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PLANT CONSERVATION IN A CHANGING WORLD¹

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"I invite you to enjoy the special privilege of studying island life."—Sherwin Carlquist

The key thought of this symposium was a particularly wonderful sentence that Sherwin Carlquist provided in his opening remarks. To study "island life" really is a privilege. We can forget sometimes, in our discouragement with the world as it is, and in the difficulty of accomplishing all of the things that we would like to accomplish, what extraordinarily privileged people we are and what great opportunities we have to see the wonders of the world and the diversity of biodiversity throughout the world, to appreciate it, to learn about it, to communicate about it, to get to it easily, and to be relatively free of disease and the many problems that would have made the kind of travels that we now take as routine, virtually impossible until recently.

I would also like, in the sense of introductory remarks, to mention with great pleasure the memory of Dr. Katherine Muller. She, of course, was a beloved citizen of Santa Barbara, who was the Director of the Santa Barbara Botanic Garden from 1950 to 1973. My first trip to an island was with Bob Ornduff to Santa Rosa Island with Katherine and Neil Muller in 1958 or 1959, and so it is appropriate, in view of the fact that she died in 1995, to remember what a wonderful contribution she made to Santa Barbara, to the botanic garden, and to the world of botany, and what a really splendid, warm, and inspiring person she was.

Having provided these introductory comments, I would now like to make some remarks about islands, organizing my remarks into three parts. First, I would like to say something about the world situation, the situation in which we find ourselves now, and then I would like to talk briefly about two different islands or island groups, Madagascar and the Hawaiian Islands. Then I would like to go on and say something about our own channel islands and about conservation and the management of information about plants in Southern California. I would also like to give some ideas and points of view about what I think the importance of the marvelous activities being pursued by

the Santa Barbara and Rancho Santa Ana Botanic Gardens, in the face of the current world situation.

There is probably no place on Earth where it is more difficult to understand that we live in a deeply troubled world situation than Santa Barbara. There is probably no more beautiful place, probably no place with a better climate anywhere on Earth, and there is probably no more generally affluent place. It is difficult for us in the United States anyway, but when you try to do it from a perspective of Santa Barbara, it is just plain unfair.

The United States is the wealthiest nation that has ever existed on the face of the Earth. It is not only the wealthiest nation that exists now; it is the wealthiest nation that has ever existed. With four percent of the world's population, we use 25 percent of the world's economy to support ourselves; we consume about 25 percent of the world's productivity; we cause 25 to 30 percent of the world's productivity; and we have caused 25 to 30 percent of the world's pollution. We depend on a wide sector of the world to support ourselves, which ought to make us the most internationally oriented of all nations of the world because, believe me, our four percent does not produce the cash or the productivity internally which lets us live at this very highly elevated station.

Against that background, it is exceedingly puzzling why we would choose to be the lowest donor of international development assistance of any industrialized country, on a *per capita* basis, or why we would find it so troublesome when the question of supporting Mexico, or trying to help it stabilize itself, comes into view. But, somehow, we live in a paradoxical situation where it is impossible for us to understand our real, close, and wide dependence on all of the nations of the world as the basis for our prosperity, and our real, honest, and direct self-interested set of reasons for being involved around the world, if we want to leave it ourselves, in anything even remotely resembling our present situation, for our children and grandchildren. It is also paradoxical that, if you sum up all of the taxes paid, we have the lowest overall tax rate of any industrialized country in the world, and yet, to hear our politicians haggling about taxes, one would assume that we had triple the tax rate of any other country on Earth and that we were saddled with an impos-

¹ Keynote address, given on May 4, 1996, at a symposium on island biology, hosted by the Santa Barbara Botanic Garden.

sible burden. We forget all too easily, in the new mantras of "no taxes for any reason," "lower taxes," "all taxes are unfair," and "Proposition 13," that we already have the lowest tax rate of any industrialized country; we already have an economy that is set up in the most entrepreneurial mode of any industrialized country; and we could, in fact, solve the problems that we have, both internally and externally, quite easily if we had the national will to do it.

As a final paradox, I would mention the cost of gasoline. The average cost of gasoline in recent years has been about \$1.00 to \$1.20 a gallon, depending on where one is in the United States. In 1945, gasoline cost 21 cents per gallon and, if one projects \$1.00 or \$1.20 back to 1945 prices, in constant dollars, it would be about 13 cents per gallon. In other words, we are now selling ourselves gasoline, as a birthright, at two-thirds of what we paid for it in 1945, and when we talk about a four cent tax, it is regarded as a serious assault against our economy and our prosperity. If one talks about \$4.00 a gallon tax, such as exists in Italy, we naturally regard that as impossible. Speaking with tongue in cheek, one knows, one who has been to Italy, that a tax at that level definitely keeps everybody from driving. There are no cars either in Rome or on the freeways in Italy, and the Italians save a lot of money by not having to repair any roads or streets as a result of this! At any rate, we use about twice as much energy per capita in the United States as people do in any other industrialized country. We are not very interested in conservation. The President's budget for energy conservation and the President's budget for alternative fuel sources was, in constant dollars, 20 percent of the amount we were spending for energy conservation on alternative fuel sources in 1978-1980. The Administration's budget was to spend 20 percent of what we were spending in 1978-1980. Congress immediately proposed that it be cut to 15 percent of what we were spending in 1978-1980. In other words, we know that, since there is an "absolutely endless supply of gasoline," and because it is so cheap—it only costs two-thirds of what it did in 1945—there is no need to investigate either conservation or alternative fuel sources. It is a very liberating kind of feeling; it is sort of like the California "experience."

The next time we whine about the Brazilians and are saying that the whole world problem arises because the Brazilians have so many children that they are stupidly cutting down their rain forests, ponder these facts. The use of contraceptives by Brazilian couples is at about 64 percent; it is about 68 percent in the United States. Brazil has had a population policy in place for the past 25 years, by virtue of which it has lowered its birth rate very considerably and, as the century comes to an end, it is approaching a replacement level. The United States has no population policy

whatever but, if the United States had the population that it had in 1943, 135 million people, which was enough to win World War II, even though we waste twice as much energy per capita as the people of any other nation on Earth, we would be able to supply our energy needs entirely with domestic gasoline and natural gas, without burning any coal, having any nuclear plants, drilling along the shores of Santa Barbara or anywhere else in California or Florida, and without concerning ourselves with the Alaska Wildlife Refuge, or worrying any more about conservation than we do.

It has been the growth in our population from 135 million to 270 million people, living at 30 to 40 times the level that many people do around the world, that has caused us to take all of these other steps and to engage in a relentless search for gasoline and other fuel sources all around the world, so that we can keep selling it to ourselves at two-thirds of 1945 prices. This is not a healthy situation, and the reason it is not is that it does not lead us anywhere. We have got to be realistic. We stumble along, in a way, with a world view that we live in a kind of a nice place, with good principles, that is running very well, and that everybody else in the world is going to somehow come up to our level. The problem is that we are *not* living in a sustainable world; we are not living in a world that is even remotely sustainable. While the world population has been growing from 2.5 billion in 1950 to 5.8 billion in 1996, and while the proportion of us living in industrialized countries has fallen from one-third to one-fifth of the world population, in that same period, those of us in this ever-decreasing section of the world population that we call industrialized countries are still consuming 85 percent of the world's economy and 85 percent of the world's goods, and we show no sign of changing.

If one thinks that the world is sustainable now, and what we are trying to do is maintain that sustainability, ponder the fact that 25 percent of the world's topsoil has been lost since 1950, and it is being lost now at a rate of 25 billion tons a year, which is equal to all of the topsoil on all of the wheat lands of Australia every year; that of the 15 to 20 percent of the agricultural land that was available to feed 2.5 billion people in 1950, 15 to 20 percent has now gone to salinization, desertification, urban sprawl, golf course development, or other modifications. The atmosphere has changed substantially with the addition of more than 15 percent in the atmospheric proportion of carbon dioxide, the main greenhouse gas, which set the world on a course that is internationally recognized as leading to a 1.5 to 4 C rise in temperature by the end of the next century; it is projected to raise average sea levels worldwide by about half a meter, which is enough to threaten many nations around the world, not to mention the 65 percent of the world's population that live within 50

miles of the coasts somewhere. One-third of the forests that were in the world in 1950 have been cut without replacement, and we have entered a biodiversity extinction spasm, which is running at 1000 to 10,000 times the rate that it has been for the past 65 million years. Therefore, those organisms with which we might put together a sustainable world, are, in fact, being wasted by the very nature of the nonsustainable activities in which we are engaging in every square mile of this planet.

Islands occupy a leading edge in all of this. There are about 250,000 kinds of plants in the world, and I estimate that about a third of them are on islands. Of course, about two-thirds of those are on the islands that flank tropical Asia, and about a third of the rest, maybe 10 to 15 percent of the plants in the world, are on islands other than those flanking tropical Asia. Islands are places where there is a very high degree of endangerment of very precious, beautiful, evolutionarily significant, and ecologically demonstrative biological diversity. Darwin's development of the theory of evolution, following his experience on the Galapagos, is well known. Island biogeography, the leading predictor of number of species in an area, was, of course, developed to account for species-area relationships on islands (MacArthur and Wilson 1967). Islands are not only ecological and evolutionary laboratories of extraordinary significance; they are also the areas that are at the very cutting edge of conservation. They are the places where the most urgent actions will need to be taken to save the greatest proportion of biodiversity.

Consider the island of Madagascar, because it is quite another matter from the Hawaiian, Juan Fernandez, and California islands. It is an island where relict species, genera, and families are really abundant. Madagascar is an island about the size of California. It lies 250 miles off the east coast of Africa, and in about the same latitude as Baja California, but is in the southern hemisphere. Madagascar varies from very severe deserts, with much less than 200 millimeters a year in rainfall, to rain forests which receive from 200 millimeters to 3500 millimeters a year of rainfall. Madagascar may or may not have been joined with Africa earlier, but if so, it was so far back that it does not affect the distribution of most of the groups of organisms that are now there. Certainly, there would have been stepping stones to Madagascar from the east, and across and around the Indian Ocean earlier. About 95 percent of the mammals, the amphibians, and the reptiles in Madagascar are endemic. There are about 12,000 species of plants in Madagascar, about three-quarters of which are endemic. Remember that Madagascar, about the size of California, has more than twice as many species of plants and about three-quarters as many endemics as California, something like

nine endemic plant families—Bembiciaceae, Didiereaceae, Didymelaceae, Diegodendraceae, Kaliphoraceae, Melanophyllaceae, Physenaceae, Sarcolaenaceae, and Sphaerosepalaceae.

A recent revision of the palms of Madagascar (Dransfield and Beentje 1995) had 16 genera and 171 species, 70 of which were described. Of those 171 species of palms, 166 are endemic. They include *Voanioala gerardii* J. Dransf., the forest coconut, which is known only from a single population in the Masoala Peninsula. The latter is a paleoendemic, with one of the highest chromosome numbers ($2n = 596-600$) known in any flowering plants, and it was discovered within the last five years. Another recently discovered species, *Lemurophoenix halleuxii* J. Dransf., is the largest palm in Madagascar, up to 25 meters tall, and is known from only two populations in northeastern Madagascar. *Ravenala* Adans. (Strelitziaceae), the signature plant in Madagascar, has recently been documented to be pollinated by lemurs (Kress et. al 1994). All lemurs are endemic in Madagascar, which is about a quarter of all nonhuman primates, and it is, in general, an incredible place.

Madagascar was settled first from the east, from Malaysia, about 2,500 years ago. Forest clearing and annual burning have reduced the vegetation covering to about 20 percent of what it once was. Madagascar is the second-highest per capita rice consumer so, as they run out of places for paddy rice, they have to go up on the hills and cut it out. Watershed maintenance for the paddy rice does not work very well then either. Twelve million people does not sound like very many by California standards, but it is very many, considering the way they live, with a growth rate of 3.8 percent—one of the highest in the world. It leaves the remaining vegetation heavily hammered. *Symphonia* L.f. (Clusiaceae), has about 20 species in Madagascar, one or two in Africa, and one or two in the New World tropics. It is a pattern that comes up over and over again. To understand what it means to have 12,000 species in Madagascar, you need to know that, in all of tropical Africa, there are about 22,000 species. There are 12,000 just in this one area. There are about 24,000 in southern Africa, which is actually richer than tropical Africa, and which is dominated by those fever trees and those large herds of destructive animals, which are always tromping around and eating up the plants in disgusting ways that characterize the continent of Africa, much to its misfortune.

Staff at the Missouri Botanical Garden are training students at three levels in Madagascar: (1) scientists, who come to St. Louis to get graduate degrees; (2) professionals trained in Madagascar—we have a class of about 12 at any one time who are trained for about a year in general knowledge of the flora, and who then are employed by conservation organizations or by the

government of Madagascar (none of them have any trouble getting jobs); and (3) what Dan Janzen in Costa Rica calls parataxonomists, of which we have about a dozen more people collecting and studying plants in Madagascar. We believe, as we operate around the world, that the greatest contribution that can be made is training and setting in place institutions in countries that will go on providing information to the countries.

I would also like to make a few remarks about Hawaii. The Polynesians arrived in Hawaii about 1500 years ago. During the period of Polynesian occupation in Hawaii, a lot of the vegetation was burned to encourage thatch and grasses, and many forests were used for firewood and timber. As a result of all of that, and the introduction of grazing and browsing mammals in the 19th and 20th centuries, a majority of the roughly thousand native plant species are now threatened with extinction. Only the montane and subalpine areas of Hawaii are relatively resistant. Some of the islands of Hawaii have as little as ten percent of native vegetation—Oahu, for example; some have as much as one-third (e.g., Hawaii). An undisturbed native forest is very rare but, because it is very rare, it is of enormous biological interest, and there are a lot of people working on it very effectively in various ways.

The situation of birds in Hawaii is very striking. I emphasize them because one can get such a clear indication of what is going on with respect to patterns of extinction. There are 90 to 100 land birds known to have gone extinct in Hawaii since Polynesians arrived there. When Captain Cook arrived, there were 45. There are 27 now, but there are only nine that exist in populations large enough to say that those birds have a reasonable or respectable future. Of course, many of the extinct birds were truly remarkable, such as the Black Mamo (*Drepanis funerea*). The Iiwi (*Vestiaria coccinea*) is extinct on Lanai and Molokai, and is nearly extinct on Oahu. Populations remain on Kauai, Maui, and Hawaii. Akialoa (*Hemignathus obscurus*) is extinct. They had curved beaks adapted for pollinating lobeliads, many of which are also extinct. There are fewer than 1000 of Akiapolaau (*Hemignathus wilsoni*); they depend primarily on koa trees (*Acacia koa* A. Gray), hammering away at soft wood in much the same way as a woodpecker. The lower part of the bill is chisel-shaped and used for this purpose, whereas the upper part of the bill is a long, grub-extracting tool. In using the lower part of the bill, the bird holds its head back and opens its beak wide, thus keeping the slender upper part of the bill out of the way and protecting it from damage. Because of the bird's requirement for soft wood, it depends on really old, large trees: and the largest trees in the forest are the old koa, which are clearly threatened by harvesting for wood chips. This is a very difficult management

problem; as many delicate island ecologies, it cannot be maintained well in a self-contained way.

Rails may have been the last great evolutionary radiation of vertebrates. David Steadman (1995) claims that 2000 species of rails have gone extinct during the last 2000 years. They are so easily driven extinct and, if one considers that, even in the current revision of the Audubon Society checklist, there are only about 9700 species of birds in the world, the idea that 2000 rail species may have gone extinct in the last 2000 years is startling. However, fossil evidence leads to suggestions that there are roughly 1000 bird species in Oceania at present, but something like 2000 others may have gone extinct in the last couple of thousand years. This seems to be quite likely and quite well justified because of bird fossils found throughout the Pacific Ocean.

The important model for understanding diversity that I want considered is the Hawaiian Biological Survey, a project that is centered at the Bishop Museum. The Bishop Museum has been engaged in biodiversity work in Hawaii for over a century, and the Hawaiian Biological Survey, which is a formal designation of the State legislature, builds on that and adds an emphasis on making data immediately available and a commitment that will provide at least baseline data for all of the organisms found in Hawaii. The strategy is basically to produce taxonomic authority files, literature, collections, databases, linkages with other databases, and then conduct selected field surveys, systematic studies, and other research. In other words, for all groups of organisms in Hawaii, how does one get them to be well known, enjoyed, appreciated, and studied? Regarding the numbers of species of various groups known from Hawaii, there are about 22,000 total species, including 8850 endemic species, 475 of which are listed at risk, but the real number is probably much higher. The basic point is that the information available in museums needs to be organized and made available, before one really understands the arguments that one may make on behalf of conservation and research, and certainly before one has any real logic in going out and doing more. Obviously, this area will be very well served by carefully organizing the available information.

California really badly needs linkages and treatments like that of the Hawaiian Biological Survey and, of course, people have tried to get at it in various ways. It is not really very easy, but it is obvious to me that the Santa Barbara and Rancho Santa Ana Botanic Gardens can very logically play this kind of a role and produce such projects in a somewhat more organized, comprehensive, and determined way for the California Channel Islands and the adjacent mainland. Then various linkages can be made with other institutions, obviously leading directly to similar kinds of linkages for animals, protists, and so forth. Of course, that base

of information, in turn, becomes the way that leads one to take effective and critical action in many other kinds of fields. It is really the contribution of knowledge and the organization of knowledge about organisms that give people the ability to be able to appreciate them, to love them, or to be able to do anything else concerning them. The Missouri Botanical Garden, for example, has been processing herbarium labels through a computer for some time, and we now have well over one million records in our database. Any of those, since they all have latitude and longitude, can be used to generate maps automatically of the ranges of anything for which we have specimens. Obviously, the capabilities of these systems now are getting to the point where anybody who thinks they are really serving their end purposes by not paying attention to them is just kidding themselves.

Institutions in southern California are really maturing. We have many fine institutions here going back to the middle of the last century, in some cases, but it is really necessary for a community as Santa Barbara, Los Angeles, San Diego, to begin to develop the special kind of philanthropy that allows these institutions to flourish and the willingness to pay taxes to support them. We are, in the United States and everywhere else, in a real confrontation with our high-consuming, swelling populations and, of course, nobody needs to point that out to anyone who has been in southern California more than about half an hour. It is obvious that things are changing, and they are changing very rapidly. It is obvious that the face of southern California, and the kinds of things that our children and grandchildren will be able to enjoy, if they are still living here, is going to be determined, to a very large extent, by the activities of organizations like the Santa Barbara Botanic Garden and the Santa Barbara Museum of Natural History, among others. By supporting those institutions, one will be helping to create the knowledge, the appreciation, and the joy about those organisms, which will allow them to be interesting and central enough for people to understand them and to want to preserve them. In that whole process, the generation of solid scientific programs is critically important in the education of young people and of casual visitors. It pleases me enormously to see the way these institutions are developing, to see the leadership that is developing in them, and to realize how capable you are of meeting those challenges for which I really commend you, because I know that the amount of service that you are doing, and will be able to do, will be a contribution that simply cannot be repeated.

It is foolish to suppose that everything is going down the drain, everything is impossible, there is not enough money, and there is not enough energy, because that kind of negative and discouraged feeling is going to get us nowhere. Human beings are an eco-

logical force without precedent in the world. Our consumption (or wasting) of 40 percent of the products of terrestrial photosynthesis is so great that we can be sure that there is no square centimeter anywhere on Earth that is not directly affected by our activities. The thing to do is to stop feeling discouraged about segregating an untrammelled and pure Earth away from a beaten up and consumed Earth, and recognize that human beings are managing this whole planet, which is the only resource we have, and that no amount of greed, caring for ourselves, ignorance of the facts, shortsightedness, or short-term thinking is going to carry us through the necessary transition into a world in which people are at harmony with this planet, and a world in which people consume at a rate where they are not impinging directly on the rights of future generations to enjoy what we can enjoy now.

In summary, we can help to create a world where people recognize our interdependence, celebrate our diversity and, by celebrating our diversity and fostering the strength of all individual human beings through institutions like the ones that I have mentioned, and individually, carry out a series of activities that are really worthy of us. I think that is the best thing in which we are all engaged, and it is a great joy and privilege to be able to be engaged in that, as the wealthiest people who have ever existed on the face of the Earth, with the institutions that we have, and to be in such a position to be able to effect it, certainly here at home, and also all over the world.

I offer these comments as a "bouquet" for Sherwin Carlquist, who is being honored at this symposium by virtue of his marvelous lifetime achievements, in the name of the science of botany. I first met Sherwin when I was a student at Berkeley in the 1950s. He had been a student a little earlier and, over the years, I have benefitted greatly from interactions with him at a personal level, just as the world of botany, and the world at large, have benefitted from the broader activities that he has undertaken. I have learned that he first became interested in botany through visits to the Huntington Gardens, which ought to be enough to make anybody interested in botany, going to high school in what is now San Marino, and then going on to the University of California at Berkeley and doing his undergraduate and graduate work there. He was then in the Society of Fellows at some college in the east called Harvard, where people try to discourage you from studying tar plants or tarweeds—maybe if they had been called tar plants, it would have been all right; it was the idea of calling them tarweeds that discouraged the Harvard professors.

Sherwin's joy in plants and his interest in plants, which he first felt as a high school student in San Marino, have been translated, through his wisdom, his intelligence, and his humanity, and the education that

he has received, and especially ignited by the first trip to Hawaii sponsored by his mother on the occasion of his graduation, into something that has made a marvelous contribution for all of us. I think that Sherwin's writings, especially his books (Carlquist 1965, 1970, 1974) have been very much in the vein of those by Alfred Russell Wallace or Charles Darwin, in that they have been models of exposition and not dry, scientific monographs intended to be stacked up somewhere on a shelf and used occasionally to find out how many bristles there are on the hind thigh of the 996th *Drosophila* to die in the lava of Hawaii. No, his writings have been models of exposition, which have been speaking to all people and, by doing that, have assumed that people are capable of understanding island life and island biology, evolution in general, and evolution in Hawaii in particular. In other words, and I use the comparison with Wallace and Darwin advisedly, they have been delivered for the people, and they have been provided on the assumption, increasingly rare nowadays, that people are capable of understanding; people want to know factual things, and people want to get near to nature. It is a pity that we now seem to have created a dichotomy between popular things and scientific things, but if you read Sherwin's books they are literally replete with wise and cogent scientific observations and hypotheses, which advance the field and, at the same time, speak to each and every educated person about the kind of joy that he has felt all of his life and which he has expressed so well. By keeping with his work, and by being well supported in his work at Rancho Santa Ana, by the Claremont Graduate School, and by Pomona College, Sherwin has been able to do a marvelous job of developing his own theories about biology, evolution, ecology, and systematic anatomy. In doing so, and in combining that work with his wonderful skill as a photographer, he has been able to teach us all a great deal and to advance his science remarkably.

When Sherwin went to Hawaii in 1953—you know he mentioned earlier that there were no pictures of silversword on post cards then—there were also no roads to drive one's convertible on, and nobody knew what you would get to when you drove up there. In other words, you were really bushwhacking through some of the nastiest country on Earth. Sherwin certainly got to some of the most remote corners of Hawaii. If you consider where his photographs came from and where he traveled in those days, and consider how difficult it is to get there now, you realize what a marvelous job he did in that and in his very extensive worldwide travels on islands, informing us all, whether as amateur lovers of nature, informed citizens, or scientists. And, of course, in appreciation of his career, one has to mention his sustained and important contributions, not only to systematic plant anatomy, but

also to an understanding of what it is all about. It is one thing to say that these woods have bigger vessels or these have smaller vessels, but Sherwin has never been content with that; he has never been content without finding explanations.

Finally, I would mention just one illuminating detail about Sherwin's career. In 1994 the Santa Barbara Botanic Garden initiated and funded a pilot program, entitled "Plant Scholars," to address issues of the environment at the high school level. Students were chosen to work on actual research topics in the structural botany laboratory at the garden, primarily working with Sherwin. The Plant Scholars program received the 1995 award for excellence for this program, bestowed by the American Association of Botanical Gardens and Arboreta at its annual meeting in St. Louis. That national award recognizes an outstanding program.

If I asked anybody at the symposium who has been touched by Sherwin's mentoring to say a few words, we would be here for the rest of the weekend. In closing, what I would like to do instead is to quote from a letter that I think sums up the kind of impact that Sherwin has made on all of us. It is from David Wheat, and it says in part:

"Dear Sherwin,

"Hearty congratulations on the occasion of your receipt of the lifetime achievement award from Rancho Santa Ana Botanic Garden and the Santa Barbara Botanic Garden.

"...Among the achievements being celebrated are the shaping of a generation of students and scholars. I am very grateful to have been one of them. From you I learned the value of close observation and the importance of that which is hidden. Your enthusiasm and wonder at the patterns of nature became part of my way of looking at the world. The woods, the islands—a closer look, and we see broader horizons. . . ."

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