"Our data are in remarkable agreement with those previously obtained [by Sibley and Ahlquist]," reported Powell and Caccone. Not only did these new data give the same evolutionary tree—grouping chimpanzees more closely to humans than to gorillas—but they also gave precisely the same genetic distances claimed by Sibley and Ahlquist. "Whatever charges have been brought against Sibley and Ahlquist, their work has passed the acid test of science," Powell told *Science*. "They have been replicated in an independent laboratory."

Marks' argument that Powell's data are irrelevant is this: "He is not replicating their data; he's getting similar conclusions to the conclusions that Sibley and Ahlquist have not been willing to substantiate." Britten dismisses this as "pretty tortuous." He does note, however, that as Powell and Caccone's method of DNA hybridization is technically different from the one used by Sibley and Ahlquist, "it is not strictly speaking a *replication* of Charles' results, but it is certainly a *confirmation* of them."

Although Powell and Caccone's results clearly bring comfort to Sibley and Ahlquist, they also bring something of a mystery. The mystery is this: if, as DNA hybridization apparently indicates, the genetic distance between gorillas on one hand and humans and chimpanzees on the other is substantial, why have other molecular techniques not readily picked this up?

It is true that after Sibley and Ahlquist first suggested the human/chimp association in 1984, several research groups using techniques such as DNA sequencing, restriction-enzyme mapping, and protein electrophoresis have since reported the same shape for the human/ape evolutionary tree. But the genetic distance indicated between gorilla and human/chimpanzee has typically been about one quarter of that given by DNA hybridization. Are these techniques missing something? Or is there something consistently amiss with DNA hybridization?

Meanwhile, the conflict over the Sibley/Ahlquist data has for the moment cast something of a pall over the use of DNA hybridization in molecular phylogenetics. There is no doubt that Sibley and Ahlquist were seriously in error in making substantial, unreported alterations to their data, and Sarich and his colleagues deserve credit for bringing this to light. Exactly how much impact these corrections, and subsequent interpretation, will have on the body of work as a whole remains to be seen. But the very combative and partisan tone with which the challenges have been made has not advanced Sarich and his colleagues' stated concern with scientific integrity.

■ ROGER LEWIN

Hard Choices Ahead on Biodiversity

With many species on the verge of extinction, biologists call for a quick and dirty survey to chart the biodiversity of the planet

FACED WITH STARTLING NEW EVIDENCE that tropical rainforests may be disappearing at an even faster rate than previously believed, a number of prominent biologists are calling for an immediate effort to chart the biological diversity of the planet.

The idea is a quick and dirty survey, using whatever tools are at hand, to identify areas rich in biodiversity—areas that house many species, or species that exist nowhere else—so that they can be protected before they disappear. There is no time for exhaustive studies, elaborate phylogenies, or science as usual, says Thomas Lovejoy, assistant secretary for external affairs at the Smithsonian Institution: "The problem is very big and the fuse very short." Although hard and fast numbers are difficult to come by, it is estimated that half the world's species will be lost within the next century, mostly to deforestation.

Lovejoy called for the mapping endeavor, an idea that has been in the air for a couple of years, at a meeting on biodiversity attended by more than 3000 scientists last month in Davis, California.* By his "top of the head" estimate, it might take 2 or 3 years to complete and cost \$250 million to \$500 million. The tab for protecting critical areas would, of course, be considerably higher, climbing into the billions by some estimates.

The proposal comes at a propitious time. Both the populace and the pols are increasingly interested in the biodiversity crisis, as the worldwide loss of species is called. No doubt, its links to global climate change, as well as the new groundswell of concern about the environment, have helped to bring what some have considered an esoteric topic into the mainstream. Last session in Congress Representatives Claudine Schneider (R–RI) and James Scheuer (D–NY) introduced a bill, with some 87 cosponsors, that would make the conservation of biological diversity a national priority and would allocate substantial funds for data management and biotic surveys, among other things. While unlikely to pass this year, the bill nonetheless signals the arrival of biodiversity on the national agenda.

In a move that signifies serious interest, the National Science Board, the policy body of the National Science Foundation (NSF),

*The annual meeting of the American Institute of Biological Sciences, 14 to 18 August 1988.

T.E. Lovejoy

Slash and burn: *The fate of an increasing proportion of tropical rainforests.*

Deforestation in progress: *The Amazon, Brazil, where 20 million hectares of forest were burned last year, almost half of which was virgin rainforest.*


R.O. Bierregaard

has set up a special task force to advise NSF on what it can do to study and preserve biodiversity. Thus, badly needed research money may be forthcoming.

The World Bank and World Wildlife Fund are drawing up an "action plan" to protect the unparalleled flora and fauna of Madagascar. At the United Nations Environment Programme, there is talk about a new international convention to protect biodiversity. The Pontifical Academy is considering the problem. And the Grateful Dead had a concert at Madison Square Garden this month to raise money for tropical rainforests.

In the face of this new interest, and perhaps new money, biologists are increasingly grappling with how to set priorities in both conservation and research—a process that has engendered no small debate among people who are otherwise united in the goal of conserving biodiversity. The debate was much in evidence at Davis, where one heretic, James Brown of the University of New Mexico, went so far as to suggest that all species do not need to be saved.

Since the last major symposium 2 years ago, discussion has clearly shifted from a somewhat arcane accounting of the number of species and rate of extinction to a more practical focus on what to do, and how to do it—fast. "I am utterly convinced that most of the great environmental struggles will be either won or lost in the 1990s," said Lovejoy, "and that by the next century it will be too late."

The sense of urgency is fueled in part by new data from Brazil. Alberto Setzer of the Brazilian Institute of Space Research reported last month that in 1987, 20 million hectares of Brazilian Amazon forests were burned, mostly for agriculture, 8 million of which were primary, virgin rainforest. That translates into a rate of loss for primary forests of 15 hectares a minute in Brazil alone, calculates Lovejoy—an estimate that was dismissed as extreme a few years ago as the rate of *worldwide* deforestation. And that is from burning alone, not clear-cutting, and just in the Brazilian part of the Amazon.

Not only does this mean the loss of lush tropical forests, home to perhaps half of the world's species, but the fires are estimated to contribute about one-tenth of global man-made emissions of carbon dioxide, the principal greenhouse gas. Thus, the data are a striking reminder of how interlinked the problems of deforestation, loss of diversity, and climate change are, and how complex solutions will be.

Without question, the root causes of deforestation and other forms of habitat destruction—population growth, economic development, and international debt—must be addressed, as several speakers at the meeting noted. But by the time those knotty problems are resolved, little will be left. That is where the quick and dirty survey comes in.

The idea is to focus on six or eight taxonomic groups—freshwater fish, for example—to find areas of high diversity or high endemism (where there are species found nowhere else), and among those to identify the most important ones in need of immediate protection. The assumption is that these groups, if correctly chosen, will serve as "exemplars"—in other words, that an area of high diversity for freshwater fish would also be an area of high diversity for other freshwater organisms. It's an admittedly "iffy" hypothesis, concedes Lovejoy, but it is the best that can be done in the time at hand.

At first cut, says Lovejoy, it would make sense to survey butterflies, freshwater fishes, woody plants, and birds and other vertebrates. The number of sites would vary by group. For birds, which are already well studied, it might be necessary to look at just a few sites to see that things have not changed. For other groups, a couple of hundred sites might be necessary. And at a selected number of sites, perhaps 100 or 200, says Lovejoy, it would make sense to look at all the groups.

A similar idea was outlined in the 1980 National Research Council report, *Research Priorities in Tropical Biology*. In its current incarnation, it has been informally endorsed by systematists and conservation biologists alike, who often part ways on how to set priorities, including Peter Raven of the Missouri Botanical Garden, Edward O. Wilson of Harvard University, and Michael Soulé of the University of Michigan.

The quick map is a significant departure from Wilson's proposal of a few years ago for a complete survey of diversity on the planet, an attempt to find out, once and for all, exactly how many species there are: 5 million, 10 million, or perhaps 30 million, as Terry Erwin of the Smithsonian Institution has suggested. To date, only about 1.7 million species have been cataloged.

"It's a laudable goal, says Lovejoy of Wilson's survey, but time is too short." Raven agrees: "In the tropics there are 8 million or more undescribed species, and there are only about 1500 systematists in the world who have the capacity to deal with tropical organisms. So the practical chance of getting an encyclopedia, a complete inventory, is very limited."

"I'll take anything I can get," says Wilson, who adds that this new survey is "far better than doing nothing, and it is better than the haphazard way we have been doing things."

Even so, the survey would be a massive task, requiring the coordinated efforts of biologists around the world to build on existing data and then fill in the gaps. Bits and pieces of this work have already been done or are under way, like Michael Goulding's work on freshwater fish in the Amazon, and the extensive databases maintained by the International Union for the Conservation of Nature and Natural Resources (IUCN) and the Nature Conservancy.

And at the National Museum of Natural History in Washington, Erwin has just embarked on what could be a prototype of this global mapping endeavor. As part of the new BioLat program at the Smithsonian, Erwin is looking at key taxonomic groups at a few sites in Bolivia and Peru.

How the venture would be funded has not been addressed—the survey has yet to be formally proposed—but one possibility is partly through NSF. The newly established task force on biodiversity, on which Raven and Wilson serve, will recommend what NSF should pursue when it reports to the National Science Board early next year.

Beyond the rough map, agreement breaks down, and fundamental questions remain about the best way to proceed. Perhaps the biggest rift is between conservation biologists and systematists, whose desire for detailed inventories and taxonomic studies are seen as inherently at odds with the rapid action needed for conservation. Their differences would not be so pronounced were not both groups vying for what to date has been a very small pot of funds.

"We can describe everything and then end up with a catalog of extinct species," mutters Soulé, president of the new Society for Conservation Biology.

Responds Raven, a key spokesman for the systematist camp: "I'm all for action, God knows we need it, but you can't neglect the knowledge base and get the job done." Systematics and conservation need not be at odds, Raven says, if they proceed simultaneously.

His gripe is that basic taxonomic research and training of scientists in the tropics—"one of the most vital and urgent things we can do"—are often overlooked or accorded low priority in conservation plans.

Nor is there agreement on which conservation strategies to pursue. Several conservation groups have been advocating a focus on critical areas, or "hotspots" of diversity, such as would be identified in this quick survey. Russell Mittermeier of World Wildlife Fund favors focusing first on the "megadiversity" countries—the 13 countries that house some 60% of the world's species.

But the real heretic at the Davis meeting was Brown, who questioned the two fundamental strategies of conservation, or at least the near-exclusive reliance on them: preserving endangered species and setting up reserves of pristine habitat.

"I am not arguing that those approaches should be abandoned, but that by themselves they are not enough," says Brown. Many species are already doomed, he says, and not all species are essential. Perhaps most important, preserving endangered species is expensive. "We can't afford to be concerned about the loss of some species."

The basic problem with reserves, contends Brown, is that most species don't live there. Reserves now account for only 1% of the world's land area, and though the figure may double soon, there are limits to expansion because few pristine habitats are left. In addition, most reserves are too small to save some endangered species.

Rather than focusing on these two strategies, Brown calls for increased attention to alternatives, especially management of 85% of the world's land that is nonurban and nonagricultural. The fate of most species, says Brown, will depend on what happens in this "semi-natural matrix" where most of the species reside, the land used by humans for mining, timbering, and grazing livestock. If these surrounding lands are degraded, then the reserves—often only small islands of pristine habitat—do not stand a chance, says Brown. He envisions land-use planning on a national scale and, eventually, planning among nations.

People quibbled with some of Brown's conclusions, pointing out, for instance, that in the tropics the only hope for survival for most species is in reserves. But it was the talk of triage, although Brown never uttered the word, that hit a raw nerve.

"Jim Brown has returned to the concept of triage," said Lovejoy. "I find that to be a very unattractive policy, at least if stated to the outside world. Triage is hard to practice wisely, other than what we are doing now, which is spending what money there is in the most intelligent way."

To Soulé, Brown's views reek of "endangered species bashing," which is increasingly popular nowadays. "Everyone has decided that there is too much attention on endangered species, or just species in general, and that they are detracting resources from the problem of ecosystem preservation. But it is an artificial dichotomy. If it weren't for the large mammals like the pandas and elephants, we wouldn't have any habitat left."

He also questions the arrogance inherent in such decisions. Says Soulé: "I am not ready to have experts say thumbs up or thumbs down on some species without letting the public know."

To Lovejoy, it is also a question of strategy. "This is biology's moment in history. We have to set our sights high and not be afraid of the cost, rather than to start admitting defeat and say triage is necessary."

Brown, by contrast, chides his colleagues for their emotionalism. "Most of us are in this business because we love wild creatures and wild places. We start with an emotional involvement. But some of that has to be put aside when we start acting like scientists." He calls on them to use scientific criteria to allocate resources among alternatives.

Brown has an ally of sorts in Raven, who points out that such decisions can be made on a number of grounds, not just scientific. Says Raven: "What species survive is up to us, and we have to make hard choices. I call for intelligent decisions on which species to save and how to do it. We can decide on scientific, aesthetic, emotional, or economic grounds." ■ LESLIE ROBERTS

Chips Made with X-ray Lithography

International Business Machines Corp. recently took an important step toward development of a 64-megabit memory chip, the powerful chip that is expected to be at the heart of advanced computers in the mid- to late 1990s. The company announced it has become the first to use practical x-ray lithography to make advanced computer chips. X-ray lithography, an etching process that can produce smaller circuit patterns than the optical systems now in commercial use, is widely seen as an essential tool for making the tiny circuits needed in coming generations of chips.

The importance of the x-ray lithography work, said IBM's Alan Wilson, is that the company has made complete computer chips using processes and techniques similar to what could be used in a full-scale manufacturing environment, rather than in a laboratory environment. "We tested it in such a way that we weren't cheating," he said.

Two factors—the size of a chip and the size of the individual components on the chip—determine the chip's maximum capacity. The densest chip made commercially is the 1-megabit dynamic random-access memory (DRAM) chip, which has a resolution of just over 1 micrometer. For comparison, the resolution of the individual components on IBM's chips was 0.5 micrometer, and the 64-megabit DRAM is expected to need a resolution of about 0.35 micrometer to squeeze all the necessary components onto it. IBM's chips were 25 millimeters square, or about twice the projected size of the 64-megabit memory chips.

The race to build chips with higher capacities is in large part a race to make the individual components on the chips smaller, while at the same time keeping the size of the chip relatively large and keeping the manufacturing process efficient and cost-effective.

Integrated circuit chips are laid down layer by layer on a base of semiconducting material, usually silicon. A layer typically consists of a collection of lines or rectangles