Costa Rica - to become a bioliterate tropical country:

Project: "Bioliteracy for all: BIOALFA". Derived from “BioAlfabetización para todos”

Costa Rica’s natural heritage is one million-plus species of wild multicellular organisms. It is 4% of the world’s. They live everywhere, but are concentrated in the 25% that is natural forest. To incorporate and integrate these species and their ecosystems into Costa Rica’s socio-economic fabric, and therefore sustain them into perpetuity, we need to come to intensively know who they are, where they live, what they do, how to find them, and freely distribute this information to all society. With this web-based biodiversity encyclopedia, a bioliterate society has diverse opportunities to non-damagingly use this enormous national resource and minimize its footprints on it. Bioliteracy is to know the natural capital of the country and use it without damage. This is learning to read and write in first grade, but reading the wild instead of books and adverts. The literate person uses literacy for both personal and village life. National bioliteracy is the goal here, while also making Costa Rica into a global example.

For centuries, Costa Rica and the international community have been knowing and using bits of its wild resource, irregularly, in fragments, and without a national strategy. They have followed traditional routes – academic, scientist, commercial, aesthetic, curious, regulatory, and conservationist. In large part, this disorder and little use at the species level was due to the absence of two modern technologies that we now have. First, now there is the internet and the power of computerization; with them we accumulate/order/disseminate information about wild biodiversity and connect it to other activities. Second, more recently available, we have "DNA barcoding" of a species to know who it is. We extract its species-distinctive DNA signature, AKA its “DNA barcode”. This is analogous to the barcode on a can of tuna in the supermarket. The DNA barcode, extracted from the genome in the laboratory or by your personal cheap and reusable pocket barcorder (on the near horizon), is wifi-compared to a barcode reference encyclopedia. With a name and Google, you have access to all humanity digitally knows about your species, including being able to add what YOU know about it.

To "DNA barcode Costa Rica", the steps are logical, visible and possible. These steps already have 37 years of "proof of concept" conducted by Area de Conservación Guanacaste (ACG) in northwestern Costa Rica (www.acguanacaste.ac.cr). ACG began conserving its abundant and diverse biodiversity by expanding its area, restoring its ecosystems, incorporating its neighbors into its’ mind-set, and in 1978, intensively starting the inventory of its biodiversity in coordination with the national and international scientific community. Today we estimate it contains as many as 65% of Costa Rica’s 1 million species in its 1,250 km2 of land (2% of the country). The dissemination of this biodiversity information progresses "traditionally" through its Biological Education Program for school children (www.acguanacaste.ac.cr/educacion/programa-de-educacion-biologica), scientific publications, ecotourist visits, and the Internet. However, until 2003 the process was impeded by the very slow traditions of identification and discovery of species by their visible traits, as has been done for centuries (and as is still the case today, along with the rest of the scientific tropical world).

In 2003 Professor Paul Hebert of the Centre for Biodiversity Genomics (CBG) of the University of Guelph, Canada (http://biodiversitygenomics.net) introduced Costa Rica to the new concept of extracting ("reading") a small 600-650 base pair fragment of the COI gene. He found that each animal species has a different DNA barcode (for plant and fungus species we use three other shorter pieces of DNA). With the rapid advances in sequencing genomes, it is now easy to do this "reading" in bulk or individually, and cheaply, with thousands of individuals in the laboratory of the CBG by NGS (Next Generation Sequencing) or by standard PCR ("Sanger Sequencing" or SEQUEL). Equally, today the ability for a person to do it in the field is emerging with the MinION sequencer (nanoporetech.com/products/minion), *if* there is a Costa Rican barcode encyclopedia for comparison. Paul Hebert's CBG is not a commercial company, but is a global academic research project in the University of Guelph, in the same mode as facilitating the existence of ACG and tropical wild biodiversity is a kind of academic research project by Daniel Janzen and Winnie Hallwachs at the University of Pennsylvania.

The first step in barcoding Costa Rica is to organize and execute a strong collecting effort for the specimens from which the first DNA barcodes will be extracted, to initiate the library of identified barcodes. We can start with three uncomplicated steps. We take advantage of what are now in collections (for example, the 43,000 species of 450,000 individuals of ACG insects that are already barcoded by the CBG, or the 30,000+ classically identified species of insects now in the national collection built 1989-2015 by INBio). Second, we do a first sweep of the country by enlisting the human and institutional resources to conduct easy "Malaise trapping" at almost no cost to them (by national parks and equivalents, ICE facilities, schools, ecotourism lodges, farms in the margin of wild areas, PES receivers, university students). Third, we coordinate the currently on-going projects to barcode the plants and vertebrates of Costa Rica. It is straightforward for CBG to process all these specimens and data into the public database and app BOLD (http://www.boldsystems.org), if there is budget for the laboratory costs and government permission. Starting this in 2019 will give an enormous array of experiences, data, and initial opportunities to build a platform for the biodevelopment of Costa Rica's wild.

The experience and biopolitical will exists today to start the process (which formally started on November 14, 2017 with MINAE Decree #40725). What is lacking is to raise international funds for the budget (a process that has already been started in 2017-2018 with the support of Costa Rica's Ambassador to the United States, Román Macaya and the former Minister of MINAE, Edgar Gutierrez, and is continuing now by GDFCF/ACG in collaboration with the current Minister of MINAE, Carlos Manuel Rodriguez). What is also lacking is an institutional "home" for the project in San José, a home that has the solidarity of the government and the flexibility of an NGO, while being strongly dedicated to the non-damaging biodevelopment of the biodiversity of Costa Rica (as is the case of the Guanacaste Dry Forest Conservation Fund (www.gdfcf.org), an NGO that is 100% dedicated to ACG). There still needs to be a quite public workshop in San Jose (January-February 2019) where the philosophy, logistics, and mechanics are exposed to the full public, so as to understand the goal of bioliteracy for everyone as part of the socio-economic fabric of a very green Costa Rica.

Cost? We estimate a cost of $100 million from international sources spread over 10 years. Of this, 50% is to conduct the direct work of collecting, processing, laboratory processing of 20 million samples, and putting the basic barcode data and its collateral on the web in CBG's public BOLD global database (http://www.boldsystems.org), as well as in any other public database that is scientifically coordinated with the world's understanding of global biodiversity. 25% is to stimulate and facilitate the users from any sector of Costa Rican society to take advantage of this ability and opportunity to read wild biodiversity. And 25% will be dedicated to an untouchable trust fund that will annually generate income for BioAlfa to continue as a process into perpetuity. BioAlfa is meant to be biosustainable financially, after its start-up costs, as well as biologically - let the capital live in peace, and eat only investment income. The dollar budget will need to be largely from international appreciators. It will be heavily subsidized by human resources and sweat equity from Costa Rica. These will service biodiversity capture and processes. Its political enthusiasm will be derived from being the first tropical country to know and divulge its biodiversity to itself and the world, and by the many scientific, agricultural, regulatory, and medical contributions that will be accessible because of the barcode library. It will even turn Costa Rica into a giant mine canary in the face of climate change, a biothermometer, for the tropical world and for its own internal adjustments.

Some examples?

Climate change: with the first 2019 rapid map of hundreds of thousands of species and where they are in Costa Rica, and continued sampling in the coming years, the country converts into a huge "mine canary" (national biothermometer) for the biological metrics of climate change - who moves and where, who survives, who dies -- in relation to ecosystems, elevations, towns, agriculture, seasons, rainfall, wind, etc. Such a biomonitor serves the private sector and institutions for their planning and acceptance of climate reality – while prognosticating for other tropical countries as they wish.

Payments for Environmental Services (PES): in addition to compensating forest owners for the national public value of water, carbon, landscape, and other services of a "forest", an individual biomonitor (a Malaise trap and other capturing devices) can cheaply measure the biodiversity of a Costa Rican forest or waterway and thus adjust the PES to this measure.

Prospecting for biodiversity: the vast majority of the commercial and medical uses of wild biodiversity (market, permits, technology, competition, treatments) depend largely on knowing the species in hand or sampled, for predictions and for accurate re-sampling. Within a barcoded country, any aspect of bioprospecting – genomic or chemical - will be much easier scientifically and contract-wise: barcode no value, genome much potential value.

Ecotourism: today, Costa Rica offers little more than a peaceful bed, breakfast, light physical adventure, green background, and sun on the beach. The 25% wild areas are huge books and green libraries almost unknown and almost unread. The $4 billion earned annually by the peace and green of Costa Rica could be much more if its biodiversity were also biodeveloped into its intellectual patterns and natural history without destroying it. But this largely requires knowing

it and giving visitors the power to read and understand it. Barcoding is akin to teaching the tourist to read the forest like a newspaper, novel, or instruction manual. The almost-here personal cheap reusable barcorder is required for the ecotourist but also needed is a barcode language and vocabulary. BioAlfa builds that. A library is merely stacked firewood if you are illiterate. Within a few years, every tourist will have a barcorder and want to use it. This demands a national as well as international barcode library.

Education - schools to universities: wild nature is a huge puzzle that can be studied, appreciated, enjoyed, experienced, disseminated, and dissected by the students of any grade. The human is fascinated with *Homo sapiens* but in that fascination, the millions of lessons on life offered by wild nature are being ignored. Today, the country recognizes the existence of the natural library in its national parks by protecting them, but the door is largely only open to specialists, guides and guards. And even they can only poorly read or inspect shelves filled with books, when they lack visible titles and a given book is impossible to locate.

Agriculture: it is well understood that many wild species can damage (and pollinate) today and tomorrow's crops. But from the frontier farmer to massive agribusiness, the actions are quite blind with respect to species of pests, application of pesticides, biological control, dates of harvest, storage, transport, sales and crop species. With a personal barcorder in the farmer's pocket, connected to the internet to give back what is known about a species name (a.k.a. barcode), anyone in the field or laboratory can know who they are dealing with, if the country has been barcoded. It is worth underlining that all Costa Rican pests and pollinators also occur in the wild world. Barcoding the wild and agroscape will give agriculture a huge and specific computerization capacity, bringing much of the fuzz into much sharper focus.

Medicine: insects and other arthropods are famous as the transmitters of various tropical diseases. These species occur in Costa Rica, and more are likely to invade and move with climate changes. With the biodiversity of Costa Rica mapped, it would be possible to follow many of these species in detail, and in relation to climate change, deforestation, urbanization, and forest restoration. With a barcode we can also biomonitor the organisms that cause diseases as well as their vectors.

Biomonitoring industrial disturbances: Every act of industrialization (deforestation of any kind, agriculture, geothermal energy, infrastructure, roads, change of land use), etc., will "disturb" the biodiversity and its ecosystem of the site. Some disturbance is trivial from some viewpoints, some disturbance is restorable by nature, and some disturbance is inevitable "damage" or "change" that always accompanies human activity. Some disturbance is acceptable, taking everything into balance. Costa Rica's nature will never return to the year 1400 AD or 2000 BC. The art and science lies in how to simultaneously protect and take advantage of the biodiversity and ecosystems of wild areas that society is willing to "protect". With the biodiversity of a country being barcoded, and all that this implies in information and its distribution, it is possible to a much greater degree to quantify the amount and extent of disturbance, and know or predict how it will continue in the future, as well as recognize invisible analogs. For example, a geothermal platform is analogous to a landslide and a riverbank if one understands its impact

on biodiversity at the level of causing changes of the community of tens of thousands of species near and far from the disturbance - Malaise traps are biomonitors. Then, the question resolves to be how many platforms and their access roads, specifically where to allow them, and how to mitigate their perturbation? Such micropositioning and microevaluating is impossible to achieve with data and methods pre-2003.

In summary, a country being barcoded is beginning to know what it has in its natural capital. By knowing the species, what they do, and the ecosystems they occupy, the country and individuals can then plan and make use of wild nature without destroying it -- by taking the details into account. It's like a doctor in an emergency room. The patient is examined, what happened known, previous condition evaluated, and a treatment dictated by the time the technology available at the moment; one protocol does not fit all patients. Costa Rica has done many good and admirable things in keeping its protected wild areas, but it is very ignorant of, and has used little of, the wild that its society protects. It is behaving like a bank that has all its resources tucked away in the vault, guarded at the door with guns and sequestering legislation written decades ago with ancient viewpoints. In 2018, how many more years will such a bank survive? Since 2003, the ACG, with much support from the people of Guanacaste, INBio, MINAE, MN, CONAGEBIO, GDFCF, CBG, the international scientific world, and friendly other governments, has shown that everything discussed above is feasible and possible if there is adequate budget and political permission. ACG has been a pilot project for Costa Rica and other countries, and has every intention to remain so. But it is clear that for ACG's survival, it has to be quite integrated with the same national process and attitude that initially allowed it to germinate and grow in 1985. Costa Rica also has become a semi-model or example for other tropical countries and their large expanses of wild species and ecosystems.

It needs emphasis that 5.6 million bioliterate people will be much more adept, at both the personal and institutional level, at dealing with the big challenges as well as opportunities that the globe creates – climate change, overpopulation, immigration, epidemics, crop failures, racism, classism, education, erosion, pollution, globalization, and all their mutants. Bioilliterate people are easier to fool and manipulate with gossip and public pronouncements. It is like learning to read and write. Cheap in first grade, enormously valuable as you and your institutions move through whatever life you choose or happens to you – doctor, lawyer or candlestick maker.

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