

# An Analysis of New Zealand's Ecological Footprint as Estimated by the Global Footprint Network: An Update



**Landcare Research**  
Manaaki Whenua



# **An Analysis of New Zealand's Ecological Footprint as Estimated by the Global Footprint Network: An Update**

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**April 2011**

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*Landcare Research Contract Report:*

LC197

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## **1 Acknowledgements**

This work was funded by the Foundation for Research, Science and Technology under contract WROX0305. The Global Footprint Network provided clarification of methodologies and validation of changes proposed in our previous report.

## 2 Introduction

The Ecological Footprint concept has been instrumental in raising awareness that humans no longer live within the means of planet Earth. The National Footprint Accounts (NFAs), produced by the Global Footprint Network (GFN), are intended to help countries manage and understand their use of ecological resources. These Accounts are calculated using international data produced by organisations such as the United Nations for consistency and transparency and the process is very data intensive. Results are published biennially by the World Wildlife Fund in the Living Planet Report, which in 2010 included the Ecological Footprint of 152 nations. The Ecological Footprint is defined by GFN as (WWF 2008, p. 14):

*the sum of all the cropland, grazing land, forest and fishing grounds required to produce the food, fibre and timber it consumes, to absorb the wastes emitted when it uses energy, and to provide space for its infrastructure. Since people consume resources and ecological services from all over the world, their footprint sums these areas, regardless of where they are located on the planet.*

The collation of the NFAs is a process that is continually being improved, with both methodological improvements and data and calculation corrections. Table 1 shows New Zealand's Footprint in all editions of the Living Planet Report, indicating significant changes as data and methodology change. In the first five editions New Zealand ranked relatively highly.

**Table 1: New Zealand's rank in per capita Footprint in all editions of the Living Planet Report in which the Footprint was included**

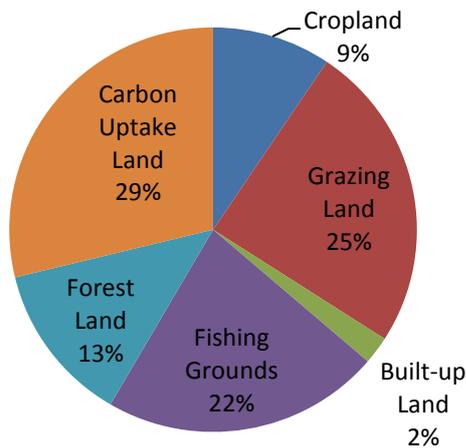
Footprint Edition	Account Year	Number of Countries	NZ's position	NZ's Footprint (gha/capita) <sup>1</sup>
2000	1996	151	6	9.5
2002	1999	146	4	8.7
2004	2001	148	14	5.5
2006	2003	147	9	5.9
2008	2005	150	6	7.7
2010	2007	152	32	4.9

According to GFN,<sup>2</sup> seventeen nations have completed reviews of GFN's National Footprint Accounts (NFAs) for their country, with Japan, Switzerland, UAE, Ecuador, Finland, Scotland and Wales formally adopting the Ecological Footprint as a sustainability indicator. GFN welcomes and encourages nations to conduct reviews of their accounts to help improve the National Footprint Accounts and create opportunities for Ecological Footprint policy applications at the national level. With this in mind, and the difficulty found in reconciling New Zealand's high position relative to other nations with an understanding of New

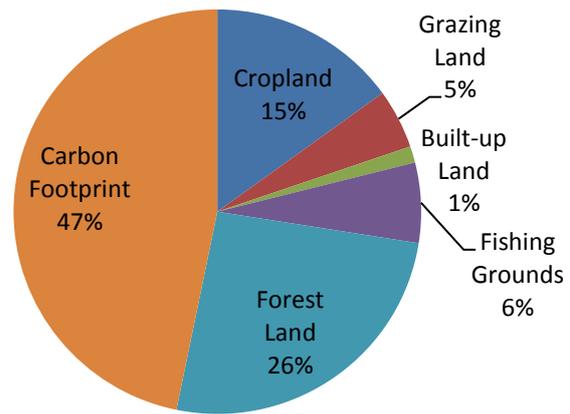
<sup>1</sup> Note the unit used in the 2000 report was 'area unit' rather than the later 'global hectare'

<sup>2</sup> [http://www.footprintnetwork.org/en/index.php/GFN/page/ten\\_in\\_ten\\_campaign](http://www.footprintnetwork.org/en/index.php/GFN/page/ten_in_ten_campaign)

Zealand's particular context, the present authors analysed the 2008 edition of New Zealand's Footprint Accounts (Andrew & Forgie 2009). That report identified some significant problems with the calculation of New Zealand's Footprint, indicating that the Footprint should be much lower. The report also suggested a range of options for improving the calculation. In the 2010 edition of the NFA, New Zealand's Footprint has dropped from 7.7 to 4.9 gha/capita, and the present report analyses the key reasons for this change, particularly focussing on the issues found in the previous report. Figures 1 and 2 show the categorical breakdown in New Zealand's Footprint in 2005 and 2007, respectively.



**Figure 1** Breakdown of categories of NZ's Footprint, 2005 (2008 edition).



**Figure 2** Breakdown of categories of NZ's Footprint, 2007 (2010 edition).

The report looks at the major Footprint categories in turn, first summarising the issues highlighted in the previous report, then analysing reasons for changes in the category. The report concludes with a summary section.

### 3 Fishing Grounds

In our previous report we observed that the per capita fishing grounds consumption Footprint for New Zealand was six times that of Japan, despite FAOSTAT figures showing that the Japanese eat more than twice as much fish per capita than do New Zealanders. We identified the following apparent problems with the determination of New Zealand's fishing grounds Footprint:

- The discard rate of 27% is from a UN publication that has since been updated, and the rate in the new publication is 8% (Kelleher 2005).
- The level of detail used for international trade in fish and fish products was poor and this caused problems because a high proportion of New Zealand's fish catch is exported.
- The extraction rates – ratios of processed weight to live weight – appeared to be high compared with official New Zealand figures. Many of the extraction rates were 1.0, implying trade in whole, unprocessed fish.

### 3.1 Production

GFN have reduced the equivalence factor (*EQF*) for all fish species and all countries from 0.40 gha/wha in the 2008 edition to 0.37. This has marginally reduced New Zealand's Fishing Grounds consumption Footprint by 0.03 gha/capita.

### 3.2 Trade

In our previous report we used international merchandise trade data from Statistics NZ at HS10 level (i.e., ten-digit harmonised system), providing 405 fish and fish product commodities, including species-level data (e.g., frozen fish fillets by 35 species). In contrast, the UN COMTRADE dataset used by GFN provides international trade data only down to HS6 level (i.e., six-digit), which gives only 127 commodities, and this is the best available from an international dataset. This aggregation necessitates significant approximation when aligning the trade data with FAO's detailed fish catch data. Because GFN's method is reliant on having consistent quality of data across all countries, there is no scope to use individual countries' higher detail trade data.

In the 2010 Accounts, trade of fish meal has been included (Ewing et al. 2010, p. 15), and this has a significant effect on New Zealand's Footprint, reducing it by 0.28 gha/capita.

The change with the single largest effect on New Zealand's fishing grounds Footprint is the change in effective trophic level assigned to the exported "Other freshwater and saltwater fish, frozen" traded commodity group, which has reduced from 4.22 to 3.63. This is because of an improvement in the methodology for all countries, as stated by GFN (Ewing et al. 2010, p. 14):

*The formula for effective trophic level has also been revised to reflect the exponential relation between fish trophic levels and Footprint intensities.*

This apparently small change in effective trophic level has a significant effect on the primary production required for this category because of a power relationship between the two. The primary biomass production required increases from 91.08 to 233.98 tonnes of carbon per tonne of wet-weight fish, which in turn decreases the yield from 0.047 tonnes of wet-weight fish per hectare of shelf per year to 0.012. The end result of this change for this one export fish category is that New Zealand's Fishing Grounds Footprint drops by 0.48 gha/capita.

The change to the calculation of effective trophic level ties the commodity trade part of the fishing grounds Footprint more strongly to the much more detailed production data, effectively addressing the issue of the mismatch of aggregation level between the two that was identified in our previous report.

We note that there appears to be an error in the calculation of 'Embodied Crop Footprint' on the 'fish\_commodity\_efe' sheet of the Excel workbook, although this has a very small effect on New Zealand's Footprint (0.01 gha/capita).

### **3.3 Extraction rates**

For “Other freshwater and saltwater fish, frozen,” which is the single biggest category of fish for New Zealand (31% of fish exports by weight and 44% of fishing grounds Footprint export), the extraction rate has been reduced from 1 to 0.65. This change to one exported commodity (group) resulted in an increase of exported Footprint, and a reduction in consumption Footprint by 0.25 gha/capita.

The extraction rate for “Frozen Fish Fillets,” also a significant category for New Zealand, has been increased from 0.5 to 0.65 (possibly to be consistent with “Other Fish”). This would have decreased the export Footprint if the yield factor had not also changed. The net effect of the increase in extraction rate and decrease in yield factor was near zero.

### **3.4 Discard rate**

The 2010 edition retains the figure of 27% for a global average discard rate despite the figure apparently having been superseded in a later edition of the same source document, as indicated in our previous report. We recommend that GFN investigate this new source document (Kelleher 2005), which gives a global average discard rate of 8%. In addition, given that discard rates appear to have dropped over recent years, time series of Footprints should potentially use a time series of discard rates appropriate to the year. Furthermore, discard rates are known to vary by species, with squid fishing particularly high. We recommend GFN consider the use of species-specific discard rates.

### **3.5 Summary**

New Zealand is a particularly difficult case, with a large fishing exclusive economic zone and a significant proportion of catch being exported. As a result of the GFN's methodology updates, the fishing grounds Footprint for New Zealand has reduced substantially. New Zealand's fishing grounds production Footprint has dropped from 2.24 gha/capita to 1.91 gha/capita, and the consumption Footprint has dropped from 1.70 gha/capita to 0.31 gha/capita. The major reasons are changes to aggregated trophic levels and to extraction rates. This consumption Footprint is now in line with FAOSTAT data indicating the relative consumption of fish per capita between New Zealanders and Japanese.

## **4 Forest Land**

In the 2010 edition, the equivalence factor for forest land has decreased from 1.33 to 1.26 gha/wha, and the world-average forest yield has decreased from 2.36 to 1.81 m<sup>3</sup>/ha/yr. The net effect of these changes is a 24% increase in both Footprint and biocapacity for all countries. However, the biocapacity has increased further because the national yield factor used for New Zealand has increased from 1.78 to 3.64 t/ha. This new figure is sourced from the Temperate and Boreal Forest Resources Assessment (Liski & Kauppi 2000, p. 214), and reflects the conifer and broadleaf mix of New Zealand's forests, both plantation and natural. When other, minor, changes are included, the consumption Footprint has increased from 0.99 to 1.26 gha/capita, and the biocapacity has increased from 2.08 to 5.06 gha/capita.

## 5 Grazing Land

Andrew and Forgie (2009) found the following main problems with the calculation of the grazing land Footprint in the 2008 edition of New Zealand's National Footprint Account:

- The method used for traded grazing land Footprint was different from that used for the production Footprint. In countries where the traded Footprints (either imports or exports or both) were of similar magnitude to production, significant error could be introduced.
- The land-use data were in some cases vastly different to official New Zealand sources of the same information.
- The 'Other wooded land' category of land use was included in grazing land, which is inappropriate in New Zealand.
- Footprints of exported wool and sheep meat were not calculated correctly because of a lookup error in the spreadsheet. These are two of the most significant exports from New Zealand with respect to the Footprint.

### 5.1 Exported Footprint

The method used to calculate exported grazing land Footprints has changed substantially since the last edition. As we identified in our previous report, the processes to calculate production and export grazing land Footprints in the 2008 edition were different and unconnected, and this had a significant effect on New Zealand's Footprint. In the 2010 edition exported grazing land Footprints are closely linked to production Footprints.

As an example, we focus on the grazing land Footprint of exported milk powder, a significant export commodity for New Zealand. In the 2008 edition of the NFA, the Footprint is calculated as follows:

$$EF_E = P_E \frac{EXTR_{grass \rightarrow milk}}{EXTR_{milk \rightarrow powder}} \frac{EQF_{grazing}}{Y_W}$$

where:

$EF_E$  is the grazing land Footprint of exported milk powder (gha),

$P_E$  is the amount of milk powder exported (tonnes),

$EXTR_{grass \rightarrow milk}$  is the extraction rate of fresh milk from grass,

$EXTR_{milk \rightarrow powder}$  is the extraction rate of milk powder from fresh milk,

$EQF_{grazing}$  is the equivalence factor of grazing (gha/wha), and

$Y_W$  is the world-average yield of grass (t/wha/yr).

In the 2010 edition, the Footprint is calculated as follows (with some simplification<sup>3</sup>):

$$EF_E = P_E \frac{EXTR_{grass \rightarrow milk}}{EXTR_{milk \rightarrow powder}} f_{grass \rightarrow milk} TFR_{milk} \frac{EQF_{grazing}}{Y_W} \frac{biocap_{grazing}}{demand_{grazing}}$$

where:

$f_{grass \rightarrow milk}$  is the fraction of feed requirement for milk supplied by grass,

$TFR_{milk}$  is the total feed requirement for milk production (t feed / t milk),

$biocap_{grazing}$  is the total area of grazing land (gha), and

$demand_{grazing}$  is the total calculated demand for grazing land (gha).

The key differences are (i) milk is now assumed to be derived not just from grazed grass but also other feeds, (ii) the total feed requirement factor (previously implicitly 1.0), and (iii) scaling the resulting Footprint so that it does not exceed biocapacity. The result of this methodological change is an increase in the Footprint associated with exported milk powder from 0.41 gha/capita to 0.58 gha/capita.<sup>4</sup>

## 5.2 Land-use data

Following the authors' enquires with the national statistics office, FAOSTAT's land-use data have been corrected to match official figures. However, while FAOSTAT's figure for pastoral land in New Zealand is 10,987,000 ha, the figure used in the Footprint spreadsheet is 11,354,000 ha – a difference of 367,000 ha that we cannot explain.

In our earlier report we also indicated that it was inappropriate to add "Other wooded land" to pastoral land in New Zealand. In the 2010 edition this land is no longer included for any country, for the following reasons (Ewing et al. 2010, p. 16):

*The land cover category "Other Wooded Land," previously included as a subcategory of grazing land, has been removed. This category is no longer reported in any available FAO dataset, and in at least some cases it appears to be double counting areas already reported in other FAO land use categories.*

The combination of these two changes has resulted in the grazing land biocapacity reducing from 20.4 million gha (5.06 gha/capita) to 13.0 million gha (3.11 gha/capita) between editions. In both the 2008 and the 2010 editions, the calculated national demand for grazing land is greater than available national grazing land biocapacity, which is physically impossible, and the grazing land production Footprint is therefore set at biocapacity. This reduction in biocapacity in the 2010 edition therefore directly decreases the production Footprint by 1.75 gha/capita. Because the traded grazing land Footprint is now linked to the

<sup>3</sup> This representation excludes imported milk, which is negligible in New Zealand.

<sup>4</sup> This change is based on the 2007 figure for milk powder exports, and includes not only the effects of the methodology change but also a small change in the equivalence factor for grazing land from 0.50 to 0.46.

production Footprint, the effect of these corrections on the consumption Footprint is less marked, with an overall 0.09 gha/capita reduction.

### 5.3 Omitted exports

The classification mismatches for two of New Zealand's most significant agricultural exports – sheep meat and wool – have been corrected. The correction for sheep meat reduces New Zealand's Footprint by 0.42 gha/capita. However, a new error in the calculation of the Footprints embodied in wool exports means that these are zero in the 2010 Account.<sup>5</sup> We calculate that correcting this error would reduce New Zealand's Footprint by a further 0.12 gha/capita.

### 5.4 Summary

Major changes have been made to the grazing land Footprint calculations and source data have been revised. The changes with the largest effects are (i) improvement of the exported grazing land calculation procedure, (ii) corrected FAOSTAT data, and (iii) the correction of lookups for two of New Zealand's key export commodities. However, a new error has been introduced for wool, which means that there is no exported Footprint associated with this commodity.

While in the 2008 edition of New Zealand's Footprint account only 63% of the production grazing land Footprint was exported, in the 2010 edition this has increased to a more realistic 95%, reflecting that much of New Zealand's key agricultural commodities are exported. The grazing land consumption Footprint has dropped from 1.90 gha/capita in the 2008 edition (for 2005) to 0.23 gha/capita in the 2010 edition (for 2007).

## 6 Cropland

In our previous report we showed that the “Arable land and permanent crops” land area used by GFN (3,406,000 ha, taken directly from the UN FAOSTAT database) was incorrect.

Following the authors' enquires with Statistics New Zealand, FAOSTAT's land-use data have been corrected to match New Zealand's official figures. FAOSTAT now gives the total “Arable land and permanent crops” area as 500,000 ha. It provides a separate figure for “Arable land” of 431,000 ha, which appears to be a subset area. However, the figure used in the Footprint spreadsheet is 932,000 ha, from which we infer that these two figures have been added together. We suggest GFN verify the meaning of these two land-use categories in the FAOSTAT data. In New Zealand the total cropping area is 500,000 ha, well short of 932,000 ha. Correcting this would reduce New Zealand's cropland biocapacity from 0.44 gha/capita to 0.24 gha/capita. However, this is a small reduction with respect to the total biocapacity of 10.77 gha/capita, and appears to have no effect on the Footprint.

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<sup>5</sup> In the *feed\_mix\_w* worksheet the code for greasy wool is 988 whereas the parent code or FAO code is 987. The spreadsheet calculation tries to look up 988 and as there is no such code this gets a N/A result.

## 7 Summary

The Global Footprint Network has produced a set of Ecological Footprint accounts for about 150 nations from global datasets using a methodology that is reasonably consistent across nations. However, on closer inspection it is evident that this significant effort requires careful validation for each country. Using local knowledge we previously analysed key components of the 2008 edition of New Zealand's Footprint accounts (for the year 2005), and a number of significant problems were found (Andrew & Forgie 2009).

In the present report we have revisited the Footprint accounts for New Zealand following methodological updates by GFN (documented by Ewing et al. 2010). We have focussed on the issues found in the previous report to see whether they have been addressed, and have not verified the accounts in their totality. There are many other changes in the methodology, and we refer the interested reader to the report by Ewing et al. (2010). We note here that the figures reported for New Zealand for cropland, built-up land, and carbon uptake land Footprints have changed very little between the 2008 and 2010 accounts.

The most significant changes to the methodology as they affect New Zealand's Footprint accounts were found to be (with changes in Footprint in parentheses where these can be calculated<sup>6</sup>):

- FAOSTAT's land areas used for pasture, forestry, and croplands have been corrected to match official NZ figures, and GFN is using these new figures (0.09 gha/capita reduction). The 'Other wooded land' category is no longer counted as grazing land.
- Classification errors that meant the Footprints of two of New Zealand's most significant exports were not correctly accounted have been corrected (0.42 gha/capita reduction).
- The calculation for export grazing land Footprint has been more closely linked to that of the production Footprint (0.17 gha/capita reduction for milk powder alone).
- The calculation of trophic levels for exported fish and fish commodities has been modified, and this change links the method used for the exported Footprint more closely to the method for the production Footprint (0.48 gha/capita reduction for the largest fish commodity category alone).
- The extraction rates (conversion rates from live fish weight to processed weight) have been modified, and this modification has had a significant impact on the Footprint (0.25 gha/capita reduction for the largest fish commodity category alone).
- Trade in fish meal has been added, which is significant for New Zealand (0.28 gha/capita reduction).
- World-average forest yield has decreased, as has the equivalence factor for forest land, leading to an increase in New Zealand's Footprint (0.24 gha/capita increase).

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<sup>6</sup> Because it is difficult to entirely separate these effects, figures are only indicative of the magnitude of the effects.

While these methodology changes and data corrections address most of the major issues found for New Zealand by Andrew and Forgie (2009), some issues remain:

- World-average fish discard rates are derived from a superseded FAO study, and are significantly higher than the more recent figures. Using the new rate would reduce New Zealand's Footprint by a further 0.05 gha/capita.
- Wool exports still appear to be incorrectly accounted in the new accounts, and correcting this would reduce the Footprint by a further 0.21 gha/capita.
- The area used for cropland biocapacity appears to be double-counted from the FAOSTAT data.
- There is a minor error in the lookup for crop requirements of fish exports on the fish\_commodity\_efe sheet.
- As discussed in detail by Andrew and Forgie (2009), the omission in the Footprint methodology of non-CO<sub>2</sub> greenhouse gases has a significant effect on New Zealand. We previously estimated that these gases add 1.05 gha/capita to New Zealand's Footprint.
- The use of the consumption perspective, where the Footprint associated with internationally traded goods are accounted in the receiving countries accounts, ignores the benefit the exporting country obtains from production. This effect is magnified in countries such as New Zealand where a large proportion of agricultural production, and hence production Footprint, is exported. A shared responsibility perspective would address this problem (e.g., Andrew & Forgie 2008).

With the changes in methodology between the 2008 and 2010 editions, GFN's estimate of New Zealand's Ecological Footprint has dropped from 7.70 gha/capita in 2005 to 4.89 gha/capita in 2007, and New Zealand's rank in about 150 countries has dropped from 6<sup>th</sup> to 32<sup>nd</sup>. With the correction of further minor errors uncovered in this work, the footprint would drop further to 4.72 gha/capita.

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