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Final Issue

The Last Good Buy

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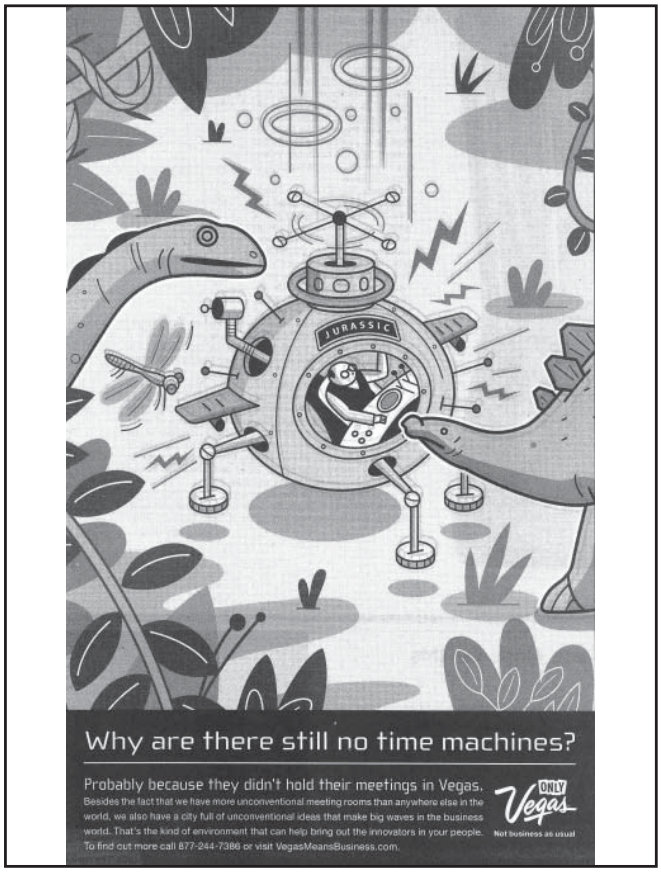
The Last Good Buy: Birds in the New Age of Extinction

By Constance M. Soja

The oldest fossils belonging to the undisputed bird *Archaeopteryx* date back 140-150 million years to the Mesozoic. During that geologic era, dinosaurs dominated terrestrial ecosystems around the globe. Pterosaurs – dinosaurs' evolutionary cousins, the flying reptiles – soared overhead, and an astounding variety of diminutive to gigantic aquatic reptiles – ichthyosaurs, plesiosaurs, pliosaurs, and mosasaurs – cruised the world's oceans. Consuming squid-like belemnoid and ammonoid prey, those top predators also swam in the shallow seaways that flooded the interior of North America and other continents. Within 80 million years, the Cretaceous-Tertiary mass extinction that brought the Mesozoic to a dramatic close had claimed all members of those great lineages (with the exception of birds) and 75% of Earth's species. Why birds, the descendants of small, meat-eating dinosaurs, survived the asteroid's collision with Earth 65 million years ago – or were able to fly in the face of the severe climate change induced by intense volcanism – is an enduring mystery.

In the wake of the other dinosaurs' demise, birds and other survivors of the end-Mesozoic biodiversity crisis experienced extraordinary evolutionary radiations. Co-adapting to the brave new world, they filled vacated ecologic niches and evolved into the iconic species that define the Cenozoic – our modern world and Earth's current great geologic era. With most animal and plant groups of the Mesozoic laid to rest, new species rose to dominance, and new competitive relationships were established. Oversized, flightless "terror birds" – *T. rex* ultimate but down-sized body doubles – were pitted against fox- and pony-sized mammals, which in the previous 150 million years had been small, nocturnal, rat-like animals eeking out a subsidiary existence. Ancient fish, including sharks, competed for the first time with predatory aquatic mammals, including the newly evolved ancestors of modern whales and dolphins.

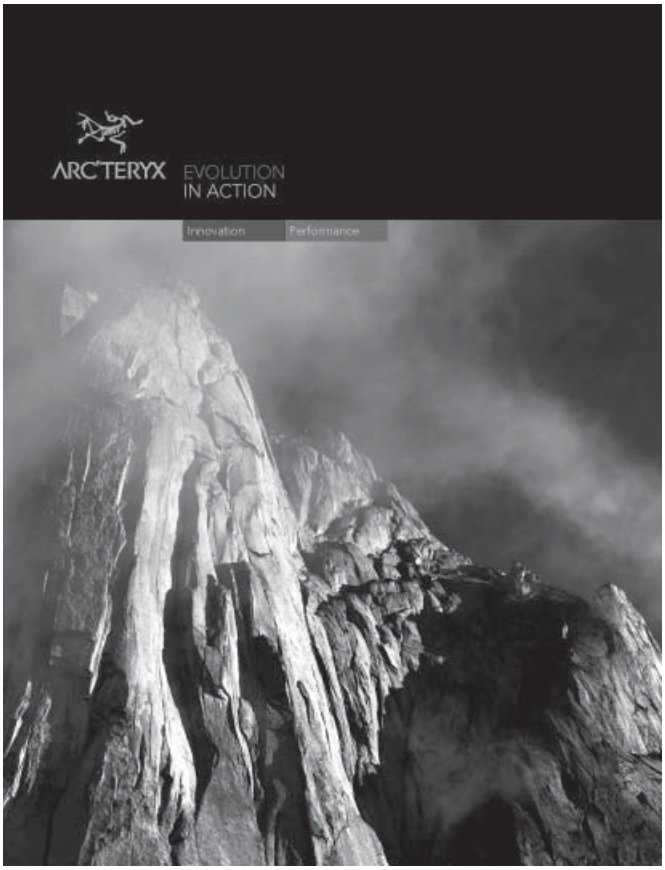
Co-operation produced innovative, mutually beneficial partnerships, especially between animals and plants. As "late bloomers" of the Cretaceous, flowering plants were the last of three great vascular plant groups to come into existence. Once re-established after the end-Mesozoic mass extinction,



Las Vegas Convention and Visitors Authority

Dinosaurs first appear as fossils in Triassic rocks 230 million years old. Geologic evidence shows that dinosaurs quickly diversified and ruled global terrestrial habitats until their disappearance 150 million years later. The two dinosaurs in this ad are representative of the saurischian (lizard-hipped brontosaur) and ornithischian (bird-hipped stegosaur) dinosaurs, which co-existed with a diversity of plants and other animals, including insects and small mammals. Although most dinosaurs went extinct 65 million years ago, a descendant lineage, which first appeared in the Jurassic, survives today in modified form. Because most of these descendants have enlarged forelimbs, fully formed feathers, and can fly, we place them in a subcategory of dinosaurs – and call them birds.

Although all non-avian dinosaurs are extinct, dinosaurs continue to perform ecological services millions of years later: insights into disease origins (evidence of osteoarthritis in fossil bone), lost worlds, and extinction dynamics related to an asteroid impact, volcanism, and climate change; K-12 science education; Dinosaur Bar-B-Que Restaurants; and tourism (natural history museums, dinosaur theme parks, dinosaur "digs," etc.).



Arc'teryx Equipment Inc.

Rare but resplendent Jurassic fossils from Germany reveal an evolutionary mosaic in *Archaeopteryx*. The oldest undisputed bird, it sports a medley of dinosaur- and bird-like features. Sharp teeth, a long tailbone, 3-fingered clawed hands, 3-toed feet with enlarged killing claws, and a flat breast bone are similar to those in feathered "dino birds." *Archaeopteryx* resembles living birds in having an enlarged brain with well-developed sight and coordination areas, a furcula (wishbone), a partially reversed first toe, and wings mantled by asymmetrical feathers. *Archaeopteryx* – an early bird with limited flight – was transitional between its dinosaur ancestors and descendant branches on the avian family tree. It is one of the most important fossils ever discovered, yielding special insights into how slight but significant evolutionary modifications allowed new ways of life, in this case flight in birds.

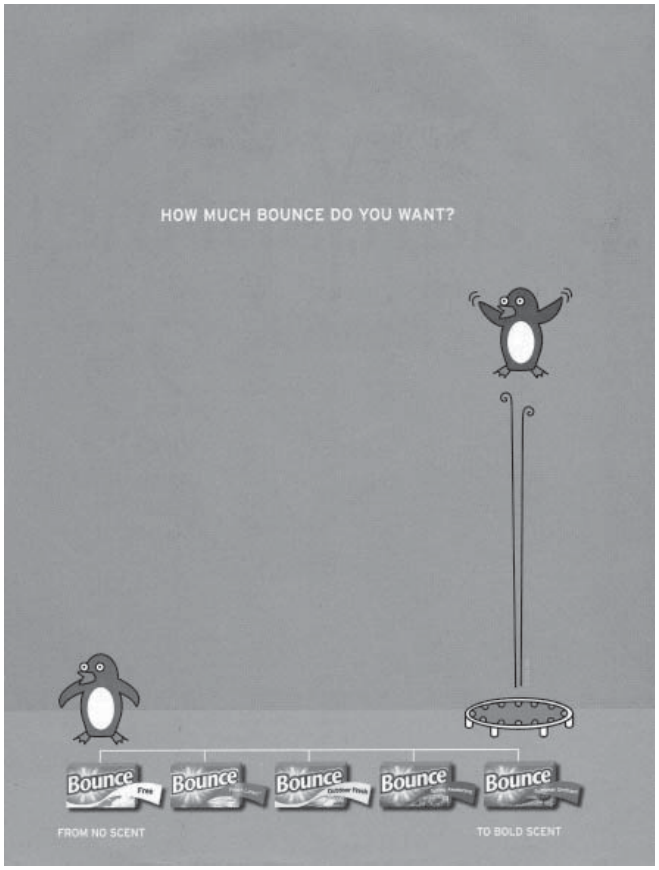
Millions of years after the genus died out, *Archaeopteryx* continues to inspire. It is the logo or mascot name for a manufacturer of outdoor clothing, for software that sorts classification questions or creates self-modifying music, for a Brooklyn-based grunge band (now extinct, like its name-sake), and a hang-glider. An asteroid and characters in literature have been named in its honor. Nothing like *Archaeopteryx* ever existed after the Mesozoic, reminding us that extinction, like a diamond, *is* forever.

flowering plants provided food and nectar to surviving insects, birds, and mammals. Via pollen and seed transport, those animals gave reproductive assistance to their stationary plant cohorts, fueling a coalition that ultimately became one of the most successful of all Cenozoic alliances.

Geologic forces, always at play, led to dynamic changes on Earth that reshaped the evolutionary landscape in the past 65 million years since the departure of the dinosaurs. Plate tectonics undermined Pangea, the supercontinent of early dinosaur reign, rifting it into the six major continents that we know today. The eruption of volcanic crust on the seafloor caused new ocean basins to expand and slowly propelled the continents into different latitudes and climate zones. As a consequence, Antarctica migrated southwards, eventually coming to rest over the South Pole. An enormous ice cap accumulated on top of that frozen empire over millions of years, lowering sea level and global temperatures. In response to reduced precipitation and increased dryness across large parts of the globe, many forest species went extinct as their habitats shrank. Grasses – flowering plants suited to areas of low rainfall and seasonal dryness – expanded to fill the gap and provided new foraging prospects to animals capable of adapting to the significant vegetation changes. These events and others provided new opportunities and new challenges, fueling a cycle of speciation and extinction that is the fundamental backbone of the evolutionary process.

That birds – now tallied at 10,000 species worldwide and representing 1/6 of all living vertebrates (second only to fishes) – survived countless upheavals on Earth is testament to their extraordinary adaptability and versatility. Yet, nearly one-quarter of bird species are either threatened with extinction today or are vulnerable to extirpation in the near future. Birds such as chimney swifts, the African penguin, and Laysan and Chatham albatrosses, which were believed only a few decades ago to have viable populations, are in urgent need of conservation.

For the first time in Earth's history, an impending mass extinction can be attributed to a single species. Humans are now considered to be the *most significant geologic agent* on the planet. Each year, we clear more land and bulldoze more rock and soil than is moved by the *combined* efforts of rivers, glaciers, wind, and volcanoes. Our agricultural practices replace the planet's naturally diverse plant communities with monocultures. Our deliberate or unwitting introduction of "alien" or "exotic" species – and the infectious diseases that they host – further disrupts the ecological landscape for native plants and animals. Our industrial gas emissions alter the chemical composition of the atmosphere and ocean. As a consequence, we are adjusting Earth's global thermostat upward, warming the atmosphere and ocean, intensifying the magnitude and frequency of storms, inducing the collapse of gargantuan ice sheets in Antarctica and Greenland, and elevating sea level. With the ability to drill several miles into Earth's crust, humans have even *caused* earthquakes. Human-



Bounce Fabric Softener

Forty species of penguins have been identified from fossil evidence extending back at least 50 million years. The 17 species of modern penguins – flightless birds restricted to the Southern Hemisphere – show an extraordinary range of adaptations for leading a unique double life on land and in the sea. Their black-and-white "tuxedos" act as camouflage from aerial and aquatic predators; interlocking waterproof feathers trap air and reduce "bounce" while swimming; sturdy wings act as "flippers" during underwater pursuit of prey; modified eyes adjust sight in air versus water; and strong webbed feet plus a sleek, streamlined shape enhance underwater maneuvers and promote "tummy-tobogganing" across snow-covered terrain.

Penguins are bio-indicators of ecosystem health (changes in Antarctica penguin populations provide early implications of global warming) and are marketing symbols in a variety of business and educational enterprises. Despite their amazing popularity, more than 70% of penguins from Antarctica to the Galápagos are at risk from habitat change (loss of sea ice and new weather patterns), pollution (including oil spills and ships' oily discharges), food reduction (over-fishing of prey and climate change's impact on nutrients), poaching, accidental capture, and introduced predators. Conservationists are monitoring populations, establishing sanctuaries and partnering with zoos to breed penguins in captivity and educate the public.

Ziploc Containers

Awesome avian acrobats, hummingbirds are best described in superlatives. For their size, they have the largest brain, longest bill, and more feathers of any bird, and proportionally the largest heart of any animal. A unique shoulder anatomy allows wings to rotate 180° up to 200 times/second, enabling hummingbirds to fly forward, backward, sideways, and hover while sipping nectar from 1,000 flowers a day! Their delicate bones and diminutive size explain hummingbirds' poor fossil record, which could extend back 30 million years. More than 300 species exist today from Alaska to Chile, where they inhabit rainforest, desert, lowland, and urban environments. Some species migrate > 2,000 miles (3,200 km) twice a year, including a grueling 20-hour, non-stop flight across the Gulf of Mexico.

Hummingbirds represent supernatural powers and are revered in rain dances and as sacred pollinators in Native American folklore. 51 species (> 10%) are threatened with extinction because slash-and-burn clearing, construction, native plant decline, and urban development are destroying their habitats. Hummingbirds fall prey to cats, predatory birds, snakes, frogs, fish, and even spiders. Projects involving schools and conservation societies in South, Central, and North America are strengthening cross-cultural partnerships to track migrating "hummers," protect flight corridors, and improve hummingbird-based tourism.

induced seismicity has been documented at deep-well sites in geothermal fields, in oil and gas operations, and where fluids are injected underground to extract economically important materials.

Speciation – and extinction – are life's responses to change. As the main driver of substantial, planet-wide transformation, humans have now become *Earth's most significant evolutionary force*. Since the onset of the Industrial Revolution in the late 1700s and early 1800s, human alteration of the planet has occurred at an unprecedented rate, far outpacing how the atmosphere, hydrosphere, cryosphere (ice-bound realms), and biosphere fluctuated in the geologic past. Our influence on physical, chemical, and biological processes around the globe is now considered so profound that it is likely to leave a recognizable imprint in the geologic record. As such, some geologists have recommended that a new "age" – the Anthropocene – be designated. Given the rate and scope of modern-day modifications being made to our planet, serious concerns have arisen that a new mass extinction, potentially rivaling that of the late Mesozoic, will demarcate the Anthropocene. Such an event is likely to produce distinctive markers in oceanic and terrestrial deposits, similar to those of the geologic past, recording widespread species loss during ecosystem collapse.

No species, including *Homo sapiens*, exists in an ecological vacuum. All are tightly bound into the fabric of life, interwoven into a vast web of ecosystem services – Nature's capital assets – on which species depend for existence. These natural assets are, in fact, humanity's safety net, as our fellow species provide crucial, life-affirming benefits, including regulation of natural disturbances (storms, floods, and drought), climate stability, soil formation, water purification, crop pollination, and potential cures for cancer, AIDS, and other diseases. Through recreation, cultural pursuits, and perceptions of beauty and harmony in life all around us, Nature also nurtures our spiritual well-being.

Birds, for example, are an important source of meat and eggs for us and for many other predators. Feathers are used in clothing, household goods, biofuels, and fly-fishing, serve as fletching on arrows and darts, and are of ceremonial importance in cultures around the world. Guano – bird excrement – has been mined from ancient deposits and modern sites as a source of fertilizer for centuries. Many birds are "ecosystem engineers," species whose activities help maintain healthy environments through pollination, seed dispersal, and control of pests.

Bird-watching, hunting, and support of athletic teams sporting bird mascots (for example, the Pittsburgh Penguins and Puffins hockey teams, University of Oregon Ducks, and Virginia Tech's Fighting Gobblers) provide recreational enjoyment. Disney's Donald and Daisy Duck, Blu in *Rio*, Zazu in *The Lion King*, the Aflac Insurance duck, NBC's peacock, and many others, are other sources of entertainment. Birds have been a wellspring of inspiration for achievements in art

Kiwi Shoe Polish

The kiwi, unique to New Zealand, is the smallest of the ratites – flightless birds like Africa's ostrich, Australia's emu, and South America's rhea. Anatomical and genetic similarities plus their restriction to the Southern Hemisphere indicate that ratites shared a common ancestor on the southern supercontinent Gondwana before it began rifting apart 80 million years ago. Because the oldest kiwi fossils date back only 1 million years, it is unknown whether they were established in New Zealand before Gondwana broke up or arrived later by "island hopping." On an island free of mammal predators, the flightless kiwi evolved unique features such as cat-like claws at the ends of its wings, fur-like feathers, a gargantuan egg 6 times larger than normal, cat-like whiskers at the end of its probing bill, and a highly refined sense of smell.

Kiwis provide evidence for plate tectonics and insight into speciation potential when evolving in predator-free isolation. Protected since 1896, the kiwi is one of world's most endangered birds. Populations of all 5 kiwi species have plummeted from 23 million in 1900 to 70,000 in 2004. Nearly decimated in the 1800s by over-hunting for its pelt, introduced predators continue to break eggs and kill chicks, wild pigs dig up its burrow, and its forest habitat is fragmented or converted to farmland. Conservationists hope to save the imperiled kiwi through captive breeding programs and protection in predator-proof sanctuaries.

and literature – Tchaikovsky's *Swan Lake*, James' *The Wings of the Dove*, and Coleridge's *The Rime of the Ancient Mariner* to name a few. Birds are also placed on a prominent pedestal in mythology and religion, representing symbols of power, chicanery, wisdom, transcendence, and the supernatural. One of the world's most important cultural symbols – the one for peace – is a dove.

Bird studies have also led to significant technological and scientific advancements that promise to improve our daily lives. The toucan's composite beak structure is the stimulus for designing better impact-resistant automobiles. More efficient propulsion systems in submarines and other aquatic vehicles are being re-designed based on the shape and movement of a penguin's flippers. Bird feathers have inspired the development of a new type of mirrorless laser. Understanding how woodpeckers avoid injury while hammering trees for food could in the future help prevent head trauma in humans.

Even though humans now dominate every part of the planet, the range of ecosystem services that we derive from birds reminds us how utterly dependent we have been and will continue to be on other organisms for our survival. Nearly two decades ago, Boston University professor Les Kaufman urged us to "stop thinking of all other life as a green blur out the window of a speeding train. When we stop and look at the oak trees, some important lessons are learned. We need to see them as part of our lives, along with athletes and soap opera stars." In an unconventional way, this article attempts to illuminate how we can do just that.

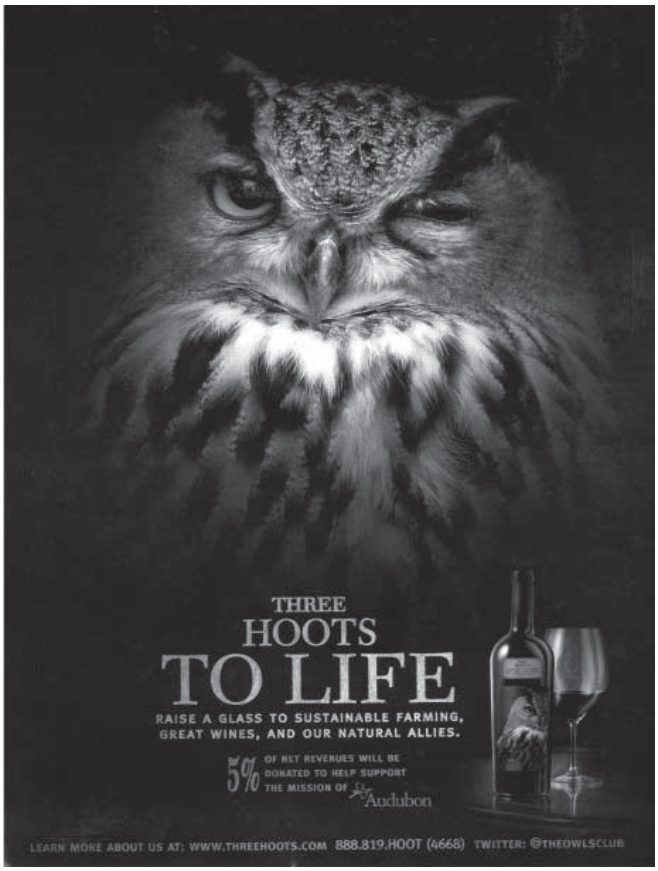
Humans, like all other animals, survive as *consumers* – of oxygen in the atmosphere, of water, of other organisms as food, of land on which we build shelter, of nutrients in the soil where we grow crops, and of trees and other fuels that provide comfort and energy. As co-dependent animals leading interconnected lives, we rely on communication to call attention to – or advertise – available (and desirable) products and services that sustain our daily, consumer-focused activities. The associated advertisements are a case in point. Culled from widely circulated magazines over many years, they showcase birds to sell things that savvy consumers might want: jewelry, fabric softener, shoe polish, luggage, wine, food storage containers, tourism, and outdoor clothing.

That our fine-feathered friends are featured so prominently in advertising (I have so far accumulated 90 ads representing 33 species!) should come as little surprise, because birds have adapted to nearly every habitat on Earth and are the most common wild creatures that we encounter in our everyday lives. In humorous, clever, sometimes quirky or unintended ways, these ads reflect many of our attitudes about birds: fear and awe, fascination and wonderment, a desire to possess or dominate, a sense of unity and kinship, bemusement and amusement, admiration of strength, speed, and stamina, and appreciation for Nature's majesty, purity, and elegance. More important, like Kaufman's "green blur," each ad has

Ghurka Luggage

Colorful in looks and personality, parakeets, cockatoos, lovebirds and the travel-minded blue-and-yellow macaw in this ad are some of the many types of parrots. More than 350 species live worldwide, mostly in tropical forests and grasslands. Ranging in size from the 0.3-ounce (10-gram) pygmy parrot to the 9-pound (4-kilogram) kakapo, parrots earn a high perch for their intelligence, inquisitive nature, and mimicry of human speech. Parrots use their bill and zygodactyl feet (the toes are arranged in pairs) to climb, swing upside down, consume hard seeds, fruit, and other food, and manipulate "manufactured" tools. Monogamous pairs bond for life, nest in tree holes or dug-out cavities, and their young sometimes go through lengthy foraging apprenticeships. The oldest parrot fossil is 54 million years old, from Denmark.

At least one-third of parrot species are threatened with extinction because of hunting, tropical deforestation, introduced species, and the wild-bird trade (an estimated 3 birds die during capture and transit for each parrot sold as a pet). Approximately 19 species have gone extinct since the 1600s, including the Carolina Parakeet in North America, killed off by early 20th-century hunting. Providing a global umbrella of support, conservationists, zoos, and local people are working on education, monitoring populations, saving habitat, and translocation programs to assure parrots' safe and secure arrival at their intended final destination – the future.



Three Hoots Winery

Most owls are nocturnal predators that use stealth, exceptional binocular vision, 270° head rotation (afforded by 14 neck vertebrae, twice the number in humans!), acute hearing, and broad wings with special, sound-dampening feathers to glide silently toward their prey during feeding forays. Most of the 216 owl species that range across all continents except Antarctica feed opportunistically. The smallest prefers insects, worms, and small vertebrates; the largest favors eagles, deer, and even young wolves. Powerful talons securely grip the owl's quarry, and a hooked, down-curved bill efficiently dispatches food and aids in defense. Regurgitated pellets contain indigestible remains – bone, teeth, fur, and feather – and as fossils date back 5-11 million years. The oldest fossil owls are from the Paleocene, 60 million years ago.

Owls are indicator species for rapidly disappearing old-growth forest. Owl decoys deter pest species from fouling boats and shoreline property. They symbolize wisdom, good fortune, evil, or death; their faces appear in Paleolithic cave art and on 2,000-year-old Athenian coins. Although less studied than other birds, owls are threatened by habitat change, by poisons, and illegal hunting. Conservation efforts are giving "3 hoots" to promote better education about owls' importance in pest control, the use of nest-boxes where nesting sites have been lost, and captive breeding programs designed to reintroduce owls into their native habitats.

a subtle message and the potential to teach an important lesson about birds – their ecology and evolution, ecosystem services, extinction threats, and efforts to conserve one of Nature's most beautiful, awe-inspiring, and life-sustaining "commodities." Appreciating the connections that link the ecology of the world around us to our own physical and emotional well-being could help save birds – and the many other endangered species with which they co-exist – from their flight towards extinction and the ultimate, ever-lasting, and final good-bye.

Acknowledgments. For help with a book from which this article is extracted, many thanks to Emily Kennedy and Alyssa Hausman for fact-checking, ad scanning, and preliminary research on > 500 ads representing species from *Archaeopteryx* to zebra. The Department of Geology at Colgate funded the student assistants. I thank Colgate students in "The Sixth Extinction" first-year seminar who enthusiastically collected ads and undertook research on the ways in which wildlife is featured in mass media, as the basis for an earlier version of this article. Special thanks are extended to the following for granting permission to use their ads: Arc'teryx Equipment, Ghurka/Accessory Network Group, Las Vegas Convention and Visitors Authority, Pomellato, Proctor & Gamble (Dawn and Bounce ads), SC Johnson (Ziploc and Kiwi ads), and Three Hoots/Davis & Dyke Winery. Finally, I am grateful to Brian White and Elinor and Stauffer Miller for sharing their knowledge and love of birds over many years.

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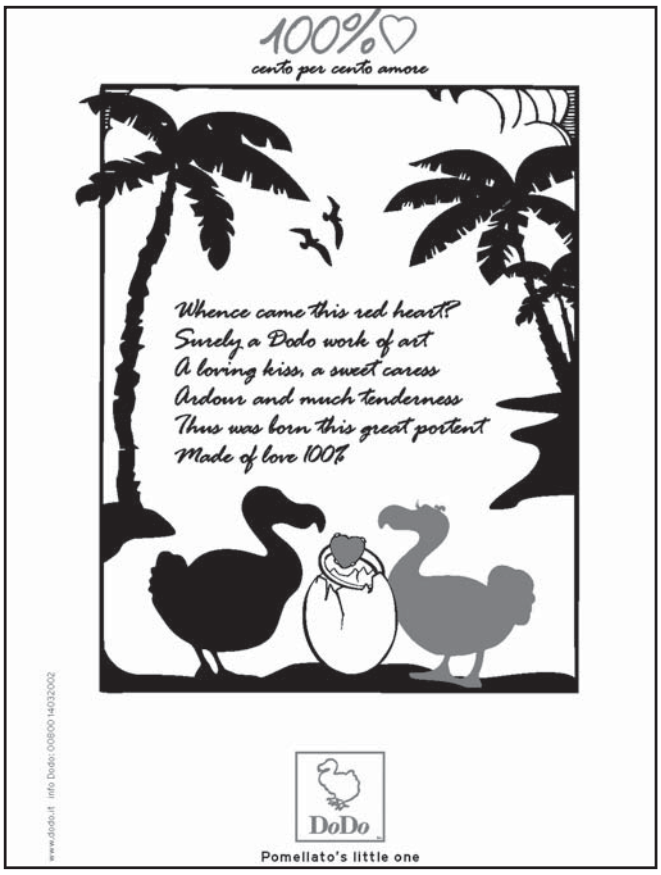

Pomellato Jewelry

The Dodo was a large, flightless bird endemic to Mauritius before the species died out there less than 400 years ago (*ca.* 1690). The 3-foot (90-cm) tall Dodo had small wings and tail, short but powerful legs, a prominent, hooked bill, and downy feathers. Although often portrayed as overweight and ungainly, fossils and historical records show that the Dodo was sleek and fleet of foot, and could successfully defend its nest, where a single egg was cared for by a monogamous pair. DNA extracted from subfossils reveals that the Dodo was an oversized, ground-dwelling pigeon, with ancestral relations that extend back approximately 25 million years. Evolving in isolation on a predator-free island, flightlessness was no problem for the ground-nesting, forest-dwelling Dodo, but once Mauritius became an important way-station for sailors by the 10th century, the Dodo was doomed. The "naïve" Dodo did not recognize humans – or the non-native rats, cats, dogs, and pigs that they introduced – as predators, and the species succumbed to hunting and loss of eggs at trampled nests in just 200 years.

Mistaken by sailors as "sluggard" or "foolish," the Dodo is a symbol of political stupidity in *Alice in Wonderland* and refers to silly people or the obsolete ("dead as a Dodo"). It's too late for the Dodo, but as an icon of evolution and extinction, it serves as a warning about the potential consequences for life on a human-dominated planet.