Understanding Whole Systems

All Species Inventory

By Kevin Kelly Whole Earth Fall 2000

If we discovered life on another planet, the first thing we would do is conduct a systematic inventory of that planet's life. This is something we have never done on our home planet.

The aim of the All Species Inventory is simple: within the span of our own generation, record and genetically sample every living species of life on Earth.

This audacious goal will be accomplished by using one billion or more dollars of philanthropic wealth to fund and train a network of local collectors and naturalists throughout the world, and to employ the latest in information technology to manage this surge of bio-information.

What we will get from the All Species Inventory:

1. It will give us, for the first time, a complete list of "who is here," the roster of our fellow inhabitants.
2. It will provide a reliable baseline for counting populations and determining endangered species.
3. It will form the foundation for developing a complete genome of all life, and a new understanding of nature.
4. It will uncover multitudes of new species, many of which will have immediate cultural and economic impacts.
5. It will train many people as naturalists and scientists, who can leverage these skills further in their own lives and that of society.
6. It will distribute wealth from the developed world to far corners of the Earth by employing indigenous and native observers and collectors.

At the present time, scientific estimates of the number of living species on Earth, including microbes, range from 1.4 million to 200 million. This laughable range means we are simply clueless about the number, let alone types, of living creatures on Earth. Here is biologist E.O. Wilson on our deep ignorance of life on Earth:

"In the realm of physical measurement, evolutionary biology is far behind the rest of the natural sciences. Certain numbers are crucial to our ordinary understanding of the universe. What is the mean diameter of the earth? It is 12,742 kilometers (7,913 miles). How many stars are there in the Milky Way, an ordinary spiral galaxy? Approximately 1011, 100 billion. How many genes are there in a small virus? There are 10 (in ϕX174 phage). What is the mass of an electron? It is 9.1×10^{-28} grams. And how many species of organisms are there on Earth? We don't know, not even to the nearest order of magnitude".

For several centuries naturalists have relentlessly explored Earth's wilds to catalog the incredible variety of species (both living and extinct). Each year their collective work takes us a few small steps closer toward the implicit goal of recording all species on Earth. In the last decade taxonomists have proposed a number of programs to accelerate this natural process, and to incrementally expand the scale of inventories around the world. The All Species Inventory builds upon these earlier proposals but with the additional—and crucial—explicit goal: to catalog ALL living creatures within the time span of one human generation (twenty-five years).

"All" is the crucial term. The difference between "many" and "all" is the difference between, say, a local public library and the universal library of all documents and texts. Knowledge crosses a threshold when it goes from "most" to "all." Geography crossed the threshold when it went from knowing a lot of the world to creating a globe with all continents in rough form; anatomy crossed the threshold once it produced a diagram of all the bones, all tissues, and all organs in a human body.

"Imagine doing chemistry knowing only one third of the periodic table," says biologist Terry Gosliner. Sure, it can be done, but with an immense handicap. We are trying to do biology knowing perhaps only a tenth, or one hundredth, of our species. It is an immense handicap that does not need to exist.

Fixing the crucial figure of all species on Earth, and drawing up the list of all life, would enrich and enable the following fields of knowledge:

1. Natural History: The identification of a species triggers a whole field of inquiries into that species. What isn't named won't get attention. Cataloging each species is the best thing in the world to do for every living thing in the world.

2. Conservation: While the concept of focusing limited conservation resources on a few species-rich hot spots is probably wise, there is no definitive way to assess hot spots (are those spots really hot? are they really where we think they are?) unless we have an all species inventory first. Biocensus tallies can only follow inventory counts.
3. Ecology: The web of interactions between organisms and their environments, including other organisms, is woefully incomplete in every case if we cannot even list the other organisms in each environment. Ecologists are working with two cards out of the full pack.
4. Evolutionary and Molecular Biology: A full understanding of evolution at the genetic level will require the full outline of genetic innovation provided by all species. Many insights in molecular evolution will depend on a snapshot of the entire range of genomic life, much as progress in deciphering human genetics required the sequencing of the entire human genome.
5. Biologic Wealth: The commercial benefit of discovering millions of new species is staggering, based only (to begin with) on the pharmacological and biotech billions made from the few species we have already identified.

But why set a goal to accomplish this within one generation, and why now?

Because technology is making the inventory of all species both possible and urgent.

The following innovations make it thinkable to catalog all species:

Foggers for arboreal insect species

Remote viewers and trawlers for deep-sea species

Cheap electron scanning microscopes for insect identification

Transmission light microscopes and microvideofor protoctists

GPS for reliable location determination

Hyperlinked keys for quicker identification

Online databases for access to museum and herberium collections

DNA samplers for unculturable bacteria

World Wide Web for globalocal bioinformatics

However, the most important technologies for this project haven't been invented yet. Furthermore there is a self-accelerating nature to technology in this realm: the faster/cheaper that technology fosters new species discovery and description, the more attractive it makes further innovations, compounding the discovery rate. Also, a global-scale effort to catalog all species self-amplifies discovery. Plant hunters, for instance, can uncover new insect, fungus, nematode, and mite species dependent on those plants, or vice versa, accelerating discovery. This means that the normal glacial pace and cost of species discovery could be shortened by many degrees fairly quickly. E.O. Wilson estimated that employing the traditional methods of long academic training, slow publishing, and no new technology, a full-scale inventory of life on earth could be accomplished in fifty years. New technologies for training, publishing, probing, and identification could certainly shorten the duration to twenty-five years, or one generation.

But this same technology, disguised as consumer technology, is accelerating the pressure on species habitat. The next fifty years will be a bottleneck where inflating human population and development will press against shrinking natural habitat. (After fifty years, declining world population and better technology will probably relieve this pressure.) The result of this near-term conflict will be the loss of species. Estimates of the loss range from 10 percent to 25 percent of all species. Taking a liberal guess of the number of species actually on Earth and the most benign-case scenario of human impact in the next fifty years, the total loss still tallies up to millions.

In other words, sooner or later we'll accumulate the list of all species if we let science proceed incrementally. But even in a best-case scenario, if we wait another generation to compile an All Species Inventory, we'll come up with a final list that is several millions shorter than if we do it now.

But making a list does not save the entries. While an all species inventory is the foundation for protecting endangered species (and must be), it is important to distinguish these two endeavors. The All Species Inventory is not a census nor a complete geographical distribution map. It counts a species with a population of one the same as one with a population of one million. This is a roster, an elemental list of all life, an inventory of all the parts.

As simple as it is to state the goal of this project—to make life's list— there are many extremely difficult challenges to overcome. These include: the ever-slippery issue of deciding which varieties are species or subspecies or mere variants, and overcoming the sheer physical hurdles of surveying the Big Remaining Primeval Vastness: the Congo, the Amazon, the Deep Oceans, the Coral Reefs, Soil and Benthic Sediments, and Islands (oceanic and continental).

Most challenging of all will be dealing with the intellectual property issues such a large-scale effort will birth. How shall ownership, credit, and reward be divvied up among native residents, governments, collectors, backers, hosts, commercializers, and the global public? While the taxonomic and systematics community has evolved methods that work in many cases, it is not clear that these ways will scale up or withstand new technologies. The more successful this project is, the more visible the issues will be, and the more complex the solutions.

The wealth ultimately generated by this project will likely be staggering—new drugs and materials, better understanding, restoration, and management of ecological systems, higher quality of life due to attention to our natural capital, and (this is a hunch) appropriate genetic manipulation—from insights derived from a full genome of all life. (Eventually, though, in more than twenty-five years, every "species" will be genetically sequenced; the more species sequenced the fuller and better the picture.)

But because this project will take at least two decades to pay off, it is unappealing to crass commercial economics. For that reason, it is an ideal project for the immense wealth being generated by digital technology in this generation. This wealth, created by imaginative individuals, is looking for imaginative ways to leverage the world. The All Species Inventory meets almost all the criteria of a lean, cascading good deed. It is truly global, fast (for natural history), deep, nature-based, technology-savvy, and entirely doable. And it feels good.

The All Species Inventory is a grand scheme. Self-made wealth is both intrigued and leery of grand schemes. The attraction of grand schemes is that they can be mythic. They connect with the spirit. They touch a lot of people. They can change viewpoints and thereby change the world. The All Species Inventory can do all that.

The caution about grand schemes is that their elaborate infrastructures can internally consume most of the available resources, so that the final result is decimated by the actual everyday operations trying to put the scheme into effect. In the end grand schemes are often not funded because they are grand, and incremental utility is funded instead.

The All Species Inventory is worth funding because it is both urgent and important, and because it can combine incremental utility and mythic depth. It can be big but lean. It will be result oriented (the more species the more successful) but grand (ALL species).

This project can be accomplished in a very decentralized manner. It may be a paragon of globally decentralized work of any type. The inventory actually benefits from the redundancy natural in such decentralized efforts. Most of the collecting, preliminary sorting work, and an increasing volume of taxonomic naming, will take place in small corners of the world, thus spreading the work to a diverse group of nationalities and biomes. Most of middle management can be accomplished by Linux servers. Most of the money poured into the project will make its way to collectors and naturalists far from the source of that money, and often in places where precious little other money flows in. Lastly, the many students, or indigenous naturalists, or lonely local experts put to work by this project would come away with both traditional taxonomic skills (now rapidly disappearing from science) and other marketable new skills of managing global databases and information flows.

Here is a challenge to anyone hoping to leave his or her mark in a big way. Can you imagine a project other than All Species Inventory with a larger global impact (more countries touched), that would consume less internal resources, require less staff, generate more scientific knowledge and more commercial products, serve the beleaguered environment more, further increase appreciation of Earth as much, and do a better job of satisfying our longing to do something bigger than ourselves?

Write us if you do.

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