weeks to nine. **In 2013, the Devils Hole pupfish population dropped to an all-time low of just 35 fish.** The population have recovered somewhat, to about 90 individuals, but the species is still teetering on the brink of extinction.

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JEFF KOZLOWSKI/NOAA

ALASKA

Chinook Salmon

Oncorhynchus tshawytscha

Region:
Alaska

Area affected:
Statewide

Climatic change:
Warming waters

Impact:
Disease, juvenile mortality

ABOUT THIS SPECIES

Chinook salmon are the largest of the eight species of Pacific salmon, capable of reaching 50 pounds or more. The most prized salmon for eating, they are commonly called "king salmon." In Alaska, Chinook salmon runs support vital subsistence, sport and commercial fisheries, and are extremely important socially and culturally. Like most salmon, they are anadromous, meaning the eggs hatch and the young "fry" spend their first year in rivers, then the "smolts" move downstream to the ocean to live for about four to six years. The adults then return to the rivers of their birth to spawn and die. Juvenile, river-dwelling Chinook salmon eat a variety of small aquatic invertebrates; older, ocean-going salmon primarily eat other fish.

DESCRIPTION OF IMPACT

Chinook salmon spawning numbers have been below average statewide since 2007, indicating a persistent reduction in survival for fish hatched since 2001. While the causes are still under investigation, warming rivers and seas are linked to several possible culprits. For instance, smolt survival decreases when sea-surface temperatures are higher, possibly due to changes in food availability. Also, survival of young fry is reduced when river flows are unusually high due to faster snowmelt and severe rains. Another problem found on the Yukon River in particular is infection by *Ichthyophonus*, a parasitic protozoan that causes lesions on heart, liver and muscle tissues, which reduces swimming ability and eventually causes organ failure and death. The parasite grows faster and spreads more readily in warmer waters. While infection rates have declined in recent years, the disease persists and the stock does not seem to be recovering.

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Species feeling the effects of climate change

SCOTT MOREY/YOLO5/CALIFORNIA DEPARTMENT OF WATER RESOURCES

SACRAMENTO RIVER WINTER-RUN
Chinook Salmon

Oncorhynchus tshawytscha

Region:
West Coast

Area affected:
Sacramento River

Climatic change:
Warming waters

Impact:
Heat mortality

ABOUT THIS SPECIES

Chinook salmon occur in streams and rivers all along the West Coast, and their conservation status varies geographically. In the Lower 48, most populations (which are designated based on the location and time of spawning) are protected under the Endangered Species Act. One small population, the winter-spawning Chinook in California's Sacramento River, is listed as "endangered." Severely restricted by dams and harmed by water pollution, this run is at the highest risk of extinction. Like most salmon, Chinook are anadromous, meaning that they hatch and begin development in rivers, move downstream to mature in the ocean, then make a final return journey upriver to spawn and die. Juvenile Chinook salmon eat a variety of small aquatic invertebrates. Older, ocean-going adults mainly eat fish.

DESCRIPTION OF IMPACT

Chinook salmon require unimpeded flows of cold, clean water to spawn successfully. Unfortunately, California has been in the grip of one of the most severe droughts in the state's history. The reduction in mountain snowpack is depriving the state's streams of a primary source of cold water flow and the lower water flows warm more easily. Exacerbated by poor management of Shasta Reservoir, these factors have caused the Sacramento River to be much warmer than the winter-run Chinook population can tolerate. **Elevated temperatures killed an estimated 95 percent of Chinook salmon eggs and fry (newly hatched fish)** during the 2014 spawning season. In 2015, fishery managers attempted to improve conditions by releasing an unprecedented number of hatchery-raised fry in the river. However, drought conditions have persisted, and biologists counted even fewer spawning fish in 2015. The winter-run Chinook has a three-year life cycle, so the loss of the juvenile cohort two years in a row could be catastrophic.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Sockeye Salmon

Oncorhynchus nerka

Region:
Pacific Northwest

Area affected:
Columbia, Snake and Fraser Rivers

Climatic change:
Warmer water

Impact:
Heat-related mortality

ABOUT THIS SPECIES

Sockeye salmon are a widespread and commercially important species in Alaska, but are imperiled in the southern part of their range, particularly in Washington's Snake River. Most sockeyes are anadromous, meaning that they hatch and spend their first one to three years in rivers, then move downstream to the ocean where they live most of their lives before making a final return journey upriver to spawn and die. Sockeyes are silver in color during the ocean phase of their life cycle, but turn a brilliant red during spawning season. Young sockeyes feed on plankton and small invertebrates, and older ocean fish live mainly on small invertebrates and fish. Sockeye salmon display tremendous fidelity to the site where they were spawned and even to the season in which spawning occurred.

DESCRIPTION OF IMPACT

Since salmon die after they spawn, they have only one chance to breed successfully. This is a risky evolutionary strategy, since the upriver migration is a perilous undertaking with predation, water pollution and encounters with dams claiming many sockeyes along the way. **Warmer stream temperatures have emerged as an additional major threat. The deaths of hundreds of thousands of migrating sockeye have been recorded during periods of high summer temperatures in the Fraser River and Weaver Creek in British Columbia.** The problem for the fish is that swimming upstream takes tremendous physiological effort, and the oxygen demand for powering swimming is very high. Warmer water holds less dissolved oxygen, and above a certain threshold sockeye simply cannot pull enough oxygen out of the water to meet their metabolic needs. The problem is particularly acute for females because they have lower cardiac capacity and are thus more sensitive to oxygen-depleted waters.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Delta Smelt

Hypomesus transpacificus

Region:
West Coast

Area affected:
Sacramento-San Joaquin River Delta

Climatic change:
Drought and increased temperature

Impact:
Habitat loss

ABOUT THIS SPECIES

The delta smelt is found only where the Sacramento and San Joaquin rivers meet in a complex delta of bays and sloughs, before emptying into San Francisco Bay. Just three inches long, the smelt is readily identified by its large eyes, an adaptation for feeding on zooplankton and small invertebrates in the cloudy, sediment-rich waters of the Bay-Delta. Foraging predominantly in cloudy, turbid waters also helps avoid predation by larger fish. The smelt live only a year before spawning in the upstream, low-salinity reaches of the rivers and sloughs. The main threats to the fish are water pollution, reduced river flow and changes to flow caused by upstream water diversions and dams. Delta smelt are listed as "threatened" under the Endangered Species Act.

DESCRIPTION OF IMPACT

The multi-year severe drought in California has had major impacts on its waterways, including the rivers that feed into the San Francisco Bay-Delta. Diversions of water for agriculture and urban use have further reduced river flow, allowing sea water from the nearby Pacific Ocean to move further into the Bay-Delta, increasing its salinity. Delta smelt prefer low-salinity water and cannot use their preferred habitats during times of low freshwater flow. Seeking lower salt concentrations, the smelt instead move upstream, where they encounter competition from other fish and dangerous impediments like water pumps. The rivers are also getting warmer, and the delta smelt cannot tolerate water temperatures higher than about 78 degrees F. **The drought's effects on flow and salinity may be helping to drive the delta smelt to extinction: Populations have fallen to new record lows for several years running, and surveys in spring 2015 found only six fish in the wild.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Longfin Smelt

Spirinchus thaleichthys

Region:
West Coast

Area affected:
Sacramento-San Joaquin River Delta

Climatic change:
Drought and increased temperature

Impact:
Habitat loss

ABOUT THIS SPECIES

Silvery in color and named for the unusual length of their front-most pair of fins, longfin smelt reach up to four inches in size and live for two to three years. They are found in estuaries and lakes along the West Coast and north to Alaska. The population that lives in the San Francisco Bay-Delta is a candidate for protection under the Endangered Species Act, but its listing to date has been precluded by higher priorities. Longfin smelt can tolerate a wide range of water salinities, from freshwater to ocean water. Most spawn in freshwater streams with sandy bottoms, and the young fish live in slightly salty coastal marshes and estuaries for their first year, then move to shallow ocean waters along the coast. The fish feed on small invertebrates.

DESCRIPTION OF IMPACT

It has been recognized since the 1980s that drought has a significant effect on longfin smelt populations. In the past, populations have rebounded with the return of wet years; however, **with the region in severe drought for much of the past decade, the species numbers have remained far below historical levels.** Drought reduces flows of fresh water into the San Joaquin and Sacramento rivers, an effect that is compounded by diversions of water for agriculture and urban use. Since the rivers' estuary is so close to the Pacific Ocean, the reduction of river flow into the San Francisco Bay-Delta allows sea water to encroach upstream, increasing water salinity. Though mature smelt can tolerate a wide range of salinities, the species' eggs and very young fish need fresh water. Saltwater encroachment thus reduces the area of the river system that is suitable as breeding habitat. The rivers are also getting warmer, and the longfin smelt prefer water temperatures below 71 degrees and even cooler waters for spawning. Furthermore, because the fish appear to rely on sediment carried in the water to hide from predators, lower flows and clearer water may expose them to higher levels of predation.

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Species feeling the effects of climate change

Bull Trout

Salvelinus confluentus

Region:
Northwest

Area affected:
Central Idaho

Climatic change:
Stream warming

Impact:
Habitat loss

ABOUT THIS SPECIES

Bull trout are found in mountain streams in Montana, Idaho, Washington and Oregon. They are listed as "threatened" under the Endangered Species Act due to ongoing threats from dams, activities that pollute and add sediment to streams, and competition from and hybridization with introduced fish species like lake trout and brook trout. Bull trout spawn in autumn in clean, gravel-bottomed, spring- or groundwater-fed headwater streams that tend to be quite cold but rarely freeze due to continuous flow. The eggs incubate over winter and the young emerge the following spring. Some bull trout remain in these high mountain streams for their whole lives; others migrate after a year or so to lower elevation rivers or lakes that may be up to 150 miles from their spawning streams. They reach maturity between four and seven years of age. Unlike salmon, bull trout can spawn multiple times and can live up to 12 years. Juveniles eat plankton and small insects, and adults prey on other fish.

DESCRIPTION OF IMPACT

Bull trout require the coldest water of any of our native riverine fish, with most spawning and juvenile habitat waters ranging from 48 degrees to 52 degrees F. Even fish that migrate to lower elevations are rarely found at temperatures above 60 degrees F. Consequently, these trout are particularly vulnerable to climate change. A study of streams in central Idaho found that from 1993 to 2006, water temperatures warmed by about one degree due to warmer air temperatures, changes in streamflow and the effect of wildfires. **Just this small increase in water temperature led to the loss of 11 to 20 percent of stream length that is cold enough for spawning and rearing of juvenile bull trout.** Additional warming threatens to cause loss and fragmentation of remaining bull trout habitat.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

USGS

Westslope Cutthroat Trout

Oncorhynchus clarki lewisi

Region:
Northwest

Area affected:
Flathead River Basin

Climatic change:
Warming streams

Impact:
Hybridization

ABOUT THIS SPECIES

Native to western Montana and northern Idaho, the westslope cutthroat trout gets its common name from the distinctive red marks across its throat and its scientific name from its discoverers, explorers Lewis and Clark. These trout require cold, clean water with very little sediment and access to deeper pools or lakes where they can survive the winter. The fish take about four or five years to mature and spawn in the upper reaches of mountain streams. They consume a wide variety of insects, a fact that makes them popular with anglers and susceptible to overfishing. Other threats include land-use activities and related effects that cause sedimentation in streams, like mining, grazing, logging and fires. In addition, competition from larger, introduced sport fish like brook, brown and rainbow trout has eliminated this native trout from much of its former range.

DESCRIPTION OF IMPACT

Competition from introduced species is only part of the problem. Westslope cutthroat trout are also known to breed with non-native rainbow trout, and this hybridization threatens the existence of the native species. Rainbow trout prefer warmer water than cutthroats, and for some time remained in lower elevation, warmer waters, leaving higher elevation strongholds for the cutthroat, particularly in the Flathead River Basin of Montana. In recent decades, however, this area has experienced reduced springtime precipitation and higher summer temperatures, increasing summer stream temperatures. Water temperatures measured above 48 degrees F (the threshold for rainbow trout) have doubled since 1978. This has encouraged rainbow trout to move upstream, increasing hybridization with cutthroats by 27 percent. **Genetically pure westslope cutthroat trout now persist in only 10 to 20 percent of their former range.**

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

Corals

Multiple species

Region:
Southeast

Area affected:
Florida coast and Caribbean

Climatic change:
Warming, acidification

Impact:
Disease, bleaching

ABOUT THIS SPECIES

Coral reefs cover a tiny fraction of the ocean floor, but their value to fisheries, tourism and coastal protection can be measured in billions of dollars. The key to their success is the symbiotic relationship between photosynthetic algae known as zooanthellae and coral polyps, the tiny invertebrates related to sea anemones and jellyfish that colonize and form coral reefs. The coral polyps provide the algae with carbon dioxide—the building block of photosynthesis—important nutrients like nitrogen and phosphorus and a protected place to live. In turn, the photosynthetic action of the zooanthellae provides the coral with oxygen and up to 90 percent of its energetic requirements. The reefs formed by hundreds of years of this symbiosis provide habitat for countless other marine invertebrates and young fish. Corals are found exclusively in clear, shallow waters and are highly sensitive to sedimentation and pollution.

DESCRIPTION OF IMPACT

Climate change is causing three major impacts to corals: bleaching, disease and acidification. Bleaching occurs when the colorful photosynthetic algae are expelled from the coral and is strongly associated with high water temperatures. Corals are also susceptible to a number of diseases caused by bacteria, fungi and protozoans. Many of these pathogens develop more quickly in warmer waters and take advantage of corals already stressed by high temperatures. Lastly, a substantial amount of the atmosphere's excess carbon dioxide has been dissolving in our oceans, making them more acidic than they have been through most of history. More acidic waters make it more difficult for corals to build their calcium carbonate external skeletons, which form the structure of the coral reefs. **While many factors have contributed to the nearly 50 percent loss in Florida's coral reefs over recent decades, our changing oceans are one of the primary drivers of decline.**

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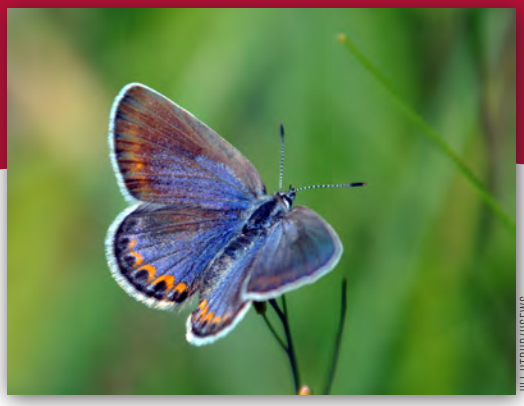
Species feeling the effects of climate change



JILL UFRUP/USFWS

Karner Blue Butterfly

Lycaeides melissa samuelis

Region:
Great Lakes

Area affected:
New York, Wisconsin

Climatic change:
Warmer, drier summers

Impact:
Reproductive changes, habitat loss

ABOUT THIS SPECIES

The Karner blue butterfly, a subspecies of the Melissa blue, is a small, bright blue butterfly with very distinct habitat requirements. While adults will feed on the nectar of a number of flowering plants, they lay their eggs exclusively on the leaves of the lupine plant, which is the sole food source for the developing caterpillar. Lupine is found mainly in fire-maintained oak savannah habitats that were once common across the Great Lakes region, but have declined sharply over the past century. The butterfly is now restricted to a few small, disjunct populations in New York, Michigan and Wisconsin, and has been listed as "endangered" under the Endangered Species Act since 1992. Karner blues generally undergo two life cycles during the course of a year: eggs laid in late summer hatch the following April, and the caterpillars feed for about a month before pupating and emerging as adults by late May. These adults mate and their offspring emerge in July. This second generation lays eggs that overwinter and hatch in spring.

DESCRIPTION OF IMPACT

The Karner blue's remaining population strongholds in New York and Wisconsin are experiencing warmer and drier summers that are having a negative effect on the butterfly and its habitat. Warmer summer temperatures can induce the second generation eggs to hatch in late summer or early fall instead of overwintering. This third generation then has less time to feed and develop, particularly if the weather is dry, which causes the lupine the caterpillars rely on for food to die back before they complete their feeding period. As a result, the extra summer generation of butterflies does not grow as large, lays fewer eggs and produces **fewer butterflies the next year than would a second generation of eggs that overwinters to spring instead of hatching.** Karner blue butterfly numbers have declined significantly in Wisconsin, where their habitat has experienced a long-term drying trend.

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Species feeling the effects of climate change

Monarch Butterfly

Danaus plexippus

Region:
Southwest

Area affected:
California and Mexico

Climatic change:
Extreme weather, drought

Impact:
Mass mortality

ABOUT THIS SPECIES

Monarch butterflies are perhaps our best-known and best-loved insect in the United States. The species is almost as famous for its mass migrations as it is for its striking black and orange coloration. In late autumn, millions of monarchs migrate to wintering grounds in California and Mexico, where they hibernate in masses that can completely cover the trees. In late winter, they begin the return journey north laying their eggs on milkweed plants along the way. The eggs hatch into caterpillars that feed exclusively on milkweed for a few weeks before pupating and then emerging as adult butterflies that live from two to six weeks. The cycle repeats to produce a second and third generation of similarly short-lived butterflies and then a fourth generation that emerges as winter approaches and lives much longer—six to eight months—to make the trip back to their southern wintering grounds.

DESCRIPTION OF IMPACT

Deforestation, pesticides and a host of other threats—increasingly including extreme weather events—have taken a huge toll on the migrating monarch population. In 2002, for instance, a highly unusual severe storm hit the species' wintering grounds, where it is normally the dry season during overwintering. Following the storm the temperature dropped, and the butterflies, which can tolerate cold when dry but freeze if they get wet, died in droves. By some estimates, nearly 270 million monarchs perished—75 to 80 percent of some wintering groups. Bad weather in recent years has further eroded the population. In 2012, breeding habitat in Texas was hit with near-record heat and drought, and, in 2013 a cold snap delayed northward migration and the onset of breeding. **Surveys in 2014 found only 35 million monarchs on their wintering grounds, down from nearly a billion in the 1990s.** This massive decline—greater than 95 percent—was steep enough that the U.S. Fish and Wildlife Service recently announced that it will consider Endangered Species Act listing for migrating monarchs.

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Species feeling the effects of climate change

GORDON PRATT/USGS

Quino Checkerspot Butterfly

Euphydryas editha quino

Region:
Southwest

Area affected:
Southern California

Climatic change:
Drought, snowpack changes

Impact:
Loss of habitat and host plants

ABOUT THIS SPECIES

The Quino checkerspot is an endangered subspecies of the more broadly distributed Edith's checkerspot butterfly. The Quino is known from only a handful of counties in southern California and adjacent areas in northern Mexico. The range of these butterflies unfortunately overlaps strongly with the expanding footprints of San Diego and Los Angeles; consequently the species has lost more than 75 percent of its historical distribution to urban and agricultural development. Like many butterflies, Quino adults lay their eggs exclusively on a few plant species—in this case, plantain and snapdragon—that become the food source of the newly hatched caterpillars. Adult Quinos feed on the nectar of flowers, but their short tongues limit them to a relatively small number of species that have shallow or open-shaped flowers.

DESCRIPTION OF IMPACT

In addition to habitat loss, climate-related events have detrimental effects on the Quino checkerspot. In Orange County, for instance, a large flood wiped out the last low-elevation population of the butterfly, and a wildfire extirpated the last high-elevation population. A comparison of Edith's checkerspot butterfly distribution in the early and late 20th century found that **the species has vanished from many of its former locations in the southern part of its range and at lower elevations.** A high proportion of the butterflies that disappeared likely belonged to the Quino subspecies. Drought seems to have a particularly negative effect on the Quino, as it causes host plants to dry out before the caterpillars complete their development. Butterfly population contractions in the past have all been associated with drought conditions, and much of the Quino's range has been affected by the severe to extreme drought that has plagued California in recent years.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change

American Lobster

Homarus americanus

Region:
Atlantic Ocean

Area affected:
Southern New England

Climatic change:
Warming waters

Impact:
Heat stress

ABOUT THIS SPECIES

Lobsters are one of our best known marine species and a tremendously important fishery—in Maine alone, the catch was valued at $495 million in 2015. Their range extends from New Jersey northward along the shallow waters of the Atlantic continental shelf. Like other crustaceans, lobsters molt (shed their exoskeletons) multiple times during their lives in order to grow. Juveniles resemble tiny shrimp and live near the surface, eating plankton and being eaten by other organisms. After their fourth molt, lobsters settle on the ocean floor to feed on other invertebrates and algae. They are highly susceptible to pollutants like nutrients and pesticides and to dredging, trawling and other activities that disturb the ocean floor.

DESCRIPTION OF IMPACT

Lobsters are temperature-sensitive throughout their life cycles. Eggs, juveniles and adults all survive best at a fairly narrow range of temperatures. Adults, for instance, seem to prefer waters of about 60 degrees F and avoid waters colder than 40 degrees F or warmer than about 70 degrees F. **The warmer the water, the higher a lobster's metabolic rate and the more challenging it is for the animal to get enough food to maintain itself.** Unfortunately, temperatures that exceed the upper threshold are now common in areas off the coast of Massachusetts. In 2012 and 2013, areas south of Cape Cod recorded multiple days with temperatures close to 77 degrees F. Lobster stocks in this region are now considered "critically depleted" by the Atlantic States Marine Fisheries Commission, with landings of less than 10 percent of 1980s levels. The peak area for lobster production appears to be moving northward to the Gulf of Maine, an area that saw record high abundance in 2015, while southern New England had record low abundance. That is good news for Maine in the short term, but continued warming could eventually move the lobster's stronghold even farther north and out of American waters.

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© FMARTIN/CREATIVE COMMONS

Quaking Aspen

Populus tremuloides

Region:
Rocky Mountains

Area affected:
Colorado

Climatic change:
Drought

Impact:
Rapid dieback

ABOUT THIS SPECIES

With its stark white trunks and brilliant gold autumn foliage, quaking aspen is one of the best known and loved trees in the American West. It is actually found throughout the northern and coniferous forests from eastern Canada to western Alaska—the most extensive range of any tree species on the continent. But is most conspicuous in the West, where it is frequently one of the only deciduous tree species in a given forest. Groves of aspen are typically all clones, with new stems sprouting from a connected root system, although the tree will also grow from seed, particularly in areas disturbed by fire or logging. Aspen stands are tremendously important ecologically, typically supporting a diversity of birds, butterflies and flowering plants.

DESCRIPTION OF IMPACT

Over the past decade, a troubling malady called "sudden aspen decline" (SAD) has spread across the southern Rocky Mountains. First observed in the San Juan Range in southwestern Colorado in 2004, SAD is characterized by the unusually rapid and wide-scale dieback of branches and mortality in aspen. **By 2010, SAD had affected over 1.2 million acres, or 17 percent of the aspens in Colorado, with mortality of over 50 percent and very little new regeneration in many areas.** While the exact cause of SAD has not been identified, ample evidence indicates that climate change is playing an important role: The region experienced unusually hot and dry conditions in the years leading up to the outbreak. Mortality was also worst in the hottest and driest areas, particularly in lower elevation stands and on south-facing slopes.

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THE **HEAT** IS **ON**

Species feeling the effects of climate change


NPS

Piñon Pine

Pinus edulis

Region:
Southwest

Area affected:
Colorado Plateau

Climatic change:
Heat, drought

Impact:
Mortality, reduced seed production

ABOUT THIS SPECIES

Although this small and unassuming tree rarely grows to more than 30 or 40 feet tall, piñon (also known as pinyon) pine is one of the most ecologically and culturally important tree species of the southwestern United States. The large, edible seeds of this pine are high in protein and fat and have been a staple food source for Navajo and Pueblo people for more than 6,000 years. Birds such as the pinyon jay and Clark's nutcracker harvest and bury huge numbers of piñon pine seeds—up to 30,000 per bird—as a food source for the winter months. Turkeys, rodents, bears and deer also feast on the cached seeds, and new trees sprout from undiscovered caches. Piñon pines grow in dry, rocky areas of the Southwest at elevations between 5,000 to 8,000 feet. The tree has an extensive root system—which is often as deep as the tree is tall—to capture what little moisture is available in the region.

DESCRIPTION OF IMPACT

Despite their adaptation to the arid climate of the mountainous regions of the Southwest, piñon pines are not immune to drought. This is especially true when a prolonged drought is combined with high temperatures, as occurred in 2000 to 2003. That period, although not drier than the last major drought in the 1950s, was marked by much higher temperatures, typically up to 2.4 degrees F higher than the long-term average. The combination of heat and lack of moisture interfered with the ability of the trees to produce sap and, consequently, to fend off beetle infestations. **Widespread die-offs of mature piñon pine trees occurred, with losses of 40 to 80 percent noted across the region, and more than 90 percent mortality at some sites.** More recently, researchers have discovered that cone production over the past decade is almost 40 percent lower than it was in the 1970s.

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Species feeling the effects of climate change

Whitebark Pine

Pinus albicaulis

Region:
Rocky Mountains

Area affected:
Greater Yellowstone Ecosystem

Climatic change:
Warming temperatures

Impact:
Mortality from insect infestations

ABOUT THIS SPECIES

What the whitebark pine lacks in towering majesty, it makes up for in ecological importance. These small pines are found at the highest elevations of the northern Rocky Mountains, Cascades and Sierra Nevadas; windblown and stunted versions only a few feet tall are found up to the tree line, where forest gives way to alpine tundra. Whitebark pines can tolerate the heavy snows and hurricane-force winds that characterize these places in winter, as well as the droughts that are common in summer. These pines are particularly important to wildlife due to the very high nutritional value of their seeds. Each whitebark pine cone contains about 75 seeds that are more than 50 percent fat and also contain protein, carbohydrates and minerals, making them one of the best food items for alpine birds and mammals. Several species of squirrels and birds, such as Clark's nutcrackers, harvest the seeds and bury them in caches. Grizzly bears and black bears raid these caches to feast on the seeds, an important pre-hibernation food source.

DESCRIPTION OF IMPACT

Whitebark pine is declining range-wide, and evidence points to a warming climate as a major contributing factor. One of the biggest threats to whitebark pine is infestation by the mountain pine beetle, a native insect that historically fed on lower-elevation forests like lodgepole pine. Beetle growth rates correlate with temperature, so the harsh conditions in whitebark habitat historically limited beetle infestations, because the beetles there developed slowly, taking two years to fully mature and many dying during overwintering. Now that winter temperatures at high elevations have warmed considerably, the pine beetle is maturing in one year and has a higher overwinter survival rate. Summers are also drier, which leaves the trees more vulnerable to insect attack. **Mortality from pine beetles has reached 96 percent in some places, and the whitebark pine is now a candidate for the federal threatened and endangered species list.**

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Species feeling the effects of climate change

PETER PEARSALL/USFWS

Sitka Spruce

Picea sitchensis

Region:
Alaska, Pacific Northwest

Area affected:
Kenai Peninsula, Alaska

Climatic change:
Warmer temperatures

Impact:
Increased beetle outbreaks

ABOUT THIS SPECIES

One of the towering conifers of Pacific Northwest forests, Sitka spruce occurs in a narrow band along the West Coast, stretching from northern California to central Alaska. Their growth form ranges from scrubby and contorted on windswept dunes in the southern part of its range, to 200-foot giants in coastal temperate rain forests. They require deep, generally acidic soils and year-round precipitation. Seeds are released from cones when the weather is dry, and cones can open and close repeatedly in response to changing conditions over a period of six weeks or more. Young trees grow fairly rapidly in optimal conditions, and the trees can live 500 years or more. The pale-colored wood of Sitka spruce is prized for its resonant qualities and is probably familiar to most people as the front surface of many acoustic guitars.

DESCRIPTION OF IMPACT

Alaska is warming faster than any other part of the United States, causing big changes statewide. On the Kenai Peninsula in south-central Alaska, spruce beetle outbreaks—linked to rising temperatures—have decimated Sitka spruce, the closely related white spruce and a hybrid of the two called Lutz's spruce. The spruce beetle is not some new, exotic invasive species, but rather a native insect that has existed in the region for millennia. Until recently, its ability to damage the forests was checked by cold temperatures that limited the insect's growth rate. Spruce beetles historically required two years to mature and suffered substantial mortality over the winter. Now longer, warmer summers mean more beetles can mature in just one year, and warmer winters mean less mortality. **Consequently, beetle populations have spiked and they have killed more than a million acres of trees on the Kenai Peninsula alone since the 1990s.**

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Species feeling the effects of climate change

MARY STENSVOLD/USDA/FS

Yellow-Cedar

Callitropsis nootkatensis

Region:
Pacific Northwest, Alaska

Area affected:
British Columbia, Southeast Alaska

Climatic change:
Changing snow patterns

Impact:
Die-offs

ABOUT THIS SPECIES

A medium-size tree that can grow to nearly 80 feet tall and 35 inches in diameter, the yellow-cedar is found along the Pacific Coast from northernmost California to Prince William Sound in Alaska. It is one of the most culturally and economically valuable trees in the Pacific Northwest, due to the unique properties of the wood: it is unusually strong and even-grained and has a pleasant aroma and yellow color. It is also virtually rot-proof: living trees and even downed logs are highly resistant to both insect attack and fungal decay. This combination of qualities makes yellow-cedar ideal for carving durable wooden products, particularly ones that will be used outdoors. Native peoples of the Pacific Northwest have long used yellow-cedar to make everything from canoe paddles to totem poles, and it is sought after for boat hulls, bridge supports, decks and other construction. Yellow-cedars live an average of 500 to 750 years and, given their resistance to rot, can persist as standing snags or fallen logs for hundreds of years more, providing habitat structure, cover and habitat for generations of seeds to germinate.

DESCRIPTION OF IMPACT

In contrast to the usual pattern of decline beginning in the southern portion of the ranges of climate-affected species, yellow-cedar trees are dying across large areas of the northern part of their range. This loss of large numbers of such famously insect- and disease-resistant trees was puzzling to scientists, until they traced the source of the dieback to the freezing of the tiny roots that supply the tree with water and nutrients. They also noticed that the hardest-hit trees were those on either poorly drained bottomlands or steep slopes with thin soils. It turns out that while yellow-cedar, like all trees growing in northern climates, is tolerant of cold temperatures, it is less so than other species in the region. The roots are especially susceptible to freezing in early spring, as the tree prepares for summer growth. During this time, the trees are highly dependent on snow cover to insulate the soil and protect their fragile roots from freezing injury. **Climatic changes at the northern part of the yellow-cedar's range have reduced early-spring insulating snow cover at a time that the area is still cold enough to experience damaging freezing in the upper soil layers.**

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