SWEDISH ENVIRONMENTAL PROTECTION AGENCY

Ecological Footprints and Biocapacity

Tools in Planning and Monitoring of Sustainable Development in an International Perspective

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Foreword

The ecological footprint has become a popular concept in both planning and teaching. Nevertheless the grounds for calculation of footprints are vague, and several methods are used. The parallel concept of biocapacity for reporting biological productivity in different areas is not well known. The use of the two concepts in planning and for international comparisons demands standard methods for their calculations. Such methods have been proposed and will be described here, but they need further improvement and development.

Biocapacity and ecological footprints have been introduced to describe the scarcity of bioproductive space on the Earth and they offer a physical base for measurement and valuing in parallel to economic valuing and market mechanisms.

Within the SAMS project (Community Planning with Environmental Objectives), modified calculations of ecological footprints have been made in some Swedish municipalities. The aim of this report is to view the Swedish efforts in a larger perspective with reference to more recent methods of calculation. The history and development of the ecological footprint since its introduction in the early 1990s is also described. Further development is in progress in several countries.

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Lund July 2000

Lillemor Lewan.

Preface by the National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency

Ever more people in the world agree that we must attain sustainable development. This is a broad concept and includes ecological aspects as well as social and economic ones. But what does it mean, how can it be realised and how do we know that we are on the right track?

This report, *Ecological footprints and biocapacity – tools in planning and monitoring of sustainable development in an international perspective*, describes in brief the background of the ecological footprint and existing calculation models. The ecological footprint illustrates the amount of productive space of land and water (biocapacity) that is necessary for the production of the food and fibres, commodities and services that a person or a group of people consumes and to absorb the pollution generated.

A footprint is the aggregated area of many small plots scattered all over the world depending on what is consumed, from where it is imported and what pollution is generated. Ecological footprints can also be used to compare areas needed for different kinds of energy. Hydropower, for example, demands much less biocapacity per energy unit than oil if you consider the amount of released carbon dioxide, which must be absorbed by growing forest to be stored for the future.

Ecological footprints and biocapacity – tools in planning and monitoring of sustainable development in an international perspective is based on international and Swedish research and surveys and is an expert assignment carried out by Lillemor Lewan, Lund University within the framework of a three-year project for generating ideas and new methods. The project has been coordinated by the National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency in cooperation with several Swedish municipalities and regional authorities. The title of the project, which finished in September 2000, is Community Planning with Environmenta Objectives in Sweden *(SAMS).* The project received economic support from EU LIFE and the Swedish International Development Cooperation Agency (Sida). Sweco/FFNS has a consultative role. Case studies were carried out in the municipalities of Burlöv, Helsingborg, Trollhättan, Stockholm, Borlänge, Falun and Storuman. Surveys were conducted by the Office of Regional Planning and Urban Transportation in Stockholm with help from the County Administrative Boards of Skåne, Västra Götaland, Stockholm, Dalarna and Västerbotten counties. Studies were also carried out in cooperation with the South African municipalities Port Elizabeth and Kimberley.

An important strategy in the work with environmental objectives in planning is close cooperation between environmental experts and planners. Such interaction was a cornerstone of the project's organisation and implementation. Environmental experts and planners from different levels of administration cooperated in the executive steering group drawn from the two government agencies involved, in the reference group and in all case studies.

Experiences and conclusions from the SAMS project are described in the reports *Community Planning with Environmental Objectives! A Guide* and in *Community Planning with Environmental Objectives! Listed Ideas.* The case studies are described in special publications and on the Internet at www.environ.se/sams.

Karlskrona and Stockholm in September 2000

The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency.

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Summary

The term ‘ecological footprint’ was coined at the beginning of the 1990s by Canadian researchers who studied the amount of land needed by cities to support their populations. An ecological footprint represents the bioproductive area needed to produce everything consumed by an individual or a population and to absorb the emissions that result from this consumption. Thus, in contrast to carrying capacity (number of animals fed on a certain area), the ecological footprint is the area necessary to support a human population. Moreover the footprint is the sum total of many small scattered areas, taking into account the resources consumed and their origin, and emissions of undesirable substances. The biocapacity is a measure of the productive capacity of the areas that are available in the world as a whole, in a country or in a smaller area. Ecological footprints can also be used to compare the areas needed for various technologies. Hydropower, for example, requires less biocapacity per unit of energy produced than oil, given the fact that the carbon dioxide released in combustion must be absorbed. Greenhouse cultivation requires a larger area than outdoor cultivation since the emissions from fossil fuels must be absorbed. One possibility of absorbing carbon emissions is to preserve growing forests as carbon sinks for “permanent” storage. Little research has been done on other techniques for absorption and storage.

Equivalence (compensation) and yield coefficients have been formulated in order to allow international comparisons to be made between the need of biocapacity for human consumption and available resources and thus to express national area data in terms of the global average. The industrialized countries generally have large ecological footprints, while in many developing countries they are small. In relation to resource needs, there is a shortage of biocapacity in both industrialized and developing countries, especially if wild animals’ need of vegetable production and biodiversity is taken into account. Twelve per cent of the biocapacity is earmarked on a preliminary basis for biodiversity. If everyone were to adopt a Swedish lifestyle, we would, given current technologies, need two more Earths.

Sparsely populated Sweden, with a footprint corresponding to 6-7 hectares per capita and a biocapacity of 7-8 hectares per capita, has a small surplus of biocapacity. However, this comparison is flawed, since the ecological footprint is calculated in relation to import from all over the world, while the biocapacity relates only to Sweden’s surface area.

The ratio between resource needs and available biocapacity has nothing to do with sustainability, which depends on how the productive areas are used. Studies of land use in Sweden show that the area used for agriculture corresponds roughly to that needed to produce the food we consume, including a large proportion of animal products, the production of which takes up large areas. The forest area is much larger than is needed for the purposes of consumption, but it is used for export production rather than for permanent storage of the carbon dioxide emitted by cheap imported fossil fuels. In addition, no land is set aside to absorb plant nutrient leakage or protect groundwater.

Regional studies indicate that the southernmost province, Skåne, as a whole has a shortage of biocapacity in relation to the population's ecological footprint. However, there are substantial variations between municipalities in Skåne, with a large deficit in the southwest, which is overexploited, and equilibrium or a surplus in the north and east. There is also great variation in the municipalities covered by the project Community Planning with Environmental Objectives in Sweden ('the SAMS project'), with a large surplus of biocapacity per capita in Storuman in the very north, near-equilibrium in Falun and increasing deficits the further south the municipality is situated, although Stockholm accounts for the largest deficit of all. Superficial studies of the possibility of the SAMS municipalities becoming self-sufficient in staple foods and alternative energy sources also indicate that, except in Falun and Storuman, there is generally a great shortage of productive areas. The ecological footprint made by the transport sector is notable in a small municipality such as Burlöv in Skåne.

There is now talk of the possibility of basing planning for and evaluation of sustainable development on other geographical areas than the traditional regions and municipalities. Water management based on river basins (cf. the new EC framework water directive) opens up entirely new prospects of reconciling the needs of communities and settlements with natural and ecosystem resources, while improving the possibility of monitoring water conditions. Using ecological footprints and biocapacity as indicators might help to reconcile anthropocentric planning with scientifically established facts.

Simple and well-defined systems and examples that are readily understood at various levels of society are necessary to facilitate the changeover to sustainable development. Ecological footprints and biocapacity are explicit indicators (though they require central control and directives to ensure that reliable estimates are made of conditions relating to individuals and municipalities, as well as central government assistance with international contacts). River basins are well-defined geographical areas, although they are not widely understood. Application of the Polluter Pays Principle, which means that polluters must deal with the pollutant emissions that they generate, may also help. In theory this could mean that every time a person filled up their car with petrol, bought an air ticket or filled their oil/gas tank, they would be obliged to purchase a piece of growing forest for absorption and permanent storage of carbon dioxide and look after it in the future. This would raise awareness of how scarce a resource the earth's productive areas are. If areas were used for the purpose of carbon storage or nutrient retention, this would open up completely new prospects for biodiversity!

Suggestions for further reading:
Recent international developments with regard to ecological footprints and carrying capacity are presented in a new book by Chambers, Simmons and Wackernagel entitled *Sharing Nature's Interes*t, Earthscan, October 2000 and in The Living Planet Report 2002, http://www.panda.org/publications

SAMS – Community Planning with Environmental Objectives in Sweden

The aim of the SAMS-project was to find new methods of working with environmental objectives in community planning especially in structure planning. Through case studies and real life applications, the project showed how physical planning can help reach environmental quality objectives, established as part of national environmental policy, and to formulate local objectives for ecologically sustainable development. The idea of continuous cooperation between environmental experts and planners throughout the planning process was a cornerstone of the organisation and implementation of the work and of methods used at the central, regional and local levels.

Case studies in municipalities and regions

Eight case studies from all over Sweden were included in the SAMS project. In all of them, the development of new methods was linked to the on-going planning process in the municipality. Municipalities involved in the project and their key objectives were (from south to north):

• *Burlöv:* A good living environment as a result of less impact from traffic.

• *Helsingborg:* Improved conditions for bicycling and public transport and reduced environmental load from road traffic.

• *Trollhättan:* Local adaptation of the national environmental quality objective: ”a good urban environment”.

• *Stockholm:* Biodiversity in the national urban park.

• *Stockholm:* Assessment of environmental consequences of in-depth structure planning.

• *Falun+Borlänge:* Planning using adjusted environmental objectives and indicators for farming and forestry.

• *Storuman:* Scenarios for sustainable development in a very sparsely populated municipality.

• *The Office of Regional Planning and Urban Transportation in the County of Stockholm* represented planning at the regional level: strategic environmental assessment in regional planning

The SAMS-project also included studies in cooperation with planners and environmental officers in the two South African cities of Port Elizabeth and Kimberley.

Three main themes in SAMS:

Some extra important problems were highlighted in three thematic studies complementing the case studies

•*Environmental objectives and physical structures*

This thematic study shows how environmental objectives and indicators can be used in physical planning, in particular focussing on how different physical structures correspond to the objectives.

There were two in-depth studies, one concerning strategies for regional water supply, the other concerning links between the city and the countryside, especially regarding energy supply.

• *Strategic environmental assessment (SEA)*

This thematic study concerned the use of environmental objectives and indicators in SEA in physical planning, especially in community/municipal strategic planning and in regional physical planning.

• *Geographic information system (GIS)*

This thematic study describes GIS as an analytical tool and how GIS can be used for better illustration and handling of planning using adapted environmental objectives and indicators in physical planning.

An in-depth study was made of GIS-based maps as tools for improved discussions and consensus debates in planning.

The results of the SAMS project are summed up in the reports *Community Planning with Environmental Objectives! A Guide.* and *Planning with Environmental Objectives! A List of ideas* and final reports from the case studies, the thematic studies and the in-depth studies. Moreover, the treatment of the sustainability problems in municipal structure plans was analysed in a special study, and a number of specialists' reports have been published.

Glossary

Absorption: Uptake of a substance/pollution by being dissolved in water or as the result of possible chemical reaction with other substances in a plant. Carbon dioxide is e.g. absorbed in trees and other plants where it reacts and makes sugar and cellulose and releases oxygen.

Biocapacity: A measure of the bioproductive capacity in a certain area, country or the Earth. Bioproductive spaces have different quality and different local yield. Arable land is generally speaking of better quality than forested land. Grazing land gives more protein per hectare than do fishing areas. With the aid of correction factors for the quality of land (equivalence factors) and for the yield (local yield factors) all bioproductive space can be expressed in unit areas – global average bioproductive space. Thus, areas of different quality can be aggregated into one area. The biocapacity of a geographical area is defined as the area of global average space that it corresponds to concerning bioproduction. The biocapacity is often expressed in hectares per capita as is the ecological footprint.

Biodiversity: Implies wildlife flora and fauna with good variation. Not only must there be many different species but also good genetic variation – it is natural that inherited traits vary concerning size, metabolism, pest resistance, etc. When estimating the amount of biocapacity available to the human population, 12 per cent is deducted for wildlife flora and fauna.

Bioproductive area: An area with biological production – 16 per cent of the Earth's surface. It may be arable land, grazing land, forest, fishing areas. Impediments, i.e. high mountains, deserts and oceans have no or insignificant biological production.

"Carrying Capacity" indicates the number of animals that can feed themselves on a certain area. Conversely, the ecological footprint indicates the area the bioproduction of which is needed to support one human being/a human society. Trade and transportation make the concept of carrying capacity irrelevant for humans. Just think of Hongkong!

Consumption analysis: Calculation of an ecological footprint is built on analysis of consumption either top-down, by use of international trade statistics, or bottom-up by individuals recording their personal purchases and activities. To calculate a national ecological footprint in Sweden, the consumption of 120 commodities was registered as found in trade statistics. For each commodity produced from area-produced raw material, the global average yield per hectare of arable land, grazing land, forest etc. was noted. Thus, the global average space needed for Swedish consumption was calculated – the result was a fractional footprint for each raw material. On top of this, the built area was recorded (houses, infrastructure for communications, hydropower installations), calculated in global average space (arable land, since cities in general occupy best-quality land), and added as a component of the footprint. Finally an energy budget was made, i.e. the amount of primary energy used from different sources, and an energy footprint calculated based on the amount of global average growing forest needed for absorption of released carbon dioxide. The energy budget was corrected for embodied energy in trade. “Energy forest” differs from “forestry forest” in being a carbon store the harvest and use of which would release the sequestrated carbon dioxide.

For calculation of net embodied energy in trade, the energy intensity during the manufacture of each of the 120 consumption goods was noted. For manufactured products, such as chemicals, machinery, china, etc., only the embodied energy was considered, and only for correction for net import.

Other energy use in the country is shown by the energy budget. This shows national energy production and net import of primary energy from different sources (hydropower, nuclear power, wind power, bioenergy, fossil fuels). The area of wind and hydropower installations are counted as built land. Biofuels are included in arable land and forestry forest. Different kinds of fossil fuels are expressed in oil equivalents, and the area demanded is calculated as the one needed for absorption of carbon dioxide in growing forest (energy forest). The area needed for nuclear power is difficult to estimate, but large areas are lost for the future if serious accidents (e.g. Chernobyl) occur, and the most probable alternative for nuclear power so far is fossil oil. Nuclear power is therefore calculated as oil equivalents, and the area demand is calculated as for oil.

Double counting: For consumption analyses and when calculating ecological footprints, double counting of areas must be avoided. One example is pork production, which does not demand a specific area since the feed for the pigs is already included as grain production on arable land. A solar panel on a roof needs no extra space since it is already included as built land. Honey does not demand space, because it is taken from flowers on arable land or grazing land, which is already counted for other consumption. In certain cases it is however important to separate similar areas with different functions. Forest for forestry must be separated from energy forest for absorption and permanent storage of carbon dioxide. In forests for forestry, the carbon dioxide is released in connection with the harvest, use and turnover of wood products such as pulp and paper, which in the end are combusted. Forest for permanent storage of carbon demands special measures to maintain the grown-up forest or the harvested timber.

Ecological footprint: The ecological footprint for an individual or a group of people is the bioproductive area necessary for production of the goods and services consumed and for absorption of generated waste. Since people consume goods and services from all over the world and have an impact on distant places through released waste, the footprint is an area aggregated from many small bioproductive spaces. Ecological footprints and biocapacities from all over the world are comparable because they are expressed in global average space with global average productivity.

Embodied energy: The energy which is consumed during the manufacture of a product follows it when traded as embodied energy.

Equivalence factors. These factors have been introduced to eliminate the differences in bioproduction (biocapacity) on arable land (2,8), grazing land (0.5), forest (1.1) and fishing grounds (0.2). Yields differ between years and the factors have been changed in later work (see Wackernagel/WWF The Living Planet Report 2002). The factors are based on comparison of the mean yield per hectare on global average productive space which according to definition is 1. Built land is considered to have a potential biocapacity equal to that of arable land (2.8), because cities and roads are generally built on best-quality land in valleys and along estuaries etc. For Sweden this is strong simplification. The biocapacity of built areas is, however, used up.

Global average area. If all biological production on the Earth (biomass yield per hectare) is divided by the bioproductive area, you obtain the global average yield on global average bioproductive space. Other concepts used are global average arable land, global average forest land, etc.

Lifecycle analysis: Analysis of material and energy use during the lifecycle of a product from the cradle to the grave, i.e. from raw material production, through manufacturing and use to destruction including operation and transportation.

National ecological footprint Calculation of a national footprint is based on statistics of the total consumption in the country (with corrections for import and export), see above Ecological footprint and Consumption analysis. Division by the number of inhabitants in the country gives an average ecological footprint per capita. If the pattern of consumption is similar all over the country, the national average footprint can be used to calculate the ecological footprint of a population in a city, a region, a water catchment area, etc.

Net import: Import with export deducted. If the export is bigger than the import, the net import will be negative.

Oil equivalents: Oil equivalents illustrate the amount of oil necessary for generating the same amount of energy as carbon, natural gas, hydropower, nuclear power etc.

Personal ecological footprint: A personal ecological footprint is based on information on personal consumption. In certain respects, this may give more accurate information and be more instructive than a national average footprint, but it is difficult to include public services (education, medical care, defence, etc. which demand built areas as well as commodities and energy.

Planning tool: Ecological footprints and biocapacities are important tools in all community planning. They are physical measurements of the use and availability of natural resources. The effect on the use of such resources of new technology and measures for socio-economic development can be taken into account. For sustainable development, the biocapacity and the ecosystem services on the Earth must be maintained and the use of them be more equally allocated. This demands considerably reduced ecological footprints in Sweden and other western countries. Planning for the absorption and permanent storage of our own pollution (especially of surplus carbon dioxide) is also necessary. Thus a change in land use is necessary. In addition, we must plan for the more rapid decrease and eventual total phase-out of non renewable energy sources. The introduction of alternative technology for both energy carriers and for the sequestration and storage of carbon dioxide must be accelerated. Concern for the serious environmental situation on the Earth and willingness to change must be developed locally and be supported by central decisions. By planning for reduced footprints and the appropriate change of land use and by estimating footprints on a regular basis, plans can be compared to real outcomes. Thus, the sustainability of the development can be evaluated.

Retention: Retention of pollutants such as phosphorus and nitrogen in order to decrease eutrophication in streams, rivers, lakes and the sea. Retention can be accomplished through uptake in planted protective zones along the waters and sedimentation in ponds and through bacterial processes for the return of nitrogen to the air. Nevertheless, measures in farming to reduce the use of plant nutrients are most important, as is the purification of sewage from cities and other nucleated settlements.

Yield factors: A measure of the local biological production in e.g. arable land and forest. In southern Sweden it is higher than in the north of the country but perhaps lower than in arable land and forest in France. The yield depends on climate, soil quality, technology used etc. Mean values for arable land in different areas/countries can be found in Swedish and international statistics. Yield factors are also estimated for grazing land/pasture, forests and fishing areas

NB! Ecological footprints concern bioproductive areas. Only in exceptional circumstances are areas included for production of water, water purification and sewage treatment or for the treatment of drainage water from farming and forestry. Demand for sand and gravel and areas for mines and deposits are not included unless they are part of built areas. The method for calculating ecological footprints and biocapacities can be improved in many ways and be combined with quality analyses of air, water, biodiversity, etc. But it is not the exact results of footprint calculations which are so important. The insights into relationships in the planning process, which the calculations provide, and also the insights into the unfair global allocation of resources per capita are more important.

Sweden in an international perspective

The ecological footprint has rapidly become a much appreciated concept for showing that people and society need large areas for their consumption. Man has gradually occupied more and more of what were once natural ecosystems and reformed them into cultural landscapes and cities to satisfy his own demands and interests. This is acceptable as long as natural resources, including biodiversity, are not impoverished. If we want future generations to be as well off as we are, they will need the same resource base as we have had. Technological development must imply replacing extraction, use and pollution by reuse and recycling in Sweden and abroad. Solar panels, biological hydrogen production, fuel cells and energy technology which are carbon dioxide neutral, offer new opportunities, but the total flow of materials and of the loads on the carbon cycle, the nitrogen cycle and others must be kept in check.

There are many threats in Sweden today and we have become ever more dependent on the rest of the world. Many species and natural biotopes are threatened in the country. Low quality water in the ground, lakes and rivers together with leakage from land in coastal areas create problems in the Baltic Sea. The ozone layer is depleted even in the Northern Hemisphere. Greenhouse gas emissions result in more storms and climate change. The coral reefs are in danger, and the world's water supply is threatened by decreased water table levels and increasingly poorer water quality.

Sweden is sparsely populated and is a large country with much productive space. Thus, from a supply point of view, we seem better off than in many other parts of the world. In Sweden the aim of planning is to support the Swedish population and satisfy its demands. We are very dependent on foreign trade but in case of emergency, we may have to support ourselves. Nevertheless, today's crises have often a background in environmental problems, and these are in general global. Climate problems may hit our part of the world just as much as other countries, and an over-populated world can lead to all sorts of problems of which we are currently unaware. Our consumption and pollution calculated per person are huge. The export of western lifestyle and living standards increases demand, consumption and pollution in other parts of the world. The fact that this is linked to an increased requirement for bioproductive space is seldom considered. This link, and the need for bio-productive space, can be illustrated using the ecological footprint. Calculating biocapacity for a nation/other region illustrates the supply of bio-productive space.

There is reason to examine our consumption and our international trade.

• Do we encroach on bio-productive space in less favoured countries?

• Are our consumption and lifestyles, our import and export such that the consumption of natural resources is reduced both per capita and totally? Does the transfer of our lifestyles to developing countries imply a sustainable future?

We have long been aware that each human being needs a number of hectares of productive land for food consumption, and that a city needs a big “Umland”. But modern trade and market mechanisms conceal the relationships. We take coffee, oranges, juice, cotton and many other goods from far-away farms. Oil import is long distance, and transportation increases not only to provide service to ever more people wanting ever more but also for packaging, distribution and price pressure. The realisation that bio-productive space is also necessary to absorb all kinds of pollution is perhaps growing.

The Swedish EPA has presented a future vision “Sweden 2021 - means for a sustainable future” with two alternatives, one based on large-scale production, the other on small-scale production. It hopes a combination will be possible. The Swedish Riksdag has approved 15 environmental quality objectives put forward by the Government. Efforts to monitor systems and identify indicators are in progress. The EPA is coordinating these efforts and many other central agencies are involved. The overall aim is to hand over a society to the next generation in which the major environmental problems have been solved.

Scope for using ecological footprints and calculations of biocapacity in planning and monitoring have been discussed internationally (Ecological Economics Forum 1999, 2000; Letters to the Editor 2000, Van den Berg 1999). Some researchers are enthusiastic, others are critical. Some have misinterpreted the method, others complain that dynamic development as the result of technological progress is not considered. Economists consider the method to be negative in relation to the gains of increased trade, economic growth and the scope for producing where it is cheapest.

It should be remembered that the proposed method is not intended for futuristic studies of (how to evaluate) dynamic development. The aim is rather to illustrate the current situation with the average technology, which has been introduced internationally. Successively repeated calculations of ecological footprints make them into indicators of natural resource use and progress in resource efficiency. The calculations and results can also be used in planning.

Continued improvement of the method is necessary. Especially the use of statistics and the calculation of (compensation) equivalence factors and local yield coefficients must be discussed.

Moreover, new knowledge on the absorption of carbon dioxide in forests, in soil and in the sea must be considered. The demand for bio-productive space in new technology for sequestration of carbon dioxide and separation of carbon as suggested in fuel production should be investigated (Ishitani et al. 1996; Azar et al. 2000). The introduction and contribution of such technology to reduce footprints will be revealed in future calculations. The use of ecological footprints in society and for local planning must be sectorized and responsibility for reducing them be allocated per sector.

Generally speaking, the views of economists/social scientists and those of natural scientists are opposite. The view of the former is anthropocentric and based on personal wishes and the right to choose what is most attractive from a personal point of view (personal preferences). This is more open to negotiation than the unequivocal laws of nature and measured results on which the views of natural scientists are based.

Ecological footprints and calculations of biocapacity offer a compromise. The method doesn't aim at providing exact information regarding the use of natural resources and sustainable development. The aim is rather to use statistics on land appropriation as far as possible in order to create a physical base on which to determine the value of natural resources and thus to offer a complement to the anthropocentric value system which governs the economic system.

The ecological footprint as an indicator

If repeated regularly every few years and using the same method, the ecological footprint will show the results of resource-efficiency measures employed to save scarce natural resources. It illustrates our consumption expressed in areas used for production of goods and absorption of waste. The areas are spread over the country and in other parts of the world because of trade and import of goods from many countries.

Thus the ecological footprint is a physical measure - an indicator - of the consumption, which complements the Swedish Government's strategy using the 15 environmental quality objectives as well as economic calculations such as GDP, etc.

The ecological footprint was preliminary used in the project ”Community Planning with Environmental Goals in Sweden (SAMS, National Board of Housing, Building and Planning/Swedish EPA 2000). The idea was to investigate the scope for domestic supply of basic food and energy in a municipality. *(Sånnek 1999. Ekologiska fotavtryck– metodansats och tillämpning i samhällsplaneringe*n). *Exam project, Royal Inst Technology, Stockholm.*

The novelty of the ecological footprint is that areas for pollution are included in the areas of consumption, especially areas for absorption of carbon dioxide from fossil fuels. Certain surveys include areas for absorption of released phosphorus and nitrogen, but no areas for general water supply. Areas for household waste, sewage sludge, fly ash, etc. are supposed to be available in built areas. The combination in the ecological footprint of areas for biological production and areas for environmental space (in area units) improves our understanding of the area demand due to lifestyles and consumption with present-day technology.

In-depth analysis shows how much of our arable land is used to produce animal feed and thus in beef and pork production. We can also illustrate how greenhouse production based on fossil fuel consumption demands large areas for absorption and permanent storage of carbon as does all transportation. Thus the planning process can become more realistic. It may seem sufficient and be easier in a region to plan just for areas of importance for local food and energy production. But this does not illustrate the present-day situation including trade within the country and across borders. Moreover, both local energy supply and energy production from alternative sources are a long way off. Meanwhile, the use of fossil fuels continues, and carbon dioxide emissions are increasing rather than decreasing. It is highly relevant in all planning to report how carbon dioxide is to be absorbed, and what productive space is necessary for fossil materials and for alternative sources of energy. On top of this comes the question of how a Swede's average footprint can be reduced by the fairer allocation of global natural resources.

The method of calculating ecological footprints can be improved in many ways and be combined with quality analyses of air, water, biodiversity etc. Nevertheless, the exact result of the footprint is not the most important issue. It is rather the insights acquired along with the calculations about the global situation, a situation that is often neglected in planning, that are the most important.

There are several ways to estimate ecological footprints.

• *A national ecological footprint* is calculated from the national consumption per year divided by the number of inhabitants.- the result *is a mean footprint per inhabitant in the country*.

• *A personal ecological footprint* is calculated from an individual's personal consumption per year. Some of this is consumption through the state or municipality and thus not seen by private individuals.

Based on the mean national footprint or the mean of several personal footprints, the collective footprint of the population of a city/municipality or a country/province can be calculated. The footprint can also be calculated for a natural physical area such as a river basin or an island.

The aim of footprint calculations can also differ and may be

• to show the real bioproductive space needed for a nucleated settlement as a result of consumption, and subsequent waste and discharge/emissions.

• to compare the bioproductive space demanded by people in different regions or nations.

• to compare the demand for bioproductive space as a result of consumption taking into account the availability of such space in the home area/nation.

• to show that different kinds of production, manufacturing and activities demand "shadow areas" of different sizes. This applies to farming which must take into account energy use and discharges during operations as well as during the manufacture of fertilisers, pesticides and machinery. Feed for animals demands large areas and so do wet areas and protective zones for the retention of leaking plant nutrients. The intensive production of vegetables in greenhouses demands even larger shadow areas because of fumes from fossil fuel heating. Fish farming can destroy large areas as the result of constructions and pollutants emissions and fish-feed production also requires large areas.

The estimation of ecological footprints for machinery, e.g. for farming or a computer, is based on lifecycle analyses and energy use during different phases of the cycle, such as raw materials production, manufacturing, repairing and finally reuse and deposition of waste.

Some rules of thumb for calculating ecological footprints or area demand for consumption

• Since ecological footprints in general are calculated per capita, we need to know the population figures and find out about its consumption of goods and subsequent emissions.

• Energy consumption is included in the ecological footprint, and different components used are reported in an energy budget.

• Carbon dioxide emitted from fossil materials is to some extent considered to be absorbed and stored in the sea. The rest can possibly be absorbed in growing forests. But present emissions are too big, the absorption is insufficient and atmospheric accumulation results in greater global warming. Very large areas of growing forests must be designated for sufficient absorption and permanent storage of carbon. Such areas are included in the ecological footprint as an index of energy use. New plots of growing forests for absorption of carbon dioxide must be planted when the first ones mature for as long as fossil materials are used. Tree-stems in such energy forest might be harvested and preserved in pits or otherwise. New technology offers other sources of energy demanding smaller areas.

• The area demand of nuclear power is difficult to estimate. A serious accident damages large bioproductive areas which must be taken out of production for a very long time. The most probable alternative to nuclear power is fossil oil. Nuclear power is therefore recalculated as oil equivalents (the amount of fossil oil needed for an equivalent amount of energy), and the footprint is the area of growing forest that is necessary for absorption of the emitted carbon dioxide.

• The total use of energy is adjusted for energy embodied in net imported goods. Since trade is international, estimated energy intensity is based on the use of world average technology.

• The ecological footprint includes built areas and roads.

• Areas for dams and cables for hydropower are added to the built area.

• Lakes and wetlands are of importance for the retention of plant nutrients. But such areas are in general not considered in footprint calculations.

• The consumption of services is included in the ecological footprint by way of built areas and energy consumption.

• The ecological footprint per capita or for a certain population is the sum of many different areas within the country and in exporting countries.

• International trade and thus use of bioproductive space in many different countries make it necessary to introduce the concepts of world average space, world average arable, world average forest, etc.

NB! So far the ecological footprint considers only production and emissions which can be included in biosphere cycles. There are no such cycles for heavy metals, persistent organic and inorganic pollutants, radioactive materials, etc. The use of these substances has to be phased out for sustainable development and their ecological footprints have not been calculated. Nor has the area demand for supply of drinking water, the demand of gravel or the health of ecosystems been considered.

History of Ecological Footprints

The ecological footprint has its origin in the “carrying capacity” concept of ecology, i.e. what animal population a certain area can support. This concept doesn’t really fit for human beings, who congregate in towns and cities and import what they need for their consumption. The ecological footprint is an inverted carrying capacity and tells what area people in e. g. Berlin, Stockholm, Hong Kong or Mexico City need to support themselves.

Canadian researchers studied the Vancouver area in the early 1990s and found that the consumption of its inhabitants demanded an area 20 times that of the sparsely populated city itself. (Wackernagel and Rees 1996). Regions with big cities make big footprints and consume products from far away arable land, pastureland, forest and fishing areas. On top of this, they need newly planted forest for the absorption and long-term storage of carbon dioxide from fossil fuel combustion or other technological processes.

The Canadian researchers extended their study and calculated ecological footprints per capita in some other countries. The footprints were relatively small in e.g. densely populated Asian countries, larger in Europe and largest in the USA and Canada. Transport and the import of goods results in footprints aggregated from many small bioproductive plots within a country and abroad. Comparison between the footprint and the biocapacity of countries often indicates the net appropriation of biocapacity in other countries. Many countries cannot support their population on a biocapacity, which is equivalent to that of their own country. Thus trade implies net import of bioproductive space from other countries.

The consumption of rich countries has increased considerably since the early 1900s. By then, their mean ecological footprint was around 1 hectare per person. In 1995 it was around 3-4 hectares per person. At the same time, the 5-6 hectares of bioproductive space available per person on the Earth in the early 1900s have decreased to around 1.5 hectares per person because of population growth. To feed the present population and absorb their waste with present western technology and lifestyle, we would need two more Earths!

Moreover, humans are not the only creatures on Earth. We have to share the resources with several million other species. Wild animals are consumers like ourselves and demand their share of green production. Man needs biodiversity and ecosystem services both for renewed production, to stabilize the climate, for fertile soils, precipitation and clean water.

A study of the Baltic Sea drainage basin showed that an area 200 times the size of its major cities was necessary for the production of food and fibres. An area 500-1100 times the area of the cities was needed to absorb carbon dioxide and plant nutrients (nitrogen, phosphorus) from the citizens. (Folke et al. 1997). Thus, the footprints from European cities seemed much bigger than that of Vancouver. This is related both to differences in calculation method and to the different infrastructure of cities. In contrast to the Canadian study, the European one included fishing grounds and space for retention of plant nutrients from human sewage. Furthermore, cities in Europe are much more densely populated than those in Canada.

Further reading: International studies, page 34.

Development of the ecological footprint calculation method

Since the concept of ecological footprint was introduced in the early 1990s (Rees 1992), improvements have been made. In particular, correction factors are used to allow hectares of different kinds of bioproductive space to be aggregated into one footprint. Thus, equivalence factors have been introduced to compensate for the different degrees of productivity of arable land, pastures, forest and productive sea areas. This is also of importance when calculating the biocapacity of a country or region. Moreover the yield per hectare of arable land, forest etc. differs because of the variation in latitude and altitude. Thus, local yield factors have been introduced, and they compensate for differences in precipitation, soil quality, technology used and variations between crops.

The analysis of consumption that is the basis of ecological footprint calculations must have trustworthy sources. National statistics may be used, but for international comparisons international statistics (FAO) may be more appropriate (Wackernagel et al. 1999 a, b). Here information regarding bioproductive space, yields and trade from different countries is scrutinized and set out in similar tables.

For analyses of consumption in sub-national geographical areas (SGA), e.g. cities/municipalities, local studies have been used (Chamber et al. 2000). In order to allow international comparison, the results of local studies should always be coordinated with the mean national footprint.

Consumption analysis, international trade and embodied energy, using Sweden as an example.

Consumption in a country is estimated as national production with import added and export subtracted. The world areas of rice and wheat fields, pastures, forest, etc. are available through statistics as are also the average yields of biomass per hectare, see Table 1. With knowledge about the amount of rice, wheat, meat, wood products, fish, etc. that is consumed in Sweden, you can calculate the areas of world average arable land, pasture, forest and fishing grounds that must be appropriated for Swedish consumption. Corresponding calculations are made for consumption in other countries. The amount of energy used during production of raw materials and during manufacture, if any, are recorded based on average international technology and considered as embodied energy. The energy embodied in total net import is registered in the energy budget and contributes to the size of the energy footprint.

In a Swedish consumption analysis, based on Swedish statistics at large, the consumption of more than 120 products organised into seven groups was analysed, see Table 1 for overview. The global yields are per hectare of global average arable land, forest, etc. The Swedish yields are per hectare of Swedish average arable, forest, etc.

Table 1. Simplified table of footprint components showing groups of raw materials and manufactured products analysed and some examples in each group (1994 data). The entire table is available as an electronic spreadsheet through the Internet (42).

CATEGORIES	Global yield [kg/ha/yr]	Swedish yield [kg/ha/yr]	Energy intensity [Gj/t]	Biological production in Sweden [t / yr]	Import [t / yr]	Export [t / yr]	Apparent consumption, raw materials [t / yr]	Net import, manufactured products [t / yr]	Footprint component of consumption [ha/cap]	Embodied energy in net imports [Pj / yr]
ANIMAL-BASED FOOD PRODUCTS										
.beef (fresh, cooled or frozen)	32	245	80	148 600	15 111	2 294	161 417		0,57 pasture	1
.milk	489	3 752	10	3 356 961	14 440	21 212	3 350 189		0,78 pasture	0
.cheese and fresh cheese	49	375	65	–	24 549	7 353		17 196	0,04 pasture	1
.traded eggs (fresh, dried or prepared)	534	734	65		12 462	2 018		113 444	0,02 pasture	1
.fish	29	–	100	311 753	127 000	59 000	379 753		1,49 sea space	7
ANIMAL-BASED NON-FOOD PRODUCTS										
.wool	16	?	10	530	310	221	619		0,00 pasture	0
.hides	32	245	10	10 980	18 000	23 000	5 980		0,02 pasture	0
.shoes	32	245	20		27 000	3 000		24 000	0,09 pasture	0
PLANT-BASED FOOD										
.wheat and rye	2 440	5 389	10	1 518 300	48 067	226 085	1 340 282		0,06 arable land	–2
.barley and other fodder grains	2 669	3 672	10	2 875 400	20 144	186 149	2 709 395		0,12 arable land	–2
.roots and tubers (mainly potatoes)	15 268	32 098	5	1 045 100	40 613	2 059	1 083 654		0,01 arable land	0
.pulses	834	2 428	10	67 000	7 608	950	73 658		0,01 arable land	0
.sugar (from sugar beets)	5 060	7 251	15	2 349 800	219 636	28 896	2 540 540		0,06 arable land	3
.coffee	528	–	75	0	107 624	10 282	97 342		0,02 arable land	7
.oil seeds	1 312	2 387	10	195 000	105 000	5 000	295 000		0,03 arable land	1
.fodder (oilseed-based)	1 312	2 387	20	–	450 228	7 383		442 845	0,04 arable land	9
NON-FIBRE, NON-FOOD PLANTS										
.rubber products	1 000	–	20	–	132 000	85		131 915	0,01 arable land	3
CHEMICAL PRODUCTS										
.synthetic fertilizers	–	–	100		1 354 000	410 000		944 000		94
METALLIC PRODUCTS										
.metal ores and scrap	–	–	2		1 871 000	16 394 000		–14 523 000		–29
.iron and steel	–	–	30		2 687 000	4 088 000		–1 401 000		–42
.heavy machinery	–	–	100		505 000	806 000		–301 000		–30
.road vehicles	–	–	100		510 000	852 000		–342 000		–34
TIMBER PRODUCTS	in [m^3/ha/yr]	in [m^3/ha/yr]		[m^3/yr]	[m^3/yr]	[m^3/yr]	[m^3/yr]			
.in round wood equivalent [m^3]	1,99	4		54 100 000	12 883 536	42 403 456	24 580 080		1,40 forest	

Energy use in Table 1 is based entirely on international average technology and only used to calculate embodied energy. Total energy use in Sweden is reported in the energy budget, Table 2.

Total Swedish biological production concerns area-based production. Data on import and export are used to calculate Swedish consumption. Data on the net import of manufactured goods are used to calculate the net import of embodied energy.

Swedish consumption divided by the global average yield gives a component footprint for each area produced commodity. Thus, these component footprints are expressed in hectares of world average arable land, world average forest etc.

A complete table with explanations and references is available as an Excel spreadsheet on the Internet: http://www.darwin.biol.lu.se/zoofysiol/Lewan /Footprint.html

Equivalence factors for different kinds of bioproductive space

The consumption analysis above results in many small component footprints using different kinds of bioproductive space, Table 1. Some commodity appropriate arable land, other pastures, forest or fishing grounds. Arable land is more productive than forest, which in turn is more productive than unimproved grazing land, etc. In order to aggregate such different areas into one single ecological footprint, the quality differences must be compensated for by the introduction of equivalence factors. The biocapacity of global average bioproductive space is considered 1.0. In comparison, the yield of biomass on global average arable land is 2.8 (3.16*), on global average forest 1.1 (1.78*), on unimproved grazing land 0.5 (0.39*), on fishing grounds 0.2 (0.06*), see list below.

*more recent values, see Living Planet report 2000: http://www.panda.org/living-planet/lpr00/

Different kinds of land, specific areas: built land and energy forest

Forests absorb carbon dioxide as long as they grow, but when harvested and used for paper or fire-wood the carbon dioxide is released again. In houses, furniture and other constructions, wood may be maintained somewhat longer before it becomes waste and is burned. For more permanent storage of carbon dioxide, the mature forest must be maintained (as wild forest with spontaneous regeneration). Alternatively, the harvested timber must be permanently maintained in some kind of pit holes etc. Thus in footprint calculations, a special kind of forest, “energy forest” or “forest for CO_2 absorption” is introduced. This part of the forest cannot be used for forestry. There is no energy forest designated in today’s land use planning. But in footprint calculations such forest is introduced as a measure of areas demanded for absorption of carbon dioxide and permanent storage of carbon from fossil fuels. The introduction of alternative technology in energy production or for storage of carbon dioxide will drastically reduce the ecological footprints.

It is difficult to translate the use of nuclear power into bioproductive space. The large demand for space appears in the case of accidents, when large areas must be taken out of production for a very long time. Oil at present seems the most probable alternative to nuclear power. Nuclear power is therefore recalculated to oil equivalents (the amount of oil which gives the same amount of energy). The footprint is the area of growing forest that must be appropriated for absorption of the carbon dioxide released. Forest for absorption of carbon dioxide and storage of carbon is given the same equivalence factor as forest for forestry, *1.1*, but must be treated differently.

Building and traffic demand ever more space. Internationally the very best land is in general used for these purposes. Cities have long since been built in fertile plains along rivers, and this is also where roads and railways are located. For Sweden with much rock and woodland this is a simplification, especially considering roads, railways and cables for hydropower, which add to built areas. Built areas are given the same equivalence factor as arable land, *2.8.*

Global average space	1 (basic value)
Arable	2.8 (3.16*)
Forest for forestry	1.1 (1.78*)
Grazing, unimproved	0.5 (0.39*)
Fishing grounds	0.2 (0.06*) (big sea areas passed for catch)
Built land	2.8 (3.16*) (lost biocapacity)
Forest for CO2 absorption	1.1 (1.78*)

*Values in parentheses from the Living Planet Report 2000
http://www.panda.org/living-planet/lpr00/

Energy budget

On top of the component footprint for the consumption of various kinds of goods and built areas, the use of different kinds of energy in a country must be analysed. Consequent appropriation of space must be added to the ecological footprint.

Sweden uses a variety of fossil energy, nuclear power, which is calculated as fossil oil, hydropower, which is calculated as built areas (dams, cables, etc.) and biofuels. The latter are included in forest and arable land and already counted in the consumption analysis. On top of this direct use of energy, the embodied energy is added, counted as fossil oil.

For each kind of energy, a specific energy value is calculated showing the area demand per gigajoule of energy supplied. Multiplication by the mean use of energy per year and person gives the energy footprint expressed in hectares of energy forest, see Table 2. An area of forest can absorb CO_2 during its period of growth, until the forest is mature. After that, a new area must be appropriated, as long as fossil fuels are used. This is not feasible in the long run. Alternative technology is necessary to absorb carbon dioxide and for energy service.

Table 2. Energy budget for footprint components of commercial energy use (1994 data).

Specific energy footprint (global average)	[Gj/ha/yr]	Swedish consumption	[Gj/yr/cap]	Swedish energy footprint component [ha/cap]	
coal	55	coal	11	0,2064	fossil energy land for coal
liquid fossil fuel	71	liquid fossil fuel	81	1,1469	fossil energy land for liquid fuel
fossil gas	93	natural gas	3	0,0349	fossil energy land for gas
nuclear energy (thermal) assumed to be liquid fossil energy	71	nuclear energy (thermal)	89	1,2501	fossil energy land for nuclear energy
embodied energy assumed to be liquid fossil energy		energy embodied in net imported goods	-26	–0,3656	fossil energy land for embodied energy in net imp. goods
hydroelectric energy	1000	hydroelectricity	24	0,0242	built-up area for hydropower
wood-fibre based energy	98	{bioenergy (fuel-wood) (not counted, since included in forest area)}	32		

Calculation of a national ecological footprint using Sweden as an example

The component footprints in the consumption analysis, Table 1, and in the energy budget, Table 2, are expressed in hectares of global average arable land, forest, pasture land etc. Multiplication by the appropriate equivalence factor gives the footprints in hectares of global average space. Thus the component footprints can be aggregated into one footprint in global average space, Table 3.

Table 3

Ecological footprint (demand per capita)				
Category of space		*total* *physical area* [ha/cap]	*equiv.* *factor* [-]	***equivalent*** ***total*** **[ha/cap]**
	calculation	*a*	*b*	*c = a*b*
fossil energy		2,3	1,1	**2,6**
arable land		0,4	2,8	**1,2**
pasture		1,6	0,5	**0,9**
forest		1,4	1,1	**1,6**
built-up area		0,2	2,8	**0,7**
sea		1,5	0,2	**0,3**
TOTAL used				**7,2**

The mean ecological footprint per capita in Sweden is 7 hectares of world average space. Use of global average space as a unit area for the Swedish footprint is well motivated considering trade in Sweden, which is very international. Moreover, a unit area facilitates international comparisons.

As the standard of living and consumption are very similar all over Sweden, the mean footprint can be used in sub-national geographical areas, e.g. an administrative county, a municipality or a river basin. Multiplication by the number of inhabitants shows the demand of the population. Nevertheless, ecological footprints in all parts of Sweden vary a great deal due to income , between men and women, etc. This is best shown by listing personal consumption and calculating personal footprints.

Calculators for personal footprints can be found on the Internet.

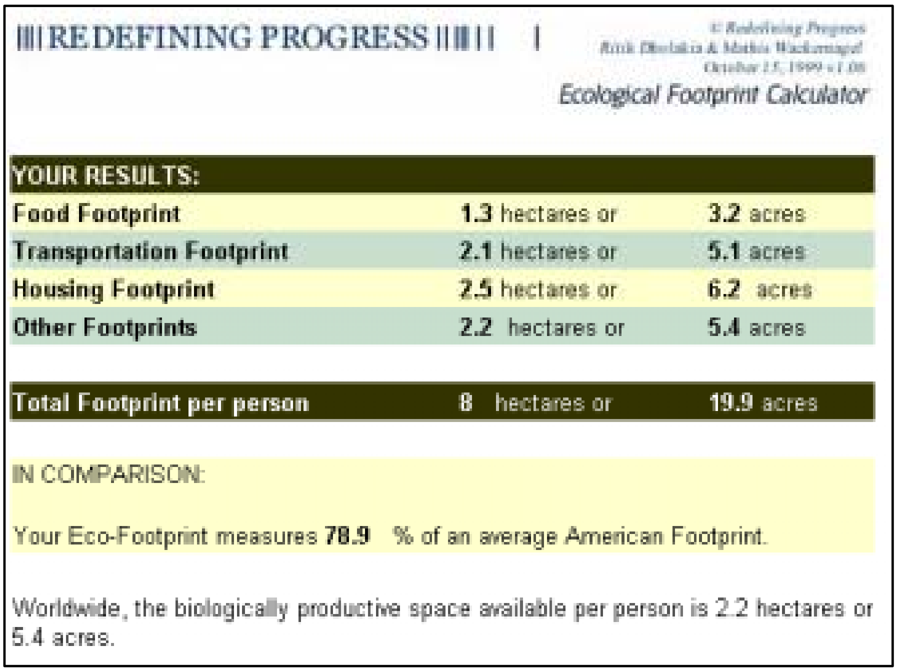
- www.rprogress.org

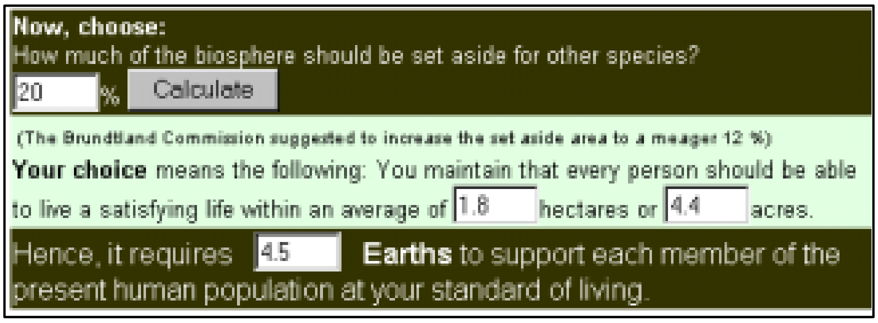
- www.bestfootforward.com

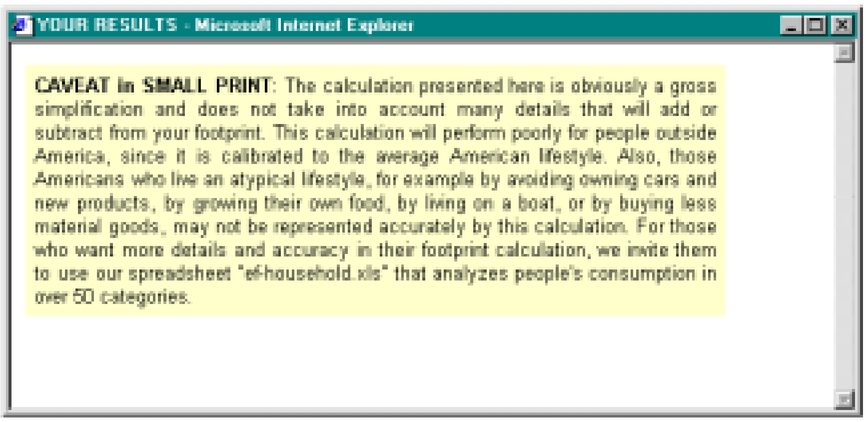
General information:

- www.utexas.edu/courses/resource

- come.to/ecofoot (har svensk version)







Some calculators are very simple and based on how much and what you eat, personal travelling, housing and some other components. The results are adjusted in order to comply with the national footprint, which includes all non-personal consumption in a nation.

Could Sweden support its own population?

The question can be divided into three:

• Can Sweden on its own offer the same goods on the market as today's international market?

• Is the bioproductive space in Sweden sufficient for survival of its own population?

• Does Sweden as a result of its trade offer others the same biocapacity as the one imported?

There is a surplus of goods on the Swedish market, which we could not produce ourselves both because of climate and skills. In a critical situation the production could certainly be diversified and thus more small scale, but we could never produce all that is available today. The solution would be a more limited market based on the bioproductive space we have.

In order to compare our present demand on the market all around the world - the ecological footprint - to what is possible within Sweden, we have to express different kinds of national bioproductive space in world average space. This is also of importance for discussions of our net import and the consequent net import of biocapacity.

Table 4

BIO-CAPACITY WITHIN SWEDEN (per capita)				
Category of space	*national area* [ha/cap] *a*	*equivalence factor* [-] *b*	*yield factor* [-] *c*	***yield adjusted world av. land* [ha/cap]** *d = a x b x c*
CO_2 absorption land	0,00	1,1	2,1	**0,0**
arable land used for crops	0,27	2,8	1,6	**1,2**
arable land used as pasture	0,12	0,5	7,7	**0,5**
pasture	0,06	0,5	7,7	**0,3**
forest	2,76	1,1	2,1	**6,5**
built area	0,15	2,8	1,6	**0,7**
sea	0,58*	0,2	1,0	**0,1**
TOTAL existing	*3,95*			*9,3*
TOTAL available	(minus 12 per cent for biodiversity)			**8,2**

*Swedish area/cap of the international fishing quota.

Bio-productive areas in Sweden. Biocapacity.

Sweden has a land area of 45 million hectares, 28 million of which are deemed bioproductive. Information on the area of arable land, forest, grazing land, fishing grounds, built areas, etc., is available (Swedish Land-use Statistics 1998).

In order to add up different categories of bio-productive space they are multiplied by their equivalence factors as when calculating the footprint. But Swedish arable land and Swedish forest render higher yields than global average arable or forest because of soil quality, precipitation, topography and technology. Conversely, the yields are lower than average in some parts of the world. In Sweden there are also big differences between yields in the north and the south. Thus national/local yield factors are introduced to claculate the mean biocapacity of the country or a sub-national geographical area, Table 4.

The yield factors are based on the mean yield of some arable crops, pasture, forest, etc. in the country/region in comparison to corresponding yields on global average areas, see Table 1 and http://www.darwin.biol.lu.se/zoofysiol/Lewan/Footprint.html

Swedish bio-productive space is 4 hectares per person. This corresponds to 9 hectares of global average space per person according to Table 4. In Sweden many national parks and nature reserves are designated in mountains and along coasts with low bio-productivity. Nevertheless we have to share the more bioproductive space with other species. Wildlife flora and fauna demand their share of the bio-productive areas in Sweden as in other countries. Thus 12 per cent of the biocapacity is generally deducted for biodiversity and the remaining 88 per cent is left for human use (Brundtland, WCED 1987). Thus in Sweden 12 per cent of the 9 hectares of world average space is deducted for biodiversity and the remaining 8 hectare is left for human use.

The biocapacity in a country is a measure of the scope for bioproduction rather than a certain number of hectares in the country. Deducting 12 per cent for biodiversity does not necessarily mean that 12 per cent of the area has to be taken out of production for human use. Instead the yield can be decreased by less intensive management. The transfer of ploughed and fertilised grazing land into non-ploughed and non-fertilised implies lower yield and relinquishes biocapacity in favour of biodiversity. Converting arable land into protective zones and wetlands and the introduction of nature reserves and protected natural areas are other means to transfer biocapacity to wildlife flora and fauna.

The biocapacity which is appropriated for human use in a country or sub-national geographical area must be adjusted to a level which allows the ecosystems services and the water quality norms, etc., to be maintained.

The general deduction of 12 per cent of the biocapacity for biodiversity is preliminary. The availability of 8 hectares of global average bioproductive space per person and an ecological footprint of 7 hectares indicates that Sweden easily could supply the demands of its population within its territory and even have a surplus of biocapacity equivalent to 1 hectare. Sustainability is, however, dependent on how the bioproductive space is used!

Is the use of bio-productive space in Sweden sustainable?

The sustainability of the development in a country must be assessed from social as well as ecological perspectives. Economics can help us economise on scarce resources but cannot bring about sustainable development without a physical resource base. Ecological footprints and measurements of biocapacities can be used to analyse the effects of economic transactions and to compare different transactions from a sustainability point of view.

Comparison between the demand for specific productive space for Swedish consumption according to the ecological footprint and the supply shown by biocapacity measurements reveals bad correlation, Fig 1 B and C. This concerns especially the use of forest and the shortage of space for absorption of carbon dioxide/storage of carbon.

The three pie diagrams in Fig.1 show the proportions between bioproductive space per person in Sweden (A, Swedish hectares), the much bigger biocapacity (B, equivalent in hectares of world average bioproductive space), and the ecological footprint (C in hectares of world average bioproductive space)

In each diagram, the proportion between agricultural land (arable + grazing), build area, forest for forestry and fishing areas is shown. In the ecological footprint (C) the need for forest for absorption of carbon dioxide is also shown. The agricultural part of the Swedish biocapacity (B) corresponds roughly to the demand for such biocapacity for food supply according to the footprint (C). Conversely, the forest part of the biocapacity (B) is much bigger than the demand for the consumption of fibres and wood products (C). The ecological footprint also shows that a big area of forest for absorption and storage of carbon dioxide is needed (C), but no such area is designated in the land use (A) and biocapacity (B) pies.

A Sweden, bioproductive space, 4 ha/person

Area productive space	**3,8**
Agricultural land	0,4
Built area	0.1
Fishing ground	0,6
Forest for forestry	2,7
Forest for carbon dioxide/energy	0

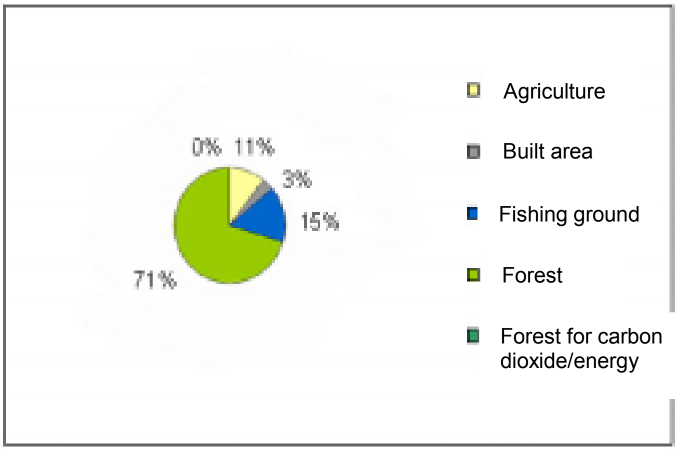
B Sweden, biocapacity, 9 ha global average space/person

Biocapacity ha	**8,6**
Agriculture	1,8
Built area	0,6
Fishing ground	0,1
Forest	6,1
Forest for carbon dioxide/energy	0

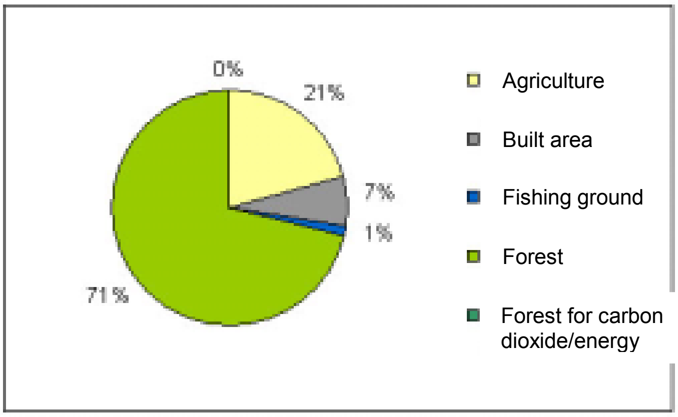
C Sweden, ecological footprint, 7 ha average space/person. This footprint is also valid for Skåne and other sub-national geographical areas.

Ecological footprint (ha)	**7,3**
Agriculture	2,1
Built area	0,7
Fishing grounds	0,3
Forest for forestry	1,6
Forest for carbon dioxide/energy	2,6

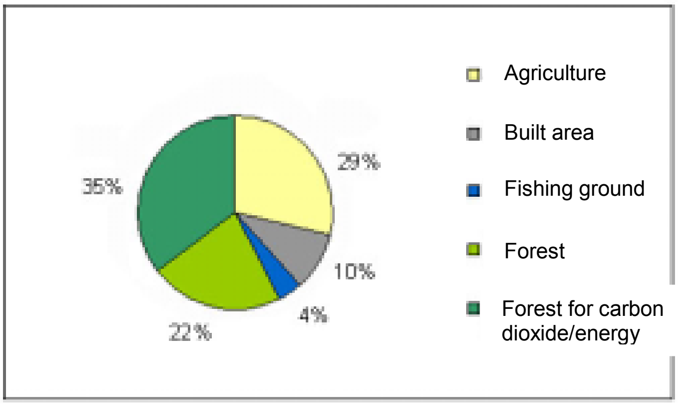
NB! The pies show the area per person in Sweden but at the same time the situation for the whole of Sweden, since multiplication by the number of inhabitants (9 million) does not alter the proportions between the three diagrams.



A



B



C

Figure 1. The size of the circles illustrate (A) the area of productive space in Sweden 4 ha per person. (B) the same area shown as biocapacity, 9 ha of global average productive space per person. The Swedish areas were multiplied by equivalence factors and local yield factors before summing up. (C) the ecological footprint, 7 ha per person shows the amount of bioproductive space per person which the Swedish consumption demands in the country and all around the world.
Please note that:
•12 per cent of the areas in B and C has not been deducted for biodiversity. The availability of different kinds of productive space (A, B) is illustrated by the sectors in the circles. The demand of different kinds of space is shown by the sectors in (C).
•forest for carbon dioxide in C includes emissions from nuclear power counted as oil equivalents (55 per cent).
Note that the consumption (C):
•only needs a small part of the forest available (B)
•demands a big area of forest for carbon dioxide (C), which doesn't exist (A, B).

The big surplus area of forest in Sweden is used for forestry and export, which is the base of the country's economy. Fossil fuels are imported, but forest areas for absorption and storage of the released carbon dioxide have not been designated, and alternative technologies have not been introduced. (Ishitani et al.1996, Azar et al. 2000).

The consumption analysis, which is the basis of the ecological footprint in Sweden, shows that Sweden as a result of its net import appropriates biocapacity equivalent to 1 hectare per person of world average bioproductive space in other countries. Is that really possible? Wasn't Sweden's biocapacity 1 hectare larger than its ecological footprint?

Remember that the biocapacity analysis was based on the existing bioproductive space in the country. This doesn't tell us if the areas are used for national consumption or for export. The ecological footprint shows the productive space needed for Swedish consumption – it doesn't tell us where in the world these areas are situated. Further analysis shows that Sweden is a net importer of biocapacity.

Land use in a country as sparsely populated as Sweden is hardly sustainable, as long as there is a net import of biocapacity from other countries and as long as Sweden does not absorb and store the pollution released.

Areas for absorption of leaching plant nutrients from arable land and from cities and other nucleated settlements are not included in the calculation. Nor are protective zones for groundwater or areas with sand and gravel of importance for the purification of water included.

Two more questions must be raised:

• Is the demand for productive space according to the ecological footprint per person in Sweden fair considering the international situation? (cf. Table 5)

• Do Swedish lifestyle and consumption patterns offer good examples to be shown internationally for reduced appropriation of natural resources in general?

International studies

The methodology for calculating ecological footprints and biocapacity described here for Sweden has also been introduced in previously mentioned international studies. As described, the calculations started in Canada. (Wackernagel and Rees 1996) and were later extended to include some 50 nations using statistics from 1993, Table 5, (Wackernagel et al. 1999 b).

The study was repeated using data from 1995 from even more nations (Living Planet Report 2000). One more study has now been published (Living Planet Report 2002). Thus, the present development of consumption and available bioproductive space can be followed in an international perspective. Nevertheless each nation, its inhabitants and politicians have to govern the development through local initiative, central decisions and international cooperation.

The ecological footprints in Table 5 illustrate the uneven allocation of consumption per person on the globe. Table 5 also shows the uneven allocation of biocapacity per person on the globe. Moreover, it has been shown that the demand for productive space (2.8) for the mean per capita consumption in the world is more than the world offers (2.1).

Not only do we have to reduce the use of natural resources in the western world, but we have to do it with such technology and such lifestyles that help social development and ecological rehabilitation in the rest of the world. The study reported in Table 5 comprises 4.7 billion people in 52 countries out of 6 billion people on the Earth.

This 80 per cent of the global population use 95 per cent of the production. They have together a biocapacity of 87 million km^2 global average space but use 117 million km^2, which is a clear over-use of the available global resources.

The international situation is alarming

The results in the international study are alarming. The available biocapacity is 2 hectares per person (12 per cent deducted for biodiversity) and the consumption demands close to 3 hectares per person (average footprint for the global population) Table 5. Many countries are short of biocapacity in relation to their consumption. At the very bottom regarding available biocapacity per person are the poorest countries such as Egypt and Bangladesh and densely populated cities such as Hong Kong and Singapore.

The poorest countries also have very small footprints whereas those of Canada and the USA are as much as 8 and 10 hectares per person respectively.

Ecological footprints and biocapacities are inexact measures

In the international study, the ecological footprint of Sweden is 6 hectares and the biocapacity 7 hectares of global average bio-productive space. These values are lower than those reported in the above Swedish study. The sources for the statistics used were partly different and they were not always from the same year.

The different results stress that it is most important to only compare results from within one series of study, and that fully compatible sources of statistics from one and the same period of time must be used. Ecological footprints and biocapacities can never be exact. It is better to give an interval, but even so it must be remembered that they are underestimates, since many land requirements, e.g. for water and many pollutants are not included. Nevertheless, the order between nations within one study illustrates the relationship between the level of consumption in different parts of the world, and shows in what direction development must move to attain sustainability.

Table 5. Population (1997), ecological footprints, and available biocapacity (data from 1993). Remainder or deficit of biocapacity in world average hectare (Wackernagel et al.1999 b).

	population	footprint	Available bio capacity	ecol. deficit (if negative)
	(in 1997)	in [ha/cap]	in [ha/cap]	in [ha/cap]
Argentina	35 405 000	3,9	4,6	0,7
Australia	18 550 000	9,0	14,0	5,0
Austria	8 053 000	4,1	3,1	-1,0
Bangladesh	125 898 000	0,5	0,3	-0,2
Belgium	10 174 000	5,0	1,3	-3,7
Brazil	167 046 000	3,1	6,7	3,6
Canada	30 101 000	7,7	9,6	1,9
Chile	14 691 000	2,5	3,2	0,7
China	1 247 315 000	1,2	0,8	-0,4
Colombia	36 200 000	2,0	4,1	2,1
Costa Rica	3 575 000	2,5	2,5	0,0
Czech Rep	10 311 000	4,5	4,0	-0,5
Denmark	5 194 000	5,9	5,2	-0,7
Egypt	65 445 000	1,2	0,2	-1,0
Ethiopia	58 414 000	0,8	0,5	-0,3

Finland	5 149 000	6,0	8,6	2,6
France	58 433 000	4,1	4,2	0,1
Germany	81 845 000	5,3	1,9	-3,4
Greece	10 512 000	4,1	1,5	-2,6
Hong Kong	5 913 000	6,1	0,0	-6,1
Hungary	10 037 000	3,1	2,1	-1,0
Iceland	274 000	7,4	21,7	14,3
India	970 230 000	0,8	0,5	-0,3
Indonesia	203 631 000	1,4	2,6	1,2
Ireland	3 577 000	5,9	6,5	0,6
Israel	5 854 000	3,4	0,3	-3,1
Italy	57 247 000	4,2	1,3	-2,9
Japan	125 672 000	4,3	0,9	-3,4
Jordan	5 849 000	1,9	0,1	-1,8
Korea, Rep	45 864 000	3,4	0,5	-2,9
Malaysia	21 018 000	3,3	3,7	0,4
Mexico	97 245 000	2,6	1,4	-1,2
Netherlands	15 697 000	5,3	1,7	-3,6
New Zealand	3 654 000	7,6	20,4	12,8
Nigeria	118 369 000	1,5	0,6	-0,9
Norway	4 375 000	6,2	6,3	0,1
Pakistan	148 686 000	0,8	0,5	-0,3
Peru	24 691 000	1,6	7,7	6,1
Philippines	70 375 000	1,5	0,9	-0,6
Poland, Rep	38 521 000	4,1	2,0	-2,1
Portugal	9 814 000	3,8	2,9	-0,9
Russian Federation	146 381 000	6,0	3,7	-2,3
Singapore	2 899 000	7,2	0,1	-7,1

South Africa	43 325 000	3,2	1,3	-1,9
Spain	39 729 000	3,8	2,2	-1,6
Sweden	8 862 000	5,9	7,0	1,1
Switzerland	7 332 000	5,0	1,8	-3,2
Thailand	60 046 000	2,8	1,2	-1,6
Turkey	64 293 000	2,1	1,3	-0,8
United Kingdom	58 587 000	5,2	1,7	-3,5
United States	268 189 000	10,3	6,7	-3,6
Venezuela	22 777 000	3,8	2,7	-1,1
WORLD	5 892 480 000	2,8	2,1	-0,7

Future scenarios of various kinds could be made based on the results of footprints and biocapacity calculations. This is avoided however because of the uncertainties linked to future studies. What is important is the present situation and to be able to illustrate effects of measures that have been more or less implemented. These may concern improved technology, environmental measures, population growth, land use, etc. along with the dynamic development that is in progress.

Is it possible to use more biocapacity than is available?

Many oppose results showing numbers of inhabitants, ecological footprints and biocapacities. It is difficult to accept that the human population uses more biocapacity/natural resources than there are available. Isn't that impossible? No, that is quite possible – nature has no fence and no stop sign. Fumes from a car or an aircraft meet no resistance, and nor do discharges from drains and sewage systems. But we can observe the impoverishment of biodiversity, and we can register air pollution and eutrophied waters, and such phenomena originate in over-use of natural resources.

In Sweden it is not sufficient to observe national and regional conditions. There is much dependence on international conditions and the uncertainty concerning population growth, long-distance air pollution, climate change and water supply in far-away countries. Trade and economy do not solve the problem of over-use of natural resources. Strong links between the market mechanisms and their physical supply in the form of productive space are necessary, not only for production but also for the absorption of waste and pollution.

Insight at different levels of society

The facts reported above regarding the international situation and the conditions in Sweden and in Swedish regions are based on mean values. They give a general background to the necessity of natural resource efficiency at all levels of society. Changes and improvements have to start locally, but need central support.

Calculation of a personal ecological footprint shows the consumer more directly what productive areas are necessary for the supply of what he buys, what he does and how he lives, **see** page 31 and Enclosure 1.

Those working with footprint calculators often encourage the use of role-plays and interesting best practice examples. Substantial change is necessary for sustainability, and ways of life with reduced footprints must be attractive! Not only must people change their consumption, industrial development must also change. Production must be for new lifestyles rather than more commodities.

Use of the mean national ecological footprint in regional studies

The mean national footprint is based on more reliable data than a personal footprint, for which each household makes its own estimate according to instructions. The problem with personal footprints is “the black box” of national and municipal consumption, which must be added, and which is not very transparent for the general public. Everybody benefits from schools, hospitals, public transport, defence, national and local governments, etc., and such activities make a large footprint, very much outside the control of the general public. The national footprint includes all activities in a country, and common utilities are divided among the inhabitants, even if they are not perceived as personal consumption. On the other hand, the national footprint misses information about household consumption from the garden, from woods and private fishing.

Income, housing, owning a car and other information from statistics show that the Swedish standard of living is quite similar in different parts of the country. Consequently, the national mean ecological footprint can also be used in regional and local studies. Multiplication by the number of inhabitants in a country, city or municipality, a river basin or other sub-national geographical area gives the footprint for the population. This can be compared to the biocapacity of the area. The comparison illustrates the area demand for the consumption of the population in relation to the near surroundings’ capacity for area production. It also illustrates the scope for export to other regions.

The aim of comparing the ecological footprint of the population in a sub-national geographical area and the biocapacity of this same area is mainly to illustrate what areas are needed for consumption.

In reality the areas appropriated are spread all over the world. Municipalities and regions are not planned for subsistence economy.

Regional and municipal footprints have been calculated in the southernmost province of Sweden, Skåne. The ecological footprints for the population in the whole province, for the 33 municipalities and for one river basin, have been compared to the biocapacity in each area, Fig. 2 A, B, C, Fig 3, Wackernagel et al. 1999 a.

As distinct from Sweden at large, the province of Skåne has a deficit of biocapacity per person, cf. B and C below. The situation in the Skåne municipalities ranges from a deficit in the densely populated municipalities in the south and west through an equal balance (Perstorp, Kristianstad) to a surplus of biocapacity in the north and east (Osby, Tomelilla). In the river basin (Kävlinge river) there is balance between the demand of biocapacity for consumption (the ecological footprint of the population) and the available biocapacity. This result depends on the size of the area, its content of various productive areas, the intensity of management, as well as the density of population.

A Skåne, productive area, 1,5 ha/person

Total area of productive space 1,47ha//person	
Agricultural area	0,51
Built area	0,05
Fishing grounds	0,58
Forest for forestry	0,33
Forest for carbon dioxide	0

B Skåne, biocapacity 4,6 ha global average productive space/person

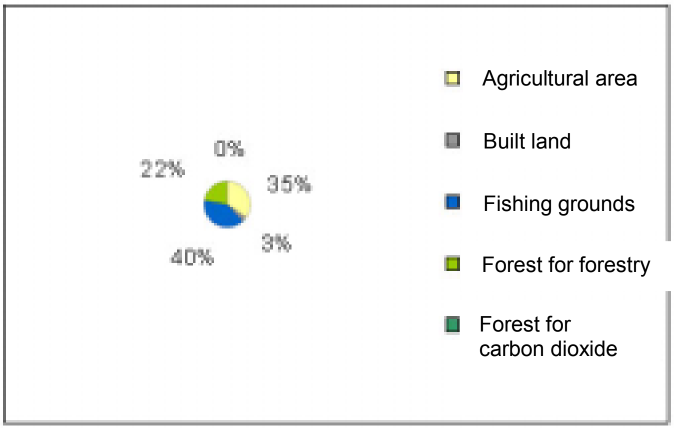
Total biocapacity 4,64 ha/person	
Agricultural area	2,76
Built area	0,27
Fishing grounds	0,12
Forest for forestry	1,49
Forest for carbon dioxide	0

C Ecological footprint in Sweden, 7 ha global average productive space/person. This footprint is also valid in Skåne and other sub-national geographical areas.

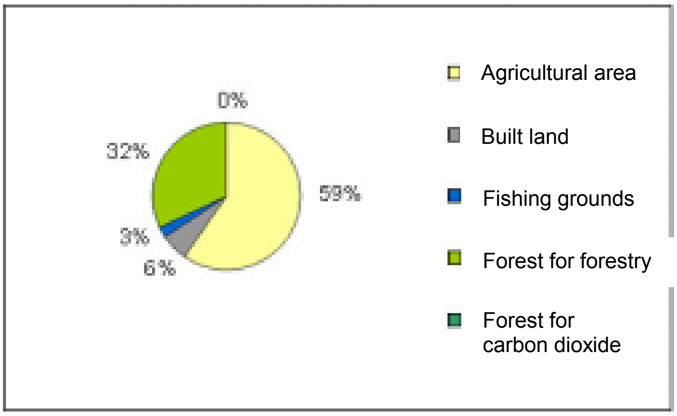
Total ecological footprint 7,3 ha/person	
Agricultural area	2,1
Built land	0,7
Fishing grounds	0,3
Forest for forestry	1,6
Forest for carbon dioxide	2,6

Figure 2. The size of the circles illustrates:
(A) the area of productive space, 1.5 ha per person in Skåne
(B) the same area counted as biocapacity 5 ha global average productive space per person, i.e. after multiplication by equivalence factors for different kinds of space and by local yield factors for Skåne.
(C) the ecological footprint, 7 ha global average productive space/person. This area illustrates the sum of small plots all over the world appropriated for consumption in Sweden. This footprint is also valid in Skåne.
Please note:
•that 12 per cent of the area in A and B has not been deducted for biodiversity
•that forest for CO_2 absorption in C includes emissions from nuclear power calculated as fossil oil (55 per cent).
•that the biocapacity per person in Skåne (B) is insufficient in relation to the area demanded for consumption (C).
The availability of different kinds of productive space (A, B) and the demand for different kinds of space for consumption (C) is illustrated by the sectors in each circle.
Note that the consumption in Skåne (C):
•demands more productive space than is available
•regarding the need of forest for forestry corresponds to what is available (B)
•needs a large area of forest for CO_2 absorption (C) that has not been designated (B).

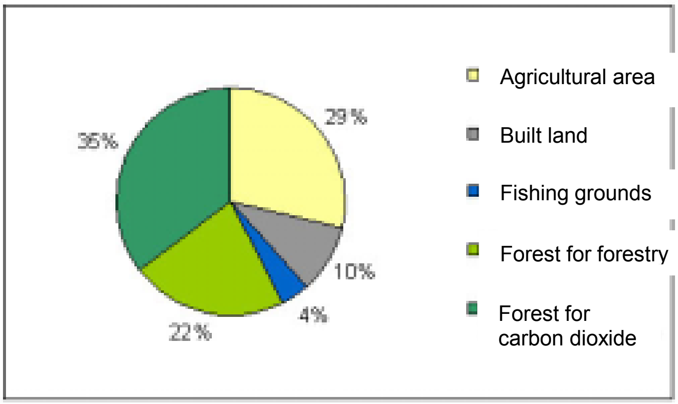
Please note, that the circles show area per person but in parallel show the situation in the whole of Skåne. Multiplication by the number of inhabitants (1 million) would not change the proportions between the circles.



A



B



C

A balance between available biocapacity in a country or sub-national geographical area and the inhabitants' demand of productive space for consumption does not tell us very much about the 'sustainability' in the area. Sustainability is more about how the available biocapacity is used, c.f. Figures. 1 and 2.

Questions raised regarding the use of natural resources in Sweden are also valid in its regions:

• Is 12 per cent of the biocapacity designated for biodiversity?

• Do municipalities take care of their own emissions?

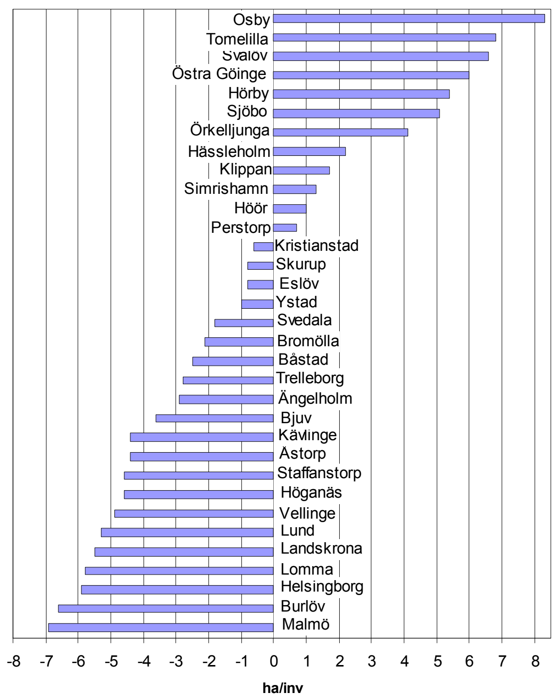
• Is the consumption such that the Swedish net import of biocapacity from other countries is decreasing?

• Is the level of consumption and thus the ecological footprint such that it can be accepted from an international point of view?

• Is the intensity of land use such that the qualities of the groundwater and of the water in rivers, lakes and at sea are safe for human use and for maintenance of the eco-system services.

Fig. 3. The municipalities in the province of Skåne ranked according to surplus or deficit of biocapacity per person. The biocapacity in world average hectare per person in each municipality was reduced by the mean ecological footprint of Sweden, 7 ha per person (Lewan, Ekberg 1999). The figure illustrates that possibilities on the market in the southwestern municipalities rather than householding with biocapacity governs urbanisation in the province. Little attention is paid to appropriation of high quality soil and yield per hectare in the area.

Fig. 3. Surplus or deficit of biocapacity in relation to the mean national footprint.



Ecological footprints and biocapacity analyses in local planning

A municipality wishes to compare its own policy and progress to those of others. As illustrated in the studies of Skåne and its municipalities, the mean ecological footprint per person in Sweden can be used to demonstrate the situation in a municipality.

There is need for basic studies and central, national supervision in order for a municipality to start its own analyses of footprints and biocapacities. These must illustrate local distinctive features and not only national means. Guidelines must be available for the conversion of national trade statistics into local data and for the evaluation of land use. In order to fit into national and local budget systems, national consumption data must be organised in relevant commodity groups. Local adjustments are necessary for making ecological footprints and biocapacity accounts reliable and useful in local planning. Moreover, guidelines must be available for the readjustment of local data to international analyses in order to show the situation of Sweden and its municipalities in an international perspective.

Recommended guidelines would comprise, for example:

• Information about joint consumption in Sweden, i.e. such consumption on which a private person has little impact. This concerns governmental issues, consumption in the Riksdag and central agencies, defence, national transport, education and medical care. Such consumption must be allocated and calculated per person in the country.

• Similarly there must be information about joint consumption as a result of municipal services, such as local administration, refuse collection, public transport, schools, care of the elderly, etc. This kind of consumption must be allocated among the inhabitants and calculated per person. It may differ between the municipalities due to the use of different technologies and different strategies.

• There must also be information to estimate private consumption in companies and households.

• For recognition in policy and administration, the above-mentioned national consumption analyses based on trade statistics should be reorganised into more sector-based consumption.

A table may be designed as follows to be complemented with more details and questionnaires for adaptation to the distinctive features in each municipality. The final national footprint as calculated from the sector-based table must be in agreement with the national footprint as calculated from trade statistics in the international calculation (Wackernagel et al. 1999 b; Living Planet Report 2000).

The mean national footprint in Sweden, sector based demand, for adaptation to municipal conditions.

Consumption Goods and services	**Amount** per year	**Components footprint** ha/cap					
		Arable	Grazing	Forestry	CO_2 forest	Built area	Fishing grounds
•Food							
-vegetarian	?	x			x		
-animal	?		x		x		x
-water	?				x	x	
•Housing							
-flat	?			x	x	x	
-garden/park	?					x	
-heating	?				x		
•Transport							
-car	?				x	x	
-train					x	x	
-air	?				x	x	
•Commodities							
-paper	?			x	x		
-clothes and shoes	?	(x)*	(x)*	x	x		
-others	?			x	x		
•Services							
-care of children, elderly	?				x	x	
-schools	?				x	x	
-entertainments	?				x	x	
-waste management	?				x	x	
-others	?				x	x	

*double counting for meat, wool and hides must be avoided **Mean national footprint 7 ha per capita**

Several questions can be asked to assess the local situation and concerning the introduction of correcting factors to convert the national footprint into local footprints. But corrections for municipal distinctive features should as far as possible be based on official statistics.

•To what extent does the municipality differ from the national average?

• How much fossil fuel is used privately and for common purposes in the municipality?

• How do industrial plants influence consumption in the municipality?

• Have Agenda 21 activities had some impact on consumption?

• What directives should the municipality set in future planning for sustainable development in an international perspective?

Analyses in river basins

In contrast to municipalities, river basins have natural borders, and they have now been pinpointed in the new EU water directives. A river basin-based environmental administration is being suggested. Water is an important natural resource and a very scarce resource in many countries. In most places, decreased intensity in the management of productive space is of importance for improved water quality. This should be considered in planning and also in future analyses of biocapacities and in ecological footprints. Since 1992, Sweden has compiled river basin-based statistics regarding land use and density of population. A first attempt to use a river basin to compare the ecological footprint of its population and the biocapacity of the area was made for the Kävlinge river in Skåne. The biocapacity of arable land was reduced by the introduction of ponds, wet areas and protective zones for the retention of plant nutrients (Wackernagel et al. 1999 a).

Only in connection to local analyses of biocapacity can attention be paid to necessary restrictions in the use of productive space. Such restriction reduces the total biocapacity of an area, even in cases where certain coordination of area use for biodiversity, for retention of plant nutrients and for absorption and permanent storage of carbon dioxide is possible. National calculations of biocapacity may be overestimates and not in agreement with sustainable development.

Ecological footprints in the SAMS-project

Modified methods for calculation of ecological footprints were used in the aforementioned SAMS project, Community Planning with Environmental Objectives in Sweden, coordinated by the National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency in cooperation with several Swedish municipalities and regional authorities.

The title of the project, which finished in September 2000, is Community Planning with Environmental Objectives in Sweden *(SAMS).* The project received economic support from EU LIFE and the Swedish International Development Cooperation Agency (Sida). Sweco/FFNS cooperated as consultants. Case studies were made in the municipalities of Burlöv, Helsingborg, Trollhättan, Stockholm, Borlänge, Falun och Storuman. Studies were made by the Office of Regional Planning and Urban Transportation in Stockholm with the help of the County Administrative Boards of Skåne, Västra Götaland, Stockholms, Dalarna and Västerbotten counties. Studies were also made in cooperation with the South African municipalities of Port Elizabeth and Kimberley.

Only some of the participating units showed an interest in ecological footprints.

The method used in the municipality of Trollhättan

A first attempt to calculate an ecological footprint for use in planning was made in the municipality of Trollhättan as a university master's dissertation (Sånnek 1999). After further modification, the method was also used to calculate ecological footprints in the municipalities of Borlänge and Falun (Sånnek et al. 2000). Footprint methodology was also used to illustrate the area demand for traffic in a small southern municipality, Burlöv. (Haraldsson 2000). The municipality of Burlöv is compared to that of Storuman in the north, and an interpretation of results shows that the northern municipality exports ecological services (biocapacity) to the south.

The attempt to calculate the ecological footprint in Trollhättan was based on the information in the book "Our Ecological Footprint – Reducing Human Impact on the Earth" (Wackernagel & Rees 1996). This book is more a description of problems than a description of a method of calculation of footprints and biocapacity. The method development, which has occurred later and is described above, is not included (Wackernagel et al. 1999 a, b). For the applications in Trollhättan and later on in Falun and Borlänge, special modifications for Sweden were introduced. The calculations made are mainly an estimation of what Swedish areas would be needed for the local supply of food and energy. It must be possible to produce food raw material in the municipality. The energy supply is based on a mixture of alternative methods such as biofuel, solar, wind, etc.

In the municipality of Trollhättan, the results show an area demand of 3.6 hectares per person or 187 000 hectares for the total population for food and renewable energy. There are 42 780 hectares in the municipality, and if subsistence economy is of importance, Trollhättan will have a deficit in biocapacity.

Similar calculations were made for the municipalities of Falun and Borlänge, but on top of the demands for food and energy, space for phosphorus recycling was added. The main focus in all three studies was on local supply of energy, and the proportion between alternative sources was varied. (*Vägvinnaren* och *Stigfinnaren/EPA)*. The results show that it is possible to reach 100 per cent subsistence in Falun, but Borlänge and Trollhättan would have deficits of biocapacity.

Local environmental load from transport infrastructure in Burlöv and Storuman.

The municipality of Burlöv is squeezed between the much bigger cities of Malmö and Lund and the coastal municipality of Lomma and is home to a branch of the Swedish University of Agricultural Sciences. Burlöv contains some of the best quality of arable land in Sweden, but 50 per cent of the municipality has been built on. The density of population is 770 inhabitants/km^2, the main railway and three highways pass through and one more is under construction. Over the next decade, road traffic, especially goods vehicles, is expected to double.

The through-traffic sets a large footprint. In the study of Burlöv, this footprint is added to that of the inhabitants of the municipality. This is not quite correct, since the traffic is not only caused by the inhabitants. The large traffic footprint is the responsibility of the whole nation and not only of those areas where the impact is heaviest. The burden of traffic in Burlöv is a service to neighbouring municipalities.

In contrast to Burlöv, the municipality of Storuman in the north is sparsely populated and exports both forest and electricity to the rest of Sweden. This can be considered a flow of biocapacity to the south equivalent to 5 hectares per capita in Storuman (Haraldsson 2000). Generally, the sparsely populated municipalities supply the densely populated ones with biocapacity. This is not economically valued. But there is general financial support to sparsely populated municipalities.

A first attempt to link sustainability studies to area needs

The studies in Trollhättan, Falun and Borlänge are first attempts to link sustainability studies to area needs for consumption. But much is missing.

• Today's consumption and energy needs are much more demanding than suggested in the three studies.

• Biodiversity was mentioned as an environmental objective but areas for this were not designated.

• Until we have introduced alternative energy we will use fossil fuels and consequently release carbon dioxide. This must be absorbed in growing forest for permanent storage, or by means of other technology. Independent areas for absorption will have to be recruited until the use of fossils is discontinued.

• The supply of good quality drinking water was not considered.

• The method employed does not provide scope for international comparisons, which must be based on common international methodology.

The investigator is uncertain: Shall subsistence among municipalities be an objective?

The question is well motivated. Conditions and possibilities are very different in different parts of Sweden. For sustainability it is more important to consider where to plan for building and traffic and the size of areas to be allowed. Valuable arable land in the south is an asset for the whole country. But paying attention to that is difficult in self-governed municipalities/administrative counties that are striving for growth, improved communications and wealthy tax payers.

You may also ask if traditional borders and geographical areas are relevant in our quest for sustainability.

What is sustainable for the municipality of Burlöv and other western Skåne in the south? Present municipalities originated from former parishes and the old church organisation. Time has passed and knowledge has grown, for example, regarding ecosystems and their services. The importance of water and water quality has become obvious. Problems are transboundary, and river basins/water districts of relevant size would be better administrative units than today's municipalities and regions/administrative counties. The EU has taken an important initiative and step forward through its new water directive and the planned introduction of river basin-based water districts for environmental policy.

The meeting between society and nature is more obvious in a river basin than in the present policy units. A river basin of relevant size is the smallest functional unit both for ecosystem services and for settlement and consumption. Water is necessary for all life and its quality must not be jeopardised as a consequence of socio-economic development. Technological solutions should be evaluated in a long-term perspective considering the continuous flow of new knowledge and unpredictability.

Ecological footprints and biocapacity in the municipalities of the SAMS project. Methodology for an international perspective.

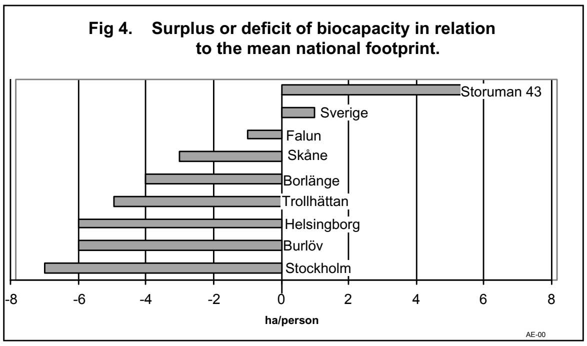
The biocapacity per person in each of the municipalities participating in the SAMS project was calculated and compared to the mean national ecological footprint of Sweden using the Wackernagel et al.(1999 a) method. Data for the whole of Sweden and for the southernmost province of Skåne were included for comparison, see Enclosure 2. The results are aggregated in Table 6 and illustrated in Figure 4. They show as previously that Sweden in total has a small remainder of biocapacity compared to the biocapacity demanded for the national consumption, which is based on international production and trade. Skåne and all SAMS municipalities except Storuman are short of biocapacity per person. The results can be directly compared to the figures in Table 5 showing the international situation. (For a more correct interpretation of results from regional studies, in-depth studies on differences in standard of living and level of income are needed.)

Table 6. Average ecological footprint in Sweden, Biocapacity in the SAMS municipalities, Skåne and Sweden. Global average space per person.

Area	**Ecol footprint/person ha global average space**	**Biocapacity/person ha global average space***
Sweden	7	8
Skåne	7	4
Storuman	7	50
Falun	7	6
Borlänge	7	3
Stockholm	7	0
Trollhättan	7	2
Helsingborg	7	1
Burlöv	7	1

*12 per cent deducted for biodiversity

Figure 4. *The Sweden, Skåne and the municipalities of the SAMS project ranked according to surplus or deficit of biocapacity per person. The biocapacity in world average hectare per person in each area was reduced by the mean ecological footprint of Sweden, 7 ha per person. Please, note that the bar for Storuman goes beyond the figure.*



As shown in Figs. 1 and 2, a remainder of biocapacity in relation to the ecological footprint is no guarantee for sustainable development. This depends on how the biocapacity is used.

The surplus of biocapacity in Sweden offers instead scope for change for a sustainable future, i.e. to use productive areas not only for production but also for absorption of waste. In parallel, it is important to hasten the introduction of alternative technology and the planned adjustment to systems of renewable resources and recycling.

If every municipality/other sub-national geographical area, sector of society and private individual becomes aware of the situation and is made responsible for reducing/taking care of their emissions –the "polluter pay principle"- the transition towards sustainable development becomes easier. In case absorption of waste cannot take place in the home area, agreements can be made with neighbouring areas/regions with more biocapacity. A market for absorption areas and strict responsibility for taking care of e.g. carbon dioxide emissions from fossil fuels and leaching plant nutrients would make the situation more concrete and be a good complement to emissions rights. The shortage of productive areas would become obvious and the economic values of such areas would increase.

Won't emissions rights trading and market mechanisms solve the problems?

Personally I don't think so. The market is governed by people's preferences, and these are based more on personal well-being and advertisements than on knowledge about the need for ecologically sustainable development. It is difficult to get political acceptance of the fact that ecological sustainability is a basic premise of socio-economic sustainability. Very simple knowledge-based systems to illustrate the relationship between consumption and effects on the environment are needed. Facts about biocapacity and ecological footprints provide such a system. Water flow and water quality within a river basin provide another system. Placing responsibility close to the consumer by letting him/her pay for the absorption of his emissions and pollution is another feasible idea. Compulsory identification of areas for absorption is a way to pinpoint the shortage of productive space on Earth and offers scope for encouraging development in the right direction.

Is the ecological footprint accepted as a tool for planning and monitoring?

How far the ecological footprint and calculations of biocapacity can be used in planning and monitoring activities is being discussed internationally. (Ecological Economics Forum 1999, 2000; Letters to the Editor 2000, Van den Berg 1999). Some researchers are enthusiastic, others are critical. Some have misunderstood the methodology, others complain that the dynamic change embedded in technical development has not been considered. Economists think that the method is negative in relation to the trade development and the scope for producing where it is cheapest to do so.

It is important to remember that the suggested method isn't supposed to be an analysis of dynamic development. The aim is rather to illustrate the situation as it is with the average technology introduced up to now. Successively repeated calculations of ecological footprints mean it can function as an indicator of development. The calculations and the results can also be used for advice in planning.

Continued improvement of the method is of importance. In particular, the statistics used and the introduced equivalence factors and local yield factors should be discussed. Adjustments for continued absorption of carbon dioxide in the oceans have been introduced, and the scope for absorption and storage of carbon in soil must be considered. The demand for productive areas for new technologies for absorption of carbon dioxide and the separation of carbon when fuels are being produced as suggested by Ishitani et al (1996) and Azar et al (2000) must be evaluated. The introduction of these new technologies and their contribution to reduced footprints must be monitored. The use of ecological footprints in the socio-economic system demands calculation per sector and also the responsibility of sectors to reduce their footprints.

As already outlined in this report, there is opposition between the views on the socio-economic system and the development among economists/social scientists and natural scientists. Social scientists have a very anthropocentric view based on human desires and the right of individuals to set preferences. These are open for debate and can be modified in contrast to the natural laws and results of measurements, which are a basic premise of the views of natural scientists. The ecological footprint and calculations of biocapacity offer a compromise. The method doesn't aim at exact information about the situation regarding use of natural resources and sustainable development. The aim is rather to use available statistics in order to as far as possible offer a physical basis for the valuation of natural resources. This physical basis is a complement to the anthropocentric value system which governs economic thoughts.

Literature

Azar, CC., Lindgren, K., Andersson, B. A. 2000. **Hydrogen or methanol in the transportation sector.** 69 pp. Dept Physical Resource Theory, Chalmer's Univ. Technology, Gothenburg.

Chambers, N., Simmons, C., Wackernagel, M. 2000. **Sharing Nature's Interest, Earthscan,** London and Sterling, VA

Ecological Economics Forum, 1999. Ecological Economics 29/1, 1-60.

Ecological Economics Forum: The Ecological Footprint, 2000. Ecological Economics 32/3, 341-394

Ecological Economics. 2000. Letters to the Editor, Ecological Economics 31/3, 317-321

Folke, C., Jansson, Å., Larsson, J. and Costanza, R.1997. **Ecosystem Appropriation by Cities.** *Ambi*o, Vol. 26 No. 3 pp. 167-172

Haraldsson, H. 2000. **Burlövs kommun – översikt av infrastruktur och dess miljöbelastning,** SAMS Boverket, Naturvårdsverket.

Ishitani, H., Johansson, T.B. 1996. **Energy Supply Mitigation Options.** In Climate Change. IPCC Report, Working group 2. Chapter 19, 588-647.

Jansson, Å., Folke, C., Rockström, J., Gordon, L., 1999 **Linking fresh water flows and ecosystem services appropriated by people: the case of the Baltic Sea drainage basin. Ecosystems 2, 351-366.**

Lewan, L. Ekberg, A. 1999. **Konsumtionens behov av produktiva arealer och tillgångar. Regionala studier i Skåne och de skånska kommunerna.** Geografiska Notiser 4, 220-231.

Rees, W. 1992. **Ecological footprints and appropriated carrying capacity: what urban economics leaves out.** Environment and Urbanization 4/2, 121-130.

SCB. 1995. **Statistik för avrinningsområden 1992,** Na11 SM9501, Statistiska Centralbyrån och Naturvårdsverket, Stockholm.

SCB. 1998. **Statistik för avrinningsområden 1995,** Na11 SM9501, Statistiska Centralbyrån och Naturvårdsverket, Stockholm

SCB. 1998. **Markanvändningen i Sverige, 1998 års länsindelning**.

Simmons, C., Lewis, K., Moore, J. 2 000 **Two feet – two approaches: a component-based model of ecological footprinting** Ecological Economics 32/3 375-380

Sverige 2021 – vägen till ett hållbart samhälle. Naturvårdsverket Rapport 4858

Sånnek, R. 1999. **Ekologiska fotavtryck – metod-ansats och tillämpning i samhällsplaneringen**. Examens-arbetet, KTH, ISBN 91-7147-549-4.

Sånnek, R. 2000´. **Ekologiska fotavtryck – kompletterande studier i Falun och Borlänge,** SAMS, Boverket, Naturvårdsverket.

Van den Berg, J.C.J.M., Verbruggen, H. 1999. **Spatial sustainability, trade and indicators: an evaluation of the 'ecological footprint'.** Ecol.Economics 29/1 61-72.

Wackernagel, M. 1997. **The Ecological Footprint of Santiago de Chile.** Local Environment.

Wackernagel, M., Rees, W. 1996. **Our Ecological Footprint – Reducing Human Impact on the Earth .** New Soc Publ, Gabriola Island, BC, ISBN 0-86571-312-X.

Wackernagel, M., Lewan, L., Borgström-Hansson, C. 1999 a. **Evaluating the Use of Natural Capital with the Ecological Footprint. Applications in Sweden and Subregions.** Ambio 28/7 604-612.

Wackernagel, M., Onisto, L., Callejas Linares, A., López Falfán, I.S., Méndez García, J., Suárez Guerrero, A.I. and Suárez Guerrero, M.G. 1999 b. **National Natural Capital Accounting with *Ecological Footprint Concept. Ecol. Economics*** *29/3 375-390*

WCED. 1987. **Our Common Future.** P. 147, p 166, Oxford University Press, Oxford.

WWF Living Planet Report 2000, 2002. Ed. Jonathan Loh in cooperation with UNEP, WCMC, Redefining Progress (CA), The Centre for Sustainability Studies (Mexico). The Living Planet Report, http://www.panda.org/publications

List of Reports in the SAMS project

Reports in Swedish

1. Bioenergi och kretslopp stad/land - en samsyn. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-625-3, Naturvårdsverket 91-620-5099-0

2. Eggimann, B. 2000. Fysisk planering med strategisk miljöbedömning (SMB) för hållbarhet. En teoretisk diskussion och förslag till SMB-process med Stockholms stad som modell.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-583-4, Naturvårdsverket 530-620-5041-9.

3. Exempelsamling temastudie GIS. 2000.
Boverket och Naturvårdsverket (SAMS). Se SAMS hemsida på Internet: www.environ.se/sams.

4. Falkheden, L och Malbert, B. 2000. Fysiska strukturer för hållbar utveckling i medelstora och små städer och tätorter. En kunskapssammanställning.
Boverket och Naturvårdsverket (SAMS), Chalmers tekniska högskola, Arkitektursektionen, Tema Byggd miljö och Hållbar utveckling. Se SAMS hemsida på Internet: www.environ.se/sams

5. För en bärkraftig samhällsutveckling – miljömål och indikatorer i fysisk planering. 1997.
Boverket och Naturvårdsverket (SAMS).
ISBN 91-7147-368-8.

6. GIS och miljömål i fysisk planering. 2000
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-619-9, Naturvårdsverket 91-620-5093-1

7. Hållbara strukturer. 1999. Regionplane- och trafikkontoret. Promemoria 15:99. ISSN 1402-134X, RTN 9710-0189. Medfinansierad av Boverket och Naturvårdsverket (SAMS).

8. Idédiskussion kring SMB i planering. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-626-1, Naturvårdsverket 91-620-5100-8.

9. Indikatorer i fysisk planering, En kunskapsöversikt. 1999.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-493-5, Naturvårdsverket 91-620-4930-5.

10. Lerman, P. 2000. Fysisk planering arena för samspel: miljömål, miljökvalitetsnormer, indikatorer konsekvensanalyser. Se SAMS hemsida på Internet: www.environ.se/sams

11. Lewan, L. Ekologiska fotavtryck och bio-kapacitet – verktyg för planering och uppföljning av hållbar utveckling i ett internationellt perspektiv. Rapport till SAMS-projektet, Boverket och Naturvårdsverket (SAMS), Miljövetenskapligt centrum, Lunds universitet, april 2000.
ISBN Boverket 91-7147-647-4, Naturvårdsverket 91-620-5123-7

12. Miljöinriktad fysisk planering. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-621-0, Naturvårdsverket 91-620-5095-8.

13. Miljömål och indikatorer i fysisk planering – Port Elizabeth och Kimberley i Sydafrika, Delrapport 1. 1998.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-484-6, Naturvårdsverket 91-620-4922-4.

14. Nordiskt projekt om SMB för planer och program. Bilaga till rapporten SMB och översiktlig fysisk planering. 2000. Boverket och Naturvårdsverket (SAMS). Se SAMS hemsida på Internet: www.environ.se/sams.

15. Planera med miljömål! En idékatalog. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-618-0, Naturvårdverket 91-620-5092-3.

16. Planera med miljömål! En vägvisare. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-617-2, Naturvårdsverket 91-620-5091-5.

17. Planera med miljömål! Fallstudie Burlöv, livsmiljöprojektet . 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147- 627-X, Naturvårdsverket 91-620-5101-6.

18. Planera med miljömål! Fallstudie Falun/Borlänge, skogs- och odlingslandskapet. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-632-6, Naturvårdsverket 91-620-5106-7.

19. Planera med miljömål! Fallstudie Helsingborg, tillgänglighet till miljöanpassade transportsystem. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-628-8, Naturvårdsverket 91-620-5102-4.

20. Planera med miljömål! Fallstudie Storuman, scenarier för hållbar utveckling. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-633-4, Naturvårdsverket 91-620-5107-5.

21. Planera med miljömål! Fallstudie Stockholm, biologisk mångfald i fysisk planering. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-630-X, Naturvårdsverket 91-620-5104-0.

22. Planera med miljömål! - Fallstudie Stockholm, miljöbedömningar i fysisk planering. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-631-8, Naturvårdsverket 91-620-5105-9.

23. Planera med miljömål! Fallstudie Stockholms-regionen, miljöbedömning av Regionplan 2000. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-634-2, Naturvårdsverket 91-620-5108-3.

24. Planera med miljömål! Fallstudie Trollhättan,
god bebyggd miljö. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-629-6, Naturvårdsverket 91-620-5103-2.

25. Planera med miljömål! Kort sagt. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket nr 7147-644-X, Naturvårdsverket 91-620-8007-5.

26. Samhällsplanering med miljömål i Sverige, Lägesredovisning 1. 1998.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-489-7, Naturvårdsverket 91-620-4927-5.

27. Samhällsplanering med miljömål i Sverige, Lägesredovisning 2. 1998.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-491-9, Naturvårdsverket 91-620-4928-3.

28. Samhällsplanering med miljömål i Sverige, Lägesredovisning 3.
Boverket och Naturvårdsverket (SAMS). 1999.
ISBN Boverket 91-7147-555-9, Naturvårdsverket 91-620-4928-3.

29. Samhällsplanering med miljömål i Sverige, Interrimrapport och Lägesredovisning 4. 2000.
Boverket och Naturvårdsverket.
ISBN Boverket 9147-7147-581-8, Naturvårdsverket 91-620-5032-X.

30. Samhällsplanering med miljömål i Sverige, slutredovisning. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-646-6, Naturvårdsverket 91-620-5122-9.

31. Sams om vatten - samhällsplanering för en långsiktigt hållbar vattenförsörjning. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-623-7, Naturvårdsverket 91-620-5097-4.

32. SAMS - SMB, vad finns inom olika sektorer ? En genomgång av olika rapporter mm. Bilaga till rapporten SMB och översiktlig fysisk planering. 2000.
Boverket och Naturvårdsverket (SAMS). Se SAMS hemsida på Internet: www.environ.se/sams.

33. Siffror, lägen och upplevelser – idéskisser för användning av GIS i samhällsplanering. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-624-5, Naturvårdsverket 91-620-5098-2.

34. SMB och översiktlig fysisk planering. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-622-9, Naturvårdsverket 91-620-5096-6.

35. Sånnek, R. 1999. Ekologiska fotavtryck -metodansats och tillämpning i samhällsplane-ringen.
KTH: Institutionen för infrastruktur och samhällsplanering. KTH examensarbete nr 98 – 79.
ISBN 91-7147-549-4.

36. Tema miljömål: Planera för hållbar utveckling. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket ISBN 91-7147-643-1, Naturvårdsverket 91-620-8006-7.

37. Översiktplanering för hållbar utveckling - exempel från 5 kommuner. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-620-2, Naturvårdsverket 91-620-5094-X.

38. Översiktsplanering med IT och GIS för hållbar utveckling – rapport från tre seminariedagar våren 1999. 2000.
Boverket och Naturvårdsverket (SAMS).
ISBN Boverket 91-7147-577-X, Naturvårdsverket 91-620-5025-7.

Reports in English

1. Environmental Indicators in Community Planning – A presentation of the Literature. 1999.
The Board of Regional Planning and Urban Transportation, The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-558-3, SEPA 91-620-5011-7.

2. Environmental Objectives and Indicators in Port Elizabeth and Kimberley, South Africa, progress report 1. 1998.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-463-3, SEPA 91-620-4923-2.

3. Environmental Objectives and Indicators in Spatial Planning and Strategic Environmental Assessments (SEA), Progress report no 1. 1998.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-490-0, SEPA 91-620-8011-7.

4. Environmental Objectives and Indicators in Spatial Planning and Strategic Environmental Assessments (SEA). Interrim report and Progress report no 4. 2000.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-582-6, SEPA 91-620-5033-8.

5. Environmental Objectives and Indicators in Spatial Planning and SEA, Kimberley and Port Elisabeth, South Africa. Final report. 1999.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-565-6, SEPA 91-620-5014-1.

6. Community Planning with Environmental Objectives! A guide. 2000.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-650-4, SEPA 91-620-5124-5.

7. Community Planning with Environmental Objectives! In brief. 2000. Planning for sustainable development. 2000.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
NBHBP No 7147-651-2, ISBN SEPA 91-620-8009-1.

8. Theme environmental objectives: Planning for sustainable development. 2000.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-649-0, SEPA 91-620-8008-3.

9. The Use of Indicators in Spatial Planning – A Situation Report. 1999.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-559-1, SEPA 91-620-5010-9.

10. Towards Sustainable Development – Environmental Objectives and Indicators in Spatial Planning. 1998.
The National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency (SAMS).
ISBN NBHBP 91-7147-464-1, ISBN SEPA 91-620-4905-4.

Enclosure 1

Assess your Household's Ecological Footprint

by Mathis Wackernagel, Ritik Dholakia, Diana Deumling, and Dick Richardson, Redefining Progress, v 2.0, March 2000

First, (and optional) calculate how many minutes of life energy it takes to earn one dollar. (Enter your income and hours worked)

2 000 dollars earned per month (after taxes) | 40,00 hours of work per week
600 work related dollars spent per month | 12,00 unpaid hours per week for work preparation (commuting etc.)

It takes** 10 **minutes of life energy to earn one dollar!

Fulfillment: Did I get fulfillment from this expenditure of life energy?
Alignment: Was this expenditure of life energy in alignment with my stated life purpose?
After FI: How much might I spend if I didn't have to work for a living?
+ : increase for more fulfillment;
- : decrease for more fulfillment;
0 : O.K. as is

Second, choose whether you want to work with metric or US measurements. S **: put "m" for metric, "s" for US standard**

Third, register your monthly consumption in column D (or your yearly consumption in column E). Optional: put the dollar amounts into column F.

Number of people in the household: 1

(land and sea space in square meters)

CATEGORIES	Units	AMOUNT per month	eqv. amount per year	Dollars spent (mth)	I) FOSSIL ENERGY	II) ARABLE LAND	III) PASTURE	IV) FOREST	V) BUILT-UP LAND	VI) SEA	monthly hours of life energy	Fulfillment	Alignment	After FI
													mark +, 0 or -	
1.-FOOD														
Enter percentage of food purchased that is wasted rather than eaten in your household.				26%	(26 percent is the national average)									
How much of the food that you buy is locally grown, unprocessed and in-season?				b	a. Most food we buy is packaged, out of season and from far away.									
					b. About a quarter									
					c. About half									
				100%	d. About three quarters									
					e. Most all the food we get is locally grown, unprocessed, and in-season.									
.Veggies, potatoes & fruit	[pounds]	0,0	0	$0,00	0	0					0,00			
.Bread	[pounds]	0,0	0	$0,00	0	0					0,00			
.Rice, cereals, noodles, etc.	[pounds]	0,0	0	$0,00	0	0					0,00			
.Beans	[pounds]	0,0	0	$0,00	0	0					0,00			
.Milk & yogurt	[quarts]	0,0	0	$0,00	0		0				0,00			
.Ice cream, sour cream	[quarts]	0,0	0	$0,00	0		0							
.Cheese, butter	[pounds]	0,0	0	$0,00	0		0				0,00			
.Eggs [assumed to be 50 g each]	[number]	0,0	0	$0,00	0	0					0,00			
.Meat														
..Pork	[pounds]	0,0	0	$0,00	0	0					0,00			
..Chicken, turkey	[pounds]	0,0	0	$0,00	0	0					0,00			
..Beef (grain fed)	[pounds]	0,0	0	$0,00	0	0	0				0,00			
..Beef (pasture fed)	[pounds]	0,0	0	$0,00	0		0				0,00			
.Fish	[pounds]	0,0	0	$0,00	0					0	0,00			
.Juice & wine	[quarts]	0,0	0	$0,00	0	0					0,00			
.Sugar	[pounds]	0,0	0	$0,00	0	0					0,00			
.Vegetable oil & fat														
..solid	[pounds]	0,0	0	$0,00	0	0					0,00			
..liquid	[quarts]	0,0	0	$0,00	0	0					0,00			
.Tea & coffee	[pounds]	0,0	0	$0,00	0	0					0,00			
.Garden [area used for food]	[sqr ft]	0,0	0			0								
.Eating out [complete meals]	[number]	0,0	0	$0,00	0	0	0				0,00			
SUB-TOTAL-1				**$0,00**	**0**	**0**	**0**	**0**	**0**	**0**	**0,00**			
2.-HOUSING														
.House [living area]														
..brick house	[sqr ft]	0	0	$0,00	0						0,00			
..wooden house (US standard)	[sqr ft]	0	0	$0,00				0			0,00			
.Yard [or total lot size incl. building]	[sqr ft]	0	0	$0,00					0		0,00			
. Hotels, Motels	[$]	0	0	$0,00	0			0			0,00			
.Electricity (also check composition--see nc	[kWh]	0	0	$0,00							0,00			
enter as fraction. ex. 25% = 0.25														
..thermally produced (fossil and nuclear)		73%			0									
..lower course hydro		23%							0					
..high altitude hydro		1%					0							
..PV solar (on exisiting roof areas)		1%												
..PV solar (on newly built-up area)		1%							0					
..wind		1%							0					
.Fossil gas (natural gas)														
..city gas	[CCF]	0,0	0	$0,00	0						0,00			
..bottled liquid gas	[pounds]	0,0	0	$0,00	0						0,00			
.Liquid fossil fuel (oil)														
..in volume	[gallons]	0,0	0	$0,00	0						0,00			
..in weight	[pounds]	0,0	0	$0,00	0						0,00			
.Coal	[pounds]		0	$0,00	0									
.Water (not included since it depends on lo	[gallons]	0	0	$0,00				0			0,00			
.Straw	[pounds]	0,0	0	$0,00		0					0,00			
.Firewood	[pounds]	0,0	0	$0,00				0			0,00			
.Constr. wood & furniture	[pounds]	0,0	0	$0,00	0			0			0,00			
SUB-TOTAL-2				**$0,00**	**0**	**0**	**0**	**0**	**0**	**0**	**0,00**			

Footprint Calculation Matrix for Households

.....CONTINUED page #2 of 3
(land and sea space in square meters)

CATEGORIES	Units	AMOUNT per month	eqv. amount per year	Dollars spent (mth)	I) FOSSIL ENERGY	II) ARABLE LAND	III) PASTURE	IV) FOREST	V) BUILT-UP LAND	VI) SEA	monthly hours of life energy	Fulfillment	Alignment mark +, 0 or -	After FI
3.- TRANSPORTATION														
.Bus/train	[pers*miles]	0,0	0	$0,00	0				0		0,00			
.Taxi / other´s car	[miles]	0,0	0	$0,00	0				0		0,00			
.Gasoline (if you have a car)	[gallons]	0,0	0	$0,00	0				0		0,00			
.Parts for repair	[pounds]	0,0	0	$0,00	0						0,00			
.Airplane	pers.*hours	0,0	0	$0,00	0						0,00			
SUB-TOTAL-3				**$0,00**	**0**	**0**	**0**	**0**	**0**	**0**	**0,00**			
4.-GOODS														
.Clothes (if bought used, count them at 1/3 of their true weight)														
..cotton	[pounds]	0,0	0	$0,00	0	0			0		0,00			
..wool	[pounds]	0,0	0	$0,00	0		0		0		0,00			
..fossil based (synthetic)	[pounds]	0,0	0	$0,00	0				0		0,00			
Durable paper products (books) and hygen	[pounds]	0,0	0	$0,00	0			0	0		0,00			
.Tools, metal parts	[pounds]	0,0	0	$0,00	0				0		0,00			
.Leather	[pounds]	0,0	0	$0,00	0		0		0		0,00			
.Plastic products and photos	[pounds]	0,0	0	$0,00	0				0		0,00			
.Porcelain, glass	[pounds]	0,0	0	$0,00	0				0		0,00			
.Medicine	[pounds]	0,0	0	$0,00	0				0		0,00			
.Hygiene products, cleaning stuff	[pounds]	0,0	0	$0,00	0				0		0,00			
.Cigarettes	[pounds]	0,0	0	$0,00	0	0			0		0,00			
SUB-TOTAL-4				**$0,00**	**0**	**0**	**0**	**0**	**0**	**0**	**0,00**			
5.-SERVICES (rough estimates)														
.Laundry service (external)	[pounds]	0,0	0	$0,00	0				0		0,00			
.Postal services														
..international	[pounds]	0,0	0	$0,00	0				0		0,00			
..domestic	[pounds]	0,0	0	$0,00	0				0		0,00			
.Household insurances	[$]	0,0	0	$0,00	0			0	0		0,00			
.Telephone, electronics, photo equipment	[$]	0,0	0	$0,00	0				0		0,00			
.Medical services and medical insurance	[$]	0,0	0	$0,00	0				0		0,00			
.Entertainment	[$]	0,0	0	$0,00	0				0		0,00			
.Education	[$]	0,0	0	$0,00	0				0		0,00			
SUB-TOTAL-5				**$0,00**	**0**	**0**	**0**	**0**	**0**	**0**	**0,00**			
6.- WASTE (assuming everything compostable is composted, and waste = packaging)														
enter percentage recycled in your household:				*35%*										
.Household waste:														
..paper	[pounds]	0,0	0	$0,00	0			0	0		0,00			
..aluminum	[pounds]	0,0	0	$0,00	0				0					
..magnetic metal	[pounds]	0,0	0	$0,00	0				0					
..glass	[pounds]	0,0	0	$0,00	0				0		0,00			
..plastic	[pounds]	0,0	0	$0,00	0				0		0,00			
SUB-TOTAL-6		**0,0**	**0**	**$0,00**	**0**	**0**	**0**	**0**	**0**	**0**	**0,00**			
											0,00			

CORRECTION FACTORS FOR THE U.S.	I) FOSSIL	II) ARABLE	III) PASTURE	IV) FOREST	V) BUILT-UP	VI) SEA
1.-FOOD	1,50	1,03	1,53			5,09
2.-HOUSING	0,92			2,30	1,53	
3.-TRANSPORTATION	0,99				0,95	
4.-GOODS	3,76	0,94	1,37	1,52		
5.-SERVICES	4,50			2,30		
6.-WASTE	3,76			1,52		
U.S. average fossil fuel area of	goods: 1371	services: 1266		waste: 1445		

	Equivalence Factors	Unadjusted Footprint
I) FOSSIL	1,2	0
II) ARABLE	2,8	0
III) PASTURE	0,4	0
IV) FOREST	1,2	0
V) BUILT UP	2,8	0
VI) SEA	0,1	0
TOTAL	-	0

Constants and Conversion Factors	
Carbon absorption factor (m^2/kj/yr)	10000/71000
Pre-purchase food loss	1,1
Structural consumption	1,0825
Weight conversion (kg/lb)	0,454
Area conversion (acres/ha)	2,47
Area conversion (m^2/ft^2)	0,093
Volume conversion (l/qt)	0,946

Ecological Footprint Assessment: The Results

Your per capita footprint is 0,0 hectares.

This corresponds to 0 acres.

The Ecological Footprint per household member (presented as a land-use consumption matrix)

expressed in average land with world average productivity [in square meters]

CATEGORIES	I) FOSSIL ENERGY LD.	II) ARABLE LAND	III) PASTURE	IV) FOREST	V) BUILT-UP LAND	VI) SEA	TOTAL
1.-FOOD	0	0	0	0	0	0	**0**
2.-HOUSING	0	0	0	0	0	0	**0**
3.-TRANSPORTATION	0	0	0	0	0	0	**0**
4.-GOODS	0	0	0	0	0	0	**0**
5.-SERVICES	0	0	0	0	0	0	**0**
6.-WASTE	0	0	0	0	0	0	**0**
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Daily Nutrition Analysis

[in kcal/day/person]

	Protein (g)	Calorie (kcal)
Animal	0	0
Vegetable	0	0
Total	0	0
RDA	60	2900

Ecological Footprint distribution

CATEGORIES	I) FOSSIL ENERGY LD.	II) ARABLE LAND	III) PASTURE	IV) FOREST	V) BUILT-UP LAND	VI) SEA	TOTAL
1.-FOOD	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	**#Division/0!**
2.-HOUSING	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	**#Division/0!**
3.-TRANSPORTATION	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	**#Division/0!**
4.-GOODS	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	**#Division/0!**
5.-SERVICES	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	**#Division/0!**
6.-WASTE	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	#Division/0!	**#Division/0!**
TOTAL	**#Division/0!**	**#Division/0!**	**#Division/0!**	**#Division/0!**	**#Division/0!**	**#Division/0!**	**#######**

Note: The ecological footprint does not document our entire impact on nature. It only includes those aspects of our waste production and resource consumption that could potentially be sustainable. In other words, it shows those resources that within given limits can be regenerated and those wastes that at sufficiently low levels can be absorbed by the biosphere. For all activities that are systematically in contradiction with sustainability, however, there is no footprint, since nature cannot cope with them. There is no sustainable regenerative rate for substances such as heavy metals, persistent organic and inorganic toxins, radioactive materials, or bio-hazardous waste. For a sustainable world, their use needs to be phased out. In other words, the above footprint calculation assumes that the person being assessed engages in none of these systematically unsustainable activities, be it for example the

Enclosure 2

Biocapacity in the SAMS-municipalities– Comparison of the national and local areas with the ecological footprints of the populations in these areas.

Biocapacity is a measure of the biological production of an area compared to that of global average productive space. It is measured in hectares of unit area (global average space). The ecological footprint is also measured in hectares of unit area. For Sweden the mean ecological footprint was found to be 6-7 hectares unit area, and this is supposed to be valid all over the country.

The data below on land use is from “Land use in Sweden”, third edition, 1998 county divisions (Statistics Sweden – in Swedish). Equivalent factors for different categories of space are based on international statistics (Wackernagel et al. 1999 a, b). Local yield factors in this study are based on Swedish agricultural or forestry statistics and estimated for each municipality analysed, alternatively administrative county or “land management area”. NB! Statistics from different years in the 1990s were used.

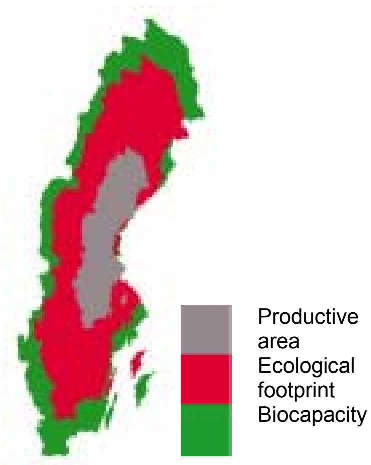
Except for the mountain range in the north-west and some impediment areas, the Swedish land area inside the coastal line is productive space. Productive fishing space is added. Productive space is grey in the pictures below. Climate, soil quality and technology provide good yields and, is expressed in ha of unit area, the biocapacity of Sweden(green) is much larger than its actual geographic area.

The ecological footprint (red), i.e. the sum of the internationally scattered areas necessary for Swedish consumption and absorption of carbon dioxide is within the Swedish biocapacity even after deduction of 12 per cent for wildlife and biodiversity.

Sweden: Land area 45 000 000 ha, 8.8 inhabitants=5.11 ha/inhab
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0.34	2.8	1,6	1.52
Pasture	0.05	0.5	7.7	0.27
Forest	2.66	1.1	2.1	6.1
Fishing ground	0.58*	0.2	1.0	0.12
Built area	0.13	2.8	1.6	0.58
Forest CO_2 abs	0	1.1	4.1	0
Total productive area/inhab	**3.8 ha**		Total biocapacity,	**9 ha unit area**
			-12 per cent biodiv.	1 ha unit area
			Available Biocapacity	**8 ha unit area**

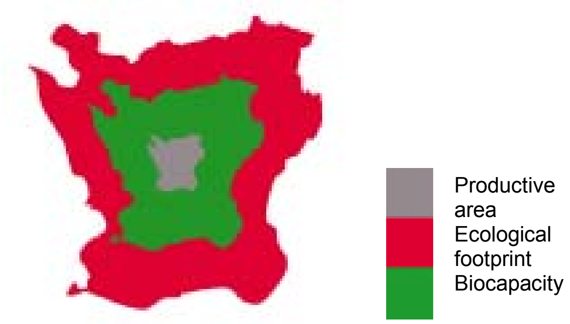
*Swedish per capita proportion of international fishing quota

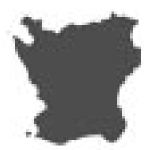


The County of Skåne: Land area 1 134 600 ha, 1 111 731 inhabitants=1.02 ha/inhab
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0.44	2.8	1,9	2.34
Pasture	0.07	0.5	12	0.42
Forest	0.33	1.1	4.1	1.49
Fishing ground	0.58*	0.2	1.0	0.12
Built area	0.05	2.8	19	0.27
Forest CO_2 abs	0	1.1	4.1	0
Total productive area/inhab	**1.5 ha**		Total biocapacity,	**5 ha unit area**
			-12 per cent biodiv.	1 ha unit area
			Available Biocapacity	**4 ha unit area**

*Swedish per capita proportion of international fishing quota





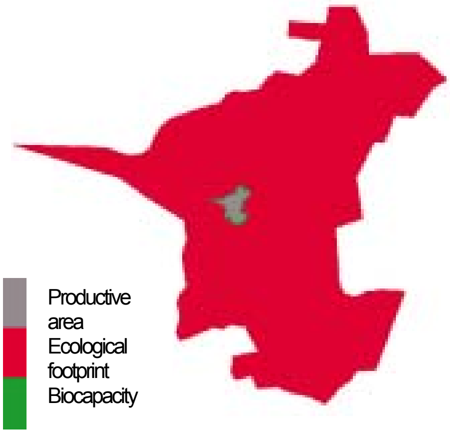
Skåne: Geographical area
1:10 000 000

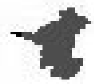
The biocapacity of Skåne (green) is much larger than the actual productive space (grey), due to the large amount of arable land and high yields but it is nevertheless insufficient to cover the ecological footprint of the population (red).
Skåne is the southern most province of Sweden.

Burlöv, municipality: Land area 1 980 ha, 14 641 inhabitants=0.13 ha/inhabitant
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0.05	2.8	1.9	0.27
Pasture	0	0.5	12	0
Forest	0	1.1	4.1	0
Fishing ground	0.58*	0.2	1.0	0.12
Built area	0.05	2.8	1.9	0.27
Forest CO_2 abs	0	1.1	4.1	0
Total productive area/inhab	**0.7 ha**		Total biocapacity,	**1 ha unit area**
			-12 per cent biodiv.	0 ha unit area
			Available Biocapacity	**1 ha unit area**

*Swedish per capita proportion of international fishing quota





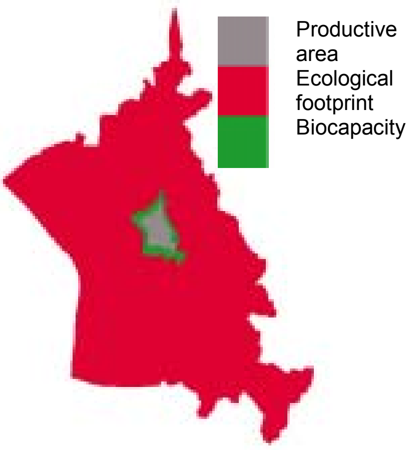
Burlöv: Geographical area
1:1 000 000

Burlöv is a small densely populated municipality that has a big ecological footprint (red). The municipality has no coastal area, but the population's part of the Swedish fishing zone is added to the productive land area. Half of the land area is built. The geographical area (grey) contains arable land, built land and fishing grounds. Calculated as biocapacity (green), it is somewhat larger than the geographical area but far from sufficient to cover the ecological footprint of the population (red). (Please note that according to the present calculation rules the built area adds to the biocapacity with the same local yield as arable land, although in reality it is destroyed biocapacity.)

Helsingborg, municipality: Land area 34 670 ha, 114 339 inhabitants=0.30 ha/inhabitant
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0,21	2.8	1,9	1.12
Pasture	0.01	0.5	12	0.06
Forest	0.00	1,1	4.1	0
Fishing ground	0.58*	0.2	1.0	0.12
Built area	0.04	2.8	1.9	0.21
Forest CO_2 abs	0	1.1	4.1	0
Total productive area/inhab	**0.8 ha**		Total biocapacity,	**2 ha unit area**
			-12 per cent biodiv.	0 ha unit area
			Available Biocapacity	**2 ha unit area**

*Swedish per capita proportion of international fishing quota



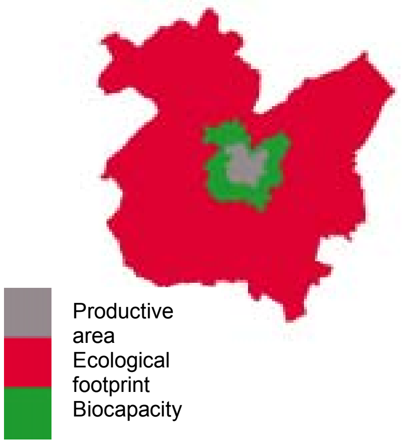
Helsingborg: Geographical area
1: 1 000 000

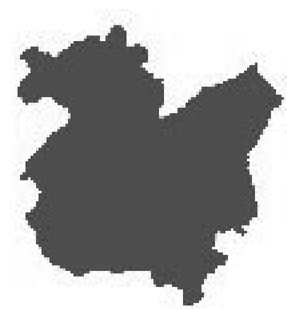
The population of Helsingborg has a big ecological footprint (red) - much bigger than the geographical area (grey) and its biocapacity (green). In similarity to Burlöv, the arable land, the built area and the municipality's part of the Swedish fishing grounds contribute to the biocapacity (green). The small pasture area has a very high local yield factor due to fodder and feed from other areas

Trollhättan, municipality: Land area 49 930 ha, 52 482 inhabitants=0.95 ha/inhabitant
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0,20	2.8	1,6	0.90
Pasture	0.02	0.5	6.9	0.07
Forest	0.25	1.1	3.0	0.82
Fishing ground	0.58*	0.2	1.0	0.12
Built area	0.05	2.8	1.6	0.22
Forest CO_2 abs	0	1.1	3.0	0
Total productive area/inhab	**1.1 ha**		Total biocapacity,	**2 ha unit area**
			-12 per cent biodiv.	0 ha unit area
			Available Biocapacity	**2 ha unit area**

*Swedish per capita proportion of international fishing quota





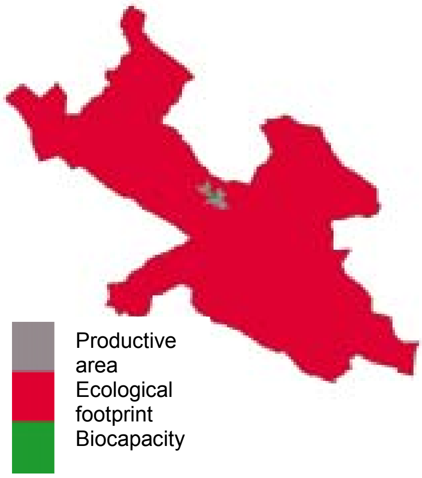
Trollhättan : Geographical area
1:1 000 000

Trollhättan is not quite as densely populated as Burlöv and Helsingborg, but even here the ecological footprint of the population is much larger than the geographical area and its biocapacity. In Trollhättan the forest contributes essentially to the biocapacity of the municipality.

Stockholm, municipality: Land area 21 550 ha, 711 119 inhabitants=0.03 ha/inhabitant
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0,0	2.8	1,5	0
Pasture	0.0	0.5	9.2	0
Forest	0.0	1.1	2.7	0
Fishing ground	0.58*	0,2	1.0	0.12
Built area	0.02	2.8	1.5	0.08
Forest CO_2 abs	0	1.1	2.7	0
Total productive area/inhab	**0.6 ha**		Total biocapacity,	**0 ha unit area**
			-12 per cent biodiv.	0 ha unit area
			Available Biocapacity	**0 ha unit area**

*Swedish per capita proportion of international fishing quota



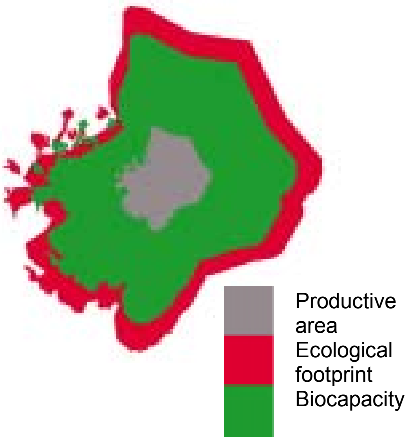
Stockholm: Geographical area
1:1 000 000

Stockholm municipality is the most densely populated municipality in the SAMS project, and the ecological footprint of the population (red) is much larger than what the productive area (grey) and its biocapacity (green) offer. The municipality's part of the Swedish fishing grounds and the lost biocapacity of the built area contribute to the biocapacity. The biocapacity per person is very small.

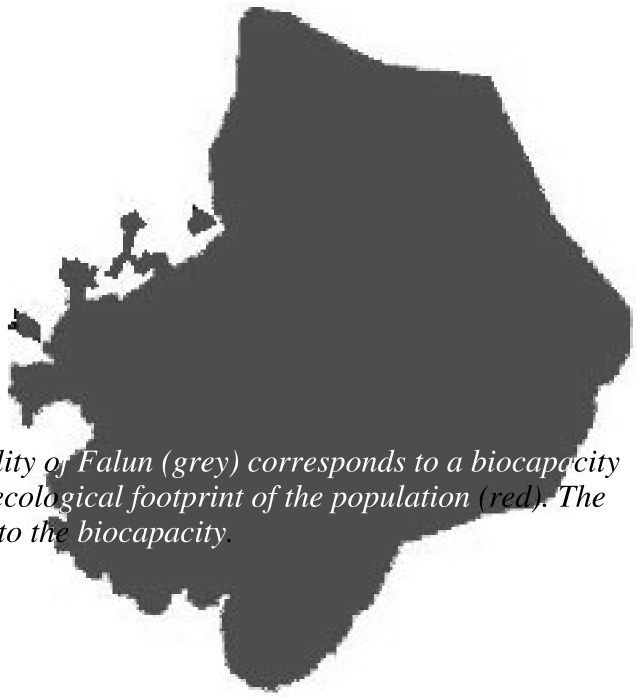
Falun, municipality: Land area 228 930 ha, 55 088 inhabitants =4.2 ha/inhabitant
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0.14	2.8	1,5	0.59
Pasture	0.05	0.5	3.1	0.08
Forest	2.90	1.1	1.8	5.74
Fishing ground	0.58*	0.2	1.0	0.12
Built area	0.08	2,8	1.5	0.34
Forest CO_2 abs	0	11	1.8	0
Total productive area/inhab	**3.8 ha**		Total biocapacity,	**7 ha unit area**
			-12 per cent biodiv.	1 ha unit area
			Available Biocapacity	**6 ha unit area**

*Swedish per capita proportion of international fishing quota



The productive area in the municipality of Falun (grey) corresponds to a biocapacity (green) that is almost similar to the ecological footprint of the population (red). The forest gives the biggest contribution to the biocapacity.

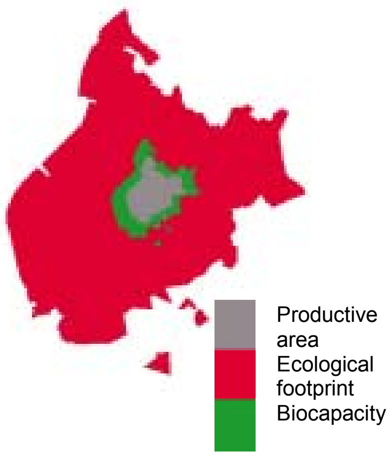


Falun: Geographical area
1:1 000 000

Borlänge, municipality: Land area 63 860 ha, 48 461 inhabitants=1.3 ha/inhabitant
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0.17	2.8	1.4	0.67
Pasture	0.02	0.5	3.1	0.03
Forest	0.75	1,1	1.8	1.49
Fishing ground	0.58*	0.2	1.0	0.12
Built area	0.08	2.8	1.4	0.16
Forest CO_2 abs	0	1,1	1.8	0
Total productive area/inhab	**1.6 ha**		Total biocapacity,	**3 ha unit area**
			-12 per cent biodiv.	0 ha unit area
			Available Biocapacity	**3 ha unit area**

*Swedish per capita proportion of international fishing quota



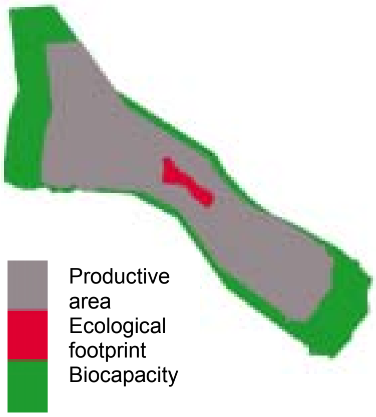
Borlänge: Geographical area
1:1 000 000

The municipality of Borlänge, near Falun, is more densely populated, and its productive area (grey) gives insufficient biocapacity (green) for covering the ecological footprint (red) of the population. In comparison to the population of Falun, Borlänge has a little more arable land but a lot less forest

Storuman, municipality: Land area 830 090 ha, 7 438 inhabitants=111 ha/inhabitant
Ecological footprint 7 ha unit area/inhab

Area category	Geograph. area ha/pers (a)	Equivalence factor, (b)	Local yield factor (c)	Biocapacity, ha unit area/inhab (a x b x c)
Arable	0.34	2.8	1.0	0.95
Pasture	0.10	0.5	2.3	0.12
Forest	39	1.1	1.4	60
Fishing ground	0.58*	0.2	1.0	0.12
Built area	0.10	2.8	1.0	0.28
Forest CO_2 abs	0	1.1	1.4	0
Total productive area/inhab	**40 ha**		Total biocapacity,	**60 ha unit area**
			-12 per cent biodiv.	7 ha unit area
			Available Biocapacity	**50 ha unit area**

*Swedish per capita proportion of international fishing quota



Storuman: Geographical area
1:10 000 000

The ecological footprint of the population in the municipality of Storuman (red) is much smaller than the geographical area (grey) and its biocapacity (green). The forest gives the largest contribution to the biocapacity.

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