

FOOTPRINT CALCULATOR

FOR K-12 SCHOOLS & POST SECONDARY INSTITUTIONS

Information Sheet



The ecological footprint measurement is one of the premier methods used to determine the extent of human impact on the Earth's ecosystems. This document explains in more detail the background, methodology and the implications of the ecological footprint concept.

1. Who 'invented' the ecological footprint?

Did you know the ecological footprint concept originated in Canada? In 1992 William Rees, a professor at the University of British Columbia was the first to use the term 'ecological footprint' in academic writing. The concept was further developed in the early 1990s by Rees' PhD student Mathis Wackernagel. In 1996 the pair published a book entitled *Our Ecological Footprint: Reducing Human Impact on the Earth*.

2. What is an ecological footprint?

In their book *Our Ecological Footprint: Reducing Human Impact on the Earth*, Wackernagel and Rees use the following exercise to introduce the ecological footprint concept:

Start by imagining what it would be like if a giant glass bubble was placed over Calgary preventing any inputs (food, water) or outputs (car emissions, solid waste) from entering or leaving the city. Consider how long, in this bubble enclosed world, would the city be able to survive? Without much imagination it's likely that before long the situation wouldn't be so good! Now, let's upgrade to an extendable bubble that stretches outward beyond the city limits. Since different land types surrounding Calgary have varying productivity levels, let's also pretend that the land encompassed by this new bubble has the same average productivity. Once the bubble covers the area needed to indefinitely support Calgary's resource demands and waste assimilation, it will automatically snap into place. It is at this point that the bubble captures the city of Calgary's total ecological footprint.



More formally, an ecological footprint can be defined as the amount of land and water area necessary to support the material demands and waste assimilation of a population given prevailing technology. To account for differences in land productivity, ecological footprints are generally measured in global hectares (gha), where one global hectare is equivalent to one hectare of land with the global average level of productivity.

3. Why should we care about the ecological footprint measurement?

While you might not see it directly outside your window, our world is in a period of extreme environmental stress. Pulitzer Prize winning Harvard biologist E.O. Wilson estimates the world is losing approximately 3,000 species per hour and is undergoing a sixth mass extinction¹. Unlike the five mass extinctions of the past, this extinction is not caused by extreme physical disturbances like tectonic plate shifts, instead this extinction is caused by the human species.



Example of overharvesting:

Photograph from the mid-1870s of a pile of American bison skulls waiting to be ground for fertilizer. Courtesy of the Burton Historical Collection, Detroit Public Library.

Worldwide, we are putting extreme pressure on our ecosystems-- pollution, invasive species, and the overharvesting of resources and species are factors that are pushing ecosystems towards collapse. Although we are just one species, it is estimated that the human population consumes or diverts 40 percent of the product of net terrestrial photosynthesis² and 35 percent of the primary production from productive marine habitats³!

What is equally troublesome is the trend in the world's population. In the 1950s there were 2.5 billion people living on the planet⁴. Today that number has almost tripled and

¹ Wilson, E.O.1993. The diversity of life. Harvard University Press, Cambridge, Mass.

² Vitousek, P., Ehrlich, P., Ehrlich, A., and Matson, P. 1986. Human appropriation of the products of photosynthesis. *BioScience* 36:368–374.

³ Pauly, D., and Christensen, V. 1995. Primary production required to sustain global fisheries. *Nature* 374:255–257.

⁴ Wackernagel, M., and W.E. Rees. 1996. *Our ecological footprint: Reducing human impact on the earth.* New Society Publishers, Gabriola Island, BC.



in 2010 the world population was an estimated 6.7 billion. To feed our expanding human population land is cleared and resources are harvested and the amount of available productive land per person decreases. As demand outpaces supply we have less room to manoeuvre to prevent the collapse of our natural ecosystems. To better manage our resources we must begin to manage ourselves.

4. So how do you calculate an ecological footprint?

The ecological footprint of a population it is necessary to compile the consumption demands of that population and to translate this demand into global hectares.

Consumption is usually separated into five categories, these include:

1. consumer goods
2. consumer services
3. transportation
4. food
5. housing

These categories consist of many, many consumption items (ie. timber, grain, fish, fossil fuels, ect.) that are both consumed and produced by natural processes. Without going into too much detail, dividing the average annual consumption of each item by its average annual average yield determines the amount of land necessary to support the given consumption of that item. The following example illustrates this idea and comes from a paper written by Rees and Wackernagel⁵.

Box 1. Productive Forest Area Required for Paper Production

Question: How much productive forest is dedicated to providing pulp-wood for the paper used by the average Canadian? (“Paper” includes food wrappings, other packaging, reading material and construction paper.)

Answer: Each Canadian consumes about 244 kilograms of paper products each year. In addition to the recycled paper that enters the process, the production of each metric ton of paper in Canada currently requires 1.8 m³ of wood. For Ecological Footprint analyses an average wood productivity of 2.3 [m³/ha/yr] is assumed. Therefore, the average Canadian requires . . .

$$\frac{244[\text{kg/cap/yr}] \times 1.8[\text{m}^3/\text{t}]}{1,000[\text{kg/t}] \times 2.3[\text{m}^3/\text{ha/yr}]} = 0.19 [\text{ha/capita}] \text{ of forest in continuous production of paper.}$$

Once the amount of land required per capita for each consumption item has been determined these values are translated from standard land-use hectares into global hectares and summed. The final result is that population’s total per capita ecological footprint. If this process sounds a little confusing, don’t worry it is! For more

⁵ Rees, W., and M. Wackernagel . 2008. Urban ecological footprints: Why cities cannot be sustainable—and why they are a key to sustainability. *Urban Ecology*(2008):537-555.

information visit the methodology section of the Global Footprint Network:
(<http://www.footprintnetwork.org/en/index.php/GFN/>)

5. What does your ecological footprint result mean?

Without a point of comparison, a population's ecological footprint has no significance. For example, you can have per capita footprint of 8.3 gha, but what does that really mean? To make a footprint calculation meaningful it is necessary to compare what is consumed with what is actually available. To do this it is necessary to roughly estimate the Earth's biological productivity. This is accomplished by first classifying the world's available productive lands into eight categories, these include:

6. energy land
7. degraded/built land
8. gardens
9. cropland
10. pastures
11. managed forests
12. land of limited availability (ie. untouched forests)
13. unproductive lands (ie. deserts and ice caps, these areas are not included in ecological footprint calculations)

Without going into too much detail, the productivity of the land categories are averaged and translated into global hectares (recall one global hectare is equivalent to one hectare of land with the global average level of productivity). Dividing the total number of global hectares by the world population, one can determine the per capita 'earth share' of global hectares. Luckily, since this is quite an intensive process, it is unnecessary to solve for per capita 'earth share' every time you complete a footprint calculation. In their book *Our Ecological Footprint: Reducing Human Impact on the Earth* Wackernagel and Rees estimate that the world is capable of providing 1.8 global hectares for every person on the planet.

Once you know your population's per capita consumption and the Earth's per capita biological productivity, these results can be compared. If your per capita consumption value is greater than the Earth's per capita biological productivity (1.8 global hectares) then the population is said to be in 'ecological deficit.' In this scenario, resources are harvested before they are replenished and waste streams are discharged more rapidly than they are absorbed. This trajectory is unsustainable since demand outweighs supply and is the current reality. Alternatively, if the per capita consumption value is less than the Earth's per capita biological productivity (1.8 global hectares) then the population is living within its means and is said to have an 'ecological remainder'. This is where we want to get to!

Summary:		
Earth's per capita biological productivity < Per capita consumption (1.8 global hectares)		Ecological deficit, unsustainable
Earth's per capita biological productivity > Per capita consumption (1.8 global hectares)		Ecological remainder, Sustainable

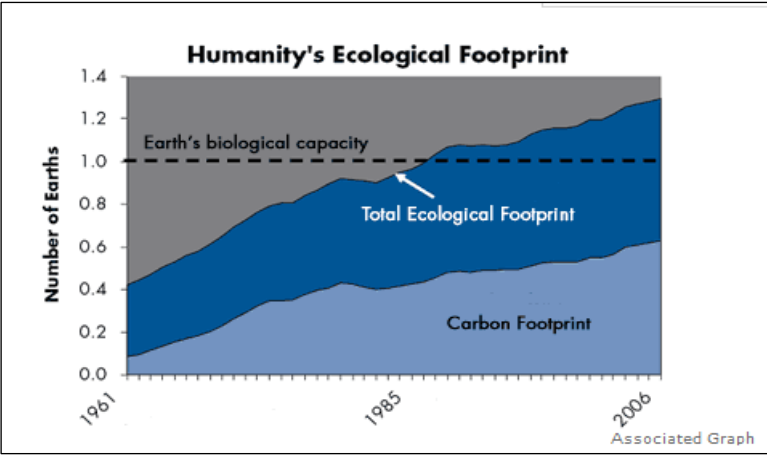
6. Where does the carbon footprint come in?

If your school is using the Eco-Footprint Calculator for K-12 Schools and Post-Secondary Institutions, you might have noticed that the calculator reports both an ecological footprint and a carbon footprint. The carbon footprint is a subcategory of the ecological footprint and reports the amount of carbon dioxide waste produced by a population. This part of the footprint accounts for the demand placed on the planet resulting from the burning of fossil fuels.

When examined alone, the carbon footprint is usually reported in tonnes of equivalent carbon dioxide (CO₂e). This unit captures the radiative forcing caused by CO₂ as well as other greenhouse gases like methane, water vapour and ozone. When used as part of the ecological footprint it is necessary to convert CO₂e into global hectares. This is done by determining the amount of average carbon-sink forest area necessary to sequester the given amount of CO₂e and translating this result into global hectares.

Translating CO₂e into a land area:		
$\frac{x \text{ amount of CO}_2\text{e waste produced}}{\text{CO}_2\text{e assimilated / area carbon-sink forest}}$	=	Area needed to sequester x amount of CO ₂ e

What is significant about the carbon footprint is that over the last century it has been the most rapidly growing component of the total calculation⁶.



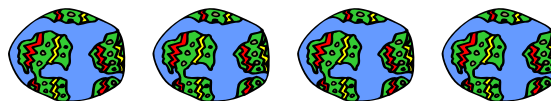
⁶ "Carbon Footprint". 2009. The Global Footprint Network. 18 Aug. 2010. <http://www.footprintnetwork.org/en/index.php/GFN/page/carbon_footprint/>.

7. What are the strengths and the weaknesses of the ecological footprint?

Strengths:	Weaknesses:
<ul style="list-style-type: none"> • The ecological footprint is not about “how bad things are”. While the numbers may crunch hard today, ecological footprints can be very positive, helping to create benchmarks, highlight opportunities and inform future sustainability goals. • The final result is easy to compare. By using one standard unit it is possible to compare the per capita ecological footprint of countries, communities, businesses and so on. • The footprint result, expressed in global hectares, is widely accessible. Unlike the carbon footprint, which is reported in tonnes of CO₂e, the global hectares unit is relatively easy to understand and can be used to create meaningful factoids that resonate with a large audience. 	<ul style="list-style-type: none"> • Like any model, there is an amount of uncertainty associated with the ecological footprint calculations. • The ecological footprint calculation does not consider the needs of other species beyond humans. By not accounting for other species, we underestimate the ‘consumption value’. • The ecological footprint is simply an index, or ecological camera. It is not capable of capturing or identifying specific socio-political, economic or environmental factors.

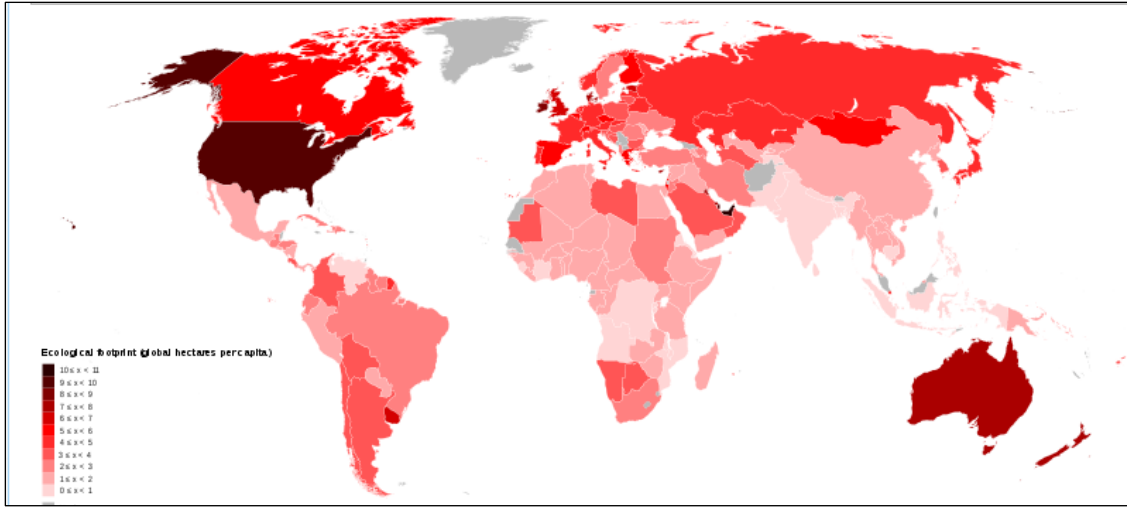
8. What is our ecological footprint like today?

- **Calgary’s per capita ecological footprint:** In 2005 the Federation of Canadian Municipalities conducted a study on the ecological footprints of various Canadian cities. With an ecological footprint of 9.86 gha per person Calgary had the highest per capita footprint of the cities surveyed. This result is almost 4.5 times greater than the 2003 global average (2.2 gha). Even more worrisome our per capita footprint is even nearly 5.5 times greater than the biological productivity that the Earth can produce for each person (1.8 gha)!
- **Canada’s per capita ecological footprint:** According to the 2007 Canadian Living Planet Report Canada’s 2003 per capita ecological footprint is 7.6 gha. If everyone on the planet adopted the same lifestyle as the average Canadian we would require four more planet earths. For more information about our footprint please visit: <http://assets.wwf.ca/downloads/canadianlivingplanetreport2007.pdf>



9. How do footprints around the world compare?

The variation in the per capita ecological footprint of nations is dramatic. According to the 2007 Canadian Living Planet Report per capita Canadians have the fourth highest ecological footprint in the world. What is most astonishing is that this result is almost 11 times greater than the footprint of low-income countries like Indonesia and Bangladesh (whose per capita ecological footprints are 0.7 and 0.5 gha respectively). The world map below highlights the difference between the have and the have-nots of our world. Notice the pronounced difference between the footprint of industrialized countries and the footprint of the Global South.

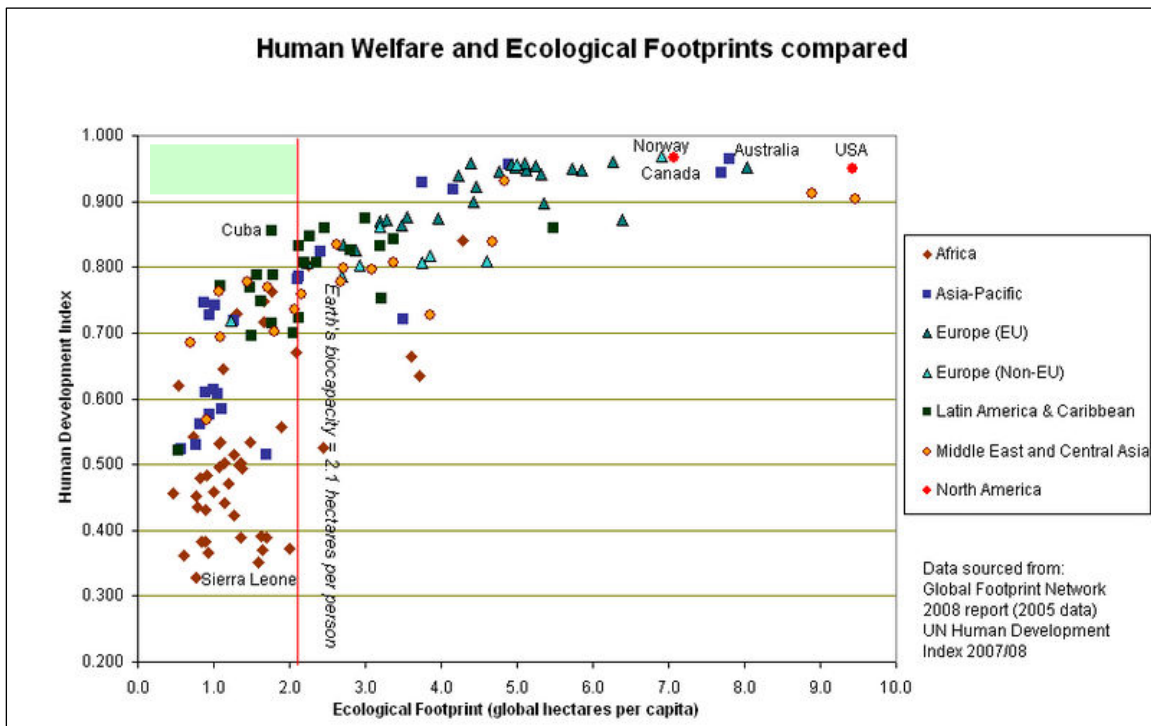


World map of countries shaded according to their ecological footprint in 2006
(published on 25 November 2009 by the Global Footprint Network).



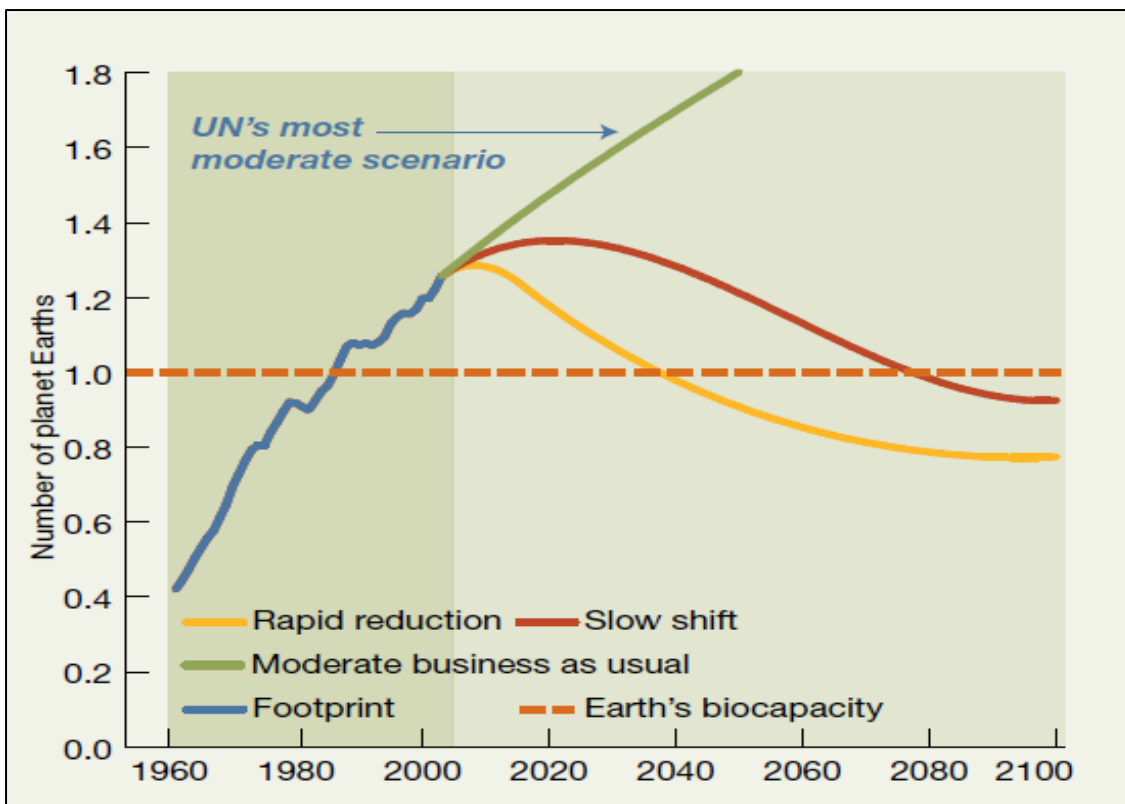
10. How is the ecological footprint related to human development?

Consider the following figure correlating ecological footprint and United Nations' Human Development Index (HDI) data. Notice how industrialized countries like Canada, Australia and Norway have high human development as well as high ecological footprints, while a country like Sierra Leone has a low development index and a low footprint. While this expresses the current reality, both these scenarios are unacceptable. To live sustainably industrialized countries must reduce their impact. Access to health care, education and economic opportunity are necessary to raise the HDI of impoverished nations. Sustaining high human development while living without degrading the planet (low footprint) should be our ultimate goal. Both of these scenarios are represented by the light green box in the top left corner of the figure below. We need to begin to think out of the box so that we can develop a future that will be in the box.



11. What are the implications of the ecological footprint?

Based on an assessment by the United Nations, if humanity remains on its current business-as-usual course we will be using ecological resources twice as fast as the Earth can regenerate them by the year 2050.⁷ This ecological debt will have consequences for us and generations to come. By realizing that human enterprise is not separate from the natural world we can begin to come to terms with our debt and begin to make wise choices for the future. It is also very important to realize that environmental issues and ecosystem stress are not solely scientific problems. The fundamental roots of many of these problems are social and behavioural. If we are serious about reducing our environmental impact we cannot rely on technical and scientific solutions alone. By managing our resources and managing ourselves we can improve the quality of human life while living within the carrying capacity of our world.



⁷ "Towards a preferred future." 2008. The City of Calgary. 16, Aug. 2010. <http://www.calgary.ca/docgallery/bu/environmental_management/ecological_footprint/towards_preferred_future.pdf>.