FOURTH EDITION

FUNDAMENTALS OF CONSERVATION BIOLOGY

MALCOLM L. HUNTER, Jr. • JAMES P. GIBBS • VIOREL D. POPESCU

WILEY Blackwell

Fundamentals of Conservation Biology

For Aram J.K. Calhoun, who inspires us with her delight in the natural world and dedication to conservation.

For Kathleen E. (Cassie) and Harold C. Gibbs, who inspired many to know and care for life on Earth.

For Tavi B. Popescu, whose wonder about the natural world gives us optimism about the next generation of the Earth's stewards.

Fundamentals of Conservation Biology

Fourth Edition

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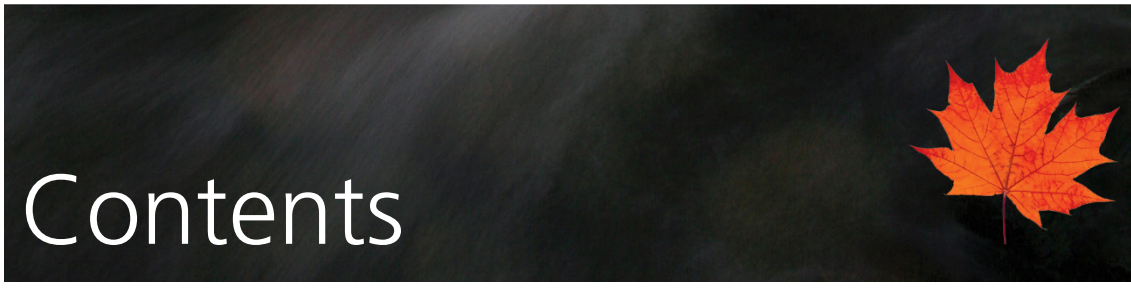

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Preface

11:15 P.M. 20 June 1990 I'm not used to being this hot so late at night. I don't know the sounds coming through the window . . . crickets? . . . frogs? . . . a wheezing air-conditioning system? I don't know what to do.

I'm in a dorm at the University of Florida; the fourth meeting of the Society for Conservation Biology has just ended; I'm sifting through various conversations of the last 4 days. I wonder if I should postpone my plans to write a sequel to my book on managing forests for biodiversity – a sequel that would focus specifically on tropical forests. At the meeting I've discovered that professors are using my book for a much broader range of conservation courses than I ever anticipated and that tells me that there is a niche to be filled.

Apparently various multiauthored books on conservation biology topics are not filling the need for a basic text. Perhaps I should add a brick to the foundation of the discipline before pursuing a more specific project. Now if I can rough out an outline before I get too sleepy . . .

27 August 1993 Over 3 years later and I have just finished the first draft. Actually the writing went reasonably quickly (I did not begin in earnest until May of 1992) because I chose a sort of stream-of-consciousness approach in which I wrote only what I knew or thought I knew. Now I look forward to spending the next several months combing the literature, correcting, refining, and updating this draft. It might seem that this approach would make it easier to convey my original thinking about conservation biology as opposed to reporting on everyone else's thinking. Perhaps so, but I claim no truly original thoughts. I tend to think each person is no more than a unique melting pot for a vast community of ideas.

24 August 1994 Sifting through the literature of conservation biology has been great fun, although it has entailed some difficult choices. If many of my readers will be North American, should I keep things familiar and easy by illustrating general principles with redwoods, bald eagles, and well-known foreign species like tigers? Or should I try to open some vistas by describing fynbos, huias, and thylacines? Many years of working abroad predispose me toward the latter approach, but I have curbed this temptation to some degree, partly to save the space it would take to describe the fynbos, and partly because I have tried to select literature that will be reasonably accessible.

As I enter the final stages of production I often think about my readers and how they will use this book. My primary audience is students who have some background in biology and ecology but who have not taken a previous conservation biology course. I also hope to reach some general-interest readers and have tried to keep the prose fairly lively so that they can manage at least half an hour of bedtime reading before dozing off.

This is an opportune place to explain two features of the book. First you will note that there are almost no scientific names in the text; they are all in a separate list of scientific names, which also constitutes an index to all the species mentioned in the text. Furthermore, the literature cited section constitutes an index to authors, because after each citation the pages where it is cited are listed.

27 December 1994 Two more days before the book goes out to copy-editing, and it is time to start listing all the scores of people who have helped in an acknowledgment section. I particularly want to thank Andrea Sulzer, the friend and artist who illustrated the book; the Department of Wildlife Ecology of the University of Maine, where a relationship that began in 1970 has recently led to a professorial chair endowed by the Libra Foundation; and Aram Calhoun who has shared all but a month of our marriage with this book. Finally a special thanks to everyone who buys this book for all its royalties are allocated to a fund to support conservation students from developing countries.

Second edition: January 26, 2001 Before undertaking this second edition I was rather dreading the prospect of replowing old ground, tearing apart my first edition and putting it back together again. In hindsight, the last 9 months of sorting through the conservation biology literature have been rather enjoyable, especially after I realized that it was okay to be selective in my reading. With 651 new references there is a lot of fresh material to chew on here; most of it is very recent (my last trip to the library was this morning) although I have also added some older papers from the "classical period" of conservation biology (the 1980s). A new glossary and many new illustrations are also prominent features of this edition.

Third edition: 15 May 2006 I am returning home from a 4-month sabbatical in Australia, where weekends were spiced with pursuing wombats, whale sharks, and lyre birds, just in time to work on the production phase of this book. Two years ago when I decided to invite a coauthor to join me it took about 10 seconds to identify James Gibbs and, the next day, it took even less time for him to accept. I have worked with James for 25 years, since he was a new student at the University of Maine and I was a new professor, and it has always been a pleasure. James' expertise with genetics and population biology, complementary experiences with field conservation projects around the world, and his willingness to dive into the social sciences was just what was needed to strengthen this edition.

Another salient feature of this edition is a strong shift to color images. Finding illustrations for this edition has been an enjoyable challenge and we are grateful to the many people whose works appear here.

Of course the substance of revising any textbook lies in new literature, and the field of conservation biology remains vigorous in this regard. The 762 new references added here are just a small sample of the high-quality research that characterizes the discipline. We have also added three new case studies, holding back somewhat because we think case studies should largely be generated and presented by faculty and students based on their own experiences and interests. Overall the book is 6% longer than the last edition

as measured by the number of words, but 50 pages shorter because of more compact formatting.

As with earlier editions, the royalties are going into a fund to support conservation students from developing countries, most recently the fieldwork of a student from Argentina studying cavity-nesting birds in the Andes for her dissertation. In time the royalties will be sufficient for an endowed, perennial source of support for similar aspiring conservationists.

Fourth edition: 31 December 2019 New Year's Eve and a steady snow is luring me outdoors to celebrate a thirtieth wedding anniversary, but first I need to draft the last few new words for our fourth edition. The most conspicuous new feature is the addition of Viorel Popescu as an author, continuing a tradition of extending academic lineages, given that Viorel earned graduate degrees with both James and me. Undertaking a collaboration like this requires considerable trust and James and I knew that Viorel had the talent and commitment to make a huge contribution to the book, leading the revision of four key chapters and carefully reviewing all of the chapters. Furthermore, he brought to the table many new perspectives as a native of another part of the world – Romania – where he remains active in conservation at many levels.

With a long interval since the third edition there has been a vast new literature to comb through, and it was challenging to limit the new additions to "only" 950 new references. The conservation literature has expanded dramatically, by embracing new theory and methods, and documenting many examples of both conservation successes, and the hard lessons of real-world "wicked" environmental problems. For example, climate change was a mere hypothesis when this book began; now it is a defining reality, the focus of one chapter, and an underlying thread in many others. Many other chapters have been reformulated to reflect the ever-changing landscape of conservation biology, among them "Conservation near People" that represents a new shift in attention to the privately owned lands where much of the future of biodiversity conservation will play out. Similarly, we have been more inclined to add new case studies than to remove old ones, but in the interest of keeping the length reasonable we have often opted for new images with long legends that constitute mini case studies. In short, this edition represents a substantial "overhaul" from the last edition.

Royalties from this book continue to support conservation students from developing countries and have finally reached a level sufficient to fund an endowed scholarship. Indeed, the first recipient, a student from Brazil, begins her PhD work 2 weeks from today.

A quarter of a century has passed since I finished the preface to the first edition of this book, and in many respects the world and this book are profoundly different. However, much remains the same: life on Earth is awesome, in the original, fundamental sense of that word, and now, more than ever, it needs the attention of dedicated stewards like you.

M. L. Hunter, Jr.

Acknowledgments

We are very grateful to the many people who have critiqued the manuscript in its various drafts, especially in its first edition: Susan Bratton, Sheila Conant, Alan Cooperrider, Phillip deMaynadier, Ann Dieffenbacher-Krall, Alison Dibble, Matthew Evans, Carol Foss, Ed Grumbine, Vicki Ludden, Gerry Niemi, Chris Norment, Kimberly Peterson, Margaret Ronsheim, Tom Sherry, Marcia Shofner, Larry Alice, Drew Allen, Fred Allendorf, Mark Anderson, Doug Armstrong, Mike Baer, Steve Beissinger, Judy Blake, Kevin Boyle, Baird Callicott, Christopher Campbell, Jim Carlton, MaryEllen Chilelli, Susan Clark, Richard Cowling, John Craig, Eric Dinerstein, Dave Field, Jim Fraser, Tom Gavin, Larry Harris, Leslie Hudson, David Jablonski, George Jacobson, Susan Jacobson, Steve Kellert, Roger King, Sharon Kinsman, Rick Knight, lrv Kornfield, Bill Krohn, Rich Langton, David Lindenmayer, John Litvaitis, Annarie Lyle, Georgina Mace, Mary Ann McGarry, Janet McMahon, Curt Meine, Laura Merrick, Ed Minot, Peter Moyle, Trinto Mugangu, Dara Newman, David Norton, Reed Noss, Judith Rhymer, Miles Roberts, Joshua Royte, Kathy Saterson, Mark Shaffer, Michael Soulé, Bob Steneck, Eleanor Sterling, Kat Stewart, Stan Temple, Shelly Thomas, Nat Wheelwright, Bob Wiese, David Wilcove, E. O. Wilson, and Joe Zydlewski. The first 16 merit special mention for reading all or most of the book.

On the production side many folks have worked hard to create this book. These include, in roughly chronological order: Jane Humphreys, Simon Rallison, Bob Calhoun, Julie Dodge, Chris Halsted, Shirley Moulton, Lincoln Hunt, Shawn Girsberger, Elizabeth Frank, Nancy Whilton, Sarah Graves, Janey Fisher, Andrew Connolly, Antony Sami, Mandy Collison and Ruth Swan.

Last but not certainly not least, are our partners in life and conservation, Aram Calhoun, Thane Joyal, and Bekka Brodie, who have helped with this book in many direct and indirect ways.

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/Conservation-Biology4e

The website includes:

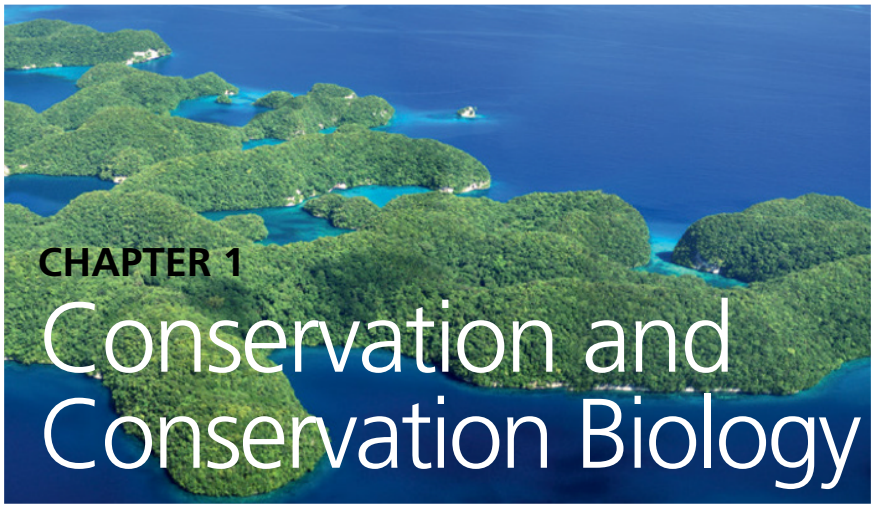
Figures from the book for downloading

PART I

Biodiversity and Its Importance

Think about our world and its wild things: a marsh splashed and flecked with the colors of flowers and dragonflies, the rhythmic roar and swoosh of waves punctuated by the strident calls of gulls, a dark forest pungent with the odors of unseen life teeming below a carpet of leaves and mosses. Now imagine a future world utterly dominated by concrete and regimented rows of crops – a hot, dry, monotonous, and unhealthy home for us and the species we have chosen for domestication. This book is about hope in the face of forces that would degrade our world. This book is about the rich tapestry of life that shares our world now and about how we can maintain it, sometimes in places that we protect and set aside, more often in places where we share the lands and waters with a wide range of other species.

The abundance and diversity of life is often apparent where water meets land, especially intertidal zones. In this photo representatives of four different phyla are evident and there are likely to be dozens of species unseen. (Terry Allen/Flickr)



CHAPTER 1

Conservation and Conservation Biology

What Is Conservation?

Since the beginning of humanity people have been concerned about their environment and especially its ability to provide them with food, water, and other resources. As our numbers have grown and our technology has developed, so has the impact we are having on our environment, and thus we are becoming increasingly concerned. Media everywhere proclaim the current issues:

- "Conservationists call for tighter fishing regulations."
- "Ecologists describe consequences of warmer climates."
- "Environmentalists criticized by chemical industry."
- "Preservationists seek more wilderness."

These headlines also reveal an ambiguous terminology. Are we talking about conservation or preservation? Are the issues ecological or environmental? Students deciding which university to attend and which major to select are faced with a bewildering array of choices – soil and water conservation, environmental studies, natural resource management, conservation biology, wildlife ecology, human ecology, and more – that intertwine with one another. In this chapter we will try to resolve these ambiguities by examining how they are rooted in human history and ethics. To start on common ground we explore the key differences and similarities among conservationists, preservationists, environmentalists, and ecologists. In the second part of the chapter we will see where conservation biology fits into this picture.

A *conservationist* is someone who advocates or practices the sustainable and careful use of natural resources. Foresters who prudently manage forests, hunters and fishers who harvest wild animal populations sustainably, and farmers who practice the wise use of soil and water are all conservationists.

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Companion website: www.wiley.com/Conservation-Biology4e

Citizens who are concerned about the use of natural resources are also conservationists and sometimes they assert that the activities of foresters, fishers, farmers, and other natural resource users are not prudent, sustainable, or wise. In theory, arguments over who is, or is not, a conservationist should turn on the issue of what is sustainable. In practice, most foresters, farmers, ranchers, and others – many of whom are careful stewards of the lands and waters they control – have ceded the title "conservationist" to their critics.

A *preservationist* advocates allowing some places and some creatures to exist without significant human interference. Most people accept the idea that conservation encompasses setting aside certain areas as parks and protecting certain species without harvesting them. The divisive issues are: how many and which areas, and which species. Many resource users believe that enough areas have already been closed to economic use, and they use "preservationist" as a negative term for people they consider to be extremists. Ironically, in the case of some set asides, like marine reserves, their preservation boosts fish harvests in surrounding areas. Nevertheless, because of this pejorative use, relatively few people call themselves preservationists. People who find themselves labeled preservationists by others usually prefer to think of preservation as just one plank in their platform as conservationists.

An *environmentalist* is someone who is concerned about the impact of people on environmental quality in general. Air and water pollution are often the proximate concerns; human overpopulation and wasteful use of resources are the ultimate issues. There is enormous overlap between environmentalists and conservationists. Many environmentalists would say that environmentalism encompasses conservation, while many conservationists would say the reverse. The difference is a matter of emphasis. By focusing on air and water pollution and their root causes, environmentalists often emphasize urban, suburban, and agricultural situations where human-induced problems and human well-being are paramount. Because conservationists focus on natural resource use, they tend to emphasize the rural areas and wildlands where natural resources are most abundant, as well as associated ecosystems and organisms, including people who might live there.

Traditionally, an *ecologist* is a scientist who studies the relationships between organisms and their environments. However, in the 1970s when concern for the environment first bloomed widely around the planet, the term developed a second meaning when the public failed to distinguish between environmentalists (activists) and the scientists (ecologists) who provided the scientific basis for the environmental movement. Now "ecologist" is often used in the popular press as a synonym for "environmentalist." Given this, a broader definition of an ecologist is a person who is concerned about the relationships between organisms (including people) and their environments.

Recently, these distinctions have become controversial and fuzzy, following a call for a "new conservation" that focuses on the benefits that nature provides for people (Kareiva and Marvier 2012) and the ways that people and nature depend on one another. This "conservation for people" movement is controversial because other people believe that conservation should also recognize the intrinsic value of nature (see next section). It is fuzzy because

people on both sides of the argument have lost sight of the fact that the origins of conservation (also see next section) were largely centered on human welfare (Hunter et al. 2014).

In summary, ever-evolving attitudes and perceptions are at the root of the confusion over who are conservationists, preservationists, environmentalists, and ecologists; each term persists because it has some utility in describing the diverse ways people interact with their environment.

A Brief History of Conservation

The roots of conservation are lost in prehistory (Fig. 1.1). No doubt there was a time when human reason, growing ever more sophisticated through the millennia, began to extend the idea of deferred gratification ("save this fruit to eat tomorrow rather than now") over much longer periods. Keep in mind that for 99% of our history as a species we were living in small, self-regulating groups of humans entirely dependent on wild species. Thus conservation has long been intrinsic to our welfare as expressed in the form of edicts and practices such as "Leave these tubers so there will be more next year when we pass this place." Or "Do not kill the pregnant females in this herd of peccaries so next year we will have even more to eat." Or "Nobody shall hunt in that sacred area near our home grounds." Certainly, such practices were simple, almost analogous to the food caching exhibited by many animals, but they were widespread and effective in governing human activity and represent conservation nevertheless. They remain relevant to this day, most notably in

Figure 1.1 The roots of conservation can probably be found among the earliest *Homo sapiens* such as the people who painted this mural in the Lascaux cave in France. (Thipjang/Shutterstock)

the practices of indigenous people who still live subsistence lifestyles in self-regulating societies using wild species (Berkes and Turner 2006).

Leaping forward, history records many examples of conservation throughout the ages and across cultures. For example, the biblical story of Noah's ark remains a popular metaphor for conservation, and the Bible also codifies the first-known game conservation law:

> If you come on a bird's nest, in any tree or on the ground, with fledglings or eggs, with the mother sitting on the fledglings or on the eggs, you shall not take the mother with the young. Let the mother go, taking only the young for yourself, in order that it may go well with you and you may live long. (Deuteronomy 22:6–7)

(In other words: don't kill mother birds.)

A far broader law was promulgated by Asoka, emperor of India 274–232 BCE:

> Twenty-six years after my coronation I declared that the following animals were not to be killed: parrots, mynahs, … wild geese, … cranes, bats, queen ants, terrapins, … tortoises, and porcupines, squirrels, twelve-antler deer, … rhinoceroses, … and quadrupeds which are not useful or edible…. Forests must not be burned.

Many laws focused on regulating rather than prohibiting the exploitation of species. For example, Middle Eastern pharaohs issued waterfowl hunting licenses, and night hunting was banned in the city-states of ancient Greece (Alison 1981). Early regulations emphasized trees and birds, mammals, and fish caught for food, but all species and whole ecosystems benefitted from the popularity of declaring preserves. Starting at least 3000 years ago with Ikhnaton, king of Egypt, and continuing with the royalty of Assyria, China, India, and Europe, as well as with the Greeks, Romans, Mongols, Aztecs, and Incas, history has recorded many decrees setting aside land to protect its flora and fauna (Alison 1981).

Conservation was an issue during the period when European states were colonizing the rest of the world because colonization often led to disruption of traditional systems of natural resource use and rapid overexploitation. Freedom from European game laws was a significant stimulus to colonization, and hunting was a major preoccupation of the colonizing class. Imagine how attractive the promise of abundant, freely available game would seem to people who feared for their lives whenever their appetite for meat led them to poach one of the king's deer. This phenomenon was particularly true on some small, tropical islands such as Mauritius and Tobago, and continental Africa (Grove 1992, 1995; Prendergast and Adams 2003).

Of course game species did not fare well under the onslaught of hungry colonists and soon regulations had to be enacted. For example, as early as 1639

it was illegal to kill deer between May 1 and November 1 in parts of Rhode Island (Trefethen 1964) and the Cape Colony in southern Africa had game laws by 1822 (MacKenzie 1988). This basic pattern – human populations growing, developing new technology for using natural resources, leaving crowded places and colonizing new lands, disrupting and displacing native peoples and their long-standing practices in these colonized areas, and then responding to overexploitation and expanding population with an array of ever more restrictive regulations – has been repeated across the globe and continues to this day.

With increasing human impacts, the abuse of resources other than trees and large animals also began to be recognized, albeit slowly, for species that lack obvious economic value such as most invertebrates, small plants, amphibians, and reptiles. Aldo Leopold (1949) called for saving every species with his well-known admonition, "To keep every cog and wheel is the first precaution of intelligent tinkering," but it was not until the 1960s and 1970s that the idea of "endangered species" (so imperiled that they were about to disappear from the face of the Earth forever) became a major issue for conservationists. During this period many nations passed laws (e.g. the United States Endangered Species Act) to form an umbrella under which all animal and plant species threatened with extinction could, in theory, benefit from conservation intervention. In practice, however, plants and smaller animals still are not given equal treatment, and other components of biodiversity such as microorganisms, genes, and ecosystems are usually not explicitly under the umbrella at all.

This brings us to the point of departure for conservation biology and this book, but first let us briefly return to preservation, environmentalism, and ecology to see how they mesh with the larger history of conservation.

Preservation

The roots of preservation are probably almost as ancient as the origins of spirituality. When religious leaders began to set rules for society, some species were protected as totems and some places like certain mountains were recognized as sacred and thus decreed off-limits or visited only on religious occasions (Fig. 1.2). Moving ahead many millennia, the establishment in 1872 of Yellowstone National Park, the world's first national park, is often identified as the beginning of governmental policy codifying the value of preservation. Here were nearly 10,000 square kilometers of evidence that society valued the landscape's sacredness; that its aesthetic qualities (particularly striking geological features like geysers and hot springs) justified removing some natural resources from the path of economic development. The national park movement has developed throughout the world and has been modified in many ways. Some preserves are off-limits even to visitors, such as the many zapovedniks (strictly protected areas) of Russia, while some parks, especially in Europe and India, maintain traditional cultural practices such as historic livestock grazing regimes. Nevertheless, the underlying value system remains largely intact. This same preservationist value system has also curtailed the exploitation of some species, such as various kinds of

Figure 1.2 Mount Fuji [*top*] has been a sacred mountain for the Buddhists and Shintoists of Japan for many centuries. (Tofoli.douglas/Flickr/Public domain) For the indigenous people of the Pacific Northwest, totem poles [*bottom*] often depict species that represent family identity and history, and have a sacred role in their culture. (Bernard Spragg/Flickr/CC0)

whales and songbirds, in many places. Obviously, species that are on the brink of extinction are slated for preservation, but others are simply species for which preservation has been deemed preferable to utilization. Many countries, for example, have banned the harvesting of all songbirds even though some species could be harvested in a sustainable manner.

Environmentalism

The first environmentalists were probably citizens of our earliest cities, more than 2000 years ago, who demanded sewers and chimneys to mitigate the impact of water and air pollution, respectively. For example, the Cloaca Maxima (which literally means "greatest sewer") was built in Rome around 600 BCE. The industrial revolution accelerated urbanization and brought its own problems such as coal burning and factory discharges into water bodies. Environmental issues became much more high profile after publication of Rachel Carson's 1962 treatise on pesticides, *Silent Spring*, and a global environmental movement finally coalesced at the first United Nations Conference on the Human Environment, in Stockholm in 1972. This event marked the beginning of an era of considerable effort toward environmental protection at the global, national, and local levels with many organizations created, laws passed, and treaties ratified.

Ecology

The elements of modern ecology can be traced to Hippocrates, Aristotle, and other Greek philosophers, but it was probably Alexander von Humboldt (1769–1859) who first articulated truly sophisticated ecological ideas, for example linking air pollution and deforestation to climate change (Wulf 2015). Nevertheless, the word "ecology" was not coined until 1869. Scientific societies of ecology and ecology journals followed in the early 1900s, and ecology soon proved useful in developing a scientific basis for forestry and other areas of natural resource management. However, ecology did not move into the public eye until the advent of environmentalism. As the environmental movement spawned new government agencies, advocacy groups, and consulting firms, universities educated large numbers of young ecologists to fill these organizations. Schools at all levels began informing students about the relationships between organisms and their environment. Consequently, there are now many professional ecologists and other experts who focus on the science of solving environmental problems, and many more people who are activists and call themselves ecologists out of concern for these issues.

An Overview of Conservation Ethics

It is easy to describe the history of conservation in terms of political benchmarks such as the passage of laws, but these are only a manifestation of a more fundamental process: the evolution of human value systems or ethics with respect to the environment. We will encounter conservation ethics in many chapters and will focus on the topic in Chapter 15, "Social Factors," but a brief preview here will complement our history of conservation and will provide a foundation for later chapters. To do so, we place conservation ethics into an historical context using three people – John Muir, Gifford Pinchot, and Aldo Leopold – as the vehicles to describe three fundamental ethics that

underpin conservation today: the Romantic-Transcendental Preservation Ethic, the Resource Conservation Ethic, and the Evolutionary-Ecological Land Ethic, respectively (Fig. 1.3) (Callicott 1990).

The *Romantic-Transcendental Preservation Ethic* became the basis for political action, most notably in the hands of John Muir (1838–1914), the writer and naturalist who founded the Sierra Club. Muir believed that communion with nature brings people closer to God (thereby providing a "transcendent" experience) and that visiting ancient forests and alpine meadows for this purpose is morally superior to using them to cut timber or graze livestock. In other words, nature is a temple that is sullied when people exploit it. Obviously, such an ethic puts a high premium on establishing parks to preserve nature.

At about the same time that Muir was calling for extensive preservation, Gifford Pinchot (1865–1946) was formulating a very different value system, the *Resource Conservation Ethic*. Pinchot was a forester and politician and founder of the US Forest Service. To Pinchot, nature consisted solely of natural resources that should be used to provide the greatest good for the greatest number of people for the longest time. This was not a call to plunder the land but rather to use it in a way that distributes benefits fairly and efficiently among many people, rather than among a few lumber barons and cattle kings, as was largely the case in his day. It also advocated wise, judicious use of natural resources so that future generations would not be shortchanged. By recognizing aesthetics as a resource, the Resource Conservation Ethic even found room for a modest amount of preservation to accommodate

Figure 1.3 Put yourself in the shoes of John Muir, Gifford Pinchot, and Aldo Leopold to view this landscape. How does this influence your perspective? (James P. Gibbs, author)

Transcendental philosophers and Romantic poets. Given these precepts and a history of overexploitation, Pinchot believed that natural resources should be owned or regulated by government.

Although there was a profound gap between Muir's and Pinchot's ethics, they both espoused an anthropocentric (people-centered) view of nature. They both wrote of nature's utility — its *instrumental value* in the terminology of philosophers. One promoted nature as a source of spiritual enlightenment, the other as a source of commodities, but neither claimed that nature had *intrinsic value,* value independent of its usefulness.

With the emergence of the science of ecology and the writings of Aldo Leopold (1886–1948) – known as the founder of wildlife conservation as a professional discipline and, ironically, a man who began his career eradicating predators but ended it as a strong advocate of wilderness – one finds a utilitarian perspective of species being questioned:

> Ecology is a new fusion point for all the sciences. The emergence of ecology has placed the economic biologist in a peculiar dilemma: with one hand he points out the accumulated findings of his search for utility or lack of utility in this or that species; with the other he lifts the veil from a biota so complex, so conditioned by interwoven cooperations and competitions, that no man can say where utility begins or ends. (Leopold 1939)

Leopold was explaining that because nature is an integrated system with transcendent properties and functions beyond a mere collection of the species that comprise it, each species is important as a component of the whole and thus has instrumental value because of its role in an ecosystem. This was the key idea that spawned the *Evolutionary-Ecological Land Ethic*. It took Leopold's ethical vision beyond the choice of either preserving nature as inviolate or efficiently developing it. Muir wrote of the equality of species in religious terms; Leopold expressed equality in ecological terms. Pinchot (1947) stressed the dichotomy between people and nature ("there are just two things on this material earth – people and natural resources"); Leopold thought of people as citizen-members of the biotic system. Leopold's ideas gave people the right to use and manage nature *and* the responsibility of doing so in a manner that recognized the intrinsic value of other species and whole ecosystems. Indeed, he contended that the very tools that had been so frequently used to destroy the environment (namely the axe and the plow) could also be creatively applied to heal it, especially if guided by science.

All three of these ethics are still prevalent. The Resource Conservation Ethic resonates with the natural resource–based industries and the associated government agencies that regulate them (although some would argue a profit

motive is more dominant than a conservation ethic). Some environmental organizations are wedded to the Romantic-Transcendental Preservation Ethic, reflecting a membership that uses nature primarily for spiritual rejuvenation. Consider the Wilderness Society, for example, and its frequent allusions to the spiritual reasons for "saving" nature. The Evolutionary-Ecological Land Ethic characterizes various groups that try to find a practical balance between the needs of people and nature, such as the World Wide Fund for Nature or The Nature Conservancy.

In the conclusion to his essay, Callicott (1990) asks some provocative questions. If people are valid members of the biotic community as Leopold asserts, why do we turn to landscapes without people (at least without industrial era people) to set benchmarks for what is natural? If beavers and reef-building corals can shape landscapes in positive ways, why can't people? Can people improve natural ecosystems? Can they promote and generate biological diversity? These are not simple issues, and we will return to them frequently in this book because this dynamic, often difficult, interface between people and nature is the crux of conservation and conservation biology.

What Is Conservation Biology?

So where does conservation biology fit among these larger issues? Conservation biology is the applied science of maintaining the Earth's biological diversity. A simpler, more obvious definition – biology as applied to conservation issues – would be misleading because conservation biology is both less and more than this. It is narrower than this definition because there are many biological aspects of conservation, such as biological research on how to grow timber faster, improve water quality, or graze more livestock, that are only tangentially related to conservation biology. On the other hand, it reaches far beyond biology into disciplines such as philosophy, economics, and sociology that are concerned with the social environment in which we practice conservation, the reasons we are motivated to maintain biodiversity, and disciplines such as law and education that shape the ways we implement conservation (Jacobson 1990; Soulé 1985). Fifty years ago, maintaining biological diversity simply meant saving endangered species from extinction and was considered a small component of conservation, completely overshadowed by forestry, soil and water conservation, fish and game management, and related disciplines. Now we know that we need a healthy and diverse biota for our own well-being. And with so many species at risk of extinction and the idea of biological diversity extending to genes, ecosystems, and other biological entities, conservation biology has moved into the spotlight as the crisis discipline focused on saving life on Earth, perhaps the major issue of our time (Wilson 1992).

Conservation biology is best conceptualized as an amalgamation of disciplines as depicted in Fig. 1.4 (Jacobson 1990). It sits between basic

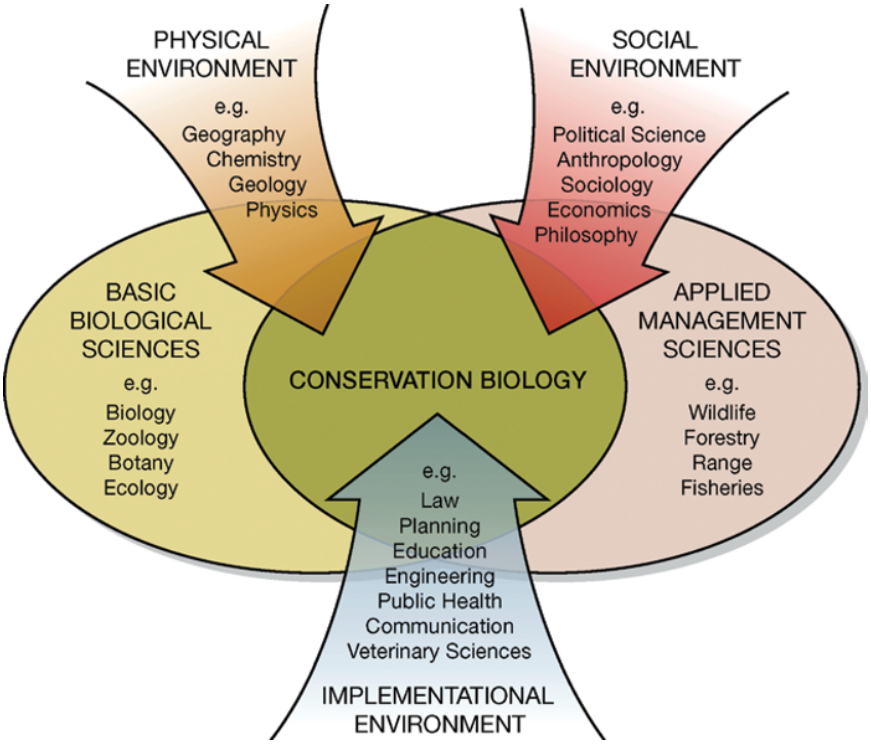

Figure 1.4 A schematic view of the relationship between conservation biology and other disciplines. (Jacobson 1990/ John Wiley & Sons)

biological sciences and natural resource sciences because it originated largely with biologists who have created a new natural resource science. It is different from traditional natural resource sciences because it places relatively greater emphasis on all forms of life and their intrinsic value, compared with traditional other natural resource sciences that usually focus on a few economically valuable species (Soulé 1985). Like natural resource sciences, conservation biology is influenced by the earth sciences because it addresses issues with strong environmental linkages. Finally, conservation biology depends heavily on social sciences, law, education, and other disciplines because it operates in the world of human socio-economic–political institutions and seeks to change those institutions to allow people to coexist with the rest of the world's species.

This model also illustrates how any student wishing to become a conservation biologist needs to focus on courses in the basic biological sciences and the applied sciences of natural resource management while acquiring a substantial understanding of the subjects that shape the legal, policy, social and cultural arena within which conservation operates. This has also led to a growing role and critical role for students with a primary background in law, economics, communication, education and so on, and a secondary foundation in biology. In fact, the term "conservation science" is