A Fifty-Year Plan for Biodiversity Surveys

Peter H. Raven and Edward O. Wilson

In the wake of the recently completed "Earth Summit" in Rio de Janeiro, it should be evident why biological systematics, hitherto regarded as "little science," is badly in need of growing large—and soon. The roughly 1.4 million species of living organisms known to date are probably fewer than 15 percent of the actual number and by some estimates could be fewer than 2 percent. The Linnaean shortfall reaches from supposedly well-known groups to the most obscure, as illustrated by the following examples:

1) Eleven of the 80 known living species of cetaceans (whales and porpoises) have been discovered in this century, the most recent in 1991; at least one more undescribed species has been sighted in the eastern Pacific but not yet collected.

2) One of the largest shark species, the megamouth, constituting the new family Megachasmidae, was discovered in 1976 and is now known from five specimens.

3) During the past decade, botanists have discovered three new families of flowering plants in Central America and southern Mexico; one, a remarkable relict, is a forest tree that is frequent at middle elevations in Costa Rica.

4) The most recent new animal phylum, the Loricifera, was described from the meiobenthos in 1983; many additional new species in the group have since come to light.

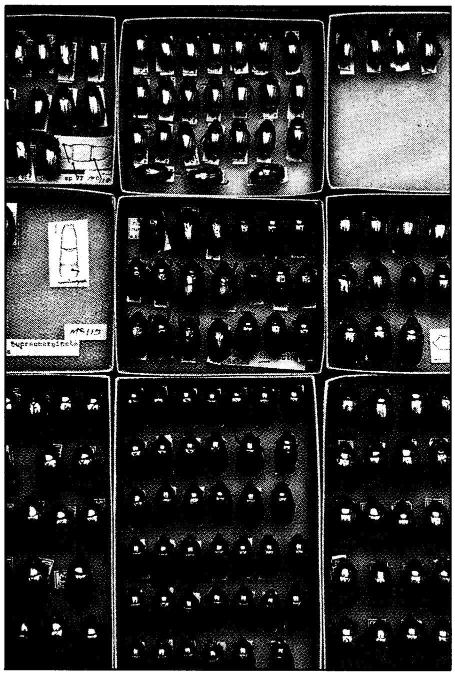
5) The great majority of insects in the canopy of tropical rain forests, possibly in excess of 90 percent in some groups, remain unknown.

6) Although only 69,000 species of fungi have been described thus far, a leading specialist estimates that the world total is 1.5 million or more.

7) The number of bacterial species recognized by microbiologists is about 4000, but the huge majority in existence remain incommunicado and hence undiscovered, because their culturing requirements are unknown. Recent studies in Norway indicate the presence of 4000 to 5000 species in a single gram of beach forest soil and a comparably large but different array in a gram of nearby marine sediment.

P. H. Raven is the director of the Missouri Botanical Garden, St. Louis, MO 63166–0299. E. O. Wilson is Frank B. Baird Professor of Science and Curator in Entomology, Harvard University, Museum of Comparative Zoology, Cambridge, MA 02138–2902.

Clearly, progress toward an overall knowledge of the Earth's prodigious biodiversity over the past 250 years has been very slow. Close attention to this problem might be postponed for the delectation of future generations, except for two compelling circumstances. On the positive side, biodiversity represents a potential source of wealth in the form of new crops, pharmaceuticals,



SHARON GUYNAP

Biodiversity. Multiple species of *Plusiotis* beetles from the INBio collection in Costa Rica.

petroleum substitutes, and other products. If used wisely, wild species will also continue to provide essential services to the ecosystem, from the maintenance of hydrologic cycles to the nitrification of soils. On the negative side, biodiversity is disappearing at a rapid rate, primarily due to habitat destruction. Tropical deforestation alone is reducing species in these biomes by half a percent per year, as estimated by the conservative models of island biogeography. This figure is likely to be boosted many times when the impact of pollution and exotic species is determined and factored in. Coral reefs, the marine equivalent of rain forests in magnitude of diversity, are also in increasing trouble.

There is growing recognition of the need for a crash program to map biodiversity in order to plan its conservation and practical use. With up to a fifth or more of the species of all groups likely to disappear over the next 30 years, as human population doubles in the warmer parts of the world, we are clearly faced with a dilemma. But what is the best way to proceed?

Some systematists have urged the initiation of a global biodiversity survey, aimed at the ultimate full identification and biogeography of all species. Others, noting the shortage of personnel, funds, and above all, time, see the only realistic hope to lie in overall inventories of those groups that are relatively well known now, including flowering plants, vertebrates, butterflies, and a few others. In order to accomplish this second objective as quickly as possible, it would be necessary to survey transects across broad geographic areas and to examine a number of carefully selected sites in great detail. A reasonable number of specialists is available to begin this task, and with adequate funding it could be completed in a decade. The results would reveal a great deal about patterns of endemism, including the existence of hot spots, those parts of the world believed to contain the largest numbers of endangered species. They could be applied directly to problems of economic development, land use, science, and conservation. Meanwhile, adequate numbers of specialists could be trained and supported to deal with all of the remaining groups of organisms. The aim would be to gain a reasonably accurate idea of the representation of these groups on Earth while attempting complete inventories of all the global biota over the course of the next 50 years. As most of the tropical rain forests of the world are likely to be reduced to less than 10 percent of their original extent during this half-century, adequate planning is of the essence. The results from inventories should be organized in such a way as to apply directly to the development of new crops, sustainable land use, conservation, and the enhancement of allied disciplines of science.

In order to propel systematics into its larger role foreordained by the biodiversity crisis, its practitioners need to formulate an explicitly stated mission with a timetable and cost estimate. In the approach outlined above, the 50-year period could be viewed as a series of successive 10-year plans. As each decade approaches an end, progress to that point could be assessed and new directions for the next decade identified.

Momentum in the enterprise will result in economies of scale. Costs per species will fall as new methods for collecting and distributing specimens are invented and procedures for storing and accessing information improved. Costs are moreover not simply additive when higher taxa are added, but instead fall off on a per-species basis. For example, entomologists could collect nematodes on the insects they gather, while identifying these hosts for the nematologists—and vice versa. Multiple groups can be collected by mass sampling of entire habitats and then distributed to systematists specializing in individual taxa.

The results of inventorying, as opposed to the costs, are not just additive but multiplicative. As networks of expertise and monographing grow, ecologists, population biologists, biochemists, and others will be drawn into the enterprise. It is also inevitable that genome descriptions similar to those now planned for the human species and *Drosophila* will feed into the database. Molecular biology is destined to fuse with systematics.

Applied systematics can develop collaterally with basic studies, as is being demonstrated by the organization of the Instituto Nacional de Biodiversidad (INBio) in Costa Rica. Chemical prospecting, the search for new natural products, is readily added to the collection of inventories. So is screening for species and gene complexes of special merit in agriculture, forestry, and land reclamation.

Fully 80 percent of the Earth's terrestrial biodiversity is likely to occur in the tropics where only a few groups of organisms can be described as reasonably well known at present. Aside from the roughly 170,000 flowering plants and 30,000 vertebrates, only about 250,000 species of all groups appear to have been described thus far. With estimates of the remainder ranging from 8 million to 100 million, one can readily appreciate the magnitude of the task at hand, and the fact that the few hundred systematists available are woefully inadequate to complete the task while most of the species are still in existence. We require, in fact, a wholly new approach to this great problem in order to be able to provide even an outline of the nature and occurrence of these species.


PETER ARNOLD, INC. ©, FRED BAVENDAM

Coral reefs. The marine equivalent of rain forests.

Abdus Salam has estimated that some 6 percent of the world's scientists and engineers live in developing countries, with a rapidly increasing share of 77 percent of the world's population, 15 percent of the world's wealth (by gross national product), and perhaps 20 percent of the world's industrial energy. A net sum amounting to tens of billions of dollars flows annually from these countries to the rich industrial parts of the world. These relations must be taken into account if our common objective is to chart the outlines of global biodiversity, use it for humanity's benefit, understand it scientifically, and preserve an intelligently selected sample of it for the future.

We believe that the best strategy for approaching this task is the implementation of national biological surveys throughout the world, conceived like INBio, and set up as management strategies for each nation's biodiversity. Such operations will expedite the increased understanding, efficient use (assisted by biotechnology transfer), and conservation, both in nature and ex situ, of as many organisms as possible. They will allow people of every nation to see themselves as benefiting from their own biodiversity, while preserving it for their own purposes.