FIVE

Interspecies Money

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The market economy has failed to price natural capital correctly. One result is a threat of mass extinction of other species. A novel central bank is proposed in response. The Bank for Other Species—or Banque pour d'autres espèces—will issue a central bank digital currency capable of accurately disbursing billions of dollars equivalent yearly to nonhuman life-forms (or their digital twins). Before 2030, "interspecies money" issued by the bank and held by nonhumans will be a significant financier of conservation. Because the poorest countries have the richest biodiversity, and because other species will pay local communities for services that improve their life outcomes, it is likely that interspecies money will help reduce extreme poverty. It may also turn the evolution of artificial intelligence toward nature. Machine interfaces can better represent other species to us, and interspecies money will, for the first time, provide a means of paying for perpetual data acquisition in the wild. Applying deep learning, GOFAI, global planning, and game theoretic models to data gathered by communities and scientists will soon make it possible to share information across the species divide. With information comes digital identity and a nonlinear leap to interspecies money.

Dum taxat, rerum magnarum parva potest res
exemplare dare et vestigia notitiae.
So far as it goes, a small thing may give an analogy of
great things, and show the tracks of knowledge.
— Lucretius

Why Do We Need Interspecies Money?

The biggest threat to diverse biological life on Earth is the failure of the market economy to correctly price natural capital.[1] The only value most nonhuman life-forms have is the value of their processed body parts. If money is memory,[2] it certainly holds no memory of the 8 million other species with whom humans coinhabit the planet. They have left no trace on the market economy, precisely because no money has ever been assigned to them or held by them. This paper proposes empowering wild animals, trees, birds, insects, and microbial colonies by enabling them (or their digital twins) to hold digital currency in a secure and divisible way, such that there will be a money memory of them and a correct weighting of their preferences in the continuance of life into the next centuries.

It makes no sense that the market economy puts money into ores, promissory notes, and blocks of computer code, but not into the continuance of rare, complex, and ancient biological life (regardless of how difficult this is). This paper outlines the urgent need for a novel central bank mandated to issue a central bank digital currency that can be held by nonhuman life-forms: in other words, an interspecies money. The Bank for Other Species—or Banque pour d'autre espèces—will mint a digital-only currency provisionally named the "life mark," after the Deutsche mark, which regenerated postwar West Germany. Before 2030, the equivalent of many billions of dollars will be held in life marks (also LM or L-mark). Interspecies money will be a primary financier of conservation in the pantropics and the largest means of payment for the acquisition of data in the wild, including through various devices. Other species will spend their LM on services that increase their chances of survival; they will also lend and invest LM to and in local communities. LM will be a direct liability on the Bank for Other Species with the transparency, trust, stability, legal standing, and finality of cash. Because LM is computational, the monetary and ecological rules guiding it will be embedded into it; it will be divisible to allow for an accurate direction of small payments across borders at unprecedented scale.

Interspecies money is a science breakthrough only in its combinatorial aspects: the technologies needed to begin building the first version of the life mark are already widely available and in use. And it is arriving at the moment of its greatest need. Some might even argue that the living system (Gaia or otherwise) is producing the tools it needs for its own continuance.

We are at a tipping point in our evolutionary history. Other species occupy

1. Dasgupta; Claes and others, Mission Économie de la Biodiversité, World Economic Forum, Network for Greening the Financial System (2021). Nature Editorial Board.

2. Kocherlakota.

a peripheral place in our consciousness. We seldom think about their needs, or how they move through the world. This will change. Over the next decade, we will begin to think about nonhumans in new ways and develop a new ethics and economics that takes better account of them. They will not be persons to us, but neither will they any longer be *things*.

The 2020s will be the most consequential decade for nonhuman life in recorded history. We are facing, in our lifetimes, a sixth mass extinction event in the last 500 million years.[3] There are half as many wild animals alive today as there were in 1970. The biomass of chickens exceeds that of all wild birds. The biomass of humans and livestock is twenty-five times that of all wild animals.[4] Tens of thousands of species are at threat of total or local extinction. As habitats are lost or cut up, the extinction rate rises: loss leads to more loss. The human footprint in ploughing, grazing, felling, in pollution and diminution of all kinds will continue to grow, given the growing human population and increased investment in meat production and monocultures.[5] This will happen regardless of whether the planet continues to warm and be subject to catastrophic weather events. Scientists are unequivocal: we are destroying the fabric of life out of which we emerged and which, in numberless ways, we are dependent upon. Interventions need to be audacious, rapid, and substantial.

In order to maximize biodiversity, scientists and governments are seeking to "fully protect 30 percent of the Earth's surface by 2030" and to sustainably manage another 20 percent.[6] This paper addresses one part of this challenge: how to create a payment system that can substantially improve human-nonhuman cohabitation at the edge of the forests, grasslands, and wetlands of the pantropics that constitute the frontline of the Anthropocene.

Better cohabitation will only happen if it is accompanied by improved life outcomes for humans. In particular, the poor and landless must benefit from the continuance of complex life-forms that live beside and among them. The biodiversity hotspots scientists would most like to protect in Africa, Asia, and Latin

3. It is the threat of mass extinction that makes Interspecies Money a reasonable and important approach. The science is clear and grim, even though it does not yet account for most nonhuman species or for the potential cascade effects of climate change. See, for example, Ceballos, Ehrlich, and Raven; Barnosky; Kolbert; World Wildlife Foundation (WWF); Beach, Luzzadder-Beach, Dunning; Ceballos, Ehrlich, and Ehrlich; De Vos, Joppa, Gittleman, and others; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). International Union for Conservation of Nature (IUCN); Pimm and others.

4. For a new perspective of one's place on this planet, see Bar-On, Phillips, and Milo.

5. Barrett and others; Yamaguchi; Wackernagel, Lin, Evans, and others.

6. Waldron, Adams, and others; Lovejoy and Hannah; Conservation is moving closer to the Harvard biologist Edward O. Wilson's half-Earth ambition of setting aside 50 pecent of the planetary surface for nature. For context, see Wilson (1984) and Wilson (2002).

America are beset by increasing insecurity and displacement. Nearly all of the world's extreme poor, 720 million people, live in communities made fragile by ecosystem loss. These communities have the highest rate of population growth in the world, the highest disease burden, they are the most likely to be left behind, to be hungry, to suffer flooding and drought, and they are the most likely to continue to deplete or destroy their surroundings.

Existing conservation solutions are underfunded. Some US$24 billion a year is spent on conservation worldwide. Most of it is spent in industrialized countries; only a tiny fraction ends up in the hands of the extreme poor. The sum is itself dwarfed by the US$97 billion the world spends each year on pet food: even as wild animals go extinct, there is a humanization of pet animals.

What is needed is a breakthrough that makes a thousandfold increase in finance available for the regeneration of biological life in areas of extreme poverty.

It is proposed that the Bank for Other Species (or, more likely, its private-sector settlement agents) will create a digital twin for other species that will serve as their identity online. In practical and legal terms, it is the digital twin that holds the value—the equivalent of a few cents, a few dollars, or even a few tens of thousands of dollars in LM (rare life-forms may hold sums equivalent to a rare Rolex watch). Computational and human proxies will allow the nonhuman to express simple preferences. Money will be spent or invested based on these preferences.

Because the richest biodiversity is in the pantropics, it is the poorest and fastest growing communities in Africa, Asia, and Latin America that stand to gain the most from interspecies money. Effectively, other species will become a source of income and investment capital for humans. Indeed, in some cases, income earned in LM will match direct cash transfers as an affordable and effective way of reducing poverty. Taken together, interspecies money will contribute to the Sustainable Development Goals for reducing poverty (SDG 1), hunger (SDG 2) and improving well-being of communities (SDG 3), as well as to increasing life on land (SDG 15) and life underwater (SDG 14).[7]

To emphasize: the life mark is conceived as a store of value for free living biological life—*wildlife*. Trillion-dollar sums may eventually be held in LM by mid-century, a capital flow constantly directed and redirected, invested and reinvested, always with the purpose of improving nonhuman and human life outcomes, and with repairing and nurturing ecosystems most at risk of destruction. Instead of mining numbers as Bitcoin does, L-marks will mine knowledge and species discovery, incentivizing communities to self-organize around the protection of nature. Gain leads to more gain.

7. United Nations.

Economists have failed to price the services of nature into GDP.[8] These services include healthy soil, nutrients, clean air, and clean water. Pollination of crops alone may be worth US$400 billion a year. Nature also provides shade, shelter, storm and flood protection, natural foods, natural products such as timber and rubber, natural pest control, study of species for biomimicry, species discovery for genetics and pharmaceuticals (most antibiotics are naturally occurring), and control of zoonotic pathogens, the most damaging of which—such as plague, leprosy, HIV-AIDS, Ebola, coronaviruses, African swine flu, and avian flu—have leaped from wild animals to humans and their livestock. By some calculations, the direct services nature provides to industry are worth US$40 trillion annually and the total value of natural capital may exceed the US$80 trillion value of Earth GDP.

Interspecies money depends on distributing value to widespread species that most contribute to the regeneration of ecosystems such as trees and insects. But initial investments will often take account of rarity. All resources gain value from being finite. So it will be with rare nonhuman life-forms. Their existence value is real, their scarcity makes them precious. And if, at some future point, some of these species reach their carrying capacity (the number an ecosystem can hold, just as, for example, African elephants have in some areas in Southern Africa exceeded their carrying capacity), the LM they hold is still held by them to pay for future services, and whatever income their investments generate will likely be paid in dividends to the local community, to investors, and to the Bank for Other Species to be reassigned.

Some studies have shown that ecosystem services can be quantified to the individual life-form. African forest elephants may give US$1.75 million value per animal against US$40,000 value for their tusks. Large whales may be worth US$2 million per animal because of their ability to draw down carbon.[9] Similarly, trees and soil biomes are being quantified in terms of the services they provide.[10]

Nonhumans undoubtedly have economic value within large complex systems, but their protection cannot be made on economic grounds. At some point, the economics of biodiversity becomes as meaningless as the economics of the entire biosphere. Nor is it clear that interspecies money can be modeled on the basis of extinction risk, because only a fraction of existing species have been recorded. Quite the opposite: LM may have utility as a species discovery tool payment mechanism precisely because our knowledge of the living world is so patchy. (For

8. Dasgupta.
9. Chami and others; Banerjee and others.
10. Liang, Crowther, and others.

example, only 45,000 of the 1 million or so mites—and only 100,000 of the 3 million fungi—thought to exist have been recorded.)

The preservation of other species will rather be made on an assembly of ethical, aesthetic, and amenity values. LM will first seek to extend the moral compass of humans to include other species. It will support the maturation of long-standing efforts to prevent cruelty to animals by improving life outcomes and mutual comprehension. A still more important ethical contribution is the survival of species. Future human societies should have the chance to work out for themselves which species they want in the world with them. This approach is synonymous with sacred or intrinsic value, where the push for 30 percent protection of nature by 2030 is an extension of the guardianship afforded to groves in countries such as Benin and India. These tiny islands of rich biological life survive on account of their perceived magical or spiritual value to people and other beings, not least in connecting them with beauty, ancestors, and fertility. The case for paying for species survival is therefore both futuristic and ancient, resting as it does both on technology and an animist recognition that human and nonhuman life are intermingled powerfully.

Anthropogenic mass in plastic, metal, glass, textiles, cement, gravel, and other materials has doubled every two decades and will continue to increase over the next decade. In 2020, anthropogenic mass exceeded global living biomass for the first time.[11] LM will help turn the economy toward biological life in a trusted way. Indeed, this will become an important rationale for L-mark as governments and markets look for ways to favor the living world over the manufactured world.

The Importance of Turning Artificial Intelligence toward Nature

There is another reason to build interspecies money at this point in time, and that is the arrival of artificial intelligence into the world. AI changes everything,[12] and the application of large sums of L-marks are needed in order to help turn it toward other living beings.[13]

Anthropologists have shown that there is a primal desire of man to know his surroundings, but as these surroundings become ever more digital and removed from the processes we were designed for, there is an existential risk that we could end up far from our evolutionary state. AI is changing the way we perceive our surroundings. It is developing fast. It is universal in application. If it shows no

11. Bar-On, Phillips, and Milo.

12. The AI community is slowly awakening to ethics. See, for example, Montreal Declaration on AI.

13. The relevant literature is vast and technical. See, for example, Vinuesa and others; Pechoucek, Ledgard, and Bosansky. For a helpful historical overview of AI, listen, for example, to Shadbolt.

curiosity for nonhumans in this early stage of its evolution, it is less likely to be a steward of their interests or even to record their disappearance. AI amplifies anthropocentrism. The animals we most often interact with are pets, subject to humanization (with names, toys, clothes, and so on), or else digital simulacra in gaming domains (for instance, US$1.5 billion was spent in 2020 on *Animal Crossing*, a bubblegum-colored game for the Nintendo Switch console, in which players build worlds with virtual animals). We can posit a rule that nature will recede in our consciousness for as long as the digital advances, unless and until it is well represented.

Because it is capital-intensive and financed by venture and military interests, the evolutionary arc of AI bends toward profit and security. The AI community shows little interest in the natural world. Stanford University's first report of its vaunted 100-Year Study on AI ("AI and Life in 2030") contained long sections on gaming and entertainment, but did not mention nature. Whatever AI finds remunerative goes fast, and whatever it judges powerful goes deep, while the unremunerative and the powerless go ignored. Since wild animals, trees, birds, and other beings lack money and voice, there is every chance AI will be incurious of them at precisely the moment it should be paying attention.

The only way to turn AI decisively toward the natural world is to feed it data about the natural world. Interspecies money, in this respect, is a self-financing data generation machine that, over longer periods of time, brings humans, nonhumans, and machine intelligences closer together—a machine that is, in some ways, a corollary to the multiplicity of proprietary sensors, from iPhones to Alexas and Fitbits, that big technology companies incentivize the sale of in order to better monitor humans.

By assigning identity and finance across the species divide, interspecies money can perpetually generate high resolution data from the wild. But large sums of capital must be injected in order to trigger such a system. This is why there is no digital platform for other species and why there is no way for them to communicate with us online. The first service for which another species will pay with L-marks is to be known: record me and my kind, what I am, where I am, consider my existence alongside yours. Verification of LM transactions will depend on accurate data. The quality and sheer scale of these data sets will allow AI to become cognizant of other species and biological systems, even as it evolves to become a nonhuman life-form in its own right. In turn, the distributed intelligent computing subsidized by LM will inform communities, increase scientific understanding, and improve the economic and ethical choices we make. It is important to note that the cost and difficulties of gathering data in the wild mean that it is unlikely to happen without the L-mark.

The year 2021 marks the fiftieth anniversary of the Intel 4004. Since that

first microprocessor in 1971, the human economy has transferred immeasurable amounts of information and value to inanimate microchips. Just as biological species have diminished and been overtaken by monocultures, so have microprocessors become numerous, dense, diverse, and complex. Interspecies money will use the same technology to transfer information and value back to animate beings. This highlights the paradox underlying the proposition: the digital technologies that push us away from nature are the same ones that can best help us understand and protect it. An Internet of Life makes more sense than an Internet of Things.

The network is densifying. In 2000, China had 23 million internet users; now it has 900 million. Similarly, the amount of data produced in the world is predicted to increase from 35 zettabytes today to 500 zettabytes by 2030. Ever richer forms of information will go ever faster. This implies that second life and digital twins will be commonplace, with human consciousness being mediated by machines. This has engineering considerations for interspecies money. Metcalfe's Law holds that the potential effect of a network is proportional to the square of the number of connected users of the system (n^2). In other words, a higher order of connections is possible as a network grows. But other species are not on the network, so no connections are possible with them online. They can be easily forgotten. In this sense, nodes matter, and interspecies money makes nonhumans nodes on the same network that humans and machines operate on.

How Will Interspecies Money Work?

The requirements for interspecies money include the ability to give nonhumans a digital identity, the ability to accurately address financial value, the availability of distributed computing, the ability to gather sufficient data to build a verification system trusted by markets and governments, the ability to model the gathered data with AI and other systems, and, above all, the support and trust of local communities.

L-marks will pay for the deployment of hardware into the wild in order to build data sets that are high-resolution and increasing in accuracy (known as "oracles"). For instance, community rangers might receive mobile handsets to record video and log or track the location of recipient species. Camera traps might be deployed at waterholes and microphones along paths and in tree canopies. Private sector partners will also build out the biometric markers necessary for money transfers; they will be paid in LM. In effect, the wild animal or the tree, or the collection thereof, becomes the identity that allows the transfer to happen: I am, therefore I own. In order to pay for a service or make an investment, the wallet holder will have to show, in a timely fashion, what condition it is in and whether it is receiving the services it paid for.

What makes interspecies money plausible is the coalescing of cloud computing, fintech (including cryptocurrency), satellites, drones,[14] and ground robots. Underlying this is the new ability to affordably use AI pattern recognition on cheap sensors and mobile phones to accurately track wildlife.[15] An early use of AI applied to camera trap images taken in the Serengeti National Park in Tanzania identified forty-eight species from 3.2 million images with 94 percent accuracy. Face recognition of primates exceeds 95 percent accuracy. Visual recognition of distinctive markings of animals such as giraffes or cheetahs is well advanced. Numerous other vision-based examples include successfully reading facial expressions in sheep to detect foot rot, and remote identification of dugongs grazing sea meadows.[16]

As AI moves from old tag-based methodologies to convolutional neural networks that automatically learn from data inputs, LM-related data will be *better than humans* for numerous species. These deep neural network approaches will be extended out to plants and insects. For instance, there has been difficulty putting together a listing for endangered orchids; orchids need expert assessment. Some 30 percent of 29,000 orchid species are threatened, but only 1,400 are accounted for in the IUCN Red List. An orchid identifier already claims 85 percent accuracy and will eventually exceed 95 percent accuracy in the wild.

Datasets will be gathered into AI machine-learning programs and multi--agent simulations. The data will be mostly (perhaps completely) open source and will feed entirely new knowledge systems built on cloud computing (such as Microsoft's Planetary Computer, which aims to build a universal model for life on Earth, and Google's Earth Engine and Wildlife Insights). Collective human intelligence will label and work through and generally improve the contribution of AI, either on a paid or a voluntary basis. Multilateral lenders, sovereign and private wealth funds, pension and insurance funds, philanthropists, and other investors will all be able to make use of granular data generated for verification of LM transfers for green finance. For instance, a private reserve in Latin America may achieve a higher market value as a biodiversity offset if it proves over long periods of time that it supports an increasing number of species.

Communities will earn value by generating new data. Some of this will be species prospecting based on vision, sound, and genetics. Payment in L-marks can help incentivize the preservation of the knowledge of the book of life.[17] Only 2 million of 8.7 million species on Earth are recorded by science. The International Barcode of Life, an organization with US$130 million of funding, wants

14. Ledgard (2015).

15. See, for example, Fang and others; Brandes, Sicks, and Berger; Iacona, Ramachandra, and others.

16. See, for example, Tanaka and others.

17. Sweetlove.

to identify a further 2 million species in the next decade. Some of this work can be undertaken by the extreme poor, possibly with windfall payments in LM for newly discovered or exceedingly rare species.

There are also reasons to be optimistic about sound as a useful data source. Acoustic signatures are complicated for AI, because vision is invariant compared to sound (a photo of a lemur is still recognizably a lemur when turned on its head, whereas a sound recording of a lemur call ceases to be an intelligible lemur call when it is played backward or slowed). Even so, there will be advances in neural processing of sound to match that of vision.[18] LM payments will contribute to solving the "cocktail party problem" so that animal and insect calls can be distinguished even in noisy environments (for example, the call of a particular macaque can be pulled apart from other chattering animals). This will allow nonhumans to pay for acoustic stations at the outer limits of tropical forests (led by NGOs such as Rainforest Connection, which has taken a lead in identifying acoustic signatures of birds and frogs in jungles).

The other necessary element of AI is in game theory approaches, which allow the incentives nonhumans pay to humans to be rewritten. The application of game theory to scalable algorithms will make LM payments superior to traditional conservation in many situations by extending the range of interventions at lower cost. Game theory is used in antagonistic situations such as stopping malicious behavior on a computer network or predicting pirate attacks on shipping lanes. It can also be applied to optimize complex networks such as flight paths into busy airports.

The life mark will take advantage of game theory by putting down on the real world a meta layer that can be tweaked and improved on a weekly basis. A basic game might inform a community that a Nubian giraffe (or, more likely, a herd) holds LMs and would like to spend them on services it needs. Payments are adjusted toward an equilibrium benefiting both giraffes and communities. The game will be played for as long as the giraffe holds LMs and only in ways that serve the norms, traditions, and long-term viability of the community. Game theory will need to be resilient against the threat that a community may hold a rare species hostage in return for higher payments, or that the treasury itself will be open to manipulation and fraud.

This is not to suggest that developing AI in the wild will be easy or always reliable. AI will need to develop open category systems (not just to identify a particular moth, but also to recognize there are many other winged insects that are not moths). But AI will not be a constraining factor for interspecies money, not least because its enormous power is that it draws on solutions that were applied in

18. Zhong and others; Hill and others; Ruffand others; Rappaport, Royle, and Morton.

quite separate domains (for instance, sensor systems developed for autonomous vehicles may have solutions relevant for sensors in the wild).

The direction of travel is clear. Just as television programs on wildlife in the 1950s were monochrome, indistinct, and fanciful, but are now Technicolor, sharp, and scientific, so will the quality and variety of data generated by LM constantly intensify. By 2050, it is possible that other sensory and chemical signatures will follow sound and vision. By then, AI might be able to smell and touch nature.

Where in the World Will Interspecies Money Be Most Usefully Applied?

Interspecies money is intended initially for targeted conservation. It will have greatest utility at the frontier in the pantropics, where nonhumans suffer because they have no means to change their economic value (and where their only value is the sum of their body parts). In the next decade, LM will often be applied first to animals capable of defining or even expressing simple preferences, including species such as primates and elephants, whose rights have already been acknowledged under habeas corpus rulings.[19]

It is possible to again use the Nubian giraffe (*Giraffa camelopardalis camelopardalis*) by way of a simple example. Giraffes are among the most iconic animals, and their preferences are simple and well understood. However, their ubiquity in toys and images does not reflect their endangered status in the wild. There are only 97,000 giraffes left alive in the wild, down from 163,000 in 1985. A further 1,700 live in captivity. In some places, their numbers have collapsed by 95 percent owing to fragmentation of habitat, incursion of farmers, and bovine tuberculosis. Giraffes are killed for meat, for their bone marrow, and for their tails (which are used for ceremonial purposes). They get snagged in barbed wire, or torn apart by vehicles when crossing roads. Nubian giraffes are critically endangered. There are only 2,100 of the subspecies left alive in Ethiopia, South Sudan, and Kenya. What would L-marks do for them?

First of all, the LM would give a Nubian giraffe a trusted identity based on facial recognition, gait recognition, and individual markings. With this identity, the animal would hold some financial value (say, US$32,000 in LM) and begin to disburse it in order to improve its life outcomes. It will pay to distribute mobile phones and for sensors to be deployed at water holes and along paths. It will pay for preferential access to water holes over cattle and goats. It may, in some instances, pay for security to stop poachers and charcoal burners.

Many of the services a giraffe asks for will result in payments or investments

19. Stone, Wise, and Posner.

Figure 5-1. Giraffes Can Pay for Their Own Protection

for better stewardship; often this will be undertaken by very poor communities. Herders might be compensated for moving their cattle away from the giraffes. Villagers might earn L-marks from planting trees, building fences, and keeping water holes in good shape in drought conditions. Payments will be made for accurate sightings of giraffes and for observation of spoor, prints, and hair. The animals will pay for periodic drone and satellite imagery, weather and farming data, and economic and security intelligence; internet connectivity from providers such as Starlink may be paid by the animals in LM. They may also pay to protect related other species, such as bees and other pollinators, and the oxpecker birds that pick them clean of insects and infections. A Nubian giraffe may pay for its own veterinary care with LM. Since translocations of giraffes are well established, it is possible that a herd might finance their own move to a safer location at some future point.

This is an example of an elementary application of the life mark. Lessons learned from rare, charismatic creatures like Nubian giraffes will be applied to other megafauna, including critically endangered hoofed animals like the Hirola antelope (less than a thousand individuals), Heuglin's gazelle (three thousand), and giant elands (twelve thousand).

However, conservation spending is biased toward charismatic animals. The most popular animals in zoos get the most money in the wild.[20] Identifying umbrella species in ecosystems may be more effective. An umbrella species is

20. Courchamp.

one whose continued existence is most likely to support an ecosystem (or to reliably indicate its health). Directing LM from charismatic to umbrella species will increase protection for the same investment (for example, a study in Australia found a conservation approach targeting umbrella species increased protection of terrestrial species from 6 percent to 46 percent).

Over time, life marks will be held by obscure small creatures, as well as trees, plants, and insects.[21] The poorest countries with the most endemic species, such as Papua New Guinea, Madagascar, Central African Republic, and the Democratic Republic of Congo stand to benefit the most. Biodiversity in these ecosystems often supports human diversity: a quarter of the world's languages are found in the Amazonian, New Guinean, and Congolese rainforests.[22] These languages and the cultures they belong to represent a profound knowledge of their surrounding ecosystems.

The cheapest and most effective way of reaching the 30 percent protection of terrestrial habitats by 2030 is to preserve tropical forests, water corridors, and animal migratory routes. LM will likely have its greatest utility at the edges of these forests,[23] as well as along rivers and estuaries where competition between humans and nonhumans is the most brutal. If crop-raiding chimpanzees in western Uganda could pay for any damage they caused, or Malaysian Sabah orangutans could use LM to gain an identity and announce themselves to local farmers before raiding their crops,[24] there would be both a basis for lasting cohabitation and a financial realization of the existence value of the nonhumans. In all instances, the purpose of the payments is to make the human invested in the survival of the nonhuman.

The L-mark will underwrite the regeneration of nature in fast-growing countries such as Nigeria, Ethiopia, India, and Peru. Nonhumans will pay humans for a multiplicity of entrepreneurial tasks, such as clearing plastic, controlling invasive species,[25] mitigating zoonotic disease,[26] planting trees, as well as recording and tracking in nature, so that day by day, little by little, the local economy becomes a natural economy.

In the early stages, L-marks will flow fastest to communities that are the most regenerative. This will have a demonstration effect, where solutions and so-called

21. Stork.

22. The work of Elinor Ostrom is useful for Interspecies Money. See, for example, Ostrom (1990), (1992), and (1995). For indigenous participation, see, for example, Novotny; Muller, Hemming, and Rigney; Arrow.

23. Laurance and others; Cooke, Köhlin, and Hyde; Lovejoy and Nobre; MacArthur and Wilson.

24. Voigt and others; Santikaand others; Campbell-Smith, Sembiring, Linkie.

25. Westphal and others.

26. Zoological Society of London (ZSL).

green hustles—where young people are incentivized with micropayments to gather data on a particular species or to undertake regenerative tasks such as repairing a water hold or providing veterinary care to a species—pioneered by innovative communities will be copied by others (for example, a group in Sri Lanka may learn best practices from a group in Niger). Communities that are too insecure, negligent, or untrustworthy will be passed over. Vitally, cash-poor, time-rich young people will earn the most money.

How Will Interspecies Money Be Financed and Organized?

Money is a social construct. Shells, feathers, coins, checkbooks, credit cards, and swipe payments have evolved with new ways of transmitting information. Digital money itself is not new: the first version appeared in 1983, soon after commerce was permitted on the internet. But the acceptance of digital money has accelerated in recent years with the emergence of Bitcoin in 2009 (Satoshi), retail e-cash solutions, and, more recently, a Facebook-founded consortium Diem, which seeks to create a stable digital currency[27] for increasing financial inclusion and cross-border micropayments. Why is it credible to expect large capital flows sufficient to mint the life mark when conservation has failed to raise adequate money to date?

One reason is that we are living through a monetary revolution connected to the explosion of data. Money is becoming liquid and digital. Intention and money are merging—dopamine is now a reliable indicator of earnings on social media. A new class of digital currencies will make this intentionality divisible, so that smaller and smaller tasks can be assigned and rewarded on much larger networks.

Digital money is already traded on a vast scale in the cryptocurrency markets. Bitcoin boasts a US$70 billion daily volume trade on a market cap of US$1 trillion at time of writing. The totality of cryptocurrencies, in many forms, will exceed US$2 trillion well before 2030. In this context, a market cap of tens of billions of dollars in LM is reachable within a few years.

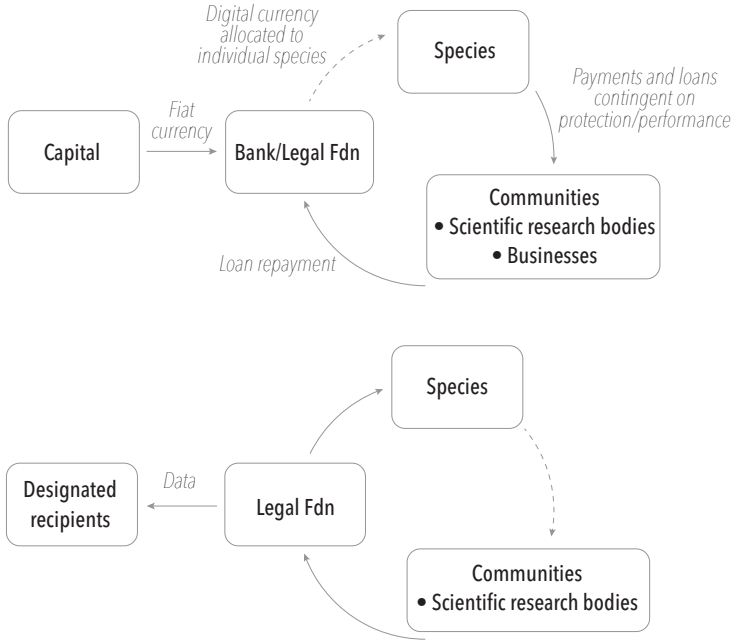
However, Bitcoin is a poor means of exchange, a poorer store of value, is opaque and possibly corrupt, and uses more electricity to validate itself than Argentina.[28] A central bank (or a decentralized private sector with the proven qualities of a central bank) offers a steadier hand.

The majority of central banks are now exploring the possibility of issuing their own digital currencies. The process has been sped up by COVID-19, the

27. Arner and others.

28. Polemis and Tsionas; Carstens (2020) and (2021).

Figure 5-2. Capital and Data Structure of Bank for Other Species



inflated value of Bitcoin, and the emergence of Diem. A consortium including the European Central Bank, the Bank of England, the Bank of Japan, the Bank of Canada, the Swiss National Bank, the Sveriges Riksbank, and the Bank of International Settlements have joined together to explore ways to build central bank digital currencies. China is more advanced: its digital renminbi is in experimental use in Shenzhen, Shanghai, and other cities. The d-renminbi will likely be the official currency of the 2022 Winter Olympics in Beijing.

The proposed Bank for Other Species will issue the life mark as a central bank digital currency. The bank will be an independent global public good working toward the agreed goals of the Convention on Biological Diversity.[29] Other central bank governors will likely sit on its board in a manner and purpose similar to the Bank of International Settlements; it will be for them to establish the structure of the bank. However, governance, science, and ethics related to the application of L-marks will be overseen by a subsidiary. This independent foundation of the bank will control all the data gathered by the payment system. It will have its own independent board of indigenous peoples, conservation, technology,

29. Convention on Biological Diversity.

government, and other stakeholders. Crucially, the foundation will write and rewrite the rules and incentives applying to L-marks while the bank will embed those rules into the currency using automatic computational execution (smart contracts adjusted by game theory).

Life marks are likely to be built using a distributed ledger technology with the bank serving as a central validator (unlike the decentralized validation of Bitcoin). It will be a hybrid model,[30] with the private sector self-organizing in a competitive and profitable payment system as settlement agents. Money transfer companies show that stability across most currencies is possible by creating internal currency baskets (Western Union uses an internal stablecoin process transactions in 137 currencies every few seconds). The L-mark will have central bank standards of stability, interoperability, transparency, privacy, and quantum resistant security against hacking and money laundering. L-marks will follow "know your customer" regulations quite literally with payments released upon verification of identity.

The public interest will always come before the technology in the design of the currency, and in this case the public interest is the contribution L-marks make to the continuance of rich and diverse life on Earth.

But where will the liquidity come from?

From many sources. Governments have publicly committed to climate change targets and to the preservation of biodiversity.[31] The European Union's €95 billion Horizon 2021–27 research fund has singled out biodiversity challenges among its goals;[32] it and similar American and Chinese initiatives will be a source of initial research funding. Philanthropy is also a significant source of early capital and innovation. The Amazon.com founder, Jeff Bezos, recently stepped back to work on philanthropic initiatives that include a US$10 billion Earth Fund focused on mitigating climate change and biodiversity loss; it can also underwrite the development of a Bank for Other Species. The Terra Carta initiative of HRH Prince of Wales is based on the Magna Carta.[33] It envisages yet larger sums invested into nature-based solutions each year.

Private investment into biodiversity is presently estimated between US$6.6 billion to US$13.6 billion a year, but loans and underwriting worth US$2.6 trillion go to industries driving biodiversity loss.[34] This makes institutional investors

30. See, for example, Auer, Monnet, and Song Shin; Auer, Cornelli, and Frost; Bank of Canada and others; Chaum, Grothoff, and Moser.

31. European Bank for Reconstruction and Development (EBRD); Moles Fanjul.

32. European Commission; EU Technical Expert Group on Sustainable Finance.

33. Windsor.

34. Picte Asset Management.

likely to buy LM.[35] Large sums will flow from the industrial north to the pantropics in the next decade as a matter of climate mitigation and climate justice reparations. Most will just be finance searching for higher returns in faster growing economies (by mid-century, the population of Italy is predicted to drop from 61 million to 28 million and of Japan from 138 million to 58 million, while that of the Democratic Republic of Congo will rise from 80 million to 130 million and of Tanzania from 54 million to 125 million). Since human demands on nature are running at the rate of 1.6 Earths, and since the biosphere clearly bounds the limits of economic growth,[36] the next decade will be one in which companies will accelerate non-fiduciary duties toward sustainability. Large purchases of L-marks will be made by fossil fuel, cement, and other biosphere-damaging companies. This will happen informally through shaming and sanctions, through market incentives, then through board decisions and divestments, and finally by the application of law.

Although the initial liquidity of the Bank for Other Species will be staked by other central banks and philanthropists, it will increasingly pay for its operation from the transaction fees it generates and from the investments nonhumans make using LM. The bank may earn money from intellectual property it develops for the purposes of its own verification protocols. Its data will be free and open for science and development; proprietary modeling for the private sector may earn additional revenue. The bank and the private sector may earn from interests in commercial carbon offsets, rewilding, debt forgiveness, and utilities controlling invasive species and zoonotic diseases. Another large income stream will be species prospecting, where discovery of new genomes is rewarded.

There is again the question of timeliness: the life mark has to be issued at this point in economic history not just because it is an ecological and AI imperative, but also because it is affordable to do so. This is likely the last decade where it is possible now to incentivize better cohabitation with billions rather than trillions of dollars. With each year that goes by, the edges of the biodiverse areas are brought into the human economy and covered with an anthropogenic mass of roads and buildings, which, however seemingly inert, has its own capital demands and incentive structures.

L-marks will move between nonhumans and humans not just through payments for services, but also through loans and investments. The bank will become a lending structure along the lines of Quaker banks or cooperatives, with local communities, institutions, and individuals borrowing at preferential rates. The same will apply to insurance. Microinsurance products pioneered by

35. United Nations Development Program (UNDP).
36. Smil.

major insurance companies (which are themselves algorithmic exercises relying on advanced technology), may in many cases be paid out in LM.

Even more significant, nonhumans will buy equity in local businesses. As those businesses grow, so will the net worth of rare life-forms. This value will be passed between generations until the carrying capacity of species is met. The L-mark will seek to be *natural*, ordering itself according to life cycles. In the simplest terms, we can envisage giraffes owning equity in local shops, electric charging points, solar arrays, rudimentary robots, seed banks, and transport. If money is directed into nonhuman life now and held over many generations, investments made in biodiversity will rise with the wealth of the economy. That will greatly increase the available finance for future conservation. By way of example, consider what would have been the value held by nonhumans in the special economic zone of Shenzhen in China. The Shenzhen economy has grown from US$40 million in 1980 to over US$40 billion in 2020. Even a tiny application of L-marks in the early days of Shenzhen would now be worth hundreds of millions of dollars. The Bank for Other Species will get richer as emerging economies get richer, so that it may eventually function like a sovereign wealth fund for other species.

Green finance is held back in the pantropics by increased investment in commodity crops. Sugar cane, palm oil, soy, and other flexible commodity crops provide enormous short-term returns to the super-rich at the cost of long-term ecological devastation for nonhumans and the extreme poor. Farming is the largest single emitter of greenhouse gases and by far the largest cause of biodiversity loss.[37] When damage to the biosphere is calculated, the cost of food production in the pantropics may already exceed its value.[38] Farming accounts for most of the livelihoods in Africa and many of the livelihoods in Asia and Latin America.

Climate change is likely to have a disruptive effect on rainfed crops and may further threaten nonhuman life. The bank will seek to align with the goals of the global food system to stay within safe planetary limits in the management of water, soil, air, and microbial life. Its finance structure and the flow of LM will incentivize farmers to reduce cattle herding, nurture the soil, and protect the watershed, as well as direct efforts to preserve rare nonhuman life. More food needs to be produced, but with far fewer inputs. Human agriculture developed over thousands of years in clement, unhurried, uncrowded, and biologically abundant conditions. It will now take place in blistering conditions of increasing fragility and scarcity. The life mark will play an assistive role in an entirely new

37. Rockström and others (2009).

38. Rockström and others (2009); Rockström and others (2020); Food and Agricultural Organization of the United Nations.

category of farming, not just of food but sharing of information with other biological life-forms for their own sake and the health of the biosphere.[39]

Conclusion

The entire notion of interspecies money and of life marks as a digital currency issued by a novel central bank (or a private sector alternative) will face criticism from some technologists, scientists, ecologists, animal rights advocates, philosophers, and from the general public, along the lines that the L-mark is an unacceptably extreme fintech, cryptocolonial in design, which seeks to drag nature into the very same human economy that has destroyed it. Pointedly, others will object that it is wrong for nonhumans to receive care while humans suffer and that the life outcomes of the extreme poor should in no way be conditioned by their ability to extend the survival of other species.

It is right to be skeptical toward the promise of a digital platform that claims to distribute financial value to nonhumans and onward to humans in the remotest and wildest bits of the world. Many digital panaceas have been promised in the twenty-first century and mostly only nostrums delivered. Wealth is notoriously tied to what is fixed, whereas biological life is shifting and unpredictable.

Some ethical concerns around interspecies money may be offset by making it provisional. For instance, there might be a clause allowing for its value to be dissolved; from 2123 onward, nature would again be outside of the economy and would cease to be monitored. But it seems more likely that a large and successful store of value in nature, with preferences of many species recognized, much new knowledge, and proven regeneration of ecosystems, would choose not to dissolve itself but to continue on as a contributor to twenty-second-century stewardship.[40]

Is it really possible that the life mark can be made to be accurate, equitable, affordable, uncomplicated, popular, and secure? Such that it neither collapses under its own weight, nor introduces a panopticon surveillance state into the natural world, nor has any other unintended or damaging side effects?

The skepticism is perhaps redundant, since interspecies money will only scale

39. See Rubin and others. According to this paper, life-forms are an "inevitable and emergent property of any random dynamical system that possesses a Markov blanket." All autonomous systems and all living things are self-organized into Markov blankets of Markov blankets, from their cellular structure to their bodily form. They are subject to a free energy principle where free energy is the dissipation of energy to the equilibrium—death. In order to contain energy, the biological life-form establishes a boundary for sensing and predicting the outside world. This boundary extends out to the communities they belong to. Such a scale-free and domain-independent approach may underpin Interspecies Money. See, for example, Kirchhoff, Parr, Friston, and others; Clippinger.

40. On stewardship, the author is indebted to a wide range of thinkers, including artists he works with, such as Olafur Eliasson. See, for example, Weil; Carson; Schama.

when it is shown to be effective. And besides, it is unlikely to work in all situations. Game theory is an approximation. It will not work when ecosystems and communities are subject to bad actors and externalities such as armed gunmen, forest fires, and crop failures. What matters is that it is effective in certain conditions, that it can be reliably replicated, and that it constantly improves.

Extinction is not inevitable. Dozens of species have been saved from extinction since 1993. Mountain gorilla population in Rwanda has increased from two hundred in the 1980s to over a thousand today. Care for the endangered nonhuman does not preclude care for the extremely poor human. On the contrary, their fates are entwined. An overemphasis on human development over nonhuman survival willfully ignores the conditions in which many of the extreme poor will live over the next decade, dependent on ecosystems that are increasingly unfit to support life.

The road map for interspecies money is short and direct. Testing will begin in multiple ecosystems in 2022–23. Support from conservation and computing circles will follow successful pilots. Work will begin on numerous relevant scientific questions, such as predation, vagility, and carrying capacity of species. The bank will be established and the LM minted before 2024. It will maintain digital autonomy and withhold its data for science and as an asset class. Large sums from governments and institutional investors will begin to be placed in life marks from 2025. Still larger sums from smaller investors will follow. Many of these investments, especially from legacies, will be made with the primary goal of limiting species extinction and supporting the regeneration of other life-forms. A separate track will advance the legal framework. The right of nonhumans (or their digital twins) to hold financial value will be settled in many jurisdictions, starting with higher animals with proven self-awareness (see, for example, the Nonhuman Rights Project, which has successfully pressed for civil rights for primates, elephants, and cetaceans not to be imprisoned or experimented on).[41]

Animism has been a defining element of humanity since Paleolithic times.[42] The aforementioned humanization of pets, together with the rise of ethical vegans and vegetarians, and advances in nonhuman rights, suggest that humans are becoming more sensitive to the needs of other species and to biodiversity more broadly.[43]

Within a decade, we may understand how to help nonhumans express simple preferences. That will have wider ethical, ecological, and economic implications, not least for livestock animals, which so greatly outnumber wild animals. The same facial recognition software that will afford an orangutan an identity and

41. Nonhuman Rights Project.
42. Weber.
43. Bawa and others; Vaes and others.

liberty in the wild may support the incarceration and eventual slaughter of other animals in industrial farms. Many of the AI solutions that underwrite interspecies money have been advanced in Chinese pig farms by technology companies looking to optimize meat production. Similar approaches will likely be applied by pastoralists in the pantropics, so that the cash value of their cattle and goats might be increased and secured year after year. But it is equally possible that some of the largest early investments in LM may be from vegans who see it as a way of undercutting industrial farming.

Interspecies money will be an expansion of the nodes available to the internet, but it could be larger and more culturally important than that. The Bank for Other Species will be the first of many digital platforms for nonhumans. What begins as a practical attempt to count, classify, and protect biodiversity may develop into an economy and culture beyond our present imagining. Breakthroughs in neuroscience and communication may, in a few instances, allow the chasm of misapprehension, blankness, and predation that has characterized our relationships with other species to be crossed. Given the diversity, number, and deep biological time, nonhuman insights are likely to alter our somewhat utilitarian understanding of the world and our place in it. The still larger question of the interspecies will be human-nonhuman-machine cohabitation. If life on Earth is to survive, machine intelligence will play the mediating role in mutual care and comprehension.

Only a centralized authority (or one taking the qualities of a centralized authority) can assure trust in a digital currency for nonhumans. It is possible that the Facebook-backed Diem, or a similar private sector digital currency, could be repurposed as LM, but it is far more likely that a bespoke central bank built from scratch and owned by other central banks would better serve the common good of a stable monetary framework for other species. Even at scale, L-marks are unlikely to influence monetary policy, but they will constitute a currency held by other species that will quite reasonably match the half a trillion dollars held by the Hong Kong Monetary Authority to back the Hong Kong dollar.

What matters is rewriting the economic rules in favor of nonhumans in a transparent and accurate way. By 2030, thousands of species will be able to spend L-marks to make themselves better known in the world. They will pay for their own veterinary and arboreal care (just as mountain gorillas already have greater access to medicine than many humans). They will live longer lives, with less pain.

Moreover, the system capable of regenerating diverse life on Earth will be self-financing and beneficial to the extreme poor, who also lack identity because they lack money. In this sense, interspecies money is a radical venture for financial inclusion and closing the informational asymmetry both of other species and of the extreme poor who benefit from living alongside them.

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