

# It's Too Late

## Introduction

Skeptics ask why it should matter whether the tiger (*Panthera tigris*) or other endangered species become extinct. Aren't all extinctions natural events? Yet enormous differences exist between the extinctions of the dinosaurs and other animals that faded out eons ago and those of recently disappeared species. Dinosaurs proliferated into a great diversity of species and dominated other life over a period of many years. Some dinosaur families endured tens of millions of years on Earth—others far less—before fading into extinction. It is difficult to grasp the reality of their immense sojourn, as some species existed for only a hundred thousand years. The Ornithischia, one major group of dinosaurs, had an enormous number of living species 135 million years ago at the dawn of the Cretaceous Period, but slowly died out over the next 60 million years. The last of the line became extinct some 65 million years ago as the last of the dinosaurs expired.

Extinctions of dinosaurs and millions of other species that disappeared from Earth at that time were natural in origin. These extinctions had many causes; changes in climate resulting from meteors colliding with Earth may have killed off the last dinosaurs. Many scientists believe the impact raised a dust cloud that blocked sunlight and reduced the enormous amounts of vegetation needed by the dinosaurs, and it may have cooled the climate as well. Another major cause of ancient extinctions was the movement of the Earth's tectonic plates, which broke up huge land masses into smaller ones. Some species became isolated on islands too small for their habitat requirements, and stronger species caused the extinctions of weaker or less adaptable species when continents were joined. Continents and islands moved into different climate zones as well. The Earth's climate and atmosphere have undergone major changes over the ages and species that could not adapt have fallen into extinction. Volcanic eruptions have spurred extinctions by inundating land with lava and cooling the climate with dust. Islands produced by volcanic eruptions have risen from ocean bottoms, become covered with vegetation and home to unique wildlife, only to sink into the sea some time later.

In the past, ecological roles left empty by extinctions were soon filled by the evolution of new species. After the last of the dinosaurs died out some 65 million years ago, mammals and other animals proliferated on Earth. The overall diversity of species remained stable or increased. At present, however, diversity of life on Earth is in steep decline as species are dying out without being replaced.

## The Recent Picture: A Rapid Rise in Extinctions

The current extinction rate is estimated to be up to a thousand times higher than prehistory rates (Leakey and Lewin 1995, Stearns and Stearns 1999). This phenomenon has been described as the sixth wave of extinctions by scientists Richard Leakey and Roger Lewin—ecosystems are being disrupted around the world, and the wondrous tapestry of living things that supports human existence is unraveling.

Since 1500, approximately 375 species of invertebrates, 81 species of fish (Hilton-Taylor 2000) and 291 species of mammals, birds, reptiles and amphibians (see Appendix) have become extinct. About three-fourths of vertebrates other than fish have disappeared since 1800, while only 80 species died out in the previous three centuries. These figures represent a minimum number. An estimated 5 million species of animals and plants exist in tropical rainforests, a conservative figure that may apply to insects alone, according to biologist Edward O. Wilson (1988). About half of these species are restricted or localized in distribution (Wilson 1988). With this in mind, at the present

rate of destruction of tropical forests, some 17,500 species are being lost per year a rate 1,000 to 10,000 times greater than extinction rates prior to human intervention (Wilson 1988).

Human activity lies at the root of this potentially catastrophic phenomenon. Killing for food or sport, as well as conditions created by humans, such as habitat destruction and competition, predation and disease from introduced animals, is responsible for the vast majority of these extinctions. It is with this perspective that we can see the present situation as an *unnatural* event, not linked to climatic changes, meteors or volcanic eruptions, but a result of human-caused changes wrought in the Earth's environments and by direct extermination.

## Plants

Extinctions of plants and trees can have a direct impact on human society. A sap found in 1997 by Dr. John Burley, research director of Harvard University's Arnold Arboretum, was tested by the National Cancer Institute and determined to be 100 percent effective in preventing cell replication of the AIDS virus (Stocker 1996). The plant sample came from an ancient swamp forest tree in Sarawak, a Malaysian state on the island of Borneo. When Dr. Burley returned to the spot a year later for another specimen from the tree, only a stump remained, and no other trees of the same species could be found (Stocker 1996). The substance is being reproduced synthetically, but it is not known whether it will be as effective as the original compound (Stocker 1996).

Sarawak's forests grew undisturbed for 180 million years, but they are now rapidly disappearing along with the rest of Borneo's ancient forests. Commercial loggers have felled tens of thousands of these old growth, towering trees in Indonesia and other tropical rainforests for the manufacture of disposable packing crates and chopsticks for Japanese and Chinese markets. Borneo's forests are also being consumed by fires set by wealthy landowners to clear land for palm plantations, or by settlers for farmland, eliminating an untold number of plants. Some tropical tree species have wide distributions over thousands of square miles, but many occupy extremely small areas. This was dramatically illustrated in the disappearance of this tree. Thousands of compounds that could cure diseases or be of great economic and ecological importance may be lost on a daily basis as the world's forests are destroyed at this unprecedented rate.

Plant extinctions have accelerated in the past few centuries. An estimated 5,050 taxa of plants, including species, varieties and other taxonomic groups, have become extinct worldwide since 1700, according to Ghilleen T. Prance of the Royal Botanical Gardens Kew (Prance 1990). This implies at least 17 plants have been lost per year since 1700. Yet however high this rate appears to be, it is probably a low estimate. A 1998 study by botanists Kerry S. Walter and Harriet J. Gillett for the International Union for the Conservation of Nature (IUCN) found that 380 species, a number that does not include varieties and other taxa, have recently become extinct. These authors admit their extinction total may be low as a result of lack of data, and they did not define the time period covered.

The data lacks exact numbers of plant extinctions. Plants rarely leave signs of their existence as vertebrates do, since bones are the basis of much data on animal extinctions. Non-woody plants, which make up the majority of plants, leave little trace when they die, and are soon consumed by microbes. This is especially true in tropical areas, where plant matter is consumed very quickly. We know of ancient plants by chance events, such as the preservation of pollen grains or other plant parts in peat, mud, amber or fossilized stone. When numbers of plant extinctions are estimated, the diversity and status of habitat are important considerations. Moreover, only a small percentage of all plants have been scientifically described. What is known is a great many regions of the Earth that once had very diverse endemic plants have been destroyed within the past few centuries, and a majority was not thoroughly assessed.

Botanical wealth is often discovered and destroyed soon after. In Ecuador's mountain ridges, botanists Al Gentry and Calaway Dodson of the Missouri Botanical Garden in St. Louis discovered many unique plants in 1978 on a crest

known as Centinela Ridge in a 20 square kilometer cloud forest in the foothills of the Andes. Among the plants were 38 endemic species, many of which were unusually dark leaved (Forsyth 1990). The two scientists found a total of 90 related plants growing under the forest canopy with epiphytic plants, such as bromeliads and orchids, on the trunks and branches of the trees (Wilson 1992). These cloud forests and paramos treeless, mossy areas in the northern Andes are centers for unique species. At the time they discovered the plants, Gentry and Dodson observed farmers from the valley below clearing the forests, as they have done on 96 percent of the Pacific ridges of the Andes (Wilson 1992). Gradually, the clearing moved up to Centinela Ridge. By 1986, the botanical oasis had disappeared; in its place were cacao and other crops (Wilson 1992). These lost species might have provided compounds to treat cancers, or been an ancestor of an agricultural plant, such as a perennial tomato, but they exist now only as pressed specimens taken by the botanists.

Near Centinela Ridge is Rio Palenque; once an extensive cloud forest, it is now diminished. It was among the most botanically diverse forests in the world 600 species per square kilometer (Forsyth 1990). Ornithologists and birdwatchers came from all over to see the 336 bird species of Palenque's diverse habitats (Forsyth 1990). The endangered harpy eagle was one spectacular native bird that disappeared when the forest was cleared (Forsyth 1990).

Cloud forests are found in tropical Asia, Africa and Latin America. These ecosystems shelter such rarities as the iridescent green and red resplendent quetzal of Central America, but this ecosystem has nearly disappeared. An impressive variety of orchids, mosses and dwarf trees grow in these misty, cool environments. Should global warming continue, cloud forests will be among the first type of forest to disappear altogether, extinguishing thousands of unique life forms in the process.

Introduction of alien species of plants can overwhelm native species and cause their extinction (Prance 1990). In Indonesia, a type of non-native grass called imperata (*Imperata cylindrica*) grows aggressively in deforested areas, spreading into forests. Once established, imperata obstructs the regeneration of native plants and trees (Prance 1990), many of which exist nowhere else. Imperata has also displaced endemic plants in other parts of the world. In Australia, exotic plants are a major factor; they have eliminated at least 117 plant taxa and endangered another 1,931 (Prance 1990). Ironically, native Australian plants have caused extinctions after they became established in parts of South Africa and the Florida Everglades.

Plants have also disappeared as a result of pollution in the form of acid rain caused by power plant emissions, heavy metal (especially lead) accumulations and other toxins in the air (Prance 1990). Forests in North America and Eurasia have been susceptible to pollution, and in some areas, all forms of vegetation have died out.

Livestock overgrazing is responsible for the extinctions of countless plants, and endemic island species are among the most vulnerable. Such plants may occupy only a few acres. The South Atlantic island of St. Helena lost at least 10 kinds of endemic trees after the introduction of goats onto the island in 1513; the St. Helena redwood (*Trochetia erythroxyton*) became reduced to a single tree in the wild (Prance 1990). Fortunately, it was saved by propagation at the Royal Botanic Gardens Kew in London and cultivated specimens have been reintroduced (Prance 1990). The sandalo (*Drypetes caustica*), a fragrant type of sandalwood tree that once grew abundantly on the island of Juan Fernandez, the site of *Robinson Crusoe*, became extinct by 1916 after centuries of heavy logging and destruction of seedlings by goats (Prance 1990).

The Mascarene Islands, east of Madagascar in the southern Indian Ocean, have been the scene of many plant extinctions. One of the three main islands, Mauritius, was home to the famous dodo. Ebony once covered the plains and mountain slopes of this island, but during colonization of the islands from the early 17th century onward by Holland, France and Britain, extraction of a huge volume of timber denuded valleys and all accessible places (Parnell *et al.* 1986). As early as 1671, Mauritius had appointed a chief woodcutter to oversee the cutting of the island's forests. Unfortunately, this had little effect on forest clearance. Of the dense tropical evergreen forests that once covered the lowlands, only a few patches remain in inaccessible areas. Trees 20 meters or more in height grew in the uplands of the island, their branches heavy with thick growths of lianas and orchids. On the ground, ferns and mosses

sprung up luxuriantly.

Today, only a single tract remains of this habitat, the Black River Gorges reserve (Sayer *et al.* 1992). By 1874, these islands, once described as verdant "earthly paradises," were dry and comparatively barren, with a vegetation composed mainly of weeds (Parnell *et al.* 1986). Only about 30 square kilometers of Mauritius forest survives since 93 percent was destroyed (Sayer *et al.* 1992). The mangrove forests that once lined Mauritius' shores have disappeared along the West Coast because they were cut for firewood. Rodrigues, a small island off the coast of Mauritius that was once a wildlife haven, lost virtually all its forests. Reunion, the third island, was also settled and heavily logged. About 61 percent of its forests, including virtually all its lowland forests, have been cleared; only 100 square kilometers remain (Sayer *et al.* 1992). A few remnants of montane forest have been protected by the French government, which controls the island.

Mauritius, Rodrigues and Reunion have lost many native plant species. Of 1,296 native plants, 53 species are extinct and 393 of the surviving species are threatened, according to the 1997 IUCN Red List of Threatened Plants (Walter and Gillett 1998). Little remains of its ebony forests, and eight ebony tree species are virtually extinct (Simon 1995). The islands have lost six of their beautiful orchid species, and 13 more are threatened (Walter and Gillett 1998). Mauritius and Rodrigues have been described as the "Islands of the Living Dead" by authors Beverly and Stephen Stearns because at least 30 plant species have ceased reproducing in the wild, living on the edge of extinction (Stearns and Stearns 1999). One, *Ramosmania heterophylla*, described in 1874, was not seen again until 1982 when botanist Wendy Strahm found the last specimen growing by a roadside. She fenced it off to protect it, only to learn this made local people consider it a "magic plant" that cured all diseases and maladies (Stearns and Stearns 1999). They cut off small pieces despite its fencing and have nearly obliterated it. Luckily Strahm took cuttings and sent one to Kew Gardens in England for propagation; it now grows there, but does not seed because the plant is defective (Stearns and Stearns 1999). A critically endangered tree, *Elaeocarpus bojeri*, native to Mauritius, has delicate, bell-like flowers with a scalloped fringe. Strahm's photograph illustrating these flowers appears on the cover of the 1997 IUCN Red List of Threatened Plants (Walter and Gillett 1998). It epitomizes the status of many Mascarene plants in need of dramatic rescue programs, as well as the need to prevent extinctions, such as that of a rare Rodrigues tree hibiscus (*Hibiscus liliflorus*); the species became extinct in 1982 after it was reduced to a single plant growing on the top of a mountain (Stearns and Stearns 1999).

Two endangered native wild coffee plants of Mauritius (*Coffea macrocarpa* and *Coffea myrtifolia*) might invigorate domestic species stricken with disease if they are protected from extinction, illustrating another reason to preserve native plants. The wild ancestors of domestic grains and crops retain many characteristics lost in cultivated varieties, such as resistance to drought, insects and disease. An outbreak of cornleaf blight in the United States in 1970 cost farmers almost \$1 billion, and the disease was not halted until a wild corn species was interbred with the domestic strain (Fenyvesi 1995). A perennial variety of maize (wild corn) found in a Mexican forest could be hybridized with domestic corn to save farmers from replanting each year. Other crops saved by crossbreeding with tropical forest wild stock include sugarcane, coffee, cocoa and banana (Schreiber *et al.* 1989). Yet with the accelerating rate of plant extinctions and destruction of native plant ecosystems, many such ancestor species may be lost.

All ecosystems are plant-based. Plants produce oxygen, making life on Earth possible, and perform a vital task for other life forms by absorbing vast amounts of toxins and carbon dioxide. They are the source of thousands of important medicines, and discoveries of new medicinal uses of plants are being made on a regular basis. Disappearance of individual species of plants can impoverish or even collapse entire ecosystems when they are key to the survival of many species of animals or form an intrinsic link in an ecosystem.

Not only do many plants fade to extinction undocumented by botanists, but only a small percentage of living plants have been scientifically described. Botanists have identified more than 250 thousand types of living plants other than algae, fungi and bacteria, but most scientists agree these represent perhaps a tenth of all living plants. Almost 10 percent of surviving species are considered threatened with extinction. Some 34 thousand plant species are listed in

the *1997 IUCN Red List* (Walter and Gillett 1998). Many of these plants have not been seen for years and may be declared extinct in the near future, or are clinging to life with only a few individuals left. Preservation of the planet's great diversity of plants to prevent further extinctions should be a priority of the first order.

## **Invertebrates**

Invertebrates are key members of many ecosystems. Insects pollinate plants, while mollusks and gastropods form the basis of many aquatic food chains. Documentation of invertebrate extinctions is incomplete, but a minimum of 375 species (approximately eight crustaceans, 72 insects, 31 bivalves and 260 gastropods, snails and related species) have become extinct worldwide in the past few hundred years, according to the *2000 IUCN Red List of Threatened Species* (Hilton-Taylor 2000). Massive destruction of many habitats, especially islands with endemic species such as land snails, has eliminated hundreds of these creatures.

Extinct bivalves include mollusks native to the southeastern United States, the world's center of diversity for freshwater mussels. Dam construction turned clear, fast-flowing rivers into still ponds, destroying prime mussel habitat. Channelization, in which the natural curves of a river are straightened and its surrounding vegetation bulldozed from its banks, wreaked havoc in aquatic ecosystems. Biologically rich rivers became muddy, sterile ditches. These government-sponsored anti-flood programs took place during the first half of the 20th century, causing numerous extinctions of mussels and crayfish.

At the time, few people lamented the disappearance of these mussels, some of which were the size of dinner plates. They grew in huge masses on river bottoms, serving as keystone species in river ecosystems by providing habitats for fish, crayfish and huge river snails. Birds and aquatic mammals fed on the fish and other aquatic wildlife produced by these mussels; these large bivalves also cleansed the water with their filtering gills. Water pollution from industry and coal mining and sedimentation from logging have contributed to their extinction. Additionally, mussels are over-harvested because of their commercial value in the cultured pearl industry—their shells are harvested and broken into tiny pieces that are inserted into living oysters to stimulate the growth of pearls. These combined threats have pushed many species to extinction and others to endangered status. Their demise has caused species dependent on mussels for reproduction and habitat to disappear as well.

Scores of colorful endemic land snail species have died out in the Hawaiian Islands, other Polynesian and Indian Ocean islands and various southern Atlantic Ocean islands. These snails were once prolific in native forests, but naturalists and shell collectors took many thousands of them during the 19th century—until the 1920s, when it became too difficult to find them (Stearns and Stearns 1999). One individual, J.T. Gulick, the son of Hawaiian missionaries, "ransacked" the islands for tens of thousands of these colorful land snails, collecting 44,500 in three years (Stearns and Stearns 1999). He alone caused the extinction of numerous species on the islands by encouraging rural residents to collect for him and by buying shells by the thousands, believing himself to be an important naturalist. He was among the collectors who scoured the woods where these shells clung to trees and low bushes by the hundreds (Stearns and Stearns 1999). Many were striped, while others were solid shades of ivory, yellow-gold and deep brown. Some collections were of no scientific value because the locations where they were obtained were not noted. No similar species remain in the wild today (Stearns and Stearns 1999).

In more recent times, exotic species of snails have been introduced onto islands for various purposes, preying on the native species. One expert estimated that when Captain Cook arrived in Hawaii in 1778, there were between 800 and 1,000 species of endemic Hawaiian snails from 11 families, but at present, only about 200 remain (Stearns and Stearns 1999). Recent extinctions have been caused by deforestation and predation by exotic snails, including the giant African snail, introduced by the Hawaii Department of Agriculture to prey on another exotic snail. Native snails

feed mainly in endemic Hawaiian trees, another reason they have failed to adapt to the introduction of exotic trees and bushes. Unusual among invertebrates, these snails reproduce slowly, one species needing 19 years just to replace itself (Stearns and Stearns 1999). At least 49 species have become extinct in recent times, according to the Nature Conservancy's book, *Precious Heritage: the Status of Biodiversity in the United States* (Stein *et al.* 2000). The remaining species of Hawaiian land snail are endangered, and species are disappearing regularly from the wild, preyed on by exotic snails or rats and losing their host trees to logging (Stearns and Stearns 1999). Conservation programs have not been well-funded, as these are among the least well-known of Hawaiian wildlife.

On the island of Moorea in the Society Islands, the giant African snail was introduced as a food source, but when it became overpopulated, a carnivorous snail, *Euglandia rosea*, was introduced to prey on it. Instead, the latter species preyed voraciously on native tree snails, exterminating all 11 species; it is now in the process of eliminating the native snails of Tahiti (Wilson 1992).

Butterfly populations have declined from loss of host plants, pesticide use, over-collecting and loss of species upon which they depend. The Xerces Blue (*Glaucopsyche xerces*) is the only native species in the United States to have become extinct in recent times. It disappeared in the early 1940s, and the Xerces Society, dedicated to preserving butterflies, was named after it. It is one of 38 butterfly species that recently disappeared around the world (Baillie and Groombridge 1996).

Invertebrates play key roles in many of the world's ecosystems as food sources, for people as well as animals. Some, such as coral and mollusks, create habitats for thousands of species. Butterflies, mollusks and snails are among the planet's most beautiful creatures, yet conservation programs often neglect these important species.

## **Vertebrates**

Vertebrate extinctions worldwide since 1500 total at least 372 species of mammals, birds, reptiles, amphibians and fish. The largest number 157 species were birds, while 100 mammal species, 28 reptile species, 6 amphibians and 81 fish species disappeared. The number and rate of extinctions have increased gradually in recent centuries, as the table "Extinct Species of Birds, Mammals, Reptiles and Amphibians" illustrates. Fewer than 80 of these vertebrates became extinct from 1500 through the 18<sup>th</sup> century, while in only the 19<sup>th</sup> century, 98 species of birds, mammals and reptiles died off. The rate accelerated during the 20<sup>th</sup> century; based on incomplete information, at least 115 vertebrates already 17 species more than in the past century were lost. (See Appendix for list of species and their dates of extinctions.) This total will be far greater when the toll for the 20<sup>th</sup> century is finalized.

229 species, almost 80 percent of the 291 extinct mammals, birds, reptiles and amphibians, were native to islands, mostly located far from the nearest land mass, such as the Hawaiian Islands, Mascarene Islands and New Zealand. (See Table The Geography of Extinction. ) Many of these island species were distinctive and unusual, the products of thousands and even millions of years of evolution in isolation. Few left close relatives.

Some islands are fragments of ancient continents, broken off more than 100 million years ago, with resident wildlife and plants. New Zealand, Madagascar, the Seychelles and the larger islands of the Caribbean are examples of this phenomenon. In exceptional circumstances, original inhabitants survived; some evolved into different forms, while others remained almost unchanged. Additional plants and animals arrived by air, ocean current or clinging to masses of vegetation or floating logs, perhaps every thousand years. Few of these survived, but occasionally these new colonists were able to adapt to the new environment and thrive. Other islands were formed by volcanic eruptions or coral reefs growing atop extinct volcanoes. Virtually all native fauna and flora of these islands, which include the Hawaiian, Mascarene and Galapagos Islands, were colonizers. The majority of extinct island species were flightless

birds, tortoises and other species unable to flee when European ships and their crews arrived in search of commodities such as spices, timber and fur animals. They were killed for food and sometimes found their habitats destroyed by logging or the many species of animals brought to the islands. They were successful species in adapting to their environment and surviving for long periods, even radiating into entire new families of animals, but nothing had prepared them for the drastic changes humans caused, or the high mortality from hunting or persecution.

Sixty-two mammals, birds, reptiles and amphibians, as well as all but one of 81 species of fish, were native to mainland areas. The continent with the largest number of non-fish extinctions is Australia, with 24 species, 22 of which were mammals, killed off by introduced animals and loss of habitat (see Mammals section in the table: *The Geography of Extinction* ). Non-native species caused the extinctions of many fish in the United States, Mexico and Africa. Killing by persecution or commercial purposes, such as for furs, meat or sport, caused extinctions in Africa, North America, Australia, Europe and Asia. Capture for pets and killing eliminated birds in the Caribbean, Australia and South America. The clearing of forests eliminated a number of tropical birds in Asia and South America. Elimination of wetland habitats was the major cause of the extinction of amphibians and fish, especially those that were ecologically isolated, such as cave fish or desert spring species.

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**Extinct Species of Birds, Mammals, Reptiles and Amphibians  
1500 to present**

<b>100-Year Periods</b>	<b>Mammals</b>	<b>Birds</b>	<b>Reptiles</b>	<b>Amphibians</b>	<b>Total</b>
1500-1599	0	6	0	0	6
1600-1699	14	15	3	0	32
1700-1799	13	26	3	0	42
1800-1899	31	56	10	0	97
1900-2000	42	54	12	6	114
<b>TOTALS</b>	100	157	28	6	291

Source: List of Extinct Species in the Appendix of this book.

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**Fish Extinctions**

The *2000 IUCN Red List* lists a total of 81 species of fish that have become extinct over the past 400 years. In addition, a large number of fish have been extinguished in Central and South American lakes – scientists are still compiling information. About 20 percent of the world's freshwater fish are indeed either extinct or in steep decline (Wilson 1992).

No version of the *IUCN Red List* has listed many species reported as apparently extinct by biologists around the world. In peninsular Malaysia, where 266 freshwater species were known to exist, a search found only 122 (Wilson 1992). In the Philippines, where massive environmental destruction has taken place, Lake Lanao on Mindanao is famous for its diversity of endemic cyprinid fish. Yet out of 18 species of three genera, an investigation found only three species of one genus (Wilson 1992). These extinctions were apparently caused by overfishing and competition

from introduced species (Wilson 1992).

During this century, several mass extinctions of endemic fish have taken place when the creatures' sole habitat was destroyed. Lakes in East Africa, the Americas and Russia have either been drained—as in the Russia's Aral Sea—or native species have been crowded out or preyed upon by introduced exotic fish.

Africa's Great Rift Valley, a product of movement in the Earth's crust eons ago, is home to several lakes of great biological diversity. Lake Tanganyika has more than 140 endemic species of fish, Lake Victoria has more than 200 and Lake Malawi has at least 500 (McNeeley *et al.* 1990). These three lakes, home to hundreds of members of the colorful cichlid family, rank three, two and one respectively in the world for their diversity of fish (Myers 1979). The lakes have been separated for millions of years, and although Lake Malawi and Lake Tanganyika are only 320 kilometers apart, they have not a single cichlid fish species in common (Myers 1979). Each of these three lakes empties into great rivers; Lake Tanganyika flows into the Zaire, Lake Victoria into the Nile and Lake Malawi into the Zambezi (Kingdon 1989). Most ancient is Lake Tanganyika, 3 to 6 million-years-old and twice the age of Lake Malawi, which is half as old as Lake Victoria (Kingdon 1989). Lake Tanganyika is the second deepest lake in the world at 1,500 meters; only Siberia's Lake Baikal is deeper (Kingdon 1989).

Lake Victoria is a shallow, enormous lake, covering an area the size of Ireland or the state of Maine (Kingdon 1989). Evolution of cichlid fish in these lakes over the ages produced an extremely rich fauna. From a few ancestor species, these fish flourished into an extraordinary diversity, each species filling a different ecological niche. Their diets are extremely varied and may include plankton, crustaceans, mollusks or fish eggs (larvae) and even other fish (Kingdon 1989). Cichlids brood their eggs in their mouths—up to a thousand at a time—protecting them from their many natural enemies. They exhibit a great range in color, including silver, sapphire and turquoise blue, orange and yellow, and they are patterned in stripes, bars, dots or circles. Resembling the fish one might see in a coral reef, many are popular in home aquariums (Kingdon 1989). Various kinds of tilapia, which are also cichlids, form a major part of the diet of Africans living around these lakes, and they are being raised in aquaculture projects around the world.

These beautiful fish and their ancient ecosystems are now disappearing. The major cause is the Nile perch (*Lates niloticus*), Africa's largest freshwater fish, at more than 6 feet in length. Since 1960, the Uganda Game and Fisheries Department has introduced thousands of these fish as a food source for the local people, despite objections from the East African Fisheries Research Organization (Simon 1995). Even as a food fish, the Nile perch is not rated highly by the local Africans, who prefer the smaller tilapia, which they preserve by drying in the sun (Simon 1995). The flesh of the Nile perch is so oily that it must be smoked, and more and more trees must be cut down for this purpose (Simon 1995). An ecological disaster occurred after its introduction; although intended to increase the lake's productivity of fish, the opposite happened. Gradually, this predatory fish became the dominant species in the lake, and completely destroyed the endemic cichlid fish fauna and fishery (Simon 1995). Of the more than 300 varieties of *Haplochromis* genus cichlid fish (including subspecies) endemic to Lake Victoria, almost two-thirds died out, and the rest became endangered (Simon 1995). Fifty known extinctions have beset Lake Victoria's endemic cichlids. One species, *Haplochromis pyrrhocephalus*, has become extinct in the lake—it exists only as a captive colony in the Horniman Museum in London (Simon 1995). Extinctions of the surviving cichlids continue because of predation by the Nile perch and siltation of the lake from erosion of farmland soil on its shores. This prevents these fish from mating because they are not able to recognize the brilliant colors and patterns of their potential mates (Yoon 1997).

The introduction of exotic fish threatens many freshwater species, and overfishing is virtually eliminating a large number of saltwater species. Research on the latter is lacking, but it is likely that many of the 156 species listed as critical in the 2000 IUCN Red List will be listed as extinct in the near future.

## **Amphibian Extinctions**

Six species of amphibians—all frogs—are known to have become extinct since 1500. No recorded amphibian extinctions have taken place on islands, despite the large number of endemic amphibians native to large islands such as Madagascar, New Zealand, Cuba and Puerto Rico. Many of these, however, now face this threat. Yet it is likely that amphibian extinctions occurred as a result of the draining of wetlands or due to their use in growing rice following the colonization of the latter islands by native peoples thousands of years ago. The extinct frogs were mainland species, and all disappeared during the 20th century. The Israel painted frog (*Discoglossus nigriventer*) became extinct around 1940, when Lake Huleh, its sole habitat, was drained for agriculture. The Vegas Valley leopard frog (*Rana fisheri*) disappeared in 1960 when its desert spring habitat was destroyed by groundwater pumping for agriculture. Two Mexican frogs endemic to wetlands north of Mexico City died out by 1979 after their wetlands were drained for the construction of homes. The best known extinction in recent times is that of the beautiful golden toad (*Bufo periglenes*), which is acknowledged by most experts to have disappeared from its rainforest home on a Costa Rican mountain in the late 1980s. This species had been featured in National Geographic Society films and articles, and was also the subject of a research study when it suddenly died out.

A large number of frogs—at least 20 species—have not been seen for many years, and many may soon be declared extinct. Some of these are among the most unusual examples of evolution on Earth. In a few pristine areas, frogs have mysteriously vanished. An Ecuadorian biologist reported in the 1990s that a dozen species he had been studying in a high altitude meadow disappeared without a trace. Experts are in disagreement over the causes of the vanishing of so many frog species. Many species are believed to be victims of ozone depletion, which increases the amount of ultraviolet radiation reaching the Earth, destroying frog eggs and often adult frogs as well. Other scientists believe frogs are disappearing from a combination of causes, including disease possibly induced by an immune system lowered by pollutants, pesticides and habitat destruction.

## **Reptile Extinctions**

All but one reptile extinction have occurred on islands. At least 28 island reptiles have died out since 1600. A large number of reptile extinctions took place in the Mascarene Islands, a group of islands in the Indian Ocean, east of Madagascar (see Appendix for more on Mascarene Island extinctions). Thousands of large tortoises were slaughtered for food by European settlers and visiting ships' crews during the 17<sup>th</sup> century. All three Mascarene Islands and most of their satellite islets were densely populated by various species of tortoises. Each island had species with differently shaped shells: domed for feeding on low vegetation, and high-fronted for other vegetation (Day 1981).

Francois Leguat described Rodrigues' tortoises in the early 18th century: "There are such plenty of Land Turtles on this Isle that sometimes you see 2,000 to 3,000 of them in a Flock; so that you can go above a hundred paces on their backs without setting foot on the ground. They meet together in the evening in shady places and lie so close that one would think those spots were paved with them" (Day 1981). The large tortoises must have numbered in the hundreds of thousands, judging from the quantity taken by ships to provision their crews and to trade for commodities. Each weighed about 100 pounds, and naval ships vied with one another for rights to them. The tortoises were plundered indiscriminately. Far more were killed than needed by crews and passengers (Durrell 1977). One expert estimated that at least 10 thousand tortoises were taken per year from Rodrigues island alone. Many died en route, as in the case of one shipment of December 6, 1761, in which the ship *L'Oiseau* arrived with a cargo of only 3,800 tortoises still living out of the 5,000 shipped (Durrell 1977). The Mauritian tortoises were extinct by 1700,

the two Reunion species by 1773, and the Rodrigues species in 1800 (Day 1981). The last of the tortoises were killed off by pigs consuming the young tortoises and rooting up their eggs in the sand (Day 1981). Eight tortoise species, including three giant tortoises, became extinct (see Table "Extinct Wildlife of the Mascarene Islands").

In all, 13 Mascarene reptile species disappeared forever. The blind cave snake and three skinks or geckoes also disappeared. The most recent extinction was the Round Island Boa, which inhabited an islet off the coast of Mauritius. Livestock and rabbits stripped the vegetation, which caused the extinction of this snake by 1975. No native tortoises or turtles still exist on the Mascarenes. The remaining species of boa and the four gecko and skink species are highly threatened, according to the *2000 IUCN Red List*.

Elsewhere in the world, reptiles have been eliminated mainly as a result of the combined effects of non-native species, such as rats, cats and mongooses. Predators prey and compete for habitat and vegetation, livestock overgraze and settlers destroy habitats. Nine species of iguanas and snakes of the Caribbean became extinct after introduced species of mongoose and rats demolished them. The iguanas were also hunted heavily for food by local people. A number of iguana species barely survive on various Caribbean islands, having become restricted to tiny islets off the main islands where rats, cats and livestock are not present. Four Caribbean reptiles have disappeared. A lizard (*Ameiva major*) and a snake (*Dromicus cursor*) were native to Martinique and became extinct in 1960 and 1962 respectively; the other two were native to Jamaica. A tree snake (*Alsophis ater*) was probably eliminated by forest destruction and predation by the introduced mongoose. The Jamaican iguana (*Cyclura collei*), thought to be extinct, was recently rediscovered, but the species is still highly endangered. The single reptile extinction on a mainland area was a South African lizard, Eastwood's longtailed seps (*Tetradactylus eastwoodae*) it disappeared in 1913.

## **Bird Extinctions**

A bleak picture has emerged, showing a dramatic rise in the rate of bird extinctions over the past 200 years. At least 157 species of birds have become extinct since 1500, and many more have not been seen in decades. In pre-history, approximately one bird disappeared each century (Leakey and Lewin 1995), but the present rate is many times that. During the 17th century, 15 birds disappeared, increasing to 26 birds in the 18th century (at an average rate of about one bird every four years); this was 26 times the pre-history rate. Nineteenth century extinctions totaled 56 bird species, or about a bird every other year. Data for the 20th century is still being totaled, but 54 birds have already been declared extinct since 1900 – already almost as many as the entire 19th century's toll. Thus, the rate of avian extinctions has likely more tripled since the 18th century. A large number of birds have not been seen in the wild for many decades and will likely soon be declared extinct; a period up to 50 years between the last sighting and formal declaration of a species' extinction is generally accorded, unless thorough surveys verify the species is indeed gone.

An important dimension of these extinctions is the fact that birds are considered indicators of the planet's health. Birds are sensitive to environmental pollution, habitat loss and other signs of deterioration, as illustrated when canaries were used by coal miners to test for the presence of lethal methane gas. Their extinctions will also affect the ecosystems in which they once lived, since many birds pollinate plants or disperse seeds, and without them, these plants die off. The story of the dodo (*Raphus cucullatus*) is an example of such a relationship.

Some of the most amazing and unusual species that ever lived are among the birds that have become extinct since 1600. Many of these extraordinary birds evolved on remote islands without human inhabitants over periods of millions of years. The heaviest bird ever to have lived on Earth was the Great elephant bird (*Aepyornis maximus*) of Madagascar, the last of many related species of elephant birds. Some experts maintain this giant bird disappeared prior to 1500 (Brooks 2000), but observers spoke of its continued presence on the island after 1600. The giant moas

of New Zealand are thought by some to have persisted until the 19th century, while others believe they died out a thousand years ago, within a few centuries after the arrival of the Maori people. The brawny great moa (*Didornis torosus*) of New Zealand was perhaps the last of many species of moas, the largest of which was the tallest known bird, some 12 feet in height. It was hunted to extinction like its relatives. Some said it persisted until 1670. Another extraordinary New Zealand bird was unique in that males and females had beaks that were completely different in both size and shape: the colorful huia (*Heteralocha acutirostris*) became extinct early in the 20th century, mainly from the effects of forest destruction and hunting for its feathers, which were sold in the European markets for ladies' hats.

The Mascarene Islands, which remained uninhabited by humans until the 17th century, once had an unparalleled diversity of birds, including an array of many odd flightless birds such as the famous dodo. Flightless herons and storks fished in the streams, and enormous parrots their beaks as large as their heads lumbered about in search of fruits and seeds. Each island had its own distinctive parrot species. Some of the native parrots had not become flightless, and each of the seven or so species occupied its own ecological niche. Gray parrots with bright red beaks, small gray parakeets and two types of lime green parrots with very long tails swooped about in large flocks (Fuller 1987).

Large numbers of the flightless, turkey sized dodos waddled about on Mauritius. The birds, weighing about 50 pounds and covered with grayish, downy feathers, fed on hard-shelled seeds. Of all birds that have become extinct, this species is perhaps the most famous. The dodo's common name apparently came from *dodoor*, a Dutch word meaning sluggard, and *dodaers*, a lubber, or awkward sailor (Halliday 1978). The creature's original scientific name was *Didus ineptus*, indicating its inability to flee humans or defend itself.

In fact, the dodo was the final result of thousands perhaps millions of years of evolution in isolation on an island with no land predators. Wild pigeons of an unknown species landed by chance on Mauritius at some early date and became resident, gradually evolving into a gigantic form of the original immigrant. The dodo may have evolved from New Guinea and Pacific Islands tooth-billed pigeons that landed in the Mascarenes, according to some zoologists (Halliday 1978). Tooth-billed pigeons also have curious hooked beaks, although the dodo's 9 inch beak was far more massive. Yet whatever its ancestry, the dodo became flightless in its predator free environment. Its feathers lost their sheen and aerodynamic quality and came to resemble the down of nestling birds.

Mauritius was first visited in the early 16<sup>th</sup> century by Portuguese sailors, and was later settled by the Dutch, who brought pigs, goats and cattle. These domestic animals soon multiplied and overran the islands. Pigs rooted in forests, devouring rare flora, and cattle and goats overran the fragile tropical vegetation. Rats swam from ships and colonized the main islands; they preyed on flightless birds, eating their eggs and young, even climbing trees to devour nesting songbirds. Mongooses native to Asia were brought to Mauritius, which presented a lethal threat to native birds and other wildlife. Long-tailed macaques (*Macaca fascicularis*) were imported as pets at some point from Southeast Asia and then released into the forests of Mauritius, spreading throughout the island and preying on native birds. Settlers also cut the trees needed by native birds for habitat and food. The delicate plants, forests and vulnerable wildlife were devastated by this onslaught.

Portuguese and then Dutch seamen and colonists slaughtered thousands of dodos, using them as a major source of food. They cut down the seed-bearing trees dodos fed upon, and their eggs and chicks may have been preyed on by rats and introduced macaques (Fuller 1987). Settlement began in 1634, and within less than 30 years, the once-common dodos were slaughtered to extinction. The settlements failed and Mauritius remained uninhabited for a period of time.

The last account of wild dodos dates from 1662. A Dutchman named Volquard Iversen was deserted on Mauritius soon after both the early settlement and the penal colony failed (Quammen 1996). Iversen and his shipmates scoured the island for food and found no dodos, but they did see some on a small islet off the coast. He described them as "larger than geese but not able to fly. Instead of wings they had small flaps; but they could run very fast" (Quammen 1996). The islet protected the last few dodos from human hunters and introduced predators, and until then, the tiny

population had remained undetected. Iversen's party waded through the shallow water to the islet and captured a dodo. "When we held one by the leg he let out a cry, others came running forward to help the prisoner, and they were themselves caught" (Quammen 1996). These were the last of their species. Altruism, a trait that has helped many animals survive through mutual aid, has also caused extinctions. Human hunters have taken advantage of this, killing animals that come to the aid of each other.

In the centuries since its demise, the dodo has come to symbolize extinction, but many still think of this bird as stupid, giving rise to the expression "dumb as a dodo." Animals are frequently deemed stupid if their natural defenses against humans are inadequate, or vicious if they are able to defend themselves. Yet this bird so many people have described with disdain came to the rescue of its fellows, even at the risk of its own life, and was an extremely successful species within its environment. If the word dodo must be seen symbolically, then it would be more reasonable to equate it with human stupidity, because our own species wantonly destroyed this extraordinary bird. In the opinion of Errol Fuller (1987), author of the authoritative book *Extinct Birds*, "The dodo was one of the most fantastic creatures ever to have lived."

In 1973, Dr. Stanley Temple, an ornithologist, made a remarkable discovery about the dodo. He noticed that a beautiful tree native to the island, the calvaria or tambalacoque tree, was reduced to 13 dying specimens, all more than 300 years old. Gerald Durrell (1977) described these trees as at least 50 feet tall, with massive crowns and silvery, gnarled trunks; cracks appeared in their buttress roots. Since no young trees were located, it occurred to Dr. Temple that no seeds had germinated since the 17th century when the dodo became extinct. Apparently, stones found in the dodo's gizzard by sailors butchering it for food might have been able to abrade the thick shell covering the seeds. Dr. Temple fed some of the seeds to domestic turkeys, which were presumed to have similar digestive systems, and of 10 seeds recovered from feces or regurgitation, three sprouted when planted (Anon. 1978).

Some scientists now believe this tree could germinate without the dodo. A surviving parakeet is thought to be able to crack its hard-pitted seeds, and the extinct Mauritius flying fox and some of the extinct parrots were able to do so as well (Quammen 1996). Dr. Wendy Strahm, in her botanical work on Mauritius, has found young trees of this species that germinated in the past 300 years, although they are quite rare (Quammen 1996). Another scientist, Anthony S. Cheke, believes seed germination has continued, but at a low rate—perhaps too low to maintain the species long-term. The rarity of the tambalacoque tree was considered to be due to seed predation by rats, deer browsing on saplings, rooting by pigs and perhaps browsing by the introduced macaque monkeys (Quammen 1996). Yet dodos were likely major seed distributors of this tree in the pre-human environment, and their role has not been successfully replaced ecologically. The introduction of a veritable zoo of non-indigenous species has reaped havoc on a variety of native plants.

The dodo's close relatives on neighboring islands are far less known. On Reunion, a bird called the Reunion solitaire (*Raphus solitarius*) was described by early visitors to the island as resembling the Mauritius dodo, except its beak was somewhat smaller, its plumage was white and the tips of the wings and the tail were black (Fuller 1987). One traveler, M. Carre, said in 1699: "The beauty of its plumage is a delight to see. It is of changeable color which verges upon yellow" (Fuller 1987). Two were taken aboard ship as a present to the French king, but both refused to drink or eat and soon died. M. Carre noted in his description that "The flesh is exquisite; it forms one of the best dishes in this country, and might form a dainty at our tables" (Fuller 1987). This was an ominous prediction of its final fate. The Reunion solitaire probably died out about 1715 as a result of being slaughtered for food.

On tiny Rodrigues, yet another dodo-like bird existed. Far more is known of this species, whose bones have been found in caves on the island. Its beak was shorter and its neck was longer, but it also apparently evolved from pigeon ancestors (Halliday 1978). It was called the Rodrigues solitaire or solitary (*Pezophaps solitaria*) for its habit of feeding alone on leaves and fruit in secluded places. Errol Fuller's description in *Extinct Birds* evokes its once peaceful existence: "In this tranquil kingdom generations of solitaires must have lived enjoying extraordinary peace and seclusion until their world was shattered by the coming of man."

Francois Leguat, a Huguenot refugee, left extensive descriptions of these birds when he spent two years on Rodrigues after he was marooned there with a small group of followers in 1691 (Fuller 1987). "They walk with such stately form and good grace," Leguat wrote, "that one cannot help admiring and loving them" (Fuller 1987). He watched them nesting and feeding their chicks until they fledged at several months. The male and female defended their territory, driving other solitaires away with a dramatic display in which a bird pirouetted for four to five minutes while whirring its wings violently to produce a loud rattling noise that could be heard 200 yards away (Halliday 1978). If this impressive display did not frighten other birds away, they used knobby growths at the joints of their flightless wings in combat with other solitaires (Halliday 1978). Some wing bones now found in museums have healed fractures, an indication of the violence of these encounters (Halliday 1978).

Leguat saw the parents of solitaires escorting their single chick to a gathering of some 30 other solitaire families, where the adults would leave the chicks. Tim Halliday wrote in *Vanishing Birds* (1978) that he believes what Leguat witnessed was actually a sort of nursery gathering, similar to that which flamingos and some penguins organize while adults go off to feed. Although these birds were able to hide in foliage and could run quickly, hunters chased them down and butchered every last bird. People slaughtering them found stones in their gizzards even in those of very young nestlings. How they got there remains a mystery, since the stones were too large to have passed down the gullet (Halliday 1978). The last solitaire was seen around 1746, and the species was deemed extinct by the 1760s (Brooks 2000).

The origin and affinities of these three species of pigeon-like birds in the Mascarene Islands will be disputed by scientists for some time to come. Tim Halliday (1978) conjectured that the dodo may have evolved from a pigeon, such as the tooth-billed pigeon (*Didunculus strigirostris*) of the Pacific which has a similar but far smaller hooked bill or that they were related to rails. It is also possible the dodo had one ancestor and the solitaires had another. What is not disputed is that they left no close relatives. No living birds on Earth are related to the dodo and the solitaire, or bear any strong resemblance to them.

Other flightless native birds of the Mascarenes disappeared as well: all the huge parrots, three kinds of owls, three rails, several small pigeons, two night herons, a stork and an ibis. Little is known about many of these birds, but two of the rails were described in detail. The Rodrigues or Leguat's rail (*Aphanapteryx leguati*) had bright gray plumage flecked with white and gray, a curved red bill, red legs and feet and a red ring surrounding the eye (Taylor 1998). The bird's call consisted of a long whistle, but when pursued, the rail gave an alarm call that sounded like a person with a hiccup (Taylor 1998). This species fed on tortoise eggs and, like the related Mauritian red rail (*Aphanapteryx bonasia*), could be lured by holding out a red object and trapped when the bird came to attack the lure (Taylor 1998). They were described as delicious, and were killed to the last bird. Among flighted species lost were a type of weaver, a starling and a falcon (Brooks 2000; Fuller 1987; Greenway 1967). The total of 31 extinct birds is more than that of any other island group or continent.

However extraordinary such a toll may seem for a group of small islands, it may represent only a percentage of Mascarene avian extinctions. Stanley Temple estimated that prior to the arrival of humans, 68 species of birds lived on the three main islands and, of these, 45 species (66 percent) became extinct after 1600 (Temple 1981). The 14 species not officially included among the extinct birds of these islands were described by travelers but have not yet been authenticated. The majority lived on Mauritius. Future archeologists are certain to discover far more about the birdlife that once inhabited these islands, and genetic studies of specimens from which DNA can be extracted may help identify their origins.

The Hawaiian Islands vie with the Mascarenes for numbers of extinctions. At least 21 species and many more subspecies have become extinct since 1600. One of these was native to the remote swamps of Kauai. The Kauai Oo (*Moho braccatus*) had pitch black plumage brightened by several long, canary yellow feathers. The male had a haunting, fluted call. The species dwindled as forests were cut, and by 1960, only 12 birds were known to remain. A single pair survived by the 1980s. The female disappeared after a hurricane in 1985 (Brooks 2000), and the male lived on a few more years as the last member of his species. He was seen singing and building a nest with each final

year, trying to attract a mate who never came (Daws 1993). He was last seen in 1987 (Brooks 2000).

The Kauai Oo was the last of a group of dramatic songbirds that once lived on all the major islands. The Hawaiian honeycreepers found only here evolved from one or a small number of ancestor species – likely a New World finch, warbler or honeyeater – into an estimated 40 to 50 brilliantly colored birds, before the arrival of the Hawaiian people. Some species were probably eliminated after they were killed in tremendous numbers for their feathers, then made into elaborate headdresses and cloaks for Hawaiian royalty, but the major cause of their extinction was the destruction of their forests by European settlers. As the honeycreepers retreated to smaller and smaller habitats, often surrounded by ranchland, sugar cane and pineapple farms, their habitats and food trees disappeared. Their fragmented populations were susceptible to avian malaria, which spread throughout the islands in the 20th century, brought by exotic cage birds that had escaped or been released by their owners. Thousands of birds died of the disease. The extinction toll of native birds within the past few hundred years stands at 21 species, in addition to even more subspecies. Twenty-three honeycreepers survive, but most are so endangered they are not expected to survive more than a few more decades. One critically endangered honeycreeper, the po'o-uli (*Melamprosops phaeosoma*), has a total population of three birds: two males and one female live in a reserve and the adjacent Haleakala National Park on Maui (BI 2000). This small, masked brown-and-white bird, discovered in 1973 by a graduate student, once numbered 200 individuals before it underwent a drastic decline between 1975 and 1985 as a result of avian malaria and habitat destruction by feral pigs within its reserve (BI 2000). All three birds live in separate home ranges, and the species has little chance of survival.

Rails are the most characteristic of all island land birds. These compact and stocky creatures are most frequently seen in wetland habitats, but some live in forests or grasslands. Almost all islands in tropical latitudes have or had endemic rails or fossil evidence of their past presence. Larger islands have several native rails, and it has been estimated that as many as 2,000 flightless rails inhabited Polynesian and western Pacific islands alone, prior to their colonization or visits by humans who exterminated them. Many of these instances were in prehistoric times by Maori, Hawaiians and other native peoples (Taylor 1998). Some 23 species of island rails, virtually all flightless, have been exterminated since 1500 – far more than any other avian family (see Appendix).

Rails are not likely candidates for colonizing islands because they are, in the words of S. Dillon Ripley (1977), an authority on rails, "loath to fly." When frightened, they usually do not take wing, but disappear into matted vegetation. When they do fly for short distances, it is rather feebly, and their legs dangle down. How could they have reached islands thousands of miles from the mainland? Some rails are long-distance migrants, while other species disperse in erratic patterns (Taylor 1998). Rails tend to travel in groups at night and are often blown off course. European rails on their way to Africa have ended up far from their wintering site (Taylor 1998). European Corncrakes, for example, have landed, exhausted, on ships in the Indian Ocean or even off New Zealand (Ripley 1977). North American Purple Gallinules, colorful rails of southern marshes, have flown to tiny Tristan da Cunha island halfway between South America and Africa in the South Atlantic (Ripley 1977). The Common Moorhen (*Gallinula chloropus*) of Eurasia, North and South America and Africa has colonized St. Helena, the Azores, the Seychelles, the Marianas and Hawaii, among other islands. These colonizing rails usually become flightless if they have no enemies, such as native predators. Some become the size of large chickens. Once flightless, however, they are vulnerable to predation by animals brought by humans.

The Laysan rail or crake (*Porzana palmeri*) was driven to extinction by imported rabbits who rendered Laysan Island devegetated. Biologists transported it to nearby Midway Island, where it flourished until World War II, when the island became a naval base. The navy personnel were entranced by this utterly fearless and agile bird that sprang into people's laps or onto the mess table in search of crumbs of food. Unfortunately, the species perished soon after 1942, when rats from a naval landing craft apparently ate the rail's eggs and preyed on its young. A few of the rails had been returned to Laysan Island after rabbits were removed, but the vegetation had not recovered sufficiently and the birds did not survive (Ripley 1977). Most other island rails have died out from similar causes.

Since about one-third of the world's birds are endemic to islands, and they have been reduced by 30 to 50 percent

since humans came to these islands. Their extinctions represent a true biological catastrophe, in the words of Storrs Olson, an authority on extinct birds (Taylor 1998). The vast majority of avian extinctions in the past 500 years have been island birds – victims of predation, competition from introduced animals and disease from cagebirds. Many were also killed for food or trade. Non-indigenous species are still causing bird extinctions on islands. In all, 137 of the 157 bird extinctions (87 percent) since 1500 have been island species, and human activities and animals introduced by humans have been responsible. Island species have been more vulnerable to extinction than mainland species because of their small populations and limited habitats. Many were flightless or slow-moving species, unable to flee predators, including humans. Some were specialized in their diet and habitat and could not adapt to changes made in their environment.

### **Mammal Extinctions**

Cuba, Puerto Rico, Hispaniola and Jamaica had a variety of unusual native rodents and shrew-like insectivores prior to the arrival of European explorers and settlers in the 1600s; many were ancient species. When native Caribbean populations settled the islands after the Ice Ages, rodents as big as marmots inhabited the larger islands. A type of giant sloth lived in Puerto Rico, and a rodent nearly the size of the American black bear inhabited the small islands of Anguilla and St. Martin until it was apparently hunted to extinction by natives (Olson 1978). Cuba, Puerto Rico and Hispaniola were once attached to the mainland of Central America, but this large land mass became separated and drifted off into the Caribbean. Some of the native fauna and flora present more than a million years ago survived until a few thousand years ago, and tiny frogs and butterflies from that period persist today.

When Europeans colonized the Caribbean islands, they began cutting forests and replacing them with huge plantations of sugar cane, other crops and grazing land for livestock. They imported thousands of slaves to farm the land. Mongooses were brought on the islands to control snakes, but they preyed on native mammals and birds instead; rats arrived in ship holds and did the same. Fifteen mammals have become extinct on Hispaniola, the island divided between present day Haiti and the Dominican Republic – this island suffered the highest number of mammal extinctions of any Caribbean island. Forests have been nearly obliterated on Haiti, which is another cause of extinctions. Cuba, Puerto Rico and Jamaica have likewise lost the majority of their forest cover, as well as many native mammals, including bats, rodents and insectivores. Jamaica was home to a monkey (*Xenothrix mcgregori*), making it the only Caribbean island with a native primate. It was hunted and its forest habitat was cut by European colonists, and it died out in the 1750s. Various species of hutias, large rodents found on most major islands, became extinct as well. Hutias remain on a few Caribbean islands but are close to extinction from forest destruction and predation by introduced mammals.

Most of the 40 mammals that became extinct on Caribbean islands after 1600 were rodents and insectivores. A muskrat and a rice rat became extinct on Martinique when Mt. Pelee erupted in 1902 – one of the few examples of a naturally caused modern extinction. Hutias, large rodents that resemble South American agoutis, proliferated into a variety of species on the large islands of the Greater Antilles. Settlement, deforestation and hunting caused at least five species of hutias to become extinct, and the few remaining species are now highly endangered.

The first mammal to disappear after 1600 was a massive wild cow called an auroch (*Bos primagenius*). This species, native to most of Europe, lived in the deciduous forests that once covered most of the continent. The auroch

was also hunted for its meat and died out about 1627. Several other wild cattle related to the auroch survive in Southeast Asia, but they are critically endangered. The tarpan (*Equus gmelini*), a wild horse of Europe, gradually became rare and restricted from hunting and destruction of its native forests during the Middle Ages. The last wild tarpans were killed off in 1851 (Day 1981). Both the auroch and the tarpan are depicted by Pleistocene humans in magnificent cave paintings found in southern Spain and France.

The Steller's sea cow (*Hydrodamalis stelleri*) was an enormous 24 to 30 feet long marine mammal, similar in appearance to the dugong and the manatee. The sea cow was larger, however, and swam in the cold arctic waters of the Bering Sea, enduring temperatures that would kill its closest relatives. The slow and sluggish sea cows were killed off only 27 years after their discovery. They were first seen by the shipwrecked crew of the explorer Vitus Bering in 1741 in the vicinity of Bering Island in the Commander Islands, off the eastern coast of Russia's Kamchatka Peninsula. These sea cows were tame and easy to spear and harpoon by the ship crews who killed most of the population, calculated at only about 1,500. This animal showed extreme protectiveness toward its fellows and strong bonds between mates. The naturalist Georg Wilhelm Steller, after whom the species was named, described their behavior on being harpooned.

*... Some of them tried to upset the boat [when another sea cow was struck] with their backs, while others pressed down the rope and endeavored to break it, or strove to remove the hook from the wound in the back by blows of their tail, in which they actually succeeded several times. It is most remarkable proof of their conjugal affection that the male, after having tried with all his might, although in vain, to free the female caught by the hook, and in spite of the beating we gave him, nevertheless followed her to the shore, and that several times, even after she was dead, he shot unexpectedly up to her like a speeding arrow. Early next morning, when we came to cut up the meat and bring it to the dugout we found the male by the female, and the same I observed on the third day when I went there by myself for the sole purpose of examining the intestine (Day 1981).*

Australia has been the scene of more mammal extinctions than any other continent or island group. Beginning in the 19th century, Australia's mammals disappeared in large numbers. Native marsupials and rodents were gradually eliminated by massive habitat destruction and predation from animals introduced by European settlers. Twenty-two mammals became extinct after 1600. A wide variety of marsupials, from small species to wallabies, was extinguished within a century of settlement. Some, like the thylacine, or Tasmanian wolf (*Thylacinus cyanocephalus*), were deliberately persecuted by livestock ranchers under the misapprehension that the species presented a threat to flocks.

The crescent nailtail wallaby (*Onychogalea lunata*) was native to the gum forests of western Australia where John Gilbert, a 19th century museum collector, found the animal common in thick scrub, "where it is occasionally seen sunning itself" (Strahan 1995). This small marsupial weighed less than 20 pounds and looked like a miniature kangaroo. It rested in hollows in soft ground beneath shrubs during the day, feeding mainly at night on roots and coarse grass (Nowak 1999). When chased, it would run to a hollow tree with a hole in the bottom and clamber up the sides until it got high up within the trunk; aborigines used smoke to chase them out and then killed them for food (Strahan 1995). The aborigines also hunted these animals by building brush fences and enclosures and driving the animals into areas where people waited with clubs (Strahan 1995). In spite of hunting, this wallaby was fairly common until 1900, and many were collected for museums (Strahan 1995). It disappeared from the southern portion of its range early in the century after intensive forest clearance and development of the country for agriculture. Gradually, it became very rare, and disappeared altogether from the wild in the 1960s (Nowak 1999, Strahan 1995). Some experts suggested the removal of the thickets where these wallabies sheltered during the heat of the day left them homeless and vulnerable to predation (Nowak 1999).

Millions of acres of eucalyptus forests and mulga woodlands of southern and western Australia were clearcut by settlers beginning in the 19th century, opening up the land to wildfires (Lines 1991). The devastation of these habitats was described in *Taming the Great South Land. A History of the Conquest of Nature in Australia*, by W.J. Lines (1991). The combination of this habitat destruction, hunting and introduced predators, such as feral dogs, was responsible for the extinction of the Crescent Nailtail wallaby and many other native marsupials.

Various endemic Australian rodents and bats died out as well, and many of the remaining native mammals are become confined to tiny islands off the coasts the only habitats where introduced animals are absent. Australia is like an island in having been isolated from other land masses for millions of years, and the majority of its mammals are endemic to the continent. In fact, it is often referred to as the "Island Continent." If Australian extinctions are included among those on islands, 87 percent of all extinctions of vertebrates other than fish have occurred on islands.

In Asia, the freshwater baiji dolphin species was until recently found throughout the Yangtze River and its surrounding lakes and tributaries. Unfortunately, the exponential growth of the Chinese population posed a variety of threats to its survival. A lack of information, growing threats and the species' small population size eventually led to the baiji's decline, despite protective efforts. Baiji dolphins were last officially sighted in 2004, and a 2006 expedition deemed the species "functionally extinct."

**THE GEOGRAPHY OF EXTINCTION (chart)**

<b>1600 to present</b>					
	<b>Number of Species Extinct</b>				
<b>Islands</b>	<b>Birds</b>	<b>Mammals</b>	<b>Reptiles</b>	<b>Amphibians</b>	<b>Total</b>
Atlantic Islands					
Ascension I.	1				1
Canary Is.	1		1		2
Cape Verde Is.			1		1
Falkland Islands		1			1
Gull Island (Off NY, USA)		1			1
Iceland, Funt I. (Canada)	1				1
St. Helena	7				7
<b>Subtotals</b>	10	2	2		14
Caribbean					
Barbuda		2			2
Barbados		1			1

Bahamas	1				1
Caribbean region	2	1			3
Cayman Is.	1	1			2
Cuba	1	7			8
Guadeloupe	2		1		3
Hispaniola (Haiti & Dominican Republic)	1	15			16
Jamaica	4	2	2		8
Martinique	1	2	3		6
Navassa I.			1		1
Puerto Rico		6			6
St Croix (Virgin Is.)			1		1
St Lucia		2	1		3
St Vincent		1			1
<b>Subtotals</b>	13	40	9		62
Indian Ocean Islands					
Amsterdam Island	1				1
Christmas Island		3			3
Madagascar	2	1			3
Mascarene Is.	31	1	13		45
Seychelles	2		1		3
<b>Subtotals</b>	36	5	14		55
Mediterranean					
Sardinia		1			1
<b>Subtotal</b>		1			1
Pacific Islands					
Auckland I.	1				1
Bering I. region	1	1			2
Bonin Is.	3	1			4
Caroline Is.	3				3
Chatham Is.	5				5
Fiji Is.			1		1
Galapagos Is.		7			7
Guadalupe I.	2				2
Guam	1	1			2
Hawaiian Is.	21				21
Lord Howe & Norfolk Is.	6				6

Kangaroo I. (Australia)	1				1
Marquesas	1				1
New Caledonia	4				4
New Zealand	14	1	1		16
Okinawa		1			1
Pacific region	1				1
Palau		1			1
Philippines		3			3
Ryukyu Is.	1				1
Samoan Is.	1				1
Santa Cruz Is.		1			1
Society Is.	7				7
Solomon Is.	1				1
Tonga Is.	1				1
Vanuatu	1				1
Wake I.	1				1
<b>Subtotal</b>	77	17	2		96
Asia					
Indonesia	1				1
<b>Subtotal</b>	1				1
<b>Island Totals</b>	137	65	27		229
<b>Mainlands</b>					
Africa		5	1		6
Asia	2	1			3
Australia	2	22			24
Europe & Near East		2		1	3
Mexico & Central America	3	4		4	11
North America	3	1		1	5
South America	10				10
<b>Mainland Totals</b>	20	35	1	6	62

Source: Table of Extinct Species in the Appendix of this book. Sources of information are listed with the table.

Note: See the Appendix for the list of these species in chronological order, and the references that describe these animals and their extinctions, as well as those that include illustrations of the extinct species.

The following account chronicles some of the many extinctions and destructions of natural ecosystems that have taken place in North America over the past few hundred years. Great biological treasures have been stolen from future generations, and the processes by which they were lost are typical of those occurring elsewhere in the world. The

sudden loss of the most abundant and prominent wildlife species of the continent created a profound shock in the public early in the century that set the stage for today's conservation and humane programs. This concern may turn the tide for species that could suffer the fate of the passenger pigeon (*Ectopistes migratorius*) and others, but unless public opinion is better translated into public policy regarding the land and wildlife, further losses will occur and the lessons that might have been learned will be ignored. A strong and pragmatic commitment to preserve what remains of the natural world on the continent, based on a realization that our fate is linked to nature's fate, is essential to prevent further extinctions.

### **Epitaphs for North America's Lost Species and Environments**

After the loss of the majority of large Pleistocene mammals, native peoples in North America became conservationists of the remaining wildlife and the continent's environment. Many tribal religions deified animals and believed they embodied the spirits of their people. They hunted and fished on a subsistence basis. This resulted in relatively few animal extinctions over the tens of thousands of years that passed before settlement by Europeans in the 16th century. The land that awaited new settlers was spectacular in its beauty and abundance of wildlife. Over the next three centuries, however, an unprecedented level of slaughter and drastic environmental alteration destroyed many of these natural treasures.

### **An Abundance of Wildlife**

Early European voyagers landing on the East Coast of North America were astounded to see animals in numbers they had never before witnessed. Fish swarmed in the millions. Captain John Smith came upon vast schools of fish in tributaries of the Potomac River, near the Chesapeake Bay, in 1608: " in diverse places that abundance of fish lying so thick with their heads above the water [that] as for want of nets (our barge driving among them) we attempted to catch them with a frying pan, but we found it a bad instrument to catch fish with. Neither better fish, more plenty, nor more variety for small fish had any of us ever seen in any place so swimming in the water " (Hawke 1970). Lobsters were so prolific that one haul of a fisherman's net would bring in more than 100; settlers used them as fertilizer and fish bait. Huge sturgeon 10 feet long swam up major rivers to spawn along the East Coast. Offshore, whales and herds of dolphins migrated along the coasts. The northern right whale (*Eubalaena glacialis*) fed on plankton in shallow lagoons as it migrated to its breeding grounds off Florida. The now-extinct Atlantic gray whale (*Eschrichtius robustus*) was a common marine resident, swimming and feeding offshore. At the present sites of Boston, New York and Philadelphia, vast saltwater marshes surrounded river deltas. Shorebirds and waterfowl darkened the sky with their millions.

Along the craggy rock strewn coasts of Maine and the Canadian maritime provinces lived a large mink, almost double the size of the American species found elsewhere in the country. Unlike any other type of mink in the world, the animal was a coastal species that soon became known to colonists and fur trappers as the sea mink (*Mustela macrodon*). One sea mink killed in 1867 measured 32.5 inches in length, enormous in comparison to the American mink, which does not exceed 23 inches (Mowat 1981). The sea mink's pelt had twice the value of the inland species in the fur trade (Allen 1942).

An early account by the English naturalist Joseph Banks, who traveled to Newfoundland in 1766 to study the local fauna, described the sea mink as "bigger than a Fox, tho not much, in make and shape nearest compared to an Italian Greyhound, legs long, tail long and tapering" (Mowat 1981). It is unlikely that the sea mink was as long legged as a greyhound, but available information indicates it was quite different from any closely related species. Bones from the

sea mink have been found along the coast of Maine and New Brunswick (Allen 1942). The fur traders decimated these minks long before scientific or biological studies could be carried out. One early observer described the avid pursuit of sea minks in Maine:

*Some seventy five years ago, and for many years thereafter, my father, who was a fur buyer, used to have nearly all the furs taken on the islands of Penobscot Bay . . . these sea mink used to bring considerably more than others on account of their great size . . . they were persistently hunted . . . with dogs trained for the purpose. As the price of mink rose, they were hunted more and grew scarcer, 'til in the sixties, when mink skins brought eight or ten dollars apiece, parties who made a business of hunting nearly or quite exterminated the race. Some of these men went from island to island, hunting any small ledge where a mink could live. They carried their dogs with them, and besides guns, shovels, pick axes and crow bars, took a good supply of pepper and brimstone. If they took refuge in holes or cracks of the ledges, they were usually dislodged by working with shovels and crow bars, and the dogs caught them when they came out. If they were in the crevices of the rocks where they could not be got at and their eyes could be seen to shine, they were shot and pulled out by means of an iron rod with a screw at the end. If they could not be seen, they were usually driven out by firing in charges of pepper. If this failed, then they were smoked with brimstone, in which case they either came out or were suffocated in their holes. Thus in a short time they were nearly exterminated (Beard 1947).*

The last known sea mink was killed in 1880, and its pelt was sold to a fur buyer in Jonesport, Maine (Mowat 1981). Only fragments of bones and teeth found in excavations of Indian cooking sites attest to its existence (Nowak 1999).

A beautiful North American waterfowl species also disappeared. The male Labrador duck (*Camptorhynchus labradorius*) had striking black and white plumage, while the female was mousy brown. During the 19th century, these birds were often seen in fall and winter off New York's Long Island and on the New Jersey coast. Named for the Canadian peninsula where naturalists of the day assumed that they bred, eggs reported to belong to this species had been seen by a naturalist, but the nests were never found (Greenway 1967). This duck had a soft bill, and inside its mouth, lamellae filtered its food. The Labrador duck was assumed to have a specialized diet, possibly of small surface invertebrates that it filtered while dabbling at the surface. The ducks also fed on mollusks, as hunters discovered when they caught them with fishing lines baited with mussels (Fuller 1987).

Labrador ducks were strong flyers who flew in tight, small flocks (Day 1981). Along with virtually all waterfowl of the day, they were shot for the feather and food markets. Gunners killed entire flocks of waterfowl, bringing them to market, where they were heaped in piles. The ducks were killed for no purpose, since they were not sought after as food and considered too "fishy" by most customers. Many of the birds shot by hunters were left to rot, unsold at markets (Day 1981, Greenway 1967). The Labrador duck, first described scientifically in 1789, was always considered rare, and the last known specimen was a bird shot off Long Island 86 years later, during the autumn of 1875. This male is kept in the US National Museum of Natural History (Fuller 1987). The Labrador duck was apparently hunted to extinction, a victim of the totally unrestricted waterfowl hunting that characterized the 19th century, based on its prevalence in game markets (Day 1981).

Further north, a flightless bird walked upright on its flippered feet. At a length of 3 feet, the great auk (*Alca*

*impennis*) was the size of a large penguin, and could have been mistaken for one. Like many northern seabirds, it had a black back and white belly, but each side of its face was dramatically marked with a large, white oval. Its bill was long and hooked. Great auks were far larger than any of their cousins – the murre, puffins and guillemots of the North Atlantic. At one time, these birds ranged along most of the coasts and islands of the North Atlantic, from northern France through Scandinavia, England, Scotland and Iceland, to North America's eastern coast as far south as Martha's Vineyard, Massachusetts (Greenway 1967). Based on fossil evidence, great auks were once as numerous as most other sea birds of the region (Greenway 1967).

The very oldest bones, excavated on the island of Jersey in the English Channel, are between 70 and 90 thousand-years-old (Greenway 1967). As the only flightless bird in the North Atlantic, it was once widespread and numerous. When people approached the birds while they were on land nesting, great auks would immediately waddle to the water's edge and dive in. They were rapid and expert swimmers, using their wings to propel them. When cornered on land, however, they were helpless. Both parents raised the chicks, and they refused to desert their nests, even when attacked. For centuries, hunters took advantage of this trait, pursuing and killing them during their breeding season. Ship crews slaughtered thousands for provisions and took live birds on board for future meals.

Gradually over the centuries, great auks disappeared from most European coastlines and offshore islands as a result of hunting. The last record in the British Isles was on St. Kilda, an island west of northern Scotland, where some local residents captured a Great Auk in 1821; although kept captive with a string attached to its foot, it managed to escape (Fuller 1987). Twenty years later, as recounted by an older resident, another auk was found asleep on a rock on the same island and captured, kept for three days, and then killed because these superstitious people feared that it was a witch (Greenway 1967).

Great auk feathers were harvested in grisly "factories" on Funk Island off Newfoundland in the 18th century. Collectors built pens of piled boulders into which they would drive the hapless great auks from their nests. Once the auks were cornered in the pens, the men would swing spiked clubs at the birds, killing or wounding them (Day 1981). The birds were then thrown over the enclosure walls into piles near the fires; there the dead and wounded birds were dropped into boiling cauldrons or thrown directly on the fires (Day 1981). The boiling water caused the feathers to float to the surface, where they were scooped up and stuffed into bags; the corpses were next dragged down to the water where they were dumped (Day 1981). Some observers, including Captain George Cartwright, an early colonist on Labrador, watched boats coming ashore laden with hundreds of carcasses from Funk Island. He wrote in July 1785, "If a stop is not soon put to that practice, the whole breed will be diminished to almost nothing" (Birkhead 1994). By 1800, all the island's great auks had been killed. The ashes and pens still remain on Funk Island as the only reminder of this extraordinary bird.

Islands off Iceland and Newfoundland became the last refuges of the great auk. When word spread in the 19th century that the species was nearing extinction, hunters went in search of them for museums and egg collections. The eggs and skins of the Garefowl, as it was known to Europeans, were sold at auction in London and to European museums for very high prices. Hundreds of English pounds were offered for each egg, encouraging fishermen to comb islets for the last of the nesting birds. The only remaining birds known to survive were killed on Eldey Island off southwest Iceland on June 2, 1844; three Icelandic fishermen who discovered two birds, a breeding pair with a single egg, strangled the adults and threw them into a boat (Birkhead 1994). These last great auks were killed for their skins, which were sold to a dealer (Birkhead 1994).

Other marine creatures barely avoided extinction during the period of unregulated killing of wildlife that began in the 1600s. The Atlantic walrus (*Odobenus rosmarus rosmarus*) herd off the Canadian coast numbered at least a quarter of a million animals prior to European exploitation. Between 1633 and 1642, vessels from the Massachusetts Bay Colony made a number of expeditions to Sable Island off Nova Scotia to kill the walrus for their tusks and oil. Glover Allen (1942), in *Extinct and Vanishing Mammals of the Western Hemisphere*, chronicles one sealing voyage in 1641 in which 12 men who spent eight months on Sable Island returned with "400 pair of sea horse teeth, which were esteemed and worth 300 pounds." The walrus colonies in the Gulf of St. Lawrence numbered seven or eight thousand

at that time; they were killed off by American sealers, who worked at night while the walrus slept on land (Allen 1942). Gradually, the Atlantic walrus became exterminated in all areas on the continent. From 1925 to 1931, the last large population in the Canadian Arctic on Baffin Island was devastated by the killing of 175 thousand animals (Nowak 1999). Although finally given protection, the species has not shown a substantial recovery because of the high kill by native peoples, which equals annual recruitment in the western Atlantic (Nowak 1999). Only 25 thousand walrus remain in this region. Russia classifies the species as vulnerable and the population in the Laptev Sea as rare (Nowak 1999). They may have increased somewhat along the coast of Norway, in the Svalbard region and Barents Sea (Nowak 1999).

Although the Pacific gray whale has now recovered from near extinction from whaling, few people are aware that this species once lived in the Atlantic as well (Allen 1942, Mowat 1981). Large numbers of Atlantic gray whales migrated along North America's eastern coast until as late as the end of the 18th century (Mowat 1981). Whalers of the 1740s saw whales whose descriptions matched those of the gray whale, but the existence of this species was not verified until fossil remains were uncovered (Allen 1942, Mowat 1981). Early Basque whalers had eliminated gray whales from European waters centuries before (Mowat 1981). Atlantic gray whales swam south along the shore of the coasts of Maine, Massachusetts and Long Island, down to the Florida Keys, where their calves were born (Mowat 1981). This whale, known as the "Scrag" in the Northeast, was a familiar species off the coasts of Nova Scotia and Maine in early colonial times. It gave rise to place names such as the Scrag Islands, Scrag Rocks and Scrag Harbor now known as Sag Harbor (Mowat 1981). These whales fed in shallow bays on abundant bottom dwelling crustaceans, making them easy prey for whalers. They were killed beginning in the early 1600s by harpooners off Nantucket Island, Cape Cod and Long Island Sound in the shallow shoals of their migration route (Mowat 1981). By the early 1700s, New England whalers had completely eliminated this whale (Mowat 1981).

Beginning in 1609, Samuel de Champlain sailed down the St. Lawrence River to the Great Lakes (Peck 1990). Other explorers and settlers established trading posts and villages. Furs were major items of trade, and soon beaver and other furbearers were traded in the millions by the French and English. Early travelers found wild turkeys (*Melagris gallopavo*) so abundant boys threw stones at them for recreation (Peck 1990). Two French explorers observed great numbers of fish in the Great Lakes and the upper Mississippi River, which soon became exploited. Vast numbers of cisco, members of the Salmonidae family, once lived in the Great Lakes. The Blackfin Cisco (*Coregonus nigripinnus*) and Deepwater Cisco (*Coregonus johanna*), native to Lake Michigan and Lake Huron, were considered "jumbo herring" by fishermen from early times (Day 1981). By the late 19th century, large fishing vessels with huge nets caught up to 15 million tons from one lake alone per year; one net haul might yield as much as 10 tons in a day (Day 1981). Fishing continued, even in winter, through ice holes, and prior to the availability of freezing facilities, dumping of unsold catches amounted to many tons (Day 1981). These fish became commercially extinct after World War I, and subsequently were declared extinct by the World Conservation Union, along with another Great Lakes species, the longjaw cisco (*Coregonus alpenae*) (Baillie and Groombridge 1996).

This overfishing was repeated in the Atlantic waters off New England and southern Canada. Cod, halibut and flounder abounded here, providing ample fish for centuries to local fishing communities. Huge cod weighing 180 pounds and halibut the size of barn doors were often caught in these times. Factory fishing ships began fishing here in the 1950s and soon depleted the stocks. National legislation banned these vessels from the Atlantic coast and smaller vessels took their place. With few restrictions on take and far too many fishermen the stocks crashed in the 1980s and early 1990s. With the encouragement of the National Marine Fisheries Service (NMFS), fishermen turned to small sharks known as dogfish. Within a few years, they also became depleted because of their extremely slow reproductive rate, a fact apparently not appreciated by the NMFS. Fishery conservation legislation has been enacted, but these stocks may never return to former abundance.

Some fisherman are being compensated for their boats by a federal program, in order to ease fishing pressure on remaining stocks, but others are turning to small fish, such as menhaden. These fish are fed on by humpback whales (*Megaptera novaeangliae*), threatened species not yet recovered from past whaling, as well as by puffins and other seabirds. Many seabirds are undergoing population decline as a result of a dwindling food supply and the drowning

risk posed by fishing nets. Shorebirds, too, are affected by overfishing. Horseshoe crabs (*Limulus polyphemus*) lay their eggs along the east coast each year, providing abundant food for shorebirds on their northward migration, and for many types of other wildlife as well. These crabs are captured by the millions for use as fish bait, which has reduced their numbers dangerously in some areas. The shorebirds have also declined precipitously in recent years, some species by 90 percent. Entire food chains are being disrupted as a result of over exploitation of the sea. Ocean pollution has contaminated Atlantic coastal waters, causing die-offs of dolphins, fish and manatees.

All along the East Coast, colonists built cities at river deltas, which were surrounded by vast salt marshes. These locations were considered prime seaport and manufacturing sites, and the marshes were filled in and polluted. Tens of thousands more acres of marshes along the Northeast coast have been ruined by construction of drainage ditches to control mosquitoes and halt malaria. In fact, these ditches created habitat for mosquito breeding and caused the water level in the marshes to drop. Waterbird populations declined sharply as a result, and they no longer filled their role as fish and shellfish nurseries, water filterers and flood controls. In a recent development, dikes in 10 thousand acres of marshes on Long Island are being blocked to open normal flow channels between marsh and bay, and exotic reeds are being removed (Lambert 1997). The marshes that have been returned to their natural state showed an immediate tripling in the number of waterfowl wintering there, and a doubling of wading birds such as ibis, egrets and herons; shorebird populations quintupled; these marshes have at least 130 species of breeding birds, and 300 species use them for wintering or migration (Lambert 1997). The marshes give a glimpse of the wealth of wildlife that once inhabited eastern coasts; with similar programs, they can be restored to help build up stock of fish and shellfish.

In most areas, however, housing and development now occupy the sand dunes and former marshes. Some barrier islands off the coasts, which buffer the beaches against the erosion effects of storms, have been preserved in portions of the East Coast, such as Virginia, North Carolina and Georgia. Elsewhere, roads, houses and businesses clutter these islands, and development has endangered many native birds. Georgia's beautiful coastal marshes were given official protection after they were nearly destroyed by phosphate mining, when it was shown that their value as shrimp and fish nurseries far outweighed their short-term value for phosphate.

At the southern tip of the United States, the Florida Everglades, one of the largest wetlands in the world, once provided nesting and feeding ground for millions of egrets, herons, pelicans and other waterbirds. This sawgrass wilderness sheltered vast numbers of American alligators (*Alligator mississippiensis*). Cougars, known as Florida panthers (*Felis concolor coryi*), were common, and preyed on the small Everglades white-tailed deer. Water diversion projects for agriculture and the new human population of Miami and coastal cities resulted in a drying out of the Everglades. Exotic plants have proliferated in the marshes, overwhelming the native grasses and choking waterways. Ninety percent of the populations of waterbirds disappeared. The Florida panther recently became extinct in Everglades National Park, one of its last refuges. The alligator has recovered from nearly disastrous hide hunting in Florida, but remains rare in many parts of its original range. A project to restore some of the waterflow to the Everglades was enacted into law in the 1990s (see Aquatic Ecosystems chapter).

The American crocodile (*Crocodylus acutus*), a saltwater species inhabiting coastal areas, was once numerous in Florida Bay and in the mangroves of the Keys. Today, this is one of the most endangered species in the country, numbering fewer than 400 animals. Early hide hunting reduced them and, in this century, pollution and loss of mangroves in their habitat have pushed this species close to extinction.

Many Everglades bird species are also endangered, and one has recently become extinct – the dusky seaside sparrow (*Melospiza maritima nigriscens*). This sparrow, with its unusually dark coloration, was a victim of the massive destruction of wetlands in Florida. By the time it received the protection of the US Endangered Species Act, this subspecies was nearly extinct. Its limited habitat of spartina grass on Florida's central Atlantic coast had been flooded for mosquito control and drained for the construction of nearby NASA facilities (Ehrlich *et al.* 1992). In an 11th-hour attempt to save these little sparrows, a captive breeding program was set up, mating them with a related subspecies to preserve some of their genes. The last purebred dusky seaside sparrow died at the age of 13 in 1987 (Ehrlich *et al.* 1992). The breeding program was not successful, and by 1997, the related subspecies had also become

endangered.

Two spectacular waterbirds, the American flamingo (*Phoenicopterus ruber*), and the scarlet ibis (*Guara rubra*), were once residents of south Florida. Both species were eliminated in the 19th century when, as William T. Hornaday (1913) observed, they "attracted the evil eyes of the 'milliner's taxidermists.'" The feather trade of the late 19th century nearly exterminated the majority of North America's wading birds and many of its seabirds through unregulated slaughter for plumes to adorn ladies' hats. Egrets, roseate spoonbills, herons, terns and other birds with long or colorful feathers were killed indiscriminately. In 1900, the Lacey Act and state laws extended protection to these birds by banning sale and interstate commerce, and the Migratory Bird Treaty Act, signed with Canada in 1918, protected native North American non game birds from capture, killing and sale.

### **The Eastern Forests**

Ancient hardwood forests stretched for thousands of square miles in eastern North America. Massive oaks, chestnuts, hickories, walnuts and beech trees dominated, some reaching heights of more than 100 feet, with trunks 20 or more feet in circumference. Giant hemlocks and many kinds of pine dominated some areas. The passenger pigeon was the most abundant denizen of these forests, and its range extended from southern Canada, New England and the Great Lakes west to the Great Plains and south to Virginia. The slim bird was somewhat smaller than the familiar rock dove or common pigeon found in cities worldwide, with a long, pointed tail. The male's plumage was beautiful; his back, wings and head were bluish gray with black streaks and spots, which contrasted with a rich, pinkish tinge on his lower throat. His breast feathers became paler on the belly, and a patch of pink or purple pink iridescence shone at his neck. His eyes were bright red surrounded by purplish skin, and his legs and feet were red (Goodwin 1983). The female was a duller version of the male, browner gray above, light gray on the breast, with a smaller iridescent pink patch on the neck, more profuse black spots on the wings and gray skin surrounding her orange eyes (Goodwin 1983).

This is the only pigeon living or extinct that flocked and nested in vast numbers, darkening the sky during their migrations. When Europeans first encountered passenger pigeons, they were dumbfounded by their numbers. One immigrant, Pehr Kalm, described their passage in the spring of 1749: "on the 11th, 12th, 15th, 16th, 17th, 18th and 22nd of March . . . there came from the north an incredible multitude of these pigeons to Pennsylvania and New Jersey. Their number, while in flight, extended three or four English miles in length, and more than one such mile in breadth, and they flew so closely together that the sky and the sun were obscured by them, the daylight becoming sensibly diminished by their shadow" (Fuller 1987). When the pigeons landed on trees, their weight was sometimes so great that not only would large limbs break off, but entire trees would topple. Prior to settlement of the continent by Europeans, as many as 5 billion birds inhabited Kentucky, Ohio and Indiana alone (Blaugrund and Stebbins 1993).

Passenger pigeons were migratory, as their scientific name, *Ectopistes migratorius*, suggested, but not in the manner of most birds, who migrate from an ancestral nesting area to an ancestral wintering area. Instead, immense columns of birds flew as a unit at speeds estimated as high as 60 miles per hour in wide areas in search of nut trees and seeds. John James Audubon, famed illustrator of American birds, described flights in the 1830s that covered the sky for days in some areas, while in other years, none would be seen in the same area (Blaugrund and Stebbins 1993). The forests that once stretched nearly unbroken across eastern North America were crucial to the survival of the passenger pigeon flocks. Nut trees (oaks, hickories and beeches) produced large crops only every few years. In order to locate adequate feeding supplies, the pigeons covered great distances.

John James Audubon visited a roost in Kentucky accompanied by some pigeon hunters in 1831:

*Many trees two feet in diameter, I observed, were broken off at no great distance from the ground; and the branches of many of the largest and tallest had given way, as if the forest had been swept by a tornado. Every thing proved to me that the number of birds resorting to this part of the forest must be immense beyond conception . . . Suddenly there burst forth a general cry of 'Here they come!' The noise which they made, though yet distant, reminded me of a hard gale at sea passing through the rigging of a close reefed vessel. I felt a current of air that surprised me. Thousands were soon knocked down by the pole men. The birds continued to pour in . . . The pigeons, arriving by thousands, alighted everywhere, one above another, until solid masses as large as hogsheads, were formed on the branches all round. Here and there the perches gave way under the weight with a crash, and falling to the ground, destroyed hundreds of the birds beneath, forcing down the dense groups with which every stick was loaded. It was a scene of uproar and confusion. I found it quite useless to speak, or even to shout to those persons who were nearest to me. Even the reports of the guns were seldom heard, and I was made aware of the firing only by seeing the shooters reloading (Schorger 1973).*

Once they located a forest with abundant food, they nested in huge aggregations. One colony in Wisconsin was estimated to cover more than 750 square miles, with 136 million nesting birds (Wilcove 1991). Audubon wrote of their courtship, "the tenderness and affection displayed by these birds toward their mates are in the highest degree" and painted two birds "billing" for his *Birds of America* series (Blaugrund and Stebbins 1993). Some described their courtship songs as a series of bell like notes (Fuller 1987).

Their nests, constructed of loose sticks, held their single white egg. A tree could hold many nests, which the birds placed on strong branches close to the trunk. The flocks rarely nested in the same area two years running, and dispersed as soon as nesting was over; this may have been to prevent natural predators from increasing enough to have a serious impact on their numbers (Wilcove 1991). Also, their food supply tended to be abundant only every few years in a given area. These great colonies made easy targets for legions of meat and market hunters, beginning in the 1600s. By the 18th century, naturalists began to observe that nesting colonies were disappearing; the last great nesting in New England took place near Lunenburg, Massachusetts, in 1851 (Wilcove 1991). By the 1860s, the large flocks had been hunted out of coastal New York State and Pennsylvania. The few laws that were enacted to protect them in the Northeast were not enforced (Wilcove 1991). Season after season, pigeon hunters killed millions of these birds, destroying one colony after another.

Neltje Blanchan, in the 1904 book *Birds That Hunt and Are Hunted*, documented that unlimited netting, even during the nesting season, had resulted in sending more than 1 million pigeons to market from a single roost at the height of the hunting; an equal number of birds were wounded or left starving, helpless, naked chicks behind. Hunters shipped 100 thousand pounds of pigeons to market from a nesting colony near Grand Rapids, Michigan (Wilcove 1991). Audubon and other observers of the time described the brutal hunting methods: young birds were knocked out of their nests with poles, and captive pigeons, whose eyelids had been sewn shut, were tethered to lure wild pigeons to the ground where they were netted (Wilcove 1991). Nesting trees were cut down or set afire, and sulphur was burned under nesting trees to kill the birds (Wilcove 1991). Blanchan (1904) described the glut of pigeons at markets as so great that the price per barrel scarcely paid for their transportation. The pigeon meat was often fed to hogs.

By the late 1800s, it had become evident to some that the killing was having a disastrous effect on the passenger pigeons. The warnings went unheeded, however. In Ohio, a bill submitted in 1857 to protect the passenger pigeon received the following report from a Select Committee of the Senate: "The passenger pigeon needs no protection. Wonderfully prolific, having the vast forests of the North as its breeding grounds, traveling hundreds of miles in search of food, it is here to day and elsewhere to morrow, and no ordinary destruction can lessen them, or be missed from the myriads that are yearly produced" (Hornaday 1913).

The final and precipitous decline of passenger pigeons began in the 1870s, a decade which began with some large flocks still attempting to nest in the Great Lakes area. In 1878, naturalists estimated that some 50 million pigeons survived, but with continued heavy hunting, only one large nesting colony in Wisconsin remained in 1887 (Wilcove

1991). This colony dispersed within two weeks after beginning to nest when hunters began shooting at them (Wilcove 1991). By the 1890s, only scattered individual pigeons who were apparently unable to breed or forage successfully remained. In 1892, one observer noted, "The extermination of the passenger pigeon has progressed so rapidly during the past twenty years that it looks now as if their total extermination might be accomplished within the present century" (Blanchan 1904). This statement proved correct. The incredible wildlife spectacle that flights of billions of passenger pigeons presented, ended completely on March 24, 1900, when the last wild bird was killed in Pike County, Ohio (Wilcove 1991).

The reason for the sudden crash in passenger pigeon numbers has been the subject of controversy in the years since. Two ornithologists from the University of Minnesota, David E. Blockstein and Harrison B. Tordoff, believe during the last 20 years prior to its wild extinction, hunters were able to disturb or destroy virtually every nesting colony. Each year, the adult birds that were able to escape previous hunting and attempt breeding were harassed or chased off the nest, or their fledglings were killed (Wilcove 1991). The adults not killed were relatively long-lived, averaging a lifespan of about 20 years, but because their numbers were not replaced by succeeding generations, when they died off, the species became extinct (Wilcove 1991). Blockstein and Tordoff noted some Passenger Pigeons nested in small groups, escaping the attention of hunters, but they conjectured that without the protection provided by large colonies, these birds rarely succeeded in producing fledgling chicks, and were easy targets for predators (Wilcove 1991). This explanation seems logical, and clearly, the birds were unable to survive in small, scattered groups, dependent on a large colony for successful reproduction. Other factors may also have entered in. It may be that only in the presence of large numbers of their own kind was instinctive breeding behavior stimulated.

A captive passenger pigeon named Martha, about 29-years-old and the last of her species, died at 1 p.m. on September 1, 1914 at the Cincinnati Zoological Gardens. This is perhaps the only species for which the exact minute of its extinction is known (Fuller 1987).

Logging and settlement of the eastern hardwood forests destroyed forever the ancient habitat of these lovely pigeons. Even if the passenger pigeon was somehow recreated, the huge expanses of nut and seed-bearing trees it required have since been cut. More than 99 percent of virgin woodland in the East has been logged, first by settlers, and later by commercial loggers. The colonists of New England, after destroying the forests, found farming the rocky soil difficult and unproductive. The short growing season, often interrupted by frosts, further limited agriculture there. Most of these farms were abandoned, and today, second-growth forest covers the region. However, it is composed of different species of trees than the original old-growth forest and is far poorer in wildlife.

The American chestnut (*Castanea dentata*) once comprised a third of eastern hardwood forests; a huge tree 100 feet tall with a spreading canopy, it had girths up to 12 feet (Jonas 1993) and produced bountiful crops of chestnuts. American chestnuts grew east of the Mississippi River from Maine south to Georgia. Of the 12 species of chestnut trees worldwide, the American was known for yielding the tastiest nuts (Jonas 1993). After heavy logging, older trees became confined to wilderness areas and towns, where they were greatly admired as shade trees. In 1904, the spores of a fungus known as chestnut blight were accidentally introduced to the country, probably on seedlings of imported Chinese chestnut trees (Jonas 1993). The blight destroyed the remaining chestnuts in the eastern forests, leaving only stumps. These stumps still sprout shoots that grow up to 20 feet until they, too, succumb to the blight (Jonas 1993). Only a few unblighted American chestnut trees remain in the country. On the West Coast, a small number of the trees were planted out of their natural range, and the blight did not reach them (Jonas 1993). Progress is being made in breeding disease-resistant strains of this tree (see Forests chapter and Projects section).

Another eastern hardwood, the stately American elm (*Ulmus americana*), which reaches heights of 60 to 120 feet, has a slim, straight trunk and a broad, graceful crown. It is also nearly extinct; it was attacked by a fungal infection known as Dutch elm disease, which is gradually killing off these trees. First seen in 1930, the disease spread west. It is still in the process of eliminating trees throughout their range in North America from Nova Scotia to Saskatchewan, south to Florida and west to Texas (Jonas 1993). A disease-resistant strain of this tree has also been bred, and the trees are being distributed for free by a nonprofit organization (see Forests chapter and Projects section).

American beeches (*Fagus grandifolia*) were perhaps the most important food tree for wildlife, producing massive amounts of beech nuts on which passenger pigeons, wild turkeys, black bears and other wildlife fed. At 50 to 70 feet tall, beeches have short, wide trunks that begin branching 10 feet from the ground and form enormous, wide crowns (Jonas 1993). The species is still fairly widespread, but old American beeches, which can live 400 years and grow to enormous girths, are extremely rare in woodland settings where they have been logged out.

Ironically, the colonists could have lived well off the land they found if they had not destroyed both the forests and much of the wildlife within a few centuries. The abundant nuts produced by hardwoods, which had nourished the passenger pigeons, also provided food to Native Americans. Many tribes had learned to remove the tannin from acorns so it could be ground into nutritious high-protein flour. Beechnuts, chestnuts, walnuts, hickory nuts, wild fruits and seeds provided excellent food for people as well as wildlife.

European settlers destroyed this rich ecosystem by commercializing the resources, turning ancient forests into short-term logging profits and wild birds, deer and furbearers into commodities. Had another road been taken, the natural environment would have endured with ample resources for all to live on. Many native tribes had cleared some forests for agriculture, but the vast majority remained in their natural state. Settlers, later supported by government policy, claimed ownership of the East and then proceeded to oust native peoples or relegate them to tiny reservations. This resulted in the killing of hundreds of thousands of natives and the extinction of many tribes.

The new Americans, in adopting the European approach to nature, tamed the wilderness and began a program of eliminating natural predators. They considered the reverence with which Native Americans had treated all living things to be a weakness. At the time of European colonization in the 17th century, almost no natural forests remained in Western Europe. Large predators had been eliminated from most of Western Europe, and most wildlife had been crowded out, killed off or confined to private estates where the animals were considered the property of landowners, providing food and sport to the upper classes. Moreover, this wildlife was hardly wild, but semi-tame. Deer lacked predators, the woods on estates were stocked with game birds and the streams with salmon and trout by gamekeepers. The vast majority of European settlers came from the lower and middle classes; they had previously been denied the right to hunt and were eager to do so with abandon. This was another motivation for the relentless slaughter that decimated wildlife during this period.

Benjamin Franklin hoped to make the wild turkey the official symbol of the United States. When colonists arrived, the species was abundant in eastern forests. Uncontrolled hunting and the cutting of forests eliminated these birds from state after state: Connecticut by 1813, Massachusetts by 1851, New York in the mid 1800s, South Dakota by 1875, Ohio by 1880, Wisconsin by 1881, Michigan by 1897, Illinois by 1903, and Iowa by 1907 (Burger 1978, Peters and Lovejoy 1990). Fortunately, the species was not destroyed altogether, and it has been reintroduced into many parts of its original range through transplants from remnant populations.

Once the eastern forests echoed with the howls of gray wolves (*Canis lupus*), common throughout the continent except the Southeast, where the smaller red wolf (*Canis rufus*) roamed. Both these wolves were deliberately persecuted into extinction by colonists who placed bounties on their heads, effectively eliminating them from the wild in the eastern United States prior to the 20th century (see Persecution and Hunting chapter). Seven races of the gray wolf are now extinct, bountied and poisoned by settlers. Around 1911, the Newfoundland race, *Canis lupus beothucus*, was the first to become extinct. This pure white, large wolf had a scientific name inspired by the Beothuk Indian tribe of Newfoundland; both the wolf and the tribe were exterminated by Europeans (Day 1981).

The red wolf became extinct in the wild in the 1970s, after centuries of persecution and habitat loss. Two subspecies, the Florida black wolf (*Canis rufus floridanus*) and the Texas red wolf (*Canis rufus rufus*), are extinct, and only one race survives. The last members of the species were taken into captivity and bred successfully. A reintroduction program in portions of its original range has brought the species back, and about 100 red wolves now live in the wild. The cruelty with which the gray wolf was eliminated is described in detail in the Persecution and

Hunting chapter. Another predator once common in these forests north of Florida was the Eastern cougar (*Felis concolor cougar*). It was also bountied and hunted until it became extinct throughout the eastern United States.

In the northern woods, eastern subspecies of the American bison, elk, caribou, moose and white tailed deer were extremely common. The hunting by Native Americans armed with bows and arrows did not, apparently, cause declines. The guns brought by Europeans, however, decimated their numbers. An unrestricted slaughter of these ungulates went on for centuries. The white-tailed deer became endangered, disappearing from the eastern forests, first from the vicinity of towns and habitations, then from wilderness areas. The other ungulates died out altogether in New England and the middle Atlantic area. The Eastern elk (*Cervus elaphus canadensis*) became extinct. One cause for the disappearance of this huge member of the deer family was hunting to obtain its teeth, which a private organization, the Fraternal Order of the Elks, used as watch chain insignia (Day 1981). Not only were these animals hunted for food and sale in meat markets by the colonists, but an active export trade in deer and elk skins sprang up. Records show an average of 100,000 of these skins exported to England each year between 1778 and 1808 (Poland 1892). Several small populations of reintroduced elk inhabit Pennsylvania, North Carolina, Tennessee and Virginia.

Hunting caused the extinction of the Eastern bison (*Bison bison pennsylvanicus*) by 1800. This race of bison was larger than the plains bison and very dark; some of the bulls were coal black with grizzly white hair around the nose and eyes (Allen 1942). The last herd of Eastern bison was slaughtered in Union County, Pennsylvania in the winter of 1799 to 1800, as the animals huddled helplessly in the deep snow; the last individuals of this race were killed near Charleston, West Virginia in 1825 (Allen 1942).

Caribou (*Rangifer tarandus*) and moose (*Alces alces*), native to northern New England and southern Canada, were hunted to extinction in the United States in colonial times, surviving only in Canada (Allen 1942). The white tailed deer has reoccupied its former range in the northeastern United States and, in fact, these deer have become overpopulated as a result of a lack of natural predators (see Persecution and Hunting chapter). The moose has been reintroduced in recent years to New England and is gradually dispersing southward. Attempts to reintroduce caribou in Maine have failed.

The heath hen (*Tympanuchus cupido cupido*) was another casualty of colonial settlement. This eastern subspecies of the greater prairie chicken, a grouse like bird, was native to forest edges, grassland and heath in portions of the Northeast, from Massachusetts to Pennsylvania and New Jersey (Greenway 1967). Pursued by market hunters, these birds became a staple food for colonists. Heath hens were so common in Massachusetts in colonial times that Governor Winthrop ordered his servants not to have them served more often than a few times a week (Greenway 1967). By 1830, the last mainland Massachusetts heath hen was shot in the western part of the state. In New York State, a 1791 law banned hunting of these birds during spring and summer, but the law was flouted, and market hunting on Long Island resulted in its extinction there by 1844 (Greenway 1967). Overhunting in New Jersey and Pennsylvania killed off the last birds in these states by the 1860s. The last population of these birds survived on Martha's Vineyard island off the Massachusetts coast and, although protected from hunting, fire and predation gradually eliminated them by 1932 (Greenway 1967).

The existence of brilliantly colored parakeets flying in large flocks in eastern North America was an unexpected surprise for European colonists settling the country. They had thought such birds lived only in tropical regions. Yet these parakeets obviously had adapted to winter snows and frigid nights. The species was named the Carolina parakeet (*Conuropsis carolinensis*) and had a long, graceful tail and a bright yellow and orange head. Its green wings were tinged with yellow, set off by its overall forest green plumage. Eastern parakeets belonged to the subspecies *Conuropsis carolinensis carolinensis* and ranged from Florida to southern Virginia, while western parakeets, *Conuropsis carolinensis ludovicianus*, had a wide distribution from the Mississippi-Missouri River drainage south to Texas, east to Mississippi and north to western New York State and the Great Lakes region (Forshaw 1989). These birds flew in enormous flocks and may have numbered in the millions prior to European settlement.

Like conures (*Aratinga* genus), native to the Caribbean and Latin America, Carolina parakeets could give away

their presence by loud and raucous calling. Because they fed on many types of wild seeds and fruits and were able to endure freezing temperatures, they were among the few species in the parrot family able to survive in harsh climates, with the ability to tolerate temperatures as low as -25 F. (Cokinos 2000). Early travelers in Kansas described the appearance of screaming bands of these parakeets during swirling winter snowstorms; flocks settled in groves of cottonwood and walnut trees, delighting travelers with their vocalizing and dazzling colors (McKinley 1985). Large, hollow trees were among their favorite roosting spots, and flocks of birds would cling to the inside of the trees with their beaks and feet (Forshaw 1989). In early morning, the birds would climb to the top branches of their roosting trees, to the accompaniment of much chattering, and then fly off to feed for several hours. When they saw a fruit or seeding tree, the flock would spiral down until they almost reached the ground, and then rise up to alight on the branches. In the afternoons, they sheltered in groves of trees, often near streams where they drank and bathed (Forshaw 1989).

These parakeets may have been most abundant in the South and the major river valleys of the Midwest. Early naturalists described them perched in huge Bald Cypress trees, their bright plumage contrasting with the pale green, feathery foliage. They would hover and flutter on the tops of these cypresses, extracting the seeds (McKinley 1985). Travelers in the southern hardwood forests and swamps, as well as in pine woods, found them very numerous. In Florida's St. John's River area, where mid-19th century observers saw large flocks, many were killed by plantation owners for food (McKinley 1985).

In Audubon's painting of Carolina Parakeets, these extremely sociable birds are clustered in a tree, feeding on Cockleburs (*Cenchrus tribuloides*), their favorite food (Blaugrund and Stebbins 1993). Only recently have the true colors of this bird, as depicted by Audubon, been revealed by a publication of his original watercolors, which shows their plumage in shades of vivid green, yellow and reddish orange. In the lithographs of previous editions, these colors were drab and dull (Blaugrund and Stebbins 1993).

As their forests were cut and prairies plowed for farms, the parakeets turned to raiding crops and orchards. Flocks would converge on farms at times of harvest, alighting on stacks of grain sheaves. So dense were the perching and feeding birds that they made the stacks look as if "brilliantly colored carpets had been thrown on them," according to Audubon (Forshaw 1989). For these raids on farms, they received "severe retaliations" from farmers; Carolina parakeets were easily approached and never learned to fly away from humans. Farmers would shoot entire flocks, killing 10 or 20 at each discharge (Forshaw 1989). When one was shot, the others refused to leave their wounded or dead flock mate. Audubon described these massacres: "The living birds, as if conscious of the death of their companions, sweep over their bodies, screaming as loud as ever, but still return to the stack to be shot at, until so few remain alive, that the farmer does not consider it worth his while to spend more on ammunition" (Poattie 1940).

Like many members of the parrot family, Carolina parakeets attempted to aid others of their kind who were stricken or threatened by predators. This behavior contributed to their survival in natural conditions, and only the devastating killing power of guns hastened their extinction. Audubon described procuring a basketful of the parakeets with a few shots in 1831 in order to choose good specimens for drawing the figures for his watercolors of North American birds (Fuller 1987). Thousands more of these parakeets were captured for the pet trade and killed for museum collections. At least 675 of the eastern race alone are found in museums. In the last decades of the 19th century, amateur collectors of specimen birds and their eggs proliferated around the country, and dealers in specimens earned large sums from the sale of rare birds. The rarer the bird, the higher the price paid, further endangering the species. Many birds were killed for specimens by collectors who failed to note the location and date of the killing (McKinley 1985). Molting adults and juvenile birds were thrown out, and the physical appearance of the latter birds remains unrecorded (McKinley 1985). One German taxidermist, August Koch, visited the home of a friend in Florida in 1887 and shot some of these parakeets in the back yard of his host as they fed on mulberries (McKinley 1985). A tree that appeared to be sporting "yellow flowers with red centers," turned out to be a flock of parakeets roosting in the early evening, and he shot two birds for his collection (McKinley 1985). Another hunter was led by a Seminole Indian to a "parakeet tree," a large, hollow cypress tree near Lake Okeechobee in Florida, where he shot "as many specimens as my ammunition would allow" (McKinley 1985).

In spite of the keen interest in the species by scientists, naturalists and members of the public, few observations were made of the behavior of these parakeets while they were still common. Almost nothing is known of their life history, flock movements, breeding seasons, nesting, feeding or ecology (McKinley 1985). It is known, however, that they were long-lived, based on the survival of the last captive specimens, which were at least 32 years old. Although a few bred in captivity, they often abandoned their eggs, and no captive-bred birds survived (Forshaw 1989). In spite of large numbers captured for sale as cage birds, no serious effort was made to perpetuate the species through captive breeding, which might have prevented their extinction.

As early as 1831, Audubon noticed a decline: "Our parakeets are very rapidly diminishing in number; and in some districts, where twenty-five years ago they were plentiful, scarcely any are now to be seen" (Forshaw 1989). Flocks of several hundred had commonly been seen when the country was first settled. Within about 90 years, by the 1880s, they had declined both in range and number, with only small flocks or pairs remaining (Forshaw 1989). Persecution by farmers was a major cause and perhaps the most important factor in the decline of the Carolina parakeet in the view of parrot ornithologist, Joseph Forshaw (1989). The last flocks sought refuge in the forests and remote swamps of Florida, where collectors and trappers pursued them (Forshaw 1989). Other factors played important roles as well. Thousands were killed for sport or for their feathers to decorate ladies' hats. Their nesting and roosting trees were cut by settlers and loggers, and their food plants were plowed under by farmers (Cokinos 2000). European honeybees, armed with stingers and introduced by colonists, also may have driven them from their hollow trees as they rapidly spread throughout the country, seeking hive sites (Cokinos 2000). These hollow tree-roosting sites may have been crucial to their survival in cold weather; the birds crowded together side-by-side for warmth. The giant hollow cypresses and sycamores, oaks and other hardwoods in the old-growth forests of the eastern United States, crucial habitat to so many species of wildlife, were among the first trees cut in bottomland swamps and forests.

A few Carolina parakeets survived into the first years of the 20th century, with sightings reported in the Panhandle and the Kissimmee Prairie of north-central Florida (McKinley 1985). The last wild specimen was taken in either 1901 or 1904; the date is still in dispute (Cokinos 2000). A flock of 13 of these birds was seen near Lake Okeechobee, Florida in 1920, and two eminent ornithologists, Alexander Sprunt and Robert Porter Allen, went in search of the last members of the species in 1936. They reported seeing a flock along the Santee River in South Carolina, but the National Audubon Society later dismissed the account (Forshaw 1989). In any case, the area was later destroyed for construction of a power project (Forshaw 1989). No confirmed sightings were made after about 1920, although a black-and-white home movie made in 1937 showed some parakeets in the Okefenokee Swamp of southeastern Georgia that *may* have been of this species (McKinley 1985). Had the Carolina parakeet been accorded legal protection and reserves set aside during the 19th century, this spectacular species would almost certainly still be alive.

A pair of Carolina parakeets kept at the Cincinnati Zoological Gardens—the same zoo that housed Martha, the last passenger pigeon—was the last known members of their species. Sixteen of these parakeets were purchased by this zoo in the 1880s for \$2.50 per bird (Fuller 1987). Over the years, the birds laid eggs, but none hatched or were even incubated, and gradually they died off until only a pair was left—cage-mates for 32 years (Fuller 1987). In the late summer of 1917, the female, Lady Jane, died. Incas, the male, became listless after her death, and in February 1918, he died of grief, the keepers claimed (Fuller 1987).

The old-growth pine and mixed hardwood forests of the Southeast, as well as Cuba, were home to a large and noisy bird that may have disappeared. The ivory-billed woodpecker (*Campephilus principalis*), at 18 to 21 inches long, is the largest woodpecker in the United States or Canada and the second largest in the world. Elegant in appearance, both male and female are predominantly black, with stripes of white feathers on both sides of the neck; the lower half of their wings is white, as is the enormous bill for which the species was named (Short 1982). Their drumming on dead tree trunks once reverberated in the forests as they removed strips of bark a foot or more long to uncover beetle larvae. They also drummed as a territorial signal, trumpeted and made a call that sounded like a child's tin horn. Their vocal repertoire also included a soft call between male and female perched side-by-side while changing places

incubating eggs in their high nest holes (Cokinos 2000). Never heard by scientists observing them in the wild, the ivory-billed woodpeckers uttered an extraordinary screech when captured and transported away from their forest, as described by ornithologist and artist Alexander Wilson early in the 19th century (Cokinos 2000). Wounding an adult male to use as a subject for a painting, he was astonished to hear him utter a loudly reiterated and most piteous note, exactly resembling the violent crying of a young child (Cokinos 2000). The bird continued to scream loudly as he was carried in a container to a town nearby, alarming people who took the noise for that of a child. Wilson rented a room where he planned to paint him, and the frantic bird began drumming on the wall, breaking off huge chunks of plaster, and damaged a mahogany table. Although offered food, the distraught bird refused to eat and died within three days (Cokinos 2000).

The ivory-bill's decline came as a result of heavy logging begun in the 18th century, which destroyed millions of acres of old-growth pine and hardwood bottomland forest in the Southeast. Each pair required a territory of at least 6 square miles of mature forest, and as their forest disappeared, ivory-billed woodpeckers became so rare that few were seen after 1900 (Cokinos 2000). Hunting also made inroads into their populations. These birds made large targets and were so conspicuous and noisy that they attracted the attention of meat and sport hunters in the 19th century. At that time, few people walked in the woods without a gun; most people took shots at any large bird or mammal.

Over-collecting of specimens by museums was another factor in the extinction of the ivory-billed woodpecker. Its size, beauty and natural rarity brought museum collectors from around the world to scour forests in the South for the last specimens of this bird. There are 400 known museum specimens worldwide (Day 1981), and most of these were taken in the last years of the 19th century, when the species had become extremely rare. Nineteenth century museum curators often sent collectors out to obtain specimens of very rare animals after they received word that the species was headed toward extinction. Responsible modern natural history museum curators do not routinely collect rare animals, but reach agreements to allow very limited collection of newly discovered species, usually only by the scientist who made the discovery. Most museums now loan specimens to scientists who wish to examine them.

Dr. Lester Short (1982), an authority on woodpeckers, believes the ivory-billed woodpecker's original habitat was probably the virgin pine forests that once covered much of the Southeast. They had become confined to hardwood swamp forests in Louisiana, which was probably not ideal habitat for them (Short 1982). Upon the discovery of a small number of Ivory-bills in a forest along the Tensas River in Louisiana, Cornell University scientists organized an expedition to film and record these birds. They later designated a young Ph.D. ornithologist, James T. Tanner, to study these last birds in the wild. In his study, *The Ivory-billed Woodpecker*, published in 1942, he estimated that at that time, no more than 22 of these woodpeckers remained in the United States. His investigation centered on the only known population of ivory-billed woodpeckers in the 120 square mile old growth forest. The Cornell team filmed the birds drumming on trees and recorded their various calls. This film is part of Stouffer Productions' *At the Crossroads* film. (See Video section, Endangered Species, General.) These recordings are retained in the Cornell Ornithological Library of bird songs, along with motion pictures of a pair of woodpeckers.

Tanner documented the presence of seven pairs and four young in 1934. He also traveled extensively in the Southeast, where ivory-billed woodpeckers were seen in the past, asking local people for sightings and listening for their unique calls; he was unsuccessful. From 1931 to 1939, the last remaining birds raised 19 young. They declined as he was observing them, however, and by 1939, only six ivory-billed woodpeckers—one pair, one young bird and three males—remained in these woodlands (Cokinos 2000). They had lost the majority of their habitat after the Singer Company sold the logging rights for these 80 thousand acres to Chicago Mills in 1937, and the old growth forest was rapidly leveled. Some of the birds may have been shot for the \$1,000 collectors were willing to pay (Cokinos 2000). In the early 1940s, the National Audubon Society's president appealed directly to President Franklin Roosevelt to spare the ivory-bills' last habitat, and the Secretary of the Interior was ordered to consider the matter (Cokinos 2000). Various federal agencies and the War Production Board agreed these trees could be spared for the war effort. These agencies and four state governors urged Chicago Mills to protect this forest (Cokinos 2000). The State of Louisiana offered the company \$200 thousand as compensation in December 1943, but it refused, and attempts in the US Congress to pass legislation to mandate protection of the Singer woodlands failed as well (Cokinos 2000). This company remained indifferent to the fate of the woodpeckers, red wolves, mountain lions, black bears

and abundant birdlife being destroyed to produce chests to ship tea to the English Army (Cokinos 2000).

Unknown to conservationists and government agencies was the fact that it was already too late. Richard Pough, a National Audubon Society employee, was sent to search for any remaining ivory-billed woodpeckers in the Singer woodlands in December 1943. He saw the last ivory-billed woodpecker, a lone female, and noted in January 1944:

It is sickening to see what a waste a lumber company can make of what was a beautiful forest. Watched them cutting the last stand of the finest sweet gum on Monday. One log was 6 feet in diameter at the butt (Cokinos 2000). This may have been the same female and her fledgling chick seen by Tanner in 1941, the only birds remaining at that time (Cokinos 2000). A wildlife artist, Don Eckelberry, heard of the disastrous situation for this species and traveled to the Singer woodlands to paint this female ivory-billed woodpecker. His observations constitute the last authenticated sightings of the species in the United States (Cokinos 2000).

Many searches have been made throughout its once wide range, which extended from southeastern Oklahoma and Missouri north to Indiana and east through northern Florida. Sightings have been made of these birds over the years in Florida and Mississippi, but none was authenticated by photographs or recordings (Cokinos 2000). The last 20th century observation was made on April Fool's Day, April 1, 1999, by a forestry student along the Louisiana-Mississippi state line, in the Pearl River basin (Cokinos 2000). He claimed to have seen a male and female at close range in a swamp forest (Cokinos 2000). Subsequent searches of this forest by ornithologists and others failed to find any trace of ivory-billed woodpeckers (Cokinos 2000).

There is slim hope that the species might survive either in the United States or in Cuba. These birds were seen in Cuba's southeastern pine forests during the early 1980s, but this population dwindled and disappeared by 1991 in spite of a reserve that had been set aside for it (Collar *et al.* 1994). In 1998, evidence of its possible survival in Cuba consisted of some likely sightings in the Sierra Maestra highlands, where it had never been seen before (BI 2000; Garrido and Kirkconnell 2000). Although unlikely, it would be a truly exciting event if the magnificent ivory-billed woodpecker survived in spite of the almost total loss of its habitat.

Bachman's warbler (*Vermivora bachmanii*), a small yellow songbird of the southeastern United States, has not been seen for decades. John James Audubon painted a pair of these birds without ever having seen them alive. The species was discovered in 1833 by his close friend, John Bachman (Blaugrund and Stebbins 1993). Audubon's painting was based on specimens sent to him by Bachman. He depicted the Bachman's warbler posed stiffly on a Franklinia tree (*Franklinia altamaha*), an equally mysterious species with large white flowers. Discovered in the South in 1765 by the noted botanists William and John Bartram, this beautiful tree was named in honor of Benjamin Franklin (Blaugrund and Stebbins 1993). In spite of thorough searches in the area in Georgia where the tree was found, the Franklinia was never seen in the wild again (Blaugrund and Stebbins 1993). Fortunately, the Bartrams had taken cuttings of the tree for cultivation, and this tree is now grown in botanical gardens and nurseries throughout the world. Bachman's warbler became very rare after 1920.

Originally, these warblers ranged from the lower Mississippi River and east Texas, north to southern Indiana, and along the east coast from Georgia north to southern Maryland (Hamel 1995). The species' original habitat was southern bottomland, hardwood forest with extensive cane (*Arundinaria gigantea*) thickets (Hamel 1995). Clearance of these forests in the 19th century and first decades of the 20th century, both in the United States and in Cuba, where it wintered, eliminated the majority of its habitat. It is not known to what extent it used canebrakes and bamboo thickets growing on bottomlands, but these were the last habitats in which it was seen.

A 19th century observer of Bachman's Warblers, O. Widmann, entered bottomland forests in the Mississippi Alluvial Valley, and wrote in 1897, "I had no trouble in finding several singing males on the day of my arrival. In the wildness of his home it takes several minutes to follow him over fallen trees and around impenetrable thickets or pools of water" (Hamel 1995). Widmann saw its nest "tied very slightly to a vertical blackberry vine of fresh growth. From above, it was entirely hidden by branchlets of latest growth. To reach the place it was necessary to go through pools of water and heaps of fallen trees and brush. Such sheltered places are probably chosen to avoid the

danger of being trampled down by hogs and cattle roving in these woods" (Hamel 1995). This wild region was a mixed habitat of sweetgum, blackgum, tulip trees, mulberry, ashes, cottonwood, hackberry and hardwoods; Bachman's warblers were seen mainly in the higher portions, which were also those first cleared (Hamel 1995).

Approximately 400 scientific specimens were collected for museums, and this may have reduced its population at a time when it was already rare (Hamel 1995). The last nest was found in 1937, and much of this species' life history remains a mystery. Intensive searches have been carried out by biologists for this bird; a total of 7,000 hours were spent between 1975 and 1979 combing likely habitat areas in South Carolina, Missouri and Arkansas. In 8,000 hectares (19,768 acres) of apparently suitable habitat, no Bachman's warblers were seen or heard (Hamel 1995). As recently as 1980, an unconfirmed sighting was reported in Cuba, but the last confirmed sighting of a Bachman's warbler was in 1961 near Charleston, South Carolina (Hamel 1995). An unconfirmed sighting was made in 1988, but none have been seen since (BI 2000).

### **Endless Grassland**

Stretching more than 1,000 miles from Illinois west to the Rocky Mountains, and from southern Canada south to Texas, the North American Prairie seemed endless. In the Midwest, tallgrass prairie interspersed with oak trees dominated, and farther west, in a north-to-south band, was an immense shortgrass prairie. Through its center flowed the Mississippi and Missouri Rivers, their confluence creating one of the world's greatest rivers. Lining the rivers were hardwood forest swamps from the Mississippi Delta at the Gulf of Mexico north to the Missouri River, where river otters, muskrats, beaver, mink and raccoon abounded. A vast mosaic of wetlands, known as "prairie potholes," dotted the northern Plains states and, during the spring, turned into ponds and marshes, making them perfect breeding areas for millions of waterfowl and shorebirds.

An estimated 50 million American bison (*Bison bison*) thundered across the prairie in a spectacle rivaling the migration of today's East African wildebeests, and far exceeding them in number. While the passenger pigeon may have been the most numerous bird in Earth's history, the bison is considered the most numerous large mammal to ever have lived on the planet. Coexisting with these bison were Plains tribes of Native Americans—Pawnee, Blackfoot, Crow, Ojibwa, Sioux, Mandan, Comanche and others.

In 1804, President Thomas Jefferson commissioned Meriwether Lewis and William Clark to travel across the newly acquired Louisiana Territory west to the Pacific to conduct the first natural history survey of the American West. Clark described the prairie near the Missouri River as "rich, covered with grass from 5 to 8 feet high, interspersed with copses of hazel, plums, currents, raspberries and grapes of different kinds" (Peck 1990). Lewis's journal entry records his awe of the landscape: "Nor do I believe that there is in the universe a similar extent of country. As we passed on, it seemed as if those scenes of visionary enchantment would never end."

Throughout their travels they saw "immense herds of buffalo, deer, elk and antelopes," some "so gentle that we pass near them without appearing to excite any alarm among them" (Peck 1990). Wolves and foxes were common, along with animals they had never seen before—pronghorn antelope, jackrabbits, prairie dogs, coyotes, grizzly bears and many beautiful prairie birds (Peck 1990). One of the purposes of their journey was to assess the marketable potential of the wildlife, especially furbearers. Their observations paved the way for the fur trade and slaughter of wildlife that effectively eliminated large mammals from the Great Plains by the end of the century.

A visual record of the original prairie was made by various artists, the most famous of which was George Catlin, whose magnificent portraits of the Native Americans, American bison and landscapes preserve them for posterity. It

was Catlin who proposed this wild land be protected:

*Nature has nowhere presented more beautiful and lovely scenes, than those of the vast prairies of the West; and of man and beast, no nobler specimens than those who inhabit them the Indian and the buffalo joint and original tenants of the soil . . . And what a splendid contemplation too, when one imagines them as they might in future be seen (by some great protecting policy of government) preserved in their pristine beauty and wildlife, in a magnificent park . . . A nation's Park, containing man and beast, in all the wild freshness of their nature's beauty (Peck 1990).*

The world's first national park, Yellowstone National Park, was set aside in 1872, protecting some 2 million acres of mixed grassland and forest and the last wild bison in Montana and Wyoming, but Native Americans were excluded. The huge prairie park, as envisioned by Catlin in the central part of the continent, has not been established. It would have been a biological treasure for future generations. A tallgrass prairie national park was established in the 1990s, and perhaps in the future, a large national park will preserve portions of the once vast shortgrass prairie.

The US government encouraged the slaughter of bison as part of a deliberate campaign to vanquish the Plains tribes by removing their means of subsistence; the slaughter was also a free for all hunting spree by crews working on the transcontinental railroad after 1830 (Allen 1942). Thousands of bison were killed just for their tongues, which were considered a delicacy. The commercialization of the bison sealed its fate. In 1840, the American Fur Company sent 67,000 robes of bison hides to St. Louis, a fur trading center (Allen 1942). In the upper Missouri country, 250 thousand bison were killed annually until the 1870s; during this decade, just as in the case of the passenger pigeon, the slaughters turned the tide for the species (Allen 1942).

With the completion of the railroad, the great herd became split in half, and migrations that once took them from Montana to Texas were ended by a shooting spree lasting until the late 1880s (Allen 1942). In Dec. 1877 and Jan. 1878, the "last great slaughter" took place on the isolated southern herd of Kansas, Oklahoma and Texas; 100 thousand hides were taken by an army of hunters, wiping out this herd (Allen 1942).

Only the protection of two small herds in Yellowstone National Park and Wood Buffalo National Park in Alberta, Canada, totaling about 541 individual bison, prevented the extinction of the species (Allen 1942). Even the 300 bison in Yellowstone were nearly killed off by poachers between 1890 and 1893; 270 animals were shot illegally, leaving only 30 in the park (Hornaday 1913). These few wild bison stayed as far as possible from tourist routes, and by 1912 the herd had grown to 49 (Hornaday 1913). Since then, herds have been re established in several parks in the West. There are now more than 150 thousand bison, but the majority is ranched animals, bred for docility. Even these represent a tiny fraction of their former numbers. Pure strains of American bison can be found only in the herds of Yellowstone and Wood Buffalo National Parks.

Other grassland wildlife was slaughtered for the meat trade. Among the millions of shorebirds that migrated through the Great Plains and bred there was a mousy brown, medium sized bird known as the Eskimo curlew (*Numenius borealis*). These birds were known to many market hunters as "prairie pigeons" or "doughbirds" because of the thick layer of fat the bird added before migration (Ehrlich *et al.* 1992). This bird became the prairie equivalent of the passenger pigeon an ominous comparison that signaled its ultimate fate. Eskimo curlews were once the second most numerous species of wading bird in North America numbering in the hundreds of thousands, possibly in the millions. Their destruction was so rapid that nesting and breeding areas were never fully documented. Only a few nests were found in arctic prairies of northwestern Canada between the Mackenzie and the Coppermine Rivers (Greenway 1967), but no one knew whether this was their prime nesting area. Their breeding behavior, number of eggs and chicks and related information remain undocumented.

Eskimo curlews flew in compact flocks and, when landing to rest and feed, were extremely tame and approachable. They were known to eat berries and Rocky Mountain grasshoppers (*Melanoplus spretus*) in burnt areas of prairie grass (BI 2000). This insect later became extinct, and prairies were plowed into agricultural fields (BI

2000). Eskimo curlews fall migration along the Atlantic coast through Labrador took them 8,000 miles to winter on the pampas of Argentina, southern Brazil and Chile (BI 2000). They were heavily hunted along the way. On one migration in 1872, three men in Cape Cod and Nantucket killed \$300 worth of curlews they sold for 6 cents per bird [5,000 birds] to local meat markets (Hornocker 1913). In the spring, the birds would return through Central America and the Great Plains (Hayman *et al.* 1986). During the spring migration, they again became targets for the hunters. If a flock was shot at, the birds would fly only a short way before landing again, and they often returned to the same spot, resulting in the slaughter of entire flocks (Schreiber *et al.* 1989). The meat market hunters could fire a single shot that would bring down dozens of Eskimo curlews (Peck 1990). This hunting endangered them (Ehrlich *et al.* 1992) and, in spite of a ban on hunting in 1916, no recovery took place (BI 2000).

Their wintering habitat had been plowed as well, beginning in the late 19th century when their pampas in Argentina were used to produce export crops for Russia (Schreiber *et al.* 1989). Their populations plummeted from loss of habitat and unrestricted hunting, and fewer and fewer curlews managed to reach their northern breeding grounds. By the turn of the century, Eskimo curlews had become extremely rare. None has been seen in South America since 1939 (BI 2000). Several birds were shot in Barbados on their southern migration in 1964, and during the 1980s through 1996, various unconfirmed sightings were made (BI 2000). There is little hope that the Eskimo curlew survives.

Dominant among all the prairie predators, the grizzly bear (*Ursus arctos horribilis*) towered more than 10 feet tall when standing upright. Very common on the prairie, these bears ranged over most of western North America, from the Arctic Circle to northern Mexico. They were common in many types of grassland. All the subspecies except *Ursus arctos horribilis* became extinct south of Canada. In spite of its great strength and intelligence, in addition to the difficulty explorers and settlers had in killing it, these great bears were hunted to near extinction. Lacking cover in most of the Great Plains, the bears made large targets as they foraged for their primarily vegetarian diet, and were eliminated here first. Hunters made expeditions to kill these animals, and wrote articles and memoirs of their hunting prowess as they eliminated grizzly bears from one area after another. South of Alaska, only Yellowstone National Park and Glacier National Park harbored grizzly bears by the 1940s (Allen 1942).

Fur trapping intensified in the 19th century, with professional trappers combing the countryside, setting leghold traps and spreading poison to kill the most valuable furbearers such as beaver and river otter. Within a short time, both these animals had disappeared from large parts of the country, including most of the Midwest. The American beaver (*Castor canadensis*) is a keystone species in aquatic environments, creating habitat for otters and other wildlife with their dams. In fact, the range of the river otter in North America nearly coincides with that of the beaver. Trappers killed beavers in their lodges and dynamited dams to scare them into the open until these once common rodents became rare in many parts of the country. Their fur was highly valued and used in the manufacturing of top hats in England and Europe. The relentless trapping wiped these animals out throughout much of the country, and the beaver ponds that once dotted the landscape disappeared, greatly altering ecosystems for the worse. Otter fur was even more valuable because of its durability and waterproof qualities, and these animals, which had never been abundant, disappeared from two-thirds of their original range south of Canada (Nilsson 1985). River otters play an important role in aquatic ecosystems by culling overpopulated fish populations.

Other predators, such as the gray wolf, the kit (*Vulpes macrotis*) and the swift fox (*Vulpes velox*), were nearly eliminated from the United States south of Alaska. Fur trapping was followed by persecution in the form of predator control programs to benefit livestock ranchers. The gray wolves of the prairie were often white or pale gray and were entirely eliminated here (see Persecution and Hunting chapter).

The fleetest animal in North America nearly became extinct. The pronghorn (*Antilocapra americana*), a species found only on this continent, is not a typical antelope, but the last survivor of a family of ungulates long extinct. Once abundant throughout the Great Plains and in the deserts of the Southwest and Mexico, they may have numbered as many as 40 million animals prior to European settlement (Peters and Lovejoy 1990). Pronghorns travel in herds able to "fairly fly over the ground," in the words of Glover Allen (1942), when fleeing predators. Their natural curiosity,

an urge to investigate any unfamiliar object, may have contributed to their near extinction. One hunter told of luring the pronghorns within gunshot by donning a white sheet and approaching them on all fours (Allen 1942). George Catlin painted natives luring them close by waving a feather on a stick.

By the turn of the century, so many pronghorn had been shot by settlers and meat hunters that the species was reduced to endangered status (Allen 1942). William T. Hornaday, director of the New York Zoological Park and a prominent conservationist who had saved the American bison from extinction in the early part of the century, predicted in 1913: "The Prong horned Antelope, unique and wonderful, will be one of the first species of North American big game to become totally extinct. We may see this come to pass within twenty years. They cannot be bred in protection, save in very large fenced ranges. They are delicate, capricious and easily upset. They die . . . at the drop of a hat" (Hornaday 1913). Fortunately, his prediction did not come to pass, and total legal protection of the last pronghorns saved the species from extinction. Yellowstone National Park was crucial to the species' survival, and the bison s as well, by protecting remnant herds. These herds provided the stock from which pronghorns were reintroduced to areas where they had been eliminated (Allen 1942). Today, they are fairly common in the western states of Montana, Wyoming and Colorado and found in smaller numbers in other parts of the West (see Grasslands, Shrublands and Deserts chapter for more on this species).

Another victim of the hunting slaughters of the 19th century was the Badlands bighorn sheep (*Ovis canadensis auduboni*), once numerous in the rugged hill country of the upper Missouri and Little Missouri Rivers in North and South Dakota and parts of Nebraska (Allen 1942). Weighing about 344 pounds, the males had massive curved horns that trophy hunters sought. While they grazed on the prairie near the high buttes, they were ambushed by hunters who cut off their escape. Even President Theodore Roosevelt contributed to their extinction by hunting them in the early 1880s (Allen 1942). The last record of this grayish brown sheep in North Dakota was an old ram killed about 1905, and the dates of extinction of the South Dakota and Nebraska populations are unknown (Allen 1942). Rocky Mountain bighorn sheep, another race of this species, have been reintroduced into the South Dakota Badlands.

Prairie streams and clear flowing rivers provided habitat for several unique species of fish. The harelip sucker (*Lagochila laura*), whose downturned mouth had a large disk with which it fed on the stream bottoms, became extinct in 1893 when grasslands were plowed and streambanks disturbed; the water became turbid and muddy, causing the fish to literally asphyxiate in the silt laden water (Day 1981).

Today, the tallgrass prairies have become wheat and corn fields, crisscrossed by highways, and dotted with towns and cities. More than 90 percent of the original prairies are gone (Peters and Lovejoy 1990). Even in the few areas where native grasses were not plowed under, diversity of grass species has declined from 200 to 30 species in most areas because of heavy livestock grazing (Peck 1990). Tallgrass prairie reserves have been established in Wisconsin, Kansas and Oklahoma. In the latter state, a herd of 300 bison was released in the early 1990s in virgin tallgrass prairie in Oklahoma by The Nature Conservancy after an absence of more than 100 years. Many National Grasslands were established in the range of the shortgrass prairie, primarily for livestock, but after many decades of grazing, rodent and predator control, this land bears little resemblance to the original prairie (see Grasslands, Shrublands and Deserts chapter).

## **Western Landscapes**

In the southwestern United States and northern Mexico, deserts harbor a great wealth of species. The Mojave, Sonoran and Chihuahuan Deserts of the southwest differ from one another in their vegetation, topography and wildlife. All are dotted with deep springs and oases, each having endemic species of fish vestiges from ancient

times when seas covered the land. The Sonoran Desert, most verdant of the three, is studded with giant Saguaro cacti (*Sereus giganteus*), more than 60 feet tall and found nowhere else on Earth, along with many other unique and beautiful desert plants. Deer, pronghorn, bighorn sheep and a variety of predators – from grizzly bears and jaguars to gray wolves and coyotes – lived in this desert, the most botanically rich in the world. Bird life was also prolific, and desert tortoises sheltered in burrows during the day. Mountain ranges jut from the Chihuahuan Desert to the south, and the Mojave of California is characterized by an extremely hot and arid climate, in which many unusual plants and animals manage to survive.

In southeastern Utah and Nevada, pinyon-juniper vegetation once covered thousands of square miles. The US Department of Interior's Bureau of Land Management has converted millions of acres into shrubland for the benefit of cattle. The pinyon pines, whose nuts have been a source of food for native tribes for thousands of years, have been destroyed in large part by chaining, wherein chains are stretched between two bulldozers, which then drag them across the pine-juniper bushes and trees, uprooting them. This ecosystem is home to desert tortoises and a wide variety of birds and small mammals, but today, the diversity and abundance of wildlife has been greatly diminished.

Much of the deserts are federally owned, and management has been primarily to benefit livestock owners and other users. Portions of the Mojave Desert and more than a million acres of spectacular Utah cliffs and desert have recently been made a National Reserve. These areas will not receive strict protection, however, since oil drilling and other activities, such as livestock grazing, will be allowed.

Streaming through the dry Southwest, the mighty Colorado River carved the vast Grand Canyon in Arizona as the land was thrust up and sunk with movements of the Earth over millions of years of geologic time. Some of the oldest rock formations have been dated at more than 1 billion years. These eons are etched in the Canyon's layered slopes. This canyon is one of the great natural wonders of the world, a wilderness of pastel-hued cliffs and beautiful vistas. Plateaus surrounding the canyon are geographically isolated, and many endemic animals inhabit these pine forests. In the Colorado River's turbid waters, a large number of unique fish evolved. The river has been dammed throughout its course, however, to supply water for irrigation, cities and suburban homes, as well as to generate electricity. One-fourth of the Colorado's water is used to irrigate the crops of California's Imperial Valley. The delta of this once immense river was described in 1922 by the conservationist Aldo Leopold as teeming with wildlife. That same year the Colorado River Pact was signed, which gradually removed its flow. Today the delta in northern Mexico is almost dry. The endemic fish and birds of the Colorado River system have been decimated by these projects. Some are being conserved under US Endangered Species Act programs conducted by the Fish and Wildlife Service. The dams that pepper the river turn the once warm and silty water cold and clear, a new habitat that native fish find intolerable.

The Sonoran Desert's unique and beautiful plant life has declined in the decades since 1970 because of unrestricted development for suburban housing; much of it is for retired persons seeking a dry and sunny climate. New houses, roads and commercial centers are gobbling up tens of thousands of acres, and in the process, the venerable giant Saguaro and other desert vegetation are bulldozed. These new communities use enormous amounts of water piped from the Colorado River and several diverted desert rivers. These desert oases turned to dust, eliminating their wildlife and plants. One of the few desert-nesting bald eagle populations became extinct as a result of the Central Arizona Project, which diverted water for agriculture and towns. Most residents in the Southwest have eliminated natural desert vegetation and planted grass lawns in front of their homes, which require almost constant watering and heavy use of chemical fertilizers, pesticides and herbicides – pollutants of the water table.

Merriam's elk (*Cervus canadensis merriami*) was native to various mountain ranges of southern Arizona and New Mexico. The antlers of this elk were the largest of all the elk races, and the animal was described as more pale and reddish than the Rocky Mountain elk (Allen 1942). Vulnerable because of its restricted range, it was hunted by cattle ranchers in the late 1800s, and crowded out by livestock. The last individuals were killed around 1906 in the Chiricahua Mountains of southeastern Arizona, where they had sought refuge in high altitudes (Allen 1942).

Thousands of elk and bighorn sheep died from diseases brought by domestic cattle. Lacking natural resistance,

entire populations died soon after they came into contact with domestic cattle and sheep that carried disease. Native Americans also died by the thousands because of diseases from measles to small pox brought by colonists and settlers. A number of tribes that had inhabited the West for thousands of years became extinct. In some cases, the tribes lost their land and dwindled to extinction.

West of the Rocky Mountains an unbelievably rich and beautiful land awaited settlers. The Sacramento and San Joaquin Rivers flow through the huge Central Valley, an area covering thousands of square miles. Prior to settlement, breathtaking vistas of wildflowers and grasslands grazed by innumerable elk and mule deer were framed by distant snowy mountains. The largest lake west of the Mississippi River, Lake Tulare, covered much of this river valley. Shallow and seasonal, this lake swelled after spring rains to serve as a breeding ground for an estimated 100 million waterfowl. Early naturalists spoke of the birds darkening the sky for days.

Spanish colonists established vast cattle ranches, beginning in the 1600s in what is now California. After Mexico lost this territory at the end of the Mexican War in 1848, American settlers poured into the region and agriculture began on a grand scale. In the late 1800s, California became thickly settled. The grasslands, deer, elk and the distinctive California grizzly bears that roamed California's valleys were eliminated by hunting and habitat destruction. The grizzly bears, still pictured on California's flag, were hunted to extinction (Nowak 1999). The Central Valley soon became California's bread basket, with agriculture displacing the tule elk (*Cervus canadensis nannodes*), whose range once extended throughout the San Joaquin and Sacramento Valleys, half the length of the state. As a result of hunting and loss of its habitat, the small herds of remaining elk became confined to a tule marsh area near Tulare Lake (Allen 1942). Transplants to other areas have not succeeded, and this subspecies remains very rare. Ninety five percent of the wetlands of California's Central Valley and marshes that once dotted the coastline have been filled in for farms and development. Tulare Lake and its millions of ducks disappeared completely from drainage and water pumping, becoming the world's largest artificial farm, irrigated by water piped from elsewhere in the state. The Central Valley Project, an immense system of ditches, canals and pipelines, pumped water from the rivers in the Sierra Nevada Mountains to supply Los Angeles with water, devastating salmon and other wildlife. The Sacramento River once had an estimated 2 million salmon, and a fishery, but today they are nearly extinct as a result of the water diversion and dams.

California has incurred the greatest loss of wetlands of any state. Damming and diking of waterways to divert water for irrigation in the Central Valley resulted in the extinction of a foot long fish once caught for the fish markets of San Francisco. The thicktail chub (*Gila crassicauda*) was very common until the 1880s, but by the 1920s, it had been driven to extinction (Day 1981). San Francisco Bay, the largest wetland and estuary on the West Coast, has been greatly altered by water diversion projects and drainage for agriculture and building. The bay has a great number of endemic species and races of birds and fish, and many of these have disappeared or become extremely rare. Federal protection under the US Endangered Species Act for many of these species may prevent their extinction.

North America's largest bird, the California condor (*Gymnogyps californianus*), soared over coasts and inland valleys as far north as Washington State. This bird came close to extinction as a result of hunting and accidental poisoning (see Persecution and Hunting chapter). The last wild birds were captured for captive breeding, and young birds have been released to the wild. It will be years before it is known whether this giant vulture will survive and breed in the wild. In the foothills of the Sierras grew thousands of immense sequoias (*Sequoia gigantea*), trees that can live for more than 4,000 years. At a height of up to 300 feet tall, these trees attain a girth of 100 feet and support wood weighing 600 tons, making them the most massive and heaviest organisms that have ever lived (Jonas 1993). Sequoias take 3,000 years to attain full growth, sprouting from a seed only a quarter inch long. These trees were logged, reducing them greatly until they received legal protection. Sequoia National Forest was declared a National Monument by President Bill Clinton in 2000 to stop logging of other types of trees in the forest, which was threatening the root systems and survival of these ancient Sequoias. It is now illegal to cut a Sequoia.

In northern California, Oregon and Washington, ancient forests of hemlocks, pines, cedars and coast redwoods (*Sequoia sempervirens*) had grown undisturbed for thousands of years. Redwoods are the tallest trees on Earth,

reaching heights of more than 365 feet and measuring up to 58 feet in circumference (Jonas 1993). These forests once lined 2,000 miles of Pacific coastal region from northern California through British Columbia, ending in southeastern Alaska, covering 70 thousand square miles. Centuries of logging have reduced these forests to only about 5 percent of their former size in the United States, and less than 40 percent in Canada (Middleton 1992). Commercial logging began in the 19th century and has proceeded throughout this century, clear cutting millions of acres of redwoods, Douglas Fir and other evergreens in forests, cutting in a few hours trees that took a thousand or more years to grow. Once cut, these forests need hundreds if not thousands of years to regenerate to their former biological richness. The land where these forests once stood has been converted to other uses, precluding their regrowth. Loggers are still fighting conservationists over the fate of the last five percent of Pacific Northwest old-growth forests and their endangered residents (see Forests chapter). Although the sequoias and coast redwoods have escaped extinction, they are far rarer than they once were, and the redwoods continue to be cut to be made into lawn furniture and decks.

A race of bison native to these forests, the Oregon bison (*Bison bison oregonus*), was distinct in being slightly larger than the Plains bison, with longer and straighter horns (Allen 1942). Once native to southern Idaho, northern Nevada to southeastern Oregon and northeastern California, they died out soon after the arrival of the early explorers. Although the history is unclear, tales from the Native Americans indicate that arms supplied to them by explorers were used to hunt these animals to extinction by the mid 1800s (Allen 1942).

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## Wetland Drainage: Page 2

Thousands of years of drainage, pollution, diversion and overuse of the rivers and wetlands in the Middle East have destroyed once verdant areas such as the site of ancient Babylon in present-day Iraq. The single exception, until recently, was the 6,000-square-mile delta of reeds, lagoons and marsh south of the confluence of the Tigris and Euphrates Rivers on the Persian Gulf in Iraq. This wilderness maze was inhabited by the reed homes of the Shiite marsh Arabs (Hedges 1993). They fished from small boats woven from marsh plants, a lifestyle unchanged for thousands of years (Dugan 1993). After the 1989 Persian Gulf War, Iraq's President Saddam Hussein ordered that the swamps be drained to vanquish the Shiites, who had opposed his government (Hedges 1993, Lewis 1993). The Iraqi portion of these marshes has also been polluted by oil spillage from the war. Within a few years, approximately 90 percent of these ancient wetlands were drained and soon dried out in the desert sun. Observers flying in small aircraft have documented that these wetlands now resemble dusty fields.

The best known animal resident of Iraq's marshes may be Maxwell's otter (*Lutra perspicillata maxwellii*), named for the charming otter who inspired the story *Ring of Bright Water*, by Gavin Maxwell (1961). This male otter had been captured in these marshes and brought by the author to the British Isles after many misadventures in trains and hotel rooms. When examined by zoologists, he was determined to be an endemic and distinct race of the smooth-coated otter. The fate of Maxwell's otters may not be learned for many years to come. Other victims of the destruction of Mesopotamian marshes may be the birdlife: several million waterfowl wintered in the wetland (BI 1993). Endangered and rare birds that winter here include the dalmatian pelican, pygmy cormorant (*Phalacrocorax*

*pygmaeus*), marbled teal (*Marmaronetta angustirostris*), white-tailed eagle (*Haliaeetus albicilla*), imperial eagle (*Aquila heliaca*) and slender-billed curlew (*Numenius tenuirostris*), according to BirdLife International (1993). Two endemic breeding birds are also at great risk. The Iraq babbler (*Turdoides altiostis*) and the Basra reed warbler (*Acrocephalus griseldis*) are restricted to these marshes in southeastern Iraq and adjoining southwestern Iran. The latter bird is listed as near-threatened in *Threatened Birds of the World* (BI 2000). Although no status surveys have been made in the breeding range of the Basra reed warbler, the number of these birds seen in wintering habitat in Kenya has declined in recent years (BI 2000). A small portion of these marshes remains in adjoining Iran, but it cannot support a fraction of the wildlife that inhabited the Iraqi marshlands.

The worst oil spill in history took place in the Persian Gulf as Iraqi President Saddam Hussein, enraged at losing the war with Kuwait, opened and set afire that country's oil wells to spill 500 million gallons of oil into the delicate Gulf (Earle 1995). This represented 45 times the amount released by the *Exxon Valdez*. It added to the 250,000 barrels of oil released into the Persian Gulf every year for the past decade. The 1991 spill killed cormorants and other sea birds, sea turtles and dugongs. The fires belched toxic chemicals into the air and water in thick black clouds that darkened the sky at noon. Every plant and animal within many miles became coated with black soot. Marine scientist Sylvia Earle witnessed a bird in the midst of this hellish landscape as it swooped into a pool of oil, lured by a struggling dragonfly. "The bird barely moved, succumbing at once to shock, the slimy embrace gluing feathers, clogging nostrils, searing bright eyes, snuffing life" (Earle 1995). The 400-mile coastline of Kuwait, an expanse of marshes and mangroves, became covered in thick black oil, leaving only a few areas of untouched beaches protected by a causeway (Earle 1995). Tens of thousands of migrating shorebirds died in this oil along with a host of invertebrates and fish, and since much of the oil sank and attached itself to sand and mud, the oil killed for many years (Earle 1995). The most common coral in the Persian Gulf, staghorn, released eggs that were killed by the oil, and most of the adult coral in the region of the spill died or bleached (Earle 1995).

### Geography-Draft

1600 to present					
Islands	Number of Species Extinct				
	Birds	Mammals	Reptiles	Amphibians	Total
Atlantic Islands					
Ascension I.	1				1
Canary Is.	1		1		2
Cape Verde Is.			1		1
Falkland Islands		1			1
Gull Island (Off NY, USA)		1			1
Iceland, Funt I. (Canada)	1				1
St. Helena	7				7
<b>Subtotals</b>	10	2	2		14
Caribbean					
Barbuda		2			2
Barbados		1			1
Bahamas	1				1

Caribbean region	2	1			3
Cayman Is.	1	1			2
Cuba	1	7			8
Guadeloupe	2		1		3
Hispaniola (Haiti & Dominican Republic)	1	15			16
Jamaica	4	2	2		8
Martinique	1	2	3		6
Navassa I.			1		1
Puerto Rico		6			6
St Croix (Virgin Is.)			1		1
St Lucia		2	1		3
St Vincent		1			1
<b>Subtotals</b>	13	40	9		62
Indian Ocean Islands					
Amsterdam Island	1				1
Christmas Island		3			3
Madagascar	2	1			3
Mascarene Is.	31	1	13		45
Seychelles	2		1		3
<b>Subtotals</b>	36	5	14		55
Mediterranean					
Sardinia		1			1
<b>Subtotal</b>		1			1
Pacific Islands					
Auckland I.	1				1
Bering I. region	1	1			2
Bonin Is.	3	1			4
Caroline Is.	3				3
Chatham Is.	5				5
Fiji Is.					1
Galapagos Is.		7	1		7
Guadalupe I.	2				2
Guam	1	1			2
Hawaiian Is.	21				21
Lord Howe & Norfolk Is.	6				6
Kangaroo I. (Australia)	1				1

Marquesas	1				1
New Caledonia	4				4
New Zealand	14	1	1		16
Okinawa		1			1
Pacific region	1				1
Palau		1			1
Philippines		3			3
Ryukyu Is.	1				1
Samoan Is.	1				1
Santa Cruz Is.		1			1
Society Is.	7				7
Solomon Is.	1				1
Tonga Is.	1				1
Vanuatu	1				1
Wake I.	1				1
<b>Subtotal</b>	77	17	2		96
Asia					
Indonesia	1				1
<b>Subtotal</b>	1				1
<b>Island Totals</b>	137	65	27		229
<b>Mainlands</b>					
Africa		5	1		6
Asia	2	1			3
Australia	2	22			24
Europe & Near East		2		1	3
Mexico & Central America	3	4		4	11
North America	3	1		1	5
South America	10				10
<b>Mainland Totals</b>	20	35	1	6	62

Source: Table of Extinct Species in the Appendix of this book. Sources of information are listed with the table.

Note: See the Appendix for the list of these species in chronological order, and the references that describe these animals and their extinctions, as well as those that include illustrations of the extinct species.

The following account chronicles some of the many extinctions and destructions of natural ecosystems that have taken place in North America over the past few hundred years. Great biological treasures have been stolen from future generations, and the processes by which they were lost are typical of those occurring elsewhere in the world. The sudden loss of the most abundant and prominent wildlife species of the continent created a profound shock in the

public early in the century that set the stage for today's conservation and humane programs. This concern may turn the tide for species that could suffer the fate of the passenger pigeon (*Ectopistes migratorius*) and others, but unless public opinion is better translated into public policy regarding the land and wildlife, further losses will occur and the lessons that might have been learned will be ignored. A strong and pragmatic commitment to preserve what remains of the natural world on the continent, based on a realization that our fate is linked to nature's fate, is essential to prevent further extinctions.