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Conservation in South America: Problems, Consequences, and Solutions

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Lack of solid data on rates of habitat conversion and on the basic biology of Neotropical organisms makes predictions of massive waves of extinction in South America premature. South America's problems regarding the use of natural resources are a result of historical, sociological, economic, and scientific factors. Most countries in South America have done a great deal to encourage conservation efforts, but the magnitude of the problem is well beyond their limited economic means to solve. The problems of species disappearance in South America are of global importance. A successful solution will involve a coordinated and massive effort of governments and specialists in all aspects of conservation biology from throughout the world. There is still time to resolve these problems. Unnecessarily dire predictions of species extinction may be counterproductive to the development of a long-term conservation strategy that is needed to manage Neotropical conservation problems.

ECOLOGISTS HAVE BEEN AWARE FOR DECADES THAT THE largest known ecosystem is the biosphere. The biospheric concept holds that all life is ecologically interrelated because the global ecosystem has many biotic and abiotic components that affect numerous subsets of the system. The world's weather patterns, for example, illustrate how quickly perturbations in one part of the biosphere can have repercussions throughout the entire system (*1*). Recent ideas regarding the global effects of nuclear war (*2*) are based primarily on climatic models showing atmospheric mixing around the world, as well as on a model devised to account for global extinctions resulting from a localized meteor impact (*3*). A nuclear winter scenario is feasible because of the interrelatedness of the ecosystems of the biosphere.

I place this article in a biospheric context because broad-scale ecological problems have little to do with national boundaries. In our complex world, where multiple links of commerce, communica-

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tions, and politics join all countries to a remarkable degree, the suggestion that ecological problems of large magnitude can or should be solved only at a local level is unrealistic. We are all involved in biospheric problems.

Loss of species and habitats in South America is not as globally threatening as nuclear destruction, but it is potentially quite serious. However, this topic has become an emotional issue. Cataclysmic terms have been used in describing the immediate future of the world's richest flora and fauna, and, in some cases, an air of hopelessness pervades the reports. How threatened are the ecosystems of South America, and what database supports such a negative view of their survival probabilities? Are we on the verge of waves of extinction that would be exceeded only by a nuclear holocaust? I examine here the nature of the conservation problem on the continent and suggest the scope of the program that is required to solve it.

Biotic Resources of South America

Macrohabitats in South America are extensive and diverse. From the massive Amazon Basin to the arid steppes of Patagonia, the continent supports abundant fauna and flora. Great diversity also exists within each macrohabitat. The Amazon forest, for example, is made up of at least seven distinct phytogeographic regions (*4*), and xeric habitats are found in at least eight desert or semidesert regions (*5*). But South America is more than the Amazon, and all of its habitats are affected by human activities.

Continental South America comprises 12% of the world's land area, yet its biotic resources are extraordinarily rich (*6*): it contains about 800 species of terrestrial mammals, 19% of the world total; approximately 90,000 species of flowering plants are found there (more than one-third of the world total); less than a square mile of forest in Colombia's Chocó may support more than 1100 species of trees; a hectare or less of forest in the Brazilian Amazon supports more than 500 species of trees and shrubs.

A discussion of the causes of such high diversity are beyond the scope of this article, but many factors have been suggested. Such a richness of species excites biologists and challenges them to explain it. Research on South America's living and extinct biota has affected biologists' views on evolution, floral and faunal development, ecology, biogeography, and other important scientific concepts. The continent has been nature's primary laboratory from the time of Darwin, and most of our major researchers in the intervening period have been motivated to decipher its past and understand its present. Now we are faced with requests to predict its future, but unfortunately, our scientific foundation in this area is especially slippery.

The Conservation Issue

Any ecological question is complex, and frequently such questions include consideration of morality, individual versus collective rights, and other issues generally in the purview of sociologists or philosophers. Ecology has been termed a "subversive science" (*7*); many ecological problems are the result of the adverse effects of human activities on ecosystems (for example, pesticide use, agricultural practices, and overpopulation). Conservation of resources impinges on all these issues and more. What are national resources and what are world resources, for example? Is a country morally or legally obligated to preserve a biospheric resource?

Are South America's ecosystems threatened? Many reports suggest widespread degradation of natural resources on the continent. Myers (*8*), for example, has predicted broad-scale extinctions in the next quarter to half century and has drawn support from scientists in diverse fields (*4, 9*). His reports are widely cited and influential, but several investigators believe that his estimates of forest disappearance rates are much too high (*10*); others (*11*) have suggested that the rates Myers uses are too conservative.

Why should a topic of such importance be seriously questioned? It is viewed as axiomatic that much of South America's fauna is endangered, particularly such groups as carnivores and primates (*12*), but in 1981, a shipment of 435 jaguar skins was reportedly intercepted in the Brazilian pantanal (*13, 14*). How many jaguars exist in the wild? Are their populations declining? Few golden lion tamarins remain in Brazil (*15*); however, few whooping cranes, red wolves, bison, or condors remain in North America. Waves of extinction are not being predicted for the United States; why are they predicted for South America? No virgin forests remain in Europe or in the United States, and well-developed cities are placed in, or supported by, the converted ecosystems of the countries in those regions.

The question is whether an ecological catastrophe is imminent in South America. Perusing the conservation literature, one notes an air of desperation and more than an implication that development has continued in the face of evidence that supports a preservationist view. South American governments and business organizations are suggested as primary agents in a policy that will culminate in many extinctions (*8*). I suggest that the data on massive extinctions are equivocal.

The United States, after virtually destroying its natural habitats, developed a conservation policy about a century ago (*16*) that included establishment of a national park, refuge, and reserve system. Today there are 186 parks and nature reserves containing 174,370 km^2 of habitats (2.2% of the continental territory, Alaska and Hawaii excluded) (*17*). This system is the result of more than a century of labor by thousands of politicians, scientists, nature organizations, governmental agencies, and private citizens.

It might seem that South America compares poorly with the United States from the standpoint of parks and reserves. Although the first national park in South America was established by Argentina in 1903 (*18*), an extensive system of parks and reserves is fairly new to the continent (*19*). Nevertheless, the 218 parks and reserves now established there contain 488,906 km^2 of habitats (2.7% of the continental land area, islands excluded) (*17*). Three times as much land area is designated as protected in South America as in the United States; in relative terms, 25% more land is protected than in the United States.

These statistics are surprising since one would assume that South American governments, plagued by enormous social and financial problems (*20*), would have been unable or unwilling to set aside as much land for conservation as such an environmentally conscious country as the United States. In most reports on nature reserve design theory, a basic assumption is that more land will be set aside as reserves in South America (*21*). Five of 13 countries (Brazil, Argentina, Uruguay, French Guiana, and Guyana) have set aside a smaller percentage of land for reserves than the United States, whereas Chile, Colombia, Ecuador, Peru, and Venezuela have designated, proportionally, three to four times as much land for reserves than the United States. All countries on the continent have extensive and complex environmental laws (*22*) that protect habitats, plants, and animals (*23*). Parks and reserves frequently have extensive development plans (*24*). Admittedly, in some South American reserves the biota has not been protected, but this is largely due to a lack of trained personnel and inadequate funding.

Despite official efforts by South American governments to limit environmental degradation, a great deal of habitat modification is occurring (*25, 26*). Much time and effort has been spent on detailing

ecological damage in the Amazon, although many of the continent's extratropical habitats are affected by human activities (*13, 27, 28*). Nevertheless, the Amazon has sparked the interest of North American scientists (*29*) and captured the imagination of the American public.

Many reports detail patterns of forest conversion, but there is great variance among them. Myers (*8*), for example, calculated that 20 million hectares (200,000 km^2) of forest are being cut each year and that two-thirds of all tropical forests will be converted between 1990 to 2000. Fearnside (*11*) predicted elimination of massive parcels of Brazilian rain forest by 1988 and perhaps of the entire Amazon by 1991. These reports cited international commerce in hardwoods as a major factor in deforestation. Lugo and Brown (*10*) reported forest conversion rates proceeding at about 1% per year, a level well below that suggested by other researchers (*8, 25, 30*). They also cited Food and Agriculture Organization statistics showing that more than 80% of deforestation is carried out to meet fuel needs within a country, rather than to supply hardwoods for developed nations. Clearly, there is cause for concern among scientists who require solid data before making decisions as to the existence, cause, and treatment of a problem. Government officials also need valid information before establishing policy, especially if they are to resist the requests by powerful constituents to speed up habitat conversion.

Imagine a typical government official in a country such as Brazil. This person must decide quickly whether a program should be implemented, often at enormous cost [the Transamazon highway cost $500 million in only 4 years (*31*)]. Political pressures are brought to bear—the program could bring jobs or wealth to an impoverished region, for example, or could attract settlers from an area where poverty and overpopulation are causing political instability. As pressure increases, the official seeks expert counsel but encounters several dismaying problems. (i) There are no accurate data on just how much forest Brazil contains (*30–33*). (ii) Data on rates of forest conversion and habitat recovery vary widely (*8, 10, 11, 34–37*). (iii) Data on soil types are incomplete and do not agree (*36, 38*). (iv) Data on the value of floral resources are limited (*36, 39, 40*), and data on faunal resources are even more limited (*26, 28*). (v) Most people calling for rapid and massive efforts to conserve habitats are from wealthy countries that have few natural habitats remaining. (vi) Data on the monetary value of unused resources are lacking. Given such a quandary, how many bureaucrats would stop development?

Too few scientists have gathered sufficient high-quality data on the status of South America's biota to determine exactly what is taking place on the continent from the viewpoint of population trends. The data pertaining to widespread habitat destruction with concomitant loss of species are not strong; they are, at best, suggestive. Moreover, some data suggest that the faunal resources in South America are being overused (*28, 41*), but these claims are also merely suggestive (*42*). Some evidence indicates that ecosystems are more intricately linked in the tropics (*43, 44*) and that such systems are more subject to perturbation and are slow to recover (*8*), but even here there is strong debate (*10*). Simberloff (*45*) pointed out the difficulty in detecting imminent extinctions, even when one examines well-studied organisms; the problem is exacerbated in the Neotropics, where few species have been studied. So, why are scientists impelled to believe that a massive problem exists? Probably many reasons account for this view, but only a few will emerge as the primary influences.

First, few scientists have extensive research experience in South America or are familiar with its flora and fauna, its peoples, and its problems. How many conferences that deal with conservation have experts present who actually have conducted research impacting on conservation on the continent? Experts need data and good data are lacking.

Second, the ecological causes of the conservation problem in South America are complex, and it is difficult to obtain the measurements needed to describe the problem fully. Adequate research efforts would require a huge input of manpower and financial support. Currently, too few people have either the desire or the ability to dedicate themselves wholeheartedly to such a massive research undertaking, which requires working under difficult circumstances.

Finally, the worst prognostications may be correct, and the scientists may be all too aware of the limitations of their data. If extinction were to occur on a large scale, then the risks of such a calamity are great. Given a high risk, it is advisable to err on the side of conservatism. Thus, the case for habitat destruction would have to be overstated relative to the database. This may not be a particularly scientific way to proceed but, because of the other socioeconomic and sociological factors involved in any problem in human ecology, overenthusiasm and hyperbole are understandable. As Soulé (*46*, p. 168) noted, "the luxuries of confidence limits and certainty are ones that conservation biologists cannot now afford. . . . To embrace the purist's motto of 'insufficient data' is to abandon the bleeding patient on the operating table." Similar views are frequently expressed by scientists involved in discussions of deforestation or extinction rates (*47*).

It is inadvisable for scientists to consider data a luxury, for such an attitude can lead to errors in judgment. Data obtained to test hypotheses are essential to science. Many papers (*21, 48*), for example, have applied island biogeographic theory to nature reserve design, but the theory may be too imprecise to be of much, if any, use to resource management planning (*49*). When confidence limits were applied to a model of faunal relaxation rates leading to extinction for species in Nairobi National Park (*50, 51*), the predicted rates for species decline were found to have their 95% probability limits extend over ten orders of magnitude. This means that over 5000 years the park will probably lose from 0.5 to 99.5% of its species because of island effects. To put it another way, if Nairobi National Park supported 1000 species, theory would predict that in 5000 years somewhere between one and 999 species would remain. Here confidence limits illustrate that, far from being luxuries, they assist scientists to discern weak theories from theories that have merit. Clearly, smaller areas support fewer species than larger areas, but what the exact, or even approximate, effect of habitat disruption will be on South America's biota is far from clear.

A review (*52*) of literature on mammalogy reported that only 2% of all publications surveyed dealt with South America, and a recent survey (*53*) found that South America's mammal literature (from technical to popular) was scarce, indeed. A similar paucity of information probably characterizes most South American taxa. If literature is so scarce on South America's biota, then either few experts are working with the organisms of the continent or a coterie of experts decline to publish their data. I believe the dearth of literature reflects a lack of people doing research. There is insufficient good information with which to plan a conservation strategy. Moreover, the conservation dilemma in South America transcends biology and is a complex social problem.

The Roots of the Problem

At least seven primary factors are involved in the conservation situation on the continent: (i) lack of data, (ii) lack of people trained in areas related to conservation, (iii) lack of money, (iv) lack of a coordinated plan for the long term, (v) weak economies, (vi) short-

term strategies, and (vii) an air of panic. It is instructive to examine each of these in some detail to clarify the status of conservation work.

Lack of data. As shown above, good data do not exist in many areas that affect conservation strategy. Several major research areas require a solid database; one example is the taxonomy of South American organisms. The situation described by Pine (*54*) for mammals is equally valid for other animals and plants. The reason that estimates of the number of undiscovered species of insects in South America vary from 5 to 50 million (*55*) is that few taxonomists are studying this diverse group. The reason a 50-kg peccary can be common in the Chaco of Paraguay and Argentina yet was thought to have been extinct for tens of thousands of years (*56*) is because few mammalogists are working on the continent. Moreover, taxonomic ignorance frequently enters into ecological, biogeographical, and evolutionary studies, and investigators are unsure of just which species they are studying. Comparing patterns of biological attributes of a species from one region to another is an uncertain enterprise, and doubts as to species identifications make many hypotheses questionable.

Recent research trends by scientists in developed countries have downplayed the value of such foundational work as taxonomy, but it is becoming increasingly clear that theory offers no panacea to the problem or any alternative to obtaining the data that form the basis of field biology. Not enough taxonomists are being trained, and research on field and museum collections is not being encouraged. Yet part of the answer to the South American conservation dilemma lies precisely in these areas.

The level of research in ecology of South American organisms is even poorer than that in taxonomy (*57*). We know almost nothing about parameters such as population fluctuations, reproduction, habitat selection, coexistence, carrying capacity, interspecific interactions or, for some species, harvest rates. All subdisciplines of ecology (for example, behavior and physiological ecology) are underdeveloped as well (*58*).

In addition, biogeography has not been adequately explored for most organisms. Little is known about the biotic and abiotic factors that influence distribution patterns on the continent—yet a knowledge of distribution is critical to assess the long-term effects of habitat destruction and to derive the maximum benefit from biotic preserves by locating them in the richest or most threatened habitats.

Finally, research on conservation and management of all groups of organisms is especially scarce. Management studies to date have dealt primarily with a select group of showy or economically important species (*59*). Real and extensive habitat and faunal management throughout the continent has not yet begun (*60*).

Lack of people trained in areas related to conservation. Heroic efforts toward dealing with conservation problems in South America are often made by a small number of dedicated workers. National parks and reserves frequently have few, if any, park guards, rangers, or researchers to carry on the business of the reserve. Therefore, reserves can be entered easily and their fauna and flora damaged. Lack of personnel is apparent at all levels that affect conservation. There are not enough researchers, wildlife officers, forest and faunal managers, law enforcement officers, bureaucrats trained in biology or wildlife science, students conducting research or assisting in conservation work, or people who are transferring technical information on conservation into popular literature or other media for use by the general public.

The United States has many experts in disciplines related to conservation, such as the federal government's employees in the Forest Service, Fish and Wildlife Service, and National Park Service. In addition, each state employs people trained to deal with conservation matters. Both smaller state parks and huge national parks are well guarded. Moreover, the massive educational system of the country allows those seeking information ready access to thousands of scientists whose work is either directly or peripherally related to conservation. Added to this large number of specialists are experts in museums, zoos, and private research organizations. Finally, large companies and consulting firms also employ hundreds of specialists on conservation topics.

This model illustrates the infrastructure that is required for a successful conservation program involving research, protection, and utilization of biotic resources. The U.S. system is not perfect, but it has proven to be effective at protecting fauna and flora from overutilization or uncontrolled habitat conversion.

Elsewhere (*53, 57, 61*) I have noted the great importance of those who popularize natural science to the development of a successful conservation program. The work of people who bring accurate scientific information and explain the importance of conservation programs to the society at large impacts throughout a society. These people—the authors of textbooks, field guides, children's books, pamphlets, and newspaper and magazine articles and the makers of films on nature—conduct the critical program of education of the masses. Without their work, the public will not support programs that limit free access to resources. South America is especially in need of work at this level; for example, there are few field guides available on any groups of organisms for any country on the continent (*53*).

Lack of money. The United States allocates almost $14 billion each year to natural resources and environment [(*62*), fiscal year 1983 data], or approximately 2% of its national budget. The figures do not include either private or state monies spent on environmental projects. In 1980, Argentina's total revenues were $4.9 billion, and Brazil's were $18.8 billion in 1979 (*62*). The approximate total revenue budget for all South American countries combined is only $69.2 billion per year.

Larger areas need larger or more reserves set aside to protect resources, and they require relatively greater monetary expenditures on conservation programs than smaller areas. South America contains approximately twice as much land as the United States, so South America would have to expend about $28 billion to have a conservation program comparable to that of the United States. Of course, this is an unrealistic expectation since this amount is 40% of the entire revenue budget of all countries on the continent.

Lack of a coordinated plan. Many plans deal with the conservation problem in South America, including those of the World Wildlife Fund, the International Union for Conservation of Nature and Natural Resources, the National Science Foundation, and various South American governments (*60*). However, a program of much greater magnitude is required if habitat deterioration is to be slowed and its damage minimized. Barrett (*63, 64*) presented an approach to resource management that used the concept of the noosphere, an interactive system that incorporates not only the abiotic and biotic portions of the ecosystem, but the sociological components as well. The concept is important, for the sociology of conservation in South America has been little appreciated to date (*41, 65*). All plans will likely fail if they do not have the support, understanding, and participation of the people of the continent. Barrett (*64*) presented a 19-step problem-solving algorithm for environmental problems. Included in the comprehensive program are steps on problem identification, goal setting, specific objectives, research design, data collection, and forecasting. Applying the program to South American conservation underscores the lack of a coordinated plan on the continent—at least 15 of the 19 steps have not been taken in most regions.

In 1947, the United States was faced with the problem of

reconstructing Europe after World War II. The region was devastated and many countries had to be rebuilt. Under the leadership of General George Marshall, meetings were held for years before a workable plan was developed (*66*). Reconstruction took 4 years and cost $14 billion (in 1947 U.S. dollars). The problems of conservation in South America are equally as complicated as those associated with European reconstruction. Man can build cities, but not forests; economies can be reconstructed, but not food webs. Only a plan of the broadest scope can hope to manage what could develop into a massive problem of habitat conversion and extinction.

Weak economies. South America's economies are in poor shape. Poverty is extensive, inflation rates in some countries are among the highest in the world, and the foreign debt is a crushing burden. Bare subsistence is often the only way of life. Impoverished farmers or unemployed workers engage in the illegal wildlife trade because they have nowhere else to turn. Their earnings, unlike the middle-level businessmen, are minimal, and they are frequently paid in goods, such as sugar or tobacco (*28, 41*). Widespread poverty leads to desperation, and desperation causes people to eke out the barest of livings by using plant and animal resources, legally or illegally, with no thought to their renewability. The foreign debt, with its unending spiral fed by high interest rates, and the strict economic standards imposed by the International Monetary Fund on debtor nations lead to societal unrest and political instability, hopelessness, and increased poverty. When the United States demands repayment of loans, while telling the countries to increase their efforts at conservation, the reluctance or inability of South American countries to do more is understandable, as is the undercurrent of anti-American feeling that has increased over the last decade. Poor people and bankrupt countries have very little interest in conserving resources for themselves or for the richest nation on Earth. The poor economic panorama on the continent affects all areas of life. For example, educational opportunities decline as university budgets are cut back. Fewer students are trained in fields related to conservation needs. In addition, the continent is experiencing the most rapid human population growth in the world (*67*). This fact impacts negatively on all aspects of conservation biology.

Short-term strategies. Businesses generally operate on a short-term basis, as capital is turned around rapidly to be reinvested, with profits fueling further development. High inflation rates spur short-term planning to an even greater degree. Rampant inflation demands high profits over a very short period. Little capital can be invested for long-term rewards since the profits would be quickly outstripped by inflation. As an example, in 1971 I paid about 1 million Argentine pesos for a new Citroen automobile—in 1983 I paid 1 million pesos for a cup of coffee. Such currency instability encourages short-term planning.

If long-term plans are to predominate in resource use within countries, then the general population, scientists, businessmen, and bureaucrats must be made aware of the potential value of wisely managed natural resources. Long-term investments can be encouraged through subsidies or other mechanisms, just as short-term strategies, such as slash-and-burn cattle ranching in the Amazon Basin, should be discouraged, rather than encouraged as they are now (*31*). But the case must be made for a policy change at all levels of society, and monetary support for alternative plans must be found.

An air of panic. The hopelessness that infuses reports detailing habitat loss may be counterproductive to long-term planning and may even be incorrect. Dire predictions of ecological catastrophe are not well supported by the available data, and current efforts at conservation may be palliative rather than fundamental. Without a comprehensive plan, it is difficult to predict where current efforts are leading. In most published reports, it appears that time has run out, or will do so very shortly. On the contrary, there may be more time than many people say, time enough to coordinate a continental-wide plan to define the problems and seek their solutions and to increase substantially the levels of fundamental research that are being supported on the continent.

The Morality of Conservation

The flora and fauna of South America are recognized as resources not only to the continent, but to the world (*8, 13, 26, 27, 29, 38, 43, 68*). Generally, the Neotropics are viewed as a biospheric resource because they may harbor innumerable food and drug resources, possible biocides, and other products that could be of great use. Thus, the genetic structure of Neotropical organisms could be of enormous value to future generations. The region is also extremely important to global weather and biogeochemical cycles, such as those of carbon, air, and oxygen (*69*). By any standard, the Neotropical biota belongs not only to those countries within whose borders it lies, but to the people of the biosphere whose existence depends upon continued efficient operation of its various ecosystems. Should massive extinctions occur, even if they are delayed for decades or centuries, it would bode ill for all nations of the world.

We are all involved in biospheric problems and their solutions. It will be difficult to manage the conservation problem in South America without an extensive program that not only slows the immediate loss of habitats, and possibly species, but deals with the roots of the problem: widespread poverty, trade imbalances, lack of specialists in all aspects of field biology, lack of financial resources to support conservation programs or to set aside large parcels of natural habitats, and lack of a research base on the biology of the continent.

I believe that it will take a large group of specialists in biology, economics, sociology, psychology, history, agronomy, government, and law a long time to derive a workable plan to solve the conservation dilemma on the continent. It is a world problem and specialists throughout the world should be involved. One thing appears certain, it will require tens of billions of dollars.

Any large program will have to concern itself with some of the issues I have discussed. All are important points; several, however, are critical. A support program must be developed for graduate education for South Americans who are interested in pursuing research related to any discipline impacting on conservation biology. Thousands of workers are needed in the fields of systematics, ecology, forestry, wildlife management, limnology, and sociology, among others. A scholarship fund should be set up to provide full support for students in these areas. The developed nations have sent researchers to the Neotropics for almost a century; these developed countries possess the educational infrastructure necessary to train Latin Americans in many disciplines that are critical to a successful program of biospheric resource conservation.

To refer again to the analogy of European reconstruction, in 1947, General George Marshall announced his plan to rehabilitate Europe. He said (*66*, p. 676), "Aside from the demoralizing effect on the world at large and the possibilities of disturbances arising as a result of the desperation of the people concerned, the consequences to the economy of the United States should be apparent to all. It is logical that the United States should do whatever it is able to do to assist in the return of normal economic health in the world. . . . Our policy is directed against hunger, poverty, desperation, and chaos . . . assistance . . . must not be on a piecemeal basis as various crises develop . . . [but we] should provide a cure rather than a mere

palliative." These words offer a fair summary of what our strategy should be in the area of South American conservation. The task is imposing, but not impossible.

To conclude, conservation efforts to date will prove to be only marginally successful. Too little is being done, although the work of those who are struggling to resolve the issues should be supported. Greater effort must be dedicated to emphasizing that this is a world concern and demands a global response. South American governments have accomplished a great deal, but the problem is well beyond their financial ability to solve. We are all a part of this problem and must work together to find its solution. There is still time to act.

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