PROVINCE OF ONTARIO

ECOLOGICAL FOOTPRINT AND BIOCAPACITY ANALYSIS

Produced for State of Ontario's Biodiversity 2010 Report

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ACRONYMS AND ABBREVIATIONS

CBD	Convention on Biological Diversity
CLUM	Consumption Land Use Matrix
DPSIR	Driving Forces - Pressures - States - Impacts - Responses model
gha	global hectare
ha	hectare
IO	input-output (economic analysis)
nha	national hectare (part of yield factor analysis)
OECD	Organization for Economic Co-operation and Development
wha	world hectare (part of yield factor analysis)
Footprint	shortened version of Ecological Footprint

1 EXECUTIVE SUMMARY

The Ecological Footprint is a tool that assesses humanity's demand for natural resources and informs us whether our collective consumption levels are approaching or exceeding the Earth's ecological limits. The Footprint can be directly compared to biocapacity, a metric that accounts for available resource supply using an anthropocentric lens, considering specific products provided by ecosystems for human use (food, fibre, timber and carbon storage). These two measures, taken together, provide a partial ecological balance sheet for the world.

Measuring biocapacity allows us to measure a portion of the provisioning and carbon sequestration potential of ecosystems worldwide, and thus to indirectly measure the amount of bioproductive resources available to supply both humans and natural ecosystems. The Ecological Footprint is a relevant environmental indicator for tracking unsustainable use of biological resources and for tracking overall efforts to reduce human impacts on biodiversity.

According to the 2008 National Footprint Accounts, the global Ecological Footprint in 2005 was 17.4 billion global hectares (gha) or about 2.7 global hectares per person. In comparison, the world's biocapacity (or total supply of bioproductive land) was only 13.4 billion gha, or 2.1 gha per person. This situation, in which the global Ecological Footprint exceeds available biocapacity, is termed ecological overshoot. If humanity continues to consume at the level we see today, by 2050 we will be consuming the resource equivalent of two planets each year. Consuming the equivalent of more than one planet's biocapacity means we are depleting our renewable resource stocks, increasing carbon dioxide concentrations in the atmosphere, or some combination of the two. Such trends cannot continue without adverse consequences for ecosystems and biodiversity.

On a per person basis, Ontario residents are among the global populations placing the highest demands on the planet's resources. In 2005, the average Ecological Footprint in Ontario was 8.4 global hectares per person; only three of 150 countries with reported Ecological Footprint data have a higher average per-person Ecological Footprint.

In 2005, the average biocapacity in Ontario was 8.5 gha per person, just above the average Ontario Ecological Footprint in size. However, Ontario's biocapacity is substantially lower than the Canadian average of 20.0 hectares per person. While Ontario enjoys the benefits of a per capita biocapacity that is four times larger than the world average available per person, the resource intense lifestyle enjoyed by Ontario residents is not sustainable at the global scale.

Conservation and sustainable management of resources are necessary for creating a base upon which biodiverse ecosystems can carry out adaptive natural processes. This includes understanding and accounting for biodiversity across biomes, species, and genetic populations, protecting established ecological assets, and working to sustainably manage the ongoing use of these resources by humans. However, no amount of protection of land or classification of endangered populations will fully ensure the conservation of biodiversity, since some human impacts (especially climate change and persistent toxins) extend broadly. What is required is a tandem effort to measure and, where needed, reduce the cumulative impacts of human activities on natural systems.

2 INTRODUCTION

The Convention on Biological Diversity (CBD) is an international treaty outlining the importance of biological resources for maintaining ecosystem health and human well-being. The treaty entered into force in 1993 with 168 signatory nations, and has promoted and paralleled the growth of an international movement toward conservation of natural resources, species, and habitats.

The CBD acknowledges the intrinsic value of biodiversity, but also the importance of maintaining biodiversity for ecosystem health. The Convention notes that human activity is having an increasing impact on biodiversity – indirectly through competitive demand for food and energy, and directly through over-exploitation of resources, habitat alteration, introduction of invasive species, and acceleration of climate change.[1] We are now losing biodiversity at a rate unparalleled in human history – the direct and indirect forces driving biodiversity loss in the 21st century are beyond any one simple policy prescription and need to be addressed by more than one tool.

In 2005, the Conference of the Parties to the Convention on Biological Diversity released an executive note outlining the benefits of using the Ecological Footprint as one of the indicators assessing progress toward 2010 targets to reduce the rate of biodiversity loss.[2] The Conference of Parties has since listed the Footprint as the only relevant indicator to tackle target 4.2 of the Convention, namely ensuring that "unsustainable consumption of biological resources, or that impacts upon biodiversity, [are] reduced."[3] The Ecological Footprint is a resource accounting tool that assesses the human demand on ecological assets (production of resources and storage of carbon dioxide waste) and compares it to biocapacity, which assesses the regenerative capacity of these ecological assets. The strength of using the Ecological Footprint is that it allows a direct comparison to be made between resource availability, and resource consumption.[4]

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[1] United Nations Environment Programme. 1993. "Convention on Biological Diversity." Available at http://www.cbd.int/doc/legal/cbd-un-en.pdf

[2] United Nations Environment Programme. 2005. "Indicators for Assessing Progress Towards the 2010 Target: Ecological Footprint and Related Concepts." Available at http://www.cbd.int/doc/meetings/sbstta/sbstta-11/information/sbstta-11-inf-20-en.pdf.

[3] Convention on Biodiversity. "COP VIII/15. Framework for monitoring implementation of the achievement of the 2010 target and integration of targets into the thematic programmes of work." Available at http://www.cbd.int/convention/results/?id=11029&kw=footprint&t0=footprint.

[4] Ibid. United Nations Environment Programme. 2005. "Indicators for Assessing Progress Towards the 2010 Target: Ecological Footprint and Related Concepts," 3.

The Ecological Footprint converts human consumption into demand on natural resources. It should be considered in tandem with a suite of other indicators (e.g. habitat degradation, invasive species, pollution, and climate change) that help explain the overall impact of human consumption patterns on biodiversity. The Ecological Footprint is relevant to biodiversity accounting for two reasons. First, the Ecological Footprint highlights the importance of looking at human demand on the environment as one of the factors influencing natural ecosystems. The causal link between unsustainable anthropogenic activities and decreasing biological capital is becoming ever more apparent, especially with respect to increasing greenhouse gas emissions and climate change. On a global scale, we are using more of the planet's "natural capital" than is being replaced on an annual basis. Second, if human activities continue to degrade ecosystems services and biodiversity continues to decline, this trend will in turn decrease the biocapacity available to supply resources and absorb wastes from the atmosphere, creating a positive feedback loop with disastrous consequences to our global societies. For example, research suggests that reduction in the diversity of pollinating species may directly reduce crop yields, therefore indirectly impacting the productive capacity (biocapacity) of cropland.[5] It will become more important in the future to directly map the links between decreasing biodiversity and the resulting impacts on the productive capacities of land and water ecosystems (biocapacity) to produce food and other materials required for human use.

Comparing human activities and their impacts (the Ecological Footprint) and the current supply of ecological resources available for human use (biocapacity) allows us to see that growth in our economies and populations is increasing the strain that humanity places on the environment. For example, while cropland currently accounts for 12 percent of the total global land area, this percentage may need to increase in the next 50 years to accommodate increasing populations and standards of living. What will this increase mean for fragmented ecosystems adjacent to human settlements? Will these areas be altered to create cropland, or managed for the benefits they provide as intact ecosystems? The Ecological Footprint and biocapacity tools can help transform complicated, value-laden conversations into more simple terms: What resources are available, and what resources are used? As resource use becomes more efficient through changes in consumption and technology, how will this help reduce human demand on the environment?

[5] Aizen, M.A., L. A. Garibaldi, S. A. Cunningham, and A.M. Klein. 2009. "How much does agriculture depend on pollinators? Lessons from long-term trends in crop production." *Annals of Botany*. 103, 1579-1588.

The overall focus of the larger *State of Ontario's Biodiversity 2010* report is assessing the state of Ontario's biodiversity, in recognition of both the intrinsic value of biodiversity and the immense benefits that it provides. The traditional approach for maintaining biodiversity has been two-pronged: (1) sustainable use of current ecological resources, and (2) species and habitat protection to maintain diverse and functioning ecosystems. The Ecological Footprint provides an additional approach to understanding underlying factors driving biodiversity loss, based on a more complete assessment of cumulative human pressure on the natural environment.

Just as biodiversity can be measured on many levels, from the local genetic diversity of a specific trout population to the global status of ecosystems, the Ecological Footprint can be measured on national, sub-national, or local scales. The Ecological Footprint allows comparison of human demands with nature's capacity to meet these demands, and thus makes it clear when this capacity is being exceeded. The Footprint provides a quantitative measure of resource demand, mirroring the commonly used "IPAT" equation, where impact is measured by population, affluence, and technology. The Ecological Footprints of high-income countries are typically much higher than low-income countries of comparable population size, largely because of the high consumption lifestyles afforded by affluent nations. The Footprint sends a clear message to policymakers and the public that the current trends of consumption in many places are unsustainable, and that efforts must be turned toward better management of all facets of environmental demand.

3 BACKGROUND: ECOLOGICAL FOOTPRINT AND BIOCAPACITY

3.1 What is the Ecological Footprint?

The Ecological Footprint is a resource accounting metric that answers the research question, "how much of the regenerative capacity of our planet do we use?" by quantifying the demand that human consumption and waste generation place on the biosphere. The complementary measure to Ecological Footprint is biocapacity, which tracks how much natural productive capacity is available to meet demand.

More specifically, the Footprint measures the area of biologically productive land and water that is needed to produce all of the resources humanity consumes, and to absorb the wastes created. Likewise, biocapacity measures the extent of key ecosystems that support human populations, in terms of the products these ecosystems provide (including food, fibre and timber, and absorptive capacity for carbon dioxide). These two measures, taken together, provide a partial ecological balance sheet for the world. If the Footprint is larger than biocapacity at the global scale, it means that humanity is using more than can be regenerated, and therefore must be drawing down the standing stock of resources or causing an accumulation of wastes that must be processed by the biosphere. Anthropogenically induced climate change is an example of the effect of exceeding the waste assimilation capacity of our global ecosystems. The Ecological Footprint and biocapacity are measured in global hectares, an area that is weighted according to the average productivity of biologically productive land and water in a given year to make different land-use types comparable at the global scale.

The Footprint of a particular human population sums the cropland, grazing land, forest land, fishing ground, built-up land, and carbon uptake land (for the carbon Footprint) required to produce the food, fibre and timber it consumes, and to absorb the carbon dioxide waste it creates. The land types utilized in Ecological Footprint and biocapacity analysis do not include areas with dispersed bioproductivity such as wetlands, swamps or tundra as these areas do not generally provide resources that can be directly harvested and accounted for in systems of national accounts. International trade allows populations to consume resources from all over the world, and thus the Footprint of a product produced in Brazil but consumed in Ontario is allocated to Ontario. For a national analysis, the Footprint of consumption is calculated as the Footprint of domestic production plus the Footprint of imported goods and less the Footprint of exported goods.

3.2 How are the Ecological Footprint and biocapacity calculated?

The Ecological Footprint converts the amount of raw materials used or carbon dioxide emitted into the amount of bioproductive land and water required to supply these resources (or store the wastes created). This translation requires knowledge of world average yields in various raw material products (e.g. average yield of roundwood in tonnes per hectare for forest products) and knowledge of the specific land-use type equivalence factor (see Annex A for more information), which takes world average bioproductive land of multiple different land-use types and translates it into global hectares (gha).

The basic calculation for the Ecological Footprint is illustrated in Equation 1. For example, two tonnes of roundwood (a cut of timber) may be harvested from a forest. This product weight is divided by the average yield per hectare for that forest, and then scaled by the yield factor. The yield factor is the ratio between national (or sub-national) average yield and world average yield for the product in question, and weights land according to its relative productivity. The final step is to multiply by the equivalence factor, a scaling value that converts the actual area in hectares of different land types (forest, cropland, grazing land, etc) into a global hectare equivalent.

$$EF = \frac{P}{Y_N} \times YF \times EQF \qquad \text{(Eq. 1)}$$

In equation 1, P is the weight of product harvested, Y_N is the average yield for P, and YF and EQF are the yield factor and equivalence factor.

For biocapacity, the calculation utilizes the area of land in that land-use type (cropland, forest land, grazing land, etc.), multiplied again by the yield factor and equivalence factor as shown in equation 2.

$$BC = A \times YF \times EQF \qquad \text{(Eq. 2)}$$

Yield factors vary by product, land use type, and location while equivalence factors only vary by land use type, and are identical for every location in a given year. The equivalence factors used for this analysis, from the 2008 Edition of the National Footprint Accounts, are listed in Table 1. The equivalence factor for cropland shows that in 2005, cropland was 2.64 times more productive than world average bioproductive land. Inland water, on the other hand, was less than half as productive.

Table 1. Equivalence factors, 2005.

Land Use Type	Equivalence factor (gha per ha)
Primary Cropland	2.64
Forest	1.33
Grazing Land	0.50
Marine	0.40
Inland Water	0.40
Built-up Land	2.64

For a more detailed analysis of the methodology for calculating the Ecological Footprint and biocapacity, please refer to Annex A.

3.3 Additional Considerations – Ecological Footprint Methodology

The Ecological Footprint concept is a conservative underestimate of human demand on the environment. As an accounting metric, the Ecological Footprint utilizes publically available data on resource production, trade, and consumption. It focuses at the national level on using widely accepted datasets such as those provided by the United Nations and the International Energy Agency. There are a number of specific ways the Ecological Footprint underestimates the total impact of human activity:

- The Footprint does not track all of the wastes generated by human activity, only those that can be absorbed by the biosphere and transformed back into biological resources in human time scales. At this time, the only waste directly tracked by the Ecological Footprint is carbon dioxide emitted into the atmosphere, using data on carbon dioxide emissions from the International Energy Agency. The Footprint does not track depletion of non-renewable resources or inherently unsustainable activities such as the release of toxic chemicals into the environment, nor does it directly track water use.

- Because the calculation of biocapacity does not set aside land specifically for conservation or use by wild species, it overestimates the amount of regenerative capacity available to humans for specific uses.

- Biocapacity does not immediately capture the impact of topsoil loss, eutrophication, or other types of ecosystem degradation. The Ecological Footprint and biocapacity are snapshots of the conditions prevailing during the year in question; therefore, one may expect degradation of natural services in one year to translate into decreased biocapacity in future years.

The Ecological Footprint is an anthropocentric measure, meaning that it does not take into account the "value" of natural ecosystems or biodiversity in an explicit way. In fact, with current data limitations[6], the biocapacity of a single species, high-yield piece of cropland is larger than that of a biologically diverse, intercropped piece of land with lower yields. Thus, it is important to take a more in-depth look at the Ecological Footprint, or combine this measure with other biodiversity measures, when attempting to compare different resource management schemes. It is not enough to say that one management scheme for a forest is more beneficial (through analysis of increased yields and the resulting biocapacity of that land) without looking at the increased effort (via the Ecological Footprint of fertilizers, intensive management, etc) that is required, or the impacts of those efforts on biodiversity.

Though the Ecological Footprint does not account for all human impacts on the environment, the measure does provide a tangible indicator of "unsustainability," when overall resource use is not matched by resource supply each year. The Footprint does not prescribe how a region can be sustainable in terms of resource use. However, when consumption outstrips the rate that resources can be supplied, then it has to be assumed that standing stocks of resources are being depleted or waste accumulation is occurring in the atmosphere. This translates into increasing risks for biodiversity.

[6] National data, reported to satisfy international agencies such as the United Nations Food & Agriculture Organization, may suppress data relevant to measures of biodiversity. However, it may be possible to evaluate in-country data with a different lens focused on natural areas, multi-use forests, parks & preserves. Such an effort is beyond the scope of the current project, but should be evaluated as a separate undertaking in future Global Footprint Network research projects. For additional information see Annex D.

4 ECOLOGICAL FOOTPRINT RESULTS

4.1 Humanity's Ecological Footprint

In 2005, the global Ecological Footprint was 17.4 billion global hectares (gha) or about 2.7 global hectares per person. In comparison, the total supply of bioproductive land at the global scale was only 13.4 billion gha, or 2.1 gha per person. Humanity's Footprint first exceeded biocapacity in the mid-1980s. As Figure 1 illustrates, in 1961 humanity was using only 54 percent of available biocapacity, but due to increasing population and higher consumption we now use more than 130 percent of available biocapacity. This situation – when humanity uses more resources than are regenerated globally – is called ecological overshoot. In the same way that it is possible to spend more money than is brought in each paycheck by drawing down a savings account, overshoot means that humanity is appropriating all the regenerative capacity of the planet, plus additional stored resources (standing stock) each year, or is creating waste faster than it can be assimilated.

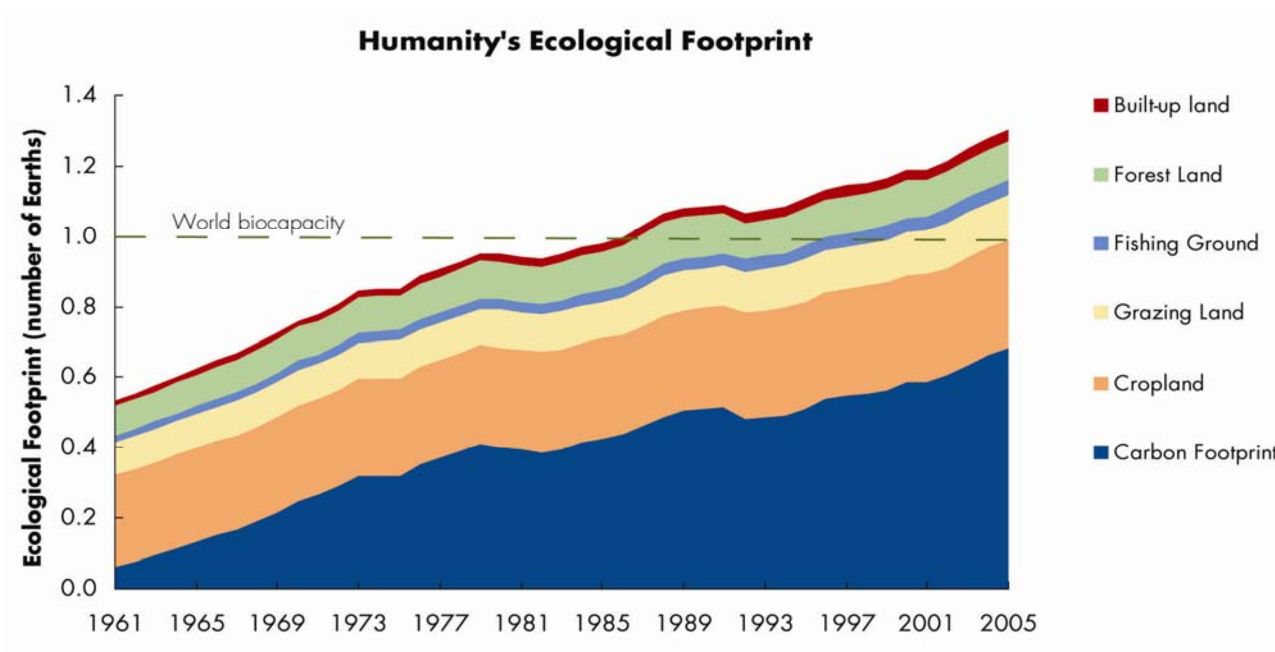


Figure 1. Humanity's Ecological Footprint, measured in number of Planet Earths.

The carbon Footprint has grown from the second smallest component of the overall Ecological Footprint in 1961 to the most significant portion in 2005, accounting for 52 percent of the total. For most high-income countries, the forested land needed to store emissions of carbon dioxide, as measured by the carbon Footprint, accounts for the largest portion of overall demand on natural resources. However, for lower-income nations with much smaller per capita Ecological Footprints and much lower levels of overall consumption, the carbon Footprint is small compared to the other land-use types.

Ecological Footprint and biocapacity are not equally distributed across nations, or even across regions. In per capita terms, the countries with the largest Footprints in 2005 included the United Arab Emirates, the United States of America, Kuwait, Denmark, and Australia. In aggregate terms, the United States and China together constituted more than 30 percent of total global Ecological Footprint in 2005. In terms of biocapacity, the countries with the largest per capita ecological wealth included Gabon, Canada, Bolivia, Australia and Mongolia. In the aggregate, the biocapacities of the United States of America, Brazil, and the Russian Federation made up 30 percent of total global biocapacity in 2005, as noted in Figure 2.

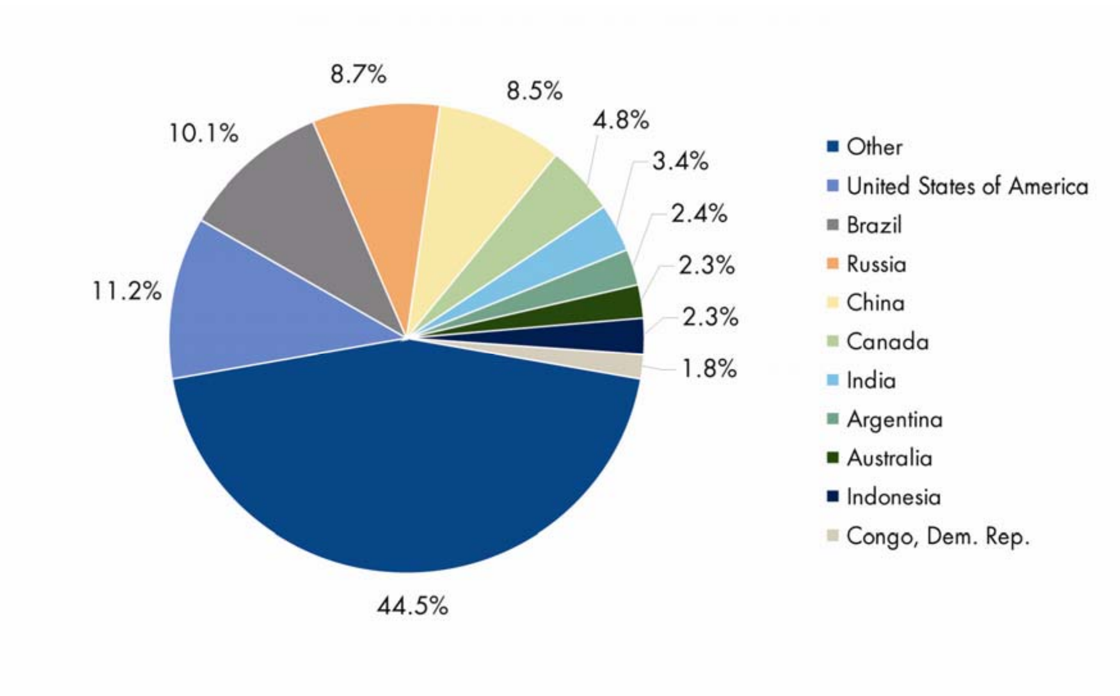


Figure 2. The 10 nations with the largest total biocapacity, along with the rest of the world.

Nations with large biocapacity reserves at their disposal will be at an advantage as we move into a resource constrained future. Canada houses only 0.5 percent of the world's population, but has 4.8 percent of its available resources and carbon sequestration potential. These resources, however, are not evenly distributed across Canada: some regions have much higher

Ecological Footprints than other regions, and some have more local biocapacity. Thus, risks to biodiversity, and indeed biodiversity losses, vary considerably across the regions of Canada.

4.2 Canada's Ecological Footprint

At the national level, the Ecological Footprint can be used to monitor changes in consumption, trade, and available resources over time. Since 1961, the earliest date for which Footprint assessments are available, Canada has been an ecological creditor country, with more domestic biocapacity available than the Canadian Ecological Footprint demands. Figure 3 illustrates a declining trend in per capita biocapacity in Canada owing to increasing population, and an Ecological Footprint that has increased from 5.3 gha per capita in 1961 to 7.1 gha in 2005, reaching a peak in 1979 at 8.6 gha. For context, this graphic also includes the world average Ecological Footprint and biocapacity, illustrating that while Canada is an ecological creditor, Canadians are using much more than the world average amount of resources on a per capita basis.

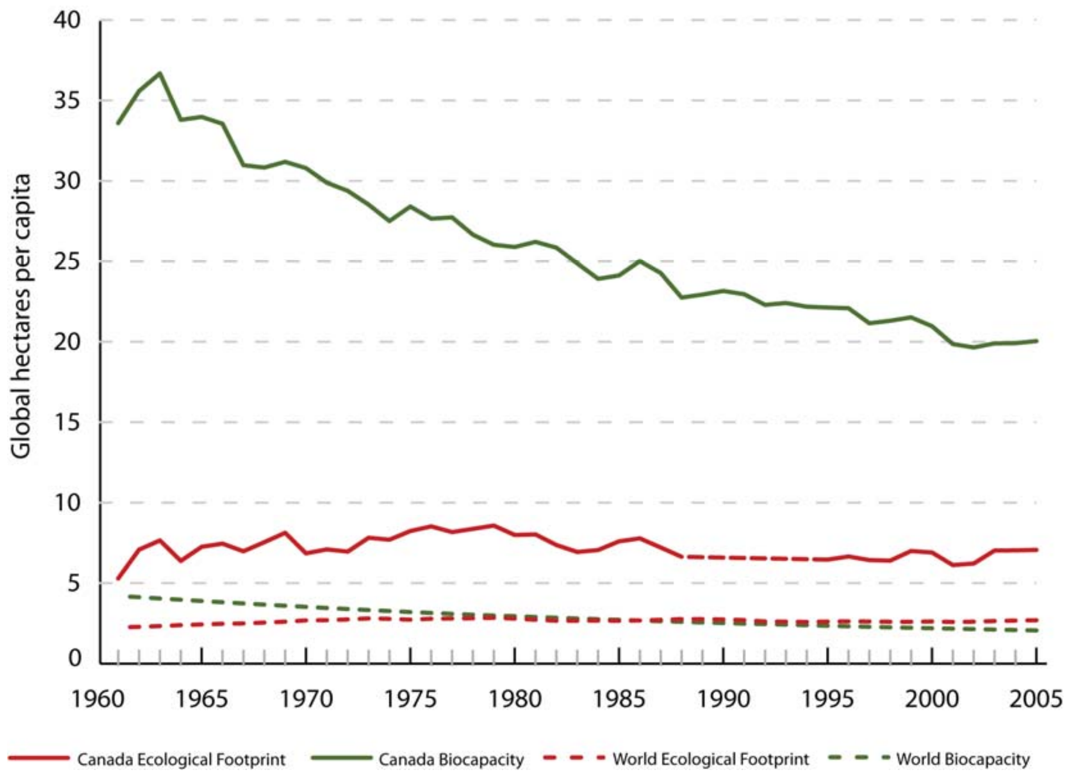
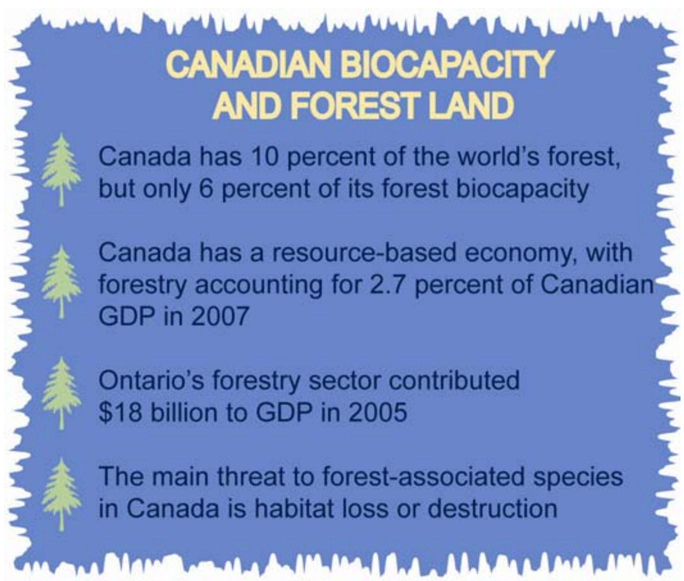


Figure 3. Canada and world Ecological Footprint and biocapacity, in global hectares per capita.[7]

[7] The dotted line in Canada's Ecological Footprint between the late 1980s and 1995 is due to anomalies in the data reported for traded goods to COMTRADE.

The time series data for Canadian resource use and availability tells a very serious story about continuing business as usual. In 1961, the Ecological Footprint was about 16 percent the size of Canada's available biocapacity, but by 2005 the ratio between Footprint and biocapacity had diminished, with Footprint closer to 35 percent the size of total biocapacity. While total biocapacity has remained relatively constant, the total Ecological Footprint in Canada has more than doubled (alongside a population increase of more than 75 percent). If the trends in per capita consumption, production efficiency (gha of biocapacity demanded per dollar spent on production), and population continue, by 2050 Canada's Ecological Footprint will exceed is biocapacity in per capita terms.

A global economy and dynamic international markets allow consumers to purchase goods, and thus natural resources, from around the globe. To understand Ontario's Ecological Footprint and biocapacity, it is necessary to know how resources are flowing between provinces, and between Ontario and the international market. If Ontario is exporting significant amounts of natural resources to satisfy demand from elsewhere, this will put strain on domestic biocapacity and biodiversity unless properly managed. If Ontario is importing significant amounts of resources, it illustrates the demand that Ontario is placing on biocapacity in other countries.



One of the issues facing Canada, and the individual Canadian provinces, is how to manage their resource wealth in an ecologically sustainable manner. For example, Canada has a large amount of forest land biocapacity at its disposal: more than nine gha per person. This forest area is utilized by Canada's large natural resource economy.[8] This economic engine must be carefully managed, however, as one of the main threats to forest-dwelling species is the loss of

[8] Ontario Biodiversity Council, in partnership with Ontario Ministry of Natural Resources. 2008. "Interim Report on Ontario's Biodiversity 2008." Available at http://www.mnr.gov.on.ca/243480.pdf

habitat caused by logging and natural disturbances to forest ecosystems.[9] Canada has maintained its position as a net exporter of biocapacity, specifically sending more forest land biocapacity outside its borders than it is importing. In fact in 2005, Canada exported the Footprint equivalent of 32 percent of its forest land biocapacity.[10] While some of this exported forest Footprint may be re-exports (or value added to previously imported goods), it illustrates the significant amount of biocapacity being exported to other countries. Trading ecological resources between nations can often lead to comparative advantages, allowing the most efficient countries to harvest resources at the lowest opportunity cost. However, as the global and regional trends caution, we are moving into an ever more resource-constrained future and these trends in trade and consumption may not be sustainable in the long run.

With more than 40 years of time series data supporting national Footprint assessments, it is possible to identify national trends in land-use, consumption and trade in the context of resource use and availability on a global scale. This concept can also extend to sub-national Footprint assessments, where an initial Footprint analysis can establish a baseline against which subsequent Footprint studies can be benchmarked. This allows cities or regions to understand current levels of resource use, while informing policy and establishing targets to help bring resource consumption levels back within manageable limits.

[9] Canadian Council of Forest Ministers. 2006. "Criteria and indicators of sustainable forest management in Canada: national status 2005." Available at http://www.ccfm.org/pdf/C&I_e.pdf
[10] Global Footprint Network. 2008 National Ecological Footprint Accounts. Available at http://www.footprintnetwork.org.

5 ONTARIO ECOLOGICAL FOOTPRINT AND BIOCAPACITY

The province of Ontario is home to approximately 40 percent of Canada's population, centered in 10 principal cities including Toronto and Ottawa. The bulk of this population is located in the southern Mixedwood Plains Ecozone, close to the Great Lakes (see Annex D for Ecozone maps). Ontario's contribution to Canadian Gross Domestic Product (GDP) is larger than any other province, accounting for about 40 percent of national GDP through strong manufacturing and financial industries. The bulk of the Ecological Footprint of the Province of Ontario is associated with household demand from the large population centres and the associated industrial and economic activity this creates.

5.1 Ontario Ecological Footprint

In 2005, the average per capita Ecological Footprint for a resident of Ontario was 8.4 gha as derived using the process described in Annex B. This is slightly higher than the Canadian average Footprint of 7.1 gha and much larger than the world average Ecological Footprint of 2.7 gha per capita. If everyone in the world were to live the same lifestyle as someone from Ontario, it would require the bioproductive capacity of four planets to support humanity's consumption sustainably

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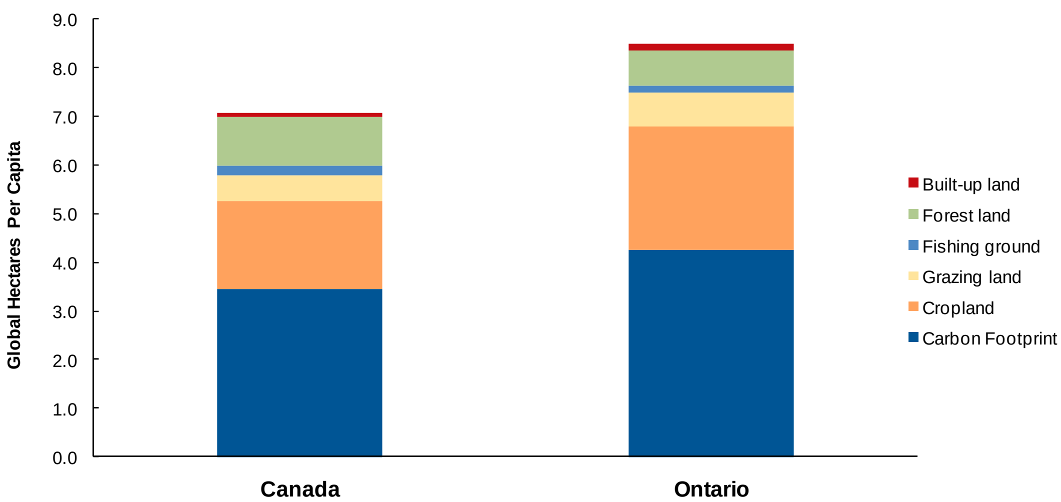

Figure 4. Canada and Ontario Ecological Footprint, in global hectares per capita, 2005.

Sub-national Footprint analysis uses national Ecological Footprint data as a starting point, scaling this data to better reflect conditions in Ontario (see Annex A for a complete description of the methodology). As Figure 4 illustrates, the composition of resource consumption between Ontario and Canada is very similar. Due to increased consumption of goods and services, Ontario has a larger carbon Footprint and a larger cropland Footprint than the Canadian average, explained in more detail below.

Table 2 splits the Ecological Footprint for the average Ontario resident into two sets of results. The first set of results, in columns, displays the same data as Figure 4: the services of each of the different land types demanded by a resident's consumption. Support of the average lifestyle in Ontario requires cropland for food and fibre, grazing land for raising livestock, forest land for timber and fuel, fishing grounds for raising fish, built-up land for infrastructure, and carbon uptake land to store carbon dioxide emissions.

The second set of data, in rows, illustrates the types of consumption driving this demand on biocapacity. Of Ontario's average Footprint, 28 percent comes from food consumption, 16 percent from demands associated with mobility (personal and public transportation), and 18 percent from the purchase and consumption of goods. The services section accounts for the Ecological Footprint associated with, but not limited to, health care, entertainment, real estate, and legal services. For governance, the per capita Ecological Footprint includes the average citizen's portion of local, provincial, and national government operations.

Table 2. Ontario's Ecological Footprint, in global hectares per capita.

	Cropland	Grazing land	Forest land	Fishing Grounds	Carbon Footprint	Built-up land	Total
Food	0.97	0.27	0.15	0.11	0.88	0.02	2.39
Housing	0.23	0.06	0.16	0.00	0.72	0.02	1.20
Mobility	0.24	0.07	0.09	0.00	0.97	0.02	1.39
Goods	0.52	0.14	0.12	0.01	0.71	0.02	1.53
Services	0.32	0.09	0.09	0.01	0.54	0.02	1.08
Governance	0.24	0.07	0.09	0.01	0.43	0.03	0.86
Total	2.52	0.69	0.71	0.14	4.24	0.13	**8.45**

As Figure 5 illustrates, the carbon Footprint makes up half of the average Ontarian's Footprint, and is significantly larger than the average Canadian carbon Footprint. When carbon dioxide is released, it does not remain within the national boundaries of the country that emitted it. Thus, the carbon Footprint measures the amount of world average forest land required to store carbon dioxide emissions. Ontario residents have an impact on global biodiversity through their high carbon Footprint, as increasing global concentrations of CO_2 put pressure on ecosystems worldwide. The carbon Footprint comes from direct CO_2 emissions from vehicles (mobility) or through consumption of goods and services with large amounts of embodied energy. This is a pattern often seen in high-income nations, where residents can afford to consume more highly processed, energy intensive goods and services.

A relatively high cropland and carbon Footprint means Ontario residents have opportunities to become more efficient in their consumption of cropland (and food products) and in their use of fossil-based transportation in order to lessen their demand on Ontario's, and the world's, biocapacity.

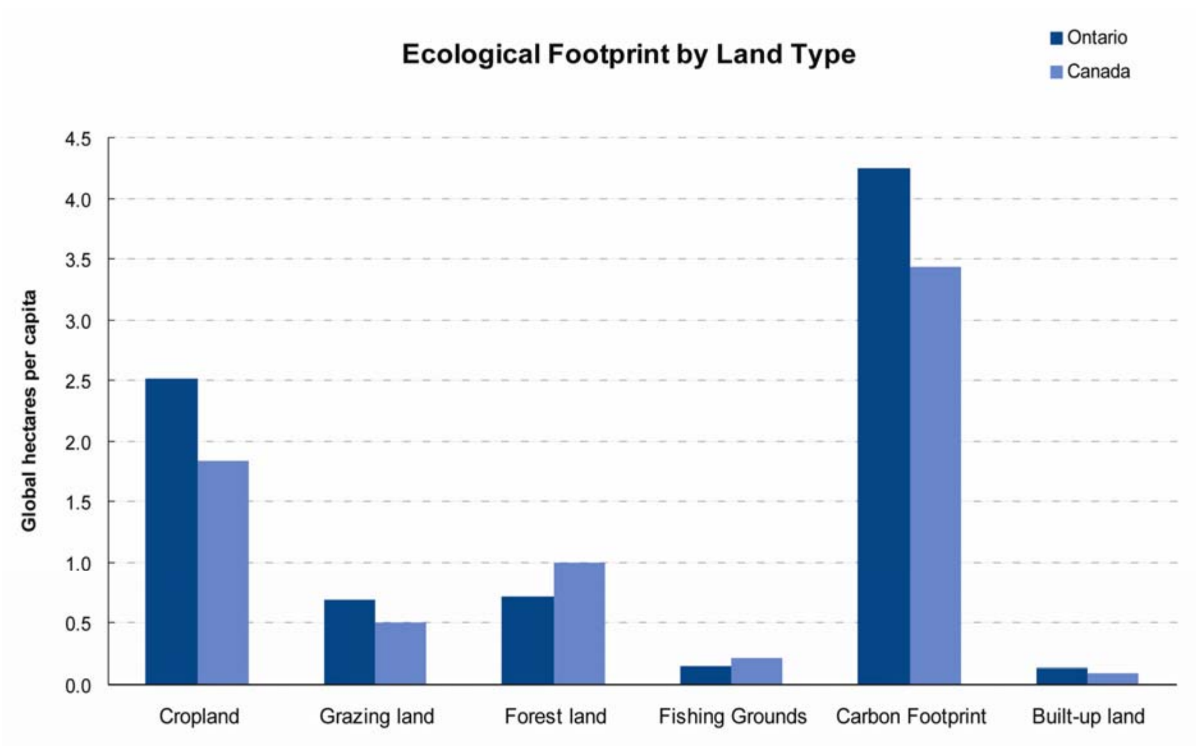

Figure 5. Per capita Ecological Footprint by land use type, Ontario and Canada, 2005.

Figure 6 gives perspective on which of the household consumption categories contribute most heavily to the average Ecological Footprint of an Ontario resident. Food accounts for the largest portion of both the Footprint of the average Canadian, and the average Ontarian. However, due to higher levels of consumption of agricultural products, the Ecological Footprint is higher for Ontario residents than for the average resident.

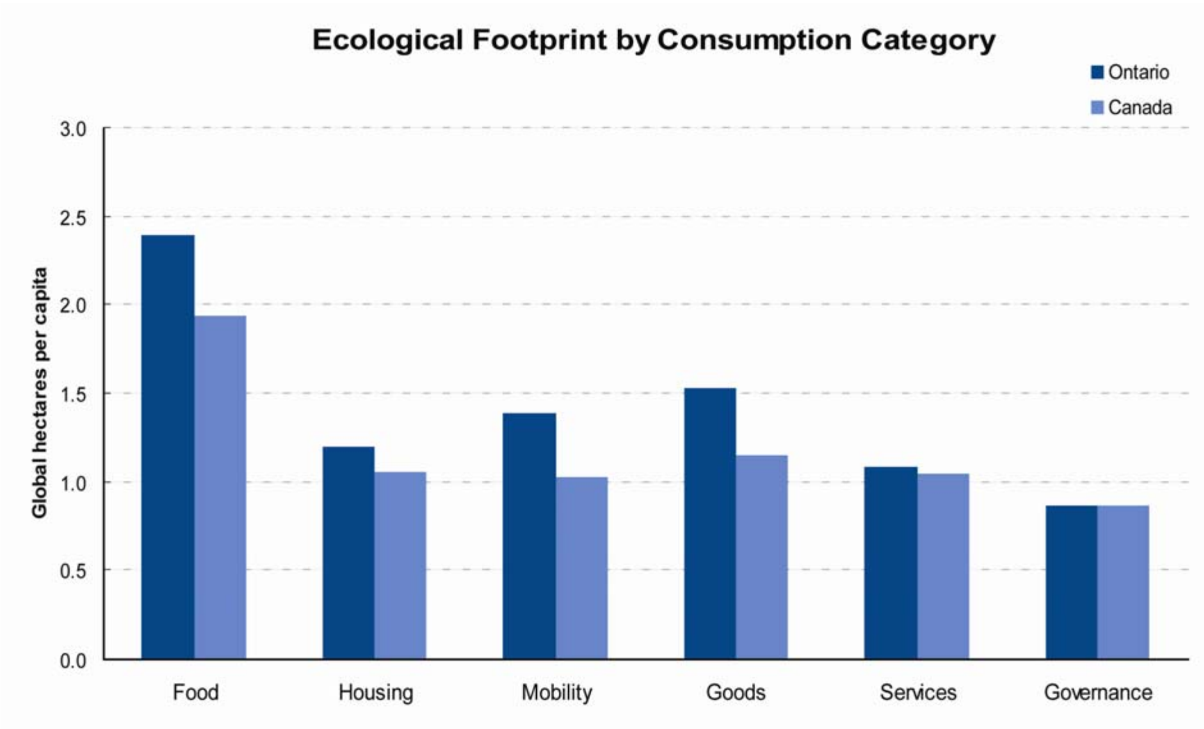

Figure 6. Per capita Ecological Footprint by consumption category, Ontario and Canada, 2005.

The larger average Footprint in Ontario may be due to the difference in the industrial structure in Ontario as compared to Canada as a whole. The industrial structure of Ontario can be thought of as the resource efficiency of its industries – what type and quantity of raw material inputs are required to create a finished product in that industry? In Ontario, part of the larger Ecological Footprint per capita is due to final demand (or consumption levels),[11] but part also may be due to less resource efficient industries, primarily manufacturing, which accounts for 45 percent of Ontario's overall Ecological Footprint by industrial sector.

[11] Final demand by industrial sector does not represent actual embodied environmental impact of that sector, but rather the Ecological Footprint embodied in the household and government demand for those goods and services produced by that sector. It can help to answer the question, what industries are Ontario citizens placing the most demand on, and in where are the impacts likely highest? Ontario has twice the final demand (in Ecological Footprint per capita terms) in crop and animal production, twice the final demand in mining and oil and gas extraction, and more than twice the final demand in manufacturing as compared to Canadian average. There may be a small amount of categorization error due to allocation difficulty between Canadian manufacturing (which is disaggregated in the input-output tables) and Ontario manufacturing (which is aggregated to one high level sector). Regardless, there is significantly higher final demand for manufacturing in Ontario as compared to Canada, and correlated to that is higher resource throughput in that sector.

It is interesting to note that the average Ontarian has a lower forest Footprint than the average Canadian. This can be explained partly by a net export of forest land Footprint out of Ontario (e.g. in terms of total trade, more forest products are exported than imported into Ontario). Due to the consumer allocation principle, the Footprint of products produced in Ontario but consumed elsewhere lies with the importing country and not with Ontario. As well, the data availability at the provincial level allows for a more detailed analysis of agricultural and forestry product Footprints, so it may be the case that part of the disparity between Ontario and Canada averages lies with data quality more so than actual consumption patterns.[12]

Ontario can strive to match Canada's per capita Ecological Footprint without changing its overall quality of life. While Ontario currently has a large Ecological Footprint per person, the Province can learn from other regions and make changes to meet, or even surpass, the resource efficiency of the national average.

5.2 Ontario Biocapacity

Ontario is the third largest jurisdiction in Canada, covering approximately 107 million hectares, representing 11 percent of Canada's total land area. The province is divided into three distinct terrestrial Ecozones: the Mixedwood Plains in the south, the Ontario Shield in the central-north, and the Hudson Bay Lowlands in the north and Northeast. In addition, there is the Ontario portion of the Great Lakes aquatic ecozone.

Similar to Canada as a whole, Ontario is rich in forested land, and the province provides almost a quarter of Canada's overall agricultural output. The sidebar below breaks down Ontario land area into categories. It is important to note that nine percent of Ontario's total land area is classified as protected: 11 percent of the Ontario Shield Ecozone, around ten percent of the Hudson Bay Lowlands Ecozone, and less than one percent of the Mixedwood Plains Ecozone.[13]

The province of Ontario has a biocapacity of 106 million global hectares or 8.5 global hectares per Ontarian. The biocapacity calculation was derived by adjusting a sub-set of provincial land

[12] See Annex B for more information on data quality and availability for the Ontario Ecological Footprint analysis. The Ontario input-output tables contain industrial sector groupings for "crop and animal production," "forestry and logging," and "fishing, hunting and trapping." These sectors feed into the cropland, grazing land and forest land Footprint. Canadian input-output tables, on the other hand, have an aggregated high level industrial sector grouping of "agriculture, hunting, forestry and fishing", making it harder to distinguish the Footprint for each of these activities in the same manner.

[13] Ministry of Natural Resources, Ontario. 2008. "State of Ontario's Protected Areas: Technical Report #2 – Protection."

data with a number of different yield factors corresponding to the Ecological Footprint land categories, as is standard in national accounts analyses. Due to the large amount of wetlands and other land types that are not considered productive with the Ecological Footprint framework, almost one-quarter of overall land area was excluded from the analysis. The total area utilized for the analysis was 81.9 million hectares of land. The yield factors reflect the bioproductivity potential of land in Ontario compared to average world yields. The biocapacity values for each land category are converted into global hectares using the same equivalence factors as described in Section 3.2. Annex D describes the derivation of each yield factor and includes a list of data sources.

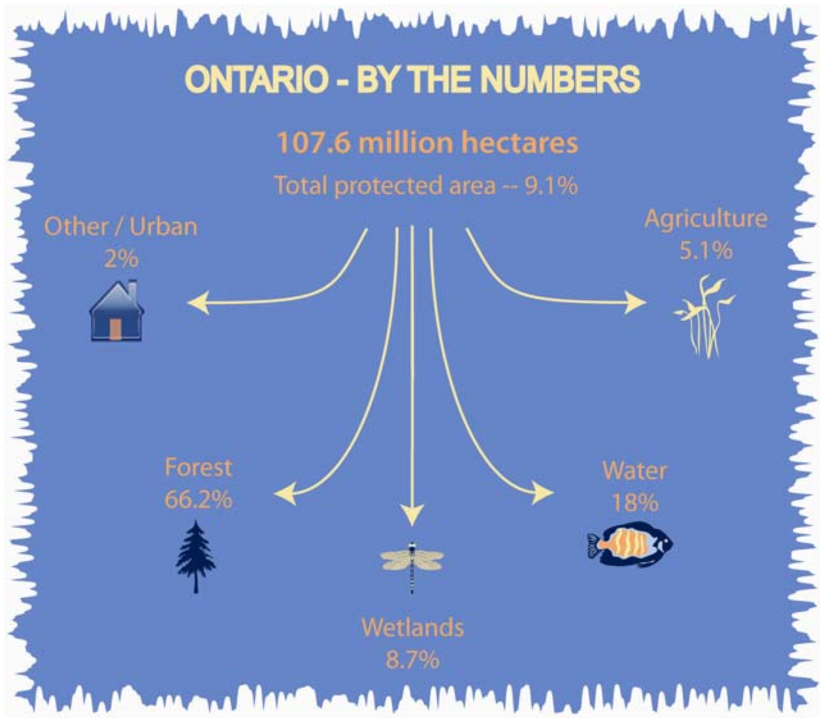

Table 3 breaks down Ontario biocapacity by land-use type. For comparison purposes, this table includes actual provincial land area and Ontario biocapacity reported in global hectares. The last column reports the same biocapacity value in per capita terms.

Table 3. Ontario biocapacity by land use type, 2005.

	Provincial land area (ha)	Ontario biocapacity (gha)	Ontario biocapacity (gha/capita)
Cropland	5,407,516	19,731,293	1.6
Grazing Land	1,905	1,031	0.0
Other wooded land	5,653,688	3,059,492	0.2
Forest	50,441,893	72,346,979	5.8
Inland Water	19,573,521	7,774,096	0.6
Infrastructure	873,842	3,188,532	0.3
Total	**81,952,366**	**106,101,422**	**8.5**
Per capita	**6.5**	**8.5**	

Note: The provincial land area used for the biocapacity calculation is a sub-set of Ontario's total land area. See Annex C for more information.

Ontario biocapacity is substantially lower than the Canadian average biocapacity per person of 20.1 hectares, as noted in Figure 7. This is expected given that Ontario is home to more than one-third of the country's population while making up only 11 percent of Canadian land area. In comparison to the average available biocapacity per person in Canada, Ontario has one third the available per capita cropland biocapacity, one-tenth the available grazing land, and only 62 percent as much available forest land biocapacity, per capita.

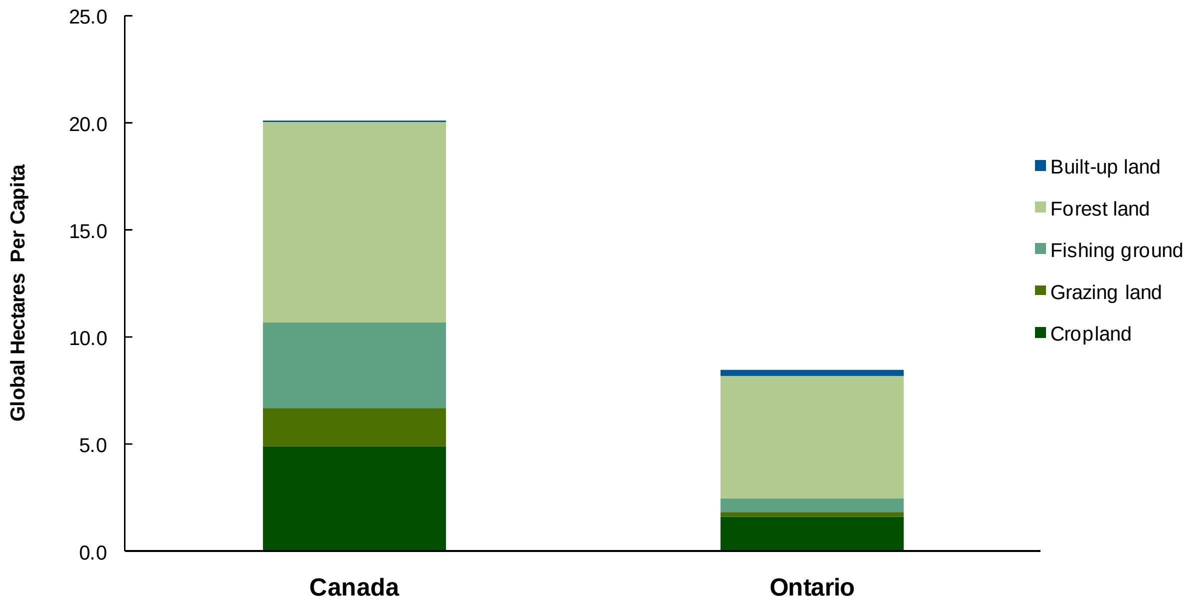

Figure 7. Canada and Ontario biocapacity, in global hectares per capita, 2005.

Forest land accounts for 68 percent of Ontario's biocapacity. Cropland accounts for 19 percent, and inland water (including the Ontario portion of the Great Lakes) accounts for seven percent.[14] These three categories together represent 94 percent of total provincial biocapacity. Figure 8 reports the percent breakdown by land category. Ontario has a much higher percentage of biocapacity per capita in forested land than Canada overall.

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[14] In terms of actual area included in the analysis (provincial hectares), forest land, agriculture land and inland waters represent 62 percent, 7 percent, and 24 percent respectively.

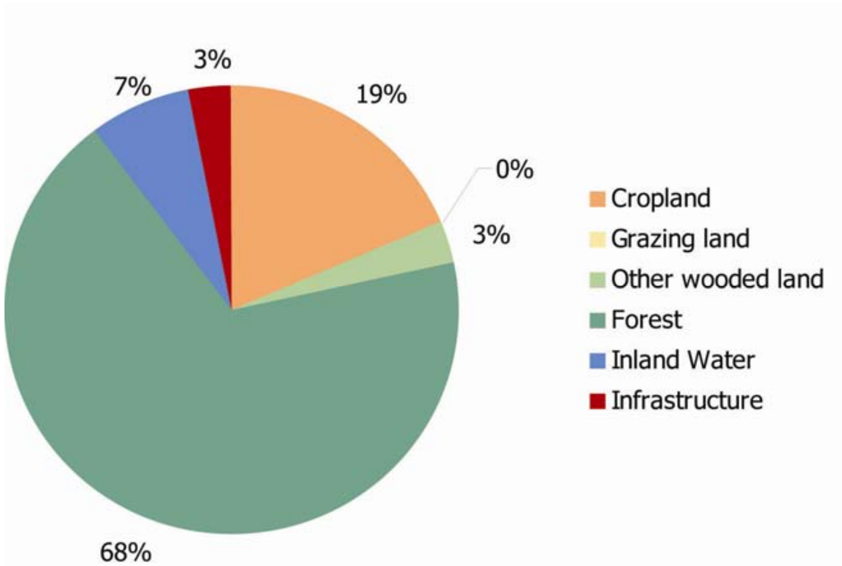


Figure 8. Ontario biocapacity by land-use type, 2005.

Biocapacity by Ecozone

Biocapacity in Ontario can be broken down by the three terrestrial Ecozones and the Ontario portion of the Great Lakes. In terms of provincial land area, the size and land-use types of the ecozones differ substantially. The Ontario Shield is 65.3 million hectares consisting largely of forest and other wooded land. Eighty seven percent of the province's forest land is in the Ontario Shield. The Hudson Bay Lowlands is the next largest Ecozone in terms of area at 24.8 million hectares, comprised primarily of treeless tundra and wetlands. The smallest ecozone is the Mixedwood Plains, in the southern part of the province at 8.5 million hectares. The Mixedwood Plains Ecozone includes almost all of the agricultural land in the province and 76 percent of the built-up land. Ontario's portion of the Great Lakes spans over 8.7 million hectares. See Annex C for land cover maps by Ecozone.

To estimate the biocapacity of Ontario land areas, the national Canadian yields for each land-use type were adjusted by Ontario-specific data. For forest biocapacity, specific forest yield factors were developed for each Ecozone. Table 4 reviews the yield factor values. Annex C describes the derivation of Ecozone-specific forest yield factors.

Table 4. Forest land yield factor values, by Ecozone, for Ontario, 2005.

	Ontario yield factors
Agriculture	1.38
Grazing land	1.09
Other wooded land	1.09
Forests	**1.13**
Inland water	1.00
Infrastructure	1.38

Ontario Ecozone specific yield	
Mixedwood Plains	2.95
Ontario Shield	1.11
Hudson Bay Lowlands	0.27

Table 5 reviews biocapacity by ecozone in global hectares. The smallest in terms of provincial land area, the Mixedwood Plains Ecozone contributes significantly to provincial biocapacity with 26 million gha (representing 25 percent of total biocapacity). The Mixedwood Plains makes a significant contribution to overall biocapacity because this ecozone contains the majority of the prime agricultural land in the province. The Ontario Shield has a biocapacity of 73 million gha (representing 69 percent of the total). Forests account for more than 88 percent of the biocapacity in this region. The Hudson Bay Lowlands has a biocapacity of 2.9 million gha (representing three percent of total biocapacity). Ontario's portion of the Great Lakes contributes an additional 3.5 million gha (three percent of total biocapacity).

Table 5. Ontario biocapacity by Ecozone (in global hectares), 2005.

	Mixedwood Plains	Ontario Shield	Hudson Bay Lowlands	Great Lakes (ON portion)	Total
Agriculture	18,284,832	1,589,441	-	-	**19,874,273**
Grazing land	1,031	-	-	-	**1,031**
Other wooded land	31,955	2,759,537	268,000	-	**3,059,492**
Forests	5,635,449	64,611,626	1,867,097	-	**72,114,171**
Inland water	144,916	3,438,423	714,570	3,476,187	**7,774,096**
Infrastructure	2,459,871	744,329	7,438	-	**3,211,637**
Total	**26,558,054**	**73,143,356**	**2,857,103**	**3,476,187**	**106,034,701**
Per Capita	2.12	5.84	0.23	0.28	8.46

Understanding the types of biocapacity available within Ontario helps to focus attention to the places where human demand on resources may be having the largest impact on biodiversity. Forests in Ontario are managed very closely to balance the need for commercial harvest of timber with the desire to maintain intact forest ecosystems. The bulk of the forest biocapacity in Ontario occurs in the Ontario Shield, where human population density is low and direct impacts on biodiversity are managed as part of best practices in forestry. Most of the agricultural activity in Ontario occurs in the Mixedwood Plains Ecozone, where the bulk of Ontario's cropland biocapacity is located. This portion of the province contributes greatly to overall biocapacity, but has the least amount of protected land. The Mixedwood Plains Ecozone is where much of the strain between human population density, expanding urbanization, intensive agriculture, and biodiversity decline occurs in the province.

Biocapacity and Excluded Land Areas

The biocapacity of Ontario only includes land types which produce resources of direct use to the people within Ontario, and for trade in international markets. This follows the Ecological Footprint methodology, which states that the metric is anthropocentric in nature, assuming that all of the biological resources produced by the land areas measured are used solely for human consumption. This is not to discount the importance of wild space or ecosystems that are not of direct use to humans. Due to differing scientific opinions on the average amount of land that must be set aside, the Footprint errs on the side of caution and removes this calculation entirely.

BIOCAPACITY AND CARRYING CAPACITY

Carrying capacity is a technical term that refers to the maximum population of a species that a given area can support. Many species have easily defined and consistent consumption needs, making carrying capacity relatively easy to define and calculate. For humans, however, carrying capacity estimates require assumptions about future per-person resource consumption, standards of living and "wants" (as distinct from "needs"), productivity of the biosphere, and advances in technology. An area's carrying capacity for humans is thus inherently speculative and difficult to define.

Ecological Footprint accounts approach the carrying capacity question from a different angle. Ecological Footprints are not speculative estimates about a potential state, but rather are an accounting of the past. Instead of asking how many people could be supported on the planet, the Ecological Footprint asks the question in reverse and considers only present and past years. The Footprint asks how many planets were necessary to support all of the people that lived on the planet in a given year, under that year's standard of living, biological production and technology.

In order to understand the "sustainability" of a population, it is imperative to first understand the quality and quantity of resources available to it. In the case of Ontario, it is also important to note that a large portion of the province contains land types not traditionally included in biocapacity estimates. This includes 24 million hectares of marsh, swamp, bog, fen, and mudflats in the northern portion of Ontario. These land areas have biocapacity that is simply too dispersed, or not conventionally productive enough, to be included in the list of land types that provide direct products or waste assimilation services to human populations. However, wetlands provide important regulation services, as well as habitat for migratory birds and numerous other plant and animal species, and protection against rising concentrations of carbon dioxide in the atmosphere. These services are currently unvalued, but as Annex E notes, there are multiple venues for increasing the applicability and specificity of biocapacity estimate to Ontario that may be broached in future studies.

6 ECOLOGICAL FOOTPRINT AND BIOCAPACITY: The Drivers-Pressures-States-Impacts-Reponses Model

To situate the Ecological Footprint and biocapacity results into a biodiversity report, it is useful to think in terms of the Drivers-Pressures-States-Impacts-Responses (DPSIR) model. This environmental framework was developed by Statistics Canada scientists more than three decades ago, and the Organization for Economic Co-operation and Development (OECD) has since adopted it for State of the Environment reporting. The DPSIR model outlines the process for understanding, managing, and ultimately responding to environmental problems in a systematic way. The Ecological Footprint is a metric that outlines the magnitude and trend of the driving forces affecting Ontario's natural environment.

Political, social and cultural forces that influence the environment – trends in population growth, rates of consumption, technology, and the impact of trade – are the driving forces behind the magnitude of the Ecological Footprint. These driving forces provide the impetus for, and the influence on, the pressure variables – increasing urban sprawl, habitat conversion, pollution and climate change that put direct stress on the environment. State indicators measure the condition of the environment; they establish a baseline, and allow for measurement of how pressures are changing environmental conditions. In this report, the state indicator is biocapacity (the supply of resources and waste assimilation capacity) though metrics tracking biodiversity and ecosystem health are also state indicators. The impact indicators analyze how our environmental states have changed – is biodiversity declining? Are habitats shrinking?

Finally, impacts require and generate a response from society – from setting aside land specifically for ecosystem protection to managing the Ecological Footprint by decreasing overall resource consumption. Figure 9 steps through each component of the DPSIR framework, explaining in bold what each component represents and offering examples of the applicability of each component to the conversation about biodiversity protection. The arrows represent connections between each component and help us to understand the required next step in the chain.

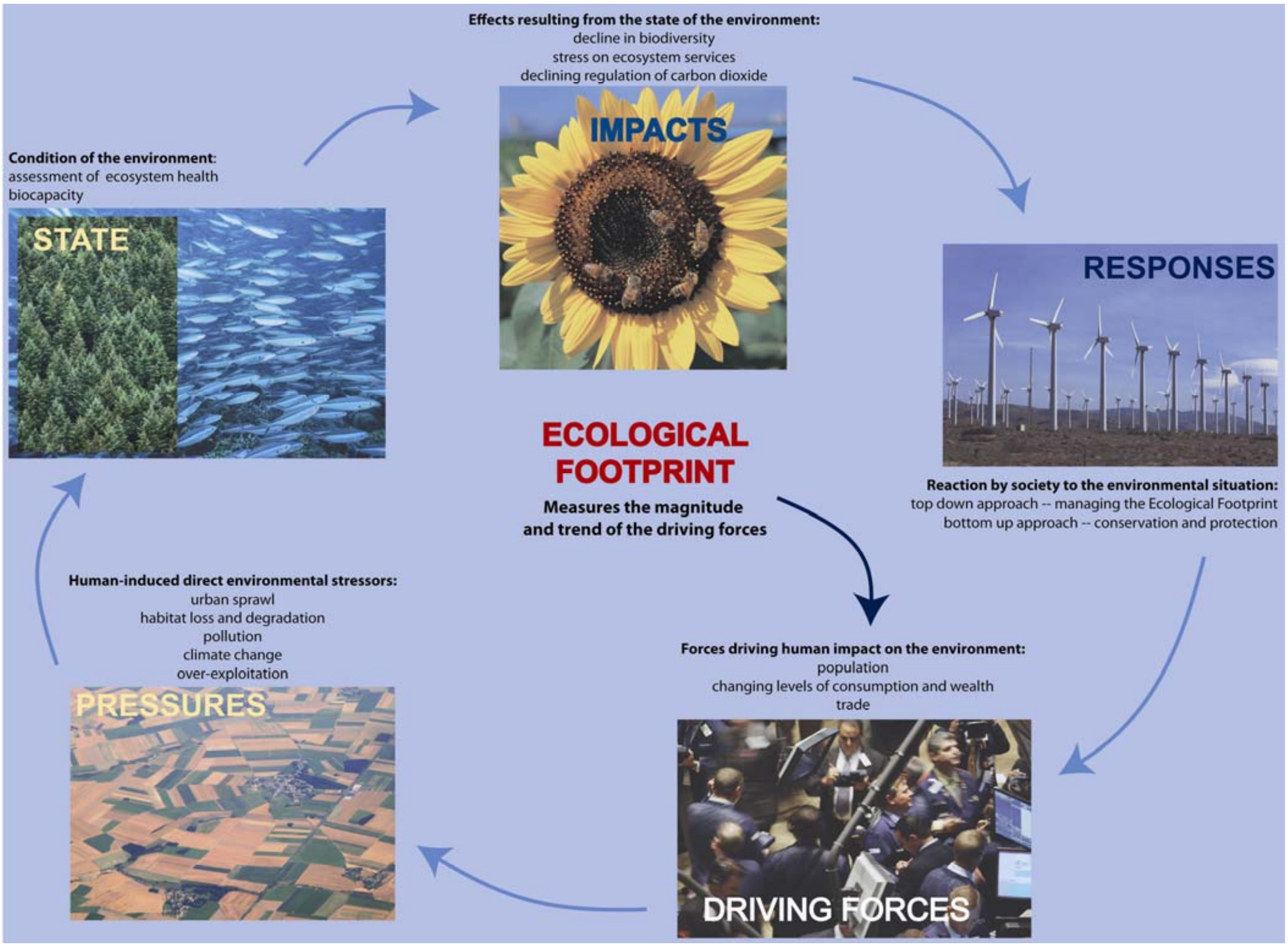


Figure 9. The Ecological Footprint and the DPSIR model.

Within this framework, the Ecological Footprint is the index responsible for assessing the driving forces, and hence the pressures, behind environmental problems. The Ecological Footprint accounts for the collective magnitude and trend of driving forces: population, increasing wealth and increasing consumption, changing technology, and changing pressures due to international trade. Normally, driving forces occur at too broad a level within society to be measured or directly linked to the environmental problems they cause. However, the Ecological Footprint allows for a new conceptual linkage to be drawn from driving forces directly to states and impacts on the environment.

The Ecological Footprint allows for a systematic, scientific comparison of the trends and magnitude of human consumption and biocapacity. It also allows for comparison to other state metrics, namely those measuring changes in biodiversity.

6.1 Changing Ontario's Current Trajectory Specific Driving Forces and Pressures

Three factors determine the magnitude and trends of the Ecological Footprint for a given population – the number of people in that population, the rate of consumption of goods and services by that group, and the overall resource efficiency and waste intensity of the goods they consume. For the province of Ontario, the Ecological Footprint is highly influenced by the rate of consumption.

Two main factors influence the amount of biocapacity available within a specific area – the actual land area of different land types, and the productivity (or yield) of the land for producing useful goods and services. In order to reduce the pressures that Ontario residents place on the environment, steps can be taken to reduce the Ecological Footprint and increase biocapacity, outlined conceptually in Figure 10.

Figure 10. Ecological Footprint and biocapacity factors that determine overall impact.

This report establishes a baseline for Ontario's Ecological Footprint and biocapacity, comparing that baseline to Canadian averages and to the world. The causal link is clear between increasing demand on nature's resources, and declining ecosystem health and biodiversity. The question now becomes, what steps can Ontario residents take to manage their resource use – and their resource base – more closely to ensure that these declines are halted, and eventually reversed?

Population

The total Ecological Footprint in Ontario is not distributed equally across the province – in fact, the biggest centers of population are in the south, primarily in the Mixedwood Plains Ecozone. In this area, Ecological Footprint intensity, human population density, and the bulk of Ontario's listed endangered species all converge. The Mixedwood Plains in southern Ontario has the highest species diversity of all the ecozones, so added pressure from an expanding population puts a greater number of species, and thus a large amount of biodiversity, at risk.

The trends in population for Ontario raise alarm when combined with the current Ecological Footprint per capita. In 2008, the Greater Toronto Area alone had a population of six million people; this number is projected to increase to around nine million by 2036.[15] Even with a static Ecological Footprint per capita, provincial population increase will drastically impact overall biocapacity availability in Ontario. With an expanding population comes expanding urban areas and expanding resource consumption – all these factors will continue to directly impact the fragile natural ecosystems remaining in the southern part of Ontario. This situation demands more careful management of human-environment interactions.

Consumption

The combination of an expanding population and a high level of consumption in Ontario will necessarily increase the Ecological Footprint of consumption. As the overall Canadian trend displayed in Figure 11 notes, increasing population and static or increasing levels of consumption of Ontario resources will continue to stretch the gap between Ontario's current Ecological Footprint and the amount of biocapacity available within the province.

[15] Ontario Ministry of Finance. 2009. "Ontario Population Projections: 2008 – 2036 Ontario and its 49 Census Divisions." Available at http://www.fin.gov.on.ca/en/economy/demographics/projections/demog09.pdf

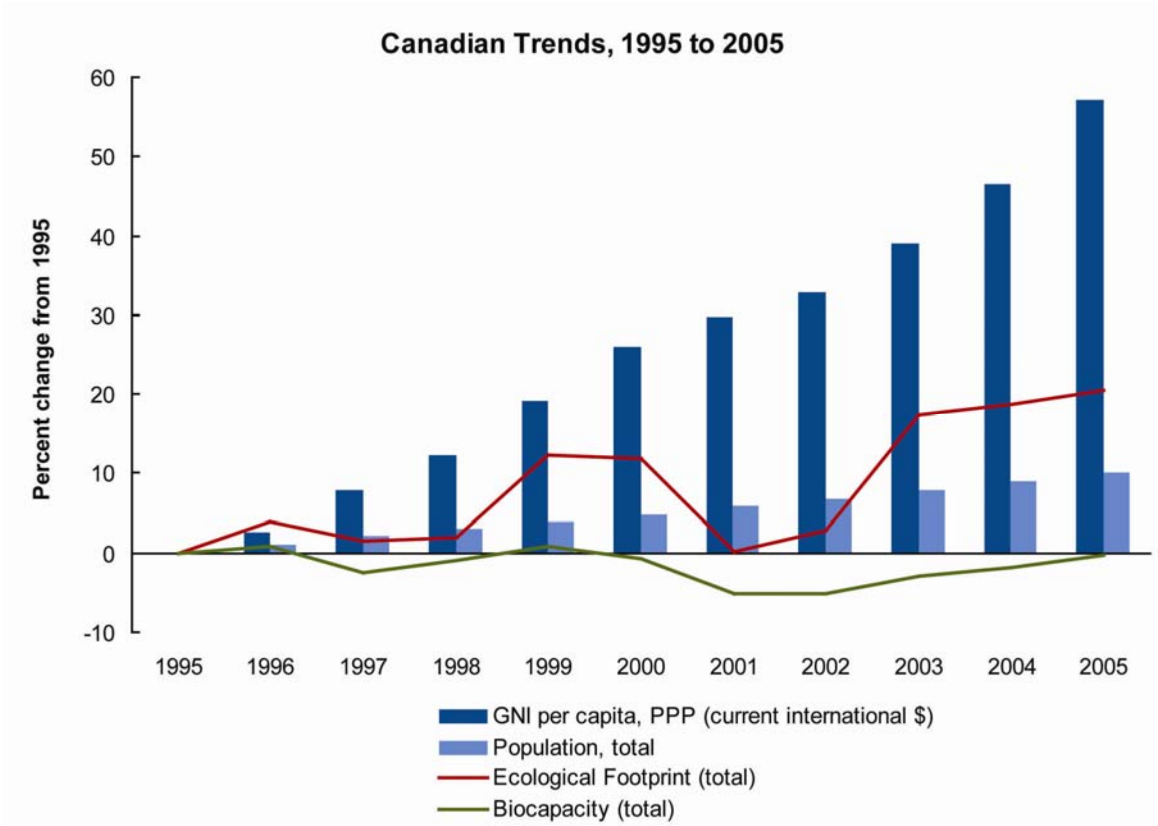


Figure 11. Interplay between population, consumption, and Ecological Footprint over time.[16]

How can consumption levels be managed and reduced to help reduce overall demand on Ontario's biocapacity and biodiversity? Ontario has a large carbon Footprint, and mitigating this demand will require reducing the amount of fossil fuels consumed in the province. Ontario has already shown leadership through its commitment to close Ontario Power Generation's coal-fired generating stations. This will place Ontario in a more competitive position in the future – use of fossil fuels will only become more politically, economically, and environmentally risky. Long-term sustainable development requires a more integrated approach to managing carbon emissions, from coordinated transportation grids to promotion of local products and consumption of local food.

[16] GNI represents Gross National Income, while PPP represents Purchasing Power Parity. See http://go.worldbank.org/1SF48T40L0 for more information.

Resource Efficiency and Waste Intensity

Direct stress on Ontario's biocapacity comes from two places – increasing global emissions of carbon dioxide, and domestic harvest of raw materials supporting human demand. This means that Ontarians need to begin purchasing goods that require fewer resources to produce across the supply chain – from low-impact harvesting of raw materials, to efficient use of energy in transportation and processing, to zero waste packaging for the final product. Increasing the amount of final product that can be produced from every ton of raw material will help reduce the Ecological Footprint of the products that Ontario produces, and ultimately consumes.

Land Area and Bioproductivity

The total amount of biocapacity in Canada has remained relatively constant since 1961. However, due to the driving forces of population and consumption, this consistent level of natural resource supply is under increasing strain by a larger, more affluent population. Land conversion and associated habitat loss are large threats to biodiversity. In Ontario, each year approximately 55,000 – 80,000 hectares of forest are converted to urban landscapes, cropland, or forest roads.[17] While this conversion may not show up immediately in biocapacity estimates due to the resolution of land cover data, it can have a very serious impact on local species.

Bioproductivity (or the yields associated with biocapacity) can also be impacted by the rate of exploitation of a resource. Forested land in Canada is closely managed to ensure timber regeneration after harvest and reduction in impacts on watersheds and native species. However, almost 40 percent of Canada's overall allowable annual cut goes to forest harvest in Ontario, though Ontario only has about 25 percent of Canada's forested land. A high rate of forestry activity requires careful management in order to ensure that productivity of forest ecosystems is not adversely affected.

[17] Ibid. Canadian Council of Forest Ministers. 2006. "Criteria and indicators of sustainable forest management in Canada: national status 2005."

7 CONCLUSION

Conservation of natural resources for future use is a process involving multiple stakeholders with different values and priorities. The Ecological Footprint and biocapacity measures can offer a snapshot view of the current state of affairs – establish a baseline, help identify the sources of greatest demand, and provide a metric that will continue to reflect successes or failures moving forward.

Ontario has many choices available to tackle a large Ecological Footprint per capita, and a smaller biocapacity per capita compared to Canada. Mitigation strategies to tackle the Footprint may include resource efficiency gains in manufacturing and value-added industries to reduce the carbon Footprint of the province. There is also the possibility of recovering biocapacity through restoration of degraded land back into bioproductive, natural ecosystems.

Most importantly, it is becoming clear that Ontario needs to address the places where high population density, high biodiversity, and increasingly affluent levels of consumption mix to create pressures on biodiversity and natural ecosystems. It is paramount that Ontarians understand that there is no tradeoff between living well, and living within the means of one planet. There are many opportunities for low Footprint lifestyles in Ontario; the focus simply needs to shift to addressing personal consumption and the cumulative pressures that human activities are placing on Ontario's fragile lands.

This report has established a benchmark for the province of Ontario to understand its Ecological Footprint in relation to Canada and the world. It furthers the measurement of the underlying factors affecting the state of biodiversity, and our understanding of the magnitude of the driving forces putting pressure on Ontario's ecosystems

A Annex A – Ecological Footprint and Biocapacity Methodology

This section is a reprinted excerpt from *Calculation Methodology for the National Footprint Accounts, 2008 Edition.*[18]

FOOTPRINT AND BIOCAPACITY CALCULATIONS

The Ecological Footprint represents appropriated biocapacity, and biocapacity represents the availability of bioproductive land. For any land use type, the Ecological Footprint EF of a country, in global hectares, is given by

$$EF = \frac{P}{Y_N} \cdot YF \cdot EQF \qquad \text{(Eq. 1a)}$$

where P is the amount of a product harvested or waste emitted, Y_N is the national average yield for P, and YF and EQF are the yield factor and equivalence factor, respectively, for the land use type in question.

A country's biocapacity BC for any land use type is calculated as follows:

$$BC = A \cdot YF \cdot EQF \qquad \text{(Eq. 2)}$$

where A is the area available for a given land use type.

Secondary Products

Summing the Footprints of all primary harvests and waste absorptive capacity of ecosystem services yields the total Footprint of a country's domestic production. However, in some cases it is necessary to know the Ecological Footprint of products derived from the primary flows of ecosystem goods. Primary and derived goods are related by product-specific extraction rates. Primary and derived goods are related by product-specific extraction rates. The extraction rate for a derived product, EXTRD, is used to calculate its effective yield as follows:

$$Y_D = Y_P \cdot EXTR_D \qquad \text{(Eq. 3a)}$$

[18] Ewing B., A. Reed, S.M. Rizk, A. Galli, M. Wackernagel, and J. Kitzes. 2008. *Calculation Methodology for the National Footprint Accounts, 2008 Edition.* Oakland: Global Footprint Network. Available at http://www.footprintnetwork.org/download.php?id=508

where Y_P and Y_D are the yield for the primary product and the effective yield for the derived product, respectively.

Usually, $EXTR_D$ is simply the mass ratio of derived product to primary input required. This ratio is known as the technical conversion factor for the derived product, denoted TCFD below. There are few cases where multiple derived products are created simultaneously from the same primary product. Soybean oil and soybean cake, for example, are both extracted simultaneously from the same primary product, in this case soybean. Summing the primary product equivalents would lead to double counting, so the Footprint of the primary product must be shared between the simultaneously derived goods. The extraction rate for a derived good *D* is given by

$$\mathrm{EXTR_D} = \frac{\mathrm{TCF_D}}{\mathrm{FAF_D}} \qquad \text{(Eq. 3b)}$$

where FAF_D is the Footprint allocation factor. This allocates the Footprint of a primary product between simultaneously derived goods according to the TCF-weighted prices. The prices of derived goods represent their relative contributions to the incentive for the harvest of the primary product. The equation for the Footprint allocation factor of a derived product is

$$\mathrm{FAF_D} = \frac{\mathrm{TCF_D V_D}}{\sum \mathrm{TCF_i V_i}} \qquad \text{(Eq. 3c)}$$

where Vi is the market price of each simultaneous derived product. For a production chain with only one derived product, then, FAF_D is 1 and the extraction rate equals the technical conversion factor.

NORMALIZING BIOPRODUCTIVE AREAS – FROM HECTARES TO GLOBAL HECTARES

Average bioproductivity differs between various land-use types, as well as between countries for any given land-use type. For comparability across countries and land-use types, Ecological Footprint and biocapacity are usually expressed in units of world-average bioproductive area. Expressing Footprints in world-average hectares also facilitates tracking the embodied bioproductivity in international trade flows.

Yield Factors

Yield factors account for countries' differing levels of productivity for particular land-use types. The yield factor provides comparability between various countries' Ecological Footprint and biocapacity calculations. In every year, each country has a yield factor for cropland, grazing land, forest land, and fishing grounds. As a default, the yield factor for built-up land is assumed to be the same as that for cropland since urban areas are typically built on or near the most productive agricultural lands. Natural factors such as differences in precipitation or soil quality, as well as management practices, may underpin differences in productivity.

Yield factors weight land areas according to their relative productivities. For example, the average hectare of pasture in New Zealand produces more grass than a world average hectare of pasture land. Thus, in terms of productivity, one hectare of grassland in New Zealand is equivalent to more than one world average grazing land hectare; it is potentially capable of supporting more meat production. Table A shows the yield factors calculated for several countries in the 2008 edition of Global Footprint Network's National Footprint Accounts.

Table A. Sample Yield Factors for Selected Countries, 2005.

	Cropland	Forest	Grazing Land	Fishing Ground
World average yield	**1.0**	**1.0**	**1.0**	**1.0**
Algeria	0.6	0.9	0.7	0.9
Guatemala	0.9	0.8	2.9	1.1
Hungary	1.5	2.1	1.9	0.0
Japan	1.7	1.1	2.2	0.8
Jordan	1.1	0.2	0.4	0.7
New Zealand	2.0	0.8	2.5	1.0
Zambia	0.5	0.2	1.5	0.0

The yield factor is the ratio of national- to world-average yields. It is calculated in terms of the annual availability of usable products. A country's yield factor YF_L, for any given land use type L, is given by

$$YF_L = \frac{\sum_{i \in U} A_{W,i}}{\sum_{i \in U} A_{N,i}} \qquad \text{(Eq. 4a)}$$

where U is the set of all usable primary products that a given land use type yields, and $A_{W,i}$ and $A_{N,i}$ are the areas necessary to furnish that country's annually available amount of product i at world and national yields, respectively. These areas are calculated as

$$A_{N,i} = \frac{P_i}{Y_N} \quad \text{(Eq. 5a)} \qquad \text{and} \qquad A_{W,i} = \frac{P_i}{Y_W} \quad \text{(Eq. 5b)}$$

where P_i is the total national annual growth of product i and Y_N and Y_W are national and world yields, respectively. Thus $A_{N,i}$ is always the area that produces i within a given country, while $A_{W,i}$ gives the equivalent area of world-average land yielding i.

Most land-use types in the Ecological Footprint provide only a single primary product, such as wood from forest land or grass from pasture land. For these, the equation for the yield factor simplifies to

$$YF_L = \frac{Y_N}{Y_W} \quad \text{(Eq. 4b)}$$

For land-use types yielding only one product, combining Eqs. 4b and 1a gives the simplified formula for the Ecological Footprint, in global hectares:

$$EF = \frac{P}{Y_W} \cdot EQF \quad \text{(Eq. 1b)}$$

In practice, cropland is the only land-use type for which the extended form of the yield factor calculation is employed.

Equivalence Factors

In order to combine the Ecological Footprints or biocapacities of different land-use types, a second scaling factor is necessary. Equivalence factors convert the actual areas in hectares of different land-use types into their global hectare equivalents. Equivalence and yield factors are applied to both Footprint and biocapacity calculations to provide results in consistent, comparable units.

Equivalence factors translate the area supplied or demanded of a specific land-use type (i.e. world average cropland, grazing land, forest land, fishing grounds, carbon uptake land, and built-up land) into units of world average biologically productive area: global hectares. The equivalence factor for built-up land is set equal to that for cropland, and carbon uptake land is set equal to that for forest land. This reflects the assumptions that infrastructure tends to be on or near productive agricultural land, and that carbon uptake occurs on forest land. The equivalence factor for hydro area is set equal to one, which assumes that hydroelectric reservoirs flood world average land. The equivalence factor for marine area is calculated such that a single global hectare of pasture will produce an amount of calories of beef equal to the amount of calories of salmon that can be produced by a single global hectare of marine area. The equivalence factor for inland water is set equal to the equivalence factor for marine area.

In 2005, for example, cropland had an equivalence factor of 2.64 indicating that world-average cropland productivity was more than double the average productivity for all land combined. This same year, grazing land had an equivalence factor of 0.40, showing that grazing land was, on average, 40 percent as productive as the world-average bioproductive hectare. Equivalence factors are calculated for every year, and are identical for every country in a given year.

Table B. Equivalence Factors, 2005.

Area Type	Equivalence Factor (gha/ha)
Primary Cropland	2.64
Forest	1.33
Grazing Land	0.50
Marine	0.40
Inland Water	0.40
Built-up Land	2.64

Equivalence factors are currently calculated using suitability indexes from the Global Agro-Ecological Zones model combined with data on the actual areas of cropland, forest land, and grazing land area from FAOSTAT (FAO and IIASA Global Agro-Ecological Zones 2000 FAO ResourceSTAT Statistical Database 2007). The GAEZ model divides all land globally into five categories, based on calculated potential crop productivity. All land is assigned a quantitative suitability index ranging from very suitable (0.9) to not suitable (0.1).

The calculation of the equivalence factors assumes the most productive land is put to its most productive use: the most suitable land available will be planted to cropland; the next most suitable land will be under forest land; and the least suitable land will be grazing land. The equivalence factors are calculated as the ratio of the average suitability index for a given land use type divided by the average suitability index for all land -use types.

B Annex B – Ontario Consumption Land Use Matrix (CLUM)

Global Footprint Network has pioneered a process for creating a sub-national Ecological Footprint that uses economic input-output (IO) tables to track the flow of money, and therefore resources, through an economy. The intermediate result of this process is an understanding of the Ecological Footprint of final demand, by industrial sector. This means the overall impact of household and government consumption in each of the industrial sectors listed in the input-output framework. The final result of the IO approach to sub-national Footprint work is a consumption land use matrix (CLUM), which apportions the Ecological Footprint into land-use types (cropland, grazing land, forest land, fishing grounds, carbon uptake land, and built-up land) by consumption category. The household consumption categories that are currently used in the CLUM align directly with the United Nations consumption classification system COICOP, allowing for standardized CLUM creation across multiple nations.

The Ecological Footprint input to the CLUM process is the Ecological Footprint of consumption, a value that takes into account the Footprint of all domestic production, adds the Footprint of imported goods, and subtracts the value of exported goods. Thus, the CLUM illustrates total per capita consumption of goods and services from both domestic and international sources. This means that the CLUM cannot be used to approximate impacts from household consumption on the biocapacity of a specific sub-national region. It can, however, be used to better structure direct consumer outreach programs as it identifies resource inputs and waste streams that can otherwise be lost when only addressing the embodied carbon emissions of purchased goods.

The Ontario IO CLUM template utilizes the most specific data for Ontario by taking the industrial structure of the province of Ontario directly into account. This process uses the Footprint intensity per dollar for each industry from the 2003 Canada IO table in order to capture the influence of imports and exports on sectoral Footprint intensities within Ontario. It allocates this Footprint according to Ontario industry structure from the 2005 Ontario IO table, and utilizes Ontario-specific final demand data (in terms of consumer spending in each industry) to allocate the Footprint of each industry appropriately.

The advantage of the Ontario IO CLUM process is that it captures the industry structure in Ontario at a more detailed level. There is also the advantage of being able to create a new Ontario CLUM for each year where Ontario IO tables are available.

The disadvantages to the Ontario IO CLUM process involve the data limitations faced when working with sub-national economic analysis. The impact of imported goods and services, whether from other regions of Canada or from outside of the country, is lost when we identify Ecological Footprint by industrial sector for Ontario. As well, this process assumes that the dollar value, and consequently the Footprint, of all goods and services that were produced outside of the province and imported before consumption fit into the Ontario industry structure. It essentially forces all of the consumption data through a local production lens. Lastly, the Ecological Footprint of international and inter-provincial trade takes the Footprint of services into account, while the National Footprint Accounts do not, introducing a layer of distortion.

The Ontario CLUM process utilizes Ecological Footprint data from the 2008 National Footprint Accounts, published by Global Footprint Network. It utilizes economic information from Statistics Canada in the form of the Canadian input-output table for 2003, and the Ontario input-output table for 2005. Lastly, this process requires supporting data for carbon dioxide emissions from the International Energy Agency for allocation of the carbon Footprint.

Ontario Ecological Footprint Results

CLUM by United Nations COICOP category

	[gha person^{-1}]	Cropland	Grazing Land	Forest Land	Fishing Grounds	Built-up Land	Carbon Uptake Land	Total
Household	1. Food and non-alcoholic beverages	0.92	0.25	0.14	0.11	0.02	0.78	2.23
	Food and non-alcoholic beverages	0.92	0.25	0.14	0.11	0.02	0.78	2.23
	2. Alcoholic beverages, tobacco and narcotics	0.08	0.02	0.03	0.00	0.00	0.17	0.31
	Alcoholic beverages bought in stores	0.04	0.01	0.02	0.00	0.00	0.09	0.17
	Tobacco products	0.04	0.01	0.01	0.00	0.00	0.08	0.14
	3. Clothing and footwear	0.06	0.02	0.02	0.00	0.00	0.12	0.22
	Men's and boy's clothing	0.02	0.01	0.01	0.00	0.00	0.05	0.09
	Men's and boy's clothing, repair and alteration	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Women's and children's clothing	0.03	0.01	0.01	0.00	0.00	0.06	0.11
	Women's and children's clothing, repair and alterations	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Footwear	0.00	0.00	0.00	0.00	0.00	0.01	0.02
	Shoe repair	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4. Housing, water, electricity, gas and other fuels	0.23	0.06	0.16	0.00	0.02	0.72	1.20
	Gross imputed rent	0.09	0.03	0.03	0.00	0.01	0.14	0.30
	Gross rent paid	0.03	0.01	0.01	0.00	0.00	0.05	0.11
	Other shelter expenses	0.01	0.00	0.00	0.00	0.00	0.02	0.03
	Electricity	0.02	0.00	0.01	0.00	0.00	0.17	0.21
	Natural gas	0.01	0.00	0.00	0.00	0.00	0.12	0.14
	Other fuels	0.06	0.02	0.11	0.00	0.00	0.03	0.23
	Direct household consumption (Hearting)	-	-	-	-	-	0.19	-
	5. Furnishings, household equipment, household maintenance	0.30	0.08	0.05	0.00	0.01	0.29	0.74
	Furniture and floor covering	0.03	0.01	0.01	0.00	0.00	0.07	0.13
	Upholstery and furniture repair	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Household appliances	0.01	0.00	0.00	0.00	0.00	0.03	0.05
	Household equipment repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Semi-durable household furnishings	0.04	0.01	0.02	0.00	0.00	0.09	0.16
	Non-durable household supplies	0.20	0.06	0.01	0.00	0.00	0.08	0.36
	Domestic and child care services	0.01	0.00	0.00	0.00	0.00	0.01	0.02
	Other household services	0.01	0.00	0.00	0.00	0.00	0.01	0.02
	6. Health	0.05	0.01	0.02	0.00	0.00	0.11	0.19
	Medical care	0.01	0.00	0.01	0.00	0.00	0.04	0.06
	Hospital care and the like	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Accident and sickness insurance	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Drugs and pharmaceutical products	0.03	0.01	0.01	0.00	0.00	0.06	0.12
	7. Transportation	0.24	0.07	0.09	0.00	0.02	0.97	1.39
	New and used (net) motor vehicles	0.08	0.02	0.03	0.00	0.00	0.17	0.31
	Motor vehicles parts and accessories	0.01	0.00	0.00	0.00	0.00	0.03	0.05
	Motor vehicle repairs	0.01	0.00	0.00	0.00	0.00	0.02	0.03
	Motor fuels and lubricants	0.11	0.03	0.04	0.00	0.01	0.24	0.44
	Other motor vehicle related services	0.01	0.00	0.00	0.00	0.00	0.01	0.02
	Purchased transportation	0.02	0.01	0.01	0.00	0.00	0.13	0.16
	Direct household consumption (Transportation)	-	-	-	-	-	0.37	0.37
	8. Communication	0.02	0.01	0.01	0.00	0.00	0.04	0.07
	Communications	0.02	0.01	0.01	0.00	0.00	0.04	0.05
	9. Recreation and culture	0.12	0.03	0.04	0.00	0.01	0.20	0.40
	Recreation, sporting and camping equipment	0.04	0.01	0.02	0.00	0.00	0.09	0.16
	Recreation equipment repair and rentals	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Reading and entertainment supplies	0.05	0.01	0.01	0.00	0.00	0.04	0.12
	Recreational services	0.03	0.01	0.01	0.00	0.00	0.06	0.11
	10. Education	0.01	0.00	0.00	0.00	0.00	0.03	0.05
	Educational and cultural services	0.01	0.00	0.00	0.00	0.00	0.03	0.05
	11. Restaurants and hotels	0.17	0.05	0.04	0.01	0.01	0.16	0.44
	Restaurants and accommodation services	0.17	0.05	0.04	0.01	0.01	0.16	0.44
	12. Miscellaneous goods and services	0.08	0.02	0.03	0.00	0.01	0.22	0.36
	Personal care	0.01	0.00	0.00	0.00	0.00	0.01	0.03
	Jewellery and watches	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Jewellery and watch repair	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Leather goods & other personal effects	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Toilet articles and cosmetics	0.01	0.00	0.00	0.00	0.00	0.02	0.04
	Financial, legal and other services	0.04	0.01	0.01	0.00	0.00	0.07	0.14
	Operating expenditures of non-profit organizations	0.01	0.00	0.00	0.00	0.00	0.11	0.13
	Sub-total Household Consumption	**2.28**	**0.63**	**0.62**	**0.14**	**0.11**	**3.81**	**7.59**
Government		0.24	0.07	0.09	0.01	0.03	0.43	0.86
Total		**2.52**	**0.69**	**0.71**	**0.14**	**0.13**	**4.24**	**8.45**

Ontario Ecological Footprint Results

CLUM by Food, Housing, Mobility, Goods, Services groupings

	[gha / person]	Cropland	Grazing Land	Forest Land	Fishing Grounds	Built-up Land	Carbon Uptake Land	Total
Household	**Food**	**0.97**	**0.27**	**0.15**	**0.11**	**0.02**	**0.88**	**2.39**
	Food and non-alcoholic beverages	0.92	0.25	0.14	0.11	0.02	0.78	2.23
	Alcoholic beverages bought in stores	0.04	0.01	0.02	0.00	0.00	0.09	0.17
	Housing	**0.23**	**0.06**	**0.16**	**0.00**	**0.02**	**0.72**	**1.20**
	Gross imputed rent	0.09	0.03	0.03	0.00	0.01	0.14	0.30
	Gross rent paid	0.03	0.01	0.01	0.00	0.00	0.05	0.11
	Other shelter expenses	0.01	0.00	0.00	0.00	0.00	0.02	0.03
	Electricity	0.02	0.00	0.01	0.00	0.00	0.17	0.21
	Natural gas	0.01	0.00	0.00	0.00	0.00	0.12	0.14
	Other fuels	0.06	0.02	0.11	0.00	0.00	0.03	0.23
	Direct household consumption (heating)	0.00	0.00	0.00	0.00	0.00	0.19	0.19
	Mobility	**0.24**	**0.07**	**0.09**	**0.00**	**0.02**	**0.97**	**1.39**
	New and used (net) motor vehicles	0.08	0.02	0.03	0.00	0.00	0.17	0.31
	Motor vehicles parts and accessories	0.01	0.00	0.00	0.00	0.00	0.03	0.05
	Motor vehicle repairs	0.01	0.00	0.00	0.00	0.00	0.02	0.03
	Motor fuels and lubricants	0.11	0.03	0.04	0.00	0.01	0.24	0.44
	Other motor vehicle related services	0.01	0.00	0.00	0.00	0.00	0.01	0.02
	Purchased transportation	0.02	0.01	0.01	0.00	0.00	0.13	0.16
	Direct household consumption (transportation)	0.00	0.00	0.00	0.00	0.00	0.37	0.37
	Goods	**0.52**	**0.14**	**0.12**	**0.01**	**0.02**	**0.71**	**1.53**
	Men's and boy's clothing	0.02	0.01	0.01	0.00	0.00	0.05	0.09
	Men's and boy's clothing, repair and alteration	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Women's and children's clothing	0.03	0.01	0.01	0.00	0.00	0.06	0.11
	Women's and children's clothing, repair and alterations	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Footwear	0.00	0.00	0.00	0.00	0.00	0.01	0.02
	Shoe repair	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Furniture and floor covering	0.03	0.01	0.01	0.00	0.00	0.07	0.13
	Upholstery and furniture repair	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Household appliances	0.01	0.00	0.00	0.00	0.00	0.03	0.05
	Household equipment repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Semi-durable household furnishings	0.04	0.01	0.02	0.00	0.00	0.09	0.16
	Non-durable household supplies	0.20	0.06	0.01	0.00	0.00	0.08	0.36
	Drugs and pharmaceutical products	0.03	0.01	0.01	0.00	0.00	0.06	0.12
	Recreation, sporting and camping equipment	0.04	0.01	0.02	0.00	0.00	0.09	0.16
	Recreation equipment repair and rentals	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Reading and entertainment supplies	0.05	0.01	0.01	0.00	0.00	0.04	0.12
	Jewelry and watches	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Jewelry and watch repair	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Leather goods & other personal effects	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Toilet articles and cosmetics	0.01	0.00	0.00	0.00	0.00	0.02	0.04
	Tobacco products	0.04	0.01	0.01	0.00	0.00	0.08	0.14
	Services	**0.32**	**0.09**	**0.09**	**0.01**	**0.02**	**0.54**	**1.08**
	Domestic and child care services	0.01	0.00	0.00	0.00	0.00	0.01	0.02
	Other household services	0.01	0.00	0.00	0.00	0.00	0.01	0.02
	Medical care	0.01	0.00	0.01	0.00	0.00	0.04	0.06
	Hospital care and the like	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Accident and sickness insurance	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Communications	0.02	0.01	0.01	0.00	0.00	0.04	0.07
	Recreational services	0.03	0.01	0.01	0.00	0.00	0.06	0.11
	Educational and cultural services	0.01	0.00	0.00	0.00	0.00	0.03	0.05
	Restaurants and accommodation services	0.17	0.05	0.04	0.01	0.01	0.16	0.44
	Personal care	0.01	0.00	0.00	0.00	0.00	0.01	0.03
	Financial, legal and other services	0.04	0.01	0.01	0.00	0.00	0.07	0.14
	Operating expenditures of non-profit organizations serving households	0.01	0.00	0.00	0.00	0.00	0.11	0.13
	Sub-total Household Consumption	**2.28**	**0.63**	**0.62**	**0.14**	**0.11**	**3.81**	**7.59**
Government		0.24	0.07	0.09	0.01	0.03	0.43	0.86
Total		**2.52**	**0.69**	**0.71**	**0.14**	**0.13**	**4.24**	**8.45**

C Annex C – Ontario Biocapacity Results

A subset of the total Ontario provincial land area was used for the biocapacity analysis, in order to match the land cover classes from Ontario to the standard biocapacity land-use types utilized by Ecological Footprint and biocapacity methodology.

Table C. Ontario land cover classes mapped to biocapacity analysis land-use types.

Land Cover Class	Classification for Biocapacity Analysis	Mixedwood Plains	Ontario Shield	Hudson Bay Lowlands	Great Lakes (ON Portion)	Total
Agriculture	**Cropland**	**4,975,051**	**432,465**	**-**	**-**	**5,407,516**
Forests	**Forest**	**1,433,897**	**43,841,802**	**5,166,194**	**-**	**50,441,893**
Forest	Forest	105,475	10,734,782	2,555,571	-	13,395,828
Deciduous forest	Forest	625,028	4,822,784	71,499	-	5,519,311
Mixed forest	Forest	379,543	14,412,313	713,789	-	15,505,644
Coniferous forest	Forest	323,852	13,871,923	1,825,335	-	16,021,109
Other wooded land	**Other wooded land**	**59,051**	**5,099,397**	**495,241**	**-**	**5,653,688**
Hedge rows	Other wooded land	57,665	86	-	-	57,751
Forest depletion cuts	Other wooded land	-	2,232,378	2,271	-	2,234,649
Forest depletion burns	Other wooded land	-	1,784,351	360,596	-	2,144,947
Forest regenerating depletion	Other wooded land	-	1,082,581	132,375	-	1,214,955
Shoreline	Scrub and/or herbaceous vegetation associations	251	-	-	-	251
Alvar	Scrub and/or herbaceous vegetation associations	888	-	-	-	888
Treed sand barren & dune	Scrub and/or herbaceous vegetation associations	248	-	-	-	248
Grazing land	**Grazing land**	**1,905**	**-**	**-**	**-**	**1,905**
Open tall grass prairie	Grazing land	354	-	-	-	354
Tall grass savannah	Grazing land	189	-	-	-	189
Tall grass woodland	Grazing land	1,361	-	-	-	1,361
Infrastructure	**Infrastructure**	**669,297**	**202,522**	**2,024**	**-**	**873,842**
Transportation	Infrastructure	268,932	2,050	-	-	270,983
Settlement	Infrastructure	400,365	200,471	2,024	-	602,860
Water	**Inland Water**	**364,869**	**8,657,218**	**1,799,134**	**-**	**19,573,521**
Water	Fishing grounds (inland)	246,470	8,648,169	1,653,584	8,752,300	19,300,523
Intertidal marsh	Inland Water	-	0	21,825	-	21,825
Supertidal marsh	Inland Water	-	-	99,363	-	99,363
Marsh	Inland Water	118,398	9,049	-	-	127,448
Mudflats	Inland Water	-	-	24,363	-	24,363
Total Area Included for Biocapacity Analysis						**81,952,366**

The total land area utilized in this biocapacity analysis matches the total in Table C. Land area data that were included are listed in Table D. These land areas provide ecosystems services, but humans are not able to appropriate these services in any significant way and thus the land types are not included in biocapacity analysis.

Table D. Ontario land cover classes which were not utilized in the biocapacity analysis.

Land Cover Class	Classification for Biocapacity Analysis	Mixedwood Plains	Ontario Shield	Hudson Bay Lowlands	Great Lakes (ON Portion)	Total
Wetlands	**Not included**	**951,130**	**6,244,991**	**17,002,738**	**-**	**24,198,859**
Swamp	Not included	17,393	4,509,064	10,060,778	-	14,587,235
Fen	Not included	930,991	28,803	425	-	960,219
Bog	Not included	2,747	1,707,124	6,941,535	-	8,651,405
Non Productive Land	**Not included**	**40,011**	**846,279**	**338,593**	**-**	**1,224,884**
Tundra heath	Not included	-	24	283,598	-	283,622
Open sand barren and dune	Not included	711	-	-	-	711
Open cliff & talus	Not included	1	-	-	-	1
Bedrock outcrop and quarry/gravel extraction	Not included	37,053	402,313	53,673	-	493,039
Unknown	Not included	1,384	234,973	1,116	-	237,472
Cloud/Shadow	Not included	728	208,969	207	-	209,904
Mudflats	Not included	135	-	-	-	135
Total Area Excluded from Biocapacity Analysis						**25,423,743**

Table E. Ontario provincial land area (in hectares) utilized in the biocapacity analysis, by Ecozone.

	Mixedwood Plains	Ontario Shield	Hudson Bay Lowlands	Great Lakes (ON Portion)	Total
Agriculture	4,975,051	432,465	-		5,407,516
Grazing land	1,905	-	-		1,905
Other wooded land	59,051	5,099,397	495,241		5,653,688
Forests	1,433,897	43,841,802	5,166,194		50,441,893
Inland Water	364,869	8,657,218	1,799,134	8,752,300	19,573,521
Infrastructure	669,297	202,522	2,024		873,842
Total Land Area (ha)	**7,504,069**	**58,233,404**	**7,462,593**	**8,752,300**	**81,952,366**
Land Area per capita (ha)	**0.60**	**4.65**	**0.60**	**0.70**	**6.54**

Table F. Ontario biocapacity results (in gha), by Ecozone.

	Mixedwood Plains	Ontario Shield	Hudson Bay Lowlands	Great Lakes (ON Portion)	Total	Per Capita
Agriculture	18,153,287	1,578,006	-	-	19,731,293	1.57
Grazing land	1,031	-	-	-	1,031	0.00
Other wooded land	31,955	2,759,537	268,000	-	3,059,492	0.24
Forests	5,636,978	64,851,166	1,858,835	-	72,346,979	5.77
Inland water	144,916	3,438,423	714,570	3,476,187	7,774,096	0.62
Infrastructure	2,442,174	738,974	7,384	-	3,188,532	0.25
Total biocapacity (gha)	**26,410,340**	**73,366,106**	**2,848,788**	**3,476,187**	**106,101,422**	**8.47**
Biocapacity per capita (gha)	**2.11**	**5.86**	**0.23**	**0.28**	**8.47**	

D Annex D – Biocapacity Analysis Methodology

Cropland Yield Factor

Yield factors account for differing levels of productivity for particular land-use types. The Ontario cropland yield factor is calculated as 1.39 world hectares per national hectare (wha/nha). The yield factor was developed by scaling the Canadian yield factor for cropland by the difference in crop yields for select crops between Ontario and Canada. The best data available comparing yields allowed for analysis of 13 crop categories representing more than 65 percent of the total agriculture land in Ontario.[19] Table G presents the average yield by crop type for Ontario and Canada. The provincial crop land yield factor is the average yield per hectare based on the total seeded area and harvest by crop type. As 92 percent of the crop land falls within the Mixedwood Plains Ecozone, we do not differentiate agriculture yield factors by Ecozone.

Table G. Ontario agriculture land yield factor

Crop Type	Ontario Seeded area (ha)	Ontario average yield (kg per ha)	Canada average yield (kg per ha)	Ontario yield compared to Canadian yield
Spring wheat	83,700	3,400	2,500	1.36
Winter wheat	420,900	5,600	4,800	1.17
Oats	53,400	2,500	2,500	1.00
Barley	89,400	3,400	3,000	1.13
All rye	30,400	2,300	2,300	1.00
Fall rye	30,400	2,300	2,300	1.00
Mixed grains	70,200	3,000	2,700	1.11
Corn for grain	638,500	9,400	8,500	1.11
Dry white beans	37,300	2,300	2,100	1.10
Coloured beans	28,800	2,200	2,100	1.05
Soybeans	872,500	3,100	2,900	1.07
Canola (rapeseed)	7,500	2,300	1,700	1.35
Tame hay	1,042,000	5,960	4,100	1.45
Fodder corn	129,800	38,420	37,870	1.01
Average crop yield per hectare				**1.21**
Cropland Yield Factor				**1.39**

The process of scaling Canadian yield factor according to Ontario yields asks: If Ontario yields were to be supported on world average bioproductive land, how much land would it take? The answer is our understanding of the difference between the Canadian yield factor, and the new

[19] Ontario Ministry of Agriculture, Food, and Rural Affairs. 2009. Horticultural Statistics. Available at http://www.omafra.gov.on.ca/english/stats/hort/index.html. Accessed July 2009.

Ontario yield factor. Because the Ontario yields used in this process are primarily bulk feed crops as listed in Table G, there may be distortion introduced within the comparison. This may be improved in the future by accessing a more robust set of crop product data.

Forest Yield Factor

The average forest yield factor for Ontario is 1.13 wha/nha. The forest yield factor is calculated based on annual increment of timber per hectare.[20] This is similar to the process of calculating a national yield for forest land in the National Footprint Accounts, and relies on the assumption that annual increment data accurately accounts for the addition of forest stock each year throughout the forest. Table H presents annual increment data and forest yield factors data for Ontario (by Ecozone), Canada, and the world.

Table H. Yield factor estimates by Ecozone for Canada and Ontario, 2005.

	Annual Increment (per ha)	Yield Factor
Mixedwood Plains	6.96	2.95
Ontario Shield	2.61	1.11
Hudson Bay Lowlands	0.64	0.27
Ontario (average)	**2.66**	**1.13**
Canada (average)	1.71	0.73
World (average)	**2.36**	**1.00**

Grazing Land and Other Wooded Land Yield Factor

In the 2008 National Footprint Accounts, other wooded land is included as part of grazing land area. Given the substantial amount of other wooded land versus grazing land in Ontario, these categories were left separate during the analysis. In terms of total provincial land area, both categories are minor: grazing land represents less than 0.01 percent of total provincial land area while other wooded land represents five percent. The grazing land yield factor is based on the amount of above-ground primary production available in a year. Given the lack of data to estimate Ontario specific values, the Canadian grazing land yield factor of 1.09 wha/nha was adopted.

[20] Ontario Government, Ministry of Natural Resources. 2007. State of the Forest Report 2006. Available at http://www.mnr.gov.on.ca/en/Business/Forests/Publication/196959.html. Accessed July 2009.

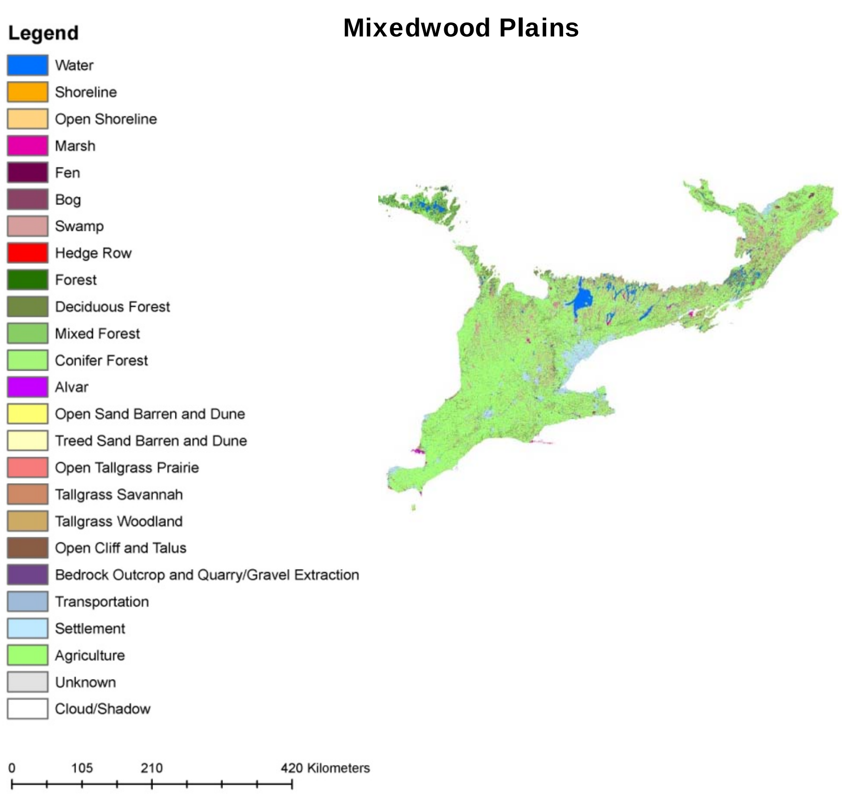
Inland water

We follow the approach taken in the Global Footprint Network National Accounts for Canada (2008) and do not adjust the inland water area. In this case, for Ontario we use a yield factor of 1.00 wha/nha and an inland water estimate that includes both the Ontario portion of the Great Lakes, and all other inland water areas (rivers, etc).

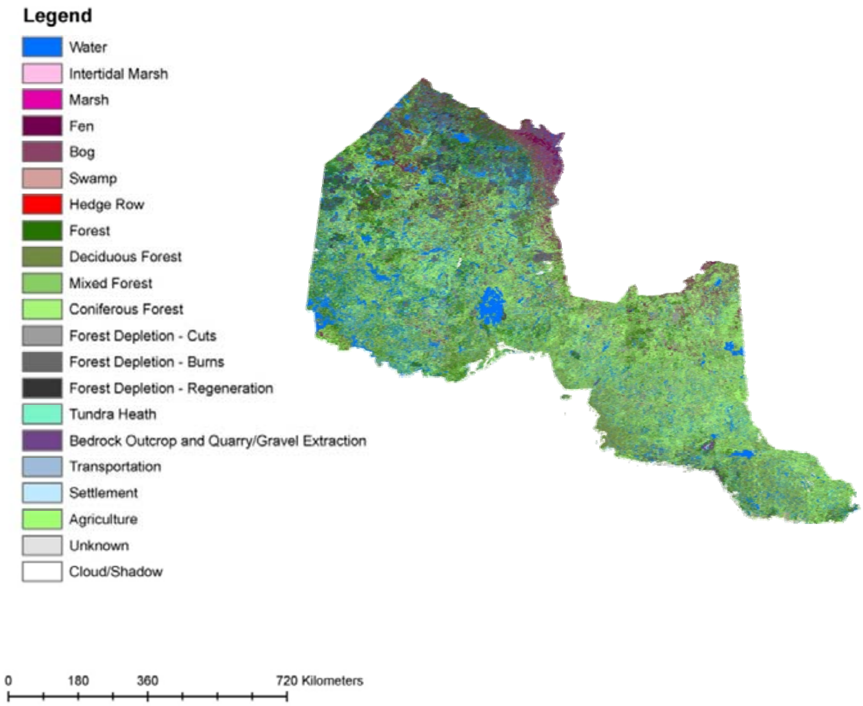
Built-up land or Infrastructure

The yield factor for built-up land (or human infrastructure such as buildings, roads, etc) is assumed identical to that of cropland since urban areas (and human settlements) are typically built on or near the most productive agricultural lands. In this case, for built-up land, we adopt the Ontario cropland yield factor of 1.39 world hectares per national hectare.

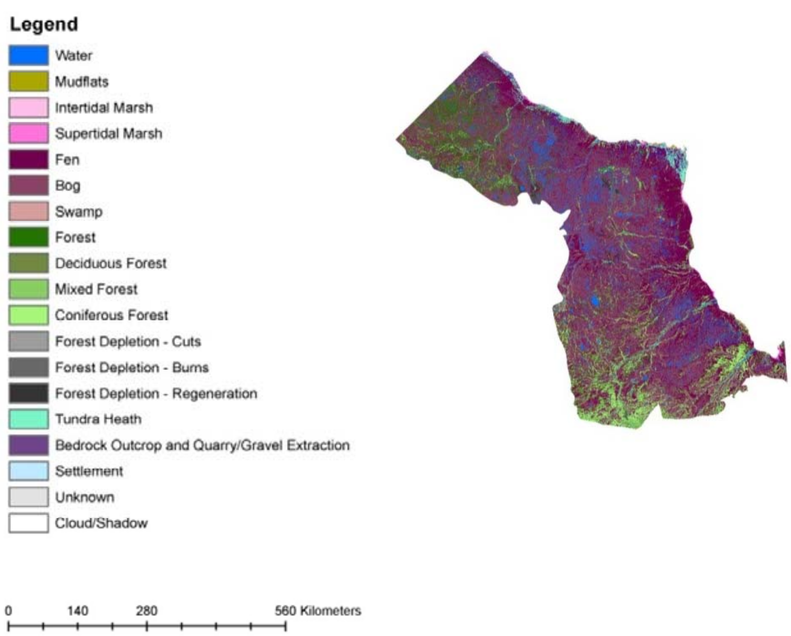
Ontario Maps by Ecozone



Ontario Shield



Hudson Bay Lowlands



E Annex E – Improvements to the Ontario Ecological Footprint Analysis

This Ecological Footprint and biocapacity analysis for the province of Ontario was undertaken with the intent of establishing a solid Ecological Footprint baseline and adding value to the discussion about pressures on biodiversity in Ontario. It follows the Ecological Footprint Standards methodology, utilizes the most appropriate provincial data, and mirrors the same process for biocapacity calculation as is present in the national level data for Canada.

This analysis is a solid first step toward accounting more holistically for resource use and availability in Ontario, and as a conservative baseline this analysis can inform discourse and policy discussions about sustainability and resource constraints. In the future, however, there are a number of possibilities for expanding the scope of the Ecological Footprint and biocapacity analysis to fit more closely with the expansive amount of data available in Ontario.

The Ecological Footprint analysis may be improved in the future in a number of ways:

(1) The Ecological Footprint embodied in Ontario's interprovincially traded goods can be improved and expanded significantly with the inclusion of input-output data for each province in Canada. The current analysis assumes that the industrial structure of other Canadian provinces is identical to that of Ontario due to a lack of information on each specific province. The practice of assuming consistency between trading nations (or provinces in this case) is fairly common in input-output analysis, but the availability of input-output data at the province level in Canada will allow future analyses to remove this possible bias.

(2) The Ecological Footprint of Ontario's internationally traded goods can also be expanded and refined in the future through the development of Global Footprint Network's National Footprint Accounts trade data. The next phase of the Global Footprint Network research agenda will remove world-average data for embodied energy of traded products and allow for country-specific intensities at the industry, and perhaps product, level. This will expand the conversation around trade to include an understanding of which trading partners are

the most efficient, and help policymakers understand what part of Ontario's overall consumption is impacting which trading partners.

(3) In the next two years, Global Footprint Network will be expanding its capacity to analyze the Ecological Footprint of production at a sub-national level. This will allow Ontario to directly compare the Ecological Footprint of production to available biocapacity, and draw links between on-the-ground impacts of economic processes (by industrial sector) and pressures on biodiversity and fragile ecosystems.

(4) Finally, the next Ecological Footprint analysis for the province of Ontario should focus specifically on increasing the economic data resolution at a municipal or city level. With a provincial-level average Ecological Footprint as a starting point, the next step is to understand how the Ecological Footprint of Ontario residents may change across ecozones, or even across a city. The data required for this type of more nuanced analysis includes detailed household expenditures data covering household consumption, consumer price index data for inter-city comparisons, and data on the carbon dioxide intensity of electricity sources for different regions.

Biocapacity estimates for Ontario can also be improved in a number of ways:

(1) The data utilized in the National Footprint Accounts for Canadian land area comes from the United Nations Food and Agriculture Organization. The benefit of this data is that it allows global comparability of national biocapacities; the disadvantage is that often we lose the ability to analyze biocapacity under high spatial resolution. In the future, Ontario biocapacity calculations should include a multifaceted approach to expanding biocapacity source data. First, we should look at the difference in biocapacity estimates that arises from using land data from the FAO versus using more spatially resolute satellite land cover data from Canadian sources, possibly Natural Resources Canada.

Once we have an understanding of the range of biocapacity values that may arise given different land area source data, Ontario will be able to undertake a combination mapping and biocapacity study. Utilizing the strong satellite and GIS mapping already used by

Statistics Canada and Natural Resources Canada, Ontario will be able to understand where and how biocapacity links to stressed ecosystems, at a much more detailed scale.

(2) There is also room to improve the source data used to calculate Ontario-specific yield factors; in particular, to improve the understanding of grazing land and other wooded land yields, inland water yields, and forest-species specific net annual increment data. As with any analysis, the more specific and local information that can be incorporated, the more complete the final result.

(3) Finally, there is room to improve upon our understanding of the role of non-standard land types in the provision of services to humans. With a very large percentage of the Hudson Bay Lowlands Ecozone classified as wetlands and bogs, it would be beneficial for Ontario to better understand how these ecosystems may provide biocapacity, either directly through harvest of products or indirectly through storing carbon dioxide.

F Annex F – Glossary

Biological capacity, or biocapacity: The capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans, using current management schemes and extraction technologies. “Useful biological materials” are defined as those used by the human economy. Hence what is considered “useful” can change from year to year. The biocapacity of an area is calculated by multiplying the actual physical area by the yield factor and the appropriate equivalence factor. Biocapacity is usually expressed in global hectares.

Biological capacity available per person (or per person): There were 13.4 billion hectares of biologically productive land and water on this planet in 2005. Dividing by the number of people alive in that year, 6.5 billion, gives 2.1 global hectares per person. This assumes that no land is set aside for other species that consume the same biological material as humans.

Biologically productive land and water: The land and water (both marine and inland waters) area that supports significant photosynthetic activity and the accumulation of biomass used by humans. Non-productive areas as well as marginal areas with patchy vegetation are not included. Biomass that is not of use to humans is also not included. The total biologically productive area of land and water in 2005 was approximately 13.4 billion hectares.

Carbon Footprint: The carbon Footprint translates tonnes of CO_2 into the amount of world average forested land that would be required to store those emissions. The Ecological Footprint encompasses the carbon Footprint, and captures the extent to which measures for reducing the carbon Footprint lead to increases in other Footprint components.

Carrying capacity: Carrying capacity is a technical term that refers to the maximum population of a species that a given land or marine area can support. Many species have easily defined and consistent consumption needs, making carrying capacity relatively easy to define and calculate. For humans, however, carrying capacity estimates require assumptions about future per-person resource consumption, standards of living and “wants” (as distinct from “needs”), productivity of the biosphere, and advances in technology. An area’s carrying capacity for humans is thus inherently speculative and difficult to define.

Ecological Footprint accounts approach the carrying capacity question from a different angle. Ecological Footprints are not speculative estimates about a potential state, but rather are an accounting of the past. Instead of asking how many people could be supported on the planet, the Ecological Footprint asks the question in reverse and considers only present and past years. The Footprint asks how many planets were necessary to support all of the people that lived on the planet in a given year, under that year's standard of living, biological production and technology. This is a scientific research and accounting question that can be answered through the analysis of documented, historical data sets.

Ecological Footprint: The Ecological Footprint is a resource accounting tool used widely as a management and communication tool by governments, businesses, educational institutions and NGOs to answer a specific resource question: How much of the biological capacity of the planet is required by a given human activity or population?

Overshoot: Overshoot, which in this context is shorthand for ecological overshoot, occurs when a population's demand on an ecosystem exceeds the capacity of that ecosystem to regenerate the resources it consumes and to absorb its wastes.

The Ecological Footprint is often used to calculate global ecological overshoot, which occurs when humanity's demand on the biosphere exceeds the available biological capacity of the planet. By definition, overshoot leads to a depletion of the planet's life supporting biological capital and/or to an accumulation of waste products.

Regenerative capacity: This is a synonym for biocapacity; it measures the ability of bioproductive ecosystems to regenerate resources that are harvested, and to store wastes that are created. Biocapacity is a regenerative process whereby natural systems take the waste we create and turn it back into useful resources.