Environmental Sustainability
http://sedac.ciesin.columbia.edu/es/hanpp.html

Human Appropriation of Net Primary Productivity (HANPP)

Description of the Data

In a June 2004 issue of the journal *Nature* a team of researchers from the NASA Goddard Space Flight Center, the University of Maryland, the World Wildlife Fund, Stanford University, the National Center for Atmospheric Research and Bowie State University published an analysis of global patterns in human consumption of net primary productivity (NPP). NPP—the net amount of solar energy converted to plant organic matter through photosynthesis—can be measured in units of elemental carbon and represents the primary food energy source for the world's ecosystems. Human appropriation of net primary productivity (HANPP), through the consumption of food, paper, wood and fiber, alters the composition of the atmosphere, levels of biodiversity, energy flows within food webs and the provision of important ecosystem services. A more detailed paper presenting similar results was published by the NASA lead researchers (Imhoff and Bounoua) in a November 2006 article in the *Journal of Geophysical Research* (see citation section below).

This Web site provides access to the spatial data sets utilized in the *Nature* and *JGR* articles: the original satellite-derived quarter-degree NPP grid (Figure 1); the intermediate model of human appropriation of NPP (low and high variants of HANPP were also produced but are not distributed here) (Figure 2); and the HANPP as a percent of NPP (Figure 3). The data are available in raster GRID and Compressed GeoTIFF formats. In addition, a downloadable Excel format file provides tabular data by country on total estimated consumption of NPP in the form of food, paper, wood, and fiber.

A popular article based on these research results is available from the NASA Earth Observatory Web site, and is entitled "Can Earth's Plants Keep Up With Us?" (Sept. 2007).

Figure 1. Spatial Distribution of Net Primary Productivity (NPP) (in grams of carbon)

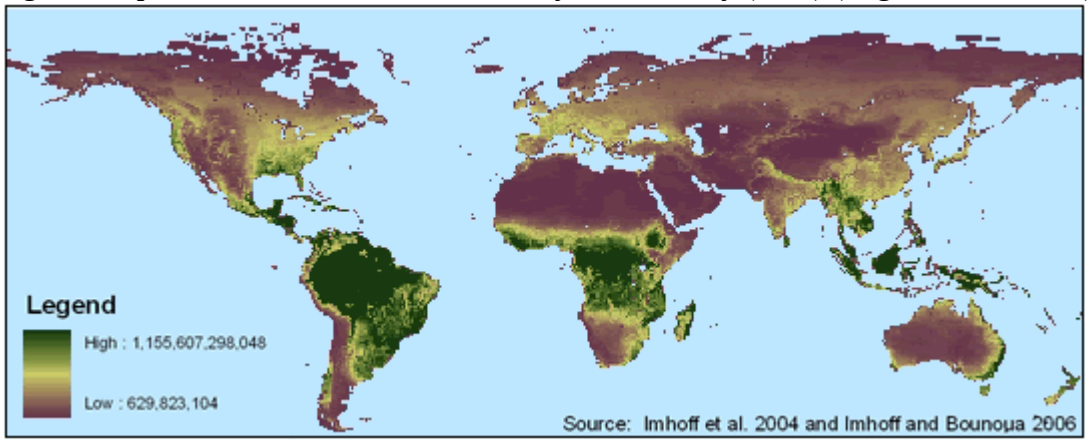


Figure 2. Human Appropriation of Net Primary Productivity (HANPP) (in grams of carbon)

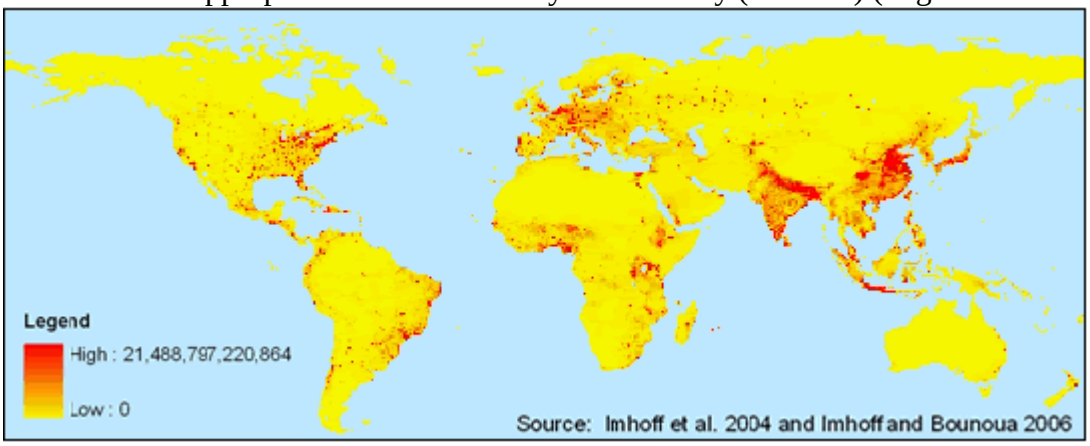
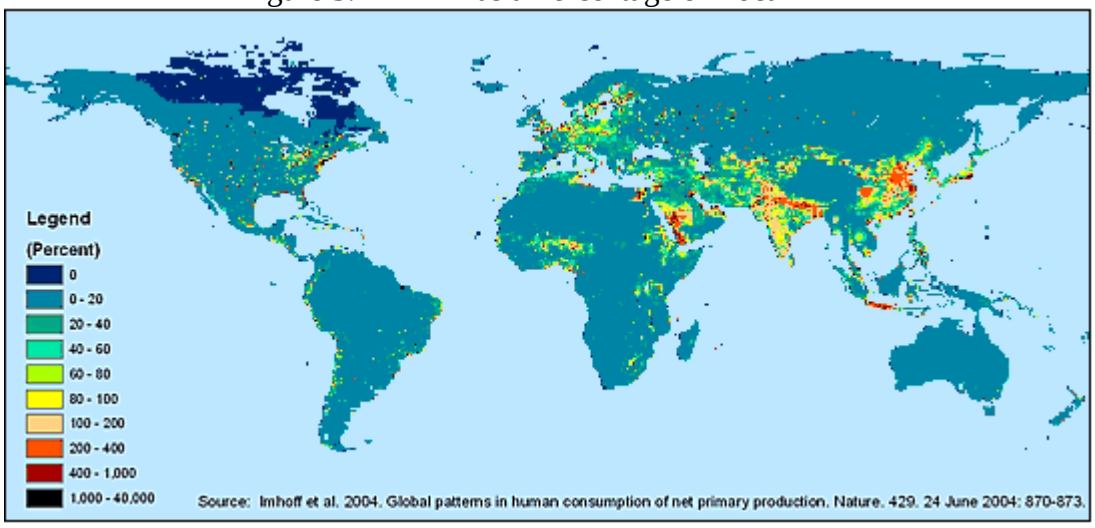


Figure 3. HANPP as a Percentage of Local NPP



Methods

A detailed description of the methods utilized to produce the data, as well as research results, are described in Imhoff et al. 2004 (see citation). Here we provide only a short summary.

To construct the estimated NPP map (the amount of carbon produced by ecosystems per quarter-degree grid cell), the authors used the Carnegie Ames Stanford Approach carbon model. The model incorporates satellite and climate data to estimate the fixation and release of carbon based on a spatially and temporally resolved prediction of NPP in a steady state.

To construct the HANPP map (the amount of carbon required to derive food and fibre products consumed by humans—including organic matter that is lost during harvesting and processing), the authors utilized data from the Food and Agriculture Organization of the United Nations (FAO) on products consumed in 1995 for 230 countries in seven categories: vegetal foods, meat, milk, eggs, wood, paper, and fiber. All calculations use the "domestic supply" quantity for all FAOSTAT country-level sums (i.e., production in country + imports – exports). This constrains the country-level estimate of NPP required to only those products that are consumed within a country's boundaries. To these data they applied harvest, processing, and efficiency multipliers, as well as estimates of below-ground production, to reconstruct the total amount of NPP required to derive final products. They then calculated the per capita HANPP of each country and applied these values to SEDAC's Gridded Population of the World v.2 (GPW) resampled to correspond to the quarter-degree spatial resolution of the NPP data. The method assumes a homogenous per capita consumption rate within each country, which although obviously incorrect, represents a starting point. The authors note that terrestrial HANPP does not directly capture other forms of environmental impact, such as freshwater abstraction, use of fossil fuels, pollutant emissions, and appropriation of NPP from freshwater and marine systems. Finally, unlike earlier studies, the authors did not include the components of NPP that are lost due to land transformations (e.g. shifting cultivation and land clearing for development).

Further details on the HANPP calculations are as follows: The authors scanned country-level FAOSTAT data for 1995 for internal consistency, missing data, and reporting errors. Missing data were assigned values using the average per capita consumption of countries in the same development category. Over-reporting because of multiple entries for the same country was corrected. For national entities or territories reporting under another administrative country, their populations were added to that of the reporting country to compute the per capita consumption. They defined consumed products as the domestic supply (i.e., production plus imports minus exports) to constrain the country totals to products consumed in situ.

For vegetal foods and fibre, mass was successively added to account for post-harvest processing, transport losses and crop residue. Crop residue is the residue to product ratio. For the intermediate estimate they used the weighted mean for major world crops whereas high and low estimates are +/– 1 s.d. For wood, fuel wood and paper products, organic matter was added to account for processing and harvest losses. For paper, recycling was also considered. If the individual plant is killed (all cases except pasture) the authors included the biomass of the root system. Meat consumption was based on wet carcass weight and it combined all meat types. The meat component of the total HANPP was estimated by adding the NPP required for grain and pasture-based feed, assuming a global average of 62% grain and 38% forage. They estimated the amount of organic matter used as feed by applying efficiency values for grain (an average of 2.3:1 kg grain/kg carcass for all meat types) and for pasture (21.46:1 for ruminants) using data from previous studies. The total NPP

required for grain feed was then calculated in the same way as for vegetal foods, adding residue and loss factors appropriate to each country's development status. Because grazing occurs in situ, no loss or residue factors were added to pasturage. Efficiency factors for milk and eggs are for the grain component only. Carbon/organic matter ratios used for the high, intermediate, and low estimates span the range (intermediate estimate uses average value) of reported values for various plants.

Data Download

The spatial data are provided in raster GRID and compressed GeoTIFF formats. Raster cell sizes are one-quarter degree. To download the zip files with accompanying metadata and documentation, click on the links below (PC users: right click and choose "save file as…" and choose a directory into which to save the file).

Global Patterns in Net Primary Productivity (NPP)
Raster GRID (887 KB, zip file) | Compressed GeoTIFF (924 KB, zip file)

Global Patterns in Human Appropriation of Net Primary Productivity (HANPP)
Raster GRID (587 KB, zip file) | Compressed GeoTIFF (585 KB, zip file)

Human Appropriation of Net Primary Productivity as a Percentage of Net Primary Productivity
Raster GRID (888 KB, zip file) | Compressed GeoTIFF (880 KB, zip file)

The tabular data are provided in Excel format. To download the data (with accompanying metadata and documentation), click on the link below (PC users: right click and choose "save file as…" and choose a directory into which to save the file).

Human Appropriation of Net Primary Productivity (HANPP) by Country and Product
Excel Workbook (31 KB, zip file)

The original work on these data was published in *Nature* and *Journal of Geophysical Research*:

- Imhoff, Marc L., Lahouari Bounoua, Taylor Ricketts, Colby Loucks, Robert Harriss, and William T. Lawrence. 2004. Global patterns in human consumption of net primary production. *Nature*, 429, 24 June 2004: 870-873.
- Imhoff, Marc L., and Lahouari Bounoua. 2006. Exploring global patterns of net primary production carbon supply and demand using satellite observations and statistical data. *Journal of Geophysical Research*, 111, D22S12, doi:10.1029/2006JD007377.

SEDAC would like to acknowledge the co-authors, and especially Marc Imhoff and Lahouari Bounoua, for providing these data for distribution.

Should you download and use these data, please ensure that any results are accompanied by the following data citation:

- Imhoff, Marc L., Lahouari Bounoua, Taylor Ricketts, Colby Loucks, Robert Harriss, and William T. Lawrence. 2004. [Title of Data Set]. Data distributed by the Socioeconomic Data and Applications Center (SEDAC): http://sedac.ciesin.columbia.edu/es/hanpp.html. [Date downloaded]