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The Chainsaw and the White Oak: From Astrobiology to Environmental Sustainability

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From Astrobiology to Environmental Sustainability

FEATURE

by Dwight E. Neuenschwander with Leo R. Finkenbinder

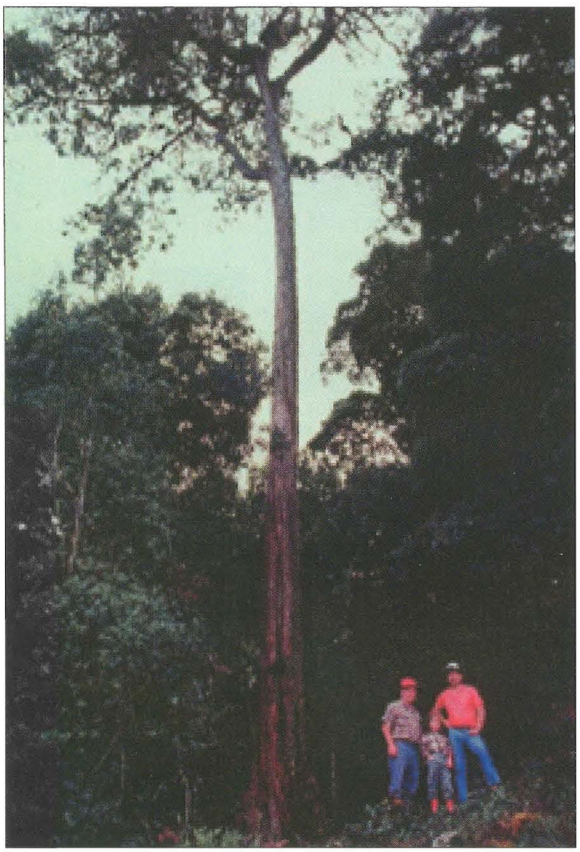
The world does not consist of happenings only; it contains life as well, and to the life in the world, so far as it comes within my reach, I have to be in a relation which is not only passive but active.
— Albert Schweitzer (1933)*

EFRAIN CHACÓN AND RIO SAVEGRE

In 1952, high in the Talamanca Mountains of Costa Rica, Efrain Chacón stepped off the new Pan-American highway and hiked down a game trail into the remote valley of the Rio Savegre. After serving as a captain in the 1948 farmer's uprising that affirmed Costa Rican democracy, Efrain started a dairy. But in a severe El Niño drought the pastures dried up and the bank foreclosed his farm. Now the Costa Rica Homestead Act had given Efrain another chance to make a living for his wife and their infant son, Marino.

The walk from the Pan Am to Efrain's homestead took four hours, as the hiker descended from the Caribbean and Pacific watershed divide at 3,300 meters elevation (11,000 ft.), to his homestead at 2,200 meters (7,200 ft). These mountains are so high only two dozen miles from the ocean because they are geologically young, the last link in the land bridge between two continents. They are also culturally young: in pre-Columbian times, there were no human settlements at these elevations, and in 1952 this cloud forest was virtually untouched. It was home to nutmeg, almond, and avocado trees. Towering above them were oaks over 100 ft. tall. Shortly before noon every day, a thick mist rolled in from the coast, filling the canopy with a moist gloom that dripped life and mystery. The thick canopy branches were heavy with epiphytes—plants growing on plants—, the sweet air scented with orchids, damp leaves, and mossy wood. The hiker could glimpse the bright colors of the sharp-eyed tropical birds, and overhear snatches of their merry conversations.

This valley held one of the few remaining habitats of the Resplendent Quetzal (see cover photo).[1] To the Aztecs and Mayans and Toltecs of old, to see the quetzal was to behold the divine. This reverence survives today in cultural symbols across Central America. For example, the quetzal forms the national symbol of Guatemala, and lends its name to that nation's currency. These regal creatures, sitting tall and proud on their oak branches, watched Efrain as he wended his way down the trail, bearing his axe.



Three generations of Chacóns next to the White Oak (l-r, Efrain, Matilda, and Marino).

Efrain knew the dairy business. Near the river, he began clearing some forest, burned off the understory, and planted African bermuda grass for pasture. His fine cheeses sold well at the roadside store up on the Pan Am. The Chacóns soon became leading agricultural innovators in Central America. Their dairy was the first in Costa Rica to expand its Holstein herd through artificial insemination, using semen imported from the Netherlands. In 1954 Efrain learned about rainbow trout. He consulted with agricultural officials, built a small hatchery, and stocked the Rio Savegre. He built *cabinas* and a rustic restaurant for the fishermen, and advertised his trout fishing camp with a small card posted in a San José sport shop. Señora Chacón served splendid meals and warm hospitality to the family's guests.

Good apples were hard to find in Costa Rica. The crispness and flavor went flat by the time the imported fruit arrived in San José. Here the Chacóns saw another opportunity. After many experiments they found in Israel the Ana apple tree, a non-seasonal species that thrived in the cloud forest climate. The fresh Chacón apples sold well from the moment they

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were introduced in 1977. Meanwhile, the dairy pastures crept farther up the mountainside as Efrain and his growing sons felled the trees, one by one, with their axes.

In the early 1980's, environmental biologist Leo Finkenbinder visited Rio Savegre valley. Leo had grown up on a Kansas farm, taught high school physics and biology in the Oklahoma panhandle, then earned his PhD in environmental health and became a professor. He had studied thermal algae in the US and Trinidad, then began visiting Central America, where he was introduced to the Chacón family and their cloud forest. Leo and his wife Zana immediately hit it off with the Chacóns. The Chacón *cabinas* became the Finkenbinder's field station as Leo and his students studied the incredible diversity of life in the cloud forest.

In January 1982, Marino took Leo, several students, and a few other professors up a trail he had built in the mountains above the pastures. On that high cloud forest trail one sees in just 400 meters of hiking a greater number of species than exist on the entire North American continent. Later that evening, Marino spread over the restaurant floor a blueprint for a 10-year dairy expansion. Pointing to the map, he enthusiastically explained his family's plans to triple the size of the pastures, which at that moment covered 80 acres. The hearts of the biologists were crushed. There was little time for talk, though, for tomorrow they were returning home. But by this time some important personal bridges had been built on foundations of mutual trust and respect, bridges that made possible everything that happened next.

For the next year Leo's students wrote to the Chacóns often and regularly. Leo encouraged the students to emphasize the positive—the beauty of the forest, the rich diversity of life in the valley. Having learned so much about the forest and its wildlife from the Chacóns, the students now tried to show the Chacóns the forest through the eyes of biologists, eyes that see on timescales of 500 years. But the biologists also respected the family's need to support itself in the Rio Savegre valley. This valley was their home.

In February 1983, back in Oklahoma, Leo returned to his office from microbiology class, to find the telephone ringing. It was Marino. "Leo, we have decided that we will not cut any more trees. We are going to sell all the cattle. Can you come down?" Leo went.

Efrain and Marino told Leo what happened. One evening after a long day of chopping and clearing, they had a rest before trekking down the mountain to home and dinner. They leaned their backs against the next tree they would chop the following morning, a colossal white oak. They laid their axes down, because they always left these heavy tools on the mountain to avoid carrying them back up the next morning. This evening Efrain said to Marino, "Look, from here we can see all the way to our houses." Suddenly it hit them. They could see the houses because they had created 80 acres of emptiness. Eighty acres of forest, which covered this slope in 1952, gone. And this white oak would be next. Efrain and Marino talked about the students' letters. Those students spoke for the future. They saw a future lacking the trees and wildlife that Efrain and Marino enjoyed so much. Leo had shown how a patch of primary forest, once cleared then left alone, still requires over 500 years to restore its original state, provided the seed bank survives. And when the trees go down so does the intricate network of life among them: the poison dart frogs that climb eighty feet to the canopy every day to take care of their tadpoles hatched in the bromeliads; the insects who aerate the soil; the brockett deer, which stand only 45 cm tall when full grown; the quetzals, whose nests now sat in the future pastures on Marino's map.

Efrain and Marino thought hard. They were used to being innovative. They were used to taking calculated risks. But should they follow the advice of Leo and his students? In Efrain's house were sixty trophies for their prize-winning cattle. Eliminating this world-class dairy herd would be a high-stakes gamble with their family's livelihood and the grandchildren's future. But the grandchildren might grow to love this forest as Efrain and Marino had grown to love it. They deserved that chance. This forest was part of their legacy too. Could they have it both ways—save the forest *and* provide a livelihood? It was decision time. Efrain and Marino knew that if they came back to this white oak and chopped it down the next morning, they would go on chopping and burning right over the top of the mountain. They decided. That evening they carried their axes down the mountain. That white oak would not fall to their axes. The next morning the family held a conference, affirmed the decision, made a plan, and Marino telephoned Leo.

The technological fruits of applied physics create tough choices. In 1989 Efrain told Leo and the students, "I thank God every day that I did not have a chain saw when I started making a dairy. By the time I would have realized the importance of the forest it would have disappeared. The forest is

The Resplendent Quetzal

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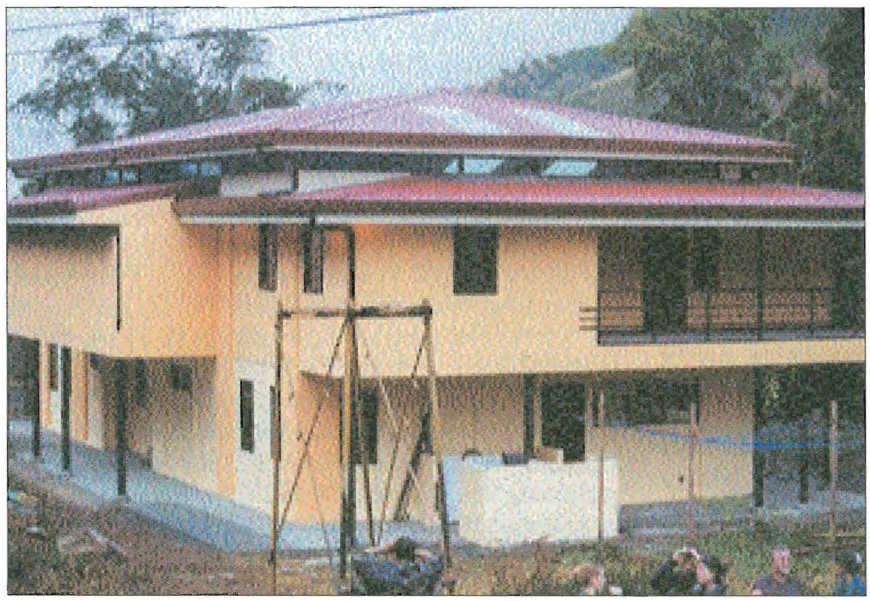
there only because I had an axe." Efrain stated with simple eloquence a principle articulated in abstract terms thirty years earlier by pioneering ecologist Eugene Odum:

"Man's power to change and control seems to be increasing faster than man's realization and understanding of the results of the profound changes of which he is now capable....

"Although nature has remarkable resilience, the limits of homeostatic mechanisms can easily be exceeded by the actions of man."[2]

The Chacóns could make an informed decision for sustainability because they had three things going for them: a sense of place, a knowledge base, and a plan. They loved this forest, even as they cut it down when it seemed initially so vast. It was their habitat. The knowledge base came through their inquiring minds and their ability to ask the crucial questions. And their plan, which depended on the availability of alternatives, was quickly implemented. They sold the cattle, and turned the existing pastures into orchards, adding peaches and plums to the apples. The remaining forest was left intact. The hiking trails were improved. The dairy barns were torn down and replaced with new *cabinas*. Through a web site, fishermen and birdwatchers were invited to come.



The laboratory/dormitory facility at the QERC, representing a commitment to study and sustainability. —*photo courtesy D. Neuenschwander*

And come they do: about 10,000 persons visit the valley each year. In smaller numbers come the researchers and scholars too, and not only biologists. Chemists. Geographers. Linguists. Historians. Photographers. Artists. And astronomers and physicists.

From Astrobiology to Environmental Awareness

Building on two decades of personal dedication by Leo and Zana, in 1998 Leo's university established in the Savegre valley a field station called the Quetzal Education Research Center (QERC). The university and the Chacóns negotiated a renewable 25-year lease of the family's cloud forest. Students and professors from universities across North America and Europe come to the QERC to hold classes and conduct research.[3] High school and middle school students come from the US. The QERC has hosted researchers from the New York botanical gardens, and film crews from *National Geographic* and the BBC.[4] To better accommodate the researchers and students, a new laboratory/dormitory building was completed in January 2001. For the visiting scholars Zana also organizes tours of other Costa Rican sites of scientific interest. In the north, these include the active Arenál Volcano, and the Caño Negro National Wildlife Refuge that is home to spider monkeys, iguanas, sloths, and caiman; on the Pacific coast, either the Marenco field station on the Osá Peninsula with its howler monkeys, scarlet macaws, dolphins, and coral reefs; or the Manuel Antonio National Park, habitat of more sloths, squirrel monkeys, and salt-water crocodiles.

For two consecutive spring breaks, this professor has taught an astronomy course at the QERC.[5] Your first arrival there is a moment of epiphany. You come prepared to teach astronomy in familiar ways, but here you are utterly overwhelmed in a forest of 100 ft. oak trees, the birds are as colorful as the flowers, and photosynthesis works overtime. The nuclear reactions at the Sun's core and its energy transport mechanisms suddenly hit you in the face with new intensity. You look up at the Sun, and you look around you where every surface is *alive*. In the abstract, you already knew that life depends on a stellar mass not too large, and a mean distance between stars not too small. But here, the union of astronomical realities and the conditions necessary for life becomes a personal astrobiology adventure.

Stellar evolution and biological evolution have always gone hand in hand, but never shown more clearly than here. The one provides energy, elements, and timescale for the other. All astronomy courses describe tidal forces, but here at 9° 30' N our lesson on tides occurs at the Manuel Antonio beach, with professor and students up to our necks in the high tide, the third-quarter moon visible over our heads. That setting leaves one awash in new appreciation for the moon that makes possible the transition zone for life to emerge from the sea onto the land.[6] Similarly, all astronomy courses describe cratering, but here we discuss planet-building while standing in the craters of the great 1968 eruption of Volcan Arenál. What was going to be an "Astronomy" course was transformed at once into "The Astronomical Basis of Life on Earth."[7]

We came to Costa Rica to study the connection between the sky above us and the life around us, but in the immediate

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reality of the here and now, another story of life on earth unfolded before our eyes.

As you travel the country, you see flatbed trucks laden with mahogany logs. In the north, and on into Nicaragua, you see seemingly endless, scrubby prairie that was rich, dense forest 40 years ago. At that time Costa Rica held 4% of all species on 0.001% of the Earth's land, giving this country the richest biodiversity density on the planet. But "Costa Rica lost almost half of its forest cover from 1950 to 1990. Much of this wasn't even used as timber, but was burned for pasturage to produce low-grade beef for export."[8] Most of this export was to supply the rapidly expanding North American fast-food market, where the beef was advertised as "raised in America." Today much of this cleared coastal land is hard-baked laterite, where neither trees nor Brahma steers live any more. Compared to being there, not even the movie "Medicine Man" fully prepares one to appreciate the scale of deforestation or its consequences. But at least in Costa Rica's case, since the 1970's, millions of acres of primary forest have been saved through one of the world's exemplary systems of national parks, wildlife refuges, and privately owned biological preserves.

"The environment" and "genetic diversity" will dominate discourse in the 21st century about the relationship between science and society. On both points the fate of tropical forests will be decisive. Tropical forest photosynthesis accounts for most of our atmosphere's oxygen production and carbon dioxide removal. Tropical forests contain most of the genetic diversity on which the vitality of life depends.

At the beginning of the 20th century, tropical forests covered about 10% of the earth's surface. In 1990, Richard Tobin wrote, "These forests provide irreplaceable habitats for as much as 80 percent of the world's species of plants and animals, most of which remain to be discovered and described scientifically." Half of all species on Earth reside in the tropical forest canopy, defined as habitat located at least 35 feet above the ground. How many scientists does one see working the canopy? Very few, as almost all of them work in temperate climates.[9] Tobin continues, "The deforestation of recent decades has diminished this area by about one-third. Estimates of current rates of deforestation vary, but some experts believe that the pace of destruction is accelerating, with a total loss of about 2 percent of all tropical forests each year." This figure gives the tropical forests a half-life of about 35 years. "If current rates of deforestation continue unabated,... humans will have destroyed a natural palliative for the greenhouse effect and condemned to extinction perhaps half of all species now known to exist."[10]

Most of the destruction of tropical forests is done for fuel wood, or for agriculture and ranching, and the long-term effects are disastrous. In tropical latitudes, about 95% of forest nutrients are found in plants, and only about 5% in the soil (the reverse of temperate latitudes). These small quantities of organics in the exposed soil wash away in two or three years, and the land suffers rapid erosion and bakes to lateritic hardpan. These results lead the inhabitants to move on with more slashing and burning, resulting a denuded landscape that eventually supports little life at all. These short-term tactics result in long-term poverty. *That* experiment has been done: witness the ecological and subsequent human disasters in Haiti and Nicaragua, where the loss of primary forest has lead to the loss of topsoil, decline of the population's ability to feed itself, and the rise of social desperation.[11] The results are so spectacularly destructive, especially in Brazil and Indonesia where deforestation has been vigorously implemented through government policies, that these nations "might be regarded as waging the equivalent of thermonuclear war upon their own territories."[12]

The mixed signals sent from the developed to the developing nations compound the problem. For example, the industrialized nations criticize the deforestation policies of undeveloped countries, but the former have already destroyed much of their own forests, and are reluctant to reduce their CO_2 emissions or their appetite for mahogany and cheap hamburger. The World Bank urges debtor undeveloped nations to produce cash crops for export, and the forests, the wildlife, and ultimately the people pay the price.

Our ability to eliminate forests and species, and our short-view propensity to do so, raises ethical questions of stewardship. The thoughtful alternative to wholesale deforestation lies in "sustainability." In 1987 the Brundtland Commission on Environment and Development defined "sustainability" as "Meeting needs of the present, without compromising the ability of future generations to meet their own needs."[13] This definition is built around the needs of *people*. It does not explicitly say what should become of primary forest and quetzal habitat, but throws such questions back on us: What shall we sustain?

Ten years ago, Leo's students counted two or three mahogany logs on each flatbed truck. Today we count eight or ten: the big logs are gone.[14] Mahogany and teak farms can make the wood available, but tree farms are "green deserts," not the species network that makes a forest. After seeing freshly cut mahogany logs on the trucks, particle board becomes a thing of beauty.

Organic chemicals found in tropical forests form the essential ingredients in about one quarter of the world's medicines. About 70% of the compounds showing anti-cancer properties come from plants found only in the tropics. Without the tropics some of our children will never meet their grandparents. Thus biodiversity can become quite personal. This is reason enough to preserve the tropics, of course. But surely we can do even better, and not stop at measuring the diversity of life or the potential of evolution in units of commodity futures. The question of environmental sustainability forces us to question our values.

Cultural symbols represent the identities and values of entire peoples. When the Resplendent Quetzal no longer exists—they have been projected to go extinct by 2015—quetzal DNA will be out of the gene pool of life's possibilities, and the world will be a less interesting place for astronomy teachers from Oklahoma as well as for the descendants of Montezuma. We can measure the capacity of a forest's biomass in economic terms, but how do we price its interestingness? "Is there a noneconomic basis that should be used to

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evaluate an environmental policy choice that is plainly inefficient from an economist's point of view?"[15]

Intellectual Diversity and a Habitat for Ideas

The Chacón family's experience provides a studied model of sustainability, known in environmental circles as the "White Oak Model."[16] Farmers and government officials across Latin America come to see how the Chacóns have been able to make a good living while preserving their primary forest. For example, one day in 1986, two Land Rovers filled with Nicaraguan Sandinastas drove into the Chacón compound. The agriculture officers in military uniforms had come to study the orchards. The visitors said, "This is what we should be doing in Nicaragua."

It is important to read articles about tropical deforestation and loss of wildlife habitat. But it's more compelling to hear with your own ears the roar of two male howler monkeys in a territorial dispute (they sound from 2 kilometers away like F-18's under full throttle), or to see nine pairs of scarlet macaws feeding in a plum tree on the beach. This professor went to Central America to teach astronomy, but there he received an education about life on earth.

It's a transforming experience for the students too. The network is being formed right now of young scientists and decision makers who in the next few decades will address our critical environmental and biodiversity problems. We met some of these young people in Costa Rica. For example, on two successive evenings at Marenco, after dinner the tables were pushed back, and under dim lights hanging from the bamboo rafters, with the Pacific breeze wafting under the thatched roof, we held colloquia featuring the research of graduate students. Two students from the University of Costa Rica described their research on howler monkeys, done in collaboration with colleagues working in Africa. The following night two students from the University of Lausanne in Switzerland described their offshore geological research on the Coco Plate. At research stations like the QERC and Marenco, student relationships are solidified into a network of young people working together around the globe in shared experience and common interest.

This network forms another kind of ecosystem, a habitat for the growth of ideas and awareness of stewardship. Our long-term well-being depends on intellectual diversity as well as biological diversity. Solutions to environmental and biodiversity problems, like solutions to astrobiology problems, require the coordinated work of physicists as well as biologists and organic chemists. The insights of anthropologists and ethicists, and the skills of bankers and politicians and entrepreneurs are also necessary, because workable solutions must take into account economic, cultural, and political realities as well as scientific realities.

Ultimately, physics education is not just about job training. It is about sharpening minds to engage the world. Physics as a discipline, and the physicists' approach as a way of thinking, have much to offer biological and environmental research.[17] The study of atmospheric greenhouse gases illustrates the application of physics to an urgent environmental problem, in this case the coupling of thermodynamics and fluid mechanics to molecular physics. Similarly, in an abandoned cloud forest pasture, where the grass gives way to the pioneer growths of secondary forest, and thus anticipates the restoration of the primary forest, a biologist thinks in terms of seed banks and dispersal mechanisms, while a physicist sees diffusion processes and a set of rate equations. The biologist and the physicist working together will see more together than either one can see separately.

For the half-century following World War II, the challenge of nuclear energy meant that physics held the keys to building superpowers. In 1989, Alvaro Umaña, the Costa Rican minister responsible for national parks, noted that because of its conservation and sustainable development accomplishments, Costa Rica was "biologically a superpower." David Wallace notes, "The claim may seem exaggerated: could a nation the size of New Jersey be a superpower of any kind? Yet, if history continues, power will reside with societies that have conserved their resources, not with those that have spent them... If history continues, the growth of park systems will be more important than wars."[18]

The Wisdom of the Axe

Efrain Chacón was right. A chain saw works too fast for us to always reflect on what we are doing. Sometimes there is wisdom in using an axe, even when a chain saw is available.

The battle for responsible environmental stewardship will be won or lost in the tropics. We need a sense of place, a place to let life in the world be what *it* is; we need knowledge—including the contributions of physics—; and we need a plan. A personal encounter forms the prerequisite to all three. It's ultimately about relationships. Places like the QERC exist to nurture these relationships. I don't know if visiting the tropics has made me a better physicist, but it has already made me a different kind of physicist. I'm not talking about professional specialty, but a new depth of gratitude and appreciation.

The quetzals and the Chacóns and the students are conducting a great experiment together. The results so far, while small in scale, are encouraging. More players are needed.

Notes and References

[1] The quetzal's plumage, when examined under the microscope, is almost colorless. The irridescent green and (at low angles of incidence) blue colors are thin film interference phenomena. The long "tail" feathers on the male quetzal grow about two inches per year and can reach 3 ft. in length. From these beautiful feathers comes the name "Quetzalcoatl," which means "feathered serpent." When the quetzal flies, these long feathers sweep out an elegant sine wave. In a conversation with Leo, the great ornithologist of Costa Rica, Alexander Skutch, called them the emerald "flowing silk thread." The male and female quetzal take turns at sitting on the nest, which are built in standing dead trees.

[2] Eugene P. Odum, *Fundamentals of Ecology*, W.P. Saunders (1959), p. 26. Efrain has a chain saw now, but uses it to prune orchard trees and maintain birdwatching trails. It's not the technology, but how it's used that matters.

[3] Recent visitors to the QERC have included groups from the Univ. of Massachusetts-Amherst, Calvin College, Oxford University, and the Max Planck Institute. For more information about the QERC, consult the web site <http://www.snu.edu/qerc>.

[4] Documentaries that contain footage filmed at the QERC include:

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"Spirits of the Jaguar," Vol. 2, "The Forging of a New World," produced by Neil Lucas and the Natural History Unit of the BBC; "The Life of Birds" by Sir David Attenborough, Vol. 3, "The Insatiable Appetite," produced by Ian Gray, again of the Natural History Unit of The BBC.
[5] The Savegre valley is a cloud forest, but the skies clear up in the March evenings, in the dry season.
[6] Neil Comins, "The Earth without the Moon," *Astronomy*, Feb. 1991, pp. 48-53.
[7] L.R. Finkenbinder and D.E. Neuenschwander, "Mixing Astronomy and Biology in the Costa Rican Tropical Forest," *AAPT Announcer*, Winter 2000, p. 118.
[8] David R. Wallace, *The Quetzal and the Macaw: The Story of Costa Rica's National Parks*, Sierra Club Books, San Francisco, 1992, p. xv.
[9] 7% of Earth's plant species but 43% of plant ecologists are found in North America; 38% of plant species and 1% of plant ecologists are found in Central and South America. Source: Baha Dioum and Gary Snyder, "Find Your Place" exhibit, American Museum of Natural History, Feb. 2001, New York, NY.
[10] Richard J. Tobin, "Environment, Population, and Development in the Third World," in *Environmental Policy in the 1990's*, N.J. Vig and M.E. Kraft, Eds., Congressional Quarterly Press, Washington D.C. (1990), pp. 291-292.
[11] In recent years, about 800,000 Nicaraguans have entered Costa Rica (pop. 3 million) seeking a livelihood. Costa Rica is not an undeveloped country, but enjoys high literacy, a high standard of living, a large middle class, long life expectancy, and low infant mortality. Part of the reason is found in the preservation of much of its forests.
[12] Nicholas Guppy, "Tropical Deforestation: A Global View," *Foreign Affairs* **62** (Spring 1984), p. 943.
[13] World Commission on Environment and Development (Brundtland Commission), *Our Common Future*, Oxford Univ. Press, New York, 1987. The Commission was charged in 1983 by the UN General Assembly with formulating long-term environmental strategies for achieving sustainable development.
[14] The trees in Costa Rica's national parks are protected. The trees going down in Costa Rican primary forests today are sold from private lands.
[15] Geoffrey Wandesforde-Smith, "Moral Outrage and the Progress of Environmental Policy: What Do We Tell the Next Generation About How to Care for the Earth?" in *Environmental Policy in the 1990's*, N.J. Vig and M.E. Kraft, Eds., Congressional Quarterly Press, Washington D.C. (1990), p. 328.
[16] Leo Finkenbinder, "The White Oak Model: Sustainability in a Cloud Forest," presented at various meetings of the Oklahoma Academy of Sciences, and as an invited paper in "The Global Dilemma" session, Pre-White House Conference on "An Aging Population, and Aging Planet, and a Sustainable Future: Thinking Globally, Acting Locally," Texas Institute for Research and Education on Aging, Univ. of North Texas, Feb. 26-28, 1995.
[17] Important papers in biological physics may be found in Eugenie V. Mielczarek, Elias Greenbaum, & Robert S. Knox, Eds., *Key Papers in Biological Physics*, Springer-Verlag/AIP Press 1993.
[18] Ref. 8, p. xvi.

*Albert Schweitzer, *Out of My Life and Thought* (Holt, New York, 1933), p. 178.

Special thanks to Efrain Chacón, Marino Chacón , and to Leo and Zana Finkenbinder. Leo is professor of biology at Southern Nazarene University, Bethany, OK, and director of the QERC. Zana manages the QERC. The QERC is available to student groups and researchers. Contact Leo or Zana at <lfinkenb@snu.edu> or <lfinkenb@sol.racsa.co.cr>.

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A Note of Thanks to Murray Gell-Mann

La Selve is a 1,500 hectare scientific preserve in northern Costa Rica, on the Sarapiquí River watershed of the Caribbean coastal plain. Since 1968 this preserve has been owned by the Organization of Tropical Studies, a consortium founded by several universities in 1963 to create field stations in Costa Rica. Through the 1970's and 1980's, La Selve was increasingly threatened to become isolated; as roads improved, more settlers moved in, and surrounding lands were cleared for croplands and pastures. La Selve is home to hundreds of migratory bird species, and if the preserve became isolated, its scientific usefulness would go to zero as these wide-ranging birds disappeared.

In 1977 OTS member Thomas Ray suggested connecting La Selve to a forest reserve in the Cordillera wilderness to the south, to form a continuous transect of all forest types extending from the coastal plain to the volcanic summits. The creation, in 1978, of Braulio Carrillo National Park in the Cordillera, about ten miles south of La Selve, provided an opportunity to make the transect. Ray told Thomas Lovejoy of the World Wildlife fund about his idea, and Lovejoy approached the Costa Rican government with the proposal. The government mapped the area and drew up a plan. However, the early 1980's devaluation of the *colon* made outright purchase impossible. So the forest corridor was, for the moment, decleard a *Zona Protectora* that left it in private hands but prohibited forest cutting.

A graduate student, Catherine Pringle, took an OTS biology course that included a visit to La Selve. Pringle heard that the *Zona Protectora* was largely unexplored biologically, and won a grant to fund a ten-day expedition in the *Zona*. The expedition members saw jaguar and tapir tracks everywhere. The area has perhaps one of the highest diversities of predators in the world. Expedition members estimated that the *Zona* provided habitat for 80% of Costa Rica's land bird species and 40% of its tree species. They found 28 plant species previously unknown to science.

In 1984 Murray Gell-Mann (who received the 1969 Nobel Prize in Physics for the SU(3) quark classifications that successfully predicted new states of hadronic matter) visited La Selve with a birdwatching group (Gell-Mann is an avid birdwatcher). The group's guide mentioned the *Zona Protectora*, and Gell-Mann, who happened to be a member of the John D. and Catherine T. MacArthur Foundation's board of directors, decided to help. Upon his return to the US, Gell-Mann invited the Nature Conservancy to submit a proposal for *Zona Protectora* land acquisition. The Conservancy did so immediately, and in December 1984 was awarded a million-dollar challenge grant by the MacArthur Foundation. The Conservancy formed a fundraising alliance with the OTS, the Costa Rica Park Service, the Costa Rica National Parks Foundation, and the World Wildlife Fund to raise within a year the million dollars in matching funds. In April 1986, President Monge signed the decree adding the *Zona* to the Braulio Carillo Park, making between it and La Selve a large continuous preserve that reaches north from just outside San José, halfway to Nicaragua.

Muchas Gracias, Professor Gell-Mann.

Account of the *Zona Protectora* story adapted from *The Quetzal and the Macaw: The Story of Costa Rica's National Parks* by David R. Wallace (Sierra Club Books, San Francisco, 1992), pp. 107-110. ◇

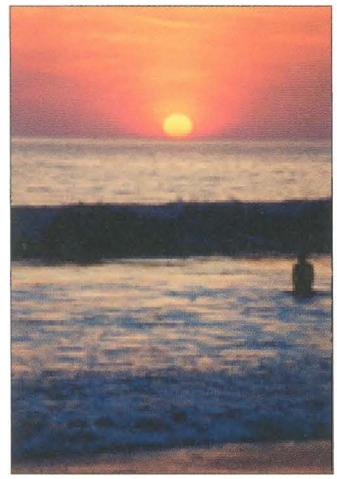
A Costa Rican Photo Gallery

The Cloud Forest at the QERC

photo courtesy of D. Neuenschwander

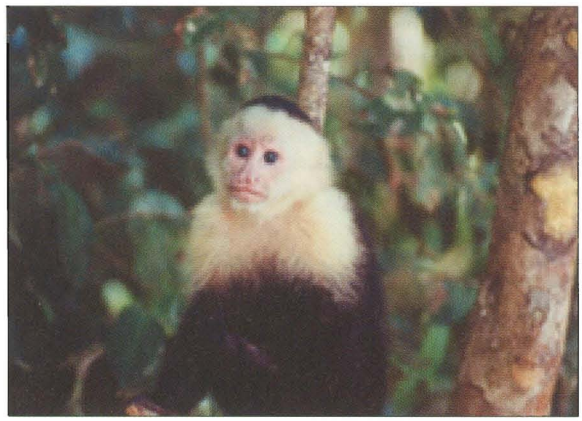
An orchid in the cloud forest. Most of the watershed in the cloud forest comes from condensation on leaves.

photo courtesy of Jill St. John



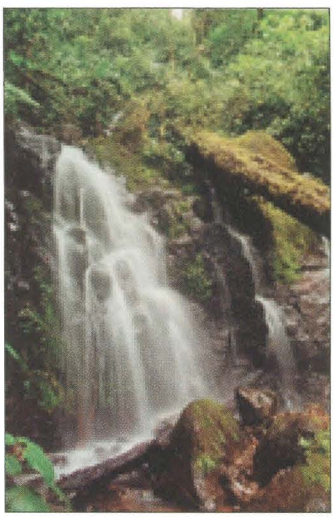
Sunset at Manuel Antonio National Park, our classroom for studying tides.

photo courtesy of D. Neuenschwander



An inquisitive white-faced monkey we met in Manuel Antonio National Park.

photo courtesy of D. Neuenschwander

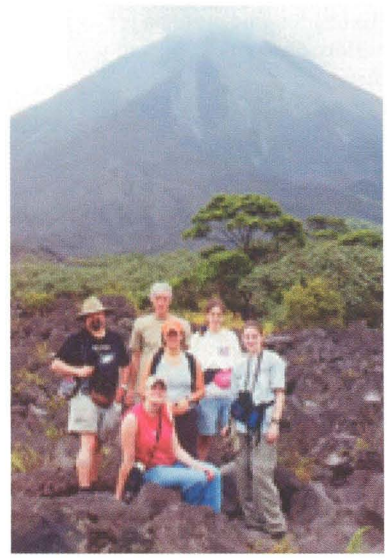


The Rio Savegre

photo courtesy of Bill Hammiter

Professor Leo Finkenbinder

photo courtesy of D. Neuenschwander



Astrobiology at Arenál volcano. The astronomy class (shown here) and the Physical Geography class of Prof. Dennis Williams traveled together; 13 students total.

photo courtesy of D. Neuenschwander