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FOR PEOPLE, NATURE, AND THE ECONOMY

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ECOLOGICAL FOOTPRINT OF NATIONS NOVEMBER 2002 UPDATE

HOW MUCH NATURE DO THEY USE? HOW MUCH NATURE DO THEY HAVE?

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This Ecological Footprints of Nations 2002 issue brief reports on the ecological impact of 146 nations. These countries include nearly 100 percent of the world's population. The issue brief shows to what extent a nation's resource consumption can be supported by its ecological capacity. It also illustrates the degree to which a nation could reproduce its consumption at a global level. These accounts document that humanity exceeds the Earth's biological capacity by 20 percent. Many nations, including the United States, are running larger ecological deficits. In spite of technological advances, an increasing human population with a growing appetite for resources continues to exacerbate the global ecological deficit. As a consequence of this overuse, the human economy is liquidating the Earth's natural capital. After introducing the rationale and assessment method for these ecological accounts, this report explains how this analysis can help to build a sustainable future.

WHY MEASURE OUR USE OF NATURE?

THE 1992 EARTH SUMMIT CHALLENGED HUMANITY TO reduce its impact on the Earth. Ten years later, we live in a riskier world with more consumption, waste, people, and poverty—but with less biodiversity, forest area, available fresh water, soil, and stratospheric ozone.[1]

We all know that we have moved further away from sustainability. *But how far?*

If we cannot measure, we cannot manage. To make sustainability a reality, we must know where we are now, and how far we need to go to reach the goal.

Any financially responsible household, business, or government uses accounts to keep track of its spending and income. Similarly, to protect our natural assets, we need accounts to keep track of humanity's demands on nature and nature's ecological resource supply.

Ecological Footprint accounts, as developed by Redefining Progress' Sustainability Program team, provide such a sustainability bookkeeping framework.

Ecological Footprint accounts can help us track our ecological expenditures. They also can help us get our ecological spending frenzy under control and avoid ecological bankruptcy.

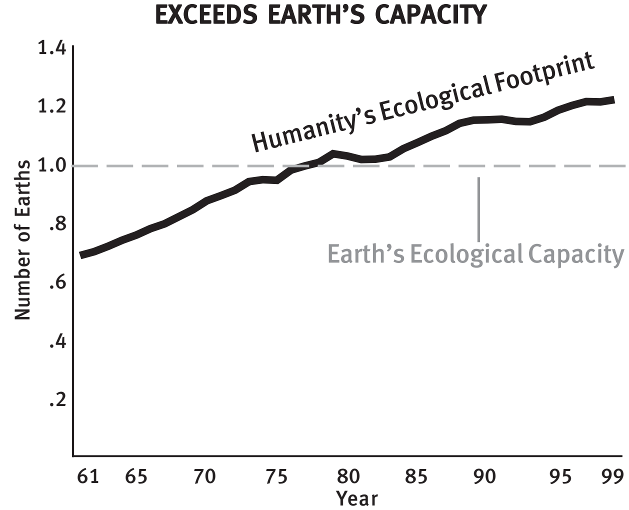
By assessing our ecological bottomline, these Ecological Footprint accounts can help people, businesses, and governments react in time to secure our well being.

ECOLOGICAL FOOTPRINT ACCOUNTS

ECOLOGICAL FOOTPRINT ACCOUNTS PROVIDE A CONSERVATIVE estimate of humanity's pressure on global ecosystems. They represent the biologically productive area required to produce the food and wood people consume, to supply space for infrastructure, and to absorb the greenhouse gas carbon dioxide (CO_2) emitted from burning fossil fuels.

The Ecological Footprint is expressed in "global acres." Each global acre corresponds to one acre of biologically

TODAY'S ECOLOGICAL FOOTPRINT EXCEEDS EARTH'S CAPACITY



Humanity's consumption and waste production today exceed the Earth's capacity to create new resources and absorb waste. We are currently liquidating natural capital to support current resource use, reducing the Earth's ability to support future life.

BOX 1

SUSTAINABILITY AND PEOPLE'S USE OF NATURE

We will achieve sustainability when everyone can lead a satisfying life within the Earth's biological capacity. Not living within our ecological means will further the destruction of humanity's only home.

Having insufficient natural resources and living in an unsatisfactory and inequitable way exacerbates tensions, degrades our social fabric, and can turn current quarrels into violent disputes.

We need to monitor whether we are living within our ecological means. To advance sustainability, we also need to know whether peoples' quality of life improves over time.

Ecological Footprint accounts measure nature's supply and compare it to the demands placed on nature by humanity, nations, or households.

After all, people are part of nature, and depend on its steady supply of the basic requirements for life: energy for heat and mobility; wood for housing, furniture, and paper products; fibers for clothes; quality food and water; ecological sinks for waste absorption; and many other life-support services.

This use of nature is measured in this report, nation by nation.

productive space with world average productivity. (An acre is approximately the size of an American football field without its end zones.)

[In metric measurement, the Ecological Footprint is expressed in global hectares. A hectare is 2.47 times larger than an acre. In this report, the hectare equivalent size will appear in brackets.]

Since people use resources from all over the world, and affect faraway places with their pollution, the footprint is the sum of these areas wherever they are on the planet.

The world's Ecological Footprint changes in proportion to global population size, average consumption per person, and prevailing technology's resource intensity. Technology can alter land productivity or the efficiency with which resources are used to produce goods and services.

The footprint calculations are conservative estimates of human impact because they do not include inherently unsustainable activities such as PCB pollution or biodiversity loss.

The calculations also assume that the technologies used in resource extraction are the average of those prevailing in the world today. They do not, however, measure the sustainability of the extraction methods practiced. This may distort the size of some countries' footprints, but does not affect the global result.

Ecological Footprint Assumptions

Ecological Footprint analysis measures the amount of the world's biological productivity an individual or a country uses in a given year. The analysis is primarily based on data published by United Nations (U.N.) agencies and the Intergovernmental Panel on Climate Change (IPCC).

The method achieves this result by measuring the biologically productive land and water area required to produce the resources consumed and to assimilate the wastes generated using prevailing technology.

This area, called the Ecological Footprint, represents the fraction of the biosphere necessary to maintain the current material throughput of the human economy under current management and production practices.

Ecological Footprint calculations are based on five assumptions:

BOX 2

THE FOOTPRINT OF NONRENEWABLE RESOURCES, TOXIC SUBSTANCES, AND WATER

Nonrenewable resources from the Earth's crust are included in these accounts only to the extent that their use damages the biosphere (for instance through the mining, processing, and burning of fossil fuels).

We classify these nonrenewable resource stocks as economic rather than ecological assets because they do not add to the biosphere's ecological biocapacity. These assets appear in the CO_2 (carbon dioxide) component of our accounts according to the amount of embodied energy used in their production.

Two significant categories of human demands on nature are not included in the present footprint accounts: the use of freshwater and the release of solid, liquid, and gaseous waste (apart from CO_2).

Freshwater collection and waste assimilation can be secondary functions of land areas, but in many cases they are not. In arid parts of the world where water is a limiting factor, water use competes directly with other primary ecosystem functions.

Similarly, excessive waste emissions can compromise primary ecosystem functions. However, insufficient data prevents their inclusion in the Ecological Footprint, leading to an underestimate of humanity's true impact on the planet.

1. It is possible to keep track of most of the resources people consume and the wastes they generate.

2. Resource and waste flows can be converted into the biologically productive area required to maintain these flows.

3. Different types of biologically productive areas can be expressed in the same unit once they are scaled proportionally to their productivity. In other words, each acre [hectare] of cropland, pasture, forests, and fisheries can be expressed in an equivalent area of world-average productivity.

4. Since these areas represent mutually exclusive uses, and each standardized acre [hectare] represents the same amount of productivity, they can be added up to a total. This total represents humanity's demand.

5. The area for total human demand can be compared with nature's supply of ecological services, which may also be expressed in standardized units of productivity.

The results underestimate human impact and overestimate the available biological capacity by:

- Counting each area only once, even if the area provides two or more ecological services.

- Choosing the more conservative estimates when in doubt.

- Including current agricultural practices as if current industrial yields would not cause any significant long-term damage to the soil productivity.

- Leaving out some human activities for which we have insufficient data.

- Excluding activities that systematically erode nature's capacity to regenerate. These include uses of materials for which the biosphere has no significant assimilation capacity. Examples include: plutonium and other radioactive elements associated with nuclear energy production, polychorinated biphenyls (PCBs), chlorofluorocarbons (CFCs), or processes that irreversibly damage the biosphere (e.g. species extinction, aquifer destruction, deforestation, and desertification).

The Ecological Footprint measures a nation's resource consumption by adding imports to, and subtracting exports from, domestic production. To put it in mathematical terms:

apparent consumption = production + imports – exports.

We compute this balance for hundreds of categories, including cereals, roundwood, fishmeal, coal, and cotton. These resource uses are translated into global acres [hectares] by dividing the total amount consumed in each category by its ecological productivity (or yield). In the case of CO_2 emissions, the total is divided by the forests' assimilation capacity.

Some of the resource and waste categories are primary resource uses (such as raw timber or soybeans), while others are manufactured products that are derived from the primary ones (such as paper or soybean oil). For example, if one ton of pork is exported, the amount of cereals and energy required to produce this ton of pork is translated into a corresponding biologically productive area and then subtracted from the exporting country's footprint. This amount is added to the importing country's Ecological Footprint.

Updated Methodology

Due to their global and comprehensive nature, Ecological Footprint accounts are dynamic and constantly evolving—both in terms of the quality of the data and refinements of the methodology.

Following the release of the previous *Ecological Footprint of Nations* report, several significant improvements have been made that have an impact on the numbers used by Ecological Footprint practitioners.

The initial impetus for overhauling the footprint accounts was improved data availability, principally from the United Nations' Food and Agriculture Organization's (FAO) directly downloadable electronic "Food Balance Sheets."[2]

In the earlier accounts, agricultural production statistics were separate from trade statistics, making it hard to assess which production categories corresponded to which trade categories. Units for production (generally in metric tons) were also difficult to equate with trade figures reported in dollars. The FAO has subsequently made all of its statistics available in tons.

Earlier electronic databases were inconsistent and unreliable, making it necessary to enter data from printed material. This tended to be time consuming, error-prone, and analytically limiting. With the advent of consistent and reliable online FAO databases, the current footprint accounts import data electronically, permitting calculations for each country to occur in a standardized data table.

The automation of the data has allowed the data tables to expand from about 400 rows and 30 columns to approximately 2,000 rows and 80 columns per country.

The Bioproductive Areas of the Ecological Footprint

The accounts include six types of bioproductive areas used to support the human economy:

- Cropland for the cultivation of food, animal feed, fibre, oil crops, and rubber
- Grazing land for producing meat, hides, wool, and milk
- Forests for harvesting timber, fuelwood, and wood fibre for paper
- Fisheries for catching fish
- Built-up areas for accommodating infrastructure for housing, transportation, and industrial production
- Forests to sequester CO_2 from fossil fuels or to replace fossil fuels with biomass

Once the human impacts are expressed in the standardized global acres [hectares], these footprint components are added together. It is possible to compare the Ecological Footprint of a population with the biological capacity that is available to that population. In 1999 there were 28.2 billion global acres [11.4 billion global hectares] of biologically productive land on the planet, covering roughly one-quarter of the Earth's surface.

These uses include:

Growing crops occupies about 3.7 billion acres [1.5 billion hectares] of the most productive land worldwide. The cropland accounts include 74 crops and 15 secondary products—more than triple earlier accounts—and report details on how food crops are used (waste, seeds, feed, food, processing), traded, and stored.[3] We have added data on fodder and forage crops, including alfalfa, mixed grasses, and clover.

In addition, each nation has country-specific efficiencies for transforming primary inputs of resources into final products, an improvement on universally applied global averages. These accounts document the area occupied to cultivate crops and omit impacts from unsustainable agricultural practices, such as long-term damage from topsoil erosion; salinization; and contamination of aquifers with agro-chemicals.

Grazing livestock requires grassland and pasture, of which 8.6 billion acres [3.5 billion hectares] exist worldwide.[4] Past pasture assessments were not as accurate due to difficulties and ambiguities in the classification of pasture areas. The FAO had stopped reporting pasture areas, but has since resumed their publication. We have also been able to refine the analysis of the grazing footprint by assessing the percentage of livestock energy requirements derived from concentrate feeds, forage crops, and crop residue and by estimating national grassland and pasture productivities from biome primary production data.[5]

These advancements permit an initial investigation into grazing pressures. Reliability, datasets, and methodology still require improvement. Datasets detailing the carrying capacity of global pastures would greatly facilitate these revisions. The paucity of pasture data is surprising considering its economic importance and relevance to food security. Until such data become accessible, we will continue to estimate grazing pressure from the metabolic requirement of livestock populations and grassland productivity.

Harvesting timber for lumber and paper and gathering fuelwood requires natural forests or human-made plantations. Worldwide natural forests and forest plantations constitute 9.4 billion acres [3.8 billion hectares], according to FAO's most recent survey, the *Forest Resource Assessment 2000*.[6] While the report is criticized for overstating the health of global forests and underestimating deforestation rates, we believe this dataset lends credibility to the Ecological Footprint accounts by providing a conservative forest pressure assessment.

Estimates of timber productivity are derived from the United Nations' Economic Commission for Europe's (UNECE) *Temperate and Boreal Forest Resource Assessment 2000* and data from the Intergovernmental Panel on Climate Change (IPCC). These sources have also introduced additional information on plantation type, coverage, timber yield, and areas of protected and economically inaccessible forest.[7,8]

Consumption figures for timber and fuelwood come from FAO.[9] Fuelwood's footprint is calculated using timber growth rates that are adjusted upward to reflect that small branches and trees are used in addition to commercially harvestable timber, and that less mature forests can be used for fuel wood production.

Fishing fleets concentrate their activities on a relatively narrow portion of the ocean located on continental shelves. Excluding inaccessible or unproductive waters, these include 4.9 billion acres [2.0 billion hectares]. Although a mere fraction of the ocean's 89.7 billion acres [36.3 billion hectares], these 4.9 billion acres [2.0 billion hectares] provide 95 percent of the marine fish catch. Inland waters consist of an additional 0.7 billion acres [0.3 billion hectares], making for 5.7 billion acres [2.3 billion hectares] of potential fisheries out of the 90.4 billion acres [36.6 billion hectares] of ocean and inland water that exist on the planet.

We used FAO fish catch figures and compared them with FAO's "sustainable yield" figure of 93 million tons per year.[10,11,12] The accounts include both fish catch for fishmeal as well as fish for direct human consumption. We also assumed an additional bycatch according to the species composition of national fish catches, except for Norway, where fishing vessels are required to land their bycatch.

Major changes from earlier accounts include: (a) taking into account the trophic level of a nation's fish catch; (b) a revision in the premise behind the standardization of ocean productivity to land productivity; (c) the inclusion of widely divergent productivities and areas of the various continental shelves for the allocation of biocapacities; and (d) the inclusion of freshwater and aquaculture.

Higher trophic level fish consume a far greater portion of the ocean's primary productivity than lower trophic level fish—roughly a 10 times difference for each trophic level.[13] Whereas the footprint was formerly proportional to the tonnage of caught fish, it is now a function of tonnage and trophic level. Thus, a ton of cod at trophic level 4 has a footprint 10 times greater than a ton of sardines at trophic level 3.

SUMMARY OF THE UNITED STATES' ECOLOGICAL FOOTPRINT

Ecological Footprint Component	Global Acres per capita
Fossil fuels/nuclear power	14.5
Built-up area	0.9
Growing crops	3.7
Grazing animals	0.8
Producing wood	3.3
Harvesting fish and other sea food	0.8
ECOLOGICAL FOOTPRINT TOTAL	**24.0**

Biocapacity Component	Global Acres per capita
Built-up area	0.9
Cropland	4.4
Pasture	3.1
Forests	3.5
Fishing grounds	1.1
BIOCAPACITY TOTAL	**13.0**
ECOLOGICAL DEFICIT	***10.9***

(numbers may not add due to rounding)

Previously, we converted fisheries into standardized units of productivity, or global acres [hectares], by comparing the cropland area demand per unit of poultry meat with the marine area demand for its energy equivalent in the form of mackerel.

We have updated this method in order to better reflect the continental shelves' potential to support human populations. The new method compares the ability of pastures to provide food energy with that of oceans, greatly boosting seafood's importance in the accounts.

Earlier accounts based fishing areas on national Exclusive Economic Zones (EEZ), under the assumption that all waters are equally productive. We have since adjusted the productivity of national waters according to the estimated maximum fish catch of 26 shelf zones.[14] We have also replaced the EEZ with inland water and continental shelves to obtain a far more accurate distribution of global fishing capacity. The diminished fishing area—from 7.7 billion to 5.7 billion acres [3.1 billion to 2.3 billion hectares]—consequently reduces the global footprint and biocapacity, introducing the largest source of change into the accounts.

ACCOMMODATING INFRASTRUCTURE for housing, transportation, industrial production, and capturing hydroelectric power occupies roughly 0.7 billion acres [0.3 billion hectares] of built-up land. This space is the least well documented, since low-resolution satellite images are not able to capture dispersed infrastructure and roads. We assume that built-up land replaces cropland, as most human settlements are located in the most fertile areas of a country.[15,16]

BURNING FOSSIL FUEL can be translated into a bioproductive area through CO_2 sequestration or biomass energy replacement. Burning fossil fuel adds formerly locked away carbon to the atmosphere.

We calculate the fossil fuel footprint by estimating the biologically productive area needed to sequester enough carbon emissions to avoid an increase in atmospheric CO_2. Since the world's oceans absorb about one-third of the CO_2 emissions from fossil fuel combustion, we account only for the remaining two-thirds, based on each year's capacity of world-average forests to sequester carbon.[17,18] This capacity is estimated by taking a weighted average across 26 forest biomes.[19,20,21,22]

Sequestration capacity may change as the atmospheric CO_2 level and global temperature increase over the next century. Alternatively, the fossil fuel footprint can be calculated by determining the amount of biologically productive area that, left alone, is able to replace the consumed energy. This approach, using fuel wood as nature's energy currency, leads to roughly the same area requirements.

BOX 3

BIOLOGICALLY PRODUCTIVE AREAS OF THE PLANET

The Earth has a surface area of 126 billion acres [51.0 billion hectares], of which 90.4 [36.6] billion are ocean and inland waters and 35.6 [14.4] billion are land. Only 22.5 billion acres [9.1 billion hectares] of land and 5.7 billion acres [2.3 billion hectares] of water provide economically useful concentrations of resources to be considered biologically productive. The remaining 97.8 billion acres [39.6 billion hectares] are marginally productive or unproductive for human use, as they are the deep oceans, are covered by ice, or lack fertile soils and accessible water.

Both methods to calculate the energy footprint yield similar results, as they represent different pieces of the carbon cycle: the assimilation of carbon from atmospheric CO_2 via photosynthesis stores the same energy released when carbon is reoxidized via combustion.

The advantage of the sequestration method is its sensitivity to the carbon intensity of fuels and its link to the prominent CO_2 debate. However, sequestration through afforestation is an insufficient long-term solution because of the magnitude of the area required and the diminished capacity of mature forests to absorb CO_2. The advantage of fuelwood equivalence is simplicity and, to some degree, relevance as an alternative energy source.

THE ECOLOGICAL BENCHMARK: BIOLOGICAL PRODUCTIVITY OF THE PLANET

A simple division tells us how much nature there is per global citizen. With a bioproductive space of 28.2 billion acres [11.4 billion hectares] and a world population of 5.9 billion people in 1999, existing biological capacity averages to 4.7 global acres [1.9 hectares] per person. This is less than the capacity of 13.0 global acres [5.3 hectares] per American that exists in the United States.

If we assume, for the sake of argument, that 12 percent of all biologically productive space should be left undisturbed for other species, the available space per person worldwide shrinks from 4.7 to 4.1 global acres [1.9 to 1.7 hectares]. These 4.1 global acres [1.7 hectares] become the ecological benchmark figure for comparing peoples' Ecological Footprints.

This is the mathematical average size of the current ecological reality. Therefore, with current population numbers, sustainability would require reducing the average footprint to this size. Some people may need more due to their particular circumstances—but to compensate, others must therefore use less than the average amount available. Assuming no further ecological degradation, the amount of available biologically productive space will drop to 2.8 global acres [1.1 hectares] per capita once the world population reaches its predicted 10 billion. If current growth trends persist, this will happen in about 30 years.

Comparing Footprints to Available Ecological Capacity

The 4.7 global acres [1.9 hectares] that exist per person in the year 1999 can be compared directly with people's demand on nature—their Ecological Footprint. Table 1 (starting on page 9) summarizes the results.

The first two number columns show the countries' population and per capita Ecological Footprint. The footprint data of the 146 analyzed nations indicate their respective ecological impact worldwide.

A 16.6 global acre [6.7 hectare] footprint, the Swedish average, means that 16.6 global acres [6.7 hectares] of biologically productive space (with world average productivity) are in constant production to support the average Swede. Compared with the available 4.7 global acres [1.9 hectares] per world citizen, this footprint occupies three times more ecological space than what is available. Countries with footprints less than 4.7 global acres [1.9 hectares] per person have a global impact that, if carefully managed, could be replicated by everybody without putting at risk the planet's long-term ecological capacity.

However, some countries are particularly well endowed with ecological capacity. As a consequence, they may be able to sustain their citizens at a higher level of resource throughput.

We measure the extent to which this is possible by comparing their Ecological Footprint (second number column of Table 1) with their biologically productive space, including the share of land and sea space, expressed in units of world-average productivity (third number column of Table 1).

For example, Austria contains 2.5 acres [1.0 hectares] of land per citizen. About 10 percent of this area are too

BOX 4

ECOLOGICAL DEFICITS

The Ecological Footprint measures how much ecological capacity we occupy. Some regions claim more ecological capacity than exists within their boundaries. This means that they run a regional ecological deficit. Consequently, they need to import their missing ecological capacity—or deplete their local natural capital stocks. Regions with footprints smaller than their capacity are living within their territory's ecological means. Often, however, the remaining capacity is used for producing export goods rather than keeping it in reserve.

mountainous and inhospitable to support high rates of photosynthesis. The remaining 2.3 acres [0.9 hectares], however, are bioproductive and suitable for crops, grazing or forestry. This bioproductive area corresponds to 6.8 global acres [2.8 global hectares] per person (as shown in Table 1), indicating that Austria's bioproductive land has currently a productivity three times greater than the average bioproductive area on the planet.[23]

If the footprint exceeds the available biologically productive area of the country, it runs a national ecological deficit (fourth column of Table 1). In this case, the country's area alone cannot provide sufficient ecological services to satisfy its population's current patterns of consumption.

This comparison shows that this existing per capita capacity is only one-fifth of what is necessary to accommodate the 24.0 global acre [9.7 hectare] footprint of an average American and less than one-third of the 11.6 global acre [4.7 hectare] footprint of an average German (see Table 1). Even at the much lower world average footprint of 5.6 global acres [2.3 hectares] per person, humanity as a whole is exceeding the biospheres' capacity by about 20 percent.

In other words, according to our conservative Ecological Footprint calculations, the biosphere needs about one year and three months to renew what humanity consumes in one year.

Humanity is, as a result, consuming the Earth's natural capital stock. The bottom line for sustainability thus becomes: "*How can each person have a satisfying life within the average of 4.7 global acres [1.9 hectares] per person or less?*" This is the most significant challenge for research, business, and politics.

PRACTICAL POLICY APPLICATIONS OF FOOTPRINT ACCOUNTS

RECOGNIZING ECOLOGICAL LIMITS AND THEIR SOCIAL EQUITY implications has direct governmental implications.

Detailed Ecological Footprint accounts allow policy analysts to more effectively monitor ecological deficits and their links to competitiveness, improve management of common assets, predict potential security threats arising from scarcity, and better identify and test the future viability of policy options.

More specifically, these accounts show the importance of addressing the current population dynamic to avoid future human suffering. If the lack of affordable, safe, and effective family planning leads to a human population (in the North and South) of 10 billion people, we implicitly condemn large segments of future generations to harsh lives.

BOX 5

WHICH COUNTRIES ARE SUSTAINABLE?

Table 1 (page 9) compares each nation's Ecological Footprint per person with the biological capacity that exists per person on this planet or within its own boundaries. The difference between a country's footprint and its biological capacity (plus a certain margin for biodiversity preservation) is its "ecological deficit."

What do these comparisons tell about a nation's sustainability? The minimum requirement for global sustainability is that humanity's footprint be smaller than the biosphere's biological capacity.

Is Sweden, with a large footprint per person, but even larger biological capacity per person, ecologically sustainable? Is Egypt, which has a per person footprint smaller than the global average biological capacity, yet larger than its domestic biological capacity?

Clearly, if everyone in the world led the same lifestyle as the average Swede, the Earth would not be able to sustain its human population for very long. Nor would humanity be sustainable if all countries ran an ecological deficit like Egypt. Some countries, including the U.S., fail on both accounts.

Does this mean that sustainability requires people to live within the world's average biological capacity, or their national biological capacity?

Footprint calculations do not answer these questions, but try to quantify the ecological challenges and conflicts humanity needs to resolve if it wants to achieve global sustainability.

At a population of 10 billion, there would be merely 2.8 global acres [1.1 hectares] of biocapacity available per person, less than what people use today in Indonesia or Peru.

This means we need to call for compassionate and equitable initiatives that help reduce reproduction rates everywhere, particularly by strengthening women's access to health care, education, and decision-making.

At the same time, we need to find ways to secure comfort and well being on smaller footprints. Technology has a great potential to help, particularly on the energy front. Advances could help find substitutes for, or reduce our dependency on, fossil fuel use. Fossil fuel consumption accounts for over half of industrial nations' footprints. Increasing reliance on non-fossil energy systems such as solar and wind power has great footprint reduction potential.

For example, although the embodied energy data for photovoltaic cells range widely, transitioning to solar energy for electricity consumption could reduce the corresponding Ecological Footprint by two orders of magnitude. Similarly, advanced and well-located wind generators could provide us with power at a fraction of the current fossil fuel footprint.

It may prove too costly to generate the same amounts of energy we currently consume with renewable energy. But there may be no need for using so much energy.

For example, if we could reduce energy use by moving to more efficient (and typically more pleasant) urban structures that do not depend on car use but offer Italian-style piazzas with food markets and coffee shops, plenty of public spaces for pedestrians, and effective public transportation. If we build them with most resource efficient technologies, moreover, we can generate a better "dolce vita" than the Italians on far less than their current footprint of 9.5 global acres [3.8 hectares] per person.

Why Would Governments Want To Know About Footprints?

Recognizing ecological limits and their implications for social equity is not just an abstract moral concern, but also a practical governmental tool.

There are many benefits to understanding the nature of ecological constraints and being able to analyze in detail the various aspects of ecological flows. The Ecological Footprint makes this possible. Such accounts allow policy analysts to:

- Catch up with the business world that is preparing for sustainability in order to decrease future vulnerability (see, for example, BP or Ford)
- Manage common assets more effectively, rather than valuing them at zero because their contribution to society is not systematically assessed
- Have access to a warning device for economic and military long-term security, recognizing emerging scarcities and overall global trends
- Recognize (decreasing) options by analyzing the compound effect of ecological pressures like climate change, fisheries collapse, agriculture, forestry, and urban sprawl
- Identify local and global possibilities for climate change mitigation and the competition between domestic sinks, joint implementation, and domestic CO_2 reduction
- Build their country's competitiveness by monitoring ecological deficits, since these deficits are becoming an increasing liability[24]
- Test policy options for future viability and possible unintended consequences

With greater accountability and more widely spread conversation skills that sharpen and engage sustainability discussions, we hope the Ecological Footprint accounts help to generate creative tension around sustainability's underlying social and environmental challenges while attracting more of society's attention to addressing them.

CONCLUSION: WE HAVE ONLY ONE EARTH

Sustainability talk is meaningless unless it is backed up by specific measurable commitments and timetables for implementation.

The Ecological Footprint accounts measure how much productive land and water a population (an individual, a city, a country, or all of humanity) requires for the resources it consumes and for the absorption of its waste (using prevailing technology).

The world average Ecological Footprint is 5.6 global acres [2.3 hectares]. But, there is only an average of 4.7 global acres [1.9 hectares] of biologically productive land and sea area for each person (not counting the space needed by other species).

The Ecological Footprint accounts show us that humanity's consumption and waste production today exceed the Earth's capacity to create new resources and absorb waste. We are, as a result, liquidating natural capital to support current resource use, thereby reducing the Earth's capacity to support future life.

We will achieve sustainability only when every person can lead a satisfying life within the Earth's biological capacity. These are, using the Ecological Footprint accounts, identifiable and measurable criteria.

Failing to keep a reliable and comprehensive accounting of our ecological expenditures will lead to an inevitable result—*ecological bankruptcy.*

We can eliminate humanity's ecological deficit by making wise choices about population, consumption, technological efficiency, and ecosystem protection.

The Ecological Footprint accounts will help make this happen by allowing humanity to define the targets so it can reach the necessary sustainable outcome.

TABLE 1

THE 1999 ECOLOGICAL FOOTPRINTS OF NATIONS

For each country, this table lists its 1999 population, Ecological Footprint, available biocapacity and ecological deficit–the last three on a per capita basis. In this scenario, we assume that all biological capacity is available for human use, and none is designated for the survival of other species. However, scientists recognize the need to allocate substantially greater areas for the conservation of biological diversity–an important yet rapidly diminishing resource. For a sample calculation for Switzerland and a spreadsheet of these results, please visit the Redefining Progress web site at www.RedefiningProgress.org/ecologicalfootprint/

Country	Population in millions (1999)	Ecological Footprint in global hectares	Biocapacity in global hectares	Domestic *Ecological* Deficit/ Remainder in global hectares	Ecological Footprint in global acres	Biocapacity in global acres	Domestic *Ecological* Deficit/ Remainder in global acres
WORLD	5,978.7	2.3	1.9	-0.4	5.6	4.7	-0.9
Afghanistan	21.2	0.9	0.8	-0.2	2.3	1.9	-0.4
Albania	3.1	1.0	0.8	-0.2	2.4	1.9	-0.5
Algeria	29.8	1.6	0.5	-1.0	3.8	1.3	-2.5
Angola	12.8	0.9	5.9	5.0	2.2	14.5	12.4
Argentina	36.6	3.0	6.7	3.6	7.5	16.5	9.0
Armenia	3.8	0.9	0.5	-0.4	2.2	1.2	-0.9
Australia	18.9	7.6	14.6	7.0	18.7	36.1	17.4
Austria	8.1	4.7	2.8	-2.0	11.7	6.9	-4.8
Azerbaijan	8.0	1.7	0.9	-0.8	4.3	2.2	-2.0
Bangladesh	134.6	0.5	0.3	-0.2	1.3	0.7	-0.6
Belarus	10.2	3.3	2.6	-0.7	8.1	6.3	-1.7
Belgium & Luxembourg	10.2	6.7	1.1	-5.6	16.6	2.8	-13.8
Benin	6.1	1.1	1.0	-0.1	2.8	2.6	-0.2
Bolivia	8.1	1.0	6.4	5.4	2.4	15.8	13.4
Bosnia and Herzegovina	3.8	1.1	1.1	0.1	2.6	2.8	0.2
Botswana	1.5	1.5	3.9	2.4	3.7	9.7	6.0
Brazil	168.2	2.4	6.0	3.6	5.9	14.9	9.0
Bulgaria	8.0	2.4	1.8	-0.5	5.8	4.5	-1.3
Burkina Faso	11.2	1.2	0.9	-0.2	2.9	2.3	-0.6
Burundi	6.3	0.5	0.5	0.0	1.2	1.3	0.1
Cambodia	12.8	0.8	1.4	0.5	2.0	3.4	1.3
Cameroon	14.6	1.1	3.9	2.8	2.7	9.7	6.9
Canada	30.5	8.8	14.2	5.4	21.8	35.2	13.3
Central African Rep	3.6	1.3	6.2	4.9	3.1	15.3	12.2
Chad	7.6	1.0	1.7	0.7	2.5	4.1	1.6
Chile	15.0	3.1	4.2	1.1	7.7	10.5	2.8
China	1,272.0	1.5	1.0	-0.5	3.8	2.6	-1.2
Colombia	41.4	1.3	2.5	1.2	3.3	6.2	2.9
Congo	2.9	0.9	9.0	8.1	2.3	22.3	20.1
Congo, Dem. Rep.	49.6	0.8	3.4	2.6	2.0	8.3	6.3
Costa Rica	3.9	2.0	2.3	0.4	4.8	5.7	0.9
Cote d’Ivoire	15.7	0.9	2.0	1.1	2.3	4.9	2.7
Croatia	4.7	2.7	2.1	-0.6	6.6	5.3	-1.4
Cuba	11.2	1.5	1.1	-0.4	3.7	2.7	-1.0
Czech Republic	10.3	4.8	2.3	-2.5	11.9	5.7	-6.2
Denmark	5.3	6.6	3.2	-3.3	16.2	8.0	-8.2
Dominican Republic	8.2	1.5	0.7	-0.8	3.8	1.8	-1.9
Ecuador	12.4	1.5	2.6	1.1	3.8	6.5	2.6
Egypt	66.7	1.5	0.8	-0.7	3.7	1.9	-1.8
El Salvador	6.2	1.2	0.5	-0.7	2.9	1.3	-1.6
Eritrea	3.5	0.8	0.8	0.0	1.9	1.9	-0.1
Estonia	1.4	4.9	4.1	-0.8	12.2	10.2	-2.0
Ethiopia	64.9	0.8	0.5	-0.3	1.9	1.1	-0.8

Country	Population in millions (1999)	Ecological Footprint in global hectares	Biocapacity in global hectares	Domestic *Ecological* Deficit/ Remainder in global hectares	Ecological Footprint in global acres	Biocapacity in global acres	Domestic *Ecological* Deficit/ Remainder in global acres
Finland	5.2	8.4	8.6	0.2	20.8	21.3	0.5
France	59.0	5.3	2.9	-2.4	13.0	7.1	-5.9
Gabon	1.2	2.1	28.7	26.6	5.2	70.9	65.6
Gambia	1.3	1.0	0.9	-0.1	2.5	2.3	-0.2
Georgia	5.3	0.9	0.9	0.0	2.2	2.3	0.0
Germany	82.0	4.7	1.7	-3.0	11.6	4.3	-7.3
Ghana	18.9	1.1	0.9	-0.2	2.6	2.2	-0.4
Greece	10.6	5.1	2.3	-2.8	12.6	5.8	-6.8
Guatemala	11.1	1.4	1.2	-0.2	3.5	3.0	-0.5
Guinea	8.0	1.2	2.0	0.8	3.0	5.0	2.0
Guinea-Bissau	1.2	0.7	4.2	3.5	1.7	10.3	8.6
Haiti	8.0	0.8	0.3	-0.6	2.0	0.6	-1.4
Honduras	6.3	1.3	1.6	0.2	3.3	3.8	0.5
Hungary	10.0	3.1	1.7	-1.3	7.6	4.3	-3.3
India	992.7	0.8	0.7	-0.1	1.9	1.7	-0.2
Indonesia	209.3	1.1	1.8	0.7	2.8	4.5	1.7
Iran	69.2	2.0	0.9	-1.1	4.9	2.2	-2.7
Iraq	22.3	1.4	0.2	-1.2	3.4	0.6	-2.8
Ireland	3.8	5.3	6.1	0.8	13.2	15.2	2.0
Israel	5.9	4.4	0.6	-3.9	11.0	1.4	-9.5
Italy	57.5	3.8	1.2	-2.7	9.5	2.9	-6.6
Jamaica	2.6	2.1	0.6	-1.5	5.1	1.5	-3.7
Japan	126.8	4.8	0.7	-4.1	11.8	1.7	-10.0
Jordan	4.8	1.5	0.2	-1.4	3.8	0.4	-3.4
Kazakhstan	16.3	3.6	3.3	-0.2	8.9	8.2	-0.6
Kenya	30.0	1.1	1.1	0.0	2.7	2.6	-0.1
"Korea, Dem People's Rep"	22.1	3.0	0.8	-2.2	7.5	2.0	-5.5
"Korea, Rep."	46.4	3.3	0.7	-2.6	8.2	1.8	-6.4
Kuwait	1.8	7.7	0.4	-7.4	19.1	1.0	-18.2
Kyrgyz Republic	4.8	1.1	1.0	-0.1	2.8	2.4	-0.4
Laos	5.2	0.8	4.5	3.7	2.0	11.1	9.1
Latvia	2.4	3.4	4.6	1.1	8.5	11.3	2.8
Lebanon	3.4	2.6	0.5	-2.1	6.4	1.2	-5.2
Lesotho	2.0	0.9	0.7	-0.1	2.1	1.8	-0.4
Liberia	2.7	0.9	3.3	2.3	2.3	8.0	5.8
Libya	5.2	3.3	0.9	-2.3	8.1	2.3	-5.8
Lithuania	3.7	3.1	3.0	-0.1	7.6	7.5	-0.1
Macedonia	2.0	3.3	1.5	-1.8	8.0	3.6	-4.4
Madagascar	15.5	0.9	1.9	1.0	2.2	4.6	2.4
Malawi	11.0	0.9	0.8	0.0	2.2	2.0	-0.1
Malaysia	21.8	3.2	3.4	0.2	7.8	8.4	0.6
Mali	11.0	1.1	1.4	0.3	2.8	3.5	0.7
Mauritania	2.6	1.3	2.6	1.3	3.3	6.5	3.3
Mauritius	1.2	1.5	1.3	-0.2	3.7	3.2	-0.6
Mexico	97.4	2.5	1.7	-0.8	6.2	4.2	-2.1
Moldova Republic	4.3	1.4	0.8	-0.6	3.4	2.0	-1.4
Mongolia	2.5	2.6	6.4	3.9	6.4	15.9	9.5
Morocco	29.3	1.1	0.9	-0.2	2.7	2.1	-0.6
Mozambique	17.9	0.5	1.9	1.4	1.2	4.6	3.5
Myanmar	47.1	0.7	1.6	0.9	1.7	4.0	2.3
Namibia	1.7	1.5	5.0	3.6	3.6	12.4	8.8
Nepal	22.5	0.8	0.6	-0.3	2.1	1.4	-0.6
Netherlands	15.8	4.8	0.8	-4.0	11.9	2.0	-9.9
New Zealand	3.7	8.7	23.0	14.3	21.4	56.7	35.3
Nicaragua	4.9	1.5	3.1	1.6	3.8	7.6	3.8
Niger	10.5	1.1	0.9	-0.2	2.8	2.2	-0.6
Nigeria	110.8	1.3	0.9	-0.4	3.3	2.2	-1.1

Country	Population in millions (1999)	Ecological Footprint in global hectares	Biocapacity in global hectares	Domestic *Ecological* Deficit/ Remainder in global hectares	Ecological Footprint in global acres	Biocapacity in global acres	Domestic *Ecological* Deficit/ Remainder in global acres
Norway	4.4	7.9	5.9	-2.0	19.6	14.7	-4.9
Pakistan	137.6	0.6	0.4	-0.2	1.6	1.0	-0.6
Panama	2.8	1.7	3.1	1.4	4.2	7.6	3.4
Papua New Guinea	4.7	1.4	14.0	12.6	3.5	34.6	31.1
Paraguay	5.4	2.5	6.7	4.2	6.2	16.5	10.3
Peru	25.2	1.2	5.3	4.2	2.8	13.1	10.3
Philippines	74.2	1.2	0.6	-0.6	2.9	1.4	-1.5
Poland	38.6	3.7	1.6	-2.1	9.1	4.0	-5.1
Portugal	10.0	4.5	1.6	-2.9	11.0	3.9	-7.1
Romania	22.5	2.5	1.4	-1.1	6.2	3.4	-2.8
Russian Federation	146.2	4.5	4.8	0.4	11.1	12.0	0.9
Rwanda	7.1	1.1	0.9	-0.1	2.6	2.3	-0.3
Saudi Arabia	19.6	4.1	1.0	-3.1	10.0	2.4	-7.6
Senegal	9.2	1.3	1.5	0.2	3.2	3.7	0.5
Sierra Leone	4.3	0.5	1.1	0.5	1.3	2.6	1.3
Slovak Republic	5.4	3.4	2.4	-1.1	8.5	5.8	-2.7
Slovenia	2.0	3.6	2.2	-1.3	8.8	5.5	-3.3
Somalia	8.4	1.0	1.1	0.0	2.6	2.6	0.0
South Africa	42.8	4.0	2.4	-1.6	9.9	6.0	-3.9
Spain	39.9	4.7	1.8	-2.9	11.5	4.4	-7.1
Sri Lanka	18.7	1.0	0.5	-0.5	2.5	1.3	-1.2
Sudan	30.4	1.1	2.0	1.0	2.6	5.1	2.4
Sweden	8.9	6.7	7.3	0.6	16.6	18.1	1.5
Switzerland	7.2	4.1	1.8	-2.3	10.2	4.5	-5.7
Syria	15.8	1.6	0.6	-1.0	4.0	1.5	-2.5
Tajikistan	6.0	0.7	0.3	-0.4	1.6	0.8	-0.9
Tanzania	34.3	1.0	1.3	0.3	2.5	3.2	0.6
Thailand	62.0	1.5	1.4	-0.2	3.8	3.4	-0.4
Togo	4.4	0.9	0.8	0.0	2.1	2.0	-0.1
Trinidad and Tobago	1.3	3.3	0.8	-2.5	8.2	2.0	-6.2
Tunisia	9.4	1.7	1.0	-0.7	4.2	2.5	-1.7
Turkey	65.7	2.0	1.2	-0.7	4.9	3.0	-1.8
Turkmenistan	4.6	3.2	2.0	-1.2	7.9	5.0	-2.9
Uganda	22.6	1.1	0.9	-0.2	2.6	2.2	-0.4
Ukraine	50.0	3.4	1.5	-1.9	8.3	3.6	-4.7
United Arab Emirates	2.6	10.1	1.3	-8.9	25.0	3.1	-21.9
United Kingdom	59.5	5.3	1.6	-3.7	13.2	4.1	-9.1
United States of America	280.4	9.7	5.3	-4.4	24.0	13.0	-10.9
Uruguay	3.3	3.8	4.6	0.8	9.4	11.3	1.9
Uzbekistan	24.5	1.9	0.7	-1.2	4.7	1.7	-3.0
Venezuela	23.7	2.3	3.3	0.9	5.8	8.1	2.3
Vietnam	77.1	0.8	0.8	0.1	1.9	2.1	0.2
Yemen	17.6	0.7	0.5	-0.2	1.7	1.3	-0.5
Yugoslavia	21.1	2.1	1.2	-0.9	5.3	3.0	-2.3
Zambia	10.2	1.3	2.7	1.4	3.1	6.6	3.5

GLOSSARY

ACRE: 4,840 square yards. One hectare contains 2.47 acres, or 10,000 square meters. An acre is approximately the size of an American football field not counting its end zones. (see: global acre)

AVAILABLE BIOLOGICAL CAPACITY: the amount of biologically productive space that is available for human use. (see: biodiversity responsibility)

BIODIVERSITY RESPONSIBILITY: the amount of biologically productive space a nation would need to set aside in order to allow the world to protect for other species a particular percentage of the biosphere. For example, if humanity decided to set aside 12 percent of the planet's surface for biodiversity preservation, as suggested by the Brundtland Report, each nation would need to become responsible for protecting biological capacity corresponding to approximately 12 percent of their national footprint. Various methods are used to allocate a country's responsibility to preserve biodiversity. One method increases the Ecological Footprint by the percent designated to biodiversity. Another reduces the potential "biological capacity" available for human use. Each method results in a slightly different estimation of amount of biological space available to a particular population. See also "ecological deficit" and "ecological remainder."

BIOLOGICAL CAPACITY: the total biological production capacity per year of a biologically productive space, for example inside a country. It can be expressed in "global acres [hectares]," i.e. the equivalent area of space with world-average productivity. See also "biologically productive space."

BIOLOGICALLY PRODUCTIVE SPACE: the land and water area that is biologically productive. It is land or water with significant photosynthetic activity and biomass accumulation. Marginal areas with patchy vegetation and nonproductive areas are not included. The total biologically productive space adds up to 28.2 billion acres [11.4 billion hectares] and hosts over 95 percent of the planet's terrestrial biomass production.

ECOLOGICAL DEFICIT: the amount by which the Ecological Footprint of a population (e.g. a country or region) exceeds the biological capacity of the space available to that population. The national ecological deficit measures the amount by which the country's footprint (plus the country's share of biodiversity responsibility) exceeds the ecological capacity of that nation.

ECOLOGICAL FOOTPRINT: a measure of how much productive land and water an individual, a city, a country, or humanity requires to produce all the resources it consumes and to absorb all the waste it generates, using prevailing technology. This land could be anywhere in the world. The Ecological Footprint is measured in "global acres [hectares]."

ECOLOGICAL REMAINDER: remaining ecological capacity, or the opposite of an ecological deficit. Countries with footprints smaller than their locally available ecological capacity are endowed with an ecological remainder—the difference between capacity and footprint. Today in many cases, this remainder is occupied by the footprints of other countries (through export production). See also "ecological deficit."

EMBODIED ENERGY: the energy used during its entire life cycle for manufacturing, transporting, using, and disposing.

EQUIVALENCE FACTOR: a factor which translates the specific land use (such as world-average cropland) into a generic biologically productive area (global average space) by adjusting for biomass productivity (see also "yield factor").

GLOBAL ACRE: one acre of biologically productive space with world-average productivity. In 1999 the biosphere had 28.2 billion acres [11.4 billion hectares] of biologically productive space corresponding to roughly one quarter of the planet's surface. These 28.2 billion acres [11.4 billion hectares] of biologically productive space include 5.7 billion acres [2.3 billion hectares] of ocean and inland water and 22.5 billion acres [9.1 billion hectares] of land. The land space is composed of 3.7 billion acres [1.5 billion hectares] of cropland, 8.6 billion acres [3.5 billion hectares] of grazing land, 9.4 billion acres [3.8 billion hectares] of forest land, and 0.7 billion acres [0.3 billion hectares] of built-up land.

NATURAL CAPITAL: the stock of natural assets that yield goods and services on a continuous basis. Main functions include resource production (such as fish, timber or cereals), waste assimilation (such as CO_2 absorption, sewage decomposition) and life support services (UV protection, biodiversity, water cleansing, climate stability).

OVERSHOOT: the situation when human demand exceeds nature's supply at the local, national, or global scale. According to William Catton, it is "growth beyond an area's carrying capacity, leading to crash."

PHOTOSYNTHESIS: the biological process in chlorophyll-containing cells that convert sunlight, CO_2, water, and nutrients into plant matter (biomass). All food chains which support animal life—including our own—are based on this plant matter.

PRODUCTIVITY ADJUSTED AREA: the biologically productive space expressed in world average productivity. It is calculated by multiplying the physically existing space by the yield and equivalence factors. These areas are expressed in global acres [hectares]

PRODUCTIVITY: a measurement of biological production per acre per year. A typical indicator of biological productivity is the annual biomass accumulation of an ecosystem.

TONS: all figures are reported in metric tons. One metric ton equals 1,000 kg, or 2,205 lbs.

WASTE FACTOR: the ratio between the quantity of prime resource compared to the quantify of output. For example in the timber calculations, it represents the ratio of cubic meter of roundwood used per cubic meter (or ton) of product.

YIELD FACTOR: a factor which describes the extent to which a local land-use category (e.g. cropland) is more productive than the world average in that same category (see also "equivalence factor").

ENDNOTES

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[22] Dixon, R. K. *et al.* 1994. Carbon pools and flux of global forest ecosystems. *Science* 263, 185-190.

[23] In earlier publications (such as M. Wackernagel and W.E. Rees, *Our Ecological Footprint*, New Society Publishers, 1996), we compared the footprint to locally existing space, without adjusting it for its productivity. As also mentioned in these publications, this exaggerates the ecological deficit for biologically highly productive countries.

[24] Sturm, Andreas, M. Wackernagel and Kaspar Müller, and *The Winners and Losers in Global Competition: Why Eco-efficiency Reinforces Competitiveness: A Study of 44 Nations*, Rüegger, Chur/Zürich, 2000.

ABOUT THIS REPORT

This report summarizes the yearly updates of our national Ecological Footprint accounts. It builds on the first comprehensive report issued in 1997. It also was called *Ecological Footprints of Nations: How Much Nature Do They Use? How Much Nature Do They Have?* and was authored by Mathis Wackernagel, Larry Onisto, Alejandro Callejas Linares, Ina Susana López Falfán, Jesus Méndez García, Ana Isabel Suárez Guerrero, and Ma. Guadalupe Suárez Guerrero. It was commissioned by the Earth Council for the Rio+5 Forum and later distributed by the International Council for Local Environmental Initiatives, Toronto.

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