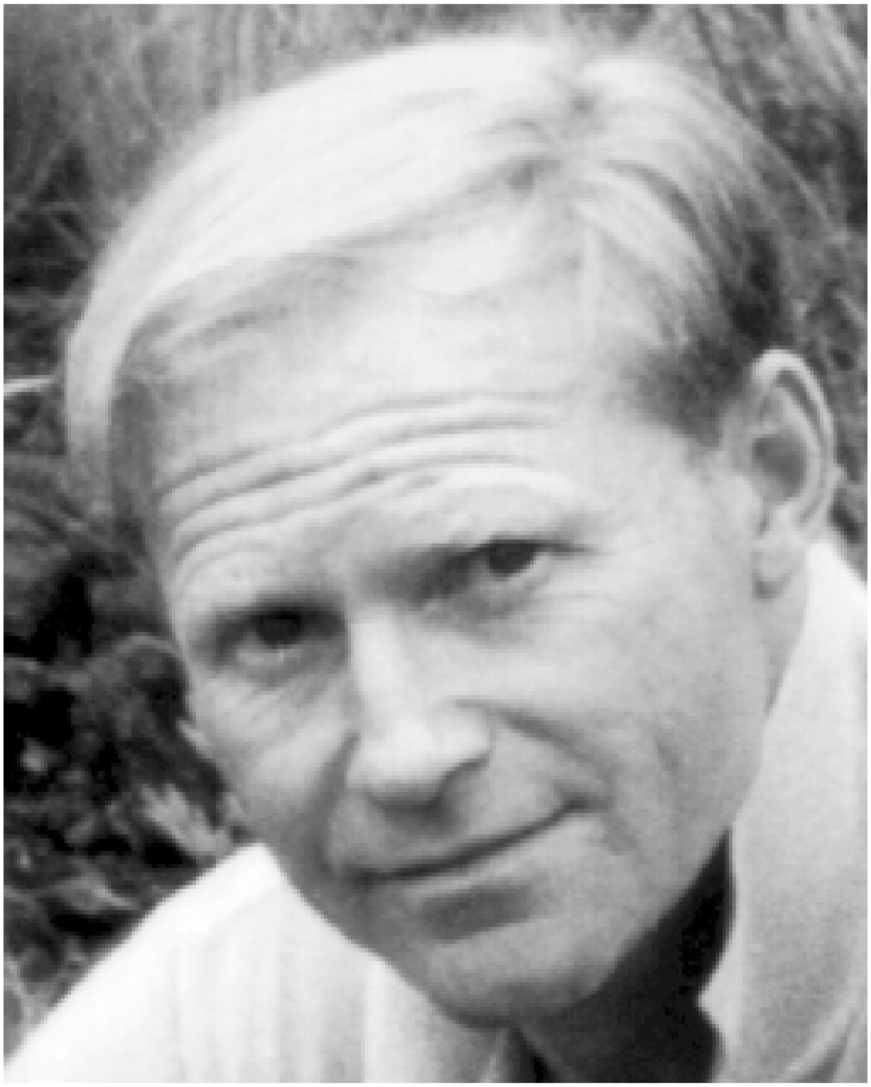

IS CONSERVATION A LOST CAUSE? FROM B.C. TO AFRICA

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Biographical Note: Born in Zambia of New Zealand parents, Dr. Sinclair received his doctorate in Zoology from Oxford. His research interests focus on the workings of ecosystems, how human activity disrupts such systems, and how we should conserve our environment. This ambitious research agenda has led Dr. Sinclair to conduct extensive field studies in the Serengeti National Park in Tanzania, Northern Australia, the Sudan, Kenya and the Yukon Territory.

Serengeti: A World Heritage

The single most important problem facing the world *today* for the *future* survival of mankind is the loss of biodiversity. Historically, conservation has protected biodiversity by setting up protected areas. UNESCO established the first list of protected World Heritage sites in 1972 at the Stockholm conference. The attending countries at that meeting listed the areas they would like to see protected in perpetuity. Canada has put forward a number of such places and some of those are now on the list. However, the site that was agreed upon as being number one in the world is Serengeti. I will tell you something about Serengeti in the context of some hard questions we must ask concerning conservation. Serengeti is unique, with open plains, active volcanoes, ironstone hills, limitless parklands of umbrella Acacias and a vast array of wildlife. The large mammal fauna is the last holdout of the Pleistocene, two million years old. Of the 28 species of large grazing mammals, the wildebeest is the dominant. The size of a small cow, it moves in great herds in an annual migration. When the plains are green, the wildebeest can be seen in long lines following the little paths that have obviously been made over the centuries. They congregate on the plains, sometimes in one herd of a million animals or more.

Some years ago I spent my time looking at these herds; I was interested in what determines the numbers of animals, their births, and what kills them. To study them I would camp alone on these plains, usually by some small rocky outcrop. In the morning I would go out to watch for vultures, because vultures find the dead animals early in the day. As the sun warms the air, thermal updrafts develop and vultures take off to use them, soaring over the great herds searching for dead animals. When vultures see a carcass they close their wings and drop like a stone. Others follow and a stream of birds comes plummeting downwards. These dropping birds can be seen a long way off, and the sight sets off a great race — I drive flat out for the carcass; the hyenas (who are also watching the vultures) are racing too, and hopefully I get there first. And if the lions get there, then we all leave.

At dawn one morning, having slept in my small tent by one of those rocky outcrops, I saw in the half-light some animals coming straight towards me. I was drinking my coffee outside my tent, and because of the poor light it was not until the last moment I realised they were lions. With an explosion of action, I dived into the vehicle and then saw that I had left the tent open. The lions slumped down around the tent and despite encouragement, they were not about to move. I had my work to do and so I left them to it, deciding to come back later. Just as I was leaving, one of the males climbed up on the rock, and started to roar — his answer to my attempt to get rid of them. By midday, my work complete, I returned to the tent. I was somewhat disconcerted to find one of the lions sitting in the tent, and the rest of them lying around it and on the rocks behind. The tent being the only shade around, they had taken advantage of the open tent. No amount of shouting and banging would move them, and the stalemate continued for sometime. Finally I chivvied the one in the tent — a female — sufficiently to move out, and she joined the rest on the rocks. I decided it was time to strike camp but every time I got out of my Land Rover the surrounding lions crouched and snarled, and would not let me near the tent. Indeed, the female that I had finally managed to evict kept running down and chasing me back again. Needless to say, I was not about to go into the tent, unable to see what was going on outside, so there was a bit of a stand-off. Eventually, I realised they were trying to tell me something: clear out. I backed off, my favourite lioness went behind the tent, into the bushes, and retrieved two small cubs. She carried them up into the rocks and I was at last able to take down my tent and leave.

The problem with scientists is that they never tell the public how much fun it is to do science. It is not the dry, boring, dull pastime it may appear. Science is exciting, and there are many interesting stories to tell, but we rarely have the chance to tell people about these interesting events. The other trouble with scientists is that they do a poor job of telling the public about existing problems in science – and, in the present context, the problems we face with the loss of biodiversity.

Biodiversity: The Sixth Great Extinction

The term biodiversity is becoming more familiar since the 1992 Biodiversity Convention in Rio. It is really a code word for a set of problems. What we really mean by this is the *loss* of biodiversity. We are concerned with changes in the ecosystem – the decline of populations, extinctions, and how to prevent them. We are concerned with whether we preserve species, or sub-species and races, or even genotypes — different genetic groupings. Of course, because everything has to live in a place (which we call habitats) ultimately we have to talk about preserving habitats. The reason why we are so concerned about these questions is that we are this century losing species at about 100 times the rate that has occurred over the past one million years. Indeed, this rate is similar to that in the five major extinction events in the history of life on our planet, including the extinction of the dinosaurs. We are now in the sixth great extinction in world history. These are the problems that we as scientists are particularly concerned with. I start this essay with the question: "is conservation achieving its role?" You will answer that question for yourselves by the end. The answer will not be self-evident; it will depend on your own values and priorities for what you would like to do. I intend to pose some questions, examine some scenarios — little vignettes if you like — as examples of the types of problems the world faces.

A History of Human Exterminations

First, let us consider the history of human populations as they spread around the world. Modern humans came from Africa and spread across Eurasia some 200,000 years ago. Our evidence for human invasions starts after that, the earliest occurring in Australia somewhere around 50,000 years ago. North America was invaded over the Bering Straits about 15 thousand years ago. From Indonesia, humans spread over the Polynesian Islands some 3,000 years ago, reaching Hawaii 1500 years ago. Other invasions occurred in Madagascar about 1,500 years ago, and finally in New Zealand about a thousand years ago.

The extinction of the large marsupials in Australia coincided with the arrival of man. These were species such as the elephant-like marsupial *Palorchestes* feeding on trees, the Diprotodonts, the size of rhinos and possibly feeding on the spiny *Spinafex* grass of central Australia, and the giant kangaroos. In Europe, with the arrival of modern humans displacing Neander-

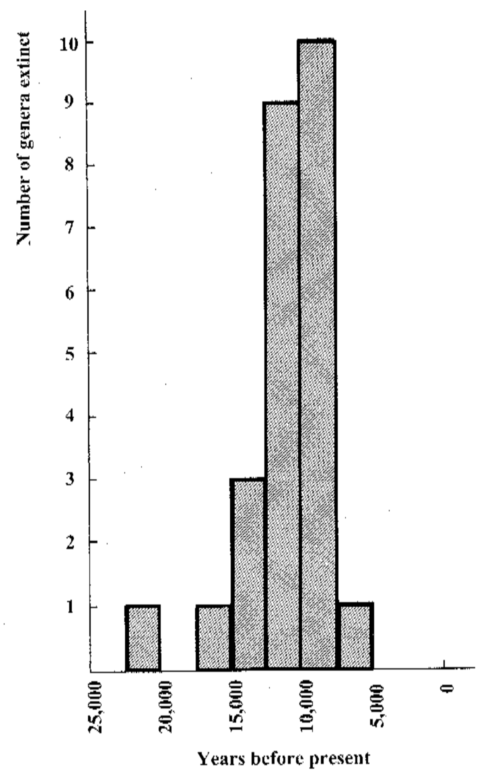

Figure 1: Timing of extinctions of North American mammal genera (adapted from MacArthur 1972, after Webb, 1969)

thal man during the ice ages, species such as the Irish elk, mammoths, and woolly rhinos disappeared. The arrival of humans in North America coincided with a spectacular increase in the frequency of extinctions beginning some twelve thousand years ago (Figure 1). Large mammals that disappeared from North and South America included the giant ground sloth, mastodons and glyptodonts (two-meter long, giant armadillos). Very large species such as mastodons, living in the slow growing low productivity conifer forests, would have had both low populations (a few thousand) and very low reproductive rates. If humans had simply killed some of the babies, this would have caused their extinction. Furthermore, humans may well have altered habitats through fire and so indirectly caused extinctions. Thus, evidence suggests these extinctions were human-related. It is strange to think that it was only a little while ago — in geological time, it was just a second ago — that we had those remarkable creatures roaming around here. We have no concept of what it was like to have those mammals — the woolly rhinos, the giant ground sloths — we have lost the memory.

In New Caledonia a meter-and-a-half long turkey-like bird disappeared 1700 years ago, at the same time as a primitive crocodile, as a result of hunting. Their remains are found in the aboriginal food middens. In Madagascar, elephant birds, like giant lumbering ostriches — the biggest birds in the world — disappeared along with giant lemurs a few hundred years ago as a result of hunting. The invasion of New Zealand by the Moa hunters (predecessors of the Maoris) about a thousand years ago killed these huge flightless birds similar to those on Madagascar — some dozen species.

In modern times, during the 1600s, we see the disappearance of the Aurochs, the progenitor of the domestic cattle, despite efforts by the Kings of central Europe to save that species. The Stellar's sea cow, a manatee, discovered by the Russians on our British Columbian coast in 1714, was extinct by 1740. The whalers and sealers killed off the Great Auk, a flightless seabird living off the Atlantic coast of Canada last century, the last one being recorded in 1844. The process of extermination continues today with the local Common Murre, a seabird related to the Great Auk on the coasts of Greenland and

Canada, rapidly facing extinction because the local people who hunt them have been given modern weapons.

In general, therefore, we find that humans have systematically exterminated species as far back as paleohistory allows us to look. I talk about the large species because they are easily found in the fossil record. There are many other species, about which we have much less knowledge, that have also become extinct. Humans, in their expansion across the Pacific, exterminated fully twenty percent of the world's bird species. In Hawaii, we do know that some 40 species of birds went extinct after the arrival of the Polynesians a thousand years ago, and we should expect similar extermination elsewhere.

Society's Lack of Memory for Nature

There is another aspect to historical extinctions that we need to appreciate. Scotland is known for its beautiful rolling hills covered in heather. They are a tourist attraction, much loved. Poetry is written about the highlands. What people do not realise is that the heather moorlands are largely an artefact. A mere two hundred years ago Scotland was covered in pine forest. It should look naturally much like Norway or Sweden today with pine, birch and aspen forests. The Scottish forest was cleared in the 1700s to graze sheep and evict people during the famous "clearances." Apart from a few small patches, virtually all of the forest has gone (Figure 2). People like Scotland as it is now, they do not appreciate that the highlands are no more natural than is a modern city park. The main point is that people have long forgotten what the highlands in their natural state were really like.

In general, two important points emerge from my review of history. First, we have been exterminating species for as far back as we can see. Every time we make an advance in technology, a new round of killing takes place. Modern extinctions are merely the continuation of extinctions caused by the first peoples to visit our lands. Second, society has little or no "memory" for what is lost or even for what is natural. It was just a blink of an eye ago that we had the

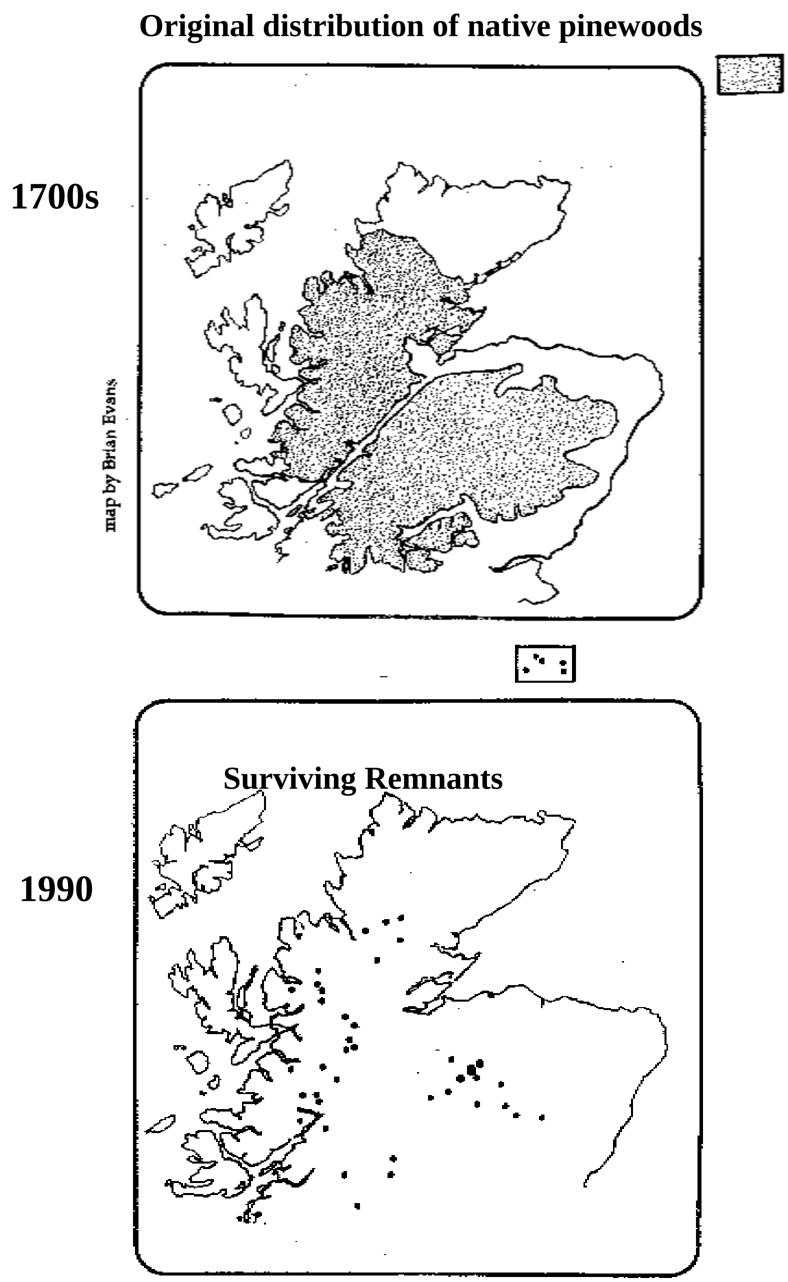

Figure 2: Disappearance of Scottish Pine Forests (adapted from Watson, 1992)

mammoths and ground sloths around here, but we know nothing about that time, we have no appreciation for times past.

The Task for Conservation

What are we trying to do in conservation? I start with the premise that we are trying to preserve species, and because species live in habitats, we have to preserve their habitats. I will not debate this premise, leaving that for another occasion, because I want to explore how we conduct conservation and achieve preservation.

There are about 10 to 30 million species of organisms in the world, give or take a few million. At the current rate at which we have been losing species, a million of them will be lost in the next ten years. Clearly, we cannot save them all, so that presents us with the problem of which to save or let go. How is society making such choices? In short, we make "seat-of-the-pants" decisions, arbitrary and whimsical. We use rules such as "save the ones we know about" — such as the large ones, pretty ones, and cuddly ones; we notice them, and we become aware of their plight. Other rules include "save the areas which have the most species" – this is the "hot spot" approach (I return to this below).

On the surface, these rules sound reasonable, and they can be rationalised through the excuse that if you "save the large species, you save lots of little species" that go along with them. These large species are called "umbrella" species and examples include the giant panda in China, the tiger in India, elephants in Africa and other big and beautiful animals. They attract public attention. Conservation organisations, both government and non-government, such as World Wildlife Fund, the International Union for Conservation of Nature, and many others use these large, charismatic species to raise funds for their preservation and hope the smaller species will be saved along with them. Most of their work is "emergency room" crisis. Every time the phone rings, there is another species that somebody has discovered about to go extinct. Decisions as to where to put the funds and effort are short-term and local. Decisions are opportunistic: we do what we can at the time in terms of funds, people and politics, and we hope for the best. Often decisions end in confrontation. The confrontations so prevalent in the 1990s on the west coast of Canada and south-east Australia involve valley by valley fights between logging companies and environmentalists.

I call this technique of conservation the First World War approach of trench-by-trench warfare. Neither side is going to do well out of this. The companies understand that quite well. There are no natural "stopping rules" to the fight, for once one valley dispute is settled, the next is in contention. Given this, it is logical for a company to put up a stand at the first valley, not the last. The environmentalists do not appear to appreciate that confrontation is enormously expensive in terms of time, money and people, with no assurance that such valleys are the ones that ought to be saved. They are the "feel good" valleys, but they could be the wrong ones because they have not been chosen on an objective basis. As a result many, if not most, present day conservation actions are inappropriate or out of context.

Let us remind ourselves what the problem is — we do not have enough resources to save everything and so we must make a list of priorities for habitats and species. This will enable us to optimise the distribution of those resources to save the most species. What sort of resources? Time is one; every year passing means more is lost. The amount of land that we can put aside to save habitats is another, because there is a finite amount available. The more land set aside in one place means the less set aside in another because there is a limit to what society is willing to pay. Given this opportunity cost to land, we must be sure that the areas we spend time and money on are the ones we absolutely need above all others. Making decisions, though, on where we should spend our resources of time, area, and money has to be done on a global and not a local basis. Decisions made on a local basis will result in more species going extinct.

Choosing Sites for Conservation

Let us consider the "hot-spots" approach to conservation. Figure 3 is a map showing the areas of highest Amazonian bio-diversity. The black areas represent the highest number of species, the shaded the next highest. By this rule, those areas with the highest biodiversity — the "hotspots" — should be set aside first and, if there are resources left over, then areas of lower species richness are included next. It sounds reasonable at first sight. Unfortunately, it is inefficient and misses rare species. We can see this using Britain as an example. (See Prendergast et al., 1993). Britain is one of the best documented areas in the world for different types of organisms because the British love collecting, bird watching, etc. The highest diversity areas for birds are on the south coast. For butterflies, high diversity areas are scattered all over the centre and east coast of England, whereas those for dragonflies are on the south coast. Liverworts, which are primitive plants, are largely in Scotland. I have considered only four groups, but there are many others. This group–by-group approach does not work because "hotspots" do not overlap

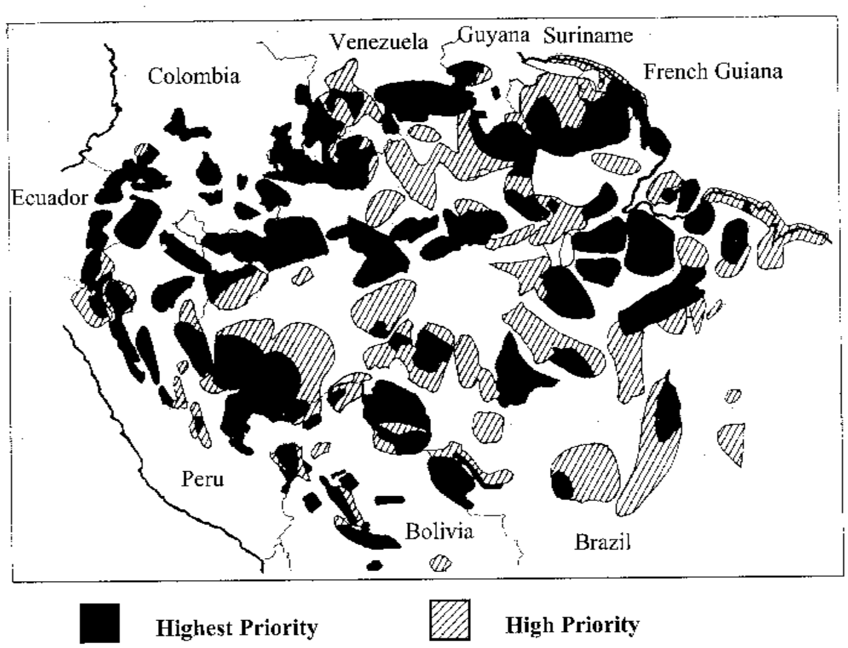

Figure 3: Priority areas for conservation in the Amazon region (based on Figure 1 in Rylands, 1991).

each other. To put reserves in hotspots for all biological groups would set aside a large part of Great Britain.

Consider British Columbia as another example. For bryophytes (mosses), the "hotspots" are mainly on the Queen Charlotte Islands, whereas those for vascular plants (the more advanced plants), are largely on Vancouver Island. The highest diversity of endemic insects, and other invertebrates, is in the Okanagan valley of southern B.C. Again, "hotspots" do not overlap each other. Thus, setting priorities for conservation areas on the basis of "hotspots" does not narrow our options sufficiently. In addition, this approach is uneconomical because it over-represents common species while often completely missing rare species. It does not give us the best distribution of land to represent as much as possible.

An alternative approach is called "complementarity." It starts by taking the areas with the rarest species first, and then adding in, with more resources, the next areas with the next rarest species. If there is a choice, it adds in the areas with the most species. This proceeds stepwise until all species are included or one runs out of resources. Each area added to the set of reserves (the priority set) complements what is already saved, so duplication is held to a minimum, and all species are represented. It has now been tried in Australia (where the method was invented by Nick Nicholls and Chris Margules), in Britain and in Oregon (e.g., see Pressey et al., 1993). In each case, complementarity was more efficient than hotspots by as much as five times; i.e. five times as much can be saved for the same cost.

For example, there were seventeen different habitats on a group of farms in New South Wales, Australia. The task was to identify which farms had to have special protection to save a representative portion of each of those seventeen habitats. The "hotspot" approach starts with protecting the farm supporting the greatest number of habitats. In total, this approach required 20 farms to represent all 17 habitats (Figure 4, line A). The complementarity approach, by contrast, required only seven farms (line B). The complementarity approach is a better way of doing things because, first, we get "the most for the least" and, second, we obtain an objective estimate of

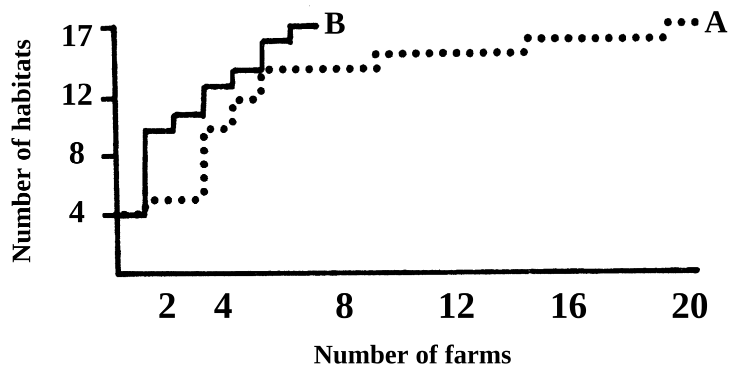

Figure 4: The "Hotspot" approach (Line A) requires 20 farms to represent 17 habitats whereas the "Complementary" Approach (Line B) requires only 7. (Based on Fig. 1 in Pressey et al., 1993)

the conservation value of each area. The farms chosen first have habitats with only one representative; if these are lost, they are gone forever — they are irreplaceable. Thus we can assign an irreplaceability index on the basis of how many alternative sites are available. With only one site, the irreplaceability index is 100, with two sites the index is 50, four sites it is 25, etc. This is an objective score which we can apply to habitats containing rare species, based on the number of alternative sites to choose from.

In our example there were three farms that had the only representative of a habitat. We say those are completely irreplaceable (an index of 100). There were two pairs of farms with the same habitat, and one each had to be chosen. These had an irreplaceability value of fifty. The important point for the management of conservation is that the index provides an objective method of conservation evaluation. This conservation index can then be compared with economic and social scores in negotiations. One could say: "There are two areas here, we need to save one, but there is room to negotiate on which one to set aside." Decisions can then be made on the basis of lost economic value, social, cultural or aesthetic values. With an objective assessment, conflicts are better avoided. The cut-off point for how much land, and hence how many species can be pre-

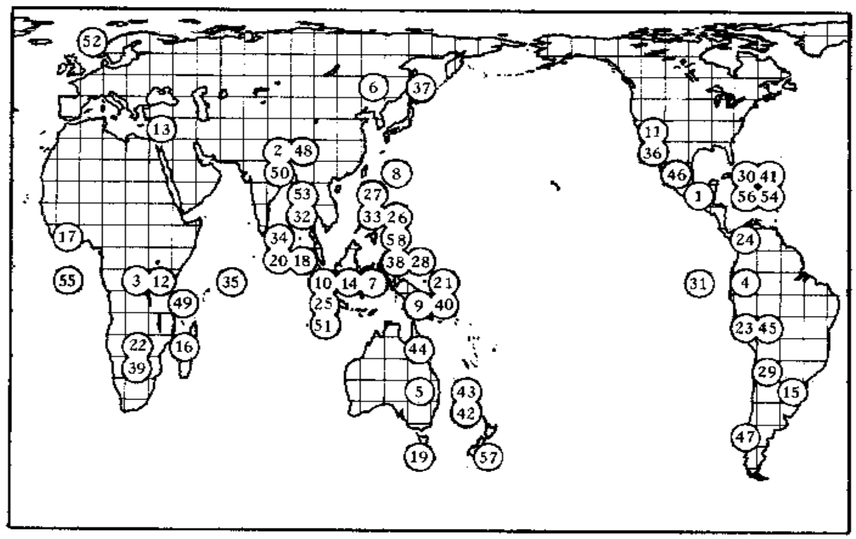

Figure 5: 58 Priority regions for all world owl species (Based on Fig. 3 in Pressey et al. 1993)

served, is of course a political decision, but now we have a way of evaluating it.

The Australian farms are merely an example of this approach. It needs to be used on a global scale, as Dick Vane-Wright and colleagues from the British Museum have done for owls. Owls are appropriate because of the spotted owl controversy in our western forests. Figure 5 documents the priority areas of the world which combined represent all species of owl. The most important area for owls is somewhere in Central America. The first site in North America is number eleven, which represents the burrowing owl. The spotted owl is represented in Central America. We do not have to worry, on this basis, about spotted owls anywhere along this coast. We are not off the hook, of course, because profits from logging the west coast must go to purchasing and maintaining forests in Central America. Indeed, the tropical forests must be secured for owls before the temperate forests are logged, not afterwards. In fact, the majority of owl species are in Southeast Asia, and we should be spending our profits from logging there, not here in B.C., for conservation.

The same analysis for milkweed butterflies (family Danaidae) shows that Southeast Asia is also the most important area for this group. A similar global assessment for bumblebees shows that an area in China has highest priority, followed by an area on the Canadian Shield. Perhaps we should consider a National Park for bumblebees. So far, no one has considered that aspect, but in principle there is no reason why we do not have a National Park for bumblebees, we merely need to think more broadly.

Protecting Conservation Sites

The next question asks, how do we protect habitat? At first sight the answer is obvious. We set up reserves and then protect them in order to prevent losses of habitat and species taking place outside the reserves. For example, tropical forests are declining rapidly in all countries (Figure 6). Vancouver Island shows the same rate of loss for its temperate forest. Forest is disappearing because of human

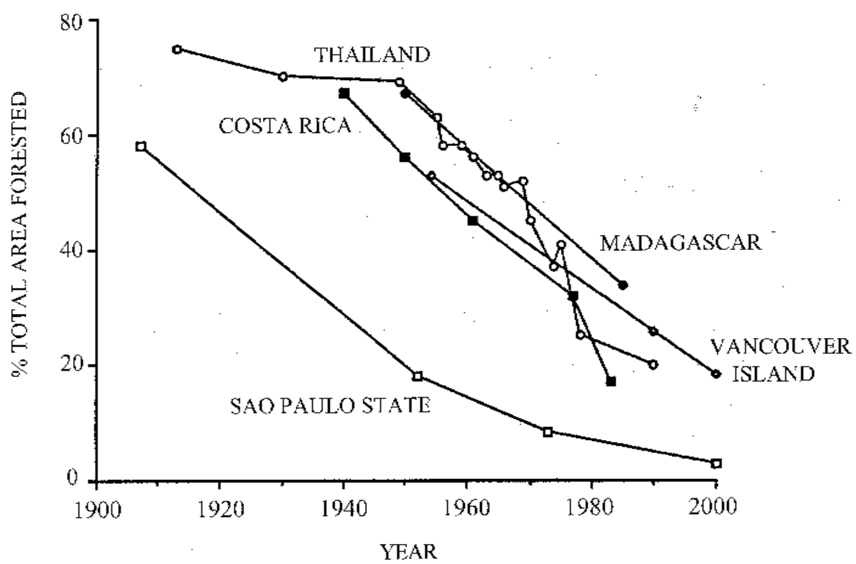

Figure 6: Loss of Forested Area - World Examples (from Sinclair et al., 1995). Reproduced with permission.

population pressure. For example, the proportion of tropical forest remaining in Southeast Asia declines as human population density increases (Figure 7).

If reserves are the solution to preventing loss, we should expect habitats and species to be safe within them. Consider Strathcona Provincial Park on Vancouver Island, to take an example close to home. Figure 8 compares the Park boundary in 1954 with that in 1990. Mice seem to have been nibbling at it — there are little indentations in the south, we have lost the corner in the south-east, and another big bite up in the north-west. It has been chipped away at; much of the good bits of temperate rainforest have been taken out.

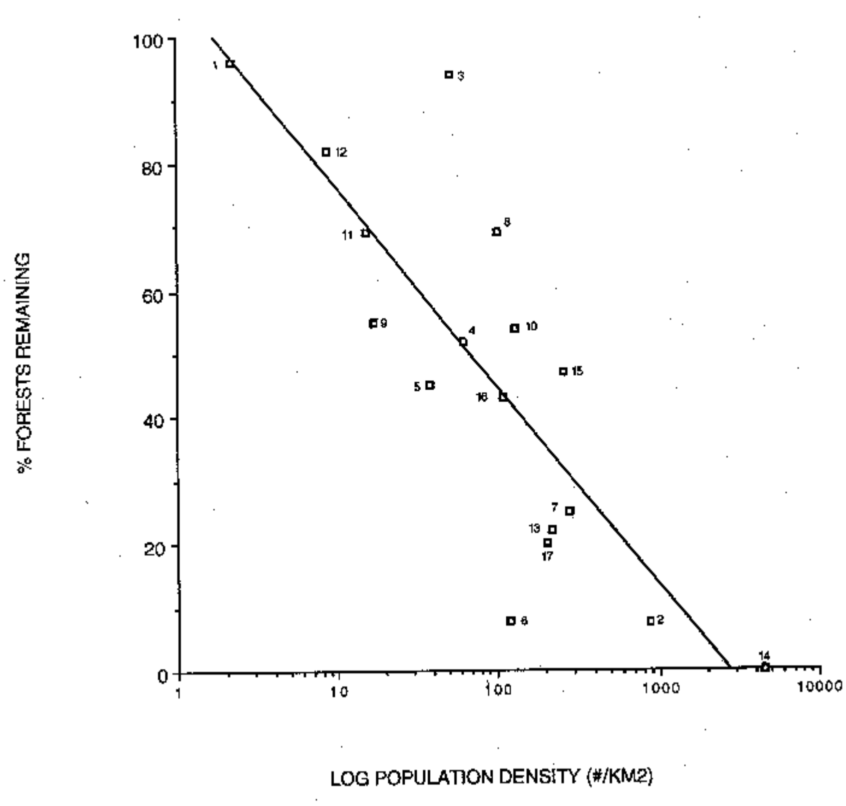

Figure 7: Population density vs. % tropical forests remaining in different Southeast Asia countries (from Sinclair et al., 1995). Reproduced with permission.

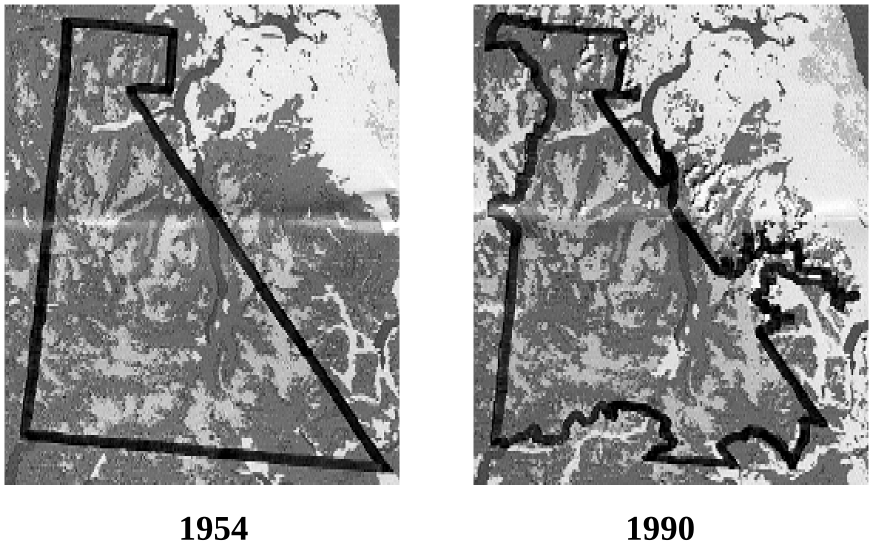

Figure 8: Strathcona Park, Vancouver Island boundaries, 1954 and 1990 (adapted from maps by The Sierra Club of Western Canada, 1993)

As if in compensation, the government has added a bit on the eastern side, but that bit is comprised of mountain peaks, snow, ice, and rocks — this is a confidence trick. The point is that all Parks and Reserves around the world suffer a gradual attrition. We are losing our protected areas bit by bit. If we have lost this much in about forty years, how much will be left after the next 200 or 500 years? That is the time span we must think about, and at the present rate we will have lost it all by the end of that time. Remember from our earlier discussion that society does not notice gradual change, it has no memory. We get used to what we have lost and so there is nothing to stop this loss.

Perhaps Strathcona Park is not important enough to protest its decay. If not, then Serengeti certainly is. If we cannot prevent attrition in Serengeti, we cannot prevent it anywhere. Serious poaching for rhino horn in Serengeti started in 1977 and by 1980 all rhinos had been exterminated from the Park. Between 1977 and 1988 some eighty percent of elephants were killed and the rest were saved only with the ivory ban in 1988. Wild dogs, some of the rarest carnivores in Africa, numbered over 100 in the 1960s in Serengeti but all are now gone. Some 40% of the lions died in 1993 as a result of canine distemper contracted from domestic dogs. Canine distemper has spread as a result of the exploding human populations with their infected domestic dogs around the periphery of Serengeti; it appears that domestic dogs first made contact with wild dogs, then hyenas, and most recently lions. Such population declines are forms of attrition because they compromise the natural workings of the ecosystem. The natural area left in the Serengeti region this century (Figure 9) has been decreasing steadily. The legally protected area started in the 1920s and built up to the 1960s and 70s. It levelled out and then declined somewhat as portions were removed, as in Strathcona

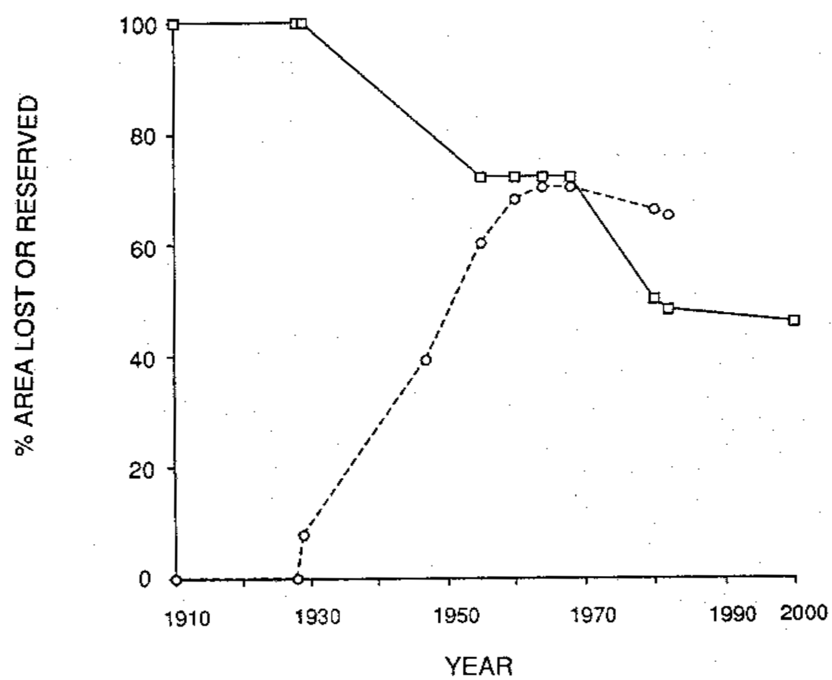

Figure 9: Natural area remaining (solid line) and legally protected area (broken line) in the Serengiti ecosystem (from Sinclair et al., 1995). Reproduced with permission.

Park. More significantly, the natural area is now less than the legally protected area. There are areas inside the Serengeti Park with no large mammals left, they have been removed by poaching. Thus, we must recognise that we cannot protect even the most important conservation areas in the world.

Renewal: Replacing Lost Habitat

It is, therefore, a delusion to think that a reserve will prevent the eventual loss of habitats and species. Within a reserve we lose as much as if no reserve had been present. The only advantage of a reserve is that it takes a little longer to lose everything. The solid curve (Figure 10) shows the rate of loss of area as a result of attrition

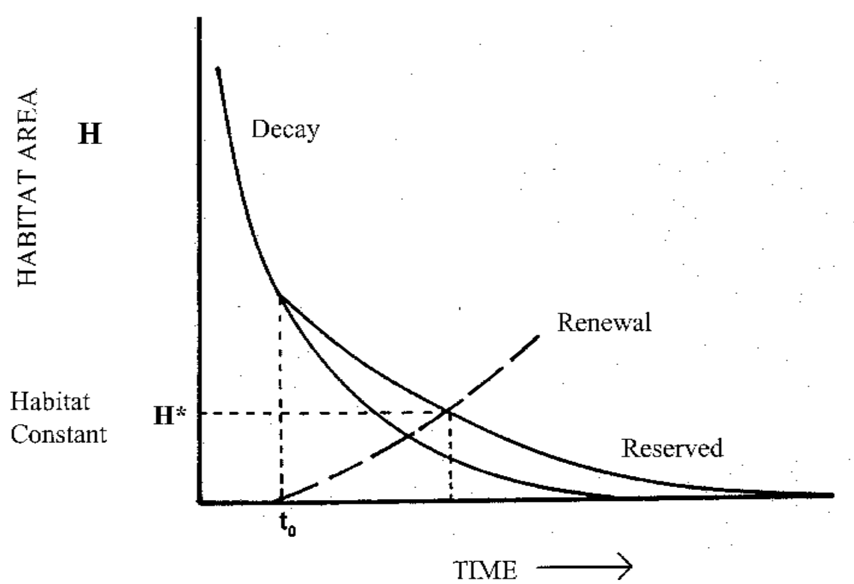

Figure 10: Loss of natural area (solid curve) results in none remaining. At time t_0, a reserve is established, and its area also declines to zero, but at a slower rate. If new habitat is added to the reserve (renewal, broken line), then we can maintain a constant area (H*) where the two lines cross. (From Sinclair et al., 1995). Reproduced with permission.

over time. If we set up a reserve at a certain point (t_0), the rate of loss is not so fast but we still lose it all eventually. The reserve allows us to buy time to do something about the attrition. But the question is: are we using this extra time to do something about this attrition? To counteract the loss of this habitat requires an addition to the reserve to balance the loss. We have to put in new habitat and new area. If we replace lost area with new area at the same rate, we can end up with some constant amount which we would call the "habitat constant." Thus, we must conclude that the only reason for having a reserve is to buy us time so that we can replace what is lost.

Are we replacing lost area, renewing lost habitat? Not only is there no renewal, but the policy has not even been considered. Therefore, unless we change policy, reserves will not achieve their ends and our descendants will have nothing left. At the present time we are so desperately responding to crises of extinction that we have not had time to examine our current long-term conservation strategies.

This is not good news for either side. Obviously, it is not good news to the conservationists to be told that merely setting up a reserve is not going to save anything. Neither is it good news to the logging companies because if they want to cut down a hundred hectares of old growth forest within a reserve, they must first grow a hundred hectares of old growth forest, not replace it afterwards — and that takes two hundred years. If governments or companies are not prepared to do this, then reserves will not save anything.

We did have some short-term successes in Serengeti. Both wildebeest and buffalo increased over the period 1963-1977. Wildebeest went up from a quarter of a million to 1.5 million animals. I well remember the time we first recorded the population reaching that level. In 1977, my friend, Mike Norton-Griffiths wrote to ask that I return to Serengeti to count the wildebeest, since it had not been done for five years. In April 1977, I flew to Tanzania and Mike then flew his own plane from Kenya to Tanzania to join me in Serengeti. We were to use his plane to conduct this count. Just that month, Tanzania closed its borders with Kenya because of a political squabble; in fact they were almost going to war. Mike's plane was the first plane to go into Tanzania after the border closure. Although no planes from Kenya were allowed into Tanzania, Mike's plane had a British registration, so technically he was allowed in. As he came in to land at Kilimanjaro Airport, the air traffic controllers, immigration officers, etc. who were completely bored for lack of any other activity, came out to watch him land. Automatically suspicious, they promptly arrested him. They questioned him for a whole day before releasing him.

He arrived the next day, grumbling about what he had to go through for me, and we set about counting the wildebeest. This is done by flying back and forth across the wildebeest herds while taking photographs with a camera pointing vertically down from the wing strut. Unknown to us, the Tanzanian Army was driving along the road across the plains, through the wildebeest herds. There were rumours of gun-running on the Kenyan border and the army was setting up a garrison in Serengeti to combat this. Army trucks just happened to be driving through as we were flying about 300 metres over the top of them with our camera hanging out. It must have been twenty times that we passed over the same trucks. If one low-level reconnaissance pass over a convoy was tactless, twenty were fairly certain to annoy them.

"Wonder who those guys are?" we had commented to each other. We landed and faced a reception committee from the army. They were not smiling. We were arrested. They asked us what we were doing and we told them we were photographing wildebeest. "Who wants to photograph every wildebeest in the Serengeti? After all, one is enough surely?" was the sceptical retort. When we explained why we were counting them, they thought this excuse just as improbable. In fact, they did not believe us and concluded we were spies from Kenya. Their problem was what to do with us. Negotiations were put on hold while they had a debate amongst themselves. Understanding Swahili, I thought I had better be helpful and so I suggested that we stay in our house, which was just next door to the airstrip, while they sorted out the problem. We were buying time hoping that the Park Warden would come to rescue us. The army contingent drove off leaving a guard on the plane. All that day and the next we sat anxiously in our house imagining trials, prison, deportation and confiscation of planes. And we were just counting wildebeest.

We could see the plane from the house, with the guard next to it. After a while, we noticed that the guard disappeared for about 45 minutes every so often. We then realised that they changed guard by the one at the plane walking back to camp, some five kilometres away, and telling his replacement that it was his turn to walk back to the plane — instead of doing it the other way around. Once we figured that out we both saw the next move without speaking. The next time the guard set off for camp, we grabbed our bags, jumped in the plane and took off. It was evening and too late that day to reach Kenya. Instead we flew the 40 minutes to Mary Leakey's camp at Olduvai. Mary Leakey, of course, is the famous archaeologist who discovered various fossil hominids originally with her husband Louis Leakey who had died some years earlier. A semi-tame cheetah was in camp, it showed up every now and again. If one slept with the door of the cabin open, it had the somewhat disconcerting habit of coming up in the middle of the night and licking one's face. Mary had just discovered the famous footprints of hominids at 3.7 million years old and she was anxious to tell us about them. We were, of course, rather more concerned with escaping from the Tanzanian army so it was a slightly bizarre conversation in all.

Mary was quite ill at the time and asked us for a lift to Nairobi, since we were the only means of exit, the border being otherwise closed. To leave Tanzania we had to go back to Kilimanjaro airport to get exit papers, and we were extremely nervous because we thought the army had probably put out an alert for us. Mike and I completed immigration without trouble but when they saw Mary they beckoned her into a backroom. And we all knew what that meant. After half an hour, with Mike and I in a cold sweat thinking that something had happened, Mary came out with a rather puzzled look on her face. We asked, "Mary are you all right?" She answered, "Yes, everything is fine, but Michael, have you been doing anything wrong recently? They seem to think you're too dangerous a pilot for me to fly with." That is what happens in research!

How Much Habitat? The 12% Myth

Returning to problems in conservation, the next question I want to ask is: How much habitat should we save? British Columbia has assigned a maximum of twelve percent of the land area for conservation. However, where does the twelve percent figure come from? In 1984 Jeff McNeelly and colleagues at the International Union for the Conservation of Nature reported that 4% of the world habitats had been put aside in reserves. In 1987 the Prime Minister of Norway, Mrs. Bruntlund, wrote a report for the United Nations in which she commented that 4% was not enough, and we should save three times that amount, hence the twelve percent figure. This figure is, therefore, arbitrary and has no biological justification. Yet, it has now become the set point of politics, written in stone. In addition to the biological irrelevance of 12%, we have the problem that we do not know what 12% applies to. Twelve percent of what? It cannot simply be 12% of what we have presently remaining because that is a nonsensical amount. Secondly, what habitats do we apply this 12% to? Some habitats are very small — do we save 12% of these also?

To understand the problem I return to our declining tropical Asian forests that I referred to earlier. The only logical and sensible way of applying the twelve percent figure is to start with the original untouched amount of forest and take 12% of that (Figure 11). What that means, of course, is that if there is only half of the forest left, then one must reserve twenty-four percent, not twelve percent of the remaining amount. If there is only twelve percent of forest remaining, then all of it must be reserved; i.e. one hundred percent. Figure 11 shows a curve of the proportion of remaining habitat that has to be reserved starting with 12% of original habitat and ending with 100%. Comparing the amount of forest reserved in these countries relative to this curve, we see there are only two countries doing better than 12%. Almost all of the countries are far below the twelve percent point. Thus, to achieve twelve percent, they need to implement the concept of habitat renewal already.

How have we been succeeding with reserving 12% in Brit-

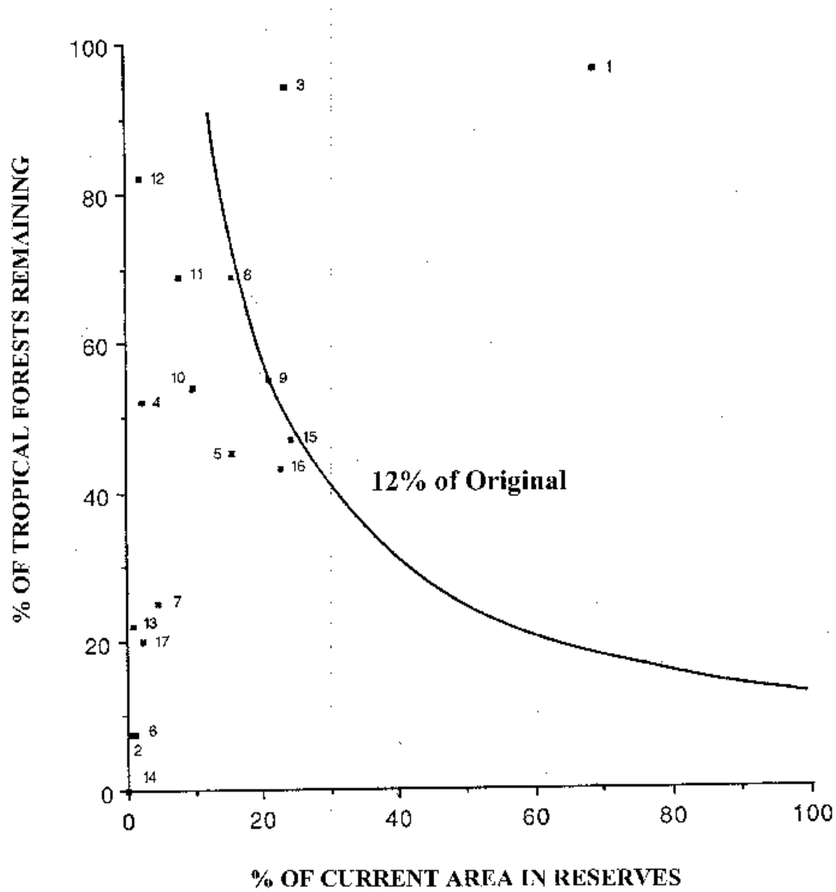

Figure 11: The proportion of tropical forests remaining in 17 Southeast Asian countries relative to what should be reserved if 12% of the original forest was protected (solid line). (From Sinclair et al., 1995). Reproduced with permission.

ish Columbia? The areas of high diversity for invertebrates are in the south Okanagan, which includes habitats of antelope brush (*Purshia*), blue bunch grassland and sagebrush. The area supports a number of important birds such as the sage thrasher and burrowing owl, and the tiger salamander. However, far more importantly, there are some 300 species of arthropods, insects, spiders, etc. The way the province is dealing with the twelve percent is simply to take twelve percent of the whole area. Since there are large tracts of conifer forests, almost all of the twelve percent can be found by reserving that habitat. Indeed, well over twelve percent of conifer forests have been reserved, but this habitat does not represent the habitat of endangered birds, salamanders and insects. Thus, nowhere close to twelve percent of the bunch grass and antelope brush habitats, where these rare species occur, is reserved. British Columbia is failing to live up to its own arbitrary legislation.

We must ask whether 12% of a habitat is sufficient to ensure long-term survival of species. Analysis of the minimum amount needed to ensure survival, using the complementarity approach, shows some 40 to 80 percent of the habitat must be protected for rare and endangered species. For some of the rare habitats, such as the remaining bunch grass in the Okanagan, all of it must be protected. Unless society recognises that far larger proportions of habitat than 12% must be protected, most of our endemic species in Okanagan will go extinct. The debate over whether 8% rather than 12% should be reserved is merely splitting hairs in this context.

Where to Place Protected Areas: Global Climate Change

The next question to ask is: where do we place reserves? As in every question I have asked so far, the answer is superficially obvious: we place them where the animals or plants occur. At first sight this makes sense. However, the world is changing from global climate change. Whether the climate gets colder or warmer is the subject of debate, but change is going on. The problem, however, is that when the climate changes, the species making up our communities change their geographic locations at different rates. We know this from changes in species distributions that have taken place after the last ice age 12,000 years ago (see Davis, 1986). Following the ice age, forest communities in Southeast USA moved northwards with the warmer climate. However, the various tree species moved at different rates so that species living together 12,000 years ago had different ranges by 6,000 years ago. Thus, a reserve placed at present times to protect a community could easily lie outside the new range of the community under a warmer climate. We have to place our reserves *now* for future requirements to protect species because by the time they are needed, the areas will no longer be available. Furthermore, several such areas will be required because the species making up the community will be moving into different areas. So far, no efforts have been made to place reserves for future conservation.

Loss of Biodiversity and Ecosystem Function

In 1994 members of a conference in the southern United States asked this question: given that we are going to lose species, how much can we afford to lose without impairing agriculture, forestry and other ecosystems? In general, the question is unanswerable because systems have an enormous number of species — in the soil, in the vegetation, and in the animals supported by them — and this complexity prevents us predicting what will happen from loss of species. One might be able to predict what would happen when A eats B; but one cannot predict what would happen two or three links down a longer line of species. One can understand each link individually, but not the outcome of a sequence of links. The technical term for this outcome is “chaos.” What it says is that one can predict short-term consequences of change but not long-term consequences.

A better approach to the above question is the one medicine uses in pathology, namely to compare systems that have gone wrong with those that still work. There are no better experimental comparisons than the true ecological disaster areas of Australia, New Zealand and the Pacific islands. Let me give you a very simple example. Several plant species of the group called *Hibiscadelphus* in Hawaii have gone extinct because the birds that pollinated them, a group of endemic honey-eaters, themselves went extinct. Another example is that of *Calvaria*, a plant on the island of Mauritius in the Indian Ocean. It had not been known to germinate for at least two hundred years until Stan Temple from the University of Wisconsin worked out the reason. The seeds of *Calvaria* had probably been eaten by the dodo, a giant flightless pigeon, the size of a turkey. It went extinct in the 1700s due to human hunting. To test this idea, Temple fed the seeds to turkeys, with a bit of help, because turkeys are smaller than the dodo. When the seeds came out the other end they germinated for the first time in two hundred years. Thus, with the loss of the dodo, the link was broken and other species were endangered. These examples illustrate how species are co-evolved, one species depending on another; if you lose one, you lose the other. We cannot, therefore, allow any species to go to extinction because we do not know the long-term effects on other species and on ecosystem function. The problem is that for most systems we do not know what those links are because they are so complicated.

The presence or absence of single species can upset even very complex habitats. Take the house mouse as an example. In North America, mice are a nuisance but they are not a serious problem. In Australia, however, house mouse populations expand into plagues; such events do not occur in North America or Europe. Why? We do not know the answer to that yet, but that problem is the one that should be attracting our attention. As another example, Asian water buffalo were imported to Australia in the early 1800s. Since then the population expanded and completely re-landscaped the habitats in the northern part of the country. Pathways created by the water buffalo drained fresh water from large areas and let in brackish water from the sea. Such major changes in hydrology have changed the habitats of northern Australia. Similar changes do not occur in Asia where water buffaloes occur naturally. Thus, we need to compare altered systems as in Australia or Hawaii with unaltered ones to understand how biodiversity loss will affect our planet.

Is Conservation achieving its ends?

I started this essay by asking whether conservationists are achieving their goals of saving the maximum amount of biodiversity. In reviewing conservation activities I have considered a number of simple questions related to biodiversity preservation. The answers appeared obvious until we started to think about them and then we realised that there are some extremely thorny problems to deal with.

Indeed some problems seem intractable.

At the present time, conservationists have been confronted with an accelerating rate of loss of species. Their response has been to do what is possible for each extinction crisis. Areas for protection are currently decided by what is left out of reserves (gap analysis) or by which area contains the greatest number of species (hotspots). I have suggested that these approaches could well result in an inefficient use of valuable resources, with money and land area being allocated to species that do not warrant them while others are left with little help. Other protocols such as complementarity or newer optimisation procedures can represent more species with greater evenness of resources and for less cost.

Conservation has traditionally protected biodiversity by setting up reserves. There is ample evidence to show that all reserves in the world are presently in a state of decline as a result of attrition from human interference. Reserves, therefore, serve only to slow the rate of decay compared to areas that are unprotected, they do not protect biodiversity forever as is commonly conceived. Reserves merely allow us to buy time to reverse the attrition through a policy of adding in habitat to replace the lost portions, a process I call habitat renewal. So far no policy of habitat renewal has been contemplated and time is being lost. Unless such a policy is instituted we will lose as much biodiversity as if no reserves had been set up.

The amount of area assigned to conservation has been arbitrarily set around 12% of land area in British Columbia. This proportion has little biological relevance and is likely to be insufficient for most endangered and threatened species. Over 50% of special habitats may be required to prevent extinction. Where habitats such as the Okanagan grasslands or tropical forests have already been reduced to less than 12% of the original area, new grassland or forests must be grown or we will lose the species in those habitats.

The location of reserves has been decided entirely on present distributions of species. There has been no consideration for future range changes due to global climate change. Consequently, many of our current protected areas will be inappropriate in about 50 years time. We must assign protected area status to future range *now* because such areas will not be available in the future.

In general, conservationists have not paid sufficient attention to these problems. Most conservationists work in the field and not enough have stood back to ask the question: are we doing the right thing? Some conservation biologists, probably those in academic institutions, should be doing more to explore these issues and advising government field staff on the priorities of conservation. These priorities must be made on a global basis and not on a country by country basis. To achieve this role, an intergovernmental committee, similar to that advising on Global Climate Change (the Intergovernmental Program on Climate Change) should be set up.

However, my belief is that if we use our brains, we can find our way around these problems. Our Centre for Biodiversity Research here at UBC is addressing these questions and looking for solutions. The solutions are for the long term; there are no quick fixes. I believe that we can do it, but we need financial support from private corporations and foundations to maintain our post-doctoral fellows and research associates, for there are no other means to attack these problems.

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