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What Is Sustainability, Anyway?

by Thomas Prugh and Erik Assadourian

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Wat Raj Burana, Thailand. © Carl & Ann Purcell/CORBIS

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Introduction

Twelve years ago this September, eight men and women said goodbye to wellwishers and walked into Biosphere II, a 3.1-acre airtight greenhouse in the Arizona desert. The door was sealed behind the "bionauts," a team of specialists right out of *Mission: Impossible*: a systems engineer, a physician, two biologists, agricultural scientists, a computer systems expert. They planned to remain under glass together for two years, proving that humans could design, construct, and live in a self-sufficient ecosystem.

The project got off to a good start and ran smoothly for several months. The $200-million enterprise represented years of planning and the most up-to-date research into ecosystem design and function, and the planners seemed to have thought of everything. Like the Earth ("Biosphere I"), Biosphere II was a closed system except to sunlight. It featured a productive mix of biomes, including miniature forests, lakes, streams, and even an "ocean." The researchers expected to live off the system's internal output, without additional food, oxygen, or other supplies, throughout the experiment.

In *Mission: Impossible*, the experts routinely encounter odds that seem impossible indeed, but the operations nevertheless always go flawlessly. Biosphere II's experts, on the other hand, were blindsided by unforeseen developments. After 18 months, oxygen concentrations had dropped from 21 percent to a marginal 14 percent, the level found at about 17,500 feet. The carbon dioxide exhaled by the bacteria-rich soils was being absorbed and bound up in the concrete walls of the building, so the plants couldn't break it down into carbon and free oxygen. Other troubles, apart from friction among the human inhabitants, included the extinction of three-quarters of the small animal species and all of the pollinating insects. Insect life in general came to be dominated by ants. Food plants grew poorly, but weedy vines ran wild. (Supplemental oxygen pumped into the greenhouse kept the crew going for the full two years.)

Biosphere II was a physical experiment in sustainability. The project scraped off all the political and rhetorical barnacles that cling to the idea of sustainability, leaving the essential question: How do we make a self-contained place to live, and keep it going for a long time? The question is important because human beings are doing many things to the planet that are, or may be, destructive to the natural systems we depend on. But scaling the question up to the full-size real world brings back the barnacles and makes the matter complex and ambiguous, because of the many "it depends" questions that must be asked: For how long? For how many people? Are they rich or poor? What are their views of other creatures? What technologies are available? and so on.

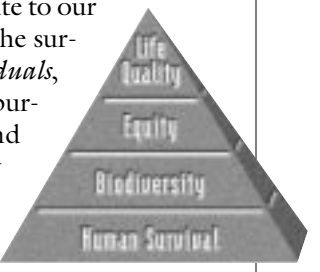
Despite its limits, the answer that came out of Biosphere II is valuable. Since it was just an experiment, it would be inaccurate to say it failed; it simply yielded data. One of the things it showed is that ecosystems are

extraordinarily complex and dynamic, poorly understood, and prone to unforeseeable behavior that may alter their functionality. (As the saying goes, ecology isn't rocket science; it's a lot harder.) These "wild facts" likewise color and inform everything that can be said about living sustainably on "Biosphere I." It's not so easy to create a robust, productive, hospitable, and long-lived life-support system, and it is very foolish to ignorantly compromise the one we've got.

Many are tempted to ignore these facts. Sustainability, despite being a relatively new term, has already been overused and corrupted. For its display at the 1992 Rio Summit, for instance, an Italian energy company chose the slogan "Sustainable Development: We're Growing With the Planet"—apparently intending no irony and without explaining in what way the planet itself was actually growing. Just as sustainability can be distorted so that it considers only humans' interests, it can also be defined in ways that force *homo sapiens* out of the picture altogether—as in the views of some "deep ecologists" who see people as a cancer on the Earth. Being human ourselves, the authors have a viewpoint that is centered on human values and experiences. But we have tried to strike a balance, and we argue below that to achieve true sustainability it is both necessary and right to have a proper regard for all living creatures.

All people and cultures try to improve their lives and conditions; this process is often called development. To achieve sustainability requires sustainable development, which was most famously defined by the Brundtland Commission in 1987: roughly, the ability to meet our needs without compromising the ability of future generations to meet theirs. It's a durable definition because it is flexible and open to interpretation. An obvious flaw, however, is that it begs the question. Of course people will always need food, water, and shelter to survive, but to *thrive* will take more than that—and we should not presume to know, beyond certain basics, what future generations will need to thrive. All we can be reasonably sure of is that they will value having choices. Ultimately, sustainable development and sustainability itself are about collective values and related choices and are therefore a political issue, almost certainly the supreme global political issue of this century. Because values, politics, and our understanding of the Earth and its systems will evolve, notions of what is sustainable will never be static.

But we have to begin somewhere. As a big, sloppy subject, sustainability can be approached in many different, and equally legitimate, ways. It may be convenient to think about sustainability in terms of four dimensions—human survival, biodiversity, equity, and life quality (see figure). Survival refers to the bare minimum conditions required for the continued presence of the species *homo sapiens* on the Earth, and we start there because without species survival, the rest is moot. This is not our main focus, however, because human environmental blunders and excesses are not likely to threaten us *as a species*. More important are the remaining three elements, which contribute to our survival as a species but also encompass the survival of humans *as communities of individuals*, as well as the forms of human welfare we pursue—freedom, fairness, fulfillment, and related ideas—after we're reasonably assured of survival. We make this distinction because history offers many examples of human cultures that were hardly fair or just but still managed to last a long time.



The four dimensions are arranged in a layered pyramid that resembles psychologist Abraham Maslow's hierarchy of needs. The idea is much the same: the dimensions are addressed from bottom to top and the upper layers build on the ones below. We end by briefly describing a core strategy for moving toward a culture of sustainability.

Human Survival

In the sci-fi film *The Matrix*, intelligent machines have bumped human beings off their self-assigned place at the pinnacle of creation and turned them into dream-pacified energy slaves. *The Matrix Reloaded*, the sequel, ends with the machines boring rapidly toward the underground city of Zion, the last refuge of the few human rebels against the new world order. Things look bad for the humans. (The final episode is set for release in late 2003.)

Is this scenario plausible as The End?

Something, if not smart machines, will no doubt kill off humanity sooner or later. The fossil record suggests that no species lasts very long in geological terms (although the humble cockroach, already 280 million years old, may prove the exception). A likely assassin is an asteroid or comet, such as the one that apparently collided with the Earth and wiped out the dinosaurs 65 million years ago.

Killer asteroids or parricidal robots seem more plausible than species-cide. Doomsday literature has tradi-

tionally fingered nuclear holocaust, runaway viruses, or environmental crisis as likely ways we might kill ourselves off. But humans (like cockroaches) have proven so resilient and adaptable that we have moved into nearly every place on Earth except the oceans. And although biologists have long debated the minimum population needed to sustain a vertebrate species for a few hundred years, the closest thing to a standard estimate is the low thousands. Given this relatively low number, and the adaptability and geographic dispersal of human beings, it's hard to imagine that even the horrors just mentioned would do more than trigger a massive eclipse of the human presence on the Earth.

So human survival *as a species* does not seem to be in much danger from anything we might do to the global ecosystem, however rapacious, stupid, and/or shortsighted. Nevertheless, the survival of billions of *individuals* certainly is. From a strictly anthropocentric point of view, the only human survival issue that concerns sustainability is that such rapacious, stupid, and/or shortsighted abuse of our environment will kill many people, cause profound suffering, and devastate cultures.

The human survival dimension of sustainability thus boils down to the question, How many people can the Earth support? This is also the title of a rich and wide-ranging book by Rockefeller University biologist Joel E. Cohen, who notes that people have been making such estimates for nearly 400 years, with results that range from less than 1 billion to more than 1 trillion. Clearly, there is no simple answer except "It depends." According to Cohen, it depends on:

- the typical level of material well-being;
- the distribution of material well-being;
- available technology;
- political institutions;
- economic arrangements;
- demographic arrangements;
- physical, chemical, and biological environments;
- how much variability in total population is acceptable;
- peoples' willingness to risk local ecological disaster;
- the time horizon; and
- fashions, tastes, and moral values.

Cohen's 36-page chapter reviewing the many complex ways these factors interact to shape the number of people the Earth can support is aptly titled "Human Choices." Carrying capacity for humans is in large part self-defined, because the limit on human population is not the maximum carrying capacity, but the cultural carrying capacity, which is lower. If everyone lives at a subsistence level, the Earth will support more people than if everyone lives at a more comfortable level that requires more resources. The factors listed above help define the difference between the maximum population and the optimum population.

Take "typical level of material well-being," for example. Despite the sloganeering of Italian energy companies, the world is finite and therefore imposes limits. If the pie ultimately cannot be enlarged, then average material well-being will probably be greater if there are fewer people on the planet at any one time. An adequate diet for all, for instance, will be easier to achieve with 3 billion people than with 30 billion. Even if the higher number were theoretically supportable, producing a decent diet for 3 billion people would require less cultivated land, less intensive farming, less disruption of natural ecosystems, less freshwater, and less energy for production and transportation. In turn, that means more undisturbed wilderness, greater biodiversity and fewer extinctions, less sprawl, less pollution, and so on—which, beyond reducing human mortality and disease, means the average quality of life can be higher.

But *average* well-being could be high and still imperil billions if the material wealth is too unevenly distributed, as it is now. For example, the United Nations Food and Agriculture Organization recently projected that the total amount of calories available per person per day will rise from about 2,800 today to 3,050 in 2030. However, 440 million people will still go to bed hungry. Malnutrition and undernourishment affect survival directly as well as by undermining health. The wealth necessary for healthcare delivery is likewise unevenly distributed; the affluent nations spend billions on healthcare related to overconsumption, while inexpensive vaccines against basic diseases common in the developing world go begging for funds.

The effects of technology on human survival, for good or ill, are even more obvious. The industrial revolution sprang from the invention of machines that could tap fossil fuels and unleash their enormous stores of energy. That flood of energy led in turn to higher production and average standards of living in industrialized countries. On the other hand, the 1986 Chornobyl nuclear power plant disaster contaminated 150,000 square kilometers of prime farmland and significantly reduced the region's agricultural output. A global nuclear exchange could slash the global carrying capacity even as it reduced the population.

Lack of space prevents us from discussing most of the other items on the list in more detail, but all have their own effects on how many people survive, and who they are. Different choices in these areas lead directly to vastly different outcomes. For instance, although human population growth now seems to be moderating somewhat, for a long time it looked as though we were lurching helplessly toward a boom-and-bust scenario: a peak of, say, 20 billion people followed by a cataclysmic crash that left a devastated and strife-torn planet. This "maximum-at-one-time" option is clearly inferior to a plan to support fewer humans at any one time, but more over the long haul, by choosing to sta-

bilize population at some lower level.

The choices we are making now are placing a heavy load on the Earth's capacity to support us. By one measure, the Ecological Footprint, we are now exceeding that capacity by about 20 percent. The margin will widen, probably at an accelerating rate, as our numbers and consumption rise. The increasing load will in turn drive changes, some gradual and others abrupt, in local and regional ecosystems. These changes will compromise our survivability. In a few instances—such as the possible collapse of the North Atlantic current (which carries heat north from the tropics and keeps Europe's climate temperate rather than Siberian)—our tinkerings with the planet's machinery could have shattering effects. Both the difficulty and cost of adapting would be high. At all scales, human survival is threatened by our reluctance to embrace sustainability.

Biodiversity

"So careful of the type she seems, so careless of the single life," said Tennyson of nature and her species. A century and a half later, however, science tells us that nature is careless with types as well. On average, a species persists for only 4 or 5 million years. It's estimated that several hundred million species have emerged since the Earth began, and most are gone.

Nature seems not to care that much about preserving biodiversity (the entire realm of existing species on the Earth). Why should we?

There are two general sorts of answer to this question. The *nonutilitarian* answer is that every species is intrinsically valuable, regardless of what humans think about it or do with it. People can be found at all points along this spectrum of reverence for other life, from the strip-mall developer knowingly obliterating a rare orchid in pursuit of profits, to the devout Jain sweeping the ground ahead of him so as to avoid treading on an ant. But this assertion carries at least some weight with most people, and rightly so: any species can be seen as a miracle of creation, whether you believe in God, Darwin, or both. In general, to wipe one out is certainly a tragedy and possibly a sin (although it's hard to argue with the 1992 World Health Organization commission that concluded, "there seems…little ground for pre-

Preah Palilay Temple ruins, Angkor-Siem Reap, Cambodia.

serving the human immunodeficiency, smallpox, or poliomyelitis viruses, malaria parasites, or guinea worm"). By this yardstick, sustainability means preserving as many species as possible and only permitting

Statue among overgrown trees, Bihac, Bosnia.

one to go extinct after the most profound reflection and debate, and for the most compelling of reasons.

The second kind of answer is the *utilitarian*, or instrumental, argument, which says that other species have value because they are useful. Philosopher Bryan Norton identifies two types of utilitarian value, *transformative value* and *demand value*. Other species possess transformative value if they provide occasions for us to examine, deliberate over, and revise our own values—that is, to grow as human beings. For instance, a hunter chasing a gazelle for his dinner might consider that the gazelle is running for its life. The hunter might further ponder the ethics of killing other animals so he can live, especially if he could have had rice or lentils instead. Transformative values can be important because humans are thinking and reflecting beings who can gain from the examined life, not just the mindless scratching of our various itches.

Other species have demand value for humans if they are useful in satisfying our needs and preferences. The gazelle, for example, has demand value (as food) to the hunter. Of course this only hints at the enormous range of biodiversity's demand values. The list of the "goods" and "services" other species of plants, animals, and microorganisms provide merely begins with oxygen, food, and fresh water. It also includes fuel, fiber, building materials, drugs and medicines, adornments and decorations, nutrient recycling, soil formation, erosion control, water control and recycling, pollination, waste absorption and recycling, and a number of others.

In other words, other species are indispensable as functional parts of the ecosystems we depend upon to sustain human life. And once survival is ensured, humans seek to improve the quality of their lives. Other species are also useful to that end, as sources of knowledge and amusement, companionship, recreation, artistic inspiration, and so on. For either survival or high quality of life, humans need other species. But how many?

No one can say for sure. About 1.4 to 1.8 million species have been named, though estimates of how many species actually exist range from 2 million to 100 million, with a best guess of perhaps 10 million. There are over 750,000 species of insects alone, and a quarter of a million flowering plants. Nature is the master of redundancy, however, and not all of these are necessary for the continued functioning of the global ecosystem. This is clear from the fossil record, which testifies that the larger system soldiers on while most species die out, one by one, over time. Endangered species make the same argument: their very rarity means they are generally (though not always) unimportant to the ecosystems they inhabit.

Stretching between these two facts—there are millions of species and some are functionally redundant—is a vast area of uncertainty. This brings us to some key aspects of how ecosystems work, and to the precautionary principle.

Ecology studies the most complex systems there are and is a relatively young science. Understanding of ecosystems is limited and still evolving. "There's a long-running debate in ecology," says Curtis Bohlen, a professor of environmental studies at Bates College in Maine: "Is an ecosystem something that matures over time, or is it a random assemblage of species that happen to be occurring together at the same time?" Ecologists' ideas have tended to shift over the last 20 years toward the latter view, and the shift has implications: "If these creatures have just been thrown together," says Bohlen, "maybe there's not that much to protect in terms of the whole unit."

The story of chestnut blight shows how major species loss can occur without compromising ecosystem function. The chestnut blight fungus arrived in New York on imported nursery stock around 1900. It raced through the hardwood forests east of the Appalachian Mountains, almost wiping out the American chestnut by 1950. The chestnut is a mast-producing tree (it makes nuts) and was the most important tree in those forests. But its devastation made almost no difference to the forests' functionality, because several other mast-producing species, including oak, hickory, and beech, remained abundant.

Lest this seem to give carte blanche to developers like the one mentioned earlier, consider the analogy of the riveted airplane. Ordinary aluminum light planes are held together by thousands of rivets. Given engineers' passion for redundancy, many of those rivets are

probably unneeded, and drilling one out will not likely cause serious harm. But keep subtracting rivets, and eventually some critical part will drop off.

The analogy isn't perfect, but it offers some important parallels to ecosystems:

Just as it may be hard to say which rivet is the critical one, ecosystems sometimes have keystone species whose loss can trigger the transformation of the system, even if it comes early in the subtraction process. But it may be unclear which, if any, of the species is a keystone. In a given ecosystem, the endangered species might be unimportant. In another, one might be critical. Species that appear redundant may actually have valuable but undiscovered functions.

When the wing goes, it does so suddenly and catastrophically, and heavily stressed ecosystems occasionally do so as well. However, they are more likely to transform from one state to a quite different state that retains some but not all of the original species. Ecosystems can have *multiple stable states*: in effect, different identities involving different collections of species, different levels of biological productivity, and so on. Changes from one state to another, especially if they take place on a large scale and we have come to rely on them in their original state, can affect the function and habitability of an ecosystem and thus human well-being.

If the wing falls off in flight, the damage is irreversible. Putting back the last rivet removed will not reattach the wing. Ecosystems losing species exhibit *hysteresis*, says Bohlen: "In going from complex to simple you go through one series of community types, but when going from simple to complex you don't retrace those steps. In other words, it may be very easy to go one direction but very hard to go the other." This has profound implications for the human response to loss of ecosystem function, because it is difficult or impossible to reverse the transformation. Simply restoring the most recently lost species won't necessarily work. If such losses are serious and widespread—as many scientists believe they already are, or will soon be—they could gravely compromise our planetary life-support system. At minimum, they would be extremely expensive to restore or replace. (One famous estimate of the value of global ecosystem goods and services, by ecological economist Robert Costanza and colleagues, yielded an estimated range of $18–62 trillion (2001 dollars) per year. The gross world product in 2001 was $47 trillion.

A final complication is the difficulty of predicting the course and consequences of ecosystem transformation. Ecologists can try to make predictions, but the uncertainties are so great that a crystal ball might do as well. As Stephen Carpenter, a freshwater ecosystem specialist at the University of Wisconsin-Madison, has written, "The future dynamics of ecosystems are contingent on drivers that are outside the domain of ecology, such as climate change, human demography, or globalization of trade. [The future behavior of these drivers] may be unknown or unknowable. Therefore the uncertainty of the ecological predictions cannot be calculated." Moreover, people are embedded in their ecosystems and affect their development, so that human action in response to any predictions could cause the predictions to be wrong.

In other words, we can guess, but we can't even tell how wild our guesses are. Carpenter adds that ecologists, more humble than many scientists, tend to use words like "projection" and "scenario" rather than "prediction" or "forecast," for just these reasons.

The only sensible response to this combination of high value and high uncertainty is "First, do no harm." In ecological terms, this is the precautionary principle: the uncertainty means we must be really, really careful. Maverick economist Nicholas Georgescu-Roegen put it this way: "Our policy toward natural resources in relation to future generations must seek to minimize regrets." That's why the current trend in the species count—rapidly downward—is so alarming. We humans are lethal to other species; we kill them directly, wreck their habitats, and introduce alien species that outcompete them. The result is that species extinction rates now vastly exceed the "natural" background rate. The rate appears to accelerate as species' original ranges are chopped up and converted to human uses.

It may be tempting to assume that, in 25 or 50 years when ecological knowledge has advanced far beyond current limits, we can then safely (if not morally) destroy any species thought to be superfluous or dangerous. Perhaps so. But human knowledge is always imperfect, and from the utilitarian standpoint it is foolish to break or discard a tool you might need some day. From the aesthetic/spiritual/nonutilitarian standpoint, further knowledge is likely only to increase the sense of awe with which we regard the natural world. Either way, the default rule ought to be preservation.

Equity

Imagine that you have been chosen to establish an entirely new island community, and that you alone get to decide how to organize the society. You can pick any government, any economic system, any division of resources that you want. The only condition is this: your place in society will be chosen at random. Would this change your answer? Would you choose a system in which most resources are controlled by a few? Or would you divide resources equitably in order to ensure your access to the community's wealth, whether you were part of the elite or the underclass?

On that island, as on Earth, the equitable distribution of resources plays a central role in social and eco-

logical health. Extreme inequity—immense disparities between rich and poor—has grown in the past half-century, within countries as well as among them, and now threatens the well-being of countless communities.

Collecting wood for charcoal, Sonoran Desert, Mexico.

According to the World Institute for Development Economics Research, income inequality increased in 48 of 73 countries surveyed between 1980 and the late 1990s. In the United States, for example, the richest 20 percent of the population earns 46 percent of the country's income, while the poorest fifth earns 5 percent. In Brazil, the richest fifth earns 64 percent of the country's income and the poorest fifth earns 2 percent. This trend may be starkest in the Brazilian city of São Paulo (population 18 million): while three million slumdwellers struggle to survive, corporate executives commute to work in helicopters and live in walled suburban communities to protect themselves from the increasing urban crime.

These inequities undermine sustainability in at least two major ways:

Health. A World Bank study of 44 developing nations revealed that infant mortality in the poorest fifth of the population averages about twice the level in the richest fifth. The weakness of public health infrastructures in impoverished countries (including substandard medical care, clean water access, and sanitation) allows outbreaks of infectious diseases, such as cholera and malaria, to spread unimpeded. Infectious diseases killed 14.4 million people in 2000, according to the World Health Organization (WHO). Of these deaths, three-quarters occurred in Africa and southeast Asia, which account for only 36 percent of the world's population.

Diseases can cripple entire regions, as HIV/AIDS has done in sub-Saharan Africa. Because HIV mainly targets the adult population, the epidemic has disrupted the economic and social system by killing off thousands of farmers, educators, laborers, and parents. AIDS has created 11 million orphans in Africa alone and is expected to create 9 million more by 2010. And we cannot pretend that an unstable Africa will affect only Africa: as the SARS outbreak recently revealed, underfunded public health systems can allow the spread of new, unknown diseases around the world. SARS turned out to be relatively containable and benign, but it still infected about 8,500 people, killed over 800, and cost an estimated $10–30 billion. A new bug, equivalent in lethality to the 1918-19 flu epidemic (perhaps 40 million dead) and spread around the world by jetliners at 500 miles an hour, could be catastrophic.

Security. Helicopter rides and gated communities may help shield the rich from the sight of poverty, but as World Bank President James Wolfensohn noted last year, the wall that divides the rich from the poor is imaginary. Terrorism is the reason du jour for the need to deal with extreme inequities, because resentment is a breeding ground for violence—whether as terrorism, crime, or military conflict. In São Paulo, kidnapping rich executives and their family members is a growing industry, according to news reports.

But inequity threatens the security of the poor as well as that of the rich. Impoverished local communities are often powerless to resist powerful government and business interests that recklessly exploit the areas where they live for short-term gain. In the Star Mountains rainforest of Papua New Guinea (PNG), for instance, the Ok Tedi Mine produces 70 million tons of tailings and rock each year, which are dumped directly into the Ok Tedi River. While the mine produces valuable metals and accounts for 10 percent of PNG's gross domestic product (GDP), the waste threatens over 2,000 square kilometers of the rainforest ecosystem and the health and food security of the indigenous tribes living along the river. Mining at Ok Tedi is enabled by a government regulation that immunizes the company from compensation claims. This keeps costs down, at least for the company (perversely named Sustainable Development Program Ltd.). But when the mine closes in 2010 or so, the company will walk away, pockets bulging with gold and other minerals, leaving the local tribes a poisoned river and a scarred landscape.

Ok Tedi is not an isolated tragedy; similar mining operations threaten nearly 40 percent of the world's large, untouched forests. Yet millions of tons of minerals are discarded each year, largely because the current economic system externalizes much of the ecological and social cost of mining by ignoring the degradation of communities and ecosystems, thus making it artificially cheaper to extract virgin minerals. Yet much of the resources we use could be recycled. Between 1990 and 2000, for example, Americans threw away 7

million tons of aluminum cans, enough to rebuild the world's entire commercial airfleet 25 times over. But instead of recycling discarded aluminum, which would use 95 percent less energy than smelting virgin aluminum, new mines were gouged out of pristine ecosystems, disrupting them and the communities that depend on them.

Inequity can also affect the security of larger regions and even the globe in general, by forcing the poor to overuse and degrade local environmental resources in ways that inflict broader effects on everyone, rich or poor. Many marginalized people, struggling with day-to-day survival, use the few resources they have inefficiently and unsustainably. While cheap and efficient solar cookers are available for cooking and water purification, lack of access to these or other clean sources of energy has forced millions to rely on wood, agricultural residues, or dung. Burning these resources contributed to 1.6 million deaths in 2000 through exposure to indoor air pollution, according to WHO data. It also increased deforestation, soil erosion, and depletion of farmland, further impoverishing the inhabitants and adding to global environmental pressures and increasingly frequent "unnatural disasters."

An example of the latter is Hurricane Mitch, which dumped as much as two meters of rain on Central America in 1999 and caused billions of dollars in damage. In Honduras, the damage was worsened by the development of fragile areas, such as the conversion of hillsides into farmland—an outcome of the fact that 90 percent of prime farmland is owned by 10 percent of the population. Eighty-two percent of the rural population now lives on and farms the hillsides. Such disparities amplify the effects of natural disasters, which have become more frequent over the last 50 years. They now afflict more than 200 million people each year and have produced 25 million environmental refugees—a number that is projected to double by 2010. Disasters also squander foreign development aid: every dollar spent on preventive measures could save seven in disaster recovery costs. Wiser use of these dollars could improve both the well-being of the most marginalized and the health of the most stressed ecosystems.

While the connection between equity and security is clear, governments' understanding of security remains myopically militaristic. In 2001, the world's military expenditures grew to $839 billion, yet illiteracy could be eliminated around the world for an annual cost of about $5 billion, clean drinking water provided for $12 billion, starvation and malnutrition eliminated for $19 billion, and soil erosion prevented for $24 billion. These would all go a long way toward improving global ecological security and societal stability, yet most governments failed to act. One notable exception was Brazil, which cut its military budget 4 percent in order to fund an ambitious anti-hunger program.

Addressing extreme poverty is essential, but it is only half of the equity problem. As Confucius observed 2,500 years ago, "excess and deficiency are equally at fault." Too much consumption is just as bad (or worse) for the environment as too little. Twenty percent of the world's people, the global consumer class, consumes 70 to 80 percent of the world's resources, and their excesses are leaving the world's ecosystems strained. The global carbon, nitrogen, and hydrological cycles have been radically altered, as much as half the Earth's land is transformed or degraded, and three-quarters of the world's fisheries are at capacity, overexploited, or depleted. The disappearance due to overfishing of 90 percent of the populations of large predatory fish is only the latest chapter in this sorry story.

As noted earlier, human consumption may already be drawing down resources 20 percent faster than the Earth can renew them. Globalization is spurring a rapid increase in the size of the global consumer class, driven by growing advertising expenditures and widening access to consumer credit. Yet if both too much and too little access to the world's natural and human-made wealth seem unsustainable, they are also unnecessary. Overconsumption involves a great deal of pointless waste, which could be eliminated. Moreover, it not only fails to proportionately improve well-being, it often is bad for the overconsumers, as we'll see in the next section. Attacking counterproductive overconsumption on these fronts would free up resources for the billions of people for whom raising consumption levels is necessary for a decent life.

Life Quality

In 2002, advertisers spent $451 billion to convince people that they would find happiness in the latest fad or fashion (especially the ones the advertisers were promoting). Often they succeeded. But more and more critics are challenging the high-consumption economic model, drawing attention to consumerism's failure to satisfy people and to the collateral damage it causes: declines in health, environmental quality, and social cohesion. At the heart of this debate is the ancient and much pondered question, What is the good life?

In our view, the definitions of sustainability and the good life are tightly interwoven. Prerequisites to both include human survival, ecosystem health, and some degree of social equity. Beyond those, what makes for a quality life? In defining development, the United Nations Development Programme says that it has to do with "creating an environment in which people can develop their full potential and lead productive, creative lives in accord with their needs and interests." If the consumer model is valid, perhaps this simply means

building more malls and McDonald's. However, we would invite mall- and fast-food fans to consider the growing evidence that goods alone cannot deliver the good life—even if there actually were enough resources to provide this lifestyle to all 6.3 billion of us.

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Abandoned police pickup truck, Umatac, Guam.

The United States, the richest nation in the world, increased its per capita gross domestic product (GDP) by 92 percent between 1970 and 2000. According to this index, Americans are nearly twice as well off now as they were 30 years ago. But GDP is blind to the social value of economic activity and simply adds up all the recorded expenditures. So the more spent on cleaning up toxic waste, housing prison inmates, or burning gasoline while trapped in traffic, the better. It also ignores all the beneficial activities not captured in the market, such as volunteer work, unpaid childcare, and housework. Factoring in these negatives and positives—as the NGO Redefining Progress does with its Genuine Progress Indicator (GPI)—paints a very different picture. In the same period that the GDP shot up 92 percent, the GPI stayed nearly flat, increasing only 4 percent (see figure). Indeed, social indicators suggest a *decline* in societal well-being over the 1970–2000 period. Income inequality rose 21 percent, teen suicides jumped 33 percent to 7.9 per 100,000 per year, and the number of Americans without health care increased from 11 percent to 14 percent of the population to a total of 40 million, according to the Fordham Index of Social Health. This index, which tracks 16 indicators, has declined 29 percent from 1970 to 2000.

The growth of total economic activity at the expense of social health reflects societal priorities, that is, the valuing of increased private consumption at the expense of essential public goods. John Kenneth Galbraith warned of this shift in 1958 in his ironically titled book *The Affluent Society*. In the United States, "public squalor," such as the weakening of the education and healthcare systems, paralleled rising private affluence.

This change turned out to be part of a larger societal shift that led to the conversion of the United States into the "consumer republic" it is today. Harvard professor Lizbeth Cohen argues that the transformation began with the mobilization of the post-World War II economy for domestic consumption and has climaxed with the current almost pathological fixation on ever increasing consumption, even at the expense of personal and social well-being—a condition many critics term "affluenza."

In the United States, affluenza is reflected in its many symptoms:

High levels of debt. In 2000, the average U.S. household held $7,500 in credit card debt, and over a million Americans filed for bankruptcy.

Increasing work stress. The average American works more hours than people in any other nation, and more of these hours fall on nights and weekends, disrupting sleep schedules and reducing time available with family and friends.

Declining physical health. Overweight and obesity, abetted by poor diet and sedentary lifestyles, now affect 61 percent of the adult population and contributed to 300,000 deaths in 2001—second only to tobacco.

Affluenza is not confined to the United States. Through the promotion of staple consumer products like cigarettes and Coca-Cola, it is compromising the health and well-being of billions worldwide. Lifestyle diseases, such as cardiovascular diseases and cancers, caused more than 42 percent of the 55.7 million deaths in 2000. These diseases weighed disproportionately on the industrial world, where consumption levels are highest. According to a WHO analysis, smoking contributed to 4.9 million deaths in 2000, overweight and obesity to 2.6 million, and physical inactivity to 1.9 million. About half of all these deaths occurred in industrial nations, even though they accounted for just 24 percent of total deaths and 22 percent of the global population.

But aren't these just acceptable side-effects of a culture that, overall, most people find deeply satisfying? Nearly 30 years ago, research by economist Richard Easterlin led him to conclude that "economic growth does not raise society to some ultimate state of plenty. Rather, the economic growth process itself engenders ever-growing wants that lead it ever onward." Since then, psychologists have extended this thinking in studies of the sources of human contentment, which reveal that once basic needs are met, wealth improves life satisfaction very little. This finding holds true both at the individual and national levels and is due mainly to constantly shifting perceptions of "needs." While telephones, air conditioners, and automobiles have been around for an eyeblink of history, they already have the feel of neces-

sities (at least for those who own them).

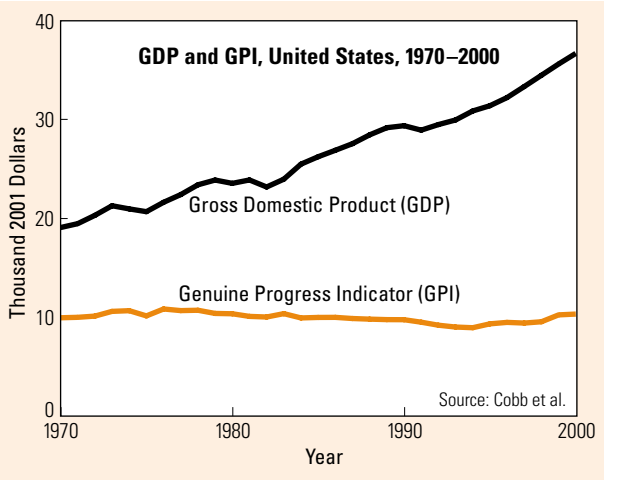
The most affluent often don't even realize they're rich. According to the 2002 RoperASW survey "Affluent Americans and Their Money," only 20 percent of a sample of 1,767 Americans in households earning over $75,000 considered themselves "affluent." Fifty-eight percent were at least $100,000 in debt and 85 percent of them worried about money at least occasionally (40 percent worry "all the time"). More than three out of four said they'd need at least a million dollars to consider themselves affluent. This group, the most affluent 24 percent of the richest country in the world, seems still unsatisfied with their wealth. Even if one achieves sudden and overwhelming wealth, it doesn't seem to help; psychological studies of lottery winners reveal that they adapt to their new levels of affluence, settling back to original levels of satisfaction after an initial burst of euphoria.

If the sense of affluence is so ephemeral, perhaps the consumer model, which promises satisfaction through increased consumption, is not the best path to a quality life—especially if its effects on social health and the environment are considered. This is not to say that there are no benefits to the consumer society. But there are alternative models that may help redirect society towards a more satisfying, equitable, and ecologically harmonious path.

Reducing the public squalor that Galbraith long ago warned of would significantly improve the life quality of millions. In the United States and France, child poverty rates are both about 25 percent. However, after government-provided payments and services are factored in, child poverty drops to 7 percent in France, while in the United States it remains at over 20 percent. While these statistics highlight a serious equity issue, when one in five children lacks adequate nutrition, healthcare, and education—when basic needs are not met—it becomes a life quality issue as well.

Sweden, which has been ranked as the most equitable nation in the world, may also provide some insights. Rather than unrestrained private affluence, Swedish social policy emphasizes public goods, providing universal health care, generous unemployment benefits, and practically free university education. Sweden uses significantly more resources than the global average, but its per-capita ecological footprint is still 31 percent smaller than the U.S. footprint, even though Swedes' standard of living is at least as high (perhaps higher, if measures of social health are included). Critics may rage that public goods depend on government spending and thus on taxation. But as *New York Times* columnist Thomas Friedman recently explained, there would probably be less revulsion if the word "services" replaced "taxes." Since all people, rich or poor, have access to public services (unlike private wealth), slogans like "read my lips, no new services" might be sneered rather than cheered.

Another lesson comes from the villages of Sri Lanka. Started in one village in 1958, the Sarvodaya Shramadana movement has now spread to over 12,000 (more than half the villages in Sri Lanka). Organized around an ideal of "no poverty, no affluence," villagers work mutually to provide not just for their communities' most basic needs, but also opportunities to live lives they value, improving education, healthcare services, and environmental quality.



Sarvodaya and its philosophy of sufficiency and shared labor may provide a model for both individuals and nations as they choose a development path. The consumer model is just one path among many. Considering there are multiple paths to fulfillment and consumerism is so ecologically costly, maybe we should look more closely at the examples of living sufficiently that Sarvodaya and Sweden offer. Sufficiency is a lesson that has been taught at least since the 3rd century BCE, when Lao-Tzu mused that "he who knows he has enough is rich." Perhaps it is time to reawaken this wisdom.

Conclusion

We began with a story about the fate of an isolated habitat, and we end with another that may also be familiar to many readers. Easter Island is a speck of land in the Pacific Ocean 2,000 miles off the Chilean coast. This remote place and its people have been intensely studied for years, for Easter Island today bears little resemblance to the island settled by voyaging Polynesians over 1,500 years ago. The island's dramatic story tells us a great deal about sustainability.

When the new arrivals beached their ocean-going canoes, they found a lushly forested place offering several valuable tree species, including large palms suitable

for building canoes and timber-framed dwellings. For food, the settlers had brought chickens (deliberately) and rats (inadvertently), but the island also teemed with edible birds. Dolphins, seals, and the crops typical of Polynesian culture—bananas, taro, sweet potatoes, and sugarcane—rounded out the settlers' diet. They thrived on the island's abundance and their numbers eventually grew to perhaps 7,000 (20,000, by some estimates). A sophisticated hierarchical culture emerged, wealthy and organized enough to produce the island's remarkable stone statues. Hundreds of these sculptures were carved over the centuries, and more than 200, some weighing over 80 tons, were raised up onto stone pedestals.

But the Easter Islanders' success triggered their undoing. Generations of harvesting trees for building, making rope, and for fuelwood—and of seed-eating by the stowaway rats—led to complete deforestation. (When the Dutch explorer Jacob Roggeveen first saw Easter Island in 1722, it was a shrubby grassland.) The spiraling competition among clans to build and raise ever-larger stone statues, which required a lot of timber for rollers and other simple machines, took a particularly heavy toll. Pollen analysis suggests that the last of the great palms was cut down around 1400. Bird nesting grounds were destroyed along with the forest; that and direct consumption drove every native landbird species to extinction. As the trees disappeared, so did the means to build the traditional big canoes. Fish and dolphins from deeper offshore waters could no longer be harvested (and escape or migration to other islands became impossible). Firewood supplies dwindled and streams dried up. Soils eroded and became less fertile.

In short, the island's carrying capacity plummeted. Food surpluses disappeared, leading to cannibalism. With the surpluses went social complexity. Eventually the population crashed by 75 to 90 percent and the culture devolved. Roggeveen found perhaps 2,000 people on the island, living in "singular poverty."

As Jared Diamond, Clive Ponting, and other writers have observed, Easter Island is a potent warning. Four lessons seem obvious:

• Human beings respond strongly to incentives to overuse resources. During most of our evolutionary history, everything we needed was abundant. We seem wired to use it up and find something else rather than regulate ourselves to stretch and conserve resources over long periods.

• We have great difficulty noticing when things are going wrong, unless it happens over relatively short periods. Gradual changes, even if noticed, are likely to be shrugged off and adapted to. Bounty is taken for granted, especially by those societies (such as the rich North) in which the hallucination of limitless wealth is sustained by importing carrying capacity from elsewhere. But the Easter Islanders didn't have the illusory comfort of imports, and they still drove their culture into the ground. Social patterns and ways of perception die hard. As Diamond has written, by the time the last tree was cut, trees would have been scarce for many years and nobody would have thought it alarming.

• Declining resource availability can undermine the very organizational structures and capacities needed to fashion a response. This is crucial: as noted above, we are well suited biologically to perceiving and responding to short-term threats but not to long-term ones. Culture, including our social organizations, social learning, science, and politics, is our only defense against the latter.

• The failure of the Easter Island culture to grasp what was happening to it led, not to its extinction, but to its radical impoverishment and simplification—in terms of numbers, capacity to act, biodiversity, wealth, and cultural richness.

Was Easter Island culture sustainable? People still live there, after all. The answer isn't worth quibbling over; it simply hinges on one's definition of sustainability. If it incorporates (as the authors' does) the notion that human communities and cultures should thrive and not just survive, Easter Island fails the sustainability test. The islanders' unwitting assault on the foundation of their tropical paradise led implacably to the loss of biodiversity and life quality (and possibly equity too, but not enough is known of the social structure to say) as the island's ecosystem was simplified.

There is no particular reason that this process cannot repeat itself on a global scale. In fact, that is precisely what seems to be happening. Unlike the islanders, however, we have no excuses. We can't plead ignorance—Easter Island and many other examples show clearly what happens to cultures that are incautious about natural constraints—or blindness: our science enables us to see changes that are imperceptible to a single generation. (Science will also improve our meager understanding of the immensely complex natural systems we live in and lead to improved quantitative measures of sustainability.)

Most important, we know that a sustainable global human society is imperative and what must be done to move toward it. In this context what usually comes to mind are familiar solutions such as solar, wind, and hydrogen energy technologies; habitat and species protection; control of our own consumption and population—all of which environmentalists have been urging for years. These share a deference to the cyclical character of the Earth's systems and the need to harmonize the human economy with them. Since the industrial revolution, we have increasingly ignored or altered the natural cycles—carbon, nitrogen, hydrological—that replenish these systems. The resulting explosion in eco-

nomic output has come at the cost of the long-term and dangerous depletion of natural capital. The costs by now are as familiar as the solutions: by relying heavily on nitrogen fertilizer instead of organic farm waste, for instance, we have reduced the fertility of agricultural lands and created enormous dead zones in our oceans and rivers. Our vast and accelerating logging operations and ubiquitous dependence on fossil fuels have increased atmospheric carbon concentrations to levels never seen before. By diverting or damming rivers, we've dried out seas (or created new ones), changed local weather patterns, and disrupted entire ecosystems.

We know this cannot go on. Returning to a cyclical system—harvesting renewable resources sustainably, reusing and recycling materials in preference to mining virgin ones, rebuilding and nurturing agricultural soils, weaning ourselves off of fossil fuels, and so on—along with respectful husbanding of biodiversity, will start us down the path of material sustainability. Giving due and purposeful attention to the inequities that lock billions into wretched poverty and undermine the security of all will start us toward social sustainability.

Together these movements amount to a revolution. Those opposed to change may cast this future as one of short rations, belt-tightening, and general deprivation. On the contrary, thriving human communities such as those that have embraced the Sarvodaya principles, as well as millions of individuals the world over who have adopted sufficiency as their touchstone, are proof that human well-being, connection, and contentment are achievable without consumerism, mass advertising, planned obsolescence, heedless and destructive waste, or the endless pursuit of profits—and without a single trip to the mall.

Ta Prohm Temple ruins, Angkor-Siem Reap, Cambodia.

Only the prospect of a truly sustainable culture offers the universal possibility of human fulfillment. It is the business-as-usual course that leads inexorably to a sad future of inequity, strife, natural and economic impoverishment, suffering, and cultural decline—a future made all the more bitter by the knowledge of superior choices foregone and forever lost.

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