CALCULATING THE ECOLOGICAL FOOTPRINT AND BIOCAPACITY

The National Footprint Accounts track individual countries' use of ecological services and resources and the biocapacity available in each country. As with any resource accounts, they are static, quantitative descriptions of outcomes for any given year in the past for which data exist. Detailed calculation methodologies of the most recently updated Accounts are described in the *Calculation Methodology for the National Footprint Accounts*, 2011 Edition (www.footprintnetwork.org, 2011). Implementation of the National Footprint Accounts through database-supported templates is described in the Guidebook to the National Footprint Accounts (Kitzes et al. 2008) and the method paper by Borucke et al. (2013). Kitzes et al. (2009) outline the research agenda for future improvements.

The National Footprint Accounts, 2011 edition, calculates the Ecological Footprint and biocapacity for 241 countries, territories and regions, from 1961 to 2008.

ECOLOGICAL FOOTPRINT

The National Footprint Accounts, 2011 edition, tracks human demand for biocapacity and compares it to how much biocapacity is available. There are five area types of biocapacity: cropland, grazing land, forests, fishing grounds and built-up land. Two biocapacity demand categories share the forest biocapacity: the Forest Product Footprint and the Carbon Footprint. The Ecological Footprint of each major land use type is calculated by adding together the contributions of products and activities which compete for bioproductive space. Built-up land reflects the bioproductivity compromised by infrastructure and hydropower. The Carbon Footprint represents the carbon absorptive capacity of a world average hectare of forest needed to absorb carbon dioxide emissions from burning fossil fuels, after having the ocean sequestration capacity is removed from the equation.

The Ecological Footprint calculates the combined demand for ecological resources, wherever they are located, and presents this demand as the global average area needed to support a specific human activity. This quantity is expressed in units of global hectares. A global hectare is defined as a biologically productive hectare with world average bioproductivity.

By expressing all results as a common unit, biocapacity and the various Footprints can be directly compared across land use types and countries.

Measurements of demand for resource production and waste assimilation are translated into global hectares by dividing the total amount of a resource consumed by the yield per hectare; and by dividing the waste emitted by the absorptive capacity per hectare. Yields are calculated based on various

international statistics, primarily those from the United Nations Food and Agriculture Organization (FAO ResourceSTAT Statistical Databases).

Yields are mutually exclusive: if two crops are grown at the same time on the same hectare, one portion of the hectare is assigned to one crop and the remainder to the other. This method avoids double counting and follows the same logic as measuring the size of a farm: each hectare is only counted once, even though it might provide multiple services.

The Ecological Footprint, in its most basic form, is calculated using the following equation:

EF = D/Y

where D is the annual demand of a product and Y is the annual yield of the same product (Borucke et al, 2013). Yield is expressed in global hectares. In practice, global hectares are estimated with the help of two factors: the yield factors, which compare national average yield per hectare to world average yield in the same land category; and the equivalence factors, which capture the relative productivity among the various land and sea area types.

Taking into account these factors, the formula of the Ecological Footprint becomes:

EF = (P/YN)*YF*EQF

where P is the amount of a product harvested or waste emitted (equal to D above), YN is the national average yield for P, and YF and EQF are the respective yield factors and equivalence factors for the country and land use type in question. The yield factor is the ratio of national-to-world-average yields, which is calculated as the annual availability of usable products and varies by country and year. Equivalence factors translate the supply of or demand for an area of a specific land use type (e.g. world average cropland or grazing land) into units of world average biologically productive area expressed in global hectares. These factors can vary by land use type and year.

Annual demand for manufactured or derivative products (e.g. flour or wood pulp) is converted into primary product equivalents (e.g., wheat or roundwood) through the use of extraction rates. These quantities of primary product equivalents are then translated into the Ecological Footprint. The Ecological Footprint also embodies the energy required during the manufacturing process.

CONSUMPTION, PRODUCTION, AND TRADE

The National Footprint Accounts calculate the Footprint of a population from a number of perspectives. The most “popular”, or most widely-reported calculation is the Ecological Footprint of the consumption of a population, typically just called Ecological Footprint. For a given country, the Ecological Footprint of consumption measures the biocapacity demanded by the final consumption of all the residents of that country. In theory, the demand from visitors and tourists should be excluded, but in practice, the existing data does not allow that distinction to be

calculated; and as a result the numbers reflect the consumption of all residents and visitors. For the same reason, the "ecological demands" made by Hong Kong residents while travelling abroad are not included in this assessment.

The final consumption figure includes the country's household consumption as well as their collective consumption, such as that made by schools, roads and fire stations, for example; which serve the households, but may not be directly paid for by the households.

In contrast, a country's primary production Ecological Footprint is the sum of the Footprints for all resources harvested and all waste generated within the country's geographical borders. This includes the total area within a country required to support the actual harvest of primary products (cropland, grazing land, forest land and fishing grounds); the country's infrastructure and hydropower (built-up land), and the area needed to absorb fossil fuel-related CO2 emissions generated within the country (Carbon Footprint).

The difference between a country's Production and Consumption Footprint is trade, and is shown by the following equation:

$EF_C = EF_P + EF_I - EF_E$

where EF_C is the Ecological Footprint of consumption, EF_P is the Ecological Footprint of production, and EF_I and EF_E are the Footprints of imported and exported commodity flows respectively.

BIOCAPACITY

The calculation of a country's biocapacity begins with the total amount of bioproductive land and sea available in that country. "Bioproductive" refers to areas of land and water that support significant photosynthetic activity and accumulation of biomass. Barren areas of low or dispersed productivity are ignored. This is not to say that places such as the Sahara Desert, Antarctica, or the alpine environments of various countries do not support life; simply that their production is too widespread to be directly harvestable and is negligible in quantity.

Biocapacity is an aggregate measure of the amount of area available, weighted by the productivity of that area. It represents the ability of a biosphere to produce crops, livestock (pasture), timber products (forest) and seafood; as well as the biosphere's ability to uptake CO2 in forests. It also measures how much of this regenerative capacity is occupied by infrastructure (built-up land). In short, it measures the ability of the available terrestrial and aquatic areas to provide ecological services. A country's biocapacity for any land use type is calculated as:

BC = A*YF *EQF

where BC is the biocapacity, A is the available area of a given land use type, and YF and EQF are the yield factors and equivalence factors, respectively, for the land use type in question in that country.

GLOSSARY

ASSETS

Durable capital that is either owned or can be used in production, whether natural, manufactured, or human. Assets are not directly consumed, but they yield products and/or services that people do consume. Ecological assets are defined as the biologically productive areas of land and sea that generate the renewable resources and ecological services for which there is human demand.

BIOCAPACITY

The ability of ecological assets to produce useful biological materials and ecological services such as absorbing the CO_2 emissions generated by humans, using current management schemes and extraction technologies. Biocapacity is measured in global hectares. "Useful" biological materials are defined as those which the human economy actually demanded in a given year. Biocapacity includes only biologically productive land: cropland, forest, fishing grounds, grazing land and built-up land; deserts, glaciers and the open ocean are excluded.

CARBON FOOTPRINT

When used in Ecological Footprint studies, the Carbon Footprint indicates the biocapacity required to sequester (through photosynthesis) the CO_2 emissions produced by fossil fuel combustion. Although fossil fuels are extracted from Earth's crust and are not regenerated in human time scales, their use creates a demand for ecological services if the resultant CO_2 is not to accumulate in the atmosphere.

The Ecological Footprint therefore includes a Carbon Footprint component, which represents the biocapacity (typically that of unharvested forests) needed to absorb the remaining portion of the "fossil CO_2" that is not absorbed by the ocean. The Carbon Footprint component of the Ecological Footprint should not be confused with the "Carbon Footprint" indicator used in climate change debates. This latter indicates the tonnes of carbon (or tonnes of carbon per euro) that are directly and indirectly caused by an activity or are accumulated over the life stages of a product, rather than the Ecological Footprint's carbon component, which measures demand on a bioproductive area (see Galli et al., 2012 for details).

COMPETITIVENESS

The ability of a country to maintain and secure its prosperity.

CONSUMPTION

Use of goods or services. The term consumption has two different meanings, depending on context. As commonly used in Footprint analyses, it refers to the use of

goods or services. A consumed good or service embodies all the resources, including energy, necessary to provide it to the consumer (also known as embedded Footprint). In full life-cycle accounting, everything used along the production chain is taken into account, including any losses along the way. For example, consumed food includes not only the plant or animal matter people eat or waste in the household, but also that lost during processing or harvest, as well as all the energy used to grow, harvest, process and transport the food. As used in Input Output analysis, consumption has a strict technical meaning. Two types of consumption are distinguished: intermediate and final. According to (economic) System of National Accounts terminology, intermediate consumption refers to the use of goods and services by a business in providing goods and services to other businesses. Final consumption refers to non-productive use of goods and services by households, the government, the capital sector, and foreign entities.

CONSUMPTION COMPONENTS

(also consumption categories)

Ecological Footprint analyses can allocate total Footprint among consumption components, typically Food, Housing, Personal Transport, Goods and Services—often with further resolution into sub-components. Consistent categorization across studies allows for comparison of the Footprint of individual consumption components across regions, and the relative contribution of each category to the region's overall Footprint.

COUNTRY INCOME CATEGORIES

Countries are assigned to high-, middle- or low-income categories based on World Bank income thresholds; for this report, the 2008 Gross National Income (GNI) per person was used as threshold. This is calculated by dividing the gross national income of each country (converted to US dollars using the World Bank Atlas method), by the mid-year population (for more information see The World Bank, 2012). The categories are: Low income: ≤US$1,026 GNI per person; Middle income: US$1,026 -12,475 GNI per person (combines World Bank categories of lower middle and upper middle income); High income: ≥US$12,475 GNI per person.

BIOCAPACITY DEFICIT

The difference between the biocapacity and the Ecological Footprint of consumption of a region or country. A biocapacity deficit occurs when the Ecological Footprint of a population exceeds the biocapacity produced by the ecological assets available in the country where that population lives. If there is a regional or national biocapacity deficit, it means that the region is importing biocapacity through trade or liquidating regional ecological assets. In contrast, global overshoot, which means

biocapacity deficit at a global level, cannot be compensated through trade.

BIOCAPACITY RESERVE

Again determined by the comparison between the biocapacity and the Ecological Footprint of consumption of a region or country, a biocapacity reserve exists when the biocapacity of a region exceeds its population's Ecological Footprint of consumption. Biocapacity reserve is thus the converse of biocapacity deficit. Although a country in biocapacity reserve may still import natural resources, over-use individual components of domestic resources, and emit carbon dioxide to the global commons, a biocapacity reserve indicates that a country may be capable of maintaining its current lifestyle utilizing only domestically available ecological assets.

ECOLOGICAL FOOTPRINT

A measure of the biologically productive land and sea area—the ecological assets—that a population requires to produce the renewable resources and ecological services it uses.

ECOLOGICAL FOOTPRINT OF CONSUMPTION

The Ecological Footprint of consumption is the most commonly reported type of Ecological Footprint. It is the area used to support a defined population's consumption. The Ecological Footprint of consumption (in global hectares) includes the area needed to produce the materials consumed and the area needed to absorb the waste. The consumption Footprint of a nation is calculated in the National Footprint Accounts as a nation's primary production Footprint plus the Footprint of imports minus the Footprint of exports, and is thus, strictly speaking, a Footprint of apparent consumption. The national average or per capita Ecological Footprint of consumption is equal to a country's Ecological Footprint of consumption divided by its population.

ECOLOGICAL FOOTPRINT OF PRODUCTION

In contrast to the Ecological Footprint of consumption, a nation's Ecological Footprint of production is the sum of the Footprints for all of the resources harvested and all of the waste generated within the defined geographical region. It represents the amount of ecological demand associated with generating the country's national income. The Footprint of production includes all the area within a country necessary for supporting the actual harvest of primary products (cropland, pasture land, forestland and fishing grounds), the country's built-up area (roads, factories, cities), and the area needed to absorb all fossil fuel carbon emissions generated by production activities within the country's

geographical boundaries. For example, if a country grows cotton for export, the ecological resources and services required to produce such cotton are included in that country's Ecological Footprint of production but are not included in its Ecological Footprint of consumption; rather, they are included in the Ecological Footprint of consumption of the country that imports the T-shirts.

ECOLOGICAL OVERSHOOT

Global ecological overshoot occurs when humanity's demand on the natural world exceeds the biosphere's supply, or regenerative capacity. Such overshoot leads to a depletion of Earth's life-supporting natural capital and a build-up of waste. At the global level, biocapacity deficit and overshoot are the same, since there is no net-import of resources to the planet. Local overshoot occurs when a local ecosystem is exploited more rapidly than it can renew itself.

GLOBAL HECTARES (GHA)

A global hectare is defined as a hectare with world-average productivity for all biologically productive land and water in a given year. Biologically productive land includes areas such as cropland, forest, and fishing grounds, and excludes deserts, glaciers, and the open ocean. Global hectares are the common, standardized unit used for reporting Ecological Footprint and biocapacity across time and for areas throughout the world. The use of global hectares recognizes that different types of land have a different ability to produce useful goods and services for humans. One hectare of cropland can produce a greater quantity of useful and valuable food products than a single hectare of grazing land, for example. By converting both cropland and pasture into global hectares, they can be compared on an equal basis. Additional information on the global hectares and the way they are calculated is provided in Borucke et al. (2013).

Also note that global hectares are standardized against the last year of analysis. They could be called "constant global hectares" similar to "constant U.S. dollars." Constant global hectares refer to the basket of ecological services that a global hectare could provide in the last year of analysis. If productivity increased, this means it took more hectares in the past to produce one global hectare worth of ecological services.

HUMAN DEVELOPMENT INDEX (HDI)

HDI is a summary composite index that measures a country's average achievements in three basic aspects of human development: Health—Life expectancy at birth (number of years a newborn infant would live if prevailing patterns of mortality at the time of birth were to stay the same throughout the child's life); Knowledge—The adult literacy rate and the

combined primary, secondary and tertiary gross enrolment ratio; and Standard of living—GDP per capita (PPP US$).

INPUT-OUTPUT ANALYSIS

Input-Output (IO) analysis is a mathematical tool widely used in economics to analyze the flows of goods and services between sectors in an economy, using data from IO tables. IO analysis assumes that everything produced by one industry is consumed either by other industries or by final consumers, and that these consumption flows can be tracked. If the relevant data are available, IO analyses can be used to track both physical and financial flows. Combined economic-environment models use IO analysis to trace the direct and indirect environmental impacts of industrial activities along production chains, or to assign these impacts to final demand categories. In Ecological Footprint studies, IO analysis is used to apportion Ecological Footprints among production activities, or among categories of final demand (or consumption categories).

NATIONAL FOOTPRINT ACCOUNTS

The central data set that calculates the Ecological Footprints and biocapacities of over 150 nations and the world from 1961 to the present (generally with a three-year lag due to data availability). The ongoing development, maintenance and upgrades of the National Footprint Accounts are coordinated by Global Footprint Network and its 70+ partners.