Reflections on 40 years of plant conservation

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When I was a small boy growing up in San Francisco, I had no idea that there was a world environmental problem or one concerning the extinction of biodiversity. In agricultural lands, I simply assumed that some of the area had been cleared from crops, some not. On my first trips to the tropics, to Colombia and Costa Rica, I could see that parts of the forest had been removed, but there was plenty that had not: life would go on. What I really didn't realize then and can realize now only in retrospect is that for every person who was in the world when I was born in the mid 1930s, there are three times as many people in the world now as there were when I was born, and that's accompanied a terrific number of changes of great importance for ourselves and for the future of sustainability on this planet.

By 1962, Rachel Carson's book "Silent Spring" came out and began to talk about the ill-effects of DDT on crops. That was one of the first environmental things that I can remember. One of the things that really terrified people the most about the cautionary tale that Rachel Carson presented was that not only was DDT, which had been used on agricultural fields only for 14 years, starting in 1948, killing off birds and other kinds of animals around the fields where it was being sprayed, but the DDT was even found in the fat bodies of penguins in Antarctica, and if DDT was found in the fat bodies of penguins in Antarctica then the conclusion was inescapable that human beings were affected negatively and affecting every square centimeter of the earth's surface on a continuing basis. That's the kind of observation that led our colleague Dan Janzen of the University of Pennsylvania to say later that the earth is all a garden, and we are the gardeners, and we must garden it for better or for worse because the division into wildland where things can be kind of a preserved and cultivated land where things won't be preserved or cities is really a false one. There is no place on earth that we are not affecting directly.

We got a bit worried by 1962 with Rachel Carson and a number of us worked to get DDT banned in the United States. I was at Stanford University through the 1960s and my next door colleague was Paul Ehrlich. By the middle of the 1960s, we had begun to get worried, and I remember one of the telling points was an article by a physicist in the "New Scientist" in the middle 60s that pointed out that if the world's human population kept growing at the speed that it was growing, that at a certain finite point in the future, the mass of human bodies would be spreading away from the surface of the earth with the speed of light, and that hardly seemed like a proper thing to do, but I went on. In 1959, I spent two months in the country of Colombia looking at tropical forests for the first time. In the early 60s, we worked for several years in highland Chiapas, Mexico. In 1966, I went to Costa Rica for the first time and was looking at vegetation there. But in no case did it really tumble that there was a serious problem about plant conservation.

By the end of the 1960s, Norman Myers, who was living in Nairobi then, had written a circular letter to dozens and dozens of people, most of whom ignored it, which said, "How do you think that human population and pressure on the earth is going to affect the

future of species?" That was really the first time that we began to put two and two together in a very concrete way.

Earth Day in the United States was in 1970. Earth Day was a celebration of the environment. Twenty million people actually showed up at demonstrations outside for Earth Day in April of the year 1970, and that was in that time one out of every ten people in the United States went out to a particular event and celebrated or demanded that attention be paid to the environment.

What's interesting though is those environmental preoccupations were largely virtually exclusively domestic. They were based on a traditional American anxiety about the loss of forests and wildlands in the western United States. On the one hand, we had to set some of it aside and keep it if we wanted to have the natural beauties of our country available to pass on for the future, and on the other hand, we were preoccupied with the environment. We were aware of the lethal fog in London in 1948 that had killed, I forget, 20,000 people. We were particularly struck by the fact that the Cuyahoga River in Cleveland, Ohio had caught on fire, indicating that there were things in it other than water and it probably wasn't a very good sign about the environment. Air pollution was spreading and becoming really evident in the United States even with clearing up the soft coal pollution that had been characteristic of the 20s and 30s. That's when comedian Jack Benny said, "Los Angeles, where you wake up to the coughing of the birds," or David Letterman said later, "autumn is my favorite time of the year in Los Angeles; it's when the birds change colors and fall out of trees." At any rate, time went on.

By the end of the 60s and by the time I went to the Missouri Botanical Garden in 1971, we wrote a review for the National Science Foundation of where research should go in systematic and evolutionary biology. And in those days, the big trends were analytical tools, databanks, and ways of analyzing large masses of data on the one hand, and secondly the need to set up and equip many molecular laboratories, which really weren't in existence at that point, in order to be able to analyze in a finer grained way the relationships between organisms, and we said you need extra money for that. A third theme of our report in about 1971 was that we had better concentrate on tropical plants and animals and organisms because tropical forests were going so rapidly that they were starting to evidently be disappearing, which hadn't been really so evident to most of us just a few years earlier, that if we didn't learn about them, something like what we knew about temperate forests and temperate organisms, we would lose the chance permanently to learn about them; they just weren't going to be there.

The next big event was the Stockholm Conference in 1972. Maurice Strong, a great longtime lifelong civil servant at the United Nations, who also convened the Earth Summit conference in Rio in 1992, convened the Stockholm Conference for the United Nations. Of course, the original intention of the Stockholm Conference was for the countries around the Baltic to think about the way in which they were all polluting the Baltic Sea and the deleterious effects of that that they all had to share. Under Maurice Strong's guidance, the Stockholm Conference in 1972 became the first really visible international focus on the fact that we were destroying the world's environment. It's not strange that it should have happened then because the fastest rate of population growth ever in a percentage sense was 1971, about the same time. From my perspective, this is half way through my life and, of course, from then onward it's been all about conservation and working together to try to do something to stem the tide.

At the 1992 Earth Summit conference there were over 150 heads of State there at one time or another all claiming to be holier-than-thou and talking about how they were going to do good things for the environment. In the 1972 Stockholm Conference, there was only one head of State present. That was Indira Gandhi, and she said, "The problem is not man's mishandling of the environment; the problem is man's exploitation of its fellow man in the name of progress." In other words, she put the finger squarely on the great dichotomy between the rich and poor, which is something that is now evidently driving a lot of the worldwide environmental problems that we see.

Going to Missouri in 1971, we began to work with this and our particular way of working with it was to establish a physical presence in many places around the world – Central America, Nicaragua, Costa Rica, Peru, Ecuador, Bolivia, Madagascar, and Viet Nam – and build up staffs there to especially work with training individual people in all of those countries so they could guard, learn about, appreciate, and sustainably use their own resources. We didn't know that's what we were doing: we thought we were working towards a plant inventory of the world, and we were doing that. There are about 30% of the world's plants under revision in some way at the Missouri Botanical Garden eventually as it's worked out. With people actually living in the countries, we have found that they had opportunities for learning what the important driving forces were in those countries and to help to educate people so that they would be able to participate effectively in their own future, which they couldn't otherwise.

I'm particularly proud of our activities in Madagascar where we have a staff of about 65 people now, all but one of whom are Malagasy. The other one, Chris Birkinshaw, is English. He might as well be Malagasy because of his affection for the country. Madagascar is around the third poorest country in the world. It is 85% stripped of its natural vegetation; it has about 14,000 species of plants; about 90% endemic; and although very few of them can be shown to have become extinct, nevertheless, many of them are present only as a few individuals, so they are very much on the edge of extinction. The reason that our group in Madagascar, along with our colleagues at Kew, Paris, and other places, has raised the number of plants so high is that being on the ground and knowing the geography of the place really well and being able to see the plants alive and be able to see them from place to place, you can gain an appreciation that you could not gain in any other way and you could see many more different things than you could see just looking at herbarium specimens from a distance.

In the villages in Madagascar, we work with individual groups in villages to try to promote sustainability in various ways. We have raised funds to build clinics. If you can build a clinic in a village in Madagascar, then the government sends people to staff it and take care of it; schools; expanded buildings for national collections of plants; and especially with Kew and with the Zoological Garden Association there, we have built up living *ex situ* collections also. We have had an agreement with the government of Madagascar way before the CBD started regulating this, on benefit sharing and using medicinal plants and find out about them with the Ministry of Health, which is regarded as a model of its kind. That's the way we operated.

To understand how we got there, let's now turn the clock back again. Four hundred human generations ago, about 10,500 years ago, crop agriculture was developed first in the eastern Mediterranean. At that time, the population of the whole world – Eurasia, North and South America, Africa, Australia – is estimated at 3 to 4 million people. In

other words, smaller than the population of Ireland at the present time. But that's only 400 generations ago and those were all of the people in the entire world, so obviously their influence on the world, on the ecology and stability of the world was very, very trifling compared with what it is now, although they did burn off lands to encourage grazing animals, and although certainly there were the beginnings of art and certainly various things got started.

Nothing really got started like it did after the invention of crop agriculture and the domestication of animals when for the first time people were able to build up food stocks to bypass unfavorable seasons. The very small villages that existed at the beginning of this period began to grow into towns and then eventually into cities. Over the last 400 generations, or 10,000 years we'll say, in those villages the elements that we now consider civilization began to grow and people began to be specialists in crops, in weapons making, in art, in storytelling, in being religious leaders, and all the rest. Half way through the last 10,000 years, written languages appeared and people began to be able to transmit their experiences in a concrete form from one generation to another. Of course, written languages appeared, on the one hand, along the Nile in Egypt in hieroglyphic writing, and on the other hand, in Babylonia in Cuneiform writing. The latter, hieroglyphics only spread up and down the Nile but Cuneiform writing gave rise to all the modern alphabets and modern ways of communicating since.

In view of the fact that written languages appeared about 5,000 years ago or about 200 human generations, it's not surprising that in most of the literature of the world from Gilgamesh to the Bible to Homer and so forth, we have about a 5,000 year window of recorded things and then an oral tradition of looking back beyond 5,000 years into what people could remember and tell one another about.

It's very interesting to think that at the time that the pyramids were being constructed, the population of the world was about like that of the population of these islands at the same time, less than a hundred million people, and we think of the world as being full of people at the time the pyramids were built. But, of course, it wasn't. By the time of Christ, there were probably 300 million or 400 million people in the world. And even by the time Thomas Malthus was saying that human ability to produce food was going to be outstripped by human population growth, there were still only about 850 million people in the world, or only a part of the population of either India or China at the present time. Human population did not reach 1 billion people until Napoleonic times; 120 years later in 1930 there were 2 billion people; in 1950 there were 2.5 billion people; and now there are over 7 billion people. In other words, that's why one begins to say that the world population tripled during my lifetime.

Assuming that we keep on steadily making family planning available throughout the world, assuming that we make a much more serious effort to empower and educate and bring into our society's women all over the world, and those are big assumptions because it is certainly not the case now, assuming that we will stop wasting children and just leaving them to miserable lives of carrying fuel and water back to their homes, assuming that we get on with all of those things, the world population might continue leveling out. Remember that I said that there was a high point in percentage growth in 1971. The high point in numerical growth because the base was going up, was in the early 1990s and it's more or less on a curve now to level out at 9 to 9.5 billion people at the middle of this century. But remember that of those 7 billion people that we have now, well over 1 billion of them, about 1 in 6, receive less than 80% of the UN

recommended minimum dietary intake and over 100 million are on the verge of starving to death at any given time, in other words, during the next few days. We don't really have a well functioning world now, and we are looking to adding 2 to 2.5 billion people over the next four decades, which will certainly not be added in the classes; they will be added at the very edges of poverty; about 99% of them will be in countries that are now considered developing countries.

Globalfootprint.org, which is a web site that I commend to all of you from a Think Tank in Oakland, California, estimates that we are using about 160% of what the world can produce on an ongoing basis up from 70% as recently as 1970 when the world population was about half of what it is now. 160% of what the world can produce gives you a very clear message that we are using more than there is. It is like drawing 15% out of a bank account every year that is earning 6%. Eventually, we will reach sustainability. We will reach sustainability because we can't go on using more than the world produces.

"Our Common Future" (the Brundtland Report), which came out in the late 1980s and talked for the first time broadly about sustainability. If you read it now, it sounds curiously antiquated, at least to me, because it talks as if all of the nations of the world will simply manage their affairs better, we'll all be well off and everybody can be everything and consume everything forever. In fact, there is no room in the world for that to happen. And it's not only population, which is an easy thing for people in affluent countries to believe, it's levels of consumption; it's how much we each think we need for ourselves, and it's the technologies that we use, technologies like burning petroleum and coal, which were very good when they were first started in the Industrial Revolution, sort of 200 years ago, and gave people the ability to move faster than the speed of a galloping horse and to build trains all over the world and do all sorts of special new things. But those technologies now aren't working; they are driving global warming, they are driving global change, they are making the world less and less habitable.

In order to unravel the world's situation, we have to do some very difficult things: we have to find a population level that we can sustain. What that population level is will depend on the level of consumption that we think we need and can justify morally around the world, and we have to find many new technologies that will help us to get away from the ones that are helping to destroy the world now. Small wonder that I wasn't worried about conservation when I was a little kid, but as my career went on, I got more and more worried about it because the world was changing all around me.

Turning to the field of biodiversity, we say there are fewer people working in biodiversity and in taxonomy and evolution than previously. In fact, there are probably more people working now than there were previously. They may not be doing the same things but the membership of most scientific societies is up. However, we now believe there are a lot more species in the world than we used to believe. There are about 1.9 million named species of eukaryotic organisms and yet there are undoubtedly at least 12 billion kinds of eukaryotic organisms in the world and maybe more. Nobody has any idea of how many bacteria there are in the world. Some of them are in my throat right now, but probably not too many kinds. How many bacteria there are in the world: nobody knows. But what's really striking and you all will know this about your own groups is that of the 1.9 billion that are named or however many plants are named, maybe 350,000, which is a conservative estimate of the number that are named and valid, the vast majority of them

we know next to nothing, so even if we identified another one, we really wouldn't be accessing a lot of additional information.

So, the demands on what people need to do in the world are so great that we feel we do not have enough people to do it. And, of course, secondly, we want to use the properties of organisms to help us build sustainability, and who's going to do that? We expect a lot more from organisms and yet we know that we can't catch, yet master, name, and understand 12 million species of eukaryotic organisms before a very great proportion of them have disappeared. Why are they disappearing?

They are disappearing, of course, for the traditional reason of habitat destruction. One-third of the world land is now devoted to agriculture, for example, and then many people are using forests and other places unsustainably. One of the things that we do in Madagascar is send out teams from business schools to try to figure out alternative ways to manage the productive systems around individual villages to allow them to be sustainable. Another very huge problem in the world that many speakers here have touched on is the spread of alien species around the world. If you drive from Honolulu up to the punchbowl, for example, to the military cemetery there, you go through this nice forest, but like some of those that other speakers have shown us here, no plant or animal that you see on your drive would be native to Hawaii. On the uplands of the Galapagos Islands where Charles Darwin laid the foundations for the theory of evolution, Guava and other introduced plants are spreading rapidly in killing off the native vegetation. These are all things that we knew about in early 2000 and 2001 and so forth when the global plant conservation strategy that began to be implemented was set up in the Convention on Biological Diversity and as we have heard, is coming up for its ten year review in the meetings of the Convention in Nagoya this October. Those were all things we know, but the additional joker that has been added is global warming.

It's not that we didn't know about global warming before: people have, in fact, known about global warming – global climate change better said – for decades. But we didn't really appreciate what a negative effect it would have on organisms worldwide, and so, for example, South African botanists who have looked at the Proteaceae in South Africa estimate that 40% of the species may be at risk of extinction between now and the middle of the next century as a result of global climate change alone. David Ackerly at the University of California, Berkeley, and co-authors have estimated that half of the roughly 2,500 endemic species of plants in California may simply not have any habitat in nature by the time another few decades have gone by.

This makes the traditional model for botanical gardens very different. In the mid-1980s when we had a joint committee between the IUCN and the WWF to think about plant conservation, then when that couldn't be sustained, the organizations were unwilling to continue to invest money in plant conservation. Vernon Heywood, who was a member of that committee that I chaired, went off and invented Botanic Gardens Conservation International, and here we are! The Center for Plant Conservation (CPC) in the United States had started a couple of years earlier. We had a meeting in the Canary Islands in the mid-1980s, but it had a feeling of the world disintegrating around us; that is, the world of plant conservation, and we didn't know very well how to move forward. It's a wonderful tribute to the efforts of Peter Wyse Jackson, Stella Simiyu, David Given, who is gone, and a number of others, David Bramwell, that they kept the faith after the 2000-2001 meetings and were able to get the global plant conservation strategy adopted by the Convention on Biological Diversity. When we started talking about it, we thought that

there should be an international agreement, but we didn't know where it should be housed. Actually, it has turned into the most active and interesting part of the Convention on Biological Diversity, which is very good. It is very good that BGCI is now toting up the results from the first ten years of operation of the strategy and within a framework that we can all understand and one that can drive us soundly home to the future.

For botanical gardens, the message is that the current world situations are various. We no longer can really depend on our traditional model of building plants in captivity in botanical gardens – not longtime traditional, but traditional over the last 50 years – and then expecting to be able to plant them out in nature and reestablish them. And the reason, of course, very similarly is that we can't expect conditions where we are planting them out to stay the same, so although we can plant them out, the climate may change and may snuff them out. Unfortunately, at the other side of the equation, we can't be sure that conditions in the botanical garden will be the same in the future, so we can't be sure that we can maintain populations there, so we are kind of caught on both ends.

Practically speaking, we have no option but to go on considering how to plant out, how to reintroduce species into nature because whether you call it assisted migration, or whatever you call it, we are going to be involved in recreating communities in the future when we have a grip on consumption population, global climate change, and all the other things. We have to learn the lessons that we can now in order to be able to do that effectively.

It has always been a criticism of holding things in botanical gardens that the numbers of individuals kept are generally inadequate and should be 30 to 50 individuals in out-crossing species: but who grows 30 to 50 individuals of anything, much less a tree, and what do you do about it if you do? At the 1975 meeting at Kew, we were already talking about how to get genetically adequate samples of organisms into cultivation, and I know that I suggested in 1975 that if botanical gardens were really going to do that, they would have to get places other than the gardens to put out these massive samples that will be necessary to preserve the genetic integrity because you never want to grow that much in the garden. In any event, very few people have done much about that.

What has been done partly as a result to responding to changing climate has been an increasing interest in seed banks, and the Millennium Seed Bank at Kew came along at the right time, thanks to the foresight of a number of people, including Iain Prance and others at Kew who have gotten Millennium funds and matched them and built up a seed bank that not only now holds 10% of the world's flora, is shooting for 20% by the end of the 20s but also is the lynchpin of the worldwide system that does have the potential of preserving a lot of plant diversity for the future. A lot of people say, well, if you are preserving the seed bank, what do you have? Well, you have them, that's what you have, and if you think it's holier to let them all go extinct without being in a seed bank, get out of town. No, that's not right!

We need to think about handling our collections, which are going to be increasingly precious, more and more carefully. The BGCI register of plants in cultivation in botanical gardens all over the world is being modernized. Many of us who have been pointing out for decades that unless people let others know what they had in cultivation, botanical gardens really wouldn't be serving the purposes for which they were built up and through a global register of plants in cultivation, we could begin to do that provided that each and

every one of us will strive very hard to keep up the records that are in there, which is something that is hard to do. But I would maintain that in this age when botanical gardens have such a heavy obligation to be engaged in plant conservation, that unless they do make their holdings known so that other people can understand what we have, whether it's from a wild native source, and so forth, and unless we are willing to go to the trouble of doing that, then our collections really won't live up to the value that they might otherwise have had. It is also going to be very important to make the kind of transition that Edinburgh has done so brilliantly over the last 30 or 40 years, and that's to make the transition from miscellaneous plants of botanical gardens in cultivated origin to plants from wild native sources. It's not going to be good enough anymore just to sort of mindlessly build up as large a collection of items as possible like notches on a rifle or something – I have 35,000 kinds of plants – what's really going to be important is the quality of the collections that we have, where they came from, what their genetic integrity is, and how well they represent the species in nature. We are going to need to get used to making vouchers of our collections in botanical gardens, which is something that we do very poorly because the cultivated flora of the world including the flora of botanical gardens is very badly documented. I would encourage anyone whose institution does not do so now to give serious attention to implementing a system of taking vouchers systematically of different appropriate stages of all the organisms that you have in cultivation and keep going on it. In the present day and age, you can also take digital images of the plants and of the color of their flowers and so forth and you can also put away vegetative material in silica gel for DNA analysis later and do a lot of different things.

We really have to be willing to share material with one another much more actively. If you ask many gardens for material, they will tend to say, we are too busy to go and make those special collections. But again, if your collection really exists for science, then we really all ought to be budgeting the ability to go and make special collections from them that can be used to advance science.

Circling back to where I started, botanical gardens also have other very important functions in the modern world. One that's been discussed well at this meeting is the function of showing not only sustainable gardening but sustainability overall. Botanical gardens are places that people look to for sustainability and by practicing sustainable energy sources, sustainable gardening, sustainable use of water, sustainable buildings, and all the rest, we will all be playing an important role in spreading the message to our respective communities about making the steps forward in society that are so necessary to win global sustainability. People depend on us for information of that kind, and we really mustn't let them down.

Botanical gardens, which have traditionally played an important role in supplying cultivated flora for their towns and their communities, should expedite and improve their efforts to doing that. Keeping that in mind, with plans for sustainability, botanical gardens should give more and more thought to the persistence of nature in the gardens and in their own communities and in urban and suburban settings. And the reason for doing that brings me full circle back to my own childhood when I was busily claiming lands for the Queen of Ireland, and that is probably the most important single thing that botanical gardens can do is the sort of thing, for example, The Brooklyn Botanical Garden does so well, but we all do to some extent and, that is, involving children.

On an individual basis, on a basis of your own family, on a basis of your own society, in your own way suitable to your own community, if you could involve young children in the same wonder and beauty of plants that inspires us, you will be making an estimable contribution to the future. Not only will those children appreciate something about nature and want to relate to and preserve nature if it's accessible to them, there is every evidence that they will also become more fully informed, decisive and thoughtful citizens when they grow up and contribute better to the construction of the sustainable world, which still awaits us in some perilously uncertain date in the future. Botanical gardens have a wonderful opportunity to do that. There are many institutions with which we can partner in doing it; it is something in which we can all find joy. The change from a non-sustainable world in which we consume as much as we can and I guess live as hunter gatherers of 400 generations ago, grabbing as much and keeping it for ourselves as we possibly can imagine to a sustainable one is going to require an interchange and a moral change that's going to simply put us through to a better and more respected society.

In getting to the other side of that and in learning how to live together in this enormously overpopulated world, how to preserve the plants that support us and how to create a world in which people's individual abilities are recognized in a sustainable system with opportunities for everyone and in which the wonderful diversity of plants that supports us all can be maintained and used and established to fulfill our needs and to fill our lives with beauty, botanical gardens have an inescapably important role to play, and I know that everyone who has come here and heard all of the marvelous presentations in this hospitable place will be going home inspired and working harder to do what we do so well, and I am delighted to say that the Queen of Ireland has agreed to come and close the meeting later on if Peter could only find her.

Thank you very much.