The Ecological Footprint of Passenger Transport in Merseyside

John Barrett
Anthony Scott
Harry Vallack

Stockholm Environment Institute
Biology Department, University of York
PO Box 373, York YO10 5YW
Tel: +44 1904 43 2897
Fax: +44 1904 43 2898
E-mail: seiy@york.ac.uk
Web: www.seiy.org

Communications Director: Arno Rosemarin
Publications Manager: Steve Cinderby
Layout: Lisetta Tripodi
Graphic Design: Erik Willis
Cover photograph: NASA

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Contacts

Dr John Barrett
Stockholm Environment Institute – York
Biology Department
Box 373
University of York
York
YO10 5YW
Tel: 01904 434744
Fax: 01904 43 2898
Email: jrb8@york.ac.uk

Mr Anthony Scott MBA BSc
Sustainable Steps Environmental Consultants
9 Winstone Road
Dovecot
Liverpool
L14 0LY
Merseyside
Tel: 0151 220 5161
Email: tonyscott@uk.packardbell.org

Foreword

Stockholm Environment Institute in collaboration with Sustainable Steps Environmental Consultants have prepared the following report. The report is built on a wealth of experience within the field of regional, city and community sustainable indicator development.

In this report, the potential use of the ecological footprint as a tool for assisting local transport authorities and their stakeholders to understand sustainable transport issues is explored. The study investigates the ecological impact of transport modes in Merseyside using the ecological footprint methodology and assesses the likely effect of future changes in modal behaviour. In addition, a methodology for assessing the status of air quality in Merseyside was developed as an adjunct to the ecological footprint.

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Executive Summary

Enhanced global warming and climate change pose significant threats to the environment and are considered to be the most serious faced by the planet and its inhabitants in the twenty-first century. The burning of fossil fuels (for heat and power in homes, industry and transportation) and land-use change are the main human activities contributing to the enhanced greenhouse effect and global warming. A major concern is the increasing output of carbon dioxide (CO_2) from these activities, this gas accounting for approximately 80% of the UK's total greenhouse gas emissions. In the UK, road transport produces 22% of total CO_2 emissions and is one of the fastest growing sources of these emissions, which is set to continue. Besides carbon dioxide, road transport also accounts for approximately two-thirds of all environmental pollutants, which can have an impact on human health and well-being. Estimates suggest that between 12,000 and 24,000 deaths are brought forward early each year in the UK because of air pollution. Not only must the relationships between transport, the environment and health be addressed at a local level, they must also be dealt with at the global scale.

The purpose of this project is to measure the ecological and potential health impacts of transport in Merseyside and to offer suggestions as to how these impacts may be reduced through scenario development. Firstly, in order to measure the impacts of transport, the project applies the ecological footprint methodology together with a characterisation of air quality. Secondly, scenarios illustrate how it is possible to reduce the ecological footprint of transport, which as a consequence, will also improve air quality by reducing harmful emissions.

The ecological footprint is a relatively new and innovative tool that can measure the ecological impacts of various activities and expresses these impacts as areas of global, common land required – usually in hectares. The ecological footprint of Merseyside's population is the area of productive land and water ecosystems that was required to produce the resources that they consumed and to absorb the waste that they produced, wherever on Earth the land and water is located. For example, in this project, transport can be considered as part of the resources that are consumed by Merseyside whilst the emissions from transportation are considered to be the waste that is produced, which must be absorbed by the planet. At the present time and on a global scale, two hectares per person is deemed to be a fair and equitable share of land.

The results of the project show that for transportation purposes only, each person in Merseyside requires just over one half of a hectare of land. In other words, a resident uses more than 25% of their fair share of global land for travelling purposes. As expected, travelling by car has by the far the greatest ecological impact. An area 11 times the size of Merseyside would have to be planted with trees to absorb the amount of CO_2 produced by car travel. Cars represent 54% of the modal split in Merseyside however, their ecological impact (almost 88%) is far greater than all other modes of transport put together. This has a number of implications. For example, a) car travel is anticipated to grow by approximately 10% by 2016; b) a sustainable transport plan would need to dramatically increase the use of trains, bus and bicycles in order to offset the impact of cars; and c) land-use initiatives should be aimed at limiting the need to travel and further encourage walking. Introducing such measures would also contribute to achieving a sustainable level of CO_2 emissions from transport. However, this would require emissions to be reduced by 65% over the next 5 years.

Air pollution is a major contributor to poor health. In order to protect the public from air pollutants, the Government introduced a National Air Quality Strategy (NAQS) in 1997, which was revised in 2000. The aim of the strategy is to ensure that the public's health is protected. The results of the air quality characterisation study show that carbon monoxide (CO) from transport did not appear to present any health-related risks during 2000 in Merseyside. However,

concentrations other air pollutants associated with the transport sector may have presented a potential risk to health. For example, annual mean nitrogen dioxide (NO_2) concentrations exceeded the NAQS objective (for 2005) at half the monitoring stations whilst particulate matter (PM_{10}) exceeded the ‘Alert’ threshold at three of the ten stations. It is particularly noteworthy that the long-term objective for annual mean PM_{10} being proposed by DEFRA was exceeded at all nine PM_{10} monitoring stations in Merseyside. Although the benzene levels measured in 2000 were all below the present NAQS objective (5 ppb as an annual mean), half the sites would have failed the new benzene objective (1 ppb) being proposed by DEFRA.

In the scenarios, three key areas are considered: policy initiatives, individual behaviour and educational programmes. Within the Local Transport Plan performance indicators have been developed to monitor targets and progress. The ecological footprint has been applied to seven of these performance indicators. The results of the scenario for policy initiatives show that achieving the targets contained in the LTP will not bring about a reduction in the ecological footprint. Should the targets for walking, cycling and the increase of bus and train passengers be met, the ecological footprint will be reduced by 6,017 hectares. However, the expectation that car ownership will increase will mean that car travel will cause the footprint to rise by 44,430 hectares – a net loss of 38,413 hectares based on present policy initiatives.

In the case of individual behaviour, the problem faced by policy decision-makers is how to persuade those that are part of the ‘car culture’ to use alternative modes of transport or at least, to car share whenever possible. One potential way to inform and raise the awareness of car owners is to illustrate the ecological impact of different modes of transport. For example, in the Walton to Liverpool city centre scenario, the ecological footprint demonstrates that cycling has the lowest impact at 40 m^2. In comparison, driving has an ecological footprint of 1,500 m^2 for one passenger whilst the impact is halved for two people sharing. The impacts of travelling by train and bus are 1,100 m^2 and 60 m^2 respectively. The ecological impact of a commuter travelling from West Kirby to Liverpool city centre by car is 0.48 hectares. However, should the commuter decide to utilise the ‘park and ride scheme’ available at Leasowe Station, the ecological footprint would be reduced by almost half to 0.25 hectares. This is a good example of sustainability initiatives influencing individual behaviour.

In the final scenario, it is demonstrated that the ecological footprint is a versatile tool, which can be used for educational purposes. The aim of this scenario is to measure the amount of carbon dioxide being emitted during the school escort trip and how much global land is required to absorb this pollutant. In the study class, 16 children collectively walked 3,567 km to school annually whilst the collective annual distance for 7 passenger children was 6,566 km. The annual emission of CO_2 from driving to school was 1.32 tonnes and the amount of land required to absorb the CO_2 was 253 m^2 or 36 m^2 per passenger child. This is equivalent to the area of 7 classrooms. In Merseyside, the ‘school run’ produced 157,000 tonnes of CO_2, which would require 30,000 hectares of land to be planted with trees in order to sequester the CO_2 that was emitted.

This report has shown that the ecological footprint can provide Merseytravel with a tool that will assist them in their monitoring of passenger transport policies that will express the ecological impacts of transport at both local and global scales, and will assist Merseytravel to be at the forefront of addressing and tackling sustainable transport issues.

1. Introduction

Current industrial trends show a persistent growth in trade flows and in transportation, not only locally but also worldwide. The increasing volumes of goods and persons will, without effective counter-measures, lead to severe environmental degradation (Veen-Groot & Nijkamp, 1999).

For more than one hundred years, human activities have significantly increased the concentration levels of certain gases in the atmosphere which are closely related to global temperature. Many consider enhanced global warming to pose a significant threat to the Earth's environment and the most serious challenge to be faced in the twenty-first century (Leggett, 1990; De Freitas, 1991; The Framework Convention on Climate Change, 1992).

Many scientists (IPCC, 2001a) believe that human activities – past, present and most likely in the near future at least, have inadvertently affected the workings of the atmosphere. All direct inputs of gases, small particles (aerosols) and heat-energy can affect how the climate operates on various scales. For example, the emission of aerosols and heat-energy can cause localised 'heat islands' and lead to photochemical smog in urban areas whilst fine particles of dust (soil aerosols) from agriculture and drylands can impede the radiation properties of the atmosphere causing a decrease in localised rainfall. On a much larger scale, gaseous emissions are likely to be responsible for an enhanced global greenhouse effect and for the depletion of ozone in the stratosphere. In addition to inputs into the atmosphere, the expansion of the urban environment to meet human needs has led to the modification of the land surface whereby changes have occurred in the reflectivity potential (albedo) of ground surfaces (Middleton, 1995).

Global temperature broadly operates as follows: energy from the sun passes through the Earth's atmosphere where some of the wavelengths are absorbed by water vapour, gases and dust (there is also some reflective activity with clouds). On reaching the Earth's surface, approximately 70% of the sun's energy is re-radiated in longer wavelengths back into space. Some of the longer wavelengths are absorbed ('trapped') in the lower atmosphere by water vapour and other greenhouse gases thus maintaining global temperature (Barrow, 1995). Without this trapping effect, the Earth's mean temperature would be 33 °C lower than at present (Houghton et al, 1990). The presence of greenhouse gases in the atmosphere is a natural phenomenon, however, the extent to which these gases affect global temperature is fundamentally related to their concentration levels. The most abundant greenhouse gas is water vapour but levels are not directly affected by human activity. (However, it is currently assumed in the IPCC scenarios that the concentration of water vapour in the troposphere will increase with global warming thus amplifying the effect of other greenhouse gases (the so-called 'positive water vapour feedback'). The other principal greenhouse gases are carbon dioxide (CO_2), methane, nitrous oxide (N_2O) and tropospheric ozone (O_3). It is the atmospheric concentrations of these particular gases that have been significantly increased by human activity. For example, the average global carbon dioxide concentration is now 31% higher than it was in pre-industrial times (IPCC, 2001a). It is estimated that carbon dioxide, methane and nitrous oxide contributed 65%, 29% and 7% respectively to the enhanced greenhouse effect in the 1980s (Houghton, 1995).

The main human activity believed to be responsible for climate change is the burning of fossil fuels (coal, oil, natural gas and peat) and their derivatives (coke, petrol, kerosene, diesel, LPG etc.) which are primarily needed for heat and power in homes, industry and transportation). Burning fossil fuels results in the release of CO_2 that is the most important of the greenhouse gases. Carbon dioxide accounts for approximately 80% of the greenhouse gas emissions in the UK (DETR, 1999). The UK is legally bound to reduce greenhouse gas emission by 12.5% on 1990 levels by 2008–12 (Kyoto Climate Change Convention, 1997). In addition, domestically, the UK aims to reduce carbon dioxide emissions to 20% below 1990 levels by 2010 (UK Climate Change Programme, 1998).

Should average global temperatures rise significantly as predicted then the impact on the global environment is likely to be considerable. Sea levels would rise causing flooding to low lying areas and increased coastal erosion. Storms and other extreme weather events would become more severe and more frequent. Meanwhile, many natural habitats would decline or fragment and individual species would become extinct. Water resources would be affected with some regions experiencing food shortages. Climate change is also likely to have wide-ranging and mostly adverse impacts on human health, with potentially significant loss of life (IPCC, 2001b).

The latest studies in the UK suggest that greater climatic extremes such as severe winter gales will be more frequent and increased autumn and winter rainfall will pose greater risks of flooding. In the south east of England, frequent summer droughts should be anticipated whilst nationally varying degrees of coastal erosion and flooding would be expected due to a sea level rise of about 5 centimetres per decade (Meteorological Office, 1998).

1.1 The contribution of UK road transport to global climate change

In the UK, road transport produces 22% of the UK's carbon dioxide (CO_2) emissions and is the third largest source by end user of carbon dioxide emissions after industry (30%) and domestic users (25%). As CO_2 emissions are directly proportional to the fuel consumption of a vehicle, traffic growth and the limited improvement in the vehicle fuel efficiency over the last thirty years has meant that road transport has been one of the fastest growing sources of these emissions (DETR, 1999). It is interesting to note that currently there is no legislation that limits the amount of CO_2 produced by vehicles (Cleaner Vehicles Task Force, 2000). In respect of road transport, it is possible to breakdown further the contribution of CO_2 for each vehicle type. In 1996, CO_2 emissions from cars (petrol 54%, diesel 7%) were more than 60% whilst HGVs, LGVs and buses were responsible for 23%, 11% and 4% respectively. On this evidence, it is clear that reducing emissions from cars must be a paramount objective for policy-decision makers. Therefore, persuading people out of their cars and onto buses would at the minimum, reduce the amount of CO_2 being emitted by cars.

Car manufacturers have made significant progress on the reduction of regulated pollutants through higher standards on fuel and technology whereby today, new vehicles emit approximately 10% less pollutants than pre-1970s models (NSCA, 1998). However, during a similar period (1970–1993), average car fuel consumption has only been reduced by some 5%. This is mainly due to average vehicle weight steadily increasing as the demand for larger cars, more safety and other features such as air-conditioning, four wheel drive and gadgets intensifies (Bouwman and Moll, 2000). By 2050, vehicle weight increases will cause fuel use to rise by 17% compared with 1990 (Bouwman and Moll, 1997). This is another reason for present and future national transport policies to place more emphasis on public transport. Locally, the issue of a potential increase in fuel consumption by cars may be offset by the transport strategy recently devised for Merseyside. In the Local Transport Plan, greater emphasis is put on the need to use public transport (Merits, 2000). However, to be able to implement its plan, policies makers must bear in mind that society has become reliant on the car and has developed a 'car culture' whereby 20% of all journeys of less than a mile, which could be walked or cycled, are undertaken by car (Root, 1996; DoT, 1995).

1.2 The contribution of UK road transport to poor health

People are increasingly concerned about the impact that air pollution has on health, and on the urban and rural environment. Increasing, scientific evidence also backs up this concern. According to the Department of Health (1998), the deaths of between 12,000 and 24,000 vulnerable people are bought forward every year by the effects of air pollution from all sources. In addition, between 14,000 and 24,000 hospital admissions and re-admissions may result from poor air quality. These effects are attributed to three of the eight pollutants for which objectives have been set in the National Air Quality Strategy (DoE, 1997): particulate matter (PM_{10}), (which is estimated to bring forward 8,100 deaths annually), sulphur dioxide (3,500 deaths) and ozone (from 700 to 12,500 deaths). Whitelegg (1993) substantiates this by showing a correlation between high morbidity rates and proximity to high traffic levels. In urban areas, carbon monoxide (CO) can exacerbate cardiovascular diseases and contribute to respiratory conditions when combined with other pollutants (Barde and Button, 1990). Benzene is a known human genotoxic carcinogen. NO_2 is highly reactive and can damage lung tissue via its oxidising properties. NO_2 has also been reported to cause bronchitis and pneumonia and increase susceptibility to respiratory infections. Not only are particulates the primary source of the soiling of buildings they can also be carried deep into the lungs where they cause inflammation, worsen respiratory problems, and increase susceptibility to asthma. Ozone is also an irritant of the lungs (DETR, 1998).

Road transport accounts for around two-thirds of all national pollutant emissions and is predominantly the source of benzene (65%), 1,3-butadiene (77%), carbon monoxide (75%) and nitrous oxide (48%) (DTLR, 2001). In effect, air pollution from road transport is primarily a local issue, which just happens to have national and global consequences. For example, on a national level, road transport is responsible for 26% of PM_{10} and 2% of SO_2 emissions however, in the case of London, road transport is responsible for 78% of PM_{10} emissions and 23% of SO_2 emissions (Cleaner Vehicles Task Force, 2000). More often than not, this means that pollution levels are higher in areas with major traffic flows where pollutants are measured at the kerbside. This is an important issue for policy-makers dealing with localised congestion, air quality and health concerns.

Transport is one of the largest sources of environmental pollution and has a number of environmental impacts associated with it, these impacts range from local and national to global level. Some of the pollutants are being addressed through regulations and technology however, in the long-term their levels may start to increase with increasing levels of road traffic thus outweighing the benefits of emission reductions through technology.

2. What is the Ecological Footprint?

The ecological footprint has grown in popularity since its co-inventors (Wackernagel and Rees) published 'Our Ecological Footprint' in 1996. The ecological footprint represents the national capital requirements of a defined population in terms of the corresponding biologically productive areas of the planet (Wackernagel et al, 1999). This includes the land required to provide the defined population with all its food and materials as well as absorb all its waste (particularly carbon dioxide emissions). Analyses using the ecological footprint have been applied to various levels, from the global scale (Wackernagel et al, 1997; 2000) right down to the household level (Simmons and Chambers, 1998; Chambers, Simmons & Wackernagel, 2000). In this study, the component ecological footprint of passenger transport has been calculated. Also, by looking at time-series data and developing scenarios, a number of potential methods to reduce the ecological impact of transport have been devised. In addition, and for the first time, a characterisation will be performed of air quality (as it relates to potential human health impacts) as an adjunct to the ecological footprint.

Initially, the ecological footprint approach considered the amount of different land types that were required by a given population. For example, cropland to grow food, forest land to grow timber and absorb carbon etc. The component-based approach, first documented by Simmons and Chambers (1998) and then Simmons, Lewis and Barrett (2000) and Barrett (2001) is a different approach to ecological footprinting. Instead of considering the consumption of raw materials, it considers the effect of transport, energy, water and waste. It has a more simplistic and educative structure with more relevance at the sub-regional level. This is mainly because it is built around activities that people can resonate with and participate in (i.e. we all produce waste and consume electricity).

In the component-based model the ecological footprint values for certain activities are pre-calculated using data appropriate to the region under consideration (Simmons, Lewis & Barrett, 2000). Within Wackernagel's approach (known as the compound ecological footprint) six major land types of productive space are used, these being: fossil energy land, arable, pasture and forest land, built land, and sea space. For a given population, the compound approach considers the human demand on each of the land types wherever the land may be. The component approach retains the original philosophy behind Wackernagel's footprinting methodology but converts the processes into activities.

Everything that we need must be provided from the finite resources of the Earth. We must be able to provide all the necessary food, timber and minerals that provide nourishment and shelter. The issue of sustainability adds another unique element to this. We must be able to provide everyone with these basic human needs. This is becoming a more and more difficult task, because as more and more people inhabit the Earth and less land is available, their equal share diminishes.

Given that the amount of land available for humanity is essentially finite, and thus its productivity ultimately bounded, issues of equity cannot be ignored. Indeed, few would disagree that there are currently considerable inequities in the global economy, with 20% of the planet's population currently consuming 83% of its resources.

An 'Earthshare' is the average amount of ecologically productive land (and/or sea) that is available, globally per capita. This has been calculated on the premise that every individual in the entire world has an equal right to land. By adding up all the various productive land types (see Table 1), 2.3 hectares of biologically productive space is available per person (Wackernagel et al, 2000a).

Table 1. The ecological benchmark for sustainability

Productive Land Type	Hectares available per capita
Arable Land	0.25
Pasture	0.6
Forest	0.9
Built-up land	0.06
Sea Space	0.5
Biodiversity	?
Total	**2.3**

Source: based on Wackernagel et al, 2000a

However, it is equally important to protect some of this land for biodiversity. With a planet of over 30 million other species, not all this land can be considered purely for human use. The World Commission on Environment and Development (1987) has suggested that 12% of productive land should be preserved for biodiversity protection. However, this has been criticised as being insufficient but may be a politically feasible target (Noss & Cooperrider, 1994). Meadows & Meadows (1992) highlight the importance of biodiversity protection believing that the annual rate of species loss is 1,000 times higher than the natural rate of extinction. It is almost impossible to derive one figure that is necessary for biodiversity protection. Each region or country will need to understand the distinctive nature of the biodiversity of their region, making an overall figure inconsequential. Moreover, Noss and Cooperrider (1994) believe that the minimum percentage of bio-productive land that needs protecting is 25%. Therefore, the following figures can be calculated for a sustainable Earthshare per capita:

- If the view is adopted that no land needs to be preserved for biodiversity protection = 2.3 ha./ per capita
- If the WCED figure of 12% is adopted = 2 ha./per capita
- Finally, if Noss and Cooperrider minimum figure of 25% is accepted = 1.6 ha./per capita

These figures are constantly changing due to the rapid rise in world population and the impacts of erosion of soil, deforestation and urban development; therefore less land has to be divided between more people. Wackernagel et al (2000) suggest that within the next 30 years the bio-productive land per capita could decline to 1.2 hectares with a world population of approximately 10 billion.

Accepting that the figure for biodiversity preservation is at least 12 percent, it becomes apparent that humanity must learn to live equitably within a per capita land footprint of around 1.3 hectares or 3.2 acres. However, assuming that the population does increase to 10 billion, the above figure will drop to just over 0.8 of a hectare.

3. The Ecological Footprint of Transport

In 2000/01, the average person in Merseyside travelled 10,121 km (6,275 miles). Although a range of different modes of transport were utilised, the vast majority of journeys were undertaken by car (84%).

In the following analysis, a complete range of passenger transport modes have been evaluated, which provide an assessment of the environmental impacts of passenger transport in Merseyside. The ecological footprint has been employed to conduct this task. The ecological footprint of cars, taxis, buses, trains, aeroplanes, ferries and bicycles have been conducted. The ecological footprint of walking has not been undertaken, as the impact of walking is negligible.

The ecological footprint of transport combines a number of important activities that have an impact on the environment. These include:

- The carbon dioxide, nitrous oxide and methane emissions from the burning of petroleum;
- The carbon dioxide emissions from the manufacture of vehicles;
- The carbon dioxide emissions from the maintenance of vehicles;
- The road space and other land that is put aside for transport (i.e. car parks).

All these various impacts of transport are converted into a land figure. This is done for all forms of transport thus permitting different impacts of transport to be compared on the same level, as well as comparing the impact of different forms of transport. Finally, the total impact of transport can be compared with an approximate sustainable level for Merseyside – the proportion of the 'Earthshare' that is appropriated by passenger transport. This provides a 'goal' for policy decision-makers and planners.

The model described below is used to calculate all the different forms of passenger transport in Merseyside. All the figures are based on one fact; the land area required in absorbing the carbon dioxide produced by that particular activity. At present, the current carbon sequestration rate employed is estimated, as 100 GJ of fossil fuel burnt being equivalent to the absorption rate of one hectare of forest. This equates to a sequestration rate of 1.42 tonnes of carbon dioxide per hectare of forest in one year (Wackernagel and Rees, 1996).

An alternative method would be to consider the land required to supply the same amount of fuel using only biomass fuel. Both methods produce similar results, with the carbon sequestration rate providing a slightly more conservative estimate. Adopting this approach does not mean that carbon sequestration is seen as the only solution to excessive emissions of carbon dioxide. Rather, it provides a land-based analogue of overshoot, since there is not enough land to provide humanity with all the necessary resources and to support the critical life-support functions of the planet such as the carbon balance.

To calculate the impact of car travel, data concerning fuel consumption, the energy requirements of manufacturing and maintenance, the land area occupied by roads in both Merseyside and the UK and the distance travelled are collected. In Table 2, the calculation demonstrates how an average ecological footprint estimate is derived for a single passenger kilometre. This can then be used to calculate the impact of vehicle use at the individual, organisational or sub-regional level as required (Simmons, Lewis & Barrett, 2000).

Table 2. An example analysis for the footprint of UK car travel per passenger-km

COMPONENT	Additional Information	CO_2 Emissions	Built-Upon Land	FOOTPRINT
[1]Petrol		0.22 kg/km		0.00004399 ha/Car km
[2]Maintenance & Manufacture		0.099 kg/km		0.00001934 ha/Car km
[3]Road Space			3,047,145 ha	
[4]Car Road Share	86%			
[5]Car km (000's)	6,160,000,000			
[6]Car Occupancy	1.6 persons			
CO^2 Sequestration Rate (CO^2/ha.)	0.0001954 kg			
FOOTPRINT			0.00000004 ha/Car km	0.0000390 ha/pass-km
			GLOBAL FOOTPRINT	**0.0000694 ha/passenger-l**

Source: Updated from Simmons, Lewis & Barrett (2000)
[1] The UK Emission Factors Database (2000). [2] Wackernagel and Rees (1996). [3] DETR (1999) with an estimated average road width of 8.2m. [4] DETR (1999, page 39). [5] British Road Federation (BRF, 1999). [6] DETR (1999) National Travel Survey (Figure 5.2).

The UK Emission Factors Database[1] provides detailed information of the carbon dioxide emission per km for a range of different vehicles. The database also provides emissions factors depending on the speed of the vehicle and the type of road the vehicle is travelling on. It was decided to use this database as it is recognised by the DTLR and local authorities as the most comprehensive collection of emission factors. Also, the database considers the full range of pollutants that are to be analysed in this study.

The ecological footprint of car travel also includes the road space occupied by cars. In total, cars are responsible for 86% of road space. This figure does not need to be converted in a footprint figure, as it is already a land type (built land). Finally, the whole figure is converted into a passenger-km by considering the average occupancy of a car (1.6 persons). The advantage of combining car occupancy into the calculations is that the higher the car occupancy the lower the impact per person will be. This makes it possible to consider three elements in the calculation:

- The ecological footprint can be calculated on a individual basis;
- The ecological footprint of car travel is not solely the impact of a particular car, but the shared impact of individuals
- When developing scenarios for reducing the ecological footprint of transport, car sharing becomes a valid option.

The ‘Global Footprint’ figure has adjusted the ecological footprint to a world-average land unit. With all the latest ecological footprint calculations, including this study, equivalence factors have been added to the different land categories. The equivalence factor compares the biomass of all the different land types to assess the amount of productive area that is being appropriated. More precisely, these factors inform us about the category’s relative yield as compared to world average land. Biomass yields, measured in dry weight, are taken from statistics from the United Nations Food and Agriculture Organisation (FAO). World-average has consequently an equivalence factor and a yield factor of 1 (WWF, 2000). Thus, the physical extensions of the global areas of

[1] The UK Emissions Database is produced by the London Research Centre and can be obtained from the following website address: http://www.rsk.co.uk/ukefd/

biologically productive space are adjusted with the equivalence and yield factors which add up to the same global total (WWF, 2000).

UK global equivalence factors have been applied in this study. For energy land this is a factor of 1.78 and for built land this is a factor of 3.16. This means that the forest-land required to absorb the carbon in the UK is 1.778 more productive than the world average.

4. The Ecological Footprint of Merseyside's Transport

A separate discussion of the ecological footprint of different transport types has been conducted below. This includes an explanation of the calculation procedure, data sources and comparisons with UK impact. While the ecological footprint of car transport has been calculated for the different road types in Merseyside, the average footprints for the different transport types are shown below (Table 3).

Table 3. The ecological footprint (EF) and ecological footprint index (100 = car) of different modes of transport

Vehicle Type	Ecological footprint (EF) (m^2 per 1000 passenger-km)	Percentage Variation in EF from Car
Car	590	100
Aeroplane	500	86
Taxi	680	115
Bus	430	73
Motorcycle	370	62
Train	210	36
Ferry	220	379
Bicycle	20	3
Walking	0	

Before considering the distance travelled by each of the different vehicle types it is clear that the car (including taxi) has a larger impact per km than the bus, train, motorcycle and cycling. Cycling has the lowest impact (apart from walking which has a zero footprint) and is only 3% of the impact of a car for every kilometre travelled.

While this calculation procedure for the ecological footprint of a car-passenger-km may only point to reducing the distance travelled by cars in order to reduce the ecological footprint, this is not necessarily the case. The actual algorithm will change over time, representing increases in the efficiency of cars and how much carbon they emit. An increase in car occupancy and even the speed with which the car travels are other factors that change the algorithm. A number of examples have been given below to demonstrate this point.

The car travel footprint has been placed into a computer model where it is easy to develop scenarios. For example, what will the ecological footprint of passenger transport be in 2005 when taking into account:

- An increase in fuel efficiency?
- An increase in car occupancy to two passengers per car?
- Driving at the most energy efficient speed?

The ecological footprint can predict this. It can also answer other questions such as: 'What will the ecological footprint be if a more efficient and reliable bus service is introduced?' and 'What will the ecological footprint be with the introduction of new train stations into urban areas?' The model is flexible enough to deal with changes in behavioural patterns and technological advances while remaining transparent and not getting lost in specificity. It can combine as many aspects as are required to demonstrate the effect of passenger transport in the future.

4.1 Cars and taxis

The ecological footprint for cars and taxis has been calculated for different road types in Merseyside. Table 4 provides an analysis of the different roads and illustrates that travelling by motorway has the greatest impact.

Table 4. The ecological footprint (EF) by road type per 1000 km

Road Type	EF (m^2 per 1000 km)
Urban	634
Single carriageway	499
Dual carriageway	505
Motorway	707

There are also other methods by which this could have been calculated such as travelling at different speeds. The most efficient speed for a car to travel at is 75 km/h (47 mph). It is 42% less efficient for a car to travel at less than 10 km/h than it is to travel at 75 km/h. With a footprint of 1140 m^2 per 1000 km, traffic congestion has a significant ecological impact. This evidence could give policy-makers and planners the option to control traffic at an optimum speed which causes the least damage to people's health and the environment whilst maintaining traffic flow.

All the calculations assume average car occupancy of 1.6 persons, which is the national average. The final method by which the ecological footprint of car travel can be calculated is by car type. For example, a small car (i.e. Nissan Micra or Ford Fiesta) has an ecological footprint of 470 m^2 per 1000 km, compared to a four-wheel drive jeep with a footprint of 1260 m^2 per 1000 km. Hence, a small car is 65% more efficient than a four-wheel drive jeep.

A range of different methods to understand the impact of car travel provides a multi-faceted tool whereby data that are available can be applied. Within Merseyside, the most relevant concern in terms of ecological impact is road type. Therefore, this approach is employed to calculate the footprint of car travel. The average footprint per 1000 km of all the different road types is 590 m^2. According to the Merseyside Information Service (MIS) the total passenger-kilometres for Merseyside was 12,000 million in 1996. The calculation: – [(passenger-kilometres)_x (the footprint for car travel)] demonstrates that car travel has an ecological footprint of 704,260 hectares, or 0.5 hectares per person. An area 11 times the size of Merseyside would have to be planted with trees to absorb the amount of CO_2 produced by car travel. As discussed earlier, cars are responsible for 25% of an individual's fair 'Earthshare'. Subsequently, 1.5 hectares of land remains to provide an individual with all their food and resources and absorb their emissions from home energy use and waste production, if they wished to be regarded as sustainable.

In comparison to the UK (0.62 ha per person), Merseyside (0.50 ha per person) has one of the lowest ecological footprints for car travel (80% of the UK per capita footprint). This variation between Merseyside and the national average is confirmed when average car ownership is considered. In Merseyside, car ownership is 16% lower than the national average, while the ecological footprint is 20% lower. As well as owning fewer cars, this figure suggests that the average distance travelled by car is also lower thus explaining the 4% variation.

By applying car ownership figures, it is possible to assess the ecological footprint of car travel for the five metropolitan boroughs of Merseyside. Table 5 gives an indication of ecological footprint of car travel, disaggregated by borough.

Table 5. The ecological footprint of car travel by Merseyside borough

Borough	Car Ownership per capita	Population	Passenger-1000 km	Total EF	EF per capita
Liverpool	0.250	454,177	2,925,415,548	172,510	0.38
Knowsley	0.271	152,672	1,065,985,028	62,893	0.41
St Helens	0.379	179,446	1,752,247,347	103,383	0.58
Sefton	0.383	290,647	2,868,052,110	169,215	0.58
Wirral	0.396	332,058	3,387,907,567	199,887	0.60

Source: MERITS, 2000

Liverpool clearly has the lowest ecological footprint for car travel whilst the areas of Sefton and Wirral have a significantly higher footprint for car travel. The total ecological footprint of Sefton is similar to that of Liverpool's even though the population is considerably smaller (nearly 164,000 less). Wirral has a very similar per capita footprint to the UK average. While the footprint of car travel in Liverpool is 37% lower than the national average. The low level of car ownership in Liverpool can mostly explain this substantially lower footprint. There is a clear correlation between car ownership and personal wealth. In many respects this raises some important issue for the more developing boroughs of Merseyside. Can individual prosperity and quality of life improve with the injection of Objective 1 funds without increasing the ecological footprint of car travel?

By employing future projections of car transport growth in Merseyside, produced by the DTLR, it is possible to estimate the potential growth in the ecological footprint of car transport. Figure 1 indicates that the ecological footprint of car travel in Merseyside is set to grow from 0.5 ha per capita to between 0.64 and 0.66 ha per capita by 2016. This is an increase of between 9 and 11 percent. The final figure has also taken into account the potential increase in engine efficiency.

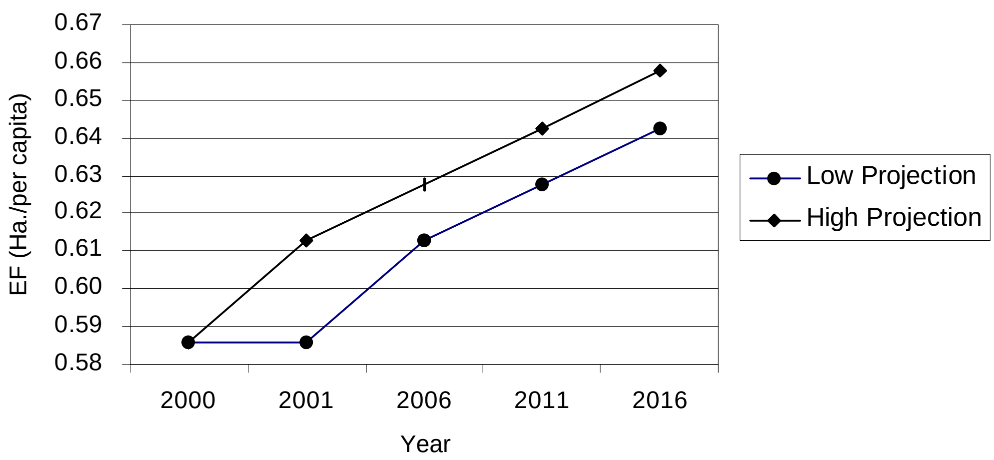

Fig 1. Projected increase in the ecological footprint of car travel in Merseyside

An ecological footprint of daily commuting in Merseyside also reveals that car transport has the most significant impact. In Merseyside the average distance travelled to work is 12.3 km (DTLR, 2000). Fifty-nine percent of these journeys are undertaken by car. As stated, the ecological footprint of car travel can be calculated using the speed of the vehicle. Figure 2 illustrates the ecological footprint of car travel at various speeds for 2000.

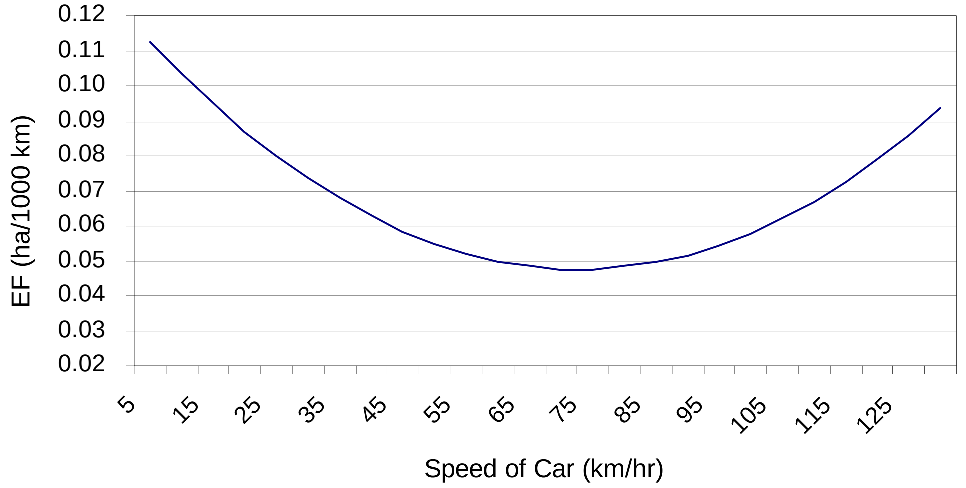

Fig 2. The ecological footprint of car travel at different speeds

The average traffic speed on major roads in Merseyside is 29.6 km during peak hour. The ecological footprint of travelling at this speed is 730 m^2 per 1000 km. Transport travelling at this speed has a substantially higher ecological footprint than the average footprint (590 m^2 per 1000 km). It is estimated that commuting to work is responsible for a total of 1,416 million passenger-kilometres. Therefore, the ecological footprint of commuting by car is 104,045 hectares (850 m^2 per capita). This represents a total of 15 percent of the total ecological footprint of passenger transport for Merseyside. Commuting by car has the highest ecological footprint of any travel activity in Merseyside.

Finally, the ecological footprint of taxi travel can be calculated for Merseyside. According to MIS, taxis are responsible for a total of 111,368,140 passenger-kilometres in 2000. The ecological footprint has been calculated precisely for a LTI Taxi-TXI-EGR, which is the most common taxi in use in Merseyside. The ecological footprint per 1000 km is 0.068 ha, which is slightly higher than the average car. A modest occupancy figure of 1.6 persons has been assumed. However, this is likely to be an under-estimate; meaning the impact of a taxi per km is very similar to that of a private car. The total ecological footprint of taxi travel in Merseyside is 7,709 hectares (55 m^2 per capita).

4.2 Buses

The ecological footprint of buses in Merseyside has been calculated using information directly from the bus operators. The energy consumption, carbon dioxide emissions and ecological footprint have been calculated for different bus types. The calculations also take into account the average occupancy of the buses within Merseyside.

4.2.1 Comparison of fuel consumption data

A wide range of data are available concerning the fuel efficiency of buses. The UK Emissions Database has provided average figures of fuel consumption for different road types, generic to the UK. AEA Technology have produced figures for the fuel consumption of the different bus classifications, calculating that there is no variation in fuel consumption from Euro I to Euro II buses. The fuel efficiencies given by these data sources are compared with those calculated by the bus operators in Merseyside in Table 6. The comparison suggests that the data provided by the Merseyside bus operators are extremely accurate. Taking the rate of fuel consumption of buses for rural single carriageway as a comparison, the UK Emissions database suggest a figure of 275g diesel/km, while the Merseyside figures are 266g diesel/km for pre-Euro, 253g diesel/km for Euro I and 273g diesel/km for Euro II. Therefore, a particularly accurate ecological footprint for bus travel can be obtained in the knowledge that the locally specific data are of adequate accuracy. Table 7 illustrates the ecological footprint for each road type and bus classification (per 1000 km) based on CO_2 emissions and bus occupancy.

Table 6. Comparison of the fuel efficiencies of buses given by different sources

[redacted]

AEAT = AEA Technology; UKED = UK Emission Database; MBO = Merseyside bus operators

Table 7. The ecological footprint of buses by road type and bus classification[2]

[redacted]

[2]One gram of diesel º= 3.14 grams of CO_2 (UK emissions data)

4.2.2 Number of buses in Merseyside

In 2000/01, a total of 1525 buses travelled over 716 million passenger-kilometres. On average, each bus travelled 469,839 passenger-kilometres. A breakdown of these results by bus category is given in Table 8.

Table 8. Merseyside bus fleet

Bus category	No. of buses	Distance covered (passenger-km)	EF[3] (ha)	EF/per capita (m^2)
Pre-Euro	803	379,771,400	16,477	120
Euro I	179	84,656,389	3,492	20
Euro II	533	252,077,405	11,217	80
Total	1525	716,505,195	31,187	220

The total ecological footprint of bus travel is 31,187 hectares. This is extremely small in comparison to the impact of car travel. In effect, the bus footprint is only 4.5% of that of cars.

4.3 Cycling

The ecological footprint of cycling considers the manufacture and maintenance of a bicycle as well as the road space exclusively for cycling (i.e. cycle lanes). There is obviously no fuel consumption to take in account. After evaluating three key references concerning the maintenance and manufacture of a bicycle the total energy requirement is 0.06 MJ/kilometre[4]. This equates to 0.0048 kg of CO_2 per km, an ecological footprint of 17 m^2 per km. The ecological footprint of a bicycle is therefore 0.04% that of a bus and 0.02% that of a car. Fundamentally, there is a 350-fold increase in eco-efficiency between a bicycle and a car.

Merseyside Information Service (1996) estimated that the average distance travelled in one year per person in Merseyside by bicycle was between 40 and 80 km. In comparison, the former DETR publish an estimate figure of 61.15 km per person/per year. As this is almost central to the MIS estimate, this figure is adopted for the purpose of this study. With a population of 1.4 million, the residents of Merseyside travel a total of 86,160,350 km by bicycle. This equates to an ecological footprint of 145 hectares.

Given that the impact of cycling is 350 times less than that of cars and the distance travelled by cycling is over 176 times less than car travel, it is not surprising that the impact is so low. The importance of a cycle calculation is that it demonstrates the huge advantages of a comprehensive cycling strategy.

4.4 Ferries

Ferries, which link Wirral with Liverpool, are used both by commuters and tourists. In 2000/01, a total of 844,194 passenger-kilometres were undertaken by ferry. The ecological footprint of the CO_2 emitted from the marine fuel was also calculated. The ferries consume 15.3 kg of fuel per km, which equates to 48 kg of CO_2 per km. In 2000/01 the ferries travelled a total of 11,348 km,

3 It is assumed that 55% of bus travel is on urban roads, 20% on single carriageway, 20% on dual carriageway and 5% on a motorway. Therefore, the ecological footprint conversion factors, taking into account this assumption were 0.091 ha/per 1000 km for pre-Euro buses, 0.086 ha./per 1000 km for Euro I buses and 0.093 ha./per 1000 km for Euro II buses.

4 The references concerning the energy requirements of bicycle maintenance and manufacture include CEC (1992), Hughes (1992) and Stead (1999).

and emitted 545 tonnes of CO_2 in the process. Considering that the average amount of CO_2 emitted per capita in the UK is currently estimated to be 13 tonnes, the CO_2 contribution of the ferry is only responsible for the same impact as 42 UK citizens.

The total ecological footprint of one passenger-kilometre is 0.00022 ha (or 2.2 m^2), which assumes an average occupancy of 75 passengers. Therefore, the total ecological footprint of ferries is 188 hectares. The ecological footprint per km travelled by a ferry is higher than that of a car (0.0000694 ha/passenger-km or 0.7 m^2). This does not necessarily mean that the car is a less damaging form of transport as there are other factors involved. For instance, the ferry is responsible for reducing traffic congestion in the Liverpool tunnels and the health related effects of car travel are reduced.

4.5 Trains

In this study, the ecological footprint of train travel for Merseyside only considers the impact of *Merseyrail* train services. In 2000/01, trains in Merseyside undertook 334 million passenger-kilometres. The ecological footprint per 1000 passenger-km for trains is 208 m^2. This is substantially lower than cars (only 36% of the total impact per km travelled). The total ecological footprint of rail travel is 6,971 hectares or 49 m^2 per capita.

4.6 Aeroplanes

The aviation industry has and will continue to grow at an extremely rapid rate. While there has been a major debate concerning the environmental impact of road transport, the impact of aviation has, in the main, been ignored. In fact, aviation has a faster growth rate then any other form of transport. Table 9 illustrates that for every passenger-km travelled by air, the impact is similar to the equivalent journey in a car (500 m^2 per 1000 passenger-km and 590 m^2 per 1000 passenger-km respectively).

With the increasing development of Liverpool Airport, air travel is becoming a more accessible and popular form of transport in Merseyside. Aviation today, is the source of about 13% of the carbon dioxide emitted by transport and 2% of all carbon dioxide emissions from man-made sources (Whitelegg and Williams, 2001). In Merseyside, the growth in air travel has not been as extreme, with aviation corresponding to 6% of transport CO_2 emissions. In terms of the ecological footprint, air travel has a footprint of 50,882 hectares (360 m^2 per capita). Air travel is second only to car travel in its contribution to the ecological footprint of passenger transport in Merseyside. However, even though this substantial threat is becoming more evident and significant, the aviation industry was specifically excluded from the Kyoto Protocol.

A forecast of worldwide aviation growth produced by the Department of Trade and Industry predicts a growth in air travel of approximately 625% by 2015. Taking into account the predicted growth in car travel, air travel will contribute to over 38% of the ecological footprint of passenger transport in Merseyside. In less than 15 years, the ecological footprint of air travel will have increased by 32%. By 2025, air travel will contribute more to the ecological footprint and carbon dioxide emissions than other forms of transport in Merseyside.

4.7 The total ecological footprint of passenger transport in Merseyside

Car travel is responsible for 88% of the total ecological footprint of passenger transport. Air travel has the next most significant impact (see Table 9). The annual distances being travelled by both car and air continue to increase while the other forms of transport have either reduced or remained relatively constant over the past 20 years. The major concern is that car and air travel are set to increase rapidly in the near future.

Table 9. The ecological footprint of transport in Merseyside

Mode	Total passenger-kilometres	EF (ha per 1000 passenger-km)	Total EF	EF per ca (m^2)
Car	11,999,607,600	0.0587	704,260	4998
Air	1,010,169,379	0.0504	50,882	361
Bus	716,505,195	0.0430	30,843	219
Train	334,483,808	0.0208	6,971	49
Taxi	113,368,140	0.0680	7,709	55
Motorcycle	68,012,430	0.0365	2,482	18
Bicycle	86,160,350	0.0017	145	1
Ferry	844,194	0.0225	188	1
Total	14,329,151,096		803,480	5,702

The average person in Merseyside travelled 10,139 km (6,300 miles) in 2000/01 of which 8,497 km (5,280 miles) were undertaken by car. With a predicted rise in GDP in Merseyside, car ownership is set to increase, which will potentially bring Merseyside parallel with the UK average. This can only have a negative effect on the ecological footprint and the health of the residents.

A comparison between the ecological footprint and modal split reveals a significantly different picture. Table 10 highlights that the modal split for car travel is approximately 54%. However, in terms of its ecological impact, car travel represents almost 88% of the total impact of all transportation in Merseyside.

Table 10. A comparison of modal split and ecological footprint

Mode	Percentage of Total EF	Percentage of Total Modal Split
Car	87.7	54.1
Air	6.3	-
Bus	3.8	15
Train	0.9	2.2
Taxi	1.0	2
Motorcycle	0.3	0.4
Bicycle	0.01	0.7
Ferry	0.01	-
Total	100%	100%

Concerning the ecological footprint, section 2 explained the amount of land that is available per person if sustainability were to be achieved (2 hectares per capita). In Merseyside, passenger transport contributes to 30% of the total ‘Earthshare’. Hence, 1.4 hectares of global, common land remains to provide Merseyside with all its resources, its food and energy, housing, built land and water for consumption. In a previous study, which involved measuring the ecological footprint of Liverpool (Barrett and Scott, 2001), the components above totalled 3.5 hectares per person. Overall, if each component of the ecological footprint were to be reduced proportionately, the ecological footprint of passenger transport would have to be reduced by 50%.

With the introduction of a sustainable transport plan, train, bus and cycling use would have to increase to offset the environmental impact of cars. In addition to this, there would need to be an overall strategy to reduce the total distance travelled, such as local land-use initiatives, which limited the necessity to travel. With an increase in bus and train mileage, there will be an inevitable increase in the ecological footprint of these services. However, the impact per passenger-km travelled of these forms of transport is substantially lower than that of car travel. Also, the increase in air travel must be taken into account. If, for example, the ecological footprint of car travel is substantially reduced, this reduction in the ecological footprint may be outpaced by the growth in air travel. The issue of air travel also goes further than just CO_2 emissions. In terms of toxic emissions, airports are comparable to large industrial plants. Research in the USA shows that airports rank alongside chemical factories, oil refineries and power stations as the top four emitters of nitrogen oxides and VOCs (Natural Resources Defence Council, 1996).

From the perspective of achieving a sustainable level of CO_2 emissions from transport, a reduction of 65% in the next 5 years would be required. This assumes that buses and trains will be used instead of car travel and that air travel will be limited to an increase of 50%. Only 5% of the 65% reduction in CO_2 emissions could be achieved through increases in the efficiency of cars. With a prediction in the growth of car transport in the UK estimated at approximately 2% a year, this figure seems impossible. Should air travel continue to grow at the predicted rate then the reduction in the ecological footprint of car transport will have to be even greater.

5. Air Quality in Merseyside

In 1997, the UK Government's National Air Quality Strategy (NAQS) set health-based standards and objectives for eight priority air pollutants – some of which were subsequently revised under the Air Quality Strategy, published in 2000. Air pollution damages health and one of the major purposes of the NAQS is to ensure a high degree of protection against risks to public health from air pollution. The NAQS standards and objectives are based on scientific and medical evidence relating to the health effects of the pollutant concerned. The NAQS objectives (Table 11) represent the Governments view of achievable air quality in the short to medium term taking into account costs, benefits and technical feasibility.

Table 11. The current NAQS objectives set by the UK Government
(Merseyside Local Transport Plan 2001/2–2005/6 targets are indicated in italic script)

Pollutant	Objective	Date to be achieved
Benzene	*5 ppb running annual mean*	*31 December 2003*
1,3-butadiene	*1 ppb running annual mean*	*31 December 2003*
Carbon monoxide (CO)	*10 ppm running 8-hour mean*	*31 December 2003*
Lead (Pb)	*0.5 mg m^{-3} annual mean* 0.25 µg m^{-3} annual mean	*31 December 2004* 31 December 2008
Nitrogen dioxide (NO_2)	105 ppb 1-hour mean (not to be exceeded > 18 times a year) *21 ppb annual mean*	31 December 2005 *31 December 2005*
Ozone (O_3)	50 ppb daily maximum of running 8-hour mean (not to be exceeded > 10 times a year)	31 December 2005
Particles (PM_{10})	50 µg m^{-3} 24-hour mean (not to be exceeded > 35 times a year) *40 mg m^{-3} annual mean*	31 December 2004 *31 December 2004*
Sulphur dioxide (SO_2)	132 ppb 1-hour mean (not to be exceeded > 24 times a year) *47 ppb 24-hour mean* *(not to be exceeded > 3 times a year)* 100 ppb 15-minute mean (not to be exceeded > 35 times a year)	31 December 2004 *31 December 2004* 31 December 2005

Since December 1997, local authorities have been required to review air quality in their area and assess it against the above objectives specified for each pollutant. In Merseyside, it is predicted that these air quality objectives will be met in all authorities except Liverpool. According to the Merseyside Local Transport Plan (LTP), part of the city centre and an area close to the end of the M62 are predicted to exceed the objectives for nitrogen dioxide and particulate matter. Liverpool City Council are preparing proposals for the designation of Air Quality Management Areas in these locations. The LTP targets for the performance indicator 'Air quality – pollutant concentrations' are to achieve the objectives shown in Italics in Table 11.

Recent health evidence shows that particles are likely to have significant long-term health effects, probably many times more severe than the short-term effects on which the NAQS objectives were based. Because of this, the Department of the Environment's Expert Panel on Air Quality Standards (EPAQS) have recommended a stricter standard for PM_{10}. EPAQS also recommended a long-term policy target of 1 ppb for benzene as a running annual mean. The Department for Environment, Food and Rural Affairs (DEFRA) is now proposing that these stricter objectives should be adopted in the UK (Table 12).

Table 12. EPAQS recommended long-term objectives for benzene and PM_{10}

Pollutant	Proposed Objective	Date to be achieved
Benzene	1 ppb running annual mean	31 December 2010
Particles (PM_{10})[a]	50 $\mu g\ m^{-3}$ 24-hour mean (not to be exceeded > 7 times a year)	31 December 2010
	20 $\mu g\ m^{-3}$ annual mean	31 December 2010

[a] Slightly different objectives are proposed for London and Scotland

The Department of the Environment Transport and the Regions (DETR), now superseded by DEFRA, devised a banding system to provide air pollution information to the public. For each pollutant, four bands ('Low', 'Moderate', 'High' and 'Very high') are bounded by three thresholds ('Standard', 'Information' and 'Alert') as shown in Table 13. Concentrations below the 'Standard' threshold are 'Low', those between the 'Standard' and 'Information' thresholds are 'Moderate', those between the 'Information' and 'Alert' thresholds are 'High' and those above the 'Alert' threshold are 'Very high'. The 'Standard' threshold corresponds to the appropriate NAQS air quality objective for all pollutants apart from the NO_2 1-hour mean (DEFRA 'Standard' threshold = 150 ppb; NAQS objective = 105 ppb).

5.1 Air pollutants included in this assessment

The air pollutants chosen for the purposes of this study are nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter (PM_{10}) and benzene. These, together with 1,3-butadiene are the main air pollutants associated with emissions from the transport sector. Data for 1,3-butadiene were not available for the Merseyside region.

5.2 Air pollution monitoring sites in Merseyside

There are 14 automatic air pollution monitoring stations within Merseyside; 7 in the Sefton Council area, 4 in Liverpool and one each in St Helens and Knowsley. All of these stations provide hourly data for NO_2 and PM_{10} and six of the Sefton automatic sites also provide 8-hourly means for CO. Benzene concentrations are measured at one of Sefton's automatic sites and are also measured using passive diffusion tubes (on a monthly basis) at 7 sites in Wirral. Numerous NO_2 diffusion tubes are also used throughout Merseyside.

Table 13. Summary of the DEFRA (formerly DETR) air quality thresholds and banding.

Pollutant	Standard Threshold	Information Threshold	Alert Threshold
Carbon monoxide CO)	10 ppm running 8-hour mean	15 ppm running 8-hour mean	20 ppm running 8-hour mean
Nitrogen dioxide (NO_2)	150 ppb 1-hour mean	300 ppb 1-hour mean	400 ppb 1-hour mean
Ozone (O_3)	50 ppb running 8-hour mean	90 ppb running 8-hour mean	180 ppb running 8-hour mean
Particles (PM_{10})	50 $\mu g\ m^{-3}$ 24-hour mean	75 $\mu g\ m^{-3}$ 24-hour mean	100 $\mu g\ m^{-3}$ 24-hour mean
Sulphur dioxide (SO_2)	100 ppb 15-minute mean	200 ppb 15-minute mean	400 ppb 15-minute mean

Air pollution banding	Low	Moderate	High	Very high
	Harmful effects unlikely to occur, even in sensitive groups	There could be a small risk of effects in sensitive individuals	Some adverse effects in sensitive individuals may occur	Risk of more serious adverse health effects, not necessarily confined to sensitive groups.

5.3 Methodology of the air quality characterisation

Air pollution monitoring data were obtained for the various monitoring stations/sites operated in Merseyside during 2000. Data from the NO_2 diffusion tubes were not included in this analysis because the average monthly levels obtained from them do not show whether the NAQS standard has been exceeded. For each site, exceedences of the DETR air quality thresholds for CO, NO_2 and PM_{10} (Table 13), the NAQS annual mean objective for NO_2, PM_{10} and benzene (Table 11) and the EPAQS recommended long-term objectives for PM_{10} and benzene (Table 12) were determined for the year 2000.

5.4 Results of the air quality characterisation

Results are summarised as the percentage of relevant sites at which a given threshold was exceeded during 2000 (Figs. 3 and 4). It should be emphasised that for Figure 3, the existence of bars for NO_2 and a PM_{10} does not necessarily imply that any of the sites breached the current NAQS objectives (up to 18 exceedences of the NO_2 1-hour criterion and up to 35 exceedences of the PM_{10} 24-hour criterion allowed per year). In fact, the maximum number of NO_2 (1-hourly mean) exceedences at any site during 2000 was only 10. However for PM_{10} (24-hour mean), two sites in Liverpool breached the current NAQS objectives (Victoria Street – 149 exceedences; Mobile monitor – 84 exceedences).

Carbon monoxide (CO) concentrations did not exceed the health-related thresholds at any of Merseyside's monitoring sites during 2000. However, 1-hourly mean NO_2 concentrations exceeded thresholds at over a third of the sites (Fig. 3) and the annual mean NO_2 values (Fig. 4) exceeded the NAQS existing objective at half of the (automatic) monitoring sites in Merseyside. The 24-hourly thresholds for PM_{10} were exceeded at least once at all but one of the sites and the 'Information' and 'Alert' thresholds were exceeded at almost a third of the sites. The existing NAQS objectives for annual mean benzene and PM_{10} concentrations were not breached at any of the sites. However, the more stringent EPAQS long-term annual mean objectives were exceeded at all sites for PM_{10} and at half of the sites for benzene.

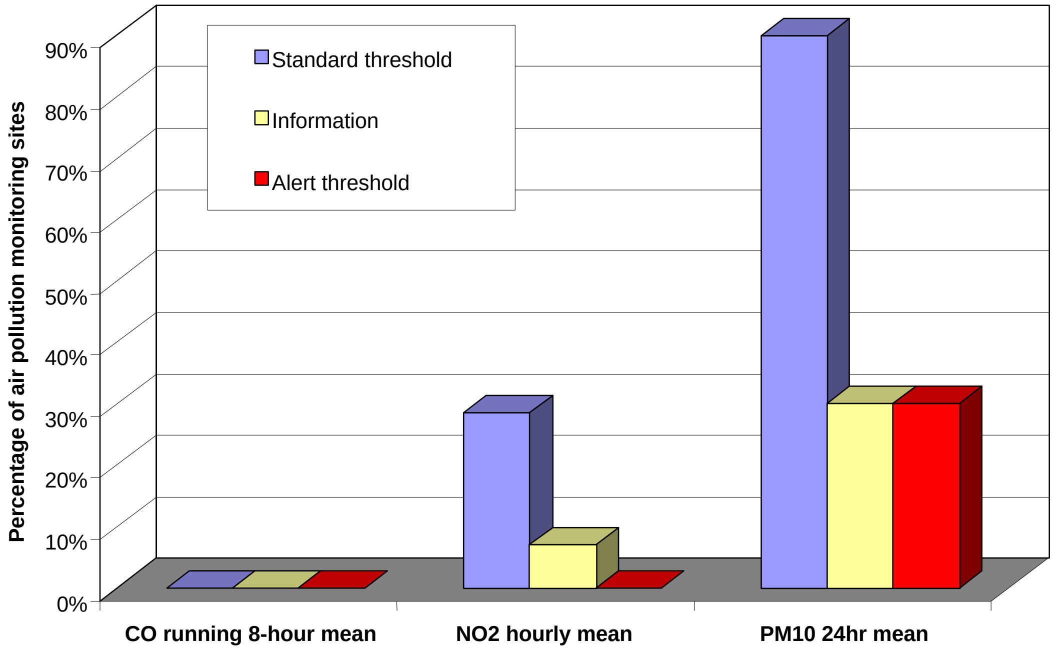

Fig 3. Percentage of monitoring sites in Merseyside at which the DETR's health-related air quality thresholds were exceeded on one or more occasions during 2000.

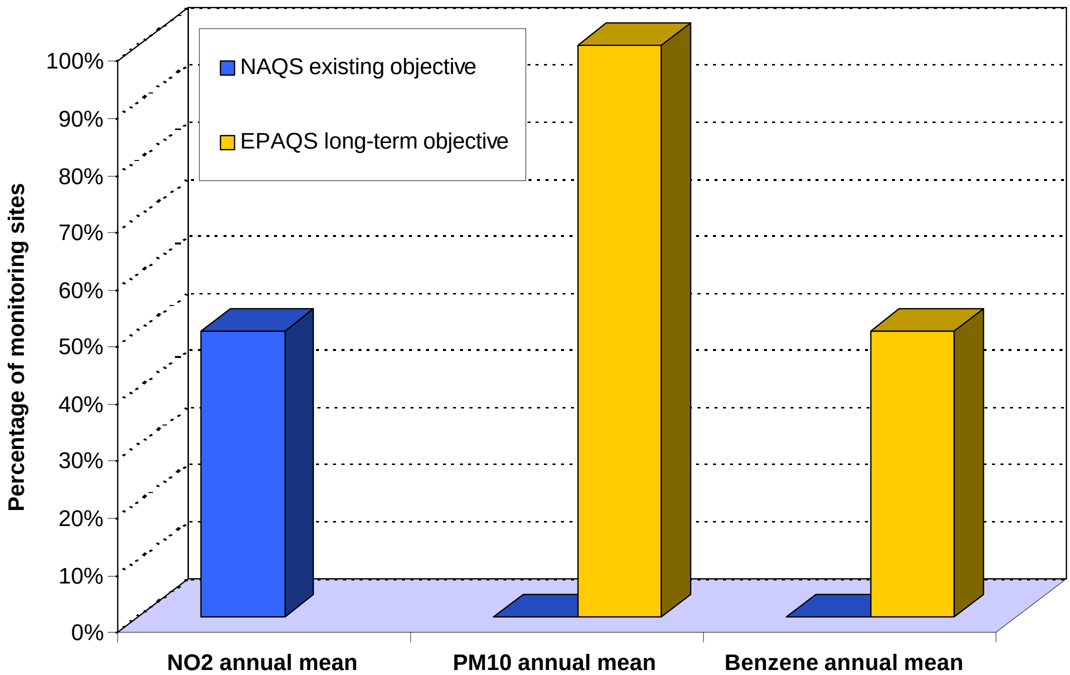

Fig. 4. Percentage of monitoring sites in Merseyside at which health-based objectives for annual mean air pollutant concentrations were exceeded in 2000.

5.5 Air quality conclusions

Of the main air pollutants associated with the transport sector, CO did not appear to present any health-related risks during 2000. However, NO_2 concentrations did present a more significant potential health risk. Almost a third of the automatic monitoring stations operated in Merseyside during 2000 recorded one or more exceedences of the hourly mean air quality thresholds for NO_2 and at half of these sites, the NAQS objective for annual mean NO_2 was also exceeded.

There were also potential health implications of the exceedences of DETR thresholds for PM_{10}, especially the exceedences of the 'Alert' threshold at three out of the ten sites, which posed a '*risk of more serious adverse health effects, not necessarily confined to sensitive groups*'. It is particularly noteworthy that the proposed EPAQS long-term objective for annual mean PM_{10} concentrations was exceeded at all nine monitoring stations. This is significant in the light of recent evidence concerning the long-term health effects of PM_{10}.

Although benzene concentrations were below the current NAQS objective at all sites, they were in excess of the proposed EPAQS objective of 1 ppb (annual mean) at half of the Merseyside sites. This may also have potential health implications given that benzene is a genotoxic carcinogen with no known safe lower threshold. It can be concluded that during 2000, air quality at certain locations in Merseyside was likely to have been significantly affected by emissions from the transport sector with potential short-term and long-term health implications.

6. Application of the Ecological Footprint for Passenger Transport in Merseyside

6.1 Introduction to Scenarios

To demonstrate the potential future application of the calculations undertaken in this study, three scenarios have been selected with the assistance of Dr Karen Booth (Environmental Officer), Sarah Dewar (Merseyside Travelwise co-ordinator) and John Smith (Transport planner). The aim of the scenarios is to demonstrate the application of the ecological footprint in three key areas. The key areas considered are:

- Policy Initiatives – can the ecological footprint help to illustrate the effectiveness of past, present and future policies;
- Education Programmes – can the ecological footprint help to educate and inform children and parents with particular reference to the 'school run'
- Individual Behaviour – can the results of an ecological footprint analysis influence individual behaviour

6.2 Policy Initiatives

Within the Merseyside Local Transport Plan (2001/2 – 2005/6) there are 103 performance indicators that are designed to monitor progress towards local objectives and targets. Of the 103 indicators identified, 29 do not have a specific target while 76 do have targets established for the years 2006 and 2011. Seven of these targets have been considered below in an attempt to demonstrate the usefulness of the ecological footprint in assessing the effectiveness of the various objectives. The

Table 14. The performance indicators that are included within the analysis.

Transport Type	Performance Indicator	Local Performance Indicators contained in LTP	Local targets or outcomes contained in LTP
1. Walking	Modal share of journeys to work	Percentage of all journeys to work made by walking	1% increase by 2006; Further 1% by 2011 (from 2001 base)
2. Walking	Modal share of all travel journeys	Percentage of all journeys made by pedestrians	Increase the 25% (1996 level) to 30% by 2006 and to 35% by 2011
3. Cycling	Modal share of all travel journeys	Percentage of all travel journeys made by cycling	Increase share to 4% by 2006 and 8% by 2011
4. Buses	Bus patronage	Number of bus passenger journeys per year	5% growth by 2005
5. Trains	Rail patronage	a) Number of rail passenger journeys per year (all services) b) Number of rail passenger journeys per year (supported services)	a) Increase from 33.7m in 1999/00 to 45.1 in 2005/06 b) Increase from 31.1m in 1999/00 to 41.7m in 2005/06
6. Road Traffic	Traffic levels – all roads	a) Growth in total traffic to centres from a 2000 base b) Growth in total traffic on all roads compared to 1996 base	a) 0% growth to 2006 in the centres for peak periods b) 0% growth for 2006-11 above 20.8% maximum to 2006

targets include cycling, walking, train, bus and road traffic (see Table 14). The reduction in the ecological footprint has been calculated on the basis of achieving individual targets. This provides an insight into which of these targets will bring about the greatest reduction in the ecological impact of passenger transport in Merseyside.

6.2.1 Walking – Performance Indicators 1–2

In total, there are nine performance indicators specifically dedicated to improving the conditions for walking and consequently increasing the amount of the walking within Merseyside as opposed to using more unsustainable forms of transport. Six of these indicators are concerned with improving the attractiveness of walking, such as increasing accessibility, adequate signposts and reducing pedestrian casualties. The other three indicators outline the effectiveness of the measures in increasing walking and are concerned with schools, commuting and all travel journeys (see Tables 15 and 16).

Table 15. Indicator 1: Percentage of all journeys to work made by walking

Target	Current Percentage and EF		Potential Reduction in EF by 2006	Potential Reduction in EF by 2011
1% increase by 2006; Further 1% by 2011 (from 2001 base)	11%	0 hectares	1040 hectares	1030 hectares
			Total EF reduction by 2011	2070

Section 4.1 calculated the ecological footprint of commuting by car as 104,045 hectares. Commuting by car has the highest ecological footprint for any passenger transport activity. Therefore, a total reduction of 2070 hectares is a substantial reduction if the target for the performance indicator is met.

Table 16. Indicator 2: Percentage of all journeys made by pedestrians

Target	Current Percentage and EF		Potential Reduction in EF by 2006	Potential Reduction in EF by 2011
Increase to 30% by 2006 and to 35% by 2011	25%	0 hectares	1,291 hectares	1,356 hectares
			Total EF reduction by 2011	2,647

Performance indicator 2 represents the overall reduction of the ecological footprint by achieving the target relating to walking (see Table 16). At present, residents in Merseyside walk a total of 437,621,310 km per year. If the target for 2006 is achieved this would increase to 459,502,376 km by 2006 and 482,477,494 km by 2011. The assumption of the ecological footprint calculation is that the increase in walking-kilometres will bring about a proportional reduction in car-kilometres. Therefore, achieving the indicator targets for walking would bring about a reduction of 21,881,066 car-passenger-km by 2006 and 22,975,119 car-passenger-km between 2006 and 2011. This would result in a total reduction in the ecological footprint by 2011 of 2,647 hectares.

6.2.2 Cycling – Performance Indicators 3

There are eight performance indicators related to cycling. Seven of the indicators are designed to improve safety (more cycle lanes) and security (better bike parks). The other indicator assesses the effectiveness of these initiatives by measuring the percentage of all travel journeys made by cycling (see Table 17).

Table 17. Indicator 3: Percentage of all travel journeys made by bicycle

Target	Current Percentage and EF		Potential Reduction in EF by 2006	Potential Reduction in EF by 2011
Increase share to 4% by 2006 and 8% by 2012	0.7%	153 hectares	167 hectares	369 hectares
			Total EF reduction by 2011	536

6.2.3 Buses – Performance Indicator 4

There are eleven performance indicators directly linked to improving the efficiency, safety and reliability of buses, all aiming to increase the use of buses in Merseyside and subsequently reducing car use. Indicator 4 demonstrates that a 5% growth in bus-passenger-kilometres is the target for 2005 (see Table 18).

Table 18. Indicator 4: Number of bus passenger journeys per year

Target	Current Percentage and EF		Potential Reduction in EF by 2006	Potential Reduction in EF by 2011
5% growth by 2005	15%	30,843 hectares	479 hectares	NA

The total reduction in the ecological footprint with the achievement of the target is 479 hectares. There is an increase in the bus footprint to accommodate the growth (increase of 1507 hectares). However, the reduction in the ecological footprint is more significant than the growth in the footprint of buses (reduction of 1,986 hectares).

6.2.4 Trains – Performance Indicator 5

This performance indicator monitors the increase in train travel with a target of increasing rail journeys by 25% by 2005/06. At present the modal split for Merseyside indicates that rail travel only accounts for 2.2% of all services.

Table 19. Indicator 5: Number of rail passengers per year

Target	Current Percentage and EF		Potential Reduction in EF by 2006	Potential Reduction in EF by 2011
Increase from 33.7m in 1999/00 to 45.1 in 2005/06 Representing 25% increase	2.2%	6,971 hectares	2,355 hectares	NA

The calculation above has taken into account the fact that the ecological footprint of train travel will increase with an increased amount of passengers. A 25% increase in passenger-kilometres by trains would result in an extra 83 million passenger-kilometres. This represents an increase in the ecological footprint of 2,436 hectares. However, the substantial reduction in car-passenger-kilometres more than compensates for this increase, with a reduction of 4,792 hectares. This represents an overall net reduction of 2,355 hectares (see Table 19).

6.2.5 Road Traffic – Performance Indicator 6

Indicator 6 is concerned with car travel and the target set for 2006 only attempts to reduce growth during peak time. Moreover, the predicted growth up to 2006 for car travel is 6.08% without any measures. If the target established in the indicator is achieved, the growth in car transport will be reduced to 5.96%. Therefore, the target for part **'a'** of the indicator is to increase car travel by 5.96% (see Table 20).

Table 20. Indicator 6: Traffic levels – all roads

Target	Current Percentage and EF		Potential Increase in EF by 2006	Potential Reduction in EF by 2011
a) 0% growth to 2006 in the centres for peak periods b) 0% growth for 2006-11 above 20.8% maximum to 2006	84%	12000 million hectares	44,430 hectares	0 hectares

Indicator 6 is the only measure that will not reduce the ecological footprint of passenger transport. An increase of 44,430 ha is expected. Part **'b'** aims to reduce the growth in all transport to 0%. Therefore, the ecological footprint will neither increase nor decrease from the increased footprint for 2006 (Table 20).

6.2.6 Conclusions concerning LTP Targets

The ecological footprint provides a tool that can indicate the relative impacts of different modal choices. Figure 5 indicates which of the entire policy targets will be the most effective in bringing Merseyside's transport towards sustainability.

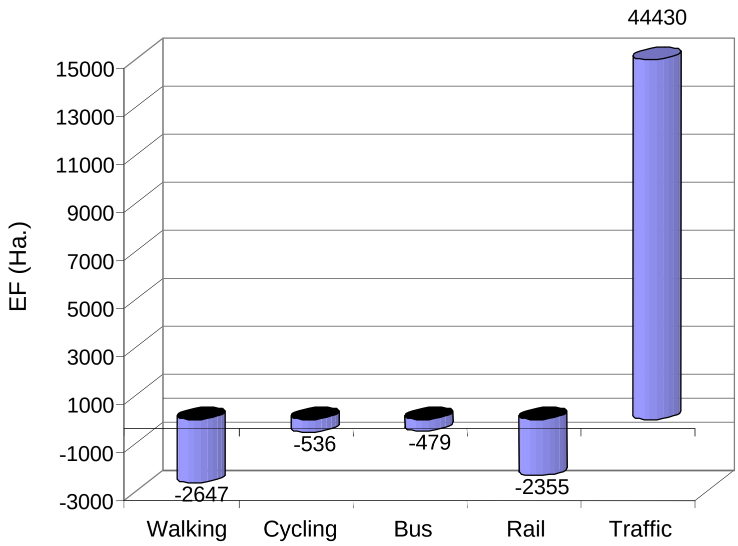

Figure 5. The effectiveness of LTP targets

Figure 5 indicates that the most effective target is connected with increasing walking, followed by rail and then cycling. The most efficient method by which to reduce the ecological footprint of passenger transport is to establish progressive and challenging targets for walking and cycling. Both these approaches will bring about a major change in the ecological footprint. As already discussed the target for car use will not bring about a reduction in the ecological footprint. Moreover, it will increase the ecological footprint by some 44,430 hectares. Overall, if the LTP targets are achieved, the ecological footprint of passenger transport will rise by 38,500 hectares by 2006. The targets set in the LTP will fail to bring about a reduction in the ecological footprint thus suggesting greater investment and a more radical programme to bring about the necessary changes, particularly concerning walking and cycling.

6.3 Individual behaviour

Understanding the impact of individual travel is crucial when attempting to inform and influence travel choices made by individuals. Three case studies of individuals have been selected to demonstrate the ability of the ecological footprint to influence travel behaviour. Different methods of transport are considered in order to calculate the relative impact of different journeys.

6.3.1 Journey 1: Macclesfield to Liverpool City Centre

Option 1 – Drive 24 km on ‘A’ road, 40 km on motorway and 8 km on urban roads into the city centre (single occupancy and multiple occupancy)

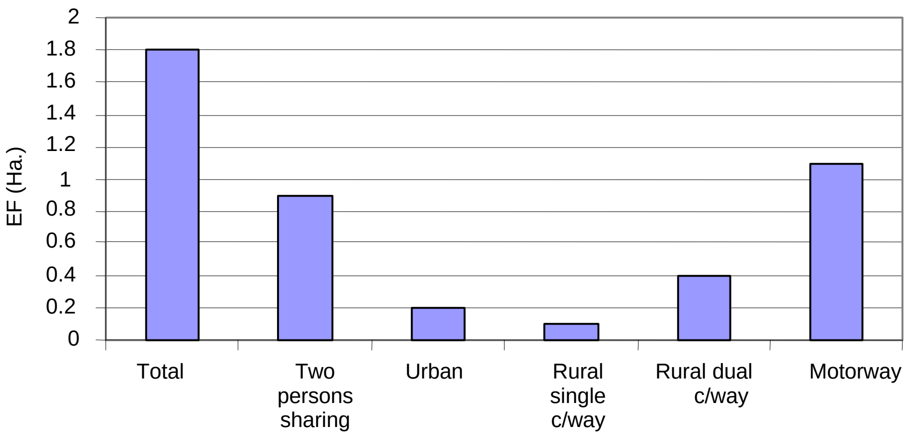

Fig 6. Macclesfield to Liverpool city centre by car

The total ecological footprint of commuting by car from Macclesfield to Liverpool and the return journey for one year is 1.8 hectares (see Fig 6). Motorway travel has by far the highest impact (1.1 hectares). With car sharing (for example three persons in the car) the ecological footprint per person is reduced to 0.60 hectares per person.

Option 2: Drive 24 km on ‘A’ road, 40 km on motorway, travel from Broadgreen to Liverpool Lime Street (5.5 km) by train and walk the last 0.8 km.

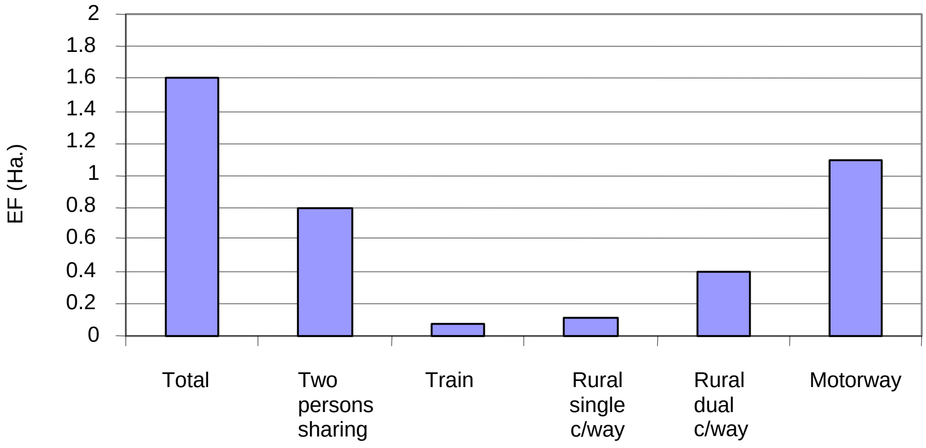

Fig 7. Macclesfield to Liverpool city centre by car and train

By changing the last part of the journey (from car to train) the ecological footprint has been reduced to 1.6 hectares (a reduction of 0.2 hectares). Motorway travel still has the highest impact. Again, with car sharing (three in the car) this would reduce the footprint to 0.53 hectares per person. Walking the last 0.8 km has no ecological footprint and therefore has no impact on nature (see Fig 7).

Option 3: Train from Macclesfield to Manchester, Manchester to Liverpool Lime Street then walk

The total distance travelled by train for the two journeys and the return trip is 124 km. This is an ecological footprint of 0.57 hectares and is by far the most sustainable option of the three considered. The first option is the most unsustainable and requires an individual's entire fair 'Earthshare' solely for travelling to work.

6.3.2 Journey 2: West Kirby (Wirral) to Liverpool City Centre

Option 1: Drive all the way

The total distance to drive all the way is 20 km (9.6 km on A-Roads, 10.4 km on motorway and tunnel approach road).

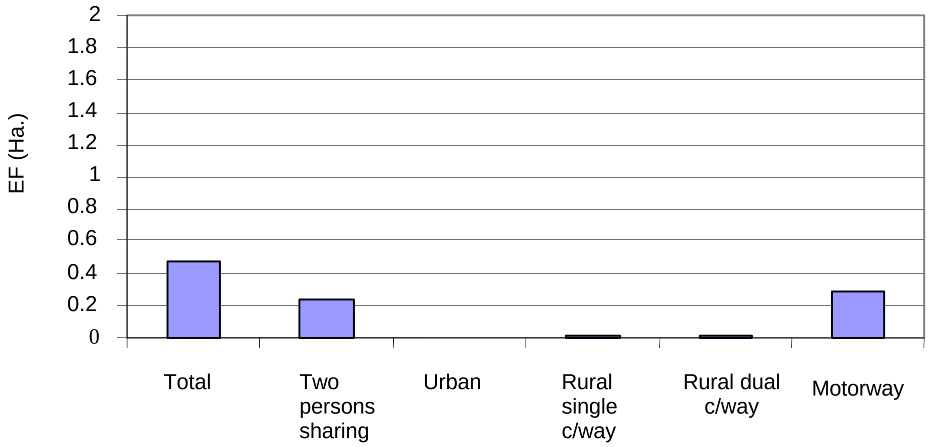

Fig 8. West Kirby to Liverpool city centre by car

The total ecological footprint is 0.48 hectares (see Fig 8). As with the other example, motorway travel has the highest impact.

Option 2: Drive to Leasowe Station Park and Ride (8.95 km on A-Road), Train to Moorfields (8.2 km) and walk the remainder.

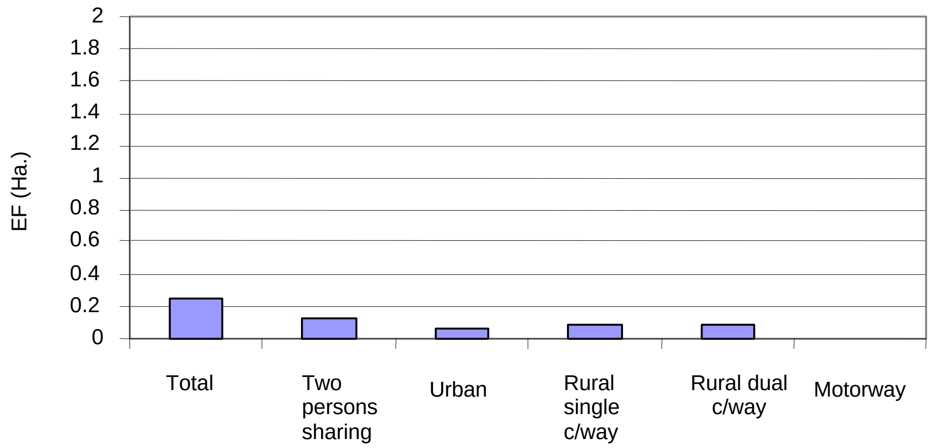

Fig 9. West Kirby to Liverpool city centre by car and train

By using the park and ride service from Leasowe station the ecological footprint has reduced considerably to 0.25 hectares. The main difference is that motorway travel no longer has an impact (indicated in Fig 9).

Option 3: Bus from West Kirby to Dale Street

The total journey by bus is 20 km. This equates to an ecological footprint of 0.37 hectares, which is higher than the using the park and ride scheme.

Option 4: Train from West Kirby to Moorfields station

The train option equates to an ecological footprint of 0.18 hectares and has the lowest ecological footprint of the four options as indicates in figure 10.

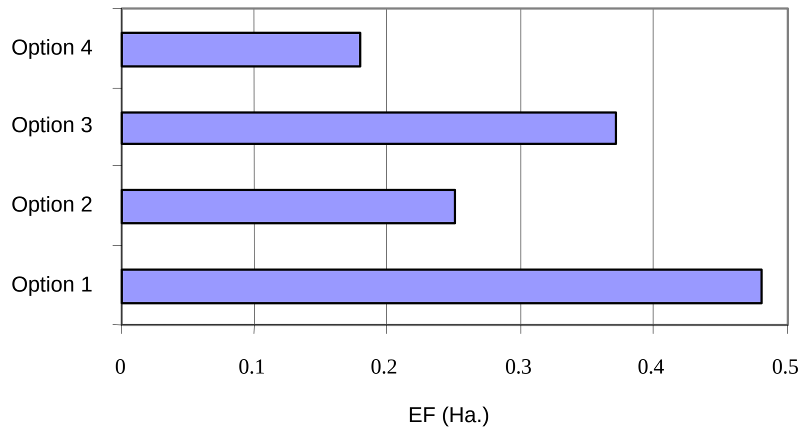

Fig 10. West Kirby to Moorfields station

6.3.3 Journey 3: Walton to Liverpool City Centre

Option 1: Bus all the way to Queen Square and Walk

The total distance by bus is 5.86 km. This equates to an ecological footprint of 0.11 hectares or 1100 m^2.

Option 2: Bike all the way

The total distance travelled is 5.86 km. This equates to an ecological footprint of 0.004 hectares or 40 m^2.

Option 3: Train from Rice Lane to Moorfields station

The total distance travelled is 6.22 km. This equates to an ecological footprint of 0.06 hectares or 60 m^2.

Option 4: Drive all the way

The total distance travelled is 5.86 km. This equates to an ecological footprint of 0.15 hectares or 1500 m^2.

A comparison of the different options demonstrates that option 2 (by bicycle) is by far the most sustainable in ecological terms and probably good for the health of the individual too (see Fig 11).

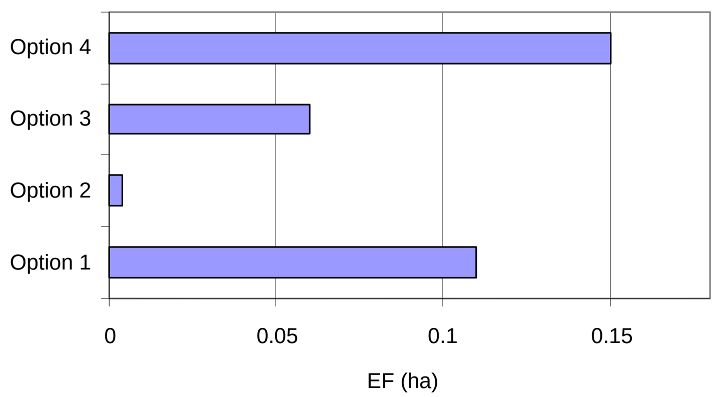

Fig 11. A comparison of the ecological footprint of different modes of transport from Walton to Liverpool city centre

6.3.4 The impact of different car types

The ecological footprint of all the journeys done by car will vary from car to car. Section 4.1 demonstrated the difference between a jeep and small car. Below, six cars have been selected to show the variation in impact of car types. The average car has a ratio of 0. Therefore, Fig 12 indicates that the Mercedes SL has a ratio of 1.2 compared to the average car. For example, the ecological footprint of driving a car from Macclesfield to Liverpool is 1.8 hectares. However, this figure would increase to over 2 hectares if the journey were undertaken in a Mercedes SL.

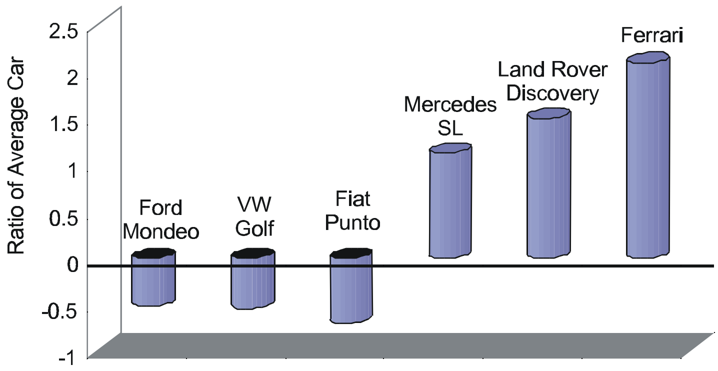

Fig 12. The ecological footprint of different car types

6.3.5 Conclusions: changing individual behaviour

In this scenario, the ecological footprint has provided an insight into the relative impacts of different modes of transportation depending on the feasible options available. Clearly, the modes of transport that has the least ecological impact in terms of the area of land required to absorb CO_2 emissions are walking and cycling. This is illustrated in Figure 11 where all modes of transport have been measured (car, bus, bicycle and train). In all of the journeys that have been analysed, travelling by car has the greatest ecological impact. Evidently, the task ahead for policy decision-makers is to persuade the majority of individuals who drive cars to change their selection of transport. However, this will be difficult. Drivers are ensconced in a 'car culture' that means every journey, no matter how small, must be undertaken in a car any thoughts of alternatives modes of transport are usually dismissed.

Despite the negativity concerning the consideration of alternatives, the ecological footprint methodology has highlighted the success of 'park and ride' schemes. For example, the ecological footprint of the journey from West Kirby to Liverpool city centre is reduced by almost 50% by the use of the park and ride at Leasowe Station. As a policy driver, this suggests the introduction of further such schemes in Merseyside.

6.4 Education: The ecological footprint and the 'school run'

Educating children about their environment through lessons in school is an effective way of making sure that the message about sustainability reaches them (Aaland and Caplan, 1999). Generally, research has shown that young people's attitude toward the environment begins to develop from a very early stage. Upon reaching adolescence, young people have attained a sufficient level of understanding of such environmental issues as ecology, sustainable development, economics and technology to be able to form their own views on these issues (Kinsey and Wheatley, 1980; Chalwa, 1988; Lozzi, 1989). Age is a constant factor in many studies that found significant relationships between environmental knowledge and environmental attitude (Ramsey and Rickson, 1976; Moore, 1981; Roth and Perez, 1989). For example, in their study of 13 to 16 year olds Lyons and Breakwell (1994) found age to be positively related to environmental concern and is not influenced by gender. However, it was highlighted that those young people who were environmentally concerned are more likely to come from higher social class backgrounds. Lyons and Breakwell (1994) put forward a number of suggestions as to why this may be the case:

a) ***Parental influence:*** higher class parents are more likely to be knowledgeable about environmental issues and are therefore more likely to discuss such issues with their children.

b) ***Academic achievement:*** differences in academic achievement between different social classes.

c) ***Priorities:*** social classes tend to attach different priorities to different social issues.

d) ***Curricular content:*** there may be significant differences in the curricular content of the schools that social classes attend.

Therefore, besides age, it can be assumed that socio-demographic conditions also influence environmental knowledge and attitudes. Eden (1993) reaffirms Lyons and Breakwells' suggestions believing that environmental responsibility and behaviour, although complex, are very much dependent upon an individual's social context. This is an important factor in relation to Merseyside and its status as a relatively poor area within Europe. For instance, potential car ownership in the future will intrinsically be linked to income and social circumstances.

As a result of the recent injection of European led funding into the region, it is expected that the rate of GDP in Merseyside will increase (GONW, 2000). As a consequence, residents will have more disposal income. One particular consumable that residents are likely to purchase is a car, which will enable them to be part of the growing 'car culture'. According to Houghton (1995) traffic volume in the UK will continue to grow until 90% of people of car-driving age (17–74) own a car. This will only serve to compound the situation in Merseyside especially as car ownership in Merseyside is the lowest in the UK. The major problems in a social context will be people of a lower social class purchasing relatively cheap and therefore older cars, which will be less efficient and more polluting whilst higher class people are likely to buy larger, heavier, gadget filled vehicles. Ultimately, this may lead to gridlock as roads fill up with more qualified seventeen year olds and lower class car owners. In essence, the overall outcome is likely to be an increase in the degradation of air quality and the consumption of more and more of the Earth's resources.

The challenge for educators is to provide adequate information for young people that examines their perceptions of mobility and the environment's ability to cope with consequences of increased car ownership.

6.4.1 The school run: a case study

To demonstrate that the ecological footprint can be used as an educational tool, Barrett and Scott (2001) undertook a study to measure the amount of CO_2 that was released into the atmosphere as a result of taking children to school by car. In addition, the study measured the ecological footprint required for the 'school run'. The study class (Primary school) consisted of 23 children, of which 16 were pedestrians and 7 were passengers in cars. The aggregate annual journey to school for all children in the study class was 10,133 km with 3,567 km apportioned to pedestrians and 6,566 km for car passengers. The modal split was 70% and 30% for pedestrians and passengers respectively.

On average, a car emits 0.2012 kg of CO_2 per kilometre therefore, the annual emission of CO_2 for 7 passenger/children was 1.32 tonnes. However, it is difficult to expect children to visualise a tonne of carbon dioxide therefore data for the distances walked or driven to school were converted into the equivalent distances to cities around the UK and Europe and into an ecological footprint, which was more easily understood (See Fig 13). For example, in a school year, 3 children were driven the equivalent distances to Madrid, Bari and Warsaw in Europe whilst some children walked as far as Inverness, Exeter and London in order to get to school.

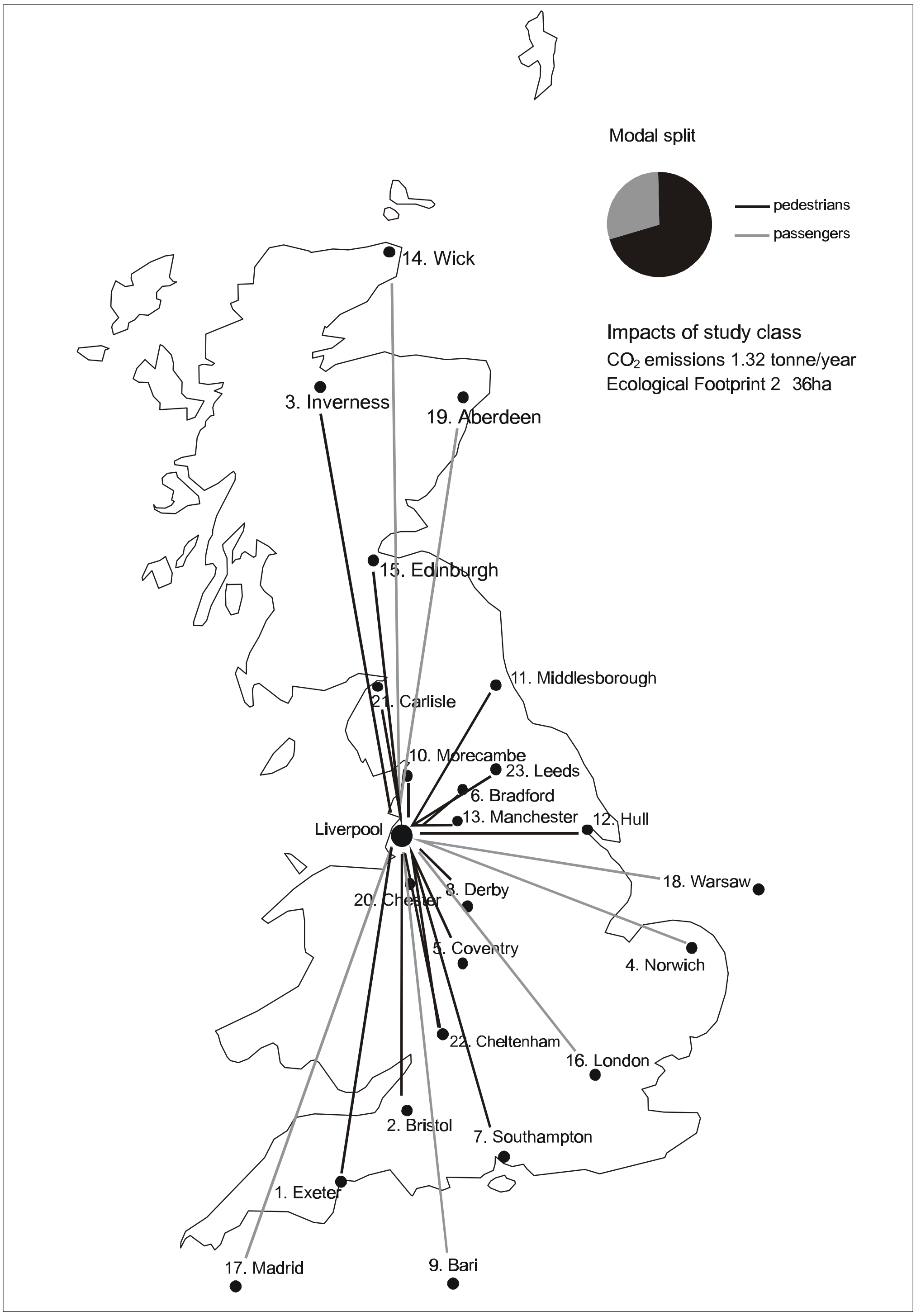

Fig 13. The ecological impact of the 'school run'

The ecological footprint required for sequestrating the CO_2 emitted by 7 passenger/children amounts to 253 square metres or 36.14 m² per passenger/child. In effect, the approximate area of 7 classrooms would need to be planted with trees in order to absorb the CO_2 that is emitted during the 'school run'.

In terms of measuring the ecological impact of the whole school (599 children), the same methodology was applied using the modal split above and the mean distance travelled by car of the study class (938 km). In total, 168,559 km are driven to (am) and from (pm) the school annually. For passenger children, this is equivalent to being driven around the Earth more than 4 times and as a result, 34 tonnes of CO_2 are emitted. The ecological footprint for the school run amounted to 6.5 hectares or 65,000 m^2. However, should the drivers return directly home then the figures above could conceivably be doubled.

6.4.2 The impact of the school run in Merseyside

A countywide survey of Merseyside in 1996, found that 6.5% of all car journeys represented the school escort trip. This percentage figure is used in the following calculation to determine the amount of CO_2 emitted in Merseyside during the school escort trip and the area of land required to absorb the emissions. In total, 779,974,494 km were travelled in Merseyside for the purpose of taking children to school. As a result, 156,930 tonnes of CO_2 were emitted. In order to sequester this amount of CO_2, an area of 30,120 hectares would need to be afforested.

6.4.3 Conclusion: education and the ecological footprint

It was found that for educational purposes and for raising awareness of the problems associated with the school run, the ecological footprint proved to be extremely useful. Such informative exercises could be promoted alongside other issues concerned with the school run such as health, safety, congestion, global equity and fairness.

7. Conclusions and Future Research

This report has provided a baseline indication of the impact of passenger transport in Merseyside with the use of the ecological footprint. In doing so, it has provided the opportunity for Merseytravel to monitor the progress of passenger transport policies both present and in the future. At the same time, the report provides three examples concerning the application of the ecological footprint.

Firstly, the analysis of the targets within the LTP provide an insight into the application of the ecological footprint in the area of policy. The analysis indicates that the ecological footprint can be employed to measure the success of past, present and future policy decisions.

Secondly, the ecological footprint of different journeys on different types of vehicles was considered. The ecological footprint provided an insight into various modal choices made by individuals. Such an approach can help to influence travel behaviour and provide a tool for businesses that may wish to implement a green transport plan.

Finally, the ecological footprint was considered as an educational tool in relation to the impact of the school run. The ecological footprint is a visual and perspective tool, which can be applied to many groups. It helps to relate the issue of individual's lifestyle to global environmental problems, such as global warming and climate change. Each individual has the potential, through the eyes of the ecological footprint, to understand their contribution to these global environmental threats.

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