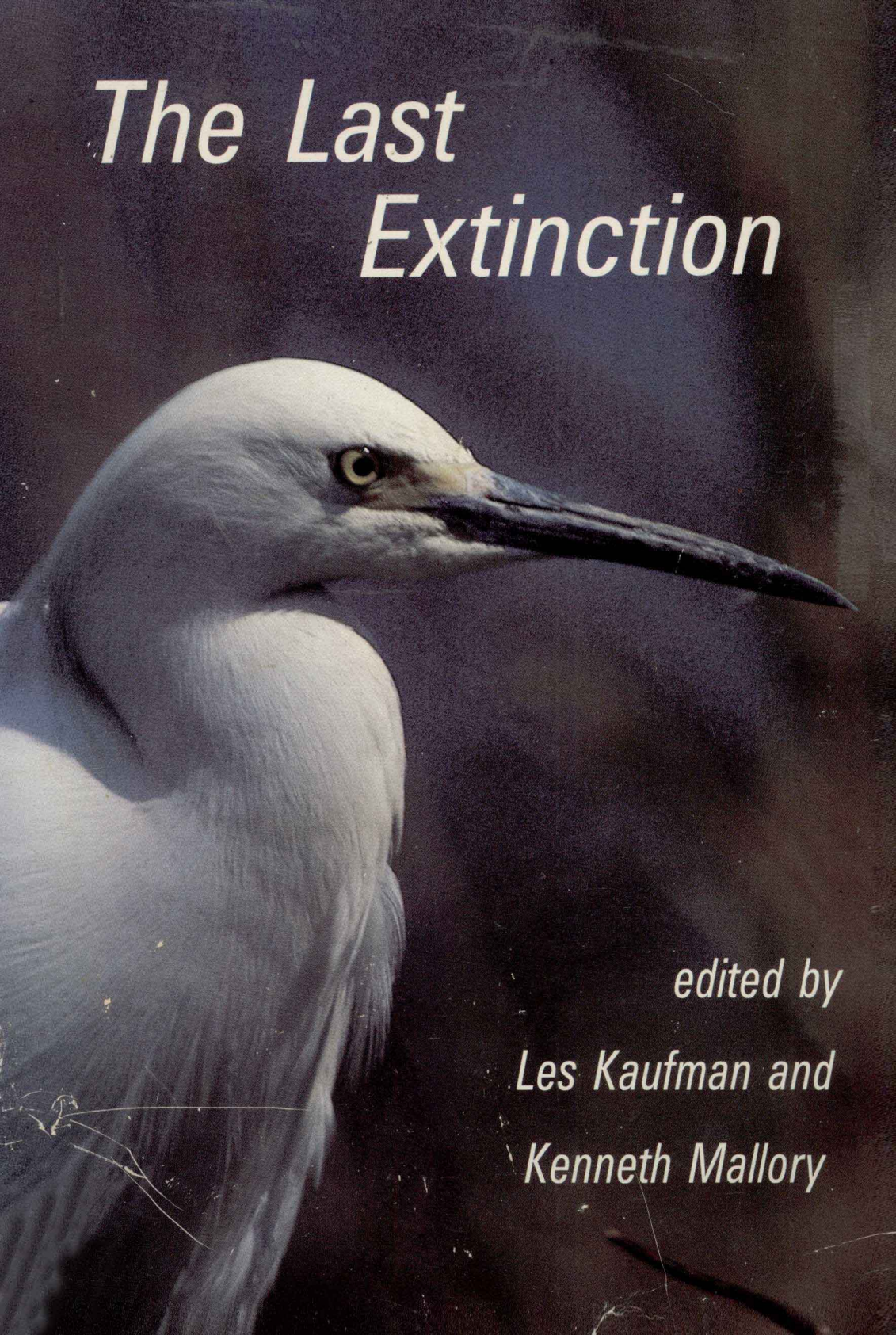
The Last Extinction



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Published in cooperation with the New England Aquarium

The MIT Press
Cambridge, Massachusetts
London, England

Second printing, 1987

This book was set in Baskerville by Achorn Graphic Services and printed and bound by Halliday Lithograph in the United States of America.

Library of Congress Cataloging in Publication Data

The Last extinction.

Based on a public lecture series, "Extinction: saving the sinking ark," held in Boston at the New England Aquarium during fall 1984.
Includes bibliographies and index.
Contents: Why the ark is sinking / Les Kaufman—Mass extinctions / David Jablonski—The Amazon : paradise lost? / Ghillean T. Prance—[etc.]
1. Nature conservation. 2. Wildlife conservation. 3. Extinction (Biology) I. Kaufman, Les. II. Mallory, Ken. III. New England Aquarium Corporation.
QH75.L36 1986 333.95 86-7347
ISBN 0-262-11115-2

Preface

This book grew out of a public lecture series entitled "Extinction: Saving the Sinking Ark," held in Boston, Massachusetts, at the New England Aquarium during the fall of 1984. Our hope for the series and for this book is to awaken the general public to the issues underlying the notion that we must prevent a "last extinction." Beyond ringing an alarm, we hope that you will realize that a mass extinction is in progress but that it can be postponed indefinitely; that doing so will require a rearrangement of your priorities; and that your decisions will affect the face of this Earth, including the economic and spiritual welfare of your children. This book is to help you make your own decisions now.

Many people know that we are rapidly losing the diversity of life on Earth, but they are not doing anything about it, either because the idea is only an abstraction or because they think that the problem is too vast for individuals to have any effect. For these people we offer a bit of bumper-sticker wisdom, revealed to us in a traffic jam: "Think Global, Act Local." This book is an attempt to bring extinction down to earth, to help you understand what it is, and what it isn't, so you can help to reverse it.

There are several new books about extinction with more on the way, but this one differs from those of our colleagues. As employees of a major public aquarium that hosts about one million visitors a year, we have heard some pretty strange interpretations of what evolution and extinction are about. We are hoping to clarify a few of these misconceptions. We have noticed a polarity in the way that our visitors perceive scientists: Some think of them as all-knowing gods, whereas others think they are a bunch of wafflers. For these people we have tried to make clear distinctions between the certainties and uncertainties of mass extinction, illuminating the uncertainties as much as possible. Other books emphasize the importance of tropical deforestation in the loss of species. This is justifiable, but most tem-

perate zone inhabitants do not understand what jungles have to do with their lives. We have brought the issues home to everybody by reviewing case studies from both the temperate zone and the tropics and from both aquatic and terrestrial habitats. Finally, we have tried to present our case without becoming too strident. We may not have tried hard enough. The authors and editors of this book are too intimately familiar with the details of mass extinction not to feel great anger and sadness over them, and sometimes these feelings show through. We hope that our words will find as receptive an audience in print as they did in the lecture hall and that the book will be something more than a catharsis.

The first two chapters of the book deal with the nature of mass extinctions and the role of people in causing this one. Les Kaufman, a marine ecologist, examines philosophical, scientific, and practical stumbling blocks to the conservation of biological diversity. David Jablonski, a paleontologist, explores the nature of extinction in the fossil record. Jablonski supports a view held by many scientists that we are presently experiencing a mass extinction, a major and catastrophic event in earth history with serious consequences for the quality, and perhaps even the continuance, of human life.

The next two chapters are case studies. Ghillean Prance, a tropical botanist, describes the situation in the Amazon rain forest, a rich tropical community sprawled across several developing nations. In comparison, Jim Williams and Ronald Nowak of the United States Office of Endangered Species assess the state of affairs in North America, whose familiar temperate communities are host to an overdeveloped world superpower. Both chapters emphasize the need to conserve habitats to safeguard the species dependent on them.

In the final chapters, two realists grapple with the future. Thomas Foose, Conservation Coordinator for the American Association of Zoological Parks and Aquariums (AAZPA), is among the principal architects of a global zoo ark known as the Species Survival Plan. Foose explores the limits of this last-ditch effort at captive preservation of species left homeless by habitat destruction in the hopes of reestablishing them in the wild once their habitats have been restored. In the closing paper, David Ehrenfeld, a biologist and conservationist, takes a long view of the kind of world we might be living in if we do, or do not, make our best efforts at preserving life's diversity.

At a glance, this book appears to have been assembled by two people. Somebody had to write it, though, and we are indebted to our five contributing authors for providing us with both a lecture and a book. The contributors themselves were brought to us by John Lowell and

the Lowell Foundation, which has provided us with generous support for two major public lecture series per year, as well as special programs for the ill and the handicapped. Mr. Lowell, in turn, was brought to us by the New England Aquarium, which sponsored the lecture series and supported our efforts to publish it. This book is a cornerstone in the Aquarium's new program in aquatic conservation. We owe special thanks to David Ehrenfeld, who helped greatly in editing several of the manuscripts; to the Cousteau Society, especially Susan Richards and Jean-Michel Cousteau, and to Loren and Sue McIntyre, for their help with the photographs that illustrate this book. Finally, we are grateful to our wives, Jackie Liederman and Margaret Thompson, who lent much to the initial conception of this book and who by now must feel as if they have lived through several successive extinctions of their mates.

Les Kaufman
Kenneth Mallory
July 4, 1985
Franconia Notch, New Hampshire

The Last Extinction

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Why the Ark Is Sinking

Les Kaufman

Human beings are the most adaptable creatures that have ever lived on Earth. Reason and insight, the chief human talents, have given us the power to forge a world increasingly fit for our own comfort. We feed voraciously on all other manner of life, from whale to lily. We have no significant predators save a diminishing roster of infectious diseases. Of course, there is also the odd shark, crocodile, or lion, but they are disappearing even faster than the diseases. We carve the planet's surface into fields and streets, shopping malls and parking lots, with little regard to what was there before, because what we replace it with offers a more immediate, short-term benefit. Never before in Earth's history has such an abundant, aggressive, industrious omnivore at the peak of the energy pyramid comprised such a large portion of the living biomass. The prognosis is clear for the five to ten million other kinds of living things that share the Earth. They are in big trouble.

The world is host to two hundred nations and what amounts to five billion rulers. The strain of catering to so many separate interests is manifest in the flow of political, economic, and social crises. All living things are affected by these crises, but humanity as a species has thus far survived them and prospered. The bounds of human habitability include nearly the whole globe, whereas the entire liveable universe of other species can vanish overnight as one river is dammed or one hillside is laid bare. As we eliminate each species that stands in our way today, we lose any hope of having it back tomorrow. Life on the planet advances irreversibly, like a ratchet, toward greater impoverishment.

The ratchet clicks faster each day. Between the years 1600 and 1900, species of mammals and birds vanished at the rate of approximately one every four years. During the twentieth century, mammals and birds have disappeared at the average rate of about one species per year. The fossil record is too poor to provide an accurate estimate

of historical extinction rates for other organisms that do not preserve as well as vertebrates, but scientists can make a reasonable guess. In 1974 the extinction rate for all species was estimated to be approximately 100 per year.[1] Because mammals and birds combined comprise less than half of one percent of all living species, this estimate is probably conservative. Norman Myers projected that by the end of this century, species will be vanishing at the rate of 100 per day, due largely to the destruction of tropical rain forests.[2] On a human time scale, these rates may seem slow. On a geological time scale, however, the wheel is spinning at a blurring rate, and the disappearance of species amounts to a virtually instantaneous mass extinction.

The enormous variety of life is regarded by many as a sort of sideshow: fascinating, but dispensable, should it stand as an obstacle to human interests. This shortsighted view is finally beginning to exact its toll. Animals and plants that have been of great value to humans are disappearing forever. A piece of America's soul died along with the passenger pigeon, plains buffalo, and American chestnut. We are now quickly losing the whales, elephants, tigers, lions, bears, apes, and rhinoceroses. Imagine a world in which our own children no longer know the fantastic wealth of creatures we associate with the word "zoo." Imagine summertime with fewer birds than during the winter. The brilliant orioles, tanagers, warblers, and wading birds will be gone because their tropical wintering grounds will no longer exist. But the extinction of any one species is of only passing significance to human society. It is the longer-term cumulative effects that should have people worried.

The long-term effects of mass extinction on human society fall along four basic lines: moral, aesthetic, economic, and ecological.[3] In each of these can be found strong arguments for arresting activities that cause extinctions, but in each case the long-term benefits of species conservation must be weighed against extremely tempting short-term gains.

One consequence of perpetrating a mass extinction is that at least some of us are going to have trouble with our consciences. In human terms, other forms of life have a right to exist, and thus to extinguish them is akin to genocide. Although morals have hardly eliminated regular attempts at human genocide, by a strange twist of fate moral persuasion has often worked against practices that threaten critical habitats and charismatic species, such as songbirds and whales. But the bans on whaling and DDT resulted from conflicts between wildlife and profits. When the conflict is between wildlife and human life, the difference between right and wrong is no longer so clear. Indonesian

farmers have been moved en masse into the rain forest as part of a national resettlement plan to ease population pressure. As a result they have been repeatedly harrassed by displaced elephants who stomp on the settlers' crops and sit on their houses.[4] Despite valiant attempts to relocate the elephants, there is little assurance that there will always be room in Southeast Asia for both its people and its magnificent wildlife, of which elephants, tigers, and rhinoceroses are only the most conspicuous elements.

A second consequence of mass extinction is that our children might hate us for the world we took away from them. Natural diversity is critical to us aesthetically, helping to satisfy an important human need for sensory and intellectual stimulation. E. O. Wilson calls this hunger for other life biophilia, a basic part of the human psyche.[5] The diversity of life is also the master key to the science of life—as we extinguish species, we snuff out countless lines of fruitful inquiry. But if diversity is a basic need, many people are out of touch with it. Squalid, dirty, lifeless cities make it difficult for us to feel closeness to nature. We do not foster the sense that biological diversity is a thing of value. And yet, it is in this environment that most of humanity may be finding itself in the future. In the noisy cities the aesthetic arguments for saving species fall on deaf ears.

The extinction will have economic impacts of fantastic proportions but of a sort that only a broker in futures can appreciate. This is most apparent in tropical rain forests. The sustainable yield from a rain forest through lumbering or shifting agriculture is low, so tropical industries have tended toward a "get in, get out" modus operandi. Although a few interests have gotten rich this way, new technologies have made this way of doing business increasingly stupid and wasteful. The major commodity in the world's rain forests lies dormant and largely unrecognized: It is information. Sequestered in the countless plants and insects of the forest is a vast chemical arsenal. To the organisms these chemicals are defensive and offensive weapons, but to people they offer medicines and chemical conveniences of great potential.[6] The importance of this chemical warehouse lies not only in the substances themselves but also in the fact that for each there already exists a genetically coded blueprint. It is such a blueprint, extracted and placed in bacteria or yeast cells, that can allow us to produce huge quantities of any desired substance. The genes of rain forest organisms also contain the secrets needed to create animals and crop plants that can live effectively under moist tropical conditions. Just as the synthetic chemical industry has made oil too precious a resource to lavish on Sunday drivers, so has biotechnology made nat-

ural diversity too valuable to let it be wasted on narrow-minded, one-shot business ventures. This is one resource that can be protected only by keeping it absolutely intact.

The fourth argument for preserving biological diversity is the simplest: Our lives depend on it. We are part of a common fabric of life. Our survival is dependent on the integrity of this fabric, for the loss of a few critical threads could lead to a quick unraveling of the whole. We know that there have been previous mass extinctions, through which some life survived. As for our own chances of surviving this mass extinction, there can be no promises. If the Grim Reaper plays any favorites at all, then it would seem to be a special fondness for striking down dominant organisms in their prime. David Jablonski examines the fates of rudist clams, mammallike reptiles, dinosaurs, and a host of other scintillating but doomed creatures in his essay. Humans are now the dominant creatures, at least in terms of their influence. So, lest history bear false witness and barring some serious conservation efforts on our part, this mass extinction could well be the last one that we will ever know about.

What Is It That We Are Trying to Save?

There is now a large community of people from all parts of the world who share a common interest in the preservation of biological diversity. Although kindred in spirit, they do not all share the same assumptions about what they should be doing. Three major stumbling blocks are (1) differing views of what biological diversity and its preservation actually mean, (2) differing thoughts on the seriousness of the threats facing biological diversity, and (3) differing notions as to reasonable goals for the future. People are certainly entitled to different opinions, and society can benefit from a diversity of views as well as a diversity of species. Still, much confusion arises from problems that have more to do with lack of knowledge than lack of philosophical agreement.

In the conservation literature, preservation of biological diversity is sometimes assumed to be synonymous with the preservation of species. Unfortunately, the meaning of the word "species" is not always clear. Biologists use it in two senses. The first, the taxonomic species, is the name by which people call a particular form of life. In the second sense of the word, the taxonomic notion has been modified by an appreciation of evolution. Evolutionary relationships can lead to species groupings that are quite different from those suggested by superficial similarities or differences among taxa. Fur-

thermore, a single species can be composed of several visibly different populations. So, although humans generally prefer things neat and clean, evolution is a bit of a mess. The second species concept has made a good deal of trouble for the first one.

The naming business, or taxonomy, is a human invention designed to help people cope with a world of bewildering complexity. Taxonomists group like forms according to their similarities and differences and then pronounce individuals that share a great many characteristics to be members of the same species. Similar species are grouped into a common genus; similar genera into families; similar families into orders, then classes, phyla, and kingdoms in an expanding hierarchy. Without taxonomic distinctions the multifariousness of life could not be appreciated or communicated, or even bought and sold.

Unlike taxonomy, the evolution of species is a natural phenomenon and not a human filing device. Toward the end of the last century, after scientists had already named and cataloged a great many living forms, Charles Darwin and Alfred Wallace began to wonder if there might be a natural mechanism that could account for the diversity of species. One telling observation was that the members of a species all bear close resemblance to each other because they breed among themselves and are unable or unwilling to breed with other dissimilar organisms. A natural species was thus a group of like individuals that maintained their genetic integrity through a series of reproductive isolating mechanisms. Darwin and Wallace realized that this genetic homeostasis is what makes it possible for a species to preserve advantageous traits that develop through natural selection. Thus natural selection both creates and maintains life's diversity.

In order for similar species to coexist without losing their integrity, they must have effective reproductive isolating mechanisms. Species-specific marks and behaviors, such as ritual mating dances, play important roles in ensuring that species find members of their own kind for procreation. This distinctness is maintained, however, only so long as it is favored by natural selection. If a hybrid is accidentally produced, it will usually be a misfit and less well adjusted to its world than purebred members of either parent species. Thus the occasional hybrid individual will generally die or fail to reproduce, and the parent species will maintain their differences. If selection against hybrids is relaxed, the species will mingle, and after a while they can lose their distinctness.

Darwin appreciated that one kind of species can give rise to another, or many others, but he never did quite fathom how this hap-

pens. Years later, with the advent of genetics, people finally began to understand how species begat species, and with this breakthrough taxonomy begat the new science of evolutionary systematics. Scientists continued their business of naming newly recognized species, but now they faced the more challenging business of inferring evolutionary relationships. They also began to realize, to their chagrin, that because evolution is an ongoing process, species in nature are simply not as clear-cut as taxonomists would like to have them. This can make conservation of species difficult, for within each species there can be many distinct varieties.

Obviously, different-looking creatures encountered side by side in nature are not necessarily different species. Caterpillars and moths represent different life stages of the same species. A towering cedar and a forest of miniature bonsai nurtured from its cuttings represent not only the same species but also identical genetic material cultured under different conditions. Many butterflies come in a range of genetically distinct varieties, suited to different times of year or ways of life, but all are part of one species. In addition to wild varieties of a species shaped by natural selection, there can be thousands of genetic varieties created and maintained through artificial selection. So, in its broadest context, conservation of biological diversity means safeguarding both species and varieties within species. To an agricultural scientist or a farmer, the preservation of the many varieties of any one crop plant is at least as important as the conservation of wild species.

Some lineages have many species that are virtually indistinguishable to us, and yet they are clearly able to tell each other apart. Other lineages are composed of relatively few species, but these differ greatly from one another in their appearance. Oak trees offer the worst of all possible worlds. They look very different to us yet hybridize freely. The hybrids survive and even abound in environments that do not clearly favor one or the other parent species.

As a college student I made part of my living as a plant geographer, identifying species of oak trees at 40 to 60 miles an hour while driving along the highways and backroads of Maryland. During this assignment we realized that a large percentage of the trees could not be assigned to species. Dry-country oaks lived on the tops of hills and wetlands oaks in the bottoms, but between the two, where most of the roads happened to be, were many apparent hybrids. Gray's *Manual of Botany* lists seventy-four "kinds" of oak trees (*Quercus*) in eastern North America: twenty-seven species and forty-seven hybrids.[7] For botanists it sometimes seems easier to reject the whole notion of species than to go about forcing odd leaves and twigs into ill-fitting

pigeonholes. Verne Grant, who has contributed a great deal to our present understanding of plant evolution, has described in detail the myriad ways in which plants fail to conform to a traditional species concept.[8]

Such irreverence for evolutionary theory is not limited to plants.[9] The penguin's formal attire disguises a great contempt for taxonomists. Several penguin lineages have spread to disparate areas and developed distinct local populations.[10] Nobody seems to be able to decide whether they should be called species. Believe it or not, such a thing can really matter. Recently, the New England Aquarium began to assemble a colony of rockhopper penguins, *Eudyptes chrysocome* (figure 1). Rockhoppers are the most widely distributed of all penguins, and as things turned out we wound up getting specimens from two different localities. Our first batch came from an island off South Africa, while the next batch came from the Falklands, near South America. After spending awhile with our South African guests, the first glimpse of the South American penguins inspired a feeling of mild culture shock—they clearly were not the same birds as the ones we had been coddling for several weeks. They looked, acted, and sounded different and, as time wore on, proved to have rather different temperaments. All penguins have somewhat bad temperaments—it is part of what makes them so endearing to humans—but our second batch was just a bit worse than usual. Were they indeed the same species?

Reference to the literature on crested penguins reveals that the rockhopper is, taxonomically, a quiet corner of an otherwise noisy battlefield. Penguinologists have yet to agree on how many other species of crested penguins there are besides the rockhopper—responsible estimates range from two to five. There is even less agreement on the total number of penguin species in the world: There may be from eleven to eighteen.[11] Most estimates average between sixteen and eighteen, but a rabid "splitter" could bring the total to twenty by raising two well-differentiated subspecies (southern gentoo, southern little blue) to full species status. Given one zealous afficionado and a pair of calipers, the rockhopper itself might awake one morning as at least two species.[12] Although penguins themselves express little concern for how many species they might comprise, the existence of each of these forms is of value and interest to biologists. The expert eye can distinguish at least twenty-one living forms, and, species or no, the extinction of any of these would eliminate one more chapter in a fascinating history.

Scientific curiousity is hardly the sole justification for trying to pre-

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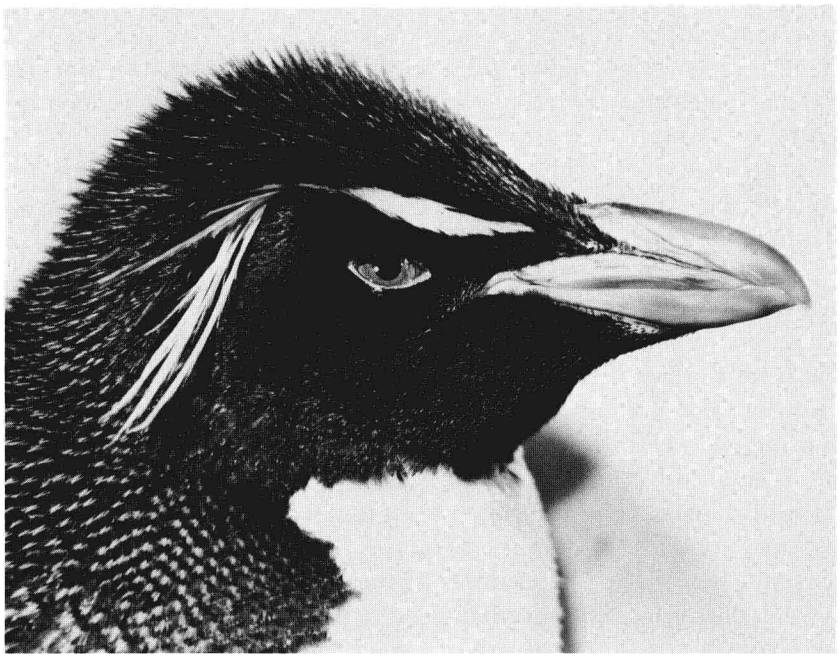

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Figure 1
Two rockhopper subspecies. (*a*) From subantarctic islands near South Africa. (*b*) From South America. Photographs by Les Kaufman.

serve all distinct forms of life, whether they are species or not. First, our notion of what a species is, or isn't, is largely an artifact of human bias. It is difficult to prove that an organism is a member of a distinct species, even though it looks and acts different from anything else around. Preserving it is the safe thing to do. Second, much of life's diversity is below the species level, especially our priceless store of livestock strains and fruit, vegetable, and grain cultivars. We obviously do not want to lose these, but we forget that natural subspecific variation also represents a library of special characteristics that could someday prove useful.

There is another purely strategic rationale for promoting conservation below the species level. Widely distributed species are often a composite of several geographically isolated populations, each a bit different from the others in appearance and behavior. In the game of environmental chess, an odd little pawn of a population can hold the key to a major victory. Because of the importance of the Endangered Species Act and similar laws in other countries, the future of an entire habitat and all the species in it can depend on the existence of one organism eligible for legal protection. Many a small, embattled wilderness has been saved by the discovery of one or two species of local concern. The eastern populations of seaside alder, *Alnus maritima,* have figured prominently in efforts to preserve the gorgeous tidelands of Maryland and Delaware. (Elsewhere this species is restricted to the Red River of Oklahoma.)[13] Most herpetologists do not regard the Plymouth red-bellied turtle, *Pseudemys rubriventris bangsi* (figure 2) as fully distinct from its common Mid-Atlantic cousins.[14] Yet because it is one of the few New England animals now on the United States list of endangered species, it is a local celebrity and the focus of a rehabilitation program likely to save both the turtle and a chunk of the Massachusetts pine barrens.

Regional variants and locally endangered populations are more than levers for protecting habitats; along with green strips and public victory gardens they are keys to the amelioration of urban people's sense of isolation from the natural world. All people yearn to be special, or a part of something that is special. This need is a source of human potential still untapped by conservationists. Everybody has heard of the Siberian tiger, but only recently has the Willow Pond stickleback become an object of pride for the people of Jamaica Plain, Boston. These dimunitive golden fish are an unusual local population of one of the most widespread vertebrates in the Northern Hemisphere, the common three-spined stickleback, *Gasterosteus aculeatus.* The Willow Pond stickleback is of some interest to educators and