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Evaluating Ecological Footprints

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Introduction

Wackernagel and Rees (1996) introduced the concept of ecological footprints to the general public. Its premise was that each of us has real areas of Earth's surface dedicated to our consumption of food and wood products; to our use of land surface for buildings, roads, garbage dumps, etc; and to forests necessary to absorb the excess carbon dioxide produced by our burning of fossil fuels. The sum of these parts could be calculated and would constitute our ecological footprint. The author will argue below that the fossil fuel (energy) footprint, which is an extremely important calculation, is a different kind of footprint and that to sum it with the food/wood products/degraded land footprint is misleading and compromises the power of Ecological Footprint Analysis.

If one drinks orange juice and eats oranges, the quantity one consumes in the course of a year requires some or all of an orange tree and the land it occupies dedicated solely to one person. The paper and wood products we use annually require some part of the world's forest to be dedicated to our personal consumption. The land under our houses, parking lots, streets, businesses, etc. is degraded ecological land that is taken out of production, and this loss is shared by all of us, as is the area of our garbage dumps. These are real areas, and form parts of a zero-sum calculation.

We need to eat; it would be hard to imagine a world without lumber, books, newspapers, magazines, wrapping materials and cardboard boxes, so we need some forest; and we are addicted to building cities, highways, airfields, etc. and to the disposal of trash. Earth has finite and recognizable areas of arable land, pastureland, and forest. Degraded areas encroach on all three of these, and expansion of any one of the three must be at the expense of another. Ecological Footprint Analysis of these real demands can give us some measure of the degree to which Earth's surface can sustainably support humanity's patterns of consumption as population grows and standards of living in developing countries rise.

Our energy footprint is not subject to area constraints. It is a theoretical area of forest that would be needed to sequester the excess carbon (as carbon dioxide, CO_2) that is being added to the atmosphere by the burning of fossil fuels to generate energy for travel, heating, lighting, manufacturing, etc. If we fail to sequester the excess, it will build up in the atmosphere and create the potential for a possibly catastrophic rate of global warming or other environmental stress. To evaluate sustainability, we must decouple the real demands on Earth generated by our food, wood products and degraded land needs from the theoretical demands generated by burning fossil fuels. They reflect different kinds of sustainability problems and are not cumulative.

The evidence that human-induced increases in atmospheric carbon dioxide are already detectable has spurred international concern reflected at the Kyoto conference in early 1998. The corollary of this evidence is that the natural global systems for carbon sequestration are not handling the human contributions fast enough. Only about half of the carbon we generate burning fossil fuels can be absorbed in the oceans and existing terrestrial sinks (Suplee, 1998). The most effective way to sequester the excess carbon would be to *add* appropriate amounts of *new* forest, because, on a global scale, forests are the largest absorbers of CO_2 that can be increased. Energy footprint analysis shows that the amount of new forest needed is unrealistically huge, and thus there seems to be no satisfactory mitigation available to limit the buildup of carbon dioxide in the atmosphere.

If we deem the carbon dioxide problem severe enough, we can speed up attempts to find alternative energy sources that would reduce the amount of fossil carbon being added to the atmosphere. In the long run, the carbon dioxide problem will be reduced for us anyway by the practical exhaustion of the finite quantities of oil, gas and coal on the planet. The supply of oil and its derivatives, upon which we rely heavily not only for their obvious use in manufacturing and transportation, but also for pharmaceuticals, plastics, fertilizers, and tires, will begin to decline by the middle of the next century (Edwards, 1997) or earlier (Campbell and Laherrere, 1998) and be practically and perhaps politically unavailable within the lifetimes of the grandchildren of young parents today.

Wackernagel and Rees (1996, p. 15) concluded that the message from their footprint analysis is "If everybody lived like today's North Americans, it would take at least two additional planet Earths to produce the resources, absorb the wastes, and otherwise maintain life-support." This essay presents a re-analysis of our United States footprint, which shows that the problem of living sustainably on Earth is somewhat less daunting than Wackernagel and Rees asserted, but it is by no means a non-problem.

What Is The Footprint Of The Average U.S. Citizen?

In order to understand why there is a problem with sustainability of our lifestyle, we need to think globally. Any good almanac or encyclopedia will provide information about the areas of the Earth that are in any way ecologically available. When areas of true desert, and those covered by water or permanent ice are eliminated, this ecologically available land area, according to my almanac source, is slightly less than 29,000,000,000 (billion) acres. A significant part of this area, such as tundra, semi-arid regions, areas above timberline, and swamplands is not practically accessible for our food, wood products and land degradation demands. United Nations estimates of areas of arable land, cropland, and pasture (FAO, 1995) and U. S. Environmental Protection Agency estimates of world forest cover (Brown et al., 1996) indicate that there are only about 22 billion acres of usable land. This sounds like a lot, but there are 6 billion people on Earth today and most reasonable projections conclude there will be about 10 billion people on Earth by 2050. Because our concern is for a sustainable future, we need to think in terms of these 10 billion rather than today. Thus, by 2050, the ecologically usable surface of the Earth will allow an average total footprint of slightly more than 2 acres per person. This number is fairly well constrained because the usable land area on Earth is not going to change on a human time scale, and population will probably not be significantly less than the projected 10 billion persons.

Table 1 and Figure 1 show the components of the ecological footprint of the average U. S. citizen, which total 3.04 acres. If we keep living as we do, our footprint will be about 50% more than the fair share of usable land on Earth by 2050. If all of Earth's population tried to live as we live, we would almost need an additional half-Earth - clearly an impossibility. Our marketers seem oblivious to this limitation of selling "the American way" to all citizens of Earth!

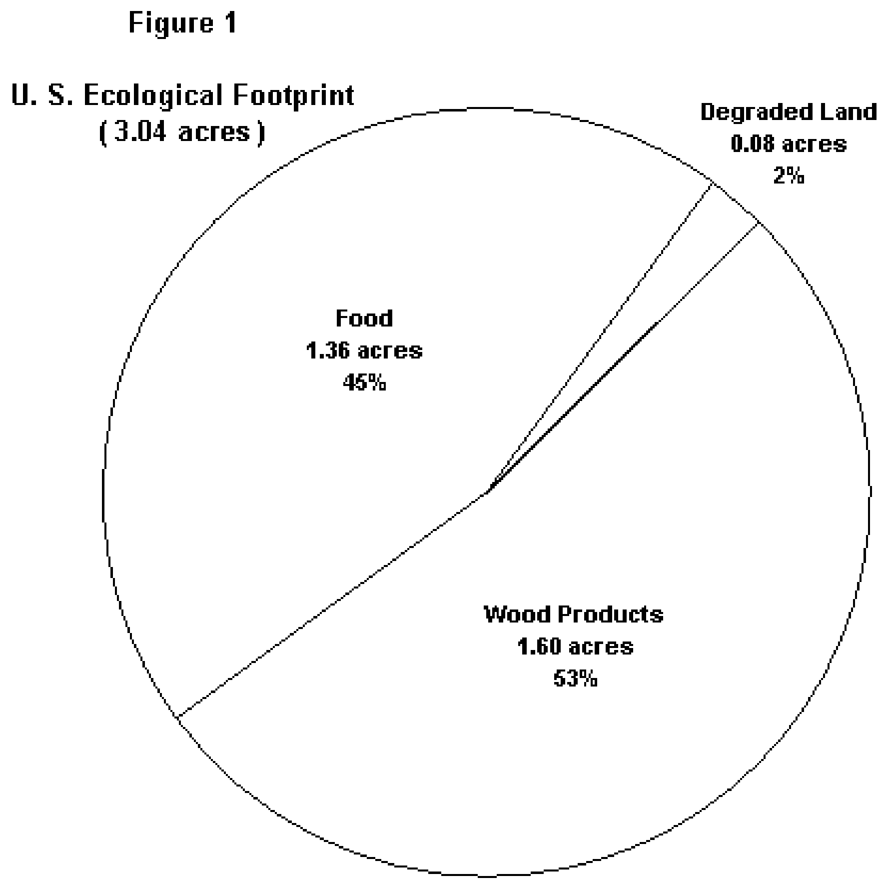
Table 1

The U. S. Ecological Footprint

Category	Acres/capita
Food	1.36
Degraded land	0.08
Wood Products	1.60

Total	3.04

(Energy 1.70)



Perhaps we need to change our lifestyles, but what might we have to give up? Three categories of consumption contribute to our ecological footprints. In order of decreasing magnitude, these are wood products, food, and degraded land, i.e. the land taken out of ecological availability by buildings, roads, parking lots, etc. As shown in Table 1, the overwhelming contributors to our footprint are wood products and food. The following sections will focus on these two aspects of our footprints.

The Wood Products Problem

According to figures from the U. S. Forest Service (Richard Hanes, personal communication, 1995) the annual U. S. demands for wood products of all kinds require about 0.04 acre of forest dedicated to each one of us. A slightly larger wood product footprint can be calculated from data provided by Wernich (Wernich et al., 1998). It takes anywhere from 40 to 70 years to restore an acre of forest following harvesting. Thus, if we wish our current level of demand to be sustainable, we really need at least 40 times 0.04 acres of forest dedicated to our per-capita consumption. This is the basis for our wood product footprint of 1.60 acres.

Earth has an estimated 10,130,000,000 acres of forest (Brown et al., 1996). A global population of 10 billion in 2050 that is consuming wood products as we do now would need 16 billion acres of forest for sustainability, IF all forest was dedicated to human consumption. We must not forget that a significant fraction (probably more than 10%) of earth's forests and other ecological land needs to be preserved in more or less pristine condition to maintain a minimum base for global biodiversity. Declining quality and quantity of Earth's forests do not bode well for this aspect of sustainability. Some cutback in our use of wood products or changes in forest management will probably be required in the next half-century.

The Food Problem

Not all of Earth's ecological acreage is capable of producing food. According to the United Nations Food and Agricultural Organization (FAO, 1995), Earth has only 3.3 billion acres of currently utilized arable and cropland, and 8.4 billion acres of pastureland of all qualities. About 5 billion acres of the pastureland could be converted to farmland, but much of it would be of relatively low quality. If we utilized ALL potential farmland by 2050, the "fair share" of this food production area for each global inhabitant would be about 0.8 acre (Table 2). Considering the declining quality of farmland worldwide, significant expansion of the potential areas of arable land, especially if it is at the expense of forest, is probably not a realistic solution.

Table 2

The food Problem

A. Basic Data
1. Global population: now, 6 billion; in 2050, 10 billion
2. Earth has 8.2 billion acres of potentially arable land. *

a. Total highly productive – 1.1 billion acres
b. Total somewhat productive – 2.2 billion
c. Total slightly productive – 4.9 billion acres

A. "Fair Share" – productive acreage per person

	Year 2000	Year 2050
Highly productive	0.18	0.11
Somewhat productive	0.37	0.22
Slightly productive	0.82	0.49
Currently productive	0.61	0.37
Potentially productive**	1.37	0.82

**if all possible acreage was fully utilizes

*from Barney, G. O., Blewett, J., and Barney, K. R., 1993, Global 2000 revisited: What shall we do? : The Millenium Institute, Alexandria, VA.

Figure 1 shows that the food footprint for the average U. S. citizen, based on data compiled by the U. S. Departments of Agriculture (DOA) and Commerce (DOC) between 1992 and 1996, is a minimum of 1.36 acres. Comparable eating habits for the world population in 2050 would require a 60% increase in available arable land and cropland, and pastureland. It would appear that the whole world of 2050 could not sustainably eat as we eat! However, when our food footprint is broken down into its food components, using per capita consumption figures from the DOA, the overwhelming culprit in our footprint is beef (Table 3, Figure 2).

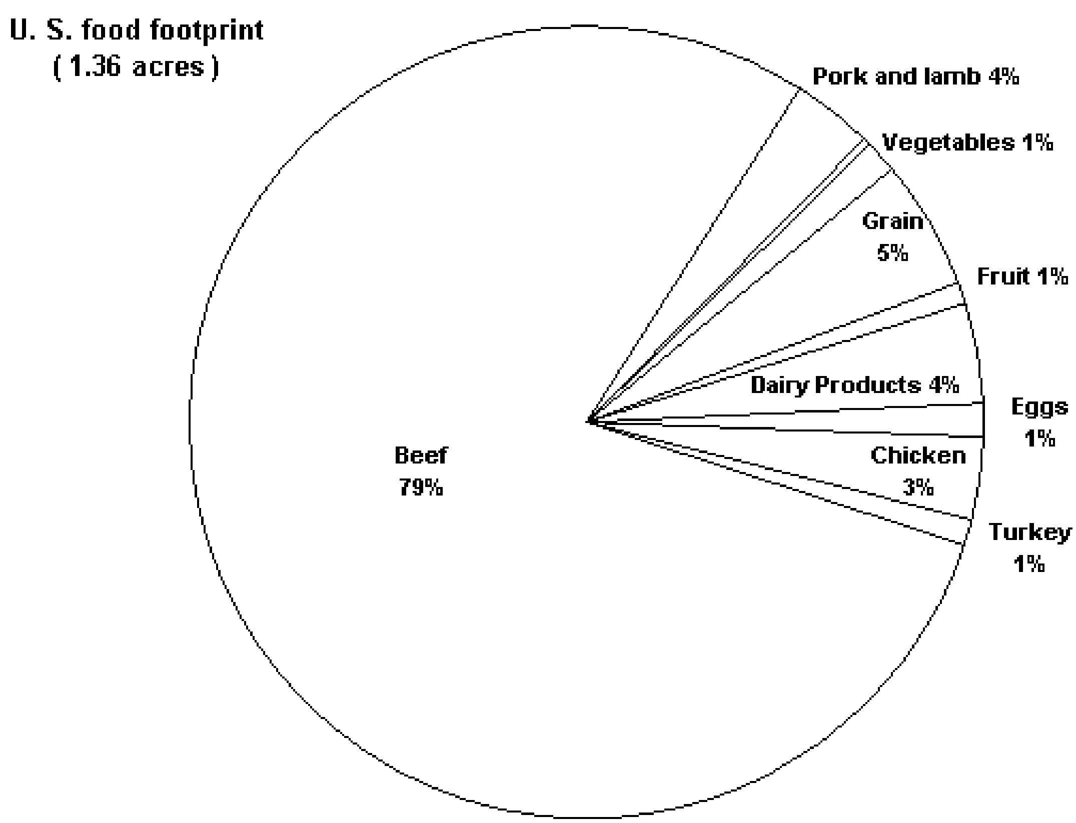
Table 3

U. S. Food footprint – summary of components

Commodity	footprint*
1. Grain	0.074
2. Vegetables	0.017
3. Fruit	0.010
4. Dairy Products	0.059
5. Eggs	0.017
6. Beef (minimum)	1.070
7. Pork	0.048
8. Chicken	0.044
9. Turkey	0.016
10. Lamb/mutton	0.002
Total	1.357

*U. S. national figures in acres/capita

Figure 2



Why is the beef footprint so large? Using DOC figures on numbers of beef cattle and acres of pasture in some of the biggest beef-producing counties in Nebraska, Texas and Colorado, the average beef cow requires about 10 acres of pastureland. Before most of these cows go to the slaughterhouse, they spend 120 to 150 days being fattened in a feedlot where the average cow consumes about 2600 pounds of grain. This grain on average represents 0.4 acre of arable land. Thus each beef cow has a footprint of about 10.4 acres. At slaughter, the average cow weighs an estimated 1,200 pounds. Only half of that shows up as meat in the supermarket. Each pound of meat that we buy therefore represents 1/600 of the beef cow's footprint, or about 0.017 acres. That doesn't seem like much, but the average U. S. citizen consumed 63 pounds of beef in 1994 (DOA), so that our per-capita beef footprint was about 1.07 acres. Much of that acreage is arable land that could be used to raise foods with smaller footprints. If each of us would simply reduce our beef consumption to about half of our present consumption on a yearly basis (about 30 pounds - slightly more than 1/2 pound per week), and substitute chicken or pork, for example, which are the meats with the next largest footprints (both about 0.0009 acres/pound), we would go a long way toward permitting a world population of 10 billion to have a potentially sustainable diet comparable to ours. Our food problem may be manageable with minimum pain.

The Energy Problem

Our energy footprint, as shown in Table 1, presents a more serious problem. The reason for this is that coal, oil, and gas, which fuel much of our immense global economy represent carbon that was gradually taken out of the atmosphere many millions of years ago by the burial of dead plants and animals in swamps and stagnant seas and lakes. Release of this carbon (as CO2) into the atmosphere has potentially troubling ecological consequences. The biosphere adapts to changes in its surroundings, given enough time, so the gradual and natural fluctuations in amounts of carbon dioxide in the atmosphere, which are documented in the geologic record, could in most cases be accommodated. However, when environmental conditions change too fast, the geologic record shows that biospheric disasters of varying magnitude can result.

When we began to burn fossil fuels in great quantities to provide energy for the industrial revolution, we began adding extra carbon, as CO2, to the atmosphere. For a while, the natural systems could handle this extra load, but in the past several decades, a clear increase in the amounts of atmospheric CO2 has been documented and the consensus among serious scientists is that this is the effect of human activity. The RATE of increase is disturbing because it may be faster than the rate at which many components of the biosphere can adapt. Everything in the biosphere, which includes humans, is interconnected. Unless we don't care about the effects on humanity of increases in atmospheric CO2 and the potential consequences of rapid global warming, we need to get the excess CO2 that comes from our burning of fossil fuels out of the atmosphere.

Forests store a large amount of CO2 in growing trees. The present global forest is already nearly fully occupied with the re-cycling of natural carbon dioxide that results from the breathing of animals, the decay of organic matter that is not buried, and from volcanic gases. Recent calculations by Brown (1996) suggest that global forests under optimum management of existing forests could absorb only about 15% of the carbon in the CO2 produced from the burning of fossil fuels worldwide. About 35% can be absorbed by the oceans (Suplee, 1998). In order to remove the remaining 50%, we would need to create new areas of forest, or other biomass equivalents because we cannot make larger oceans. The dimensions of this task are formidable.

In 1996, the U. S. alone added almost 1.5 billion tons of carbon to the atmosphere by burning fossil fuels. After accounting for the part absorbed by the oceans and existing forest, the footprint for each one of us is about 1.7 acres of new forest. This new forest acreage needed to absorb 50% of just the carbon generated by the U.S. is almost 450 million acres, which represents somewhat more than half the total acreage of forest in the U. S., excluding Alaska and Hawaii! Thus, if we wish to continue to burn fossil fuels at the 1996 rate and not add to the CO2 problem, somewhere in the world we must create and maintain new forests equal to at least half the area of all the forests in the lower 48 states! This is probably an unrealistic expectation, so either we have to find an energy source from something other than fossil fuels, or we have to live with the consequences of atmospheric buildup of carbon dioxide.

The Messages From Ecological Footprint Analysis

Four major conclusions can be reached from the information presented above.

1. The assertion by Wackernagel and Rees that we would need two more Earths to sustain the world population of 2050 with consumption levels comparable to those of present North America is a bit over-stated. Part of this was a consequence of adding the energy footprint to the food, wood products and degraded land footprints. However, the new calculations still show the U. S. footprint to be unsustainable as a goal for the world.

2. From Table 1 it is clear that we can only sustain our present footprint at the expense of other communities of the world. The whole of humanity cannot consume as we do because there isn't enough ecologically productive land on Earth for them to do so. Thus, the "selling" of the American Way is not only shortsighted for the long-term health of the world, but also immoral.

3. The good news is that the our food footprint may be mitigated fairly easily by simply reducing our consumption of beef to about half of our present levels and substituting other meats with smaller footprints. If we could accomplish this, a world of 10 billion people might be able to eat more or less at the quality level of our food consumption today, but the problems of increasing agricultural pollution and decreasing quality of arable land will have to be addressed.

4. The challenging message is that carbon dioxide in the atmosphere will continue to increase unless we find alternative energy sources of sufficient magnitude to greatly reduce our current dependence on fossil fuels. This is primarily a problem for the next century because we will be forced to alternative energy sources for petroleum, at least, by about 2100 as the finite pool of world oil is used up (Edwards, 1997). Depletion of other fossil fuels will follow shortly thereafter.

Problems For The Future

All sustainability problems are population-driven. We need to work seriously to see that long-term global population stabilizes at 10 billion or fewer. While attempting to accomplish this, we need to preserve our best quality farmland from ravages of poor farming practice and conversion to alternative uses, such as housing developments and industrial parks. Water quality and soil degradation, and the capacity of the world's fisheries, are not involved in the footprint calculations, but are essential components of food production and human health.

We need to assure adequate supplies of clean water for all people, and fresh water for all food production. We need to face up to the evidence of declining soil quality and the already troubling over-fishing of the world's oceans. We also need to face the political problem of declining petroleum supply and increasing world competition for this diminishing resource. It is in our best interests to get off of our petroleum addiction while we can still do it peacefully and develop sustainable consumption habits while we can still do it humanely.

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