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INTERVIEW WITH THOMAS LOVEJOY

Thomas Lovejoy is an innovative and accomplished conservation biologist who in 1980 coined the term "biological diversity." In 2010 he was elected professor in the department of environmental science and policy at George Mason University. He is senior fellow at the United Nations Foundation in Washington, DC. He served as president of the Heinz Center from 2002 to 2008 and held the Biodiversity Chair. Before assuming this position, Lovejoy was the World Bank's chief biodiversity advisor and lead specialist for environment for Latin America and the Caribbean. In the 1980s, he brought international attention to the world's tropical rain forests, and in particular to the Brazilian Amazon, where he has worked since 1965. Lovejoy also developed the now ubiquitous "debt-for-nature" swap programs and led the Minimum Critical Size of Ecosystems project. In 2001, Lovejoy was awarded the prestigious Tyler Prize for Environmental Achievement. In 2009, he was the winner of a BBVA Foundation Frontiers of Knowledge Award in the ecology and conservation biology category. That same year, he was appointed Conservation Fellow by National Geographic. In 2012 he received the Blue Planet Prize. Lovejoy holds BS and PhD (Biology) degrees from Yale University.

The National Geographic Magazine (2015). Credit: The National Geographic. Retrieved from [https://news.national-geographic.com/2015/10/151015-qa-biologist-thomas-lovejoy/]

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Adalberto Val: Biodiversity. What do we know, what do we need to know?

Thomas Lovejoy: The term biodiversity is a contraction of biological diversity, a term first used in 1980 to collectively encompass the astounding variety of nature. While thought of most simply as the total number of species of plants, animals and micro-organisms, it also applies at the level of genetic diversity within a species or even a single organism, as well as at larger aggregations such as the main biomes of the planet. It also encompasses the diversity of higher levels of relatedness such as vertebrates or seed plants. The second highest level (after Domains) of that organization is at the level of the phylum, e.g. mollusks, flowering plants, insects or arachnids. All phyla are represented in the oceans, but not on the land.

Science only has discovered and described a fraction of diversity at the species level, let alone at the other levels of biological organization. There is a heavy bias in that knowledge toward terrestrial organisms and toward vertebrates (mammals, birds, reptiles, amphibians and fish). Two unanswered questions are 1) how many kinds species are there and related to it 2) how much remains to be described. Current views estimate the number of species as at an order of magnitude of ten million species (rather than 100 million) but it is hard to say whether that means ten or fifteen or twenty million, but for practical purposes most agree on the ten million range.

There are vast unknowns in the biodiversity picture. Prime among them is biodiversity in the soil, even though that is essentially intertwined with soil fertility and all the benefits that flow from that to humanity. While there is a Global Soil Biodiversity Atlas, it is at best just a first approximation in our understanding of soil biodiversity, its functions and benefits.

As someone fascinated by the variety of life, it has been exciting to see understanding go beyond just more new forms in existing groups, but also occasional discoveries of new phyla, and even an unrecognized domain of life in addition to the one composed of bacteria and the second including plants, animals and fungi. Named the Archaea it includes an astonishing variety of organisms with odd metabolisms and appetites many dating back to the origins of life on earth.

Biological exploration has also revealed entire biological communities in the bottom of the oceans around deep-sea vents which cannot derive energy from the sun because it does not penetrate so deep. Rather these micro-organisms are able to fix energy from thermal vents, essentially the primal energy of the earth, and serve as the base for a food chain involving some higher organisms.

Science has probably explored/discovered/recognized about 20% of all species so there is an enormous agenda and an amazing frontier to be explored. Since each species is both a unique set of solutions to a unique set of biological challenges and is busy generating new ones on an ongoing basis, the exploration of life on Earth is fundamental to generating new advances in the life sciences. So, loss of a species not only terminates a 3.8-billion-year line of evolution, it forecloses the potential contributions to the life sciences from that particular line.

AV: Which are the specificities regarding the Amazon's biodiversity?

Thomas Lovejoy: The Amazon stands out as the greatest tropical wilderness and forest, but yet more, as the single largest repository of biodiversity on earth. That includes 14,003 species of flowering plants of which 6,727 are trees because woody vegetation dominates the basin. A lot of it remains to be discovered. Currently 1300 species of birds are known but new ones are being recognized all the time. Many are look alike species on different sides

of large rivers but sing differently and when examined genetically are really distinct. One authority estimates in the end that perhaps 3,000 species will be known from the Amazon. The Amazon river probably holds 3000 species of fish (of which a significant number remain to be described) from the gorgeous aquarium fish species, like the cardinal and neon tetras and the angelfish, to very large fish species, like the catfish, many of which have life cycles that span the length of the basin. There is a whole set of fish species which are adapted to annual cycle of rise and fall of the rivers which allow them in high water months to swim into the floodplain forests for their principle feeding time during the year.

The plants and vertebrates, probably the best-known groups, as are butterflies and ants among the insects and other invertebrates. The soil biota is particular poorly known even though it includes incredibly important to the functioning of the forest ecosystem. There is probably a multitude of mycorrhizal species which provide important nutrients to tree species, perhaps as a multitude of species-specific relationships. What this means is that a vital aspect of Amazon forest function is tied to a set of species scarcely known to science.

Even for better known groups, there are often great gaps in our knowledge about them. For example, only in the last two or three decades have many of the bird songs been recorded and described. And only in the last year has the biology of molt – a central part of the life cycle -- in Amazon birds been recorded for Amazon birds, and it turns out to be quite different from molt in strongly seasonal temperate climates. To put that into perspective, when I was working on my dissertation research in the forests on the outskirts of Belem, there were no field guides or even English or local common names for most of the bird species – I basically had to make my own field guide by taking photographs of museum specimens.

So, the Amazon is basically a biodiversity treasure chest to be explored by science with all the benefits that may produce even if only dimly perceived at this point. To permit it to be degraded or largely destroyed would be equivalent to discarding the most important library for building the life sciences.

AV: So, what are the biggest threats to Amazon biodiversity?

Thomas Lovejoy: When I first set my foot in Brazil and the Amazon in 1965, it was basically a vast wilderness essentially the size of the 48 contiguous United States. It was about 3% deforested almost entirely near the rivers or the coast. The estimated population was about three million, much lower than it would have been in pre-Colombian times or when Francisco de Orellana descended the river from the equivalent of modern-day Ecuador.

Most of the deforestation was in the region of Belém to Bragança, in the State of Pará, which were connected by a still functioning narrow gage railway. The Brazilian government had launched a major side scanning radar survey of the Amazon and almost inadvertently had discovered Carajas a two-century world supply of high grade iron ore.

The Belém-Brasília highway had been constructed, and foreshadowing things to come, the spontaneous colonization along the highway was viewed as a surprise.

That highway was part of a larger vision for a Transamazonica highway system, seen as a means for Brazil to exert its presence in the vast Amazon – an understandable view but with no sense of some of the potential consequences. Some of the TransAmazonica has been built subsequently, and in most instances with the same spontaneous colonization and deforestation. Volkswagen bought a 1000 sq kilometer tract and deforested and burned it

Forest Fragments Project (1979). Thomas Lovejoy viewing forest cleared to make way for cattle pasture north of Manaus.
Credit: Forest Fragments Project (Personal archives).
Retrieved from [http://revistapesquisa.fapesp.br/en/2017/01/13/thomas-lovejoy-fifty-years-in-the-amazon-2/]

with a view to raising cattle. In the early 1980s, the World Bank and the Brazilian government developed a triad of integrated development projects for Rondonia.

It was quite well designed, focused on good soil areas (terra preta enriched over centuries if not millennia by the Amazon Indians), and included some strict conservation areas, and demarcation of indigenous areas. In fact, it was touted at the time as very progressive and forward looking. The spine of the three integrated projects was a construction of a highway.

The execution was nothing short of disastrous. The governor of Rondonia, in the early 1980s, kept advertising for settlers from the south of Brazil, a lot of the initial elements of the project which would have led to a more orderly process somehow were delayed. So, the project was overrun by settlement and deforestation in what is now known as the classic fishbone pattern ensued.

Unfortunately, the broad lesson was not recognized, namely that infrastructure projects can often, indeed most of the time, lead to unintended consequences and highway construction has led to a sprawl of deforestation and unsustainable development in the Arc of Deforestation in the southern and eastern Amazon, mostly in the states of Mato Grosso, Rondonia and Para. That is almost uniformly the case with one possible exception, namely the conservation areas created along the highway in the Tapajos region. That has been effective, but the presence of government and enforcement is thin and this strategy to buffer the impacts depends in the end of management and enforcement.

Similar impacts come from ill-designed hydropower projects. The conventional designs have blocked normal sediment flow, shortening both the effective lifespan of the dam while simultaneously depriving nutrients downstream. They also block the path of the migratory fishes with life histories that span the estuary to the headwaters. There is a serious need to modernize energy plans for the Amazon.

Conventional agriculture has also been a serious driver of Amazon deforestation spreading – almost sprawling – out from highways in vast areas of cattle ranching and soy beans. Much of the cattle raising is marginal and not a really productive use of the land; EMBRAPA has estimated that cattle production in the Amazon could be doubled using half the land. Industrial style and scale agriculture of soy has moved from the cerrado into the southern reaches of the Amazon forest. The current moratorium on buying soy from newly deforested land needs to remain as do similar efforts by slaughterhouses not to buy cattle from unsustainable sources.

It is important to recognize multiple efforts to address the deforestation problem. The Brazilian government has worked on enforcement but the strength of the effort ebbs and flows. There also has been an amazing commitment to creation of protected areas. About 25% of the Brazilian Amazon is in various forms of conservation areas and another 25% exists as demarcated indigenous areas (much of that funded by the G7 Pilot Program for the Brazilian rainforests with funds from Germany. A large number of the conservation areas were funded by the ARPA (Amazon Region Protected Area) program with funds from the World Bank and WWF. ARPA2 was created to assist the Brazilian government in the protection and management of these extensive new units of conservation. Now both Peru and Colombia are seeking to create similar programs. The Norwegian government provided a billion dollars to Brazil to create an Amazon Fund to help with the challenge.

AV: How climate change is impacting biodiversity?

Thomas Lovejoy: The third book on climate change and biodiversity (and the second with Lee Hannah) is about to be published by Yale University Press. The first appeared in 1992, at which point it was mostly about what might one understand from past impacts of climate change on biodiversity that could provide a glimpse of what might be the impacts of human caused climate change. By the time of the second, in 2005, the fingerprints of climate change could be discerned almost everywhere in the planet.

The current volume highlights major impacts: rising sea level, plants and animals changing the timing (phenology) of their annual cycles, and moving geographically to track their required climatic conditions, increasing ocean acidification, and a proliferation of decouplings in which two species or features that have been closely linked are disrupted because one party use daylength as a cue while the other uses temperature. The fingerprints of climate change are ubiquitous. One in tropical forests is that growth of lianas seems to be favored over rain forest trees.

More alarming is, we now understand, that there are serious limitations on what can be learned from climate modeling and vegetation modeling. However, well those might be done that cannot account for the idiosyncratic relationships between individual species like the coral animal and the alga, which is the basis for the entire coral reef ecosystem. Or similarly the relationship between native bark beetles of coniferous forests in North America, which warming has tipped in favor of the beetles (because more overwinter in milder winters, and there is opportunity for an additional generation). Massive tree mortality (up to 70% in some instances) is the consequence.

Our conclusion is that a world warmer than 1.5 degrees above pre-industrial conditions will be a world very hard to manage biologically. That in turn is essential to maintain human society. This represents a real crossroad in human history: do we choose sustainability or chaos?

This would seem to be an impossible and totally alarming challenge to human and biospheric sustainability. But while not really widely understood by the public, biological carbon plays a major role in emissions, and potentially can do similarly in providing an important contribution to the solution. In fact, the fossil fuels which are the largest source of the problem are actually nothing but remains of ancient ecosystems which trapped solar energy through photosynthesis years ago.

All life on earth is built of carbon so the biosphere is a major stock of carbon (and ecosystem destruction principally deforestation is roughly a 30% in gross terms of carbon emission) offset by reforestation and other ecosystem activities so it is only 10% a net contributor to annual emissions.

So, from a planetary (as well as Brazilian) point of view it is important for the carbon of the Amazon region to stay intact.

Globally very new figures reveal that the amount of carbon in the atmosphere from destruction and degradation of ecosystems is much larger than previously estimated. It is roughly 450-500 gigatons and roughly equal to what remain sin extant ecosystems.

What this means is that ecosystem restoration not just of forests – although they loom large in importance – but also of all ecosystems can literally pull significant amounts of carbon back out of the atmosphere with consequent reduction in global warming.

Forest Fragments Project (2014). Thomas Lovejoy in the north of Manaus teaching people to recognize a Cecropia leaf. Credit: Amazon Biodiversity Center. Retrieved from [https://www.amazonbiodiversitycenter.org/photos].

It is now abundantly clear that the planet works not just as a physical system but as a linked biological and physical system, and that it is imperative to manage it that way. Should that sound hopeless arrogant, that is only possible if we manage our own behavior. We inhabit a living planet and it is time to recognize that.

Jacques Marcovitch: Which are your views regarding the 2015 Paris Accord?

Thomas Lovejoy: The 2015 agreement in Paris on climate change was a landmark: a real international agreement – albeit voluntary – to start working to try and limit climate change to less than 2.0 degrees. That it was less than 2.0 was in large degree due to the efforts of small island states (of course very vulnerable to sea level rise). We now know it is equally important to limit climate change to no more than 1.5 degrees to have a biologically manageable base for civilization.

A major challenge is that the mechanism of the Paris Accord is through Nationally Determined Contributions (NDCs) and they are voluntary. That means of course the outcome will depend on what the individual nations actually do. It does not help that my own country has announced an intent to withdraw from the agreement (but the good news is that it is a long process that will only culminate in November 2020, and it looks like the efforts of individual US States, and cities and the business sector will actually mean the US will reach its committed goal).

My personal sense is that the signals and impacts of climate change (and not just sea level rise) will only become clearer and more imperative with time and that the reality and science deniers will be a shrinking minority.

I can only hope that the 2020 Climate Change Conference of the Parties will see an accelerating rate of commitment and aspiration which will among other things recognize that the future of the biosphere, the climate and humanity are inextricably interlinked.

JM: How cooperation among nations which share the Amazon Biome could support the Paris Accord?

Thomas Lovejoy: One of the big challenges of the Amazon is that it includes eight sovereign nations plus French Guyana (Guyane Francaise). Traditionally the Amazon Treaty Organization has not been particularly strong except for a year or two at the end of Fernando Henrique Cardoso's presidency when it was proactive on issues of sustainability.

Nonetheless, it is an existing instrument that could become very important in managing the Amazon as a system to secure the hydrological cycle (see next section). As a starting point, an Amazon fisheries agreement is a logic early step because many of the fish are not restricted to the waters of a single nation, and some like the great catfish actually swim the length of the Amazon in the course of their annual life cycles.

From the perspective of forest management and achieving the 2030 NDCs, there is a lot to be gained by sharing knowledge and capacity, as well as integrated approaches to enforcement. For example, the remote sensing capabilities of INPE as well as the remote sensing capacities of SIVAM could be of great value if they could be shared with other ACTO countries. Monitoring and enforcement through having real time relevant information could assist a control of various illegal activities like logging, drugs or wildlife trafficking.

In addition, there is potential for substantial inter Amazonian scientific activity such as the LBA project.

JM: What do you mean by the Amazon Biome tipping point?

Thomas Lovejoy: One of the insufficiently heralded research results was that of Eneas Salati, when he demonstrated unequivocally in the mid-1970s that the Amazon generated half of its own rainfall. Prior to that time the reigning wisdom was that vegetation is simply the consequence of climate and had no influence on it whatsoever. Salati's research shattered that dogma.

By studying the isotopic ratios of oxygen in rainwater from the Atlantic to the Peruvian border he showed that the water was recycled about five to six times as rain. This was driven by the complex surfaces of the rain forest promoting both evaporation as well as evapotranspiration. The rainforest was making some of its own rain through this hydrological cycle.

That raised the question early on: how much deforestation could cause the hydrological cycle to degrade to the point where the Amazon could no longer support rainforest – at least for a major portion of its extent. A student of my colleague Carlos Nobre made the first attempt to model this question and the initial conclusion was there could be a tipping point at somewhere between 30 and 40 % deforestation. It seemed comfortably far away.

In the ensuing years the signal of climate change became stronger. At one point one of the global climate models suggested a tipping point in the southern and eastern Amazon could lead to insufficient rainfall to support rain forest and conversion to savannah vegetation. With refinement, that model ceased to show that signal but it was based on the reality that those portions of the Amazon do have lower rainfall than the rest.

Also, in those years the occupation and deforestation of the Amazon in that same region advanced considerably. A lot of it was driven by small landers as well as some larger ones who were inexperienced with but nonetheless used fire extensively to clear and maintain their fields. The scale of the latter was such that in 1987 there literally was a smoke cloud as big as Brazil hanging over the Amazon.

Carlos Nobre and I grew to recognize that climate change, fire and deforestation were probably interacting synergistically. Weather events have become more extreme. If that was the case the tipping point would occur at a lesser extent of deforestation.

There were also historically unprecedented droughts in the Amazon (so extensive that some river communities could not be reached by boat) in 2005, 2010, and 2015/2016. We interpret these as first flickers of the tipping point and consider it wise to do so.

Our conclusion, which we published in Science Advances in February 2018, is that the Amazon Tipping Point is in the vicinity of 20-25% deforestation. We also strongly make the point that there is no point in discovering the precise tipping point by tipping it. So better to think 20%. It makes additional sense to put the brakes on further deforestation as firmly as possible, AND to build back a margin of safety by reforestation. That is in part because history is replete with examples of people going right up to some limit and then being surprised when some unanticipated factor flips them beyond the limit.

It is also important to recognize that Brazil's official figures of deforestation while excellent and solid data from INPA do not include data on forest degradation. Degraded forests will contribute less to the hydrological cycle so the "equivalent" deforestation rate from the point of view of the hydrological cycle is higher.

We also recognize that the Amazon hydrological cycle does more than maintain the Amazon rainforest and its extraordinary biodiversity. It is actually part of a continental climate system. We know that when the westward moving airmass encounters the Andes and rises until it drops the 20% of the world's river water that is the Amazon river system, that some moisture is deflected beyond the basin. Some goes as far as the La Plata basin and northern Argentina, and there is some contribution to rainfall in the Brazilian agricultural belt and urban reservoirs.

The real challenge here will be to get this recognized widely even by the short-term economic interests which have been chafing at various restraints. The vision of the Amazon as a system, and that it has to be managed as a system, needs to be universally embraced.

AV: Which are the main outcomes of the Forest Fragments Project?

Thomas Lovejoy: In the early 1970s habitat fragmentation had not been recognized as the major conservation issue it is currently recognized to be. That is mainly because the effects splay out over time and are not instantly obvious other than the habitat destruction that creates the fragment. Obviously, fragmentation was a problem if one thought about creatures that need large territories but there was not much awareness beyond that.

Starting in the late 1960s with the advent of the Theory of Island biogeography attempted to understand what drove different sized islands to have different numbers of species, it was probably inevitable that soon some scientists might wonder to what extent that might apply to islands of habitat created by human activity in habitat that had once been continuous.

A ferocious argument broke out in the scientific literature as to what was better: a single large reserve vs several more that would add up to the same area. Regardless of that probably never being a real-world choice, the debate raged as it is only possible in the lack of immediate direct evidence. My job was to advance projects to the board of World Wildlife Fund- United States and I realized until more was understood that there was no possibility to know whether any of those projects might be successful in the end.

Then the Monday before Christmas 1976 while meeting with one of the protagonists of the debate I suddenly wondered (out loud) whether the 50% that all projects in the Amazon were required to leave in forest (today that is 80% more in tune with maintenance of the hydrological cycle) might be arranged to provide for a giant experiment. We could study the forest before it was fragmented, follow the fragments thereafter, but also have comparable plots in continuous forest to distinguish general change from habitat induced change.

The National Science Foundation bought me an air ticket to Manaus and within an hour of meeting with then INPA Director Warwick Kerr, who passed away recently, I had the agreement in principle and by that afternoon agreement from SUFRAMA to do this is in the Zona Agropecuaria north of Manaus. The project started in 1979 and today is 39 years-old.

By 2003 we had the answer about size. Big was really more important than small. A 100-ha forest fragment loses half the bird species of the forest interior in less than 15 years. But that was the simple result. In the meantime, we have been studying complex changes which are likely to be occurring for decades in the future. For example, trees can be very long lived, and while one individual can live for a very long time in a fragment if there is no opportunity for reproduction it will eventually drop out.

The fragments project had depended on ranching interests to clear the forests around the fragments. Ranching was clearly a marginal activity and when certain subsidies were eliminated the ranching activity around our fragment largely ceased. Suddenly our fragments were no longer isolated. Was the experiment ruined? Our decision was no: we could maintain the isolation of the fragments ourselves, so we have re-isolated three times most recently in 2016.

In between we have been able to study vegetation succession in the "matrix around the fragments". Among other things we discovered two distinct pathways of regeneration. One we expected dominated initially by Cecropia – a classic tree fall pioneer within continuous forest. The other is dominated by Vismia in areas where fire had been used; it is toxic and reproduces vegetatively so is much less receptive of colonization.

At the start we were highly focused on the big vs small question but noted that almost instantly that the size of protected areas being created in the Brazilian Amazon were large. The Ministry of Environment in Brasilia had taken the topic seriously and was factoring it in to their decision making almost before we had results. The project was initially called the Minimum Critical Size of Ecosystems. Our sense is that to have a forest which will be representative of Amazon biodiversity essentially in perpetuity it should be at least 1000-square kilometers.

The technical publication list is now at around 750 publications. It is considered the most productive field station in the Amazon Andes region (along with Reserva Ducke) and most geographically influential tropical field site (in part because anybody who writes about fragmentation usually cites us). Equally important are the couple hundred Masters and PhDs the project has produced at least half of whom are Brazilian. It has also been a great place to take people to understand the forest: ranging in Brazil from the legendary Paulo Nogueira Neto to more recently Juliana Santiago who headed the Amazon Fund at BNDES.

I concluded a few years ago that the value of the exercise in scientific results and capacity building was such that it needed to be institutionalized so that it can continue beyond my involvement.

JM: Which are the best practices for investment to conserve and sustainably use biological diversity?

Thomas Lovejoy: I learned early on that whatever idea one might have going into a discussion it really pays to listen to the others first. It is an important way to demonstrate respect but also it is a way to gain new perspectives that can lead to a better solution.

In particular, when it comes to the Amazon there is abundant and very practical local knowledge. I continue to be amazed by the skills of the "mateiros" who work on the forest fragments project and can identify myriad kinds of trees or birds without any fancy formal education. When I was doing my dissertation field work in the forests outside Belem do Pará I caught a bird one day which was new to me. It also was gorgeous and so distinctive I banded and photographed it, and let it go. I could never identify it because as it turned out it had never been recorded with 500 km of Belem. Two years later Geraldo Pereira da Silva who assisted me in the field saw it again when another ornithologist caught it and immediately remembered it as the one I couldn't identify.

That is in one sense a parochial example, but it represents the great wealth of knowledge that ribeirinhos and others of the Amazon have about the place where they live. So, we need to think carefully before jumping to a conclusion about a solution. I think a lot of the problems of

The National Geographic Magazine (2015). Credit: The National Geographic
Retrieved from [https://news.nationalgeographic.com/2015/10/151015-qa-biologist-thomas-lovejoy/]

the Amazon have come from trying to impose out of the Amazon ideas without real thought. Just think of Fordlandia or the mistakes of Daniel Ludwig at Jari. Brazilian diplomat Marcos Azambuja understood that when he came to realize the environmental impact of a road is not so much the trivial one of construction but rather it is what follows.

Creative rather than conventional approaches can make a major difference, for example working with Shell and then subsequently Hunt Oil in the Camisea gas fields in the Peruvian Amazon (and the associated Trans-Andean pipeline). The Shell leadership really listened to the challenges about creating unintended access and the like. They invented an entirely new approach where the exploration phase was conducted without building a single road – everything came in by air or river.

Shell never took it to production, but Hunt was part of the consortium that did and once again I was involved. The wells were connected by pipelines buried and then revegetated on top. They had lots of sensors so if there was a problem, they could get to it instantly by helicopter – this was actually quite cheaper than maintaining right of way and avoided the problem of access to spontaneous colonization. This approach is now known as the Offshore-Inland approach and has been adopted by Urucu in the Brazilian Amazon. Later when I flew over Camisea all I could see were the original wellheads – just pinpricks in the rainforest. This should be required as national policy in all Amazon nations.

One of the real issues is that in any country the environment ministry is relatively weak relative to the finance ministry or financially powerful ones like the Ministry of Mines. Individual ministries can (but not necessarily) have a narrow sectoral view and it can be really challenging to work through the issues with a long list of ministries. The real key in the end may lie in the planning ministry because if it has knowledge and wisdom about sustainability more traction is possible within a government.

I have had a long history with the Inter-American Development Bank which I believe is one of the real leaders in sustainability. My first interactions were during the Presidency of Enrique Iglesias who understood environment having assisted Maurice Strong at the first UN Conference on the Environment in 1972 (Stockholm), but that understanding was not uniform within the institution. I think that was more a matter of the times. Today the IADB, while not perfect (after all our understanding of sustainability continues to deepen and evolve) is infused with a sustainability outlook and wonderfully open and willing to listen, learn and experiment.

Even though I am regarded as "green" I think that sustainable cities are part of the solution for the Amazon. And I am intrigued by Manaus not because it is an economic free zone, but because the majority of the industry is assembly using material that don't depend on the forest (computer boards, Harley Davidson motor cycles etc.). While not perfect what this means as Manaus economic productivity increases deforestation decreases. We need creative thinking like that and in the end, recognize there will not be a sustainable Amazon until there is an adequate quality of life in Amazon cities.

JM: Could you highlight some economic benefits from ecosystems and biodiversity regarding genetic resources?

Thomas Lovejoy: Starting at the basin and national level it is important to recognize the Amazon's contribution to the national and continental climate systems. While it may be hard to put an actual financial figure on that and whatever figure is derived will certainly be an under estimate, it nonetheless is worth the effort because it can some degree help to drive sustainable national and ACTO policies. Central to this should be protection of the amazing hydrological cycle.

Beyond that of course is the very large role the Amazon plays in the global carbon cycle and thus the global climate. This has been recognized for some time, and indeed is inherent in NDCs which include forest protection and reforestation. That is at the heart of the REDD (Reducing Emissions from Deforestation and Forest Degradation) concept and REDD+, which includes proactive reforestation. This still holds a lot of promise although the more successful efforts have been at the level of states (e.g. California) rather than entire nations (Costa Rica is a likely exception). This should lead to substantial economic flows.

Nonetheless to value the forests for their carbon is analogous to valuing computer chip for its silicon: important as it is, it is their lowest value. The greatest value is in the genetic resources, i.e. the biodiversity. Famously the greatest one to date is rubber, which has been undercut by plantation rubber elsewhere in the world (where natural enemies of rubber trees are absent) and synthetic rubber (although there are some uses for it which is inadequate, e.g., surgical tubing).

Whether rubber, Brazil nuts, quinine or acai, the value reaped is as a commodity. There clearly are others with that potential whether tambaqui, cupuacu, aquarium fish or valuable tropical timber and care must be taken to produce and harvest in a sustainable way - which has often not been the case.

The real power in the end of Amazon biodiversity lies in the multiplicity of adaptations to various biological challenges, in which individual species solutions to particular aspects of their life histories can prove to be of enormous benefit. An instructive example is how ACE (angiotensin converting enzyme) inhibitors can trace their origin to research at Butantan that discovered an unknown system of regulation of blood pressure, the angiotensin system,

which the venom of the bushmaster targets. Alas, because venom is not practical as a medicine, completely different molecules were devised by pharmaceutical chemists and the profits go to companies in on-Amazonian countries.

What this story suggests is that creation of a research institute to explore useful compounds and materials from the Amazon in partnership with industry so that useful products could generate economic activity in country.

The usual immediate first thought is to identify important pharmaceutical products. That is certainly worthwhile, but pharmaceuticals take a long time, usually many years before they in fact are deemed effective and safe for use. That means a long time before return on investment.

A more practical first concentration should be on compounds like natural fungicides and insecticides and other natural pesticides which require less elaborate testing than pharmaceuticals. They could substitute for synthetic molecules that so often turn out to have negative side effects like the chlorinated hydrocarbons (DDT and related compounds). An important shortcut to identifying prospective useful molecules was suggested to me once by George Milne then head of the Pfizer Research Laboratory who pointed out there could be an elevated discovery rate if an ecological screen was applied. An example would be the trees that leaf cutting ants avoid which enhances the probability of discovery of natural fungicides. (The ants use the pieces of leaves as mulch for an underground fungus farm and will have evolved avoidance of trees with natural fungicides).

The key in all of this will be to facilitate the research that leads to such important discoveries and to make whatever regulation is necessary user friendly. Brazil has made a real effort due to the leadership of Braulio Dias to improve scientific access to genetic resources. I would not be surprised if there is still need to make the system more researcher friendly than it currently is just because of an abundance of caution and the usual nightmare of IT systems that are less than user friendly (something we all encounter almost on a daily basis).

JM: How to Improve the capacity of local communities to pursue sustainable livelihood opportunities?

Thomas Lovejoy: One of the keys to success for sustainable livelihoods is to empower the local communities by given them most of the necessary control. Amazon fishing communities generally are very successful when they can manage their own fish stocks and avoid predatory harvesting by non-local fishing interests. The Mamiraua Sustainable Development Reserve is a stunning example. Once the community was able to manage its own fishery resources and fend off itinerant exploitive fishing the stocks of pirarucu recovered quickly and produce an impressive healthy harvest.

Another interesting example is the Rio Negro Sustainable Development Reserve where the population is fairly dispersed through the reserve harvest fish and other forest products. The leadership promotes sustainable practices and at the village of Tumbira there are both health and educational facilities connect by broad band to the outer world.
Children come from different parts of the reserve for two weeks at a time for schooling in an analog to a boarding school and some of their lessons are conducted by teacher through the internet. Similarly, the clinic can consult by broad band connection with doctors and medical facilities in Manaus, and in certain instances send the patient to a Manaus hospital.

The most interesting thing about this sustainable development reserve is the broad band has not led to a big exodus to the bright lights of Manaus.

The Brazilian Amazon has a major potential in ecotourism, which for some reason is quite poorly developed compared to the Peruvian Amazon despite it being immensely larger. Most tourists fly in to Manaus and do a day trip to the meeting of the waters. There are ecolodges and fishing camps, but it is not easy (with a couple of significant exceptions) to get a really rich biodiversity experience even though the flora and fauna is right there. Most guides have a pretty superficial and sometimes even inaccurate knowledge. Interestingly birdwatching has exploded in Brazil so there is no reason it can't become important in the Amazon. I recently had the experience of being on a boat at dawn in the Solimoes as river level was dropping, islands beginning to emerge as a consequence. and flocks of birds in attendance just waiting for the chance to use the islands for nesting. That is a great example – and just one of many - of a largely overlooked spectacular nature viewing opportunity.

The mystery and magic of the Amazon together with its staggering biodiversity has the capacity to build a major ecotourism industry complete with trail systems and the like, to be complemented by visits to local communities which can share their knowledge and culture in quite charming ways. I of course have had multiple experiences visiting Amazon communities, appreciating the wisdom and intelligence with which they have developed their systems.

While there already is some handicraft work available it is neither easy to access or always of great quality. Perhaps some cooperatives could be developed to assist in that. In the market in the capital of Madagascar one can buy (or commission) table cloths with exquisite stitching of local fauna and flora (lemurs and travelers palms in that case). It is easy to imagine equivalents with giant water lilies, birds and monkeys and more. Those might be best marketed in major cities but can be sourced from local communities which could take it to scale.

JM: Then, ecosystem and biodiversity values should be integrated into national/local planning and development processes?

Thomas Lovejoy: This is a very important question especially because it is not likely to happen – at least not easily – without explicit engagement by those who care and are knowledgeable. It is all too easy for ecosystem and biodiversity values to be left out, and it is particularly risky when it involves a region that needs to be managed as a system and is also so biologically rich. Science must be at the table.

These values have to be included at the various levels of government: national state and municipal in an integrated fashion. While at the federal level certain ministries will be the most knowledgeable, they are not necessarily the most powerful. That is likely to be mirrored at the state and municipal level with the important caution that very often as one goes to such levels the overall capacity and knowledge with respect to ecosystem and biodiversity values may often diminish and be quite weak.

Consequently, the role of civil society organizations to speak up for these values is essential. Having been in government, I know how annoying, impatient and seemingly near-sighted civil society organizations can often be. Nonetheless they have a role which is to be respected, mainly to be a voice for voiceless biodiversity and nature.

JM: To conclude, which message would you like to convey to new generations?

Thomas Lovejoy: I like to say one of the amazing things about growing up is that grown up jobs sometimes come your way – if only because there is nobody else to give them to. But that trivializes the important intergenerational partnership involved in science and conservation.

One of the things I drill into my students is to understand the origins of science and conservation, so they understand where they came from and avoid the trap of repeating a mistake or proving something already proven. The longer perspective is really valuable in being able to learn from the past and to avoid repeating mistakes. That doesn't mean of course that understanding of a topic can change with time and sometimes dramatically as recognizing the earlier rejected continental drift.

Most important do not refrain from disagreement or questioning something generally taken as a given. Also, be careful to really listen and try and understand the basis for somebody else's statements.

In addition, when writing an academic paper, realize that somebody other than an academic could read it and easily come to a mistaken policy conclusion. Make sure to state clearly what the policy implications are in a way that supports thoughtful conservation.

More than anything, remember that you can make a difference not only academically if you are an academic but also in whatever profession you may be. My generation is leaving you an Amazon very different from the one we encountered: a lot of that is good but obviously there has been considerable and unfortunate destruction. The job of attaining a sustainable Amazon replete with amazing ecosystems and the world's largest concentration of terrestrial biodiversity is hardly finished: it needs you.