Systematics, Natural History, and Conservation: Field Biologists Must Fight a Public-Image Problem

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Systematics, Natural History, and Conservation

Field biologists must fight a public-image problem

Harry W. Greene and Jonathan B. Losos

Field biology has a public-image problem at a time when conservation desperately needs the expertise of systematists and natural historians. Recent anecdotes illustrate this irony.

- The leader of a well-known environmental group visited a research station in Costa Rica and asked pointedly, "When are you scientists going to start *doing* something for conservation?"
- Animal rights advocates in the San Francisco Bay Area demanded that the University of California prohibit all animal research not directly related to human welfare, and they objected specifically to studies aimed at clarifying the biological species status of certain songbirds.
- An employee of a major zoological park congratulated one of us (H. W. G.) on working with animals in the wild, "unlike most herpetologists, who just kill them and count scales."

Even some laboratory biologists view field research as simply an intellectual exercise and ask, "What good does it do?"

Academic scientists long have been involved in traditional conservation activities (e.g., Janzen 1986a, Stebbins and Cohen 1976), but the above vignettes are symptomatic of widespread misunderstanding of field biology among lay people, environmentalists, and even biologists. This article is intended to summarize some important roles of systematics and natural history in the preservation of organismic diversity, suggest ways those roles can be enhanced, and promote their discussion in classes, public lectures, governmental agencies, and conservation organizations.

The importance of systematics and natural history for conservation lies in defining the boundaries of organismic diversity

Roles of systematics and natural history

Systematics encompasses the characteristics, genetic status, and evolutionary history of organisms. Once simply the description of obvious phenotypic variation and the application of formal names, systematics now uses a variety of biochemical, multivariate statistical, and other sophisticated approaches in explicit analytical frameworks (e.g., Gould and Woodruff 1986, Wake and Yanev 1986). Natural history focuses on where organisms are and what they do in their environments, including interactions with other organisms. It encompasses changes in internal states insofar as they pertain to what organisms do (e.g., chronologies of reproductive events; Bartholomew 1986, Greene 1986).

Given increasingly limited resources, society must carefully articulate the reasons for conserving nature, decide which places and species to protect, and determine how to accomplish these goals. Much has been written on why we should preserve species (e.g., Ehrlich and Ehrlich 1981), but recognition of the necessity for choosing among species and potential refuges for preservation is a recent phenomenon (Conway 1980, Lovejoy 1980). Such difficult choices require an evaluation of sites and taxa, and necessarily will involve a "principle of relative replaceability" (Colwell in press); distinctive and unique landscapes, biotas, and evolutionary lineages have greatest value. The importance of systematics and natural history for conservation thus lies in defining the boundaries and contours of organismic diversity.

The nature and geography of genetic and phenotypic variation. The emergence of biochemical systematic techniques has disclosed that genetically distinct units are not always recognizable on the basis of traditional external characteristics. The North American leopard frog, long used for laboratory research, is an impressive example. What is called *Rana pipiens* in hundreds of papers actually comprises at least 20 species, some of them with highly restricted distributions

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(Hillis et al. 1983). Furthermore, there is not always a single entity, "the species," in nature. Instead, there may be reproductive continuity among populations over broad areas, varying levels of hybridization and introgression within reproductively connected populations, or complete isolation of adjacent gene pools (Wake and Yanev 1986). Because a major goal of conservation is to preserve both genetic and phenotypic diversity, comprehensive, modern studies of local and geographic variation must be included in the identification of "least replaceable" biological entities at various taxonomic levels.

Detailed comparisons among living and fossil organisms are the only basis available for inferences about their origins and relationships. It is because of phylogenetic systematics that we can place special value on the coelacanth, the tuatara, and other "living fossils," and that we hypothesize that chimpanzees, not gorillas, are our closest relatives (e.g., Goodman et al. 1983). Such analyses indicate that armadillos, sloths, and anteaters are not only a small group of strange animals, but also that they are one another's closest relatives (the Xenarthra) and among the few survivors of one lineage of the earliest divergence event in the history of placental mammals (Novacek 1986).

In addition to the problem of unrecognized genetic diversity, it is not widely appreciated that even the best known parts of the earth still hold undiscovered organisms. Herpetologists have explored California in great detail for more than a century, yet they continue to uncover new amphibians and reptiles (Table 1). Recent field studies in arid regions have disclosed populations of three salamanders, a toad, an alligator lizard, and a garter snake that are distinctive and new to science.[1]

Such discoveries are often not merely minor variants of known organisms, but dramatically different. Just over a decade ago, in a desert canyon, scientists discovered *Batrachoseps campi*, the largest and morphologically most primitive living species in a well-known genus of common California salamanders (Marlow et al. 1979). In the early 1970s, a third species of living peccary was discovered in the Chaco region of Paraguay, more different from the two known species than they are from each other (Wetzel et al. 1975). The proportions of tropical biotas that are still undescribed are, of course, far larger than in temperate regions, and the need for understanding them is especially urgent (Wilson 1984).

What good does it do to study snakes? This emerald tree boa, *Corallus caninus*, is a 1.5-meter-long snake endemic to South American lowland tropical rain forests. Photo: H. W. Greene.

Research museum specimens, the core of systematic biology, provide documentation for systematic conclusions and future analyses; both are necessary because conservation often resolves to political, legal, and economic confrontations (e.g., Dodd 1982, Gallaway et al. 1985). Given the ongoing environmental changes now occurring globally, repeated sampling is also imperative to assess short-term changes (e.g., the effects of DDT on bird eggshells were first detected with museum specimens; Foster 1982). Ideally, specimens (including tissues and other nontraditional material) would represent geographic and recent temporal variation in all taxa. That goal will never be possible for most species, because of the general difficulty in obtaining specimens and the inadvisability of doing so in the case of genuinely rare forms. These factors make adequate representation of common, easily studied taxa all the more important.

How organisms interact with the environment and each other. The information implicit in Joseph Grinnell's concept of an ecological niche, that "range of values of environmental factors that are necessary and sufficient to allow a species to carry out its life history" (James et al. 1984), will always be crucial to the management

Table 1. Numbers of amphibian and reptilian taxa in three summaries of California herpetology, based on Stebbins (1954, 1966, 1985). A frog and a turtle, recently introduced, are not included in the 1985 counts.

Taxa	1954	1966	1985
Frogs	16	20	22
Salamanders	17	18	24
Turtles	4	4	4
Lizards	32	34	36
Snakes	32	33	35
Totals	101	109	121

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[1] T. J. Papenfuss, 1988. Personal communication. Museum of Vertebrate Zoology, University of California, Berkeley.

of wild and captive animals, as well as to assess ecological divergence as a measure of relative replaceability. Ideally, we need to characterize in detail the geography of organism-environment interactions for each species of interest (Grinnell 1917), so that predictions can be made about unstudied sites.

Although detailed ecological and behavioral inventories are impossible for many species because of their rarity and the difficulty of study as well as the sheer magnitude of the task, often extrapolation from a few investigations is useful. Jaguars (*Panthera onca*) occurred within historic times from the southern United States to temperate South America, but they are now extinct in some areas and so rare as to be essentially unstudiable in many others. However, four projects in divergent habitats show that certain generalities characterize their ecology: these cats typically are associated with watercourses, even in xeric regions, and their diet is always both broad and focused on a few especially common, moderately large, prey species (Table 2).

Areas to be saved. After more than a decade of debate, it is clear that no simple relationship between area, species richness, and endemism can guide the design of refuges (Soulé and Simberloff 1986, Zimmerman and Bierregaard 1986). Criteria for establishing refuges must vary with goals and local circumstances, but systematics and natural history provide crucial raw data on the geography and underlying mechanisms of species richness. Those disciplines delimit areas and components of high endemism (Prance 1982) and point to critical ecosystem factors (e.g., "keystone mutualists," Gilbert 1980, Terborgh 1986; inclusion of peccary wallows as breeding ponds for certain frogs, Zimmerman and Bierregaard 1986). They thereby define potential gains and losses in alternative conservation strategies.

How organisms should be managed. The importance of systematics and natural history in effective captive maintenance is obvious (e.g., Kleiman et al. 1986, Murphy and Collins 1980), and these disciplines also help zoos define critical taxa on which to focus scarce resources. Potential genetic compatibility must be assessed for management of captive populations and reintroduction programs to avoid the deleterious effects of inbreeding depression (Ralls and Ballou 1983), outbreeding depression (Templeton et al. 1986), and production of ecologically inappropriate phenotypes. For example, when ibex from Sinai and Turkey were introduced to Czechoslovakia, they gave birth in winter; then introgression from local stock led to hybrids that also bred out of season, and the entire population perished (Greig 1979).

Why and how nature should be appreciated. For conservation to succeed, wild organisms and places must have value in human society. The myriad interactions among plants and animals hold countless examples of novel solutions to problems with analogues in human welfare (Colwell in press, Ehrlich and Ehrlich 1981, Wilson 1984). Field biology can enhance those values and their cultural acceptance, in that knowledge exposes the practical applications and inspires esthetic rewards. Indeed, since ethnobiological research incorporates systematics and natural history (e.g., Patton et al. 1982), those disciplines also can assist the transfer and evaluation of cultural knowledge among human societies.

Television nature programs are increasingly popular, and a visit to any major bookstore confirms the enormous public demand for field guides and books about wilderness. The information sought focuses on identification and the interactions among free-living organisms and environments, all of it based on field biology. A nature tourist's questions about garter snakes at a pond in California can be answered with more accuracy today because herpetologists continue to struggle with this difficult group (Stebbins 1954, 1966, 1985). Examples of convergent evolution, such as gliding adaptations in diverse reptiles and mammals, are widely used in environmental education. Usually left unstated is the fact that we could not marvel at the striking resemblances of unrelated organisms from distant, similar environments without phylogenetic evidence that the similar traits were indeed independently acquired (Luke 1986).

The future: What's needed now?

Three widespread fallacies downplay the importance of field biology. The first is that field guides and other popular nature books are miraculous gifts to humanity; a corollary is that television nature programs convey information gained fresh by the narrator, or perhaps the filmmaker. The second fallacy is that we now know everything about nature that will be necessary to save it; less extreme versions are that we do not require precise information in cases where it is lacking, or that this information can be gained on short notice. The third, perhaps most cherished, fallacy is that we can still devote ourselves primarily to ideals of pristine ecosystems. Conservation then would be simply a matter of buying large tracts of land, and there would be no need for extensive knowledge and management.

The realities are stark and unambiguous. However far back one could talk of pristine ecosystems—a century or several millennia—it was long enough ago to be of limited relevance today (Martin and Klein 1984). A global extinction crisis is fast upon us, the impact continues to accelerate in many quarters—especially in the richest and most fragile ecosystems, and the solutions must be largely in place within our lifetimes. Even the world's largest parks are inevitably embedded in adjacent human cultures and will require active management (e.g., Carr 1988, Chase 1986, Janzen 1986b). Unfortunately, we still know little about the lives of many large, popular vertebrates in those reserves, and we know nothing about most species of small animals beyond their existence. The political forces opposing conservation are powerful and clever, and, despite our ignorance, the best possible data must be used to counter them. Tellico Dam was not delayed for years because of some casual observer's *intuition* that a small, nondescript, snail-eating fish *might* be new to science and endangered by its construction. Instead, careful studies on a taxonomically difficult group disclosed that a new and unusual species of darter inhabited the Little Tennessee River.

Unfortunately, systematics and natural history are misunderstood, and

Table 2. Geographic variation in habitat and diet of jaguars, *Panthera onca,* based on detailed studies at four sites. Percent occurrence and total number of items in diet samples in parentheses.

Location	Habitat	Diet	Reference
Pantanal, Brazil	Swamp, gallery forest, savanna	Various vertebrates, but predominantly one species of large rodent	Schaller and Vasconcelos (1978)
Manu, Peru	Seasonally flooded primary rain forest	Various vertebrates, but turtles and caimans were prominent items (33%, N = 40)	Emmons (1987)
La Selva, Costa Rica	Primary rain forest	Various vertebrates, but sloths (46%) and green iguanas predominated (N = 59)	H. W. Greene, H. E. Braker, and M. A. Santana (unpublished data)
Cocksomb, Belize	Secondary rain forest	Various vertebrates, but armadillos predominated (54%, N = 185)	Rabinowitz and Nottingham (1986)

their progress impeded at the very time when they should play a crucial role in global conservation. Species are literally going extinct before they can be formally described, let alone studied and legally protected (Wilson 1984). What we know about nature represents the accumulation of decades of painstaking research by thousands of people with diverse expertise. The missing information will come much harder, yet the task is increasingly burdened with bureaucracy. Field biologists now must fill out mountains of redundant paperwork, try to persuade institutional animal-use committees that accurate information is important, and pay fees to wait months for research permits that may never materialize. Ironically, the discovery of new species often underscores areas that need special protection (e.g., the Chaco peccary and its habitat), whereas the negative impact of research on most wild populations is trivial compared with that of human greed, technology, and population growth. Of the almost 62 million bird deaths annually from human-related causes in the United States, 61.5% result from hunting, 32% result from collisions with manmade objects, and only 0.01% are from scientific collecting (Banks 1979).

We need broader understanding by society of the obligate roles of field biology in environmental appreciation, education, and conservation. Gratuitous, divisive polemics from other environmentalists (as in the anecdotes described early in this article) waste time and energy that could be devoted to solving serious problems. Opposition from animal-rights groups emphasizes the lives of a few individual animals, rather than the health of populations; without consideration of the benefits of research and provision of alternatives, that opposition amounts to fiddling while the biosphere burns. Governmental controls on field biology should be streamlined to avoid redundant paperwork and actively encourage responsible research. A good yardstick would be, "Is this legislation's overall effect on nature conservation positive?"

Given the magnitude and urgency of nature conservation problems, governmental funding for basic research in systematics and natural history is pitifully inadequate (Ehrlich 1986, Wilson 1985). Massive increases in financial support for field biology are needed, as is appreciation by funding agencies of the connections between basic biology and conservation. Training of new systematists throughout the world is especially important (Foster 1983, Wilson 1985). In this regard it is heartening that the National Science Foundation is considering formal support for such interactions (Anonymous 1987).

The problem, of course, is partly of our own making. Many field biologists derive immense personal satisfaction from the activity itself, and, therefore, some see little need to communicate formally with lay people. Even textbooks written by organismal biologists rarely discuss systematics as a modern scientific discipline, let alone its relationship to broader societal issues. Cinematographers and journalists routinely rely upon scientists for information and direct assistance but, beyond listing names in the credits, the underlying research activities usually are not reflected in the final public product.

Field biologists, especially those with talents for communication, can seek opportunities to explain the methods and ramifications of systematics and natural history. We should include implications for conservation and management in primary research papers, write popular articles, talk with visitors at study sites, interact with local agencies, explain our research to undergraduates, and insist that the media integrate the role of scientific studies in their reports. Educators should treat systematics and natural history as important, modern disciplines—if monoclonal antibodies deserve a special, explanatory box in textbooks, so do museum curation techniques and cladistics. Farmers, bankers, and biochemists cannot be expected to appreciate automatically the roles of systematics and natural history in society. If we do not take an active part in educating the public, who will?

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