20 Further Research and Refinements to the Ecological Footprint Analysis

This report represents the first comprehensive attempt to estimate the ecological footprints of New Zealand regions although Bicknell et al (1998) estimated the national ecological footprint for New Zealand. In the process of undertaking these estimations it became apparent that further extensions and refinements to this analysis should be undertaken. These however are beyond the immediate scope of this current project.

20.1 Improving the relevance of the analysis for individuals

In this report the ecological footprint was calculated using input–output analysis. This has a number of advantages that have already been outlined in Section 2 (more comprehensive than the 'bottom up' methods, avoids double counting, deals with complicated networks of indirect flows and so forth). However, although arguably more methodologically rigorous than the 'bottom up' methods such as the 'best foot forward' Ecoindex™ method, the input–output methodology is more difficult to understand for the layperson.

It has been suggested that a 'bottom up' component analysis be utilised to estimate regional and personal ecological footprints. It is often argued that such 'bottom up' analyses are expressed in terms that are more easily understood by end-users – personal energy use, eating (food consumption), shopping behaviour (purchases of goods and services), travel behaviour, recycling and use of materials, and water usage. One reviewer commented that 'bottom up' footprint analyses are 'more intuitive and meaningful for individual action'. This can help individuals to decide how and where to make improvements in their lifestyles. It is therefore recommended that further studies of the ecological footprint for New Zealand regions focus on refining the input–output analysis to reflect individual-level behaviours and purchasing patterns. This could be achieved by integrating input–output results with a 'bottom up' analysis or probably (more expeditiously) by using a sector-by-commodity matrix in the input–output analysis. The latter would at least express the results in terms of purchases of commodities that individuals would recognise rather than the current sector-based analysis.

A hybrid of 'bottom up' component analysis and 'top down' input–output analysis would probably provide the best outcome, enabling the results to be presented in terms understood by the individual whilst retaining the methodological rigour and accuracy of the input–output approach. Such hybrid approaches have been widely used in related Lifecycle Assessment methods, but seemingly have not been applied in ecological footprinting (eg. refer to IFIAS (1975) and Patterson and Earle (1985)).

Another way of improving the accessibility and usefulness of the ecological footprinting exercise for individuals, is to construct a personal ecological footprint calculator. Several of these ecological footprint calculators appear on the web, eg. Redefining Progress (www.progress.org/programs/sustainability/ef) and Best Foot Forward's (www.bestfootforward.com) calculators.

Indeed from October 2002 such an ecological footprint calculator has appeared on the Ministry for the Environment website (www.environment.govt.nz). This footprint calculator is designed for New Zealand conditions based on the national-level analysis contained in this report. The next step would be to develop such a web-based ecological footprint calculator for every region in New Zealand.

Diagrammatic and graphical depiction of ecological footprints would also be useful in communicating the results, to individuals and a lay audience. In this respect, the Lifecycle Assessment diagrams, as presented in Patterson and McDonald's (2002) report *How Clean and Green is New Zealand Tourism: Lifecycle and Future Impacts* could be useful. They explicitly show all of the direct and indirect inputs of embodied land into the ecological footprint.

20.2 Improving the relevance of the analysis for policymakers and planners

The ecological footprint has been widely promoted as a sustainability indicator that will assist policymakers and government planners to make better decisions. It provides a broad measure of the direct and indirect environmental impacts of countries, regions and cities which is of relevance to policy development and planning.

The ecological footprint analysis presented in this report, and for that matter footprint analysis in general, needs to be fine-tuned for planning and policy analysis purposes. Firstly, a number of strategic issues directly arise from the footprint analysis and need to be addressed. In this respect, the following policy questions emerge from our analysis:

- What happens to New Zealand's footprint and its underlying function, when New Zealand's petroleum resources deplete and the country has to rely on imported transport fuels?
- What happens to New Zealand's export potential from about 2020 when the mid-point of the world oil reserves is passed and major flows of materials between countries might become constrained?
- What does economic growth and population growth mean for the New Zealand footprint from 2020 and even to 2050?
- Will population growth in our main international trading partners confer a maintenance of trade demand for each region's traded products?
- How do we break the link between an increasing per capita affluence and standard of living and an increasing footprint?

It would be informative for policy development to deal with these questions in any further ecological footprint study of New Zealand and its regions. It could be argued that the current static analysis, without answering such questions about the future, promotes a false sense of security. In this respect, although most regions do not currently overshoot their carrying capacity, within 20–30 years they could do so if current trends and structural patterns persist. A dynamic analysis focusing on such policy issues would be useful to the policy and planning community.

The current study emphasises the land footprint, which is useful in understanding land constraints and thresholds as they relate to sustainability. However, in understanding sustainability and the limits to economic growth, it is critical that other resources and pollutants be considered. For this reason, in order to better inform the policy debate, it would be useful to calculate water, carbon, energy and other footprints. These footprints would measure the direct and indirect resources/emissions required by a nation, region or city. The calculation of these footprints will undoubtedly deliver different messages to policy makers to the land footprint, and a combined study of all of these footprints would provide a richer analysis of the sustainability issue.

The ecological footprint analysis initiated in this report needs to be further developed for setting priorities for action towards sustainability including setting specific targets. Particularly if the 'bottom up' component approach was used (possibly in conjunction with the 'top down' approach), then the footprint analysis would give guidance as to what behaviours would need to be changed to reduce the ecological footprint. In this way, the ecological footprint analysis can provide guidance on how to reduce environmental impacts and improve sustainability.

In so far as the Ministry for the Environment has already implemented the first recommendation of the publication *Headline Indicators for Tracking Progress to Sustainability in New Zealand*, the place of the ecological footprint as a national sustainability indicator has been established. However, there is arguably a need to go further to establish national and regional targets for the ecological footprint indicator in the same way that the Dutch government does for their national policy performance indicators.

20.3 Methodological and accuracy improvements

Although carried out at the 23 sector level (instead of 80 sectors), as well as using a different base year of 1997/98 (instead of 1991) and using different land-use data, our study arrived at a very similar estimate for New Zealand's ecological footprint to Bicknell et al's (1998) previous study. Despite the close correspondence between the two studies, there are definite ways in which both the methodology and application could be improved in future studies.

Firstly, the current input–output model should be extended from 23 sectors to at least 50 sectors. This in particular would improve the differentiation of the agricultural sectors, enabling a better estimate of the food components of the footprint. This disaggregation of the agricultural sector should be able to be readily achieved for the land use data by utilising data available from Statistics New Zealand. The disaggregation of CO_2 emission data for the agricultural sector is however more problematic, meaning that the energy component of the ecological footprint may not be able to be accurately calculated at this level of disaggregation.

Besides the agricultural sector, in particular more accurate results would be obtained by disaggregating the transport sector into air, road, water and sea transport. Unlike the agricultural sector, we foresee few problems in doing this as good CO_2 emissions, land and economic data exist for these transport sub-sectors.[19]

In general terms, the estimation of land use data for the manufacturing and service sector below the 23 sector level becomes problematic and difficult. It would take a great deal of research effort and interagency co-operation to derive greater disaggregation of the land use data for these sectors of the economy.

Secondly, no allowance has been made for land quality factors in the regional analysis of ecological footprints. To a significant extent, this limits the ability to meaningfully compare the ecological footprint performance across regions. For example, the average quality (productivity) of land in Otago is much lower than that of the Bay of Plenty and therefore it is not strictly valid to directly compare the ecological footprint of both regions. Some adjustment needs to be made to convert land to a common unit of measurement (numeraire).

[19] The regional economic data (regional input–output matrices) required for the calculation of ecological footprints at the 50 sector level can reasonably reliably be generated by using the GRIT method. National level input–output matrices disaggregated down to about the 160 sector level are routinely produced by Statistics New Zealand.

Commensuration of land quality in terms of their net primary productivity seems to have logical appeal — in other words, three hectares of Class A land could be deemed to be equivalent to 1 hectare of Class C land because it produces three times as much in terms of its productivity. Very crude global adjustments for land quality using net primary productivity have been implemented by Wackernagel and Rees (1996) but because they are very crude and because they are of dubious applicability to New Zealand they were not utilised in our study.[20] It is therefore recommended that major research effort be put into developing the land quality factors for New Zealand conditions. This will require significant methodological and scientific research to derive such factors, probably to be funded through the Foundation of Research, Science and Technology.

Thirdly, as one reviewer pointed out, the accuracy of the results depends on accurate regional input–output matrices as well as an accurate model of interregional flows. In New Zealand, survey-based regional input–output matrices do not exist, instead estimated regional input–output matrices have been developed by Hubbard and Brown (1981), Butcher (1986) and more recently by McDonald and Patterson (1999b) using the GRIT method. Although this technique of generating regional input–output matrices is widely regarded as providing reasonable results, there is no doubt that survey-based regional input–output matrices would be more accurate. Statistics New Zealand is currently investigating the feasibility of constructing survey-based regional level input–output matrices in New Zealand.

Similarly, the interregional flows which proved to be significant in most regional footprints, could only be estimated in our study by using a minimisation of travel time method. This method needs to be checked where possible against existing data and adjusted if need be. Given the complexity of interregional flows in New Zealand and the lack of data, there is little likelihood of the interregional trade flows model being built up from survey data. However, the introduction of any superior data into the interregional flow model would be helpful in eventually improving the accuracy of the regional ecological footprints.

Fourthly, given the large amount of coastal and marine 'land' in New Zealand, and the ecological and economic importance of this 'land', it could be argued that it should be included in the footprint calculations. It wasn't included in our current analysis primarily because it would unreasonably 'distort' the size of our footprint. There would also be methodological difficulties in allocating marine and coastal areas to economic sectors and to regions. For example, although the fishing sector uses the marine area, there are other economic and ecological functions provided by the marine area. Therefore, some decision-rules would be needed to ascertain what proportion of the marine area should be allocated to the fishing sector – justifying such decision rules is likely to be quite difficult.

20.4 Updating the ecological footprint analysis

The current analysis was undertaken for the 1997/98 March year, based on the data availability. It is recommended that the analysis be updated on a biennial basis at the 23 sector level (ie. for

[20] Murray and Lenzen (2002) suggested that 'land disturbance' factors be used to measure land quality in ecological footprinting, instead of the 'productivity' based approach. They argue that the 'disturbance' factors 'better reflect the image of the footprint on the land because it describes the effects of human land use on ecosystems'. It is difficult to see how such an approach could be operationalised in New Zealand due to the lack of data and due to methodological issues concerning the interpretation of the 'disturbance concept'.

1999/2000, 2001/2002 and so on). It is unlikely that there will be sufficient movement in the ecological footprints, to justify an annual update.

There are however data problems that will limit the accuracy of these updates:

- Over recent years agricultural statistics has been produced every three years. More up-to-date agricultural land information may be obtained from Agribase, but for a nationwide analysis this may be prohibitively expensive. If Agribase data proves to be too expensive we would need to use an estimation method that would be less accurate.
- Estimates of CO_2 emissions were obtained from our update of the EECA database. These give reasonably accurate sector level estimates of CO_2 emissions for 1997/98. However, with the last update of the EECA database being for 1994, to validly use it for 2002 (even with the use of the most sophisticated estimation methods) would be very questionable. Fundamentally, a survey-based update of the EECA database is required.