1994 STARKER LECTURES

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College
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Management & Biological Conservation

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compiled by Bo Shelby and Sandie Arbogast

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Dedication

T. J. Starker

The Starker Lecture Series is sponsored by the Starker family in memory of T.J. and Bruce Starker: As leaders of modern forest management, T.J. and Bruce Starker were visionaries for sustainable forestry in Oregon.

THURMAN, known to all as T.J., was born in Kansas and lived his youth in Burlington, Iowa. He moved with his family to Portland in 1907 and began working in and studying forestry, graduating in the first class of foresters at Oregon Agricultural College in 1910. He then studied two years for an M.S. degree in forestry at the University of Michigan and returned to Oregon to work for the USDA Forest Service. Subsequent employment with the forest products industry and a variety of summer jobs while he was teaching forestry at O.A.C./O.S.C., gave T. J. broad and thorough experience in all aspects of forestry.

T.J. began purchasing second growth Douglas-fir land in 1936, the beginnings of Starker Forests. Through his work experiences, teaching forest management, T.J. had a major influence on sound forestry and community development in Oregon.

Bruce Starker

Bruce Starker studied for a forestry degree from O.S.C. in 1940 and an M.S. in forestry in 1941. After service with the Coast Guard, Bruce joined his father, T.J., in acquiring and managing Oregon forest land, always with an eye for sound reforestation, management, and conservation for multiple benefits and values. He worked with university, state, and federal forestry agencies, as well as with private industry, to advance reforestation, management, and equitable taxation to encourage private forest management. Bruce continued the family tradition of active community service in many ways, including civic activities, regional forestry work, and contributing to writing the Oregon Forest Practices Act.

With advances in knowledge, technology, and public environmental issues, forestry in Starker Forests has changed, but the constant value of tending the land remains unchanged. The sound, progressive forestry and community spirit of T.J. and Bruce Starker continue today.

We, at Oregon State University, College of Forestry, family and friends, are pleased to be honored with this lecture series.

Foreword

Conserving resources through wise management is a great challenge and a great irony of our times. Gone are the days when we could simply leave things alone and expect them to stay the same. This year's Starker lecture theme, "Management and Biological Conservation," focuses on both the challenges and ironies. Our speakers come from a variety of backgrounds and offer diverse views of the future of natural resources.

WILLIAM LIBBY is a forest geneticist, professor emeritus at University of California at Berkeley now serving as a consultant at the Tasman Forestry Centre for Biotechnology in New Zealand. He is interested in the trade-offs associated with choosing to manage land for timber production or other non-timber uses. His presentation emphasizes the utility of wood for a diversity of purposes and explores the benefits of intensive forest management in some areas as a way to allow other forest uses in others.

NIRO HIGUCHI is the deputy director and professor of forest mensuration at the National Institute for Research in the Amazon in Brazil. He is interested in land use issues in Amazon rain forests. His presentation focuses on the character of the Amazon region and the diverse challenges presented by the demands for its resources.

DEBORAH JENSEN is the vice president responsible for scientific activities and land management policies at the Nature Conservancy. Because the Nature Conservancy acquires and manages land as part of its conservation mission, she is particularly interested in how a conservation philosophy can be translated into on-the-groundpractices. Her presentation offers a definition of ecosystem-based management and insights into the challenges of implementing such an approach.

Starker Family:
Bond, Betty Starker Cameron, and Barte

CHARLES WILKINSON is the Moses Laskey Professor of Law at the University of Colorado. As an attorney he has taught at several Universities and has written widely on the challenges facing law and natural resources in the American West. His presentation focuses on the Anasazi heritage of the Southwest and the legal and cultural barriers to respecting and preserving that heritage.

As always, organizing this series requires a major effort on the part of the Starker Lecture Committee. I thank Sandie Arbogast, John Garland, Royal Jackson, Mike Newton, and Jim Wilson for the dedication and creativity that turned disparate ideas into a coherent theme and a group of outstanding speakers. It is truly a joint effort that accounts for the fine tradition of the Starker Lecture Series.

Bo Shelby
Professor of Forest Resources

Harvests Foregone, Species Extinctions, and Plantations: Mitigating damage at a distance


Photo by Iris Libby

Dr. William J. Libby
Professor Emeritus, University of California
Forest Products Laboratory
Richmond, CA

Forestry Consultant
Tasman Forestry Centre for Advanced Forest Biotechnology
Te Teko, New Zealand
and Zobel Forestry Associates
Raleigh, NC

In the first of the 1992 Starker Lectures, Marc Reisner addressed the topic of sustainability. In doing so, he told several stories about water. The theme of this talk is similar, and I'll tell several stories about wood.

Uses of Wood

What is wood used for? Most of us can answer this question easily, because wood is among our most versatile resources. We might do better, however, to consider the question: What will wood be used for? The prediction that we will return to wood as an increasingly important fuel (Smith 1981) is beginning to prove accurate. As Smith noted, the forests of Earth are much more evenly distributed than are fossil fuels, which tend to be concentrated in only a few regions. The potential for growing trees nearby exists in nearly every place where people have settled. Sweden's massive effort to replace the electricity generated by all 12 of its nuclear reactors with energy from biomass willow plantations is an example of a recent and effective program (Johnson 1991; Holmen et al. 1992).

Nonetheless, in some regions of Earth, particularly in some third-world nations, harvesting wood for fuel without renewing forests has damaged and continues to damage both economies and the environment. This problem is or may be improved by increased recognition of the importance and value of sustaining the amount of wood available for harvest for fuel.

A recent issue of *EVERGREEN*[1] covers many of the topics I'll be discussing, and I want to acknowledge my general agreement with it. This issue is a good source of ideas, data, and arguments, not only for using wood, but also for growing more of it in such regions as the Pacific Northwest, where forests grow exceptionally well.

[1] For a more general, local, and up-to-date treatment of the future uses of wood, see the Summer 1993 issue of *EVERGREEN* (Wood Products and the Global Environment, The Evergreen Foundation, 2680 N. Pacific Highway, Medford, OR 97501).

Reducing Harvestable Wood

When wood harvest is reduced or eliminated in a region, one or more of several things will happen. Among these are the following:

(1) In response to the reduced availability of wood, people may increase wood conservation and thus reduce demand. This course of action is particularly desirable where wood has been used inappropriately.

(2) As a result of reductions in wood supplies, people may increase efforts to recycle wood. Recycling solid wood and paper is (usually) environmentally and (often) economically preferable to adding these materials to landfills. Thus, recycling is usually, or often, appropriate for wood and wood products used well. However, because recycling has high environmental and financial costs, it is a less desirable alternative than is reducing unnecessary or inappropriate consumption.

(3) In response to reduced availability, the price of wood and wood products may increase. Increases in the price of wood will probably result in reductions in the amount of wood that is used. Thus, people may be unable to use wood where it is appropriate, and thereby effectively lower their standard of living. Captain Cousteau's (1992) Plenary Address to world leaders, delegates, and journalists at the United Nations Conference on Environment and Development focused on human popu lation and resource husbandry. He used Easter Island and Haiti as examples in which, both in the past and at present, respectively, the human population failed to renew forest resources. Speaking of

Easter Island, Cousteau noted that after eight centuries, this lush tropical island had become "...a barren, totally deforested piece of rock where a few hundred cannibals were hunting each other for survival. Easter Island's natural exuberance had expired under the load of too many consumers. All that remained were indecipherable tablets and proud statues...." Cousteau was chiding the world's leaders for wasting 22 of the 30 years' breathing time provided by the recent Green Revolution. His warning was clear: "Surviving like rats is not what we should bequeath to our children and grandchildren." To purposefully reduce the supply of a renewable resource such as wood will speed Cousteau's undesired bequest. What we need are actions to lengthen the time in which to find the bigger solutions.

(4) Another consequence of reduced harvest is that people may substitute other resources for wood. In some cases this is environmentally near-neutral, for example, when bagasse is substituted for wood fiber where people are already growing sugar cane for sugar. However, most of the substitutes for wood are environmentally more harmful than is wood. For example, Peter Koch (1992) has calculated the relative costs of such alternatives as concrete, bricks, steel, aluminum, and synthetic fibers. These alternatives are, with few exceptions, more costly than is wood in terms of energy required for production, amount of fossil CO_2 released during manufacture, and the various toxic pollutants released incidental to production. Thus, rather than reduce the proportion of wood used for appropriate human needs, strong arguments can be made that we need to increase the proportion of wood used in such cases.

(5) Finally, when harvests from a particular forest are reduced or eliminated, people may obtain wood from other places. If a region is self-sufficient, as Oregon still is, then wood may be obtained somewhere else within the region. If wood must be imported, however, it may come from such places as the pine plantations in Chile and the southeastern United States, the radiata pine fiber farms in New Zealand, the eucalypt fiber farms in Brazil, the native forests and plantations of the Pacific Northwest, and the great wood mine in northern Russia. But harvesting and exporting rainforest wood is also a possibility. Additions to import demand are likely to result in increased harvest from all of these sources, and (particularly in some third-world rainforests) this increase in harvest occurs both legally and illegally (e.g., see Linden 1994).

With the exception of wood taken from ancient Pacific Northwest forests and extensive cutting in the Russian wood mine, and with the strong exception of increased harvest in tropical rainforests, the importation and use of wood is environmentally near-neutral, and beneficial to the economies of these wood-growing regions. As wood from old-growth forests has become scarce, wood from plantations and fiber farms has tended to be preferred to wood from tropical rainforests for import. This is because the qualities of rainforest wood are less technically reliable, and because of increasing recognition of the environmental costs of harvesting rainforests.

Connectedness and Tropical Rainforests

I use metric measures in this paper, a gentle reminder that this is how most of Earth's countries measure forests and wood. We need to remember to think globally. Many conservationists say things like, "Everything is connected to everything else" — which reminds us to think about the consequences of our actions. Saying this is one thing, but quantifying even parts of it is another. I'll briefly try to quantify the relationship, or the consequences of our activities in productive tropical, subtropical, temperate, or boreal forests and the effects that these activities can have on extinction rates in tropical rainforests.[2]

It's useful to make this calculation as a function of area disturbed. For this, one needs to know three things: how much area is/was occupied by tropical rainforests; how many species recently existed there; and what percentage of them is/was at risk of extinction? The first of these variables is reasonably well known; answers to the other two are at best semi-informed guesswork. Taking some conservative low-medium estimates from the many that have been made (Lugo 1988) leads to an average of one species going extinct per 210 hectares of tropical rainforest disturbed or deforested.

To manage this problem of species extinctions, and to mitigate it effectively, it is crucially important to recognize the dynamics of the species extinction process. Some extinctions occur during early stages of ecosystem disturbance, as species with local distributions are by chance included in early percentiles of cutting, or as the requirements of fragile species are compromised. Most extinctions, however, occur as the last vestiges of a regional ecosystem are disrupted or destroyed.

Thus, if our actions here in Oregon (or elsewhere) can simply reduce the rate at which tropical forests are being harvested, that can have a beneficial effect. It can provide conservation organizations, governments, and local peoples the additional time needed to educate, to negotiate, and finally to set aside reserves sufficient to prevent the high rates of species extinctions that would otherwise occur if the final percentiles of regional forests were harvested.

Case Examples of Plantations as Mitigation

New Zealand

I fly to New Zealand fairly frequently. On some of these flights, which normally leave late and arrive early, the captain has roused the passengers by announcing breakfast in a few minutes. (S)he has then noted that we've crossed the International Dateline as we slept, that we'll arrive in Auckland in about 90 minutes, and that we should all set our watches back 20 years. Well, I rather like some features of life as it was 20 years ago, and that's one of the things I like about New Zealand.

I recently imagined a flight going the other way — a charter full of New Zealand conservationists, foresters, and environmentalists (some people on board truly are all three). As the plane approached Los Angeles, the captain in a similar vein suggested that all passengers set their watches back 80 years. What was going on 80 years ago in New Zealand?

From the first felling of a kauri tree by Europeans in 1772 until the peak of native-forest logging in 1907, kauri, rimu, southern beeches, and other native tree species served New Zealand's needs for sawn wood and fuel. Furthermore, an important export trade in lumber and logs developed (Simpson 1973).

[2]These calculations are spelled out in reasonable detail in the Proceedings of the 1994 Inland Empire Tree-Improvement Cooperative Meeting (Libby 1994a). The longer version in Libby (1994b) provides additional information.

As the availability of kauri wood fell behind rising demand during the period between 1899 and 1922, its price climbed sharply. This, and the 1907 peak and subsequent decline in timber harvest from native forests, drew the official attention of a 1909 Royal Commission on Timber and Timber Building Industries. This Commission concluded that changes in logging or milling practices would not reverse the decline in native-forest timber availability. (Does this sound familiar?)

As the timber-harvest decline continued, a Royal Commission on Forestry was convened in 1913 (Healy 1982). That Commission concluded that New Zealand's needs for wood and wood products could not be met by harvest from its native forests, no matter how these forests were managed (i.e., by clearcutting, selective cutting, or other management system), and recommended initiation of an aggressive program of intensive forest plantations. Thus began the world-famous New Zealand school of plantation silviculture. Might this bit of New Zealand history give us a preview of what happens next here? I hope so. The "Planted Forests: Contributions to Sustainable Societies" meeting, scheduled to take place in Portland next 28 June - 1 July, might, 82 years later, serve as our analog to the 1913 New Zealand Royal Commission. I plan to attend, and hope to see many of you there.

Today, New Zealand imports small amounts of specialty timbers from the Tropics and elsewhere, and continues to cut in some areas of its own native forests. These relatively small import volumes are more than balanced by wood produced in New Zealand plantations. Recently, for every unit of wood used by New Zealanders in New Zealand, another has been shipped overseas. Thus, 80 years after launching their plantation program, this country now meets more than 100% of its net domestic wood needs from plantations.

These plantations occupy about 5% of New Zealand's land area, and about 90% of them are growing radiata pine. The harvest productivity of radiata pine plantations per unit area is about ten times that of New Zealand native forests. Because of this, for every hectare of radiata pine harvested, 10 hectares of native forest need not be entered for timber extraction. As a result, an active conservation movement in New Zealand has been able to arrange for about 30% of the original native forest (about 23% of New Zealand's land area) to be kept or placed in protected reserves.The differences in harvest productivity between planted forests of Douglas-fir or mixed conifers and native Douglas-fir or mixed-conifer forests are considerably less than ten-fold, but the principle holds. Even here in the Pacific Northwest, one can set aside more native forests in reserves, and simultaneously continue to produce a sustained or even increased renewable wood harvest, if more of the nonreserve areas are intensively managed primarily for wood harvest.

One can view that another way. In times of plenty, we can set aside forest reserves with regulations and other pieces of paper, and simply buy other peoples' wood to make up the difference. In times of crisis or need, however, these reserves are safe only if the needed resources can be obtained less expensively and with greater reliability elsewhere. Plantations not only provide an economically smart choice in times of plenty, they provide conservation lifeboats in times of crisis or need.

Colombia

A second case example is a story from the Tropics. In 1982, Smurfit Carton de Colombia (SCC) depended completely on wood from native tropical forests. To obtain a more uniform raw material for processing economically, and also to respond sensitively to increasing concerns over tropical deforestation, SCC began a major plantation program (with local labor on previously cleared land). As of 1994, 100% of their wood needs are met by wood from their plantations. As in New Zealand, the relative harvest productivity of the SCC plantations is about ten times that of nearby native forests (Wright 1992; J.A. Wright, personal communication, 1992, 1994).

As an added note, I had previously thought that Jeff Wright was a bright scientist hired by SCC to carry out a good plantation program. Jeff told me, however, that he had recognized that human-caused species extinctions in tropical rainforests constituted a major practical and ethical problem even before he graduated with a new Ph.D. more than 13 years ago. He took that job as a way of doing something about it. Thus, Jeff Wright is not simply a lucky hired hand, but rather he is one of our most far-sighted and effective conservationists.

Tasmania, Australia

A substantial portion of remaining native forest in Tasmania is reserved in World Heritage Forests. In response to a recent proposal to set aside even more old-growth eucalypt forest, a "Hellsham inquiry" concluded that sufficient old-growth Tasmanian eucalypts were already reserved in World Heritage Forests. The central government in Canberra overrode this finding. However, in addition to setting aside additional World Heritage Forests, it sent AUS$50,000,000 (about US$35,000,000) to Tasmania, to be used as follows:

$8,000,000 to "compensate" owners, presumably to buy their land (nothing new there);

$8,000,000 for developing alternative industries, and retraining workers (we've also done this a bit);

$9,000,000 to help wood-processing companies make the transition from old-growth to young-growth products;

and $25,000,000 to mitigate harvest foregone, to be used for such things as fertilization in existing wood-producing forests, and to establish new plantations.

This last item is new, and, to the best of my knowledge, the first time harvest foregone has been thus recognized and mitigated.

South Island, New Zealand

Similarly, some native southern beech/rimu forests on the west coast of South Island, New Zealand, were withdrawn from harvest and designated as reserves. These forests had been part of the native forest still designated to be managed for timber harvest, but pressure from New Zealand conservationists was effective. The New Zealand government, having agreed with the conservationists' arguments, then followed the Tasmanian precedent and allocated NZ$6,000,000 (a bit more than US$3,000,000) to mitigate that harvest foregone, this time strictly by establishing new west-coast plantations.

Trade-offs in Species Diversity

Species diversity in fiber-farm plantations of forest trees is generally less than that in natural forests, but typically becomes much greater than that found in fields of such substitute fiber crops as cotton, kenaf, or hemp. This trade-off needs to be better understood by both policy-makers and the concerned public. Genetic diversity of the keystone plantation species is, of course, an important variable that the plantation planners need to get right.

Genetic Improvement as Mitigation

Tropical rainforests produce harvestable wood at a rate of about 2 cubic meters per hectare per year (reviewed in Libby 1994b). Thus, an increase of 1 cubic meter per hectare per year harvested from 420 hectares of forest elsewhere will make cutting 210 hectares of rainforest unnecessary. This will, on average, prevent or at least delay the extinction of one species.

As an example, radiata pine plantations in New Zealand produce about 27 cubic meters per hectare per year, and the improved breeds of radiata pine now available should produce over 30 cubic meters per hectare per year. At present, New Zealand plants about 100,000 hectares of radiata pine per year, most of it genetically improved breeds. When these trees are harvested and enter international trade, that is a *lot* of conservation leverage. Many of the ships leaving New Zealand harbors display a green banner stating that the wood on board is helping to save tropical rainforests. Unlike the United States, most conservation organizations in New Zealand strongly support the plantation program, and thus recognize its part in saving both local and tropical native forests.

American conservationists are, in general, fighting a defensive battle to preserve some of our native forests. This often has had the downside effect of increasing the rate of forest cutting elsewhere, in less-protected and more fragile ecosystems (Libby 1994b). In their radiata pine plantation program, New Zealanders are addressing the core problem as defined by Cousteau (1992). Not only are they meeting the legitimate needs of their own people for a decent standard of living, but they are also contributing this renewable resource to wood-deficient areas elsewhere on Earth. Radiata pine breeders in New Zealand probably help save more species from extinction in a month than most American conservationists help save in their lifetimes.

By increasing the harvest productivity of Oregon's plantations, thereby increasing available wood in the Pacific Rim market, you could act similarly. One does this effectively with genetics, through breeding, and perhaps with the biotechnical advances coming dimly into view. One can also do it by improving regeneration establishment, silvicultural practices, fertilization effectiveness, and harvest efficiency. I invite you, like many New Zealander foresters, to address both sides of the problem, and thus to become some of our most effective American conservationists.

References

Cousteau, J. 1992. Convince to conquer. *Calypso Log* August: 3-6.

Healy, B. 1982. *A Hundred Million Trees. The Story of N.Z. Forest Products Ltd*. Hodder & Stoughton. Auckland. 222 pp.

Holmen, H., I. Kolare and G. Lundeberg, Eds. 1992. *International Evaluation of Energy Forestry*. Joint Publication of the Swedish National Board for Industrial and Technical Development and The Swedish Council for Forestry and Agricultural Research. Stockholm. 44 pp.

Johnson, R., Ed. 1991. *Tomorrow's Energy*. Swedish National Energy Administration. Stockholm. 68 pp.

Koch, P. 1992. Wood versus nonwood materials in U.S. residential construction: some energy-related global implications. *Forest Products Journal* 42: 31-42.

Libby, W.J. 1994a. The role of production forestry in preventing tropical species extinctions. Pages 5-9 *in*: L. Fins (*Ed.*). *Nimbyism, Genetic Improvement and Plantation Forestry: Growing Wood for the 21st Century*. Proceedings of the Inland Empire Tree Improvement Cooperative. Moscow, ID. 40 pp.

Libby, W.J. 1994b. Mitigating some consequences of giant sequoia management. Pages 142-148 *in*: P.S. Aune (*Tech. Coord.*). *Giant Sequoias: Their Place in the Ecosystem and Society*. Pacific Southwest Research Station, Albany, U.S.D.A. Forest Service. Berkeley, CA. 170 pp.

Linden, E. 1994. Chain saws invade Eden. *Time Magazine* 29 August 1994: 58-59.

Lugo, A.E. 1988. Estimating reductions in the diversity of tropical forest species. Chapter 6. Pages 58-70 *in*: E.O. Wilson (*Ed.*). *Biodiversity*. National Academy Press. Washington, D.C.

Simpson, T.E. 1973. Kauri to Radiata. *Origin and Expansion of the Timber Industry of New Zealand*. Hodder & Stoughton. Auckland. 442 pp.

Smith, N. 1981. *Wood: An Ancient Fuel with a New Future*. Worldwatch Paper 42. Worldwatch Institute. Washington, D.C. 48 pp.

Wright, J.A. 1992. Vegetative propagation of pines and eucalypts at Smurfit Carton de Colombia. Pages 397-405 *in*: M-N. Bey, M. Leroy, and S. Verite (*Eds.*). *Mass Production Technology for Genetically Improved Fast Growing Forest Tree Species*. Tome I. AFOCEL. Nangis, France. 441 pp.

Land Use Problems in the Brazilian Amazon

Dr. Niro Higuchi
National Institute for Research in the Amazon
Caixa Postal 478
Manaus, Amazonia, Brazil

The name of the region known as Amazonia is taken from the Amazon Basin and its main river system, the Amazonas-Solimoes-Ucayali axis. This system originates on Mt. Huagra in Peru at 5182 m above sea level, 195 km from the Pacific Coast. The river mainstem, 6762 km in length, drops 4876 m during the first 965 km that it travels from its source. During the remainder of its course, the fall to sea level is only 306 m. Almost 30,000 km of the mainstem and tributaries are navigable during the rainy season. The region is rich in forest, mineral, and energy resources.

There are two Amazonias in South America: the Amazonia Territory and the Amazon Basin. The Amazonia Territory extends outside the Amazon Basin, most particularly in the Orinoco region and into Guyanas. The area, relative distribution, and respective population of each country in the Amazonia Territory are presented in Table 1.

In Brazil the Amazon region is divided into Legal Amazonia, a geopolitical division, and the Amazon Basin. Although its population represents only about 10% of the country's total, Legal Amazonia comprises almost 60% of the Brazilian Territory (Table 1). The Amazon Basin or "hileia amazonica" in Brazil occupies an area of 3,940,000 km^2.

Description of the Amazonia Region

Climate

Temperatures do not vary greatly throughout Amazonia. Belem, about 100 km from the Atlantic Ocean, has a mean annual temperature of 25°C. Manaus, nearly 1500 km from the coast, has an equivalent temperature of 27°C, and Taraqua, some 3000 km inland, has a mean annual temperature of 25°C. The maximum temperatures are around 37-40°C with a diurnal variation of 10°C.

Variation in rainfall is greater than that in temperature across the region. Approximately 3000 mm of rain fall annually at the coast, 3500 mm at Taraqua, 1500 mm at Boa Vista (the capital of Roraima State), and 1600 mm at Conceicao do Araguaia (south of Para State). Seasonal variations are determined primarily by the amount of rainfall. Basically two distinct seasons exist: the wet season (from November to April) and the dry season (May to October). The wettest months are January and February, and the driest months are August and September.

Soils

The soils of Amazonia are very old, and date as far back as the Paleozoic era. The region is composed of a sedimentary basin (Amazon Valley) located between two shields (Guyana and Brazilian). These shields are made up of igneous Precambrian and metamorphic rocks from the Cambrian-Ordovician which contain some spots of sediments from the Paleozoic/Mesozoic (60-400 million years ago). The Amazon Valley comprises coarsely textured fluvial sediments, which eroded from the Precambrian shields and were deposited from the Cretaceous to the Tertiary periods. This is the process of "terra-firme" (nonflooded ground) formation.

Another important formation in Amazonia is the "varzea," or annually or periodically flooded region. The varzeas are formed by the Holocene floodplains of the Solimoes and Amazon rivers, as well as by their white water tributaries. Where the region is flooded by black water rivers, the formation is called "igapo."

The main soil orders in Amazonia are: yellow latosols (46%) and red yellow podzolics (30%). In general, the soils are acidic (pH 4.5-5.5) and extremely poor in nutrients. In fact, the above-ground biomass contains almost the entire nutrient stock required by the forest. Nearly 95% of Amazonian soils are not suitable for agriculture or grazing.

Mineral and Energy Resources

The mineral and energy resources of Amazonia are significant. Among the main mineral resources are Iron, Bauxite, Tin, Kaolin, Niobium, Manganese, Zinc, Gold, Diamond, and Gypsum. In addition to its fantastic hydroenergy reserves, this region contains petroleum and natural gas deposits.

Vegetation

The forested area of the Amazon Basin is 3,648,000 km^2 or 364.8 million hectares (Table 2). Dense and varzea forests make up more than 90% of this total. Dominant timber species represent the botanical families: Leguminosae, Lecythidaceae, and Sapotaceae, and Myristicaceae in varzea. “Mahogany” or “Mogno” (*Swietenia macrophylla*) is the most important tree species economically. “Brazil nut” or “Castanheira” (*Bertholletia excelsa*) and “rubber tree” (*Hevea surinamensis*) are also important, though for resources other than timber. The total volume for dense forests is approximately 50 billion m^3, from which 10% is merchantable.

Amazonia contains the world’s largest continuous tropical moist forest, characterized by considerable vegetation diversity. At first sight, however, vegetation appears somewhat uniform. Of the approximately 30,000 different species of angiosperms in Amazonia, one-sixth are tree species that grow to commercial size. The distribution of these trees varies tremendously, particularly in relation to soil and topography. Although the Amazonian forests provide important timber resources, the more important feature of these forests is that they guarantee that biodiversity and numerous ecological functions are maintained.

Biodiversity

The biodiversity of Amazonia is legendary, yet little reliable information exists about the number of species present. Trees dominate the physical structure of the forest, but make up a relatively small share of the total number of species of organisms present. Plants other than trees contribute significantly to plant diversity in non-Brazilian parts of the region. Brazil as a whole has an estimated 55,000 species of angiosperms.

Mammals are significantly less numerous in the Brazilian portion of the Amazon than they are in Peru and Ecuador. Brazil has 428 species of mammals, the third largest number in the world. In addition, Brazil provides habitat for 1622 bird species, a number exceeded only by Colombia and Peru. Further, Brazil’s 516 species of amphibians constitute the world’s greatest number in a single country, and the 467 species of reptiles inhabiting Brazil are the fourth greatest number in the world. Fish species described in 1967 totaled 1300 (estimates vary from 2000 to 3000). In contrast, Europe has an estimated 300 species.

Invertebrates make up by far the largest share of the total biodiversity. Studies of forest canopy insects carried out in Manaus (Brazil), in Peru, and in Panama have more than tripled the total number of species estimated to exist on earth. Brazil provides habitat for 74 species of butterflies alone. Although one can debate the validity of extrapolating species numbers from small samples to large areas, the finding that arthropods are tremendously diverse is incontestable.

The biodiversity of the region is not uniform. Amazonia comprises a number of “centers of endemism,” where unique species of a variety of taxa are concentrated in certain locations. One of the theories that has been proposed to explain these centers is that “refugia” formed in islands of forest surrounded by grassland during the Pleistocene glaciations. Speciation occurred in these islands. Later, advancing forests coalesced in the formerly nonforested portions of the region. The composition of the formerly nonforested areas is less diverse and unique than is that in the refuges.

Land Use in Amazonia

Agriculture and Cattle Ranching

Since the beginning of the 1970s, agriculture and cattle ranching activities have dominated the landscape in clear-cut Amazonian forests in Brazil's Legal Amazonia. This situation developed because of a large federal subsidy program for this kind of land use in an effort to integrate the Amazon region with the rest of the country. Agriculture and cattle ranching have contributed to increased deforestation rates in the Amazon region. In contrast, the impact of shift cultivation in the Brazilian Amazon has been negligible.

The "hamburger connection," which creates devastating commercial pressure for beef production in Central America, has not been an important factor in Brazil's Legal Amazonia. Land speculation has been a key factor in making unproductive cattle pastures attractive to their owners. Profits from logging have also been a critical source of income to ranching operations and to small land holders. For small farmers, the traditional system of squatting to obtain titles to land has resulted in increased amounts of deforestation. Further, clearing land for cattle pasture is still considered to be an "improvement" on the land by state and federal government land agencies.

Mining

Mining activities are having an increasing impact on the environment in Brazil's Legal Amazonia. These impacts are both direct and indirect. Open pit mines completely transform the environment in the specific localities affected, such as the iron mine at Carajas (Para), manganese at Serra do Navio (Amapa), kaolin at Jari (Amapa), bauxite (aluminum) at Trombetas (Para), and cassiterite (tin) at various locations in Amazonas and Rondonia. Although the areas destroyed are relatively small, the destruction is total.

Mining activities in Brazil produce significant impacts in less direct ways as well. These include impacts from building highways to mineral-rich areas, and local processing of ores in ways that consume forests. Carajas, with the world's largest high-grade iron ore deposit, is coupled with a regional development plan that produces pig-iron from some of the ore. Charcoal is used both as a reducing agent and as an energy source, and is derived largely from native forest wood — contrary to the claims of the plant owners. Supplying charcoal to support the activities proposed in the development plan would result in deforestation of as much as 1500 km^2 per year.

Hydroelectric Dams

As a result of the petroleum crisis in the 1970s, the Brazilian government made large investments in alternative energy with natural resources. The program to substitute alcohol for gasoline was given priority in the Brazilian northeast region, and hydroelectricity was elected to substitute for petroleum in the Amazon region. All Amazonian states used petroleum as the unique source of energy until the 1990s. Today, the Tucurui, Balbina, and Samuel hydroelectric plants are operating in the states of Para, Amazonas, and Rondonia, respectively. These hydroelectric plants now partially supply the needs of each state.

Hydroelectric development represents a potentially large source of forest loss. Large areas covered by pristine Amazonian forests have been flooded when reservoirs were formed. Submerged trees subsequently have been harvested for timber. Brazil's 2010 strategic development plan calls for a series of dams (temporarily postponed as a result of the country's financial difficulties) that involve a total of 100,000 km^2 in Amazonia, or 3% of the forested area.

The hydroelectric dam at Balbina, for instance, located 146 km north of Manaus, was completed in 1987, and filled to its normal reservoir level at 50 m above sea level. The reservoir, which flooded 2360 km^2, contains approximately 1500 islands; thus, the area of land affected is much larger than that which is actually submerged.

Logging

Logging activities are rapidly increasing in importance as a factor in Amazonian deforestation. In the past, timber harvesting has been much less prominent in Amazonia than in the tropical forests of Africa and southeast Asia. The official statistics for the production of charcoal, firewood, and roundwood in the region in 1988 and 1989 (Table 3) indicate that, after some economic problems in 1990 and 1991 throughout Brazil, timber production in the Amazon is now back to the 1989 rate. Para state contributes more than 90% of the total production, whereas Amazonas, which has the largest area covered by forests, produces less than 5% of the total.

The main reason for this difference in production doesn't lie in the characteristics of the forest, but in the availability of infrastructure (mainly access facilities) in each state. Until the 1980s, forest activities functioned only as a subproduct of other development projects, e.g., subsidized agriculture and cattle ranching programs. Today, however, forest products are being used as indispensable subsidies for those programs. When federal subsidy programs were ceased in the beginning of the 1990s, deforestation rates were expected to decrease. Because of the increase in the value of forest products, however, deforestation remained at the same level. This has happened mainly in the state of Para.

Decimation of the tropical forests of Africa is almost complete from a commercial standpoint, and those of southeast Asia are rapidly nearing a similar end. Exports from Legal Amazonia are therefore increasing. Logging in the uplands (terra firme) is rapidly destroying stocks of some of the most valuable species, including cerejeira (*Amburana acreana*) and mogno. The flooded varzea forests, which are the main source of raw materials for forest industries in the state of Amazonas, will be the first to be affected because of the ease of transporting logs by water; commercial species such as "ucuuba" (*Virola* spp.), "sumauma" (*Ceiba petandra*), and "louro" (*Ocotea* spp.) are rapidly declining.

Deforestation and Related Impacts

The area comprising forest and savannah in each Amazonian state in Brazil, as well as the area of deforestation through 1989 are presented in Table 4. Of the entire Legal Amazonia (4,988,939 km^2), 478,882 km^2 have been deforested. The most recent figures for annual rates of deforestation in the Brazilian Amazonia, officially presented during Rio-92 (National Institute for Spatial Research 1992), are:

1978-1988 . . . . .21,130 km2 per year
1989 . . . . .17,860 km2
1990 . . . .13,810 km2
1991 . . . .11,130 km2

One million km2 (70% of the total), including national and state parks, National Production Forests, Ecological Reserves, Experimental Stations, and Indian Reserves, are protected. Of the Amazon Basin in Brazil, 3,648,000 km2 are forested and 292,000 km2 are non-forested (Table 2). Impacts of deforestation on the region are both environmental and social. These impacts include greenhouse gas emissions, alteration of the hydrologic cycle, genetic erosion, and sedimentation and pollution of rivers, as well as social impacts.

Greenhouse Gas Emissions

Carbon, which makes up half of the biomass dry weight, is released to the atmosphere as carbon dioxide and other gases. The average total biomass (dry weight, including below-ground and dead components) for all unlogged mature forests present in Legal Amazonia is 397 metric tons per hectare. The net committed emissions from deforestation in 1990 are estimated as 234 million tons of carbon in terms of carbon dioxide alone. Thus, the annual flux represents approximately 4% of the global total carbon dioxide flux from fossil fuel combustion and tropical deforestation.

Alteration of the Hydrologic Cycle

The dynamic equilibrium between water and energy in the Amazon depends on the forest cover. Changes in the water cycle will influence the energy cycle and vice-versa. When the forest is clear-cut, more water runs off and less water is available for evaporation. This causes a decrease in the available water for evapotranspiration and in the relative air humidity which, in turn, alters the energy equilibrium. Deforestation also causes a decrease in the atmospheric water vapor, which affects rainfall distribution.

One of the consequences of widespread Amazonian deforestation that has the greatest potential for impacting Brazil is alteration of the hydrologic cycle. Precipitation in Amazonia is characterized by tremendous variability from year to year, even in the absence of massive deforestation. Reductions in rainfall have the potential to affect not only Amazonia, but also Brazil's major agricultural regions in the south-central part of the country.

Genetic Erosion

Deforestation, particularly as a result of selective harvest, also reduces the potential to obtain valuable genetic material from the forest. Selective logging removes the most desirable individuals, and the residual stand tends to contain different genetic material than that comprised by the original stand. Germ plasm can be valuable, both in supplying new crops to agriculture and in providing a store of varieties of already cultivated species. Geographic isolation provides the principal protection against disease and pests. For example:

> Rubber was taken from Brazil to southeast Asia, and left behind such diseases as the fungus *Microcyclus ulei*.
>
> Cacao, from Central and South America, was taken to Africa and Asia, where it grows free of "witches" broom disease (*Crinipellis pernisciosa*).
>
> Coffee was brought from Arabia and the horn of Africa to the New World, which freed it of coffee rust (*Hemileia vastatrix*).

In 1964 the last remnants of forest in Ethiopia provided invaluable genetic material, collected from native coffee species, for developing strains resistant to coffee rust. This disease was a threat to the Brazilian economy, because at that time coffee was the country's primary export commodity.

Sedimentation and Pollution of Rivers

The fines from bauxite mining form a "red mud" that suffocates trees along the margin and approaches to rivers. Gold mining also contributes greatly to the siltation of rivers. Because much of this mining occurs in river beds, the water is often a milky color. As is true for other minerals, road-building, spurred by gold strikes, sets in motion the process of invasion and deforestation of affected areas. Use of mercury to amalgamate fine gold particles resulted in the input of an estimated 250 tons of highly toxic mercury into the rivers between 1984 and 1988. Mercury concentrations in fish in the Madeira River (Rondonia) are as high as six times the levels permitted by the World Health Organization.

Social Impacts

Endemic disease: Malaria is widespread in the region, and has caused the greatest number of casualties in certain locations, such as Rondonia. Many diseases, such as measles, have had devastating effects on indigenous peoples who come into contact with populations from the rest of Brazil. Other endemic diseases include leishmaniasis, debilitating, though nonfatal sores transmitted by sand flies. Onchocerciasis, or African river blindness, is spread by blackflies that occur throughout the region. Thus far, this disease has been limited to areas along the borders of Brazil and Venezuela.

Migration and colonization: Amazonia has served as a safety valve for social problems in Brazil's other regions. Highway construction and settlement projects have been developed in response to such problems as the 1970 drought in northeastern Brazil (the official justification for building the Transamazon Highway). The population outflow from Parana was absorbed by paving the BR-364 Highway to Rondonia in 1982, with financing from the World Bank's POLONOROESTE Project.

Toward the Future

Besides minerals, timber, and nontimber products, the Amazonian forests provide important environmental benefits or services. These benefits include:

- Regulation of droughts and floods
- Control of soil erosion
- Watershed and catchment protection
- Groundwater recharges
- Conservation of genetic resources and biodiversity
- Protection against weather damage
- Recreational opportunities
- Aesthetic values

Despite the significant contribution to humanity and the important role to the functioning of the ecosystem, the Amazonian forest is often undervalued. The effects of destruction often are not realized until after the benefits of this short-term use have been enjoyed.

To change the current trends of land use in the region, the main initiatives of the Brazilian government include implementation of an economic and ecological zoning program, and enforcement of existing environmental legislation (i.e., forest code). In addition, increasing environmental awareness of national and international societies increases pressure for conservation and protection of the Amazon region. From the forest standpoint, only timber products that are derived from sustainable management projects will be marketable in the near future.

Table 1. Area (km^2), relative distribution, and population of each country in the Amazonia Territory

Country	Area (km^2)	NT*(%)	AT*(%)	Population
Bolivia	824,000	75.0	10.9	344,000
Brazil	4,988;939	58.7	65.7	17,000,000
Colombia	406,000	36.0	5.3	450,000
Ecuador	123,000	45.0	1.6	410,000
French Guyana	91,000	100.0	1.2	90,000
Guyana	5,870	2.7	0.1	798,000
Peru	956,751	74.4	12.6	2,400,000
Surinam	142,800	100.0	1.9	352,000
Venezuela	53,000	5.8	0.7	9,000
Total	**7,591,360**		**100.0**	**21,853,000**

*NT = Percentage of Amazonia Territory that is located within the national territory; *AT = Percentage of the total Amazonia Territory

Table 2. Composition of vegetation in forested and nonforested areas of the Brazilian Amazon Basin

Composition of Vegetation	Area (km2)
Forested areas	
Terra-firme (nonflooded) Forests:	
Dense Forests	3,303,000
Dense Forests with Lianas	100,000
Open Forests with Bamboo	85,000
Hillside Forests	10,000
High Campina* or Campinarana	30,000
Dry Forests	15,000
Varzea (flooded) Forests	55,000
Igapo (flooded) Forests	15,000
Manguezal (Mangrove) Forests	1,000
Campina	34,000
Total	**3,648,000**
Nonforested areas	
Varzea Fields	15,000
Terra-firme Fields	150,000
Serrana (Mountain) Vegetation	26,000
Restinga (Beach and Dunes) Vegetation	1,000
Water	100,000
Total	**292,000**

*Campina = forest on white sand; Campinarana = transition between Campina and dense forest

Table 3. Timber production (in 1,000 m^3) in Brazil's Legal Amazonia in 1988 and 1989

	Charcoal		Firewood		Roundwood	
State	1988	1989	1988	1989	1988	1989
Acre	1.6	1.7	1,285	1,265	310	309
Amapa	0.5	0.6	369	440	471	549
Amazonas	0.0	0.0	78	22	552	626
Para	45.6	75.8	7,503	7,738	28,428	43,139
Rondonia	1.5	0.9	1,009	968	2,190	2,255
Roraima	0.0	0.2	61	69	56	37
Tocantins	-	2.2	-	2.183	-	570
Total	**49.2**	**81.4**	**10,305**	**12,685**	**32,007**	**47,485**

Table 4. Vegetation (km^2) cover in Brazil's Legal Amazonia and amount of deforestation through 1989

State	**Original Vegetation**		**Deforested**		**D*(%)**
	Dense Forest	Savanna	Forest	Savanna	
Acre	152,589	-	8,836	-	5.8
Amapa	99,525	42,834	1,016	-	0.7
Amazonas	1,562,488	5,465	21,551	-	1.4
Maranhao	139,215	121,017	88,664	20,664	42.0
Mato Grosso	572,669	308,332	79,549	25,568	10.0
Para	1,180,004	66,829	139,605	1,722	7.3
Rondonia	215,259	27,785	31,476	169	13.0
Roraima	173,282	51,735	3,621	-	1.6
Tocantins/Goias	100,629	169,282	22,327	34,114	20.9
Total	**4,195,660**	**793,279**	**396,645**	**82,237**	

*D = Percentage of area of original vegetation deforested

References

Commission on Development and Environment for Amazonia. 1992. Amazonia Without Myths. Amazon Cooperation Treaty. 99 pp.

Fearnside, P.M. In preparation. Environment and the forest sector in Brazilian Amazonia over the past two decades. Contribution for International Tropical Timber Organization Volume on Forestry in Amazonia.

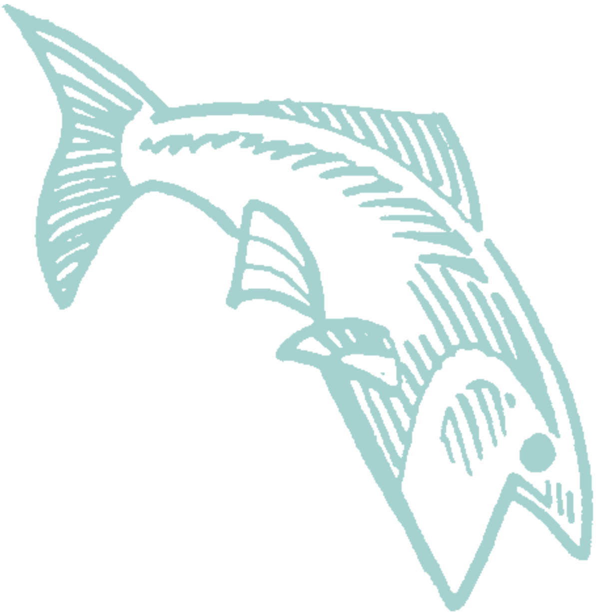
Fearnside, P.M., A.T. Tardin and L.G. Meira Filho. 1990. Deforestation Rate in Brazilian Amazon. 8 pp.

Higuchi, N., J.M. dos Santos, M. Imanaga and S. Yoshida. 1994. Aboveground biomass estimate for Amazonian Dense Tropical Moist Forests. The Memoirs of the Faculty of Agriculture XXX (39): 43-54.

National Institute for Spatial Research. 1992. Deforestation in Brazilian Amazon. Poster presented during the United Nations Environmental Conference, Rio-92.

Ecosystem-Based Management: A conservationist's view

Dr. Deborah B. Jensen
Vice President, Conservation Science Division
The Nature Conservancy
Arlington, VA



Ecosystems are now in vogue. Previously only ecologists talked about ecosystems, species interactions, nutrient cycles, and disturbance regimes. Now, however, businessmen, politicians, conservationists, and resource managers also discuss ecosystems and ecosystem management. This change reflects changes in the importance that society places on ecological systems, and a growing awareness that healthy ecosystems play a critical role in sustaining goods and services important to humanity.

Nonetheless, the growing consensus regarding the necessity of an ecosystem approach to natural resource management belies underlying disagreements about the ends. Agreement on the practices of ecosystem-based management is not equivalent to agreeing on either the goals or the desired products of lands and waters. Let us explore, therefore, (1) the change in approach that ecosystem-based management represents, (2) some of the lessons learned by The Nature Conservancy in taking an ecosystem-based approach to managing our own lands for the long-term conservation of biological diversity, and (3) the critical question, "Ecosystem-based management for what end?"

A Shift to Ecological Thinking

Increasingly, people are recognizing that ecological systems, economic systems, and human communities are inextricably intertwined. The long-term health of local communities depends upon healthy economies, which in turn require healthy and diverse forests, fisheries, and agricultural systems, and clean air and water. As a result, a shift in perspective, from management of individual species to management of ecological processes, is occurring. Ecosystem-based management has been touted as a paradigm shift that includes recognition of the importance of sustaining ecological health. However, two very distinct arenas of change exist in the ongoing shift. The first is a change in the approaches that are used to manage lands and waters. The second is a change in the goals and purposes for which lands and waters are managed. Changes in both "the means" and "the ends" need not co-occur. Ecosystem-based management can be practiced without a paradigm shift in the goals of land management. Thus, the need to clarify management goals has become increasingly important in the management of lands and waters.

A Shift toward Ecosystem-Based Management in The Nature Conservancy

The Nature Conservancy is a private, nonprofit conservation organization that has been in the business of biodiversity conservation and "quietly protecting nature" for over 40 years. An international organization with 750,000 members, we work in the United States, Canada, Latin America, and the Pacific region. The Nature Conservancy's mission is to preserve the plants, animals, and natural communities that represent life on earth by protecting the lands and waters they need to survive.

The Nature Conservancy has not undergone a paradigm shift in its goals ("the ends"). But we are shifting our thinking about the strategies we use to accomplish the goal of biodiversity conservation ("the means"). We are changing our practices because we have new scientific knowledge about how ecosystems function, and because we recognize that a diversity of actions is necessary to manage for the long-term protection of biological diversity. Initially the Conservancy took a simple approach to accomplishing our conservation mission. We defined our conservation targets as species and natural communities, and set about protecting populations of rare species, and sites containing either rare community types or excellent examples of common community types. Recognizing that loss of habitat was a critical threat to biodiversity, we decided that our most effective conservation action as a private conservation group would be to raise funds and buy lands to establish a system of private nature reserves.

To identify what biodiversity we wanted to protect and where, we helped establish a network of inventory programs that use a common inventory method. These Natural Heritage Programs are private/public partnerships working to understand the location and distribution of key elements of biological diversity. There are programs in all 50 states, 5 Canadian provinces, and 13 countries in Latin America. Heritage programs provide high quality data, collected by a standard approach, to ensure that the best possible information is available to inform conservationists, natural resource managers, private industry, and government agencies.

Managing Lands and Waters

Although inventory and assessment continue to play a key role in our work, the struggle to conscientiously manage our preserves for the long-term survival of key species and natural communities has taught us the most about ecosystem-based management. The many obligations of landownership — building fences, paying taxes, working with neighbors, and worrying about trespass — are a routine part of the Conservancy's work. However, for the Conservancy, landownership holds another obligation: managing the land to assure the long-term protection of the species and natural communities for which the site was acquired. We acquired our first preserve in 1951 in New York State, and quickly learned that acquisition and protection are not identical. Frequently, essential ecological processes have been altered or eliminated from a site, and must be reintroduced. In addition, threats are present that must be averted or mitigated. This requires that we actively manage many of our preserves.

Reestablishing Ecological Processes

Numerous ecological processes occur in natural systems and collectively create the conditions that favor one group of species over another, influence the successional dynamics of the landscape, and are critical to long-term ecological health. For example, fire plays a key role in maintaining many natural communities. Yet, reintroducing fire into ecosystems presents a host of technical, ecological, legal, and public relations challenges. Nine years ago the Conservancy started a program to reintroduce fire into appropriate preserves. This program helped us realize both how important natural disturbances are to ecosystems, and how difficult it is to reintroduce fire into a human-dominated landscape — even when you are working on your own land.

Florida receives more lightning strikes than anywhere else in the country. As a result, the longleaf pine forests of Florida once burned quite frequently in the summer. When longleaf pine stands burn often, the understory contains a mix of grasses and forbs, with some shrubs and palmetto. When fire is excluded from these stands, shrubs and small trees move in and create impenetrable thickets.

Wire-grass, a characteristic species of the longleaf pine understory and an important forage plant for such species as quail, requires growing season fires to reproduce. Dr. Ron Myers, Director of the Conservancy's fire management program, has discovered that wire-grass will not set seed if it is burned in the winter. In fact, Myers' research has demonstrated that growing season fires are needed to maintain the characteristic understory of the longleaf pine community. However, the typical land management practice in Florida is to burn in longleaf pine forests in the winter, primarily because winter fires are easier to manage.

Summer fires can be pretty flamboyant, and require sophisticated knowledge of fire management and skills to safely reintroduce fire into these landscapes. As a result, the Conservancy has had to develop a program of ecological fire prescription, buy new types of equipment (e.g., pumper trucks and nomex fire-resistant suits), and teach our staff many new skills. In addition, we have learned to work with staff of other agencies with fire expertise — state agencies, federal agencies, and local fire departments — to safely reintroduce fire into our preserves. The seemingly small decision to restore ecological processes has resulted in significant changes in our staffing and equipment needs, and in our expenditures of time and resources.

Reintroducing fire has also taught us a lot about working with our neighbors. Many of our neighbors were not initially thrilled to see 10-, 20-,or 30-foot flames on the preserve across the street from their property. We have, therefore, spent significant time talking with our neighbors so that they understand what we are doing, and why. For example, we are reintroducing fire to a preserve in New York State in the Albany pine barrens where the Karner blue butterfly, an endangered species, lives. The Karner blue's food plant is a lupine, a plant species which needs the open ground created by fires to thrive. The pine barrens preserve has lots of neighbors, including a nursing home and a condominium complex. Our neighbors have come to understand why The Nature Conservancy is burning up its nature preserve, and they are confident that we can conduct safe prescribed fires.

One of the lessons of ecosystem-based management is that, even if you are the landowner, your activities have to fit into the social and legal context of the surrounding lands. In addition to learning about the ecological processes, gaining the skills and technology to prescribe fire, and working with our neighbors, we have to comply with local laws. We work with the local fire departments so that they know when we plan to conduct a burn. We follow air quality laws and ensure that we don't create smoke problems on the nearby New York State Thruway. We have even worked with other natural resources managers to get the laws changed, because 10 years ago it wasn't legal to use prescribed fire in forests in New York State.

Ownership Boundaries Aren't the Only Ones that Matter

Managing ecological processes has changed our thinking about boundaries. We have had to distinguish between ecological boundaries and ownership boundaries. Sometimes, as in the case of the smoke from prescribed burns, our actions have impacts outside the preserve boundaries. In other cases, critical ecological processes may depend on land and land uses outside the preserve boundary. For example, the flooding regime of a river drives the regeneration of the forest in the riparian ecosystem. The Cosumnes River preserve in California contains a beautiful stand of valley oak forest, which is naturally regenerating. Most other stands of this forest are no longer reproducing. Research suggests that the reason this forest stand is able to regenerate is that the river still floods — it is one of the few remaining undammed Sierran rivers.

The preserve is a relatively small parcel at the bottom of the river. In this case, the preserve boundaries don't match the ecological process boundaries, which encompass the entire watershed. Most of our neighbors are farmers. They don't really mind if the river floods every once in a while. Thus, the ecosystem-based management lesson of the Cosumnes is that we not only have to maintain the ecological processes essential to the conservation of this forest type, but we also must work outside of our own property lines with other landowners to help maintain flooding regimes essential to the forest's health. Conservation will increasingly require partnerships among landowners working across ownership boundaries to achieve mutually acceptable goals.

These lessons have taught us to look at our preserves as part of the human-dominated landscape, and have led us to rethink our approaches. We call our current campaign the Last Great Places Campaign, and in it we are trying to take an ecosystem-based approach to identifying and managing our preserves. Our preserves are often a core of dedicated, protected area within a landscape dominated by human activities. The human communities must work together with the ecological processes essential for protecting the species and natural communities in our preserves if our conservation actions are to succeed.

Adaptive Management

Ecological research continues to show that ecosystems are not static, but rather are dynamic in both space and time. Unfortunately, our ignorance about most ecosystems and how they function is vast. As land managers, we acknowledge that, although there are many things we do not know, and others we will not be able to know, often we must take action "today." The Nature Conservancy tries, therefore, to practice adaptive management of our lands, and to recognize that unpredictable events will occur.

Our adaptive management plans begin with the goals. Why do we have this preserve? What species or community types is this site designed to protect and maintain? What do we want this site to look like in the future, and what range of variation in our goals is acceptable? After the goals are clearly articulated, we develop an ecological model of ecological processes at this site. Sometimes these models are fairly general and conceptual, such as recognizing that fire is essential to grow lupines which are the food plant for the Karner blue. Alternatively, these models may be quite detailed and incorporate quantitative data to back them up. In either case, the models help us clarify appropriate management actions. We then take the necessary management actions, such as introducing fire, removing invasive exotic species such as purple loosestrife, or reintroducing species such as bison at our Tall Grass Prairie preserve. Finally, we monitor the results of the management actions. If we didn't follow through and see what actually occurred as a result of our actions, we would not know whether or not our ecological model was appropriate or our management actions had the intended results.

One of the strengths of the adaptive management approach is that it admits that the manager always has incomplete knowledge about how the ecosystem works, but must make management decisions nonetheless. Monitoring the results of management actions can improve knowledge of the species or the ecosystem. Furthermore, the results of management actions help us to identify key research needed to improve basic understanding of the systems.

Ecosystem-Based Management for What End?

Some authors have argued that ecosystem-based management is a significant paradigm shift reflecting a change in management goals, a change in understanding about the dynamic nature of ecological systems, and a change in thinking about our relationship with nature. Too often, however, ecosystem-based management is a change only in "the means" without a review of "the ends." Because management actions can be seen as tools, ecosystem-based management actions can be limited to adding new tools to the tool kit. Plant species can be added or removed. Fire can be introduced. Grazing ungulates can be introduced or removed. Trees can be planted or cut. However, the tools alone will not suffice to achieve conservation.

The key question is, "What are the goals of ecosystem-based management approaches?" If the goals are to maintain biodiversity and the long-term integrity of the system, the management practices and the outcomes will differ from a case in which the goals are to assure the persistence of a particular suite of species or the productivity of a specific species.

Setting goals that can ensure both the long-term integrity of ecosystems and the species they comprise is a challenge. This is, in part, a result of our ignorance about the relationship between key ecological processes and the structure and function of the species and biological communities. If management goals for a site are set on the basis of an ecological process such as fire, the objectives will be stated in terms of return intervals, fire intensity, and acres burned. If, however, the management goal is to maintain the species and communities at that site, the measures of success will be different. The objectives will focus on the composition, structure, and function of the species and communities at the site. As the longleaf pine forest example shows, management goals can be set for the ecosystem to ensure regular and successful prescribed fire, but they may have devastating consequences for some of the characteristic species. Goals are needed both for the elements of bio-diversity and for the ecological processes.

The Nature Conservancy and society are struggling with setting appropriate goals for managing lands and waters. How shall we value biodiversity conservation as compared to other goals? How can we establish goals that will maintain species and biological communities for our children's children? How can we coordinate our actions across ownerships and with other people, some of whom have different goals? How do we manage lands and waters when needs among species and natural communities conflict? How can we build systems of land management that will ensure that future generations have a wealth of natural resources to work with? Moreover, how can we make decisions within a framework of insufficient knowledge, while recognizing that we will have to adapt in the future as we learn more, and as our research provides us with new input? Setting goals and designing means by which to achieve them are the most important challenges posed by ecosystem-based management.

Conclusion: Changing Strategies, Constant Goals

The Nature Conservancy has learned a lot about how to do conservation in our 40-year history. We have expanded the numbers of places where we work, and increasingly are working with neighbors, landowners, and local communities to build integral landscapes containing both sustainable human communities and dedicated protected areas.

Our experience has taught us a few lessons. First, nature conservation isn't as easy as we once thought. Success requires that we establish clear goals for species, natural communities, and ecological processes; maintain the best possible information; and manage lands and waters for the long term. Conservation also requires new skills, working with neighbors, and making learning a regular part of our actions.

We recognize that ecosystem-based approaches to management are necessary to achieve our goals, but that they are not easy to implement. They require overcoming institutional, legal, political, and conceptual barriers. They involve commitment to research, because, frankly, we're too ignorant about most of the systems that we work in to be able to meet such ambitious goals as sustaining ecosystem function or maintaining viable populations. Finally, ecosystem-based approaches require that we look at both species and ecosystems. Species are part of the composition and function of ecosystems and one of our best windows into understanding ecosystem health. Thus, ecosystem-based approaches to management are not easy, but they are our best chance for success.

In The Nature Conservancy, we've found that our efforts to preserve biological diversity have inevitably led us to the conclusion that we must have an ecosystem-based approach to the planning and management of our nature preserves. We have not changed our goals or our mission. But we are changing our strategies and practices. We are working across ownership boundaries, because biodiversity conservation depends on the actions of many. Working collaboratively with others allows new solutions for many of us, by creating management options where they had not previously existed. Therefore, I hope that each of you will incorporate conservation goals in your ecosystem management plans and practices. If we all do this, we can leave our children and their children a legacy of healthy ecosystems, rich in biological diversity.

Honoring the Legacy of the Continent's First Peoples: The case of the Anasazi sites of the Colorado Plateau

Charles Wilkinson, Esq.[1]
Moses Lasky Professor of Law
University of Colorado
Boulder, CO

In May a few years ago, when my son Philip was 13, we took a backpacking trip down into one of the canyons that drain off of Cedar Mesa, in southern Utah. Grand Gulch is the most famous of these canyons, and rightly so. It holds an extraordinary diversity of Anasazi sites, and, while no single site in Grand Gulch is as elaborate as, for example, those at Mesa Verde or Chaco Canyon, the sheer profusion of ancient cultural architecture and art may exceed even those places.

[1] This paper is drawn from the current book-in-progress, *Land of Fire: The Story of the Colorado Plateau.*

But Grand Gulch draws numbers of people, especially at this time of year, and I wanted for us to get off by ourselves. So we decided on another canyon, less well known and less well stocked with evidence of the lives of the Old People, but still from all accounts a fine Anasazi canyon, and a lovely one, too.

We headed out in our van toward the Four Corners Area. Every other backcountry trip we had taken involved fishing and Philip had gotten pretty good with his fly rod. I had made it clear that this was not trout country and was worried that he might not much be looking forward to the trip, or that, once there, he might be disappointed. But Philip is an intellectually curious boy and, although perhaps I shouldn't have been, I was surprised by the intensity of his interest in the Old People. By the time we had reached the redrock canyon country west of Cortez, he began peppering me with questions.

"How long ago were the Anasazi here?" A hard question, one that I nibbled at with caution. Although I had devoured a good amount of literature and had many talks with archaeologists and anthropologists, I lacked any formal training on the subject.

It seemed to me easiest to work backwards, since we can be more certain about events at this end. We know that the Anasazi left their villages in the Four Corners Area between about 1150 and 1300 a.d. There wasn't a mass exodus, but rather a gradual out-migration of individual families or kinship groups. Philip asked, "Why did they leave?" No one knows for sure. There was a deep, prolonged drought from 1276 through 1299. Philip: "How do we know there was a drought exactly then?" Tree ring studies are very accurate. Each year the trees put on a new ring. The rings are wide in good growing years, thin in a dry year. We know from old trees that the rings were very thin during this period in the late 1200s. Also, carbon-dating tests of cut timber show that by the late 1200s and early 1300s there is almost no new cut timber, either for fires or construction of dwellings.

"Where did they go?" You see some accounts that the Anasazi "vanished." All the scholars agree that this is wrong. They traveled over to the Rio Grande country and to the pueblos at Zuni and especially Hopi, settling in with friends or relatives in existing pueblos or founding new ones. Today's Pueblo people are the descendants of the Anasazi.

"Why did they leave?" It could have been the drought, although scholars are increasingly skeptical. As one archaeologist told me, "these folks had lived here a very long time. They knew how to deal with dry country and its cycles." Another possibility is that Utes, Apaches, and Navajos, all of whom were in the area, might have pushed them out. This hypothesis also runs counter to other important evidence. The Anasazi's departure was a planned, orderly movement: "They left their houses in order, with no dead people, no signs of burning."

Or the gradual exodus might have just been part of their own culture. Although we often think of Pueblo people as having settled permanently in their villages, the Anasazi actually seem to have been only semi-sedentary. They had a pattern of living in an area for 60, 80, 100 years or more, and then moving on. The moving seems not to have been on a wholesale basis, entire villages all at once; it was gradual, a few families at a time. Often other Anasazi groups or descendants of the original inhabitants resettled the vacated pueblos, and rebuilt the old structures or constructed their own, sometimes right on top of the previous ones.

We don't know why, I told Philip, they had this habit of settling in for several generations and then packing up. The practice may have had religious overtones. It may have had to do with the capability of the land to sustain the Anasazi people — that, in order to preserve soil productivity, they may have regularly had to move along, letting the land lie fallow. Certainly, in spite of their thousands of years of residence in the Four Corners region, there is no physical proof that the Anasazi had abused the land, no indication, for example, of salinization or water-logging. This would be similar to the findings made in the Phoenix area, where the Hohokam civilization grew so large and stayed so long. There are no indications of soil degradation, and scholars believe that the Hohokam simply moved their canals and fields to minimize the impact of farming on the land.

The idea that the exodus was the voluntary act of the Anasazi would be consistent with the Hopis' own oral history, told and retold over the centuries. The Hopis arose from the sacred emergence place near the mouth of the Little Colorado, not far from the floor of the Grand Canyon. The clans then went out in every direction, experimenting, looking for the best place to live. Finally, after many centuries, all of the clans had decided on Black Mesa and its smaller connected mesas, First, Second, and Third, spreading out like long, graceful fingers to the south. One of the clans, the Badger, is known to have come down from the north and its members consider Spruce Tree House, at Mesa Verde, to be a sacred ancestral place.

So the great exodus from the whole Four Corners Area, 30,000 people or more, may have been for the Anasazi's own cultural reasons rather than outside forces such as drought or raiding. Perhaps the interior and exterior forces were both at work.

Back to when they came. Archaeologists have developed categories to define the Anasazi tradition, which they establish as beginning about 2100 years ago — Basketmaker II, they call it. Over time, the Anasazi evolved from pit houses to masonry pueblo residences with great kivas and reached their greatest geographic distribution and highest population numbers between about 900 and 1100 a.d., called the Pueblo II period.

The Anasazi did not, of course, just appear 2100 years ago. These dates are all approximations, categories sketched out by archaeologists. They have the advantage of providing helpful groupings that show cultural change, the disadvantage of arbitrariness, of suggesting fixed boundaries when in fact the cultural change was gradual. The point is that by about 2100 years ago the people we (using a Navajo term) call the Anasazi had shifted from a nomadic life to a generally sedentary one. Among other things, building villages that would be lived in for many generations was a main cultural trait of the Anasazi.

But those same people had been living on the Colorado Plateau for long before that. We know that human beings have been in the region for at least 12,000 years. These are the Clovis people, distinguished by their use of distinctive arrowheads shaped on both sides, first found near Clovis, New Mexico. They were hunters following big Pleistocene animals, the mastodon, the mammoth, and the bison antiguus. These animals migrated long distances and the hunters followed them. By the end of the Pleistocene, about 8000 years ago, the mastodon, mammoth, and the giant bison had gone extinct. Their pursuers had no need to continue their long hunting journeys and they became more localized, hunting rabbits, other small animals, and, occasionally, deer and bighorn, and also doing much more foraging of native vegetation such as piñon nuts, berries, and wild potatoes. This process of settling down became much more pronounced as corn and squash were obtained from peoples to the south. The changeover from foraging to farming was completed about 2100 years ago, at which time the distinctive culture we call Anasazi was in place.

Many if not most archaeologists seem to believe that it is just a matter of time before hard evidence is found proving the presence of human beings in the New World long before the currently accepted date of 12,000 years ago. Some respected scholars already argue that there is already sufficient data to place the true date much, much earlier. Professor Joseph Greenberg, a linguist from Stanford, and other linguists believe that the first migration from Asia — called the Amerinds (some of whom evolved into the Anasazi, Hopi, and other Pueblo peoples) — took place between 15,000 and 30,000 years ago. The Na-Dene (including the Navajo and Apache) must have come from Asia between 10,000 and 15,000 years ago, and the third wave, the Eskimo-Aleut, who remained in the north, crossed between 6000 and 9000 years ago.

These linguists do not rely on the physical evidence looked to by archaeologists. Rather, the Amerind must have arrived at such an early date, they believe, because the longer time frame is essential to account for the diversity of languages on this continent. If, they ask, human beings came to America just 12,000 years ago, "how could the American languages have diversified to such an extent?" Molecular archaeologists, analyzing DNA residues and mapping genetic lines of descent, have made findings that corroborate Greenberg's work and suggest settlement of the Americas about 30,000 years ago.

A respected archaeologist, Richard S. "Scotty" MacNeish, may have succeeded in pushing the date back even farther. In Pendejo Rock Cave in southern New Mexico he has found stone chopping implements, animal bones gnawed on by humans, human hair, and fire pits lined with rocks from outside the caves. He has used carbon-dating techniques to determine their age. (This technology is based on the fact that all living things take in carbon-14, a small part of which is mildly radioactive. The half-life of carbon-14 — the point at which the concentration is reduced by half — is 57,000 years. Depending on the sample, this dating technique can be very accurate, at least +500 years, sometimes down to + 30 years.)

At the 1993 annual meeting of the American Association for the Advancement of Science in Chicago, MacNeish announced that the evidence shows human habitation in Pendejo Rock Cave back to 30,000 years ago, perhaps 38,000. Numerous archaeologists have taken off after MacNeish, but he has many supporters also. Robson Bonnichsen, Professor of Anthropology here at Oregon State University, says, "My personal conclusion is there had to be humans here before Clovis. Scotty's out there on the firing range with a lot of people taking potshots at him, but he's working hard and doing it well."

The dignity of this long occupation, regardless of exactly how long it may actually be, is captivating. I tried to articulate this to Philip. Few non-Indians today can claim four generations on the Colorado Plateau, and only a handful of Mormon families can claim five or six, perhaps a few seven. The Pueblo people today, tracing back through their ancestors — the Anasazi and the gatherers and hunters before them — can show 600 generations, and, if Scotty MacNeish is right, perhaps three times that. Eighteen hundred generations. And we await still other discoveries.

We drove on for a while and Philip broke the silence. "I can't wait to see that perfect kiva." He was referring to an Anasazi kiva — one of the classic, circular, subterranean chambers that Pueblo people use for their prayer ceremonies — that a friend had told us about in the canyon we were visiting. Philip's comment, though, alarmed me. My friend and I had agreed we would get on the phone, each with our topographic maps, and that she would give me exact directions. But we'd both gotten busy, she with family matters, me with other last-minute details of the trip. I'd never gotten the final directions, and knew only that it was in the upper half of the canyon, which had several forks. "Yeah," I said, "I hope we can find it."

After another 2 hours on the highway and a bumpy drive over various dirt roads on Cedar Mesa, we pulled off and parked. There wasn't a designated trailhead, but this was about the point where a faint trail headed off to an arm of the canyon. After a half an hour of traversing the scrubby piñon-juniper forest on top of Cedar Mesa, we hit the edge of the side canyon and began to work our way down. Right away we came across an Anasazi granary and inspected the tight masonry, nearly 1000 years old. Probably they irrigated their corn on top of the mesa and brought it down into the side canyon for safe-keeping.

It was getting dark and we set up camp for the night on a bench up off the floor of the side canyon. In the early morning we were greeted by a sudden, violent cloudburst. I had almost — almost — decided to sleep in the open air without pitching the tent.

We had a hard hike the next day. The trail had petered out and the side canyon, dry except for two springs, was mostly boulders. We clawed our way as much as we walked. Three hours later, wondering if we would ever reach the main canyon, we did.

I had a campsite picked out about 4 miles upcanyon. We needed to be especially vigilant now, for this wider canyon was prime terrain for Anasazi dwellings; the little stream ran perennially, or nearly so, and would have given them a good opportunity to divert water for their rows of corn. The hiking, now along a sandy streamside trail, was much easier than in the narrower side canyon. We found two more granaries, but no homes. And no perfect kiva.

We camped in a splendid place, at the junction of the main canyon and a side canyon, just across from a large balanced rock. We had been talking all day about our planned dinner, fresh pasta and sun dried tomato pesto. We were starving and ate early. Our fare was a bit effete, perhaps, for southern Utah, but it was other-worldly delicious.

During dinner, we had spied some Anasazi structures across the canyon, up on a broad shelf, beyond the balanced rock. The site looked fairly elaborate. Several squares seemed to be windows. With the last bit of his pesto mostly chewed, Philip jumped up. "Let's go: Maybe this will be the perfect kiva."

We forded the stream and worked our way up to the site. The shelf was easy to reach. The Cedar Mesa sandstone was layered, almost in staircases, up to the site, about 100 feet above the canyon floor.

Once on top, we could see that the shelf was much broader than it seemed from below. This may well have been a gathering spot of some sort, perhaps for ceremonies. Those squares had been windows, for the Anasazi had built their tight masonry walls up under an overhang that reached out over the back part of the shelf. There were several rooms and a granary with a door of juniper branches. The door was removable and you could look inside.

This would seem to have been a residential unit for three or four families, but there was no way to know. The Anasazi had no written language and left no audio or video tapes. We have only the hard parts: walls, doors, pictographs and petroglyphs, arrowheads and metates, and pots and bowls. We also have contemporary Pueblo cultures. Although they have been subjected to four centuries of assimilation, we surely can learn a lot about the ways of the Old People through the ways of today's Pueblo people. The business of trying to piece together lifeways nearly a millennium old, the business of archaeology, is a challenging, fascinating, expanding process.

Yes, we imagined, this could have been a year-round residential village. It was south-facing and had plenty of sun. It was near the bottomland where they grew corn. But there were also structures up on top, 1000 feet above us, on Cedar Mesa. The deer and rabbit hunting and piñon-nut gathering would be better up there. Perhaps they lived up on the mesa and farmed and held ceremonies down here. Perhaps they lived part of the year above, part below. Perhaps this, perhaps that.

It was getting toward dark and we headed down. Our campsite was next to a generous overhang, and we spread our sleeping bags underneath. The storm had passed and the sky was clear — later, I knew, the moon would be full and bright — there would be no weather. But even if there were, our overhang would protect us well.

In my sleeping bag, I was left with my stiff joints after our long day. I would always, I imagine, think of the Anasazi in terms of their supple joints and my stiff ones. With Philip next to me, I thought back 40 years. How often had my father taken me off, just the two of us? He had tried. He came from a southern family and, when I was 10, took me down to Atlanta and Tampa. Twice, in exchange for a baseball game at Yankee Stadium or a basketball game at Madison Square Garden, he took me into the hospital in New York so I could watch him do an operation. For a while in the summers we went out sailing in the catboat together in the Atlantic off Martha's Vineyard. Then, when I was about 13, things turned bad. His work and his own demons began to consume him. He drank too much and took too many pills on his self-prescriptions, and I lost him.

I sank into sleep and hours later awoke to the full moon, straight above Balanced Rock. I hoped we would find the perfect kiva, but worried that it was a needle in a haystack.

The morning came in clear and crisp. My muscles and joints had loosened up. This would be our main day. We would start early, hike the main canyon — 6 miles to the top if we had to — and then return to our camp. Tomorrow we would

head out, going up a side canyon that was a candidate for the perfect kiva. But the main canyon was much more likely, and today would be our last chance. We made breakfast, packed water and lunches, and headed out upcanyon.

Much of the canyon floor was halgaito shale, chocolate and brittle. It came in thin sheets and broke off easily at the edges. The walls of this sublime canyon, deep backcountry, plain old BLM land, were Cedar Mesa sandstone, a soft, inviting, glowing pink.

By now Philip had learned a great deal about this canyon and how the Old People lived in it. The village sites would always be on a large, level, south-facing ledge, up off the canyon floor and preferably with a significant overhang. We hiked at a determined pace, but slowed to make careful inspections of the canyon walls when the conditions seemed right. We found more granaries, a site with two rooms, and, high up on a ledge only 20- or 30- feet deep, a multi-storied village with many rooms. By late morning, although we had done a great deal of scrambling to get up to the sites, we both commented on how we didn't feel particularly tired. We were sustained by the trickle of a stream, the fire in the sandstone, and the Old People all around us.

"Dad! Isn't that a door up there? Way up, on the fourth shelf up?"

"Where? Just to the left of that juniper tree?"

"No. Farther to the right, at the end of that long ledge."

My eyes just weren't as good as his. I worked at it but, even with further directions, couldn't see a door or other structure. I did tell him that I thought I saw a wall at the other end of the ledge. He said, yes, that it was a wall.

"Come on, Dad, let's get up there."

It was a sturdy climb to the ledge, well more than half way up the side of the canyon. Several places were dicey, hard spots to find a way, but we worked up past them. We stopped. Yes, even I could tell that there definitely was a door to a granary, which looked beautifully constructed. We were now on a slope of scree, down below the ledge, and couldn't see up over the outer edge. But we were close, only about five more minutes. I let Philip go on ahead. He scrambled for all he was worth

Minutes later, from the ledge I heard that cry from the depths of his generation's culture.

"Yesss! Yesssss!! Yesssss!!! It's the perfect kiva! Dad! Dad! Hurry! Hurry!"

I did. I worked up to the ledge and soon stood there, breathing hard and trembling through all my limbs. There were numbers of structures — granaries, rooms for living — and the perfect kiva. The roof, at ground level, was completely intact. The old ladder, which the BLM had reinforced with aluminum bolts, rose up through the opening. There were some hiking-boot footprints around, but not many. There was little traffic in this canyon, and this site was easy to miss. Without Philip, I might well have.

Philip was desperate to go down into the kiva, but I was firm. No, we are going to take our time and enjoy this. You always open the best present last. And we were going to be here a while.

We were hungry and climbed up on a high rock to have lunch. This village was set in the elbow of a bend in the canyon and, like the Old People, we had long views up and down the canyon. Across the way we could see the piñon-juniper top of Cedar Mesa.

We finished up and began to explore around the village. There were pictographs, a snake about 2-feet long, a small black animal, and white hand marks with red concentric circles on the palms. A white-painted man had red arms and legs. On one of the walls, earlier visitors had placed pot shards and corn cobs, each as small as my pinkie. I was reminded that we have created our own traditions, built on respect: it is now custom, as well as the law, to leave these remains for other visitors to enjoy.

Corn had been a major influence in Anasazi culture. Maize is completely domesticated — it has lost its capability to reproduce naturally. Carbon dating has placed corn in Mexico 5600 years ago. It apparently did not reach the Southwest until 3500 years ago, but, when it did, it spread rapidly among the Natives. The cultivation of maize was perhaps the main factor in the Pueblo peoples' move from foraging to farming.

Corn was mostly ground into flour, and it seems that Anasazi women spent huge amounts of time grinding — and thinking and talking. Time was spent, too, with the young ones. We had brought several books on this trip. Philip had read Terry Tempest Williams' *Coyote's Canyon* and much of *Wind in the Rock*, by Ann Zwinger, both of which dealt with the Cedar Mesa canyons. Philip still liked me to read to him, and at the village I read a passage from Mary Sojourner's *Sisters of the Dream*, about Choovio, an Anasazi mother, and her small daughter Talasi, because it seems to be insightful of the daily life of the Old People:

> Choovio built up the fire, warmed cornmeal soup and fed them both, grateful for the shadows flickering on the walls, for the food in their bellies.… She sat for a time with Talasi, smiling down at the round sleeping face. Then she turned to her grinding stones and ground corn far into the night, corn for the ceremonies, corn for the feasts, sacred corn for the sacred work of Soyal. Talasi, drifting in and out of dreams, heard the rasp of her mother's work, the music of the grinding, the music of her mother's songs and saw, behind her closed owl eyes, the Spirits dancing high above, laughing and playing, bounding from star to star.

That made Philip wonder about the Anasazi children in this high-ledge, steep-canyon village. He thought it might be dangerous for them. Perhaps, he reasoned, that shows that they lived up on the mesa all year, and that adults came down to this site for farming and ceremonies.

My own response, because I have come to think that the canyon sites were occupied year-round, was that there may well have been a wall along the side of the ledge; we inspected and saw many cut rocks down the slope, suggesting such a possibility. Even if there weren't a wall, my own experience is that Indian societies work especially hard at disciplining their children, and that the Anasazi would probably have had an effective way of teaching their children to stay away from the edge. I hadn't thought of it in years, but when Philip and the other boys were little, and Ann and I would take them to pow-wows at Warm Springs or over on the Oregon Coast, all the Indian people would always be looking after the kids. “At an Indian get-together,” one Indian friend had told me, and I told Philip, “you’ve got baby-sitters all over the place.” But, like so much with the Anasazi, we can only have the pleasure of engaging in the speculation, and may never know. We inspected the buildings. I knew that the Cedar Mesa pueblos had been settled late, during the 1100s and 1200s, when Anasazi architecture had become highly refined. These buildings were not as elaborate as those at Chaco Canyon, 150 miles to the southeast, with their immense size and exquisite detail work. Our village was not nearly of Chaco’s magnitude, and the masonry work not so polished, but the same intelligence and industriousness showed through. These buildings were sturdy and employed passive solar heating. The Anasazi showed the way and, even today, the same principles of architecture are used throughout the Southwest.

Much the same is true of the pottery that our shards came from. The Anasazi developed a profusion of vessels and artistic styles. One potter told me, “their work is magnificent. And they didn’t even have the wheel. It’s hard to imagine how they could turn out work like that without a wheel.” It was mid-afternoon, and it was finally time to go into the kiva. We gingerly descended the old ladder, and gave our eyes time to adjust to the dim light. This was not a great kiva, which would be larger, big enough to hold, say, 100 people. Rather, this kiva was used by a few small villages in the immediate vicinity. Yet, we could see that this was a place to which these families ascribed great importance. For one thing, it required an enormous amount of work to create. This kiva, after all, had been hand-dug 7-1/2-feet down into the sandstone. It was about 15 feet in diameter. The ceiling was made of thick juniper beams. This was done without any beasts of burden. We could see, even 700 years after the area had been abandoned, that this kiva had been well cared for. The circular walls had been coated with a smooth mortar and then painted a dark red. There was a yellow circle on the west side and another on the east. In this protected space, I was reminded that, while we often think of the Anasazi villages in terms of grays and browns and unadorned sandstone, in fact these were colorful societies. We usually see only the exposed surfaces, weathered by the many centuries. Yet archaeologists have found that interior walls were regularly decorated, as was this kiva, ablaze with colors.

Philip and I sat down on the floor, backs against the wall, he at the north, I at the east. We’ve since talked about that trip a great deal, but for whatever reason we’ve never discussed our thoughts during our silent hour in the perfect kiva. Perhaps it was simply because we moved beyond specific thoughts to a slow, steady flow of reverence for the people, gods, and ideas that made for such a long-lasting and admirable way of life in this beautiful but difficult landscape.

We got up, climbed the ladder, stood for a while on the ledge where once the kachinas had danced, hugged, and then moved down the canyon side. By the time we had hit the trail, we were talking again as we made our way back to the campsite. That night, lying in my sleeping bag under the protective sandstone shelf, after Philip had trailed off, I remember something that hadn’t occurred to me all day. The kivas were in continual use. And, just as Choovio instructed Talasi in her own way as she steadfastly worked her stone mano, grinding the corn to flour in the trough-like metate, so too was the kiva the place where the fathers instructed their sons. I imagine, in a society where they caressed time rather than raced against it, the Anasazi fathers knew that, to be good fathers, they had to be neither strong nor handsome nor rich, that they had only to give their time to their sons. And, while my world may be too different, and my own limitations too many, to live that idea as well as they, at least now I have that idea, born not so much from analysis as from reverence visited in a perfect kiva carved by hand 7-1/2-feet deep in Cedar Mesa sandstone almost 1000 years ago.

The question for us to face is how much we now value the archaeological resources of southern Utah and of the whole Colorado Plateau — the legacy of not just the Anasazi, but also the Fremont, Mogollon, Singua, and Hohokam — and how we ought to value them in the years ahead.

There is a great deal at stake. No one knows the number of archaeological sites, but we know it is immense. In San Juan County, Utah, alone, where our perfect kiva is located, there are 300,000 recorded sites on BLM lands alone, and estimates of unrecorded sites run into the millions. There are 120,000 recorded sites in New Mexico, with a potential for another 1 million.

The numbers of recorded sites are estimates only and have many limitations. Much discretion is left to the people doing the surveys. Most of the tribes refuse to release any information on sites within their reservations. Another problem involves the definition of a site. The generally accepted standard is any place where there are material remains, at least 100 years old, that could represent a pattern of human activity. This includes something as small as a fire circle, but not lithic scatter — a dropped arrowhead or pot shard. The range of importance is enormous. Many sites have little significance, but even one fire circle can open up a new frontier of knowledge if carbon dating gives the kind of readings that Scotty MacNeish found in Pendejo Cave. Further, we know that there are still extraordinary treasures to be unearthed, undoubtedly including whole villages the equal of the most elaborate at Chaco Canyon or Mesa Verde.

Whatever the numbers may show, the Colorado Plateau is one of the greatest, perhaps the single greatest, storehouse of archaeological resources in the world. It is the world's University of Archaeology.

This is due in part to the long and far-flung range of human activity. So too does the aridity help — wood does not rot in this dry country. It also matters a great deal that the Anasazi were such master builders and that their structures are so durable. Dr. Linda Cordell, one of the country's leading archaeologists and a specialist in the Anasazi, told me that the Four Corners Area is "an unparalleled resource for understanding the past. I've seen grown Peruvenists [specialists in ancient Peru] cry over the quality of what we have on the Colorado Plateau."

But the loss has been tremendous. Looting at sites for pots, baskets, jewelry, and other artifacts — all nonrenewable resources — proceeds at a sickening rate. Legally sanctioned development has taken a heavy toll. Two hundred-mile long Lake Powell, created by Glen Canyon Dam, destroyed tens of thousands of sites. There are hundreds of other dam and reservoir sites, large and small, across the Plateau. Strip mining for coal has taken out hundreds of square miles of land. Highway and road projects, commercial buildings, and residential subdivisions have dug up or bulldozed countless numbers of archaeological sites. Grazing, clearcutting, and recreational use have also caused significant losses. The dramatic loss of these cultural resources raises the same large policy and philosophical issues as do endangered animal species.To date, we have chosen to do relatively little to protect ancient cultural resources. One important, and generally successful method is designation of key sites as national parks (examples include Mesa Verde and Canyonlands) or national historical parks (as with Chaco Canyon). Otherwise, federal statutory protections are procedural only. That is, the laws do not prevent destruction of archaeological sites through mining, dam and reservoir building, road construction, cattle grazing, or logging. Rather, laws such as the Archaeological Resource Protection Act require only that agencies attempt to identify threatened sites (though survey money is very tight) and, if a site is discovered, balance the development project against the value of the site. To date, although sometimes you will see a jog in a road whose course was altered to protect some remnant of the Old People, the development has nearly always won out. In most cases, the only action is salvage archaeology, where you lose the context for the old remains by uprooting the archaeological material from its setting and storing it away, usually in the basement of some federal building. Federal laws place no restrictions at all on development on private lands. State laws are few, young, and largely untested.

The public's level of appreciation of these old cultural resources is steadily rising as we lose more and more of them forever, as we see the similarity to the loss of the natural world through overdevelopment, as we gain respect for minority cultures, and as we yearn for a sense of community and place in a fast-paced, impersonal society. In this context, the Old People become an anchor. They give us data about sustainability of the environment: by any standard the Anasazi developed a brilliant set of ideas on how to live in a desert land. Their complex society, with its intricate and demanding religious traditions and its rigorous mores for personal behavior, sets out a valuable model of religion and law. The Old People had a fundamentally different way of living a life, and, whether in a particular person's view theirs was a better or worse way, or an equal way, it was a formidable way, one that has lasted and lasted and lasted, one that ought to be studied, understood, and respected.We can articulate, then, the reasons for changing our archaeological resource laws, policies, and individual conduct in terms of ethical, societal duties. A duty to honor the dead, to respect their accomplishments. A duty of historical preservation — an acknowledgment by us in the American West that, no, not all of the ancient history in this country is back East. A duty to the modern Hopi, Zuni, and other Pueblo people to see that their heritage is preserved. And, in a certain way most profound of all, a duty to maintain information that will benefit our society now and in the future — information that may prove precious to us as we now understand that we are hard up against the limits of sustainability of this earth. All of these duties are ultimately clothed in the sacred, for all parts of the lives of the Old People were clothed in the sacred.

We could reflect these priorities and duties in our laws, where our society lodges its highest priorities. We could require that no archaeological site of significant importance — not sites that are redundant or superfluous — can be altered except on a finding that alteration is clearly justified by some other compelling public interest. These requirements could be applied to private, as well as public lands. This would not run afoul of the constitutional prohibition against the taking of private property. Government, acting in the public interest, has broad authority to place restrictions on the use of private property — zoning, wetland preservation, and clean water and air statutes are all examples of similar restrictions on the use of private lands.

Let me say, by way of conclusion, that my own guess is that we will not see the needed deep reform of our laws until we resolve a set of ideas, all related.

Ultimately, we have probably chosen not to give more substantial protection to Anasazi culture because of an unspoken assumption that this, and other Native cultures, are less worthy than ours. They are "primitive" or, more politely put, less "advanced."

To which one must ask, "advanced at what?" Technologically, even given the superb pottery and architecture, the Old People were not as elaborate as our society, with its computers and high-powered land, air, and water machines, but their religion was far more elaborate than ours. True, they had no written language, and no audio or video tapes, but they did and do have an elaborate exacting oral tradition — a demanding method of communication that took decades to study and master and that had the singular advantage of being more interpersonal, a direct relationship between human beings. Our society assesses cultural value in terms of linear progress, always pushing forward. Pueblo people see life holistically, as a series of stable relationships with the earth, its people, and the gods. Do we not need to understand both of these worldviews at this critical time in our species' existence?

We well understand, then, why we must preserve the Parthenon, Chartres, the Liberty Bell, and other such historical remnants. We still have not, in our core beings, put perfect kivas in that category. I can still hear Bob Heyden, the impassioned superintendent of Mesa Verde National Park, his voice rising as he went, "there's coal under this park. Someday they'll want to mine it. I think they will. They wouldn't mine coal under Gettysburg, but they would under Mesa Verde. They don't think of Anasazi as our people."

I hope, as he does, that he's wrong. The Anasazi are our people, our oldest people here, 12,000 years at least, 38,000 years back into misty millennia if Scotty MacNeish or some later archaeologist is right. When you go to the Anasazis' places, and try to transport yourself back, it becomes very tangible, very direct. The Anasazis' teachings — about arid country, about respect, about obligation, about beauty, about the sacred, about daughters and mothers, about sons and fathers, about how to live a life — are luminous. We need to honor those teachings by learning them and seeing that their context, which gives them life even today, is preserved.

References

Archaeological Resources Protection Act of 1979, 16 U.S.C. §§470aa-470mm (1988 and Supp. II 1990).

Barnes, F.A. and Michaelene Pendleton. 1992. Canyon Country Prehistoric Indians: Their Cultures, Ruins, Artifacts and Rock Art. Wasatch Publishers. Salt Lake City.

Cole, Sally J. 1990. Legacy on Stone: Rock Art of the Colorado Plateau and Four Corners Region. Johnson Books. Boulder, CO. Pages 109-200.

Cordell, Linda S. and George J. Gumerman, Eds. 1989. Dynamics of Southwest Prehistory. Smithsonian Institution Press. Washington, D.C.

Dutton, Bertha P. 1963. Sun Father's Way: The Kiva Murals of Kuaua. University of New Mexico Press. Albuquerque.

Grand Canyon Trust. 1994. Preserving Traces of the Past. Grand Canyon Trust. Flagstaff, AZ. Pages 1, 7.

Greenberg, Joseph H. and Merrit Ruhlen. 1992. Linguistic origins of Native Americans. Scientific American 267: 94.

Greenberg, Joseph H., Christy G. Turner II, and Stephen L. Zegura. 1986. The Settlement of the Americas: A comparison of the linguistic, dental and genetic evidence. Current Anthropology 27: 488-491.

Hutt, Sherry, Elwood W. Jones, and Martin E. McAllister. 1992. Archaeological Resource Protection. Preservation Press, National Trust for Historic Preservation. Washington, D.C.

Indian ruins ravaged at night. 1994. Arizona Republic 26 March 1994: A1.

Indian-site looters dig for dollars. 1993. Albuquerque Journal 11 May 1993.

Lister, Robert H. and Florence C. Lister. 1983. Those Who Came Before: Southwestern Archaeology in the National Park System. Southwest Parks and Monuments Association. Globe, AZ. Pages 72-73.

McCombs, Phil. 1993. The cave bear Scotty MacNeish. Washington Post 18 April 1993: F1.

Murphy, Michael. 1994. State’s history trampled. Phoenix Gazette 9 May 1994: A8.

National Historic Preservation Act, 16 U.S.C.A. §§ 470-470x-6 (West Supp. 1993).

Nobel, David Grant. 1991. Ancient Ruins of the Southwest: An Archaeological Guide (revised edition). Northland Publishing. Flagstaff, AZ. Pages 74-78.

Rensberger, Boyce. 1992. Placing man in America 28,000 years ago. Washington Post 10 February 1992: A1.

Society of American Archaeology. 1990. Save the Past for the Future: Actions for the ’90s. Society of American Archaeology. Washington, D.C.

Sojourner, Mary. 1989. Sisters of the Dream. Northland Publishing. Flagstaff, AZ. Page 7.

Stokes, Marvin A. and Terah L. Smiley. 1968. An Introduction to Tree-ring Dating. University of Chicago Press. Chicago.

Talayesva, Don C. 1942. Sun Chief: The Autobiography of a Hopi Indian. Yale University Press. New Haven, CT. Pages 137-140.

Waters, Frank. 1963. Book of the Hopi. Penguin Books.