# LIVING PLANET REPORT 2002
# (Table 2)

and

# OPT SUSTAINABLE POPULATIONS BY COUNTRY
# (Table 2E)

**Questions and Answers**


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**Answers to**

**A PLAIN PERSON'S QUESTIONS CONCERNING LPR 2002**

This is a first draft and comments would be welcome—contact the author and OPT Research Co-ordinator:

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The *Living Planet Report 2002*, published by WWF-World Wide Fund for Nature, provides a wealth of data for consideration of the Earth's ecology. Table 2 of the report (pp 22-29) concerns the ECOLOGICAL FOOTPRINT AND BIOCAPACITY and this has been used by Andrew Ferguson, OPT Research Co-ordinator, to develop calculations of SUSTAINABLE CARRYING CAPACITY, and to produce these in an Excel spreadsheet labelled as Table 2E.

The subject is complex, and the concepts, terminology and conclusions may be better understood from the following question and answer session—questions by Edmund Davey, OPT Campaign Secretary and answers by Andrew Ferguson.

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## Section 1. Changes in global areas *LPR 2000* to *LPR 2002*

> *Question 1:* The *Living Planet Report 2002* (*LPR 2002*),[1] prepared by the WWF, Worldwide Fund for Nature, is surely saying something important. The part that is most pertinent to OPT's focus is the Ecological Footprinting section, which deals with the vital matter of the relationship between population and biocapacity. However, I have to say that when I came to study it, particularly when I compared it with the previous *LPR 2000*, I found much that puzzled me, so I'd like to ask some questions.

*Answer:* You are right, there have been some big changes in *LPR 2002* and some errors which produce complications.

> *Question 2:* Let me start at page four of *LPR 2002*. I note that the Earth's biologically productive space is assessed as 11.4 billion hectares, compared to 12.6 billion in *LPR 2000*. Why the change?

*Answer:* By time *LPR 2000* was updated to make *LPR 2002*, the FAO staff, who compile the data, had changed some of their categorizations. These evaluations are very difficult, as you can well imagine. Views change about classification of, for instance, failed crops. In *LPR 2002*, the defined cropland was up by 0.2 bn ha as compared to *LPR 2000*, grazing land down by 1.1 bn ha, forest land up by 0.5 bn ha, fishing grounds down by 0.9 bn ha, and built-up land up by 0.1 bn ha. These are not surprising changes, neither are they really significant in terms of the sort of rough overview that eco-footprinting can provide.

[1] WWF, 2002; World-Wide Fund for Nature International, UNEP World Conservation Monitoring Centre, Redefining Progress, Center for Sustainability Studies. *Living Planet Report 2002*. Ed. J. Loh. Ecological Footprints led by M. Wackernagel. WWF, Gland, Switzerland. (36 pp.).

## Section 2. Changes in footprint size (in gha) in the United Kingdom

> *Question 3:* OK I'll accept that in general terms, but now let me get down to a particular case. I've been looking at the UK, and comparing *LPR 2002* and *LPR 2000*. I am baffled by the size of the variation. For instance, these are the figures for the UK Footprints given in *LPR 2002*, with figures for *LPR 2000* in brackets: cropland 0.68(1.03); grazing land 0.33 (0.69); forest 0.32 (0.36); fishing grounds 0.47 (0.05); carbon dioxide 2.99 (3.80); and built-up land 0.21 (0.37).

*Answer:* Those changes arise from other causes than different data sets. The general point to realize is that the area given in terms of "*LPR 2002* global hectares" cannot be compared directly with areas given in "*LPR 2000* global hectares", because different equivalence factors are used. What one can compare is areas which are expressed in *worldwide* productivity terms, or local area terms (sometimes called 'national' areas). Let me demonstrate by dealing with the different land types in the UK, changing your figures into *worldwide* productivity terms.

**Cropland:** If we return the UK *LPR 2000* figure, of 1.03 gha/cap, to worldwide ha (wwha), by dividing by the equivalence factor, we get 1.03 / 3.16 = 0.33 wwha/cap. Doing the same for the 0.68 gha/cap *of LPR 2002*, we get 0.68 / 2.11 = 0.32 wwha/cap, so little change there. It was mainly the equivalence factors that changed the gha figures; and remember that equivalence factors affect the Footprint and the biocapacity equally, so the relationship between Footprint and biocapacity does not change purely because equivalence factors are changed.

**Grazing land:** The change here goes beyond equivalence factors. The change in pasture land equivalence factors was from 0.39 to 0.47, which does cause some change in the gha figures, but there has been actual change in footprint size without compensating change in the biocapacity, not only in the UK, but generally. The changes are substantially due to a revised method of estimating footprints (based on forage requirements), though of course there may be errors in compiling the vast spreadsheets. That is a complex matter, and I will leave it until later.

**Forest:** This is partly explained by the change in equivalence factors; thus the 0.36 gha/cap of *LPR 2000*, becomes 0.36 / 1.78 = 0.20 wwha/cap; the 0.32 gha/cap of *LPR 2002,* becomes 0.32 / 1.35 = 0.24 wwha/cap. So there has been a 20% *increase*, rather than an 11% *decrease*. A 20% variation in footprint size is well within the accuracy one should expect. We will encounter far larger ones.

**Fishing grounds:** The 0.05 gha/cap of *LPR 2000* = 0.05 / 0.06 = 0.83 wwha/cap. The 0.47 gha/cap of *LPR 2002* = 0.47 / 0.35 = 1.3 wwha/cap. So some increase remains, even after removing the distortion of equivalence factors. That change is due to a new method of assessment: the type of fish is now taken into account. As you noted, the change in terms of global hectares is very large, from 0.05 gha/cap to 0.57 gha/cap, and I should comment on that.

It is a result of the very large increase in equivalence factor, but why did that happen? It is due to a different assessment method, essentially using the protein yield as a guide rather than the calorie yield. There was probably some justification for increasing the equivalence factor for fishing grounds, but I would suggest that the increase from 0.06 to 0.35 is probably overdoing it, because, as I have pointed out to Wackernagel, fishing grounds now represents 14% of the bioproductivity of the sum of (cropland + grazing land + fishing grounds), whereas before it was 3%. The nutritional value of fish is estimated

to provide about 5% of proteins, so 14% is more or less certainly too high, even if 3% was a shade to low. David Pimentel and I have always thought that it would be better to exclude fishing grounds from eco-footprinting, and also exclude equivalence factors altogether.

> *Question 4:* OK, I think I get the idea. Equivalence factors can be significantly different, and it does not matter much, because they are applied to *both* the Footprint and the biocapacity. Moreover, if two analyses use different equivalence factors, then the figures in global hectares from one analysis cannot be compared directly with figures from the other analysis.

*Answer:* You've got it exactly, but it is not all that easy to grasp, and that's mainly why David Pimentel and I advocated not using equivalence factors. Also, as you will readily appreciate from the change in the equivalence factor for fishing grounds, choosing a correct figure is far from easy.

## Section 3. Changes in assessment of grazing land—both footprints and biocapacity

> *Question 5:* Let's go on to another thing that really puzzled me. In *LPR 2002*, the world grazing land biocapacity is 0.27 gha/cap, and the grazing land footprint is 0.12 gha/cap. Since the world population is given as 5979 million, as I see the matter, the grazing land carrying capacity must be (5979 x 0.27) / 0.12 = 13.5 billion. Surely that's absolutely crazy.

*Answer:* You are right. You have brought me back to the matter which I said called for further discussion, namely the change in the assessment of grazing land, also called pasture.
Let us look at *LPR 2000* to start with. Although no figure is shown for grazing land biocapacity in the *LPR 2000* booklet, a world value can easily be worked out; I will do so later. Then it becomes apparent that the size of the grazing land biocapacity and the size of the related footprint are virtually the same in *LPR 2000*. That accords with the underlying reality that not a lot of grazing land goes begging.

In *LPR 2002*, unfortunately there is a major error in China's grazing land carrying capacity. If you calculate the grazing land carrying capacity according to the simple method that you used above, what you get is (1272 x 0.44) / 0.09 = 6200 million. In other words, Table 2 is trying to tell us that, China has so much grazing land that it could satisfy the demand for grazing land even were the population to be nearly five times its present size.

I recalculated the grazing land biocapacity from various data, including *LPR 2000*. A good approximation is 0.13 gha/cap (*LPR 2002* terms) instead of 0.44 gha/cap. If we build in the 12% margin for biodiversity (Brundtland's somewhat arbitrary figure but better than none), then the change in China's grazing land carrying capacity, by correcting the 0.44 gha/cap to 0.13 gha/cap, is from 5550 million to 1650 million.

> *Question 6:* That is a huge reduction - what effect does that correction have on world carrying capacity.

*Answer:* Building in the biodiversity allowance again, world *grazing* land carrying capacity reduces to 9400 million. That starts to look more realistic, though still too high. It is difficult to follow through the ramifications to the world picture of the error in China's biocapacity, but the world biocapacity, at 0.27 gha/cap, is clearly right, as I will explain later, so it seems to me that the main error lies in the world's low grazing land footprint, only 0.12 gha/cap.

## Section 4. The effects of errors in assessing grazing land

> *Question 7:* Doesn't the doubt about grazing land figures rather undermine confidence in using Table 2 of *LPR 2002*?

*Answer:* Not as much as you might think, because grazing land is not a large part of the whole. I agree that the errors and uncertainties are not desirable, and perhaps it would have been better to stick with the figures in *LPR 2000*.

Moreover there is a real problem with checking *LPR 2002* spreadsheets on account of their sheer size. On a computer screen, a segment of the spreadsheet can be viewed satisfactorily at about 75% size, yet even at that scale, one national spreadsheet is effectively 9 metres, or 30 feet, tall. A guide book is needed to find one's way around a spreadsheet of that size. Also, a few thousand dollars could be spent studying each one, that is if one includes the team which would be needed at "Redefining Progress" to deal with the questions arising. Checking all 146 spreadsheets might cost half a million dollars, which is unlikely to be forthcoming, so I think one must expect some slips.

Perhaps David Pimentel and I were right, when each spreadsheet occupied 50 kb instead of 500 kb, to recommend that things should be kept simple. Nevertheless, in my opinion the data presented remains generally useful, because, as we have seen, gross errors usually stand out by showing implausible carrying capacities. Also one can check the *LPR 2002* results against *LPR 2000* figures, and also the earlier *Ecological Footprint of Nations* (based on 1993 data).

Pasture yield factors have always been a bugbear, but previously they had not given me too much cause for concern. As I mentioned before, total grazing land footprint and total grazing biocapacity were about equal in *LPR 2000*. Moreover, in conjunction with A.R. (Pete) Palmer, I checked out the USA against other data that Pete had collected. For the USA at least, overall cropland and grazing figures in *Ecological Footprint of Nations* were about right. As *LPR 2000* grazing figures were based on the same method, I have some confidence in *LPR 2000* figures too. Nevertheless there were serious problems with a few nations, like the Netherlands. Again that is something we must come back to.

> *Question 8:* I am not entirely convinced. Pasture still seems a real problem to me. Can you tell me how you knew that in *LPR 2000* grazing land biocapacity and grazing land footprint were about equal, because *LPR 2000* did not give biocapacity figures for the various components?

*Answer:* Yes indeed. That brings me to the calculation I was promising you. On a world basis, it is easy to see what *LPR 2000* is telling us. The pasture *footprint* was 0.31 gha/cap, and the population was 5745 million. Turning now to biocapacity, world "pasture and wooded area, including the arable land used as pasture" amounted to 4.6 bn ha in *LPR 2000*. Applying the *LPR 2000* equivalence factor, that is equal to 4600 x 0.39 = 1794 million *global hectares*. Thus in *LPR 2000* the per capita grazing land biocapacity was 1794 / 5745 = 0.31 gha/cap. That is the same as the pasture footprint.

So *LPR 2000* indicated that pasture land carrying capacity was the same as the population — at the time 5.7 billion. The same type of calculation can be used to show that the 0.27 gha/cap of *LPR 2002*, for the world's grazing land biocapacity, is about right.

*Question 9:* How do you know that there are not other gross errors in *LPR 2002*—similar to that of China?

*Answer:* One can check to see if there are other nations which have gross disparities between their grazing land populations and their actual populations, and then compare them with the *LPR 2000* figures, as well as seeing if the result is plausible in terms of general knowledge of the nation. I have to say, the *LPR 2002* figures for grazing land often seem erratic and implausible.

For instance, the USA had a grazing land carrying capacity of 250 million in *LPR 2000* which was fairly plausible, but in *LPR 2002*, that had shot up to 980 million. South Africa was 40 million, and it shot up to 130 million; Peru, which was 20 million, increased to 130 million in *LPR 2002*, Australia's grazing land carrying capacity was 40 million in *LPR 2000*, and it shot up more than threefold, to 130 million in *LPR 2002*.

Incidentally, for the USA and Australia you won't see those figures in Table 2E, because adjustments have been made to the yield factor for those nations for sustainability (in column AF). Perhaps this is the point to note that, for further sophistication, one might allow *separate* sustainability adjustments to the yield factor, for cropland, pasture, and forest, on the other hand, excessive complication should be avoided.

## Section 5. How *LPR 2002* got the grazing land figures wrong, and the significance of that.

> *Question 10:* I wonder how this latest analysis could have got things so wrong.

*Answer:* In the four cases just mentioned, I note that the pasture yield factors increased, relative to *Ecological Footprints of Nations*, by factors of 2.9, 2.9, 6.0, and 2.1 respectively. So in all cases the explanation lies substantially in an increase in yield factor. However, looking at the world as a whole, it is the low pasture footprint which strikes me as implausible.

> *Question 11:* It seems that it might be wise to go back to *LPR 2000* figures, but presumably you will want to go on working with the *LPR 2002* figures, because Table 2 shows the biocapacity components as well as the footprints; but what I am wondering is whether using *LPR 2002*, with its huge errors in grazing land footprint assessment, will not detract from the work that you and David Willey [OPT Founder, now deceased] have done on carrying capacity.

*Answer:* I think it is probably best to stick with *LPR 2002* data; at least people have the hardcopy of *LPR 2002* to look at, showing the relevant biocapacity figures for the three components. In fact there may be a few things to be said in favour of *LPR 2002* methodology. I understand your worry, but David Willey and I always saw that proper use of eco-footprinting, for a guide to individual nations, requires an in-depth study of each individual nation.

But to address your specific point about using other analyses: I have already looked at that, and added column AL to Table 2E, to show the Modest Footprint carrying capacities that we arrived at when using *Ecological Footprints of Nations* (EFN) 1993 data. The figures are not always precisely comparable with *LPR 2002*. For instance, for the EFN analysis, we assumed that China would choose 4 $tCO_2$/cap/yr (4 / 3.664 = 1.09 tC/cap/yr) for the Modest Footprint, whereas in *LPR 2002* we assume 0.63 tC/cap/yr for China, i.e. 1 kW/cap instead of 2 kW/cap. Also, in the EFN analysis, we incorporated logic to anticipate nearly all nations decreasing their biocapacity by encroaching on ecologically productive land with built-up land. After making allowance for such differences, inspection of the figures shows that generally the two analyses are telling the same story, although some nations require in-depth investigation.

> *Question 12:* I have already looked at those figures. Most carrying capacity figures agree fairly well, but there are some substantial disagreements. For instance, in EFN, the Netherlands, with its present population of 15 million was shown as having a Modest Footprint carrying capacity of 11 million, but that reduces to 3 million in *LPR 2002*. Which is right?

*Answer:* David Willey and I were concerned about the Netherlands figure under EFN. The trouble arose from the very high pasture yield factor, of 25, so we had already concluded that much more attention should be given to the cropland figure of zero million, and the forest figure of 1. So you see that *LPR 2002* has arrived at the sort of figure we had already concluded it should be according to EFN data.

> *Question 13:* OK, I'll buy that, but how about Peru which has a population of 25 million. EFN put the Modest Footprint carrying capacity at 9 million, whereas *LPR 2002* puts it at 44 million. Explain that difference if you can.

*Answer:* Peru certainly needs an in-depth study by someone familiar with the geographical situation there. I can only point at a few reasons why the *LPR 2002* figures are so over the top. The grazing land carrying capacity in EFN was 3 million; this shoots up to 133 million in *LPR 2002*; as already mentioned that is partly explained by a sixfold increase in pasture yield factor. That is an extreme example of what we have already observed, that in *LPR 2002*, the grazing land assessments are unreliable.

Then there is a further problem with Peru. Assessing forest yield factors has always been difficult. Peru is a dramatic example of that too. In EFN, the forest yield factor was assessed as 0.21, whereas in *LPR 2002* it is 1.12 (column AU) over 5 times as much, giving a forest carrying capacity of 285 million. So forest is another possible distorting feature in Peru's carrying capacity. We have been aware of forest yield factor problems for a long time, and have been advocating that efforts should be directed at improving the reliability of the original fifty or so nations, rather than widening the net and adding complications. I was first worried about forest yield factors, and wrote about the problem, when the second version of EFN was produced. I stuck with data from the first version for my EFN analyses, mainly because the forest yield factors of the second version seemed the less plausible.

I don't know how reassuring you will find that, but to sum up, while I would have preferred that *LPR 2002* had kept the more plausible grazing land figures of *LPR 2000*, and avoided the error over China's biocapacity, it is still perfectly possible to look at each component of the footprint, cropland, grazing land, and forest, and then draw useful conclusions. What one must always bear in mind, too, is that sometimes—Australia and the USA being prime examples—the errors in the footprinting are dwarfed by the need to adjust biocapacity for sustainability. Once one starts looking at nations in detail, a lot of important points emerge, even if it has to be admitted that the assessment of the Footprint size is so unreliable that it is better to use an average figure for that lifestyle. I stressed that point long ago, in *The Logical Foundations of Ecological Footprints*.[2] Moreover David Willey and I always preferred to use the Modest Footprint, which is of course largely a standardised Footprint.
In conclusion, I would maintain that, despite any errors, Table 2 in *LPR 2002* provides a reasonably useful overview.

> *Question 14:* I can't help wondering if that is true. Despite what you say, those large errors in grazing land carrying capacity still worry me.

*Answer:* Those errors don't change the overview as much as you might think. Let us suppose that we decide that the measurement of the grazing land biocapacity, and of the related grazing footprint, is so unreliable that we will eschew all estimation of grazing land, and just make the commonsense assumption that grazing land footprint and biocapacity are equal. As already observed, on a world basis that seems fairly certain to be true, as there is a lot of overgrazing and few nations have a large surplus of grazing land.

We could effect that assumption simply by increasing the world grazing land footprint by 0.15 gha/cap, which would make it 0.27 gha/cap — equal to the grazing land biocapacity. The effect of adding the same 0.15 gha/cap to the total ecological footprint would make it 2.43 gha/cap. World biocapacity is 1.90 gha/cap, thus the overshoot would increase to (2.43 / 1.90) - 1 = 28%, instead of the 20% that was assessed in the report. That has brought the *LPR 2002* report more in line with the *LPR 2000*

[2] Ferguson, A.R.B., 1999. The Logical Foundations of Ecological Footprints. *Environment, Development and Sustainability* 2: 149-156.

report. Anyhow, no one who has studied eco-footprinting would expect an accuracy of better than 20%, so the overall effect of the dodgy grazing land assessment, in *LPR 2002*, is really not too bad. As I have said before, in studying any particular nation, one should look at the figures with considerable care and, in one way or another eliminate or minimize the dodgy figures.

> *Question 15:* The most important thing in using Footprints seems to be not to overestimate their accuracy and to aim for only ball park figures.

*Answer:* You have put your finger on it there. One might almost say that the chaotic results for grazing land in *LPR 2002* are a blessing in disguise, because there is a strong tendency to keep on worrying away at more and more esoteric detail; yet such detail is completely irrelevant in the context of the really important issues that need to be dealt with.

## Section 6. The multiple meanings of carrying capacity and overshoot

> *Question 16:* One thing I have noticed is that we, in OPT, tend to talk about changes in *carrying capacity*, whereas in most eco-footprinting literature the talk seems to be about *overshoot*. Is there any fundamental difference between the two?

*Answer:* Overshoot of the biological capacity and overshoot of carrying capacity are merely different ways of expressing a similar idea. I think overshoot of carrying capacity makes more immediate sense. A point to bear in mind is that overshoot, like carrying capacity, has multiple meanings, dependent upon the context. The following are the main meanings: (1) overshoot when no allowance is made for *biodiversity*; (2) overshoot when allowance is made for *biodiversity*; (3) overshoot when allowance is made for *sustainability* (with or without allowance for *biodiversity*); (4) overshoot when allowance is made for the need to give people a *decent lifestyle* (with or without allowances for *biodiversity* and *sustainability*).

So overshoot and carrying capacity have multiple meanings. Yet it would be troublesome to have different names for all the types of overshoot, so writers usually assume that readers will understand the intended meaning from the context. Unfortunately, though, a lot of print is wasted in denouncing eco-footprinting because the writer has not seen his or her particular type of overshoot being dealt with.

### (7) The effect of equivalence factors and the essence of eco-footprinting

> *Question 17:* I recall that somewhere, I think it was when you were defining the meaning of terms, you said that the energy/land ratio is about 3 kW per worldwide hectare of forest. What would the ratio be per hectare of cropland?

*Answer:* The equivalence factors in *LPR 2002* for cropland and forest are 2.11 and 1.35 respectively, so the energy/land ratio would be 3 x 2.11 / 1.35 = 4.69 kW per worldwide hectare of cropland.

> *Question 18:* OK I get that, but in the U.S. the cropland yield factor is 1.56, so what would the energy/land ratio be in terms of local U.S. cropland?

*Answer:* It would be 4.69 x 1.56 = 7.32 kW/ha. However, you may have noted in Table 2E, that we make a 30% allowance for the extent to which U.S. is not using its land sustainably, so the ratio is effectively 7.32 x 0.70 = 5.12 kW/ha.

> *Question 19:* I feel that we have sorted out most of my worries about *LPR 2002*, but I am still a bit troubled about whether equivalence factors distort things.

*Answer:* The most sensible way to use eco-footprinting is to look at each component individually, cropland, grazing land, and forest. Then it does not matter what the equivalence factors are, because both the footprint and the biocapacity are multiplied by the same equivalence factor, so the relationship between the two remains the same.

> *Question 20:* That's a relief. But by separating the components, one has to make a rough judgement on the basis of the different overshoot results. I keep on getting the message that the important thing to keep in mind is the limited accuracy that can be achieved with eco-footprinting.

*Answer:* You are absolutely right. That is something which has frequently been reiterated by David Pimentel. Perhaps I might summarize the situation thus: there are three essential messages that come through from eco-footprinting, despite the inevitable inaccuracies. They are:

a) In order to *sustain* lifestyles, biocapacity is fundamentally important. (That may seem too obvious to state, but it is ignored by most economists).

b) When we run out of fossil fuels we will require a substantial amount of biocapacity to provide renewable energy.

c) It is impossible for nations such as China, with a biocapacity of 0.7 gha/cap (after subtracting 0.3 gha/cap for the grazing land biocapacity error), and India, which also has 0.7 global hectares per person, to enjoy even a modest version of the lifestyles of Western Europeans (with their mean biocapacity of 2.1 gha/cap)

The existing problem of these overpopulated nations will be amplified over coming years, because they still have increasing populations, with their environmental problems getting worse, for instance they are experiencing soil loss, lowering of water tables, and loss of agricultural land to building.

> *Question 21:* That brings home the importance of the *2nd Footprint forum, Part II* (OPT Journal, October 2003). It is essential to have an ethical principle for dealing with overshoot. What is apparent, too, is that there is no way of escaping the fact that lifestyles are constrained by available biocapacity. I wonder how many people are aware of that.

*Answer:* Few economists, I am sorry to say, but Mahatma Gandhi appeared to be. He warned that India should not follow the path of 'development' because, "If an entire nation of 300 million took to similar economic exploitation, it would strip the world bare like locusts." Since he said that, the Indian population has increased to about 1000 million.

## Section 8. Finding one's way around Table 2E

> *Question 22:* I have had an extensive look at Table 2E, on the Optimum Population Trust website but did not find it that easy to find my way around the table. Could you give me an overview of what it is you have added to the original Table 2 from *LPR 2002*.

*Answer:* Yes. Column AC, near where I start adding extra columns, relates to overshoot due to excess carbon dioxide emissions. As you will know from the *2nd Footprint forum, Part I*, carbon dioxide emissions are a separate issue from eco-footprinting. The population overshoot shown in column AC is (5962 / 2770) - 1 = 115%. This is lower than the figure that one might calculate from the "Modest" Footprint assumption of a mean 1.26 tC/cap/yr fossil fuel emission. The reason is that I made adjustments, to be seen in column AG, for a few nations like China, India, and Indonesia, based on the assumption that they would not actually achieve that mean (although the rest of the world would). Of course that is very much open to dispute, but the adjustments in column AG can easily be altered.

The next column gives carrying capacity according to existing lifestyles, and the one to the right of that is based on our "Modest" footprint, which is essentially a European Footprint, but assumes about two fifths of European energy use. The three columns further to the right facilitate making alterations to the assumptions, for instance, the amount of land that will be lost to buildings: that can be important in some cases.

The columns after that show the carrying capacities according to the separate components, cropland, pasture, and forest. As we have seen, this can be helpful in picking up errors. They are also vital for seeing the underlying realities. For instance, a nation is in a precarious position if it must rely on importing the whole of one component, say the products of cropland, even if it has a lot of biocapacity in the form of forest.

Column AL shows, for comparison purposes, Modest Footprint carrying capacities extracted from *Ecological Footprints of Nations*. To the right of that, columns AN to BB show the yield factors for cropland, pasture, and forest and sea. To the right of that, columns BE to BI contain the per capita cropland, pasture, and forest local areas. On the right of that, BK to BM, the per capita areas are translated into national areas, partly to check totals. There is a note about that in the cells located at BJ170. Finally, in the cells located at BQ2 are some notes about China's grazing land area. That's just a quick overview.

## Section 9. Curious figures in Table 2E for grazing land yield factors

> *Question 23:* Looking over the pasture yield factors in column AR, I was amazed to find that all of west, central, and east European nations had the same pasture yield factor of 1.23, surely that is not remotely correct?

*Answer:* Those figures are misleading. I put in a long arrow pointing to cell AR1, which explains the point, but let me give more background here. The figures were extracted directly from the spreadsheets, cell F41 to be precise; actually another cell, E752, gives precisely the same figures. I have not fully got to the bottom of why the yield factors in the spreadsheets tie up so poorly with the one that are *actually being used*, related to the equivalence factors quoted in *LPR 2002*.

The procedure for calculating what is *actually being used* is simply this. Divide the gha/cap figure by the equivalence factor to get the worldwide ha/cap figure. Then divide by the local area/cap to get the yield factor. That, of course, is based on a simple rearrangement of the relationship: local area x yield factor x equivalence factor = area in global hectares.

The most useful yield factor figures are of course the ones which are actually being used; they are shown in the wide, heavily margined columns (with red caps), AQ, AS, and AU. The other columns are there mainly to show the difficulty of working with the spreadsheets. Apart from their sheer size, 9 metres tall, the captions don't always mean what you might take them to mean; moreover no guide to the spreadsheets has been written.

> *Question 24:* I looked over the pasture yield factors column AS, those actually being used, and found some that seemed somewhat implausible. For instance New Zealand at 8.4 seems high in relation to say France at 4.1 and Germany at 3.7.

*Answer:* I would agree with you there, but they are an improvement on the pasture yield factors in *LPR 2000*. The previous method of working out pasture yield factors produced some bizarre results. For instance, in *LPR 2000*, the pasture yield factor for the Netherlands was 46, and Japan 53. That used to worry Jill Curnow and David Pimentel in particular, and of course I told Mathis Wackernagel about the problem. While I tried to defend these high figures, I was only half convinced myself. The 'distortion' was due to intensive farming which in some cases almost dispenses with pasture (by using animal feed grown on cropland).

It can be argued that there is *some* justification for accepting these very high pasture yield factors, insofar as they would be balanced by an enlarged cropland footprint. However, there would still be a distortion in the case of food being grown for export. Japan, at 7.8, and Switzerland at 9.0 still seem to be affected to some extent by the same problem, but overall the figures are much better than in *LPR 2000*. The problem with the *LPR 2002*treatment of pasture is not so much *biocapacity*, as the tendency to produce implausibly low pasture *footprints*.

> *Question 25:* The forest yield factors also seem a bit erratic to me.

*Answer:* Yes, cropland yield factors are fairly secure, but forests certainly present yield factor problems. At one time I thought that forest yield factors were more of a problem that those for grazing land.

> *Question 26:* Just clarify for me why you think that it is the grazing land *footprints* which are the problem, rather than grazing biocapacity.

*Answer:* Let us take the U.S. as an example, because Pete Palmer and I took some time checking it. In EFN, the pasture footprint was 1.84 ha/cap in terms of worldwide productivity. From Table 2 in *LPR 2002*, you can see, by dividing by the equivalence factor, that it is 0.31 / 0.47 = 0.66 ha/cap in worldwide productivity terms. No wonder carrying capacity has shot up. Moreover that is obviously fairly typical of what has happened in *LPR 2002*, because the world grazing land footprint has dropped down to 0.12 gha/cap, producing absurd results, as you pointed out earlier.

I fear that in answering your questions, I have made everything seem complicated; yet there is an underlying simplicity about eco-footprinting. There is already plenty of evidence that humans are over-using biocapacity, provided by: (1) *The Living Planet Report* itself, and (2) Pimentel's numerous writings, stretching over many years (for example *Will Limits of the Earth's Resources Control Human Numbers?* [3]). Pimentel's books and papers virtually say it all. What eco-footprinting adds is a quantitative indication of the extent to which use of those resources *varies between nations*.

Eco-footprinting also emphasizes, just possibly even more strongly than Pimentel, the need to think ahead to the time when we will require a lot of extra biocapacity to produce renewable energy.

> *Question 27:* Wouldn't it greatly strengthen our work if the eco-footprinting figures that we are using were more academically secure?

*Answer:* I would like that as much as you; but as I see it the following steps would be required:

(a) to reduce the spreadsheets to about a tenth of their present size, to something like the 10 by 8 screenfuls of Table 2E;

(b) to produce a guide to the spreadsheets, say on the lines of "Notes and Index" document;

(c) to make the whole suite of spreadsheets freely available, so that they can be checked as widely as possible;

(d) to have a sufficiently large team at "Redefining Progress" to handle all the queries that would inevitably arise.

At present the complete suite of spreadsheets cost $500 ($2,000 for commercial organizations). That is not because of the cost of copying them, which is minimal, but because of the amount of work it would cause Redefining Progress, in terms of queries that would arise. However, even as they stand at present, the spreadsheets have some credibility, as I hope I have demonstrated.

[3] Pimentel, D., Bailey, O., Kim, P., Mullaney, E., Calabrese, J., Walman, L., Nelson, F. and Yao, X. 1999. Will Limits of the Earth's Resources Control Human Numbers? *Environment, Development and Sustainability* 1: 19-39, 1999.

## Section 10. Edmund's conclusion

*Question 28:* Well, I think I now have eco-footprinting just about wrapped up. My overview of the world scene is this. If we maintain our present level of per capita carbon dioxide emissions, population needs to be about 2 billion in order to stabilize the concentration of carbon dioxide in the atmosphere. Eco-footprinting indicates that we need about that level of population in order that all should be able to live *sustainably* and enjoy an acceptable lifestyle.

*Answer:* Your summary is absolutely correct.