LIVING PLANET REPORT 2002
(Table 2)

and

OPT SUSTAINABLE POPULATIONS BY COUNTRY
(Table 2E)

Notes, Terminology and Index

Optimum Population Trust

www.optimumpopulation.org

Part I - Notes explaining Table 2E, the OPT extension to Table 2 of the Living Planet Report 2002

Contents

Note 1: Introduction

Table 2E extends Table 2 of the *Living Planet Report 2002*. In columns A to Z of Table 2E, Table 2 is repeated (with a correction, to be discussed in Note 8); Table 2 fills about 3 screen widths. Then the spreadsheet is extended to add columns AA to BZ, adding a further 4 screen widths. These columns show calculations of carrying capacities, and provide facilities to vary some of the assumptions.

The cells of Table 2E are copiously annotated with notes. A general principle is that a note in row 1 explains the column below it. However, some things are better described on a wider canvas, hence the need for this 'htm page' (5 A4 pages), to present an overview, giving some detailed explanations. The page is divided into numbered "Notes" for ease of reference.

As it is vital to understand the units used, I will expand here on the brief remarks made in the index in Part II below— although if you have already grasped the concepts, there is no need to read the rest of this section.

In *LPR 2002* (and in *LPR 2000*, but under the name "area units") the basic unit of eco-footprinting is the global hectare (gha). To move from local area, in ha, to gha requires two steps. There are four basic crop types, namely cropland, grazing land (also called pasture), forest, and fishing grounds. Because eco-footprinting aspires to make planet-wide assessments, it measures footprints in terms of worldwide productivity, in units of worldwide hectares (wwha). To get biocapacity into the same units, the local area of cropland, for example, needs to be multiplied by the yield factor, that is the ratio of local productivity to worldwide productivity of cropland. The yield factor will be less than 1 if the local hectares are below the planetary average in productivity, and more than 1 if the soil in the area—naturally or because of artificial inputs —is above the planetary average. Thus the relationship is:

local hectares x yield factor = worldwide hectares (wwha)

These worldwide hectares are specific to the four crop types previously mentioned. In order to be able to amalgamate the different types of area, the wwha are next multiplied by an equivalence factor to convert them to ghas. Note that this is also done to the footprint, so the relationship between, say, the cropland footprint and cropland biocapacity does not change on account of using an equivalence factor. The equivalence factors for cropland and forest are more than 1, and for grazing land and fishing grounds less than 1, a device which recognizes the differences in bioproductivity of the four main crop types. Whilst a wwha can easily be visualised, as a hectare of land which just happens to have the mean world yield for a particular crop type, a gha is harder to visualise, in that it is a hectare of indeterminate crop type. The advantage claimed for it is that it allows the continued use of hectares, while integrating the bioproductivity of the different crop types. The relationship is:

wwha x equivalence factor = gha

Conflating these two equations, the overall relationship is:

local hectares x yield factor x equivalence factor = gha

Note 2: Carrying Capacity based on carbon dioxide emissions
Column AC

The three carrying capacity columns in the spreadsheet are AC, AD, and AE. Let us consider these in turn—Column AC first:

The limiting carbon dioxide emission for the whole world, in order to stabilize carbon dioxide (at 1990 levels), has been calculated by the Intergovernmental Panel for Climate Change; also it is fairly arithmetically obvious, as has been pointed out several times in the *OPT Journal*. That limit — the fossil fuel emissions needed to achieve carbon dioxide stabilization — is 2.5 billion tonnes of carbon per year (present emissions 6.3 billion tonnes, or 6.3 x 3.664 = 23 billion tonnes of carbon dioxide).

In previous calculations, we have divided up the rights to this emission limit on the basis of 1990 populations; but here, for simplicity (with 146 nations to deal with!), we use the 1999 populations which are available in Table 2 (repeated as column AB of Table 2E). Once the rights to national emissions have been calculated on that equitable principle, each national emission figure needs to be divided by some appropriate figure for per capita carbon emission. For this purpose, *as a starting point*, we use the energy figure of the Modest Footprint (1.26 t/cap/yr, based on 2 kW/cap, about two fifths of current European use). As we shall see, the figure can easily be adjusted for nations that would prefer to aim for either a higher or a lower per capita emission figure. The adjustment is made by changing the factor in column AG.

With that background, we can spell out the logic of the cell formula for column AC:

> (2.5 x 10^9 [tC] x national population / world population) / (carbon emission for a Modest Footprint x adjustment to size of Modest energy footprint [column AG]).

The general principle involved is simple. With an acceptable global limit of 2500 million tonnes of carbon a year, from fossil fuel emissions, then at 1.26 tC per person per year, world population must be limited to 2500 / 1.26 = 1980 million, i.e. reduced to 1980 / 6000 = 33% of current levels. But individual nations should have a choice, whether they wish to have lower per capita emissions with more people, or higher per capita emission with fewer people.

Thus, for example, if India decides to aim for only half of the "standard" 1.26 tC/cap/yr (as is currently shown — by the adjustment in column AG), then carbon dioxide emissions will limit its population to 660 million instead of 330 million (1999 Indian population was 990 million). Take another example: if the USA decides to aim for twice the 'standard' 1.26 tC/cap/yr (as is also currently shown in the spreadsheet), then carbon dioxide emissions will limit its population to 47 million instead of 93 million (1999 US population was 280 million).

The two examples bring home that, in terms of changes required, the challenge is as hard for developed nations as for undeveloped ones. Note these figures can all be checked using the spreadsheet (altering the value in column AG).

A point worth noting is that the limit for the world as a whole (in cell AC11) appears as 2770 million, rather that the 1980 million calculated above. The reason is that China, India, and Indonesia have all had the size of their Modest energy footprint reduced to half size (by setting 0.50 in column AG). We tend to call this a 'Super-Modest' Footprint. The choice for these nations is mainly illustrative: each nation might choose otherwise. For instance changing China back to a full "Modest" Footprint reduces the world carrying capacity figure to 2350 million.

Note 3: Carrying capacity based on present lifestyle and Footprints Column AD

The cell formula by which this is calculated in the spreadsheet is as follows:

> (national population x (biocapacity - builtup land - builtup land adjustment [column AH]) x adjustment to yield factor to allow for sustainability [column AF] x factor to allow for biodiversity) / (Footprint - builtup land)

Again the general principle is simple: the total national biocapacity is divided by the per capita Footprint. However, there are complications in the formula which we need to dwell on.
Built-up land can introduce a distortion, so in calculating carrying capacities we subtract it, from footprint and biocapacity, so as to deal only with ecologically productive land. Yet our spreadsheet makes it possible to allow for the fact that some nations, like Britain, currently with high density housing, tend gradually to use more built-up land per person, moving in the direction of Scandinavian norms. There is the possibility of allowing for more built-up land per capita (column AH). Note that since all eco-footprinting is presently done in global hectares, the correction has to be in terms of global hectares. An example of such adjustment will be given later.

The factor that we choose to use in the formula for "factor to allow for biodiversity" is the 12% suggested by the Brundtland commission (although most people think this is inadequate). To adjust for 12%, a factor of 0.88 is used in cell AB4 (the value can of course be changed).

Note 4: Carrying Capacity based on the "Modest" Footprint Column AE

In general, we think that carrying capacities based on a "Modest" Footprint are the most useful. The "Modest" Footprint is based on a European lifestyle, but with much lower use of energy (about two fifths of present European use). It is clear that as fossil fuel scarcity becomes a fact of life, developed nations will do all they can to reduce their energy use; moreover before then most undeveloped nations will strive to improve their lifestyle toward the "Modest" Footprint (although it seems likely that many will not get far along that path).

The enormous difference between the developed and undeveloped countries can easily be seen from the spreadsheet figures. If the "High income" countries, row 12 of the spreadsheet, *reduce* their lifestyle to a "Modest" Footprint, then they could slightly *increase* their existing population of 910 million, to 950 million (column AE), whereas by maintaining their present lifestyle a 54% *reduction*, to 420 million, is called for (column AD). Except that we should never forget the carbon dioxide problem overriding these figures: "High income" countries are limited by carbon dioxide emissions, which require population to be reduced by 67%, to 300 million (column AC).

On the other hand, were the "Low income" countries, row 14, to *increase* the physical quality of their lifestyle to that of a "Modest" Footprint, then they would need to *reduce* their populations from a present level of 2110 million to 550 million (column AE), whereas with their existing Footprints the limit is 2130 million (column AD). These figures are useful ball-park figures, but it should be noted that—as the notes on the cells say—the spreadsheet calculates these figures (rows 12, 13 and 14, for "High Income", "Middle Income", and "Low Income") on a somewhat approximate basis, using Table 2's mean values, rather than picking out each nation (for some of which adjustments have been made in columns AG-AH) belonging to each group in Table 2E, and summing them. Improved accuracy would be worth achieving if all the adjustment parameters, that we will discuss more fully later, had been set with care, but for present, uncorrected mean values will do.

Now we can look at the formula for column AE. In simple terms, we can say that the calculation uses the same numerator as the previous calculation, but the denominator is altered to fit the "Modest" Footprint. The principle of calculation is this:

$$\frac{\text{(national population x (biocapacity - builtup land - builtup land adjustment [column AH]) x adjustment to yield factor to allow for sustainability [column AF] x factor to allow for biodiversity)}}{\text{(European Footprint - European builtup land - European energy footprint + (the "Modest" energy footprint [cell AB2] x adjustment of size of energy footprint [column AG]))}}$$

In general terms, the denominator merely adjusts the current European energy footprint for the use of energy as assumed for the "Modest" footprint. Also it permits the size of the assumed "Modest" *energy* footprint to be changed by any desired factor (column AG), as will be illustrated later.

Note 5: Cropland, pasture and forest carrying capacities

Columns AI, AJ, and AK give cropland, grazing land and forest carrying capacities respectively. These indicate why aggregation of carrying capacities may present a false picture. For instance, one can see at a glance that Brazil's high carrying capacity results from its massive forest, giving it a forest carrying capacity of 650 million. Conversely, one can see the area of weakness for the UK and the Netherlands is their very low forest carrying capacities: two million and zero million respectively (with 1999 populations of 59 and 16 million).

Note 6: **Yield factors**
Columns AN to BB

Fundamentally important in determining the biocapacity of a nation are the assumed *yield factors* for cropland, pasture, forest, and fishing grounds. In the *Living Planet Report 2000*, figures in Table 2 made it easy to derive the yield factors, but in the *Living Planet Report 2002*, the equivalent columns are not available.

One service which Table 2E offers is to reveal the yield factors which have been used. The information appears in the columns AN to BB. The broad columns, with a heavy outline (and a red cap), AQ, AS, and AU, give the yield factors as they actually must be, based on the equivalence factors given in *LPR 2002*. That is to say, they are the yield factors which, when multiplied by the local area and the equivalent factor will produce the global hectares shown in Table 2.

The other columns are there mainly to show the difficulty of extracting relevant yield factors from the main spreadsheets themselves. That explanation will suffice for present. There is a good deal to be said about yield factors, but for that see The “Questions and Answers” document which contains a draft of *A Plain Man's Questions Concerning Eco-footprinting*.

Note 7: **An overview**
Concluding examples

Taking an overview of Table 2E — looking at the world as a whole — we may note that, with parameters as presently set, the population limit of 2.8 billion (column AC), resulting from the need to reduce global carbon dioxide emissions to 2.5 GtC/yr, is not too different from the 3.1 billion (column AE) that applies to a "Modest" Footprint. Moreover, inadequate account is presently taken of sustainability. *In other words, whether we are planning to reduce carbon emissions, or planning for a time when we will have to rely on renewable energy, carrying capacity limits are much the same.*

The world carrying capacity of 4.6 billion (column AD), appropriate to the present lifestyle, is much higher than the other two, but it needs always be borne in mind that the 4.6 billion takes no account of the fact that about half the world is suffering from some form of malnutrition, often combined with miserable living conditions and inadequate fuel even for cooking: it is simply based on current lifestyles.

Neither does the calculation take adequate account of unsustainable agriculture (except for the adjustments Table 2E makes for Australia and the USA). What we may observe from Australia and the United States, which have large adjustments for sustainability (column AF), is that without taking account of sustainability, calculating carrying capacities often makes little sense. Far more care could have been taken to put appropriate figures into column AF to adjust for sustainability in more nations, and into AH to take account of the area likely to be used up as buildings extend on to land (often cropland), but such adjustments are left up to users of the spreadsheet. These adjustments are of vital importance, but regrettably something to which eco-footprinters have so far paid scant attention. Choosing plausible figures really calls for local knowledge.

Now let us illustrate how the adjustment columns can be used, by taking the UK as an example (present population 60 million). The 'three limits' to carrying capacity are carbon dioxide, existing lifestyle, and "Modest" lifestyle. Without any adjustments, figures for these three are:

CO_2	**Existing**	**"Modest"**
20 million	15 million	28 million.

No allowance has been made for sustainability. A reasonable estimate might be that making UK agriculture sustainable would reduce yields by 20%. To reflect this, set cell AF147 to 0.80. This changes the three carrying capacity limits to:

CO_2	**Existing**	**"Modest"**
20 million	12 million	23 million.

We may note, from cell M147, that currently the UK has a built-up footprint of 0.21 gha/cap. Let us, for simplicity of the example, assume that in the course of time this will double, i.e. a 0.21 gha increase (fairly plausible as Sweden currently uses 0.48 gha/cap); this entails putting 0.21 into cell AH147. This changes the 'three limits' to:

CO_2	**Existing**	**"Modest"**

20 million	10 million	20 million.

Let us now use the remaining adjustment column, and suppose that the UK decides it cannot manage to reduce energy use to the 'standard' 2 kW/cap (63 GJ/ha/yr), but needs 3 kW/cap, in other words, 150% of the energy consumption per person that is normally assumed by the "Modest" Footprint. That entails putting 3 [kW] / 2 [kW] = 1.50 into column AG. The result, on top of the other adjustments, is to change the 'three limits' to:

CO_2	**Existing**	**"Modest"**
13 million	10 million	17 million.

It must now be clear why OPT does not try to be too specific about carrying capacities, but states loosely the need for the UK to reduce its population to about a third of present levels. Further comments are outside the scope of this introduction, the purpose of which is mainly to lay before the reader the potential that eco-footprinting has for getting a handle on carrying capacities, and the way in which Table 2E can facilitate this.

A more comprehensive perspective on the subject of eco-footprinting is available at this site as a draft paper, as mentioned in the next paragraph.

Note 8: China's grazing land

A point of some importance is that the original Table 2 contains a substantial error in China's grazing land biocapacity. Table 2E corrects China's grazing land biocapacity, changing it from 0.44 gha/cap to a more plausible 0.13 gha/cap. Some background information on this is given to the right and below cell BQ2 on Table 2E. Along with other things, the matter will be treated in more detail in a future issue of the *OPT Journal*, in a paper *A Plain Man's Questions concerning LPR 2002*. A first draft of the paper is available as "Questions and Answers"—as a PDF download. Comments on that document, as well as this one, would be welcome.

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The responsibility for Table 2E (i.e. the extension to Table 2) lies with the Research Co-ordinator for OPT:

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These notes were last updated 12 April, 2003

Part II - Terminology and index

LIVING PLANET REPORT 2002 *and* OPT SUSTAINABLE POPULATIONS BY COUNTRY

The written commentary in Part I of this document explaining the technical details of our changes to Table 2 of the *Living Planet Report 2002* (making *Table 2E - OPT Sustainable Populations by Country*) is supplemented also with details on the GLOSSARY and ECO-FOOTPRINTING pages of this website.

A more wide-ranging discussion of *LPR 2002* is contained in the "Questions and Answers" which may also be downloaded as a PDF document and which may be taken as answers to *A Plain Man's Questions Concerning Eco-footprinting*.

Many of the carrying capacity concepts which are explained have been developed over several years and covered in OPT papers, but this is the first time that we have presented on our website a spreadsheet designed to facilitate investigation and exploration by other users.

The responsibility for **SUSTAINABLE POPULATIONS BY COUNTRY: Table 2E** (i.e. the extension to Table 2) lies with the Research Co-ordinator for OPT:

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MEANING OF TERMS USED

Those who are not familiar with standard eco-footprinting terminology should refer to the glossary on page 33 of The *Living Planet Report 2002*. However, the meaning of "Ecological Footprint", as used here, needs adjusting to take into account the *2nd Footprint Forum, Part I* (OPT Journal, October 2002), which established that the energy component of the Footprint (the energy footprint) needs to be based on the amount of ecologically productive land required to provide renewable energy (rather than absorb the carbon released from burning fossil fuels). The size of the energy footprint remains essentially unchanged, because the energy/land ratio is about 3 kW per worldwide hectare of forest for both concepts.

An OPT concept is the *modest footprint*. It is simply a mean western European footprint, but with reduced energy use of 2 kW/cap (about two-fifths of current use). *Local hectares* or *national hectares* are areas in a simple physical sense. For where to find explanations of these and terms such as *worldwide hectares (wwha), carrying capacity* (with its different meanings) and *overshoot* see the INDEX below or the GLOSSARY section on the website.

INDEX TO NOTES & TABLES

The reference to "**Note**" is the applicable note in Part I of this document.
The reference to "**Section**" applies to that Section of the "Questions and Answers" document.

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