TRANSPORT AND LAND TAKE

A report for

CPRE

by

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October 1994

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INTRODUCTION

Land is a finite resource. The amount of land used for different purposes is a key indicator of the impact of public policies and public expenditure priorities and is a key indicator of progress towards sustainability.

The UK strategy for sustainable development (HMSO, 1994a) identifies land take as an important issue. An estimate of 1.2 - 1.5% is given for the proportion of land in the UK occupied by roads . No supporting evidence or regional breakdown is given and no definitions of land take are advanced. The area occupied by roads and road related uses depends entirely on the definitions used and on the extent to which parking areas can be included in the estimates.

The estimate of 1.2 - 1.5% is applied to the whole of the UK and to England (Davies, 1994). Clearly such a broad estimate will be unreliable when applied to components of the whole. In the case of England 1.2 - 1.5% produces a land take in the range 1603 km^2 to 2004 km^2 (618 sq miles to 773 sq miles). The mid point of this range (expressed in sq miles) produces the figure 695 sq miles which is very close to the figure of 690 sq miles which has been quoted by the Department of Transport as the area occupied by roads.

The amount of land available for housing, industry, health care, education, retailing, recreation and transport is very much a matter for government, both central and local. There are important linkages between traditional compartmentalised policy areas. The development of low density housing in suburban and rural locations reduces the land available for agriculture. The longer distances between these residential locations and urban facilities increases the demand for transport and hence for land allocation for new roads. The decline of traditional industries and transport activities associated with ports, docks and railway sidings release land in urban areas for new developments associated with urban regeneration initiatives. Manufacturers, distributors and transport industries require increasingly large blocks of land to service their road centred activities and in turn generate vehicle movements that provide the impetus for motorway widening schemes and new roads such as the Birmingham Northern Relief Road (BNRR).

In a German study it was shown that a 150 gram pot of strawberry yoghurt is responsible for moving one lorry 9.2 metres (Böge, 1994a) and one 500 gram container of mushrooms is responsible for moving one lorry 65 metres (Böge, 1994b). Our life styles and consumption patterns are dependent on a space extensive and time intensive organisational system. Lorries are space greedy. They need wider roads to take account of turning circles, they need generous parking areas at every supermarket and loading bay and they need overnight parking and rest areas. Roads designed to take 38 tonne, 15 metre long lorries need more space for their junctions and curves than do roads designed for cars or smaller lorries (Schult and Holzwarth, 1988). Increases in lorry length require more generous road alignments and curve radii and larger areas for vehicle parking. Increases in lorry weight require more substantial structures and road pavements which in their turn demand more of the raw materials of construction particularly sand, gravel, cement and steel reinforcements. Heavier demands on raw materials require greater areas for extraction and processing.

German calculations (Teufel, 1989) reveal that a lorry requires 0.007m^2 of space per tonne kilometres in comparison to rail which needs 0.0025m^2. The lorry, therefore, requires almost three times as much space to do the same work as the train.

Translating these space requirements into the UK context produces a land requirement for road freight of 849.1km^2. This is the result of multiplying the 1992 tonne kilometre figure (Great Britain) for road freight (121.3 billion) by 0.007m^2:

$$121{,}300{,}000{,}000 \times 0.007 = 849{,}100{,}000 m^2 = 849.1 km^2.$$

Teufel (1991) has made similar calculations for passenger travel. Table 1 summarises his results:

Table 1

Comparisons of different modes of passenger travel

	Car 1	Car 2	Train	Bus	Bike	Foot
Land Use (1)	120	120	7	12	9	2
Energy (2)	90	90	31	27	0	0
CO_2 (3)	200	200	60	59	0	0

Notes

1 Land use is measured in m^2 per person

2 Energy use is measured in grams of coal equivalent units per passenger kilometres

3 CO2 is measured in grams per passenger kilometres

Table 1 makes a number of points. Land take is very dependent on mode of transport. Motorised modes are very greedy in their land requirements and there is no difference in this respect between car1 (no catalytic converter) and car2 (with a catalytic converter). Land take is also closely associated with other indicators of non-sustainability, particularly energy use and CO2 emissions. Modal transfer to walk and cycle, for example, offers enormous potential to reduce the impacts measured by all three indicators.

TRANSPORT'S LAND TAKE

The European Community's green paper on the impact of transport on the environment: "A community strategy for sustainable mobility" (CEC, 1992a) identifies land take by transport as an important issue.

> *"Transport infrastructure has a permanent and often irreversible impact on the environment in terms of land use and land intrusion"*
>
> CEC (1992a) page 25

The same report goes on to describe the community severance aspect of land take, the loss of habitat and green space and the reduction of available living space. The road network of the European Community takes up a surface area of 28949 km^2 or 1.3% of the total land area. This is a minimalist estimate and does not include the surface area used for intersections and junctions, nor car parks, nor all the land set aside for motorised transport in garages, service areas, petrol stations etc.

There are no reliable data sources for land take for different purposes in the UK or its constituent countries/regions. Such data sources as do exist are reviewed briefly below. Whilst not particularly reliable they do represent the base data used by government in their policy discussions. As such they are an important starting point for any evaluation of land take and any discussion of land take and sustainability.

DoE (1993) has produced detailed estimates of land allocation in GB based on satellite imagery of 240,000 x 1km grid squares. This is summarised below in Table 2.

Table 2

National land cover for GB from the 1990 Countryside Survey

Figures in '00 km^2

	Railway	Road	Total
England	3	32	35
Wales	+	4	4
Scotland	2	8	9
GB	4	44	48

Notes: + = presence <50 km^2 or < 0.5%

The apparent arithmetical errors in the table are due to rounding and standard errors. The numbers in this table are exactly as given in Tables 3.6 and 3.7 of DoE (1993)

The data on road and rail land cover are derived from a sample of km grid squares (N=508) and are therefore subject to error. The surveys were of rural land and excluded areas covered by more than 75% built land or curtilage.

The breakdown of land allocations in the UK is also given in EC statistics (CEC, 1992b):

Table 3:

UK Land allocations

	km^2	%
Arable Land	68666	28.1
Permanent Grassland	111970	45.9
Perennial Crops	590	0.2
Woodland	22970	9.4
Other Land	37746	15.5
Total	241942	99.1

Note: because of rounding errors the percentage total does not sum to 100% and the land area total does not sum to the figure given for the total land area in the UK of 244139 km^2.

The category 15.5% (Other land) in Table 3 roughly corresponds with the definition of land that is occupied by buildings, transport uses and mixed uses associated with non-agricultural and "disturbed" land. This is very similar to the German figure of 13.4% calculated in Pauen-Hoppner (1987). Pauen-Hoppner goes further than a crude national classification and calculates from German statistical sources that 5% of the total land area of the Republic of Germany (1987) is occupied by transport uses. The amount of land given over to transport uses is greater than the total occupied by all built up land including all housing in Germany.

The Umwelt und Prognose Institut in Heidelberg in Germany has calculated that road transport in Germany (the old Federal Republic) occupies 60% more land than the total for all housing purposes (UPI, 1993a). The total land area occupied by roads and parking was estimated as 3,800 km^2 in 1992 or 200 m^2 of asphalt and tarmac per vehicle.

The total area of the old Federal Republic of Germany was 249,000km^2. The land occupied by road transport uses (3800 km^2) represents 1.52% of the total. This is very close to the unsubstantiated figure given for the UK in HMSO (1994a).

The significance of transport's consumption of land lies in comparisons with other major land uses and in the increasing rate with which land is reallocated to transport, particularly road transport uses. Between 1981 and 1985 the amount of land allocated to transport in Germany increased by 25% as a result of 8000km of new road construction and the construction of wider roads. In Germany, as in Britain, new roads are engineered to much more generous standards in terms of width and curvature/alignment than roads built 20 years ago. The land take of a mile of new motorway in 1994 is likely to be much greater than a mile of new motorway when the Preston Bypass (Britain's first motorway, subsequently part of the M6) was opened in December 1958.

German data (Pauen-Hoppner, 1987) also shows that the daily rate of land take for new roads was 23 hectares or 160 m^2 per minute.

Swiss data on road traffic and its land take is revealing. Metron (1989) have calculated that the land allocation for road transport is 113 m^2 per person and for all living purposes (houses/gardens and yards) is 20-25 m^2 per person.

THE UK ROAD PROGRAMME AND ITS LAND REQUIREMENTS

The UK sustainable development strategy (HMSO, 1994a) estimates that between 1985 and 1990, 14000 hectares of land in Britain was used for road construction. The present road programme for England would increase the total area of land under roads by just under 5% (HMSO, 1994a, para 26.14). The sustainable development report does not offer a view about the likelihood or sustainability of continuing to develop 2,800 hectares pa over the next 25 years, nor does it offer a view about the "collateral damage" associated with road building eg loss of important habitat and impact on further rounds of traffic generation. Pfleiderer and Dietrich (1994) have provided evidence of the traffic generation effect of new road construction. New roads occupy land, consume land in the process of extracting raw materials for construction and generate new demnds for land through car parking and additional pressure in the direction of longer journeys and more car dependency.

New roads have large land requirements which must often be accommodated in tightly defined "green" corridors. An example of this is the Birmingham Northern Relief Road.

The Birmingham Northern Relief Road has been designed as a 44km (27 miles) motorway link and is a dual 3 lane motorway for the majority of its length. Total land take for this road is shown in Table 4.

Table 4

Land take for the Birmingham Northern Relief Road

	Hectares
Road, toll stations and maintenance compounds	536
Motorway service area	22
Stream improvements	11
Temporary diversions	4

Source: Birmingham Northern Relief Road, Environmental Statement, Non-Technical Summary, Department of Transport and Midland Expressway, 1994

The Environmental statement presented by the Department of transport and Midland Expressway details land take by section providing a useful insight into the land requirements of major road construction projects These data are summarised in Table 5.

Table 5

Land requirement for sections of the BNRR

	Length km	Land-take ha	Miles	Acres
M6 Saredon Brook to Churchbridge	6	80	3.7	198
Churchbridge to Chasewater/ Burntwood exc service area	6	102	3.7	252
Chasewater/Burntwood to Weeford	9	123	5.6	304
Weeford Island to Wishaw Holly Lane	9.3	111	5.8	274
TOTALS	**30.3**	**416**	**18.8**	**1028**

The land take per kilometre of road is 13.729 hectares. For ease of comparison this can also be expressed as 54.68 acres per mile of dual 3 lane motorway.

Road schemes detailed in "Trunk Roads, England into the 1990s" (HMSO, 1990) have been converted into estimates of land take. The estimates have been made under three headings:

- National Trunk Road Programme schemes completed 25.4.87 - 31.12.89
- National Trunk Road Programme schemes under construction at 1.1.90
- National Trunk Road Programme schemes in preparation at 1.1.90

Engineering specifications for land take have been taken from the description of the road in HMSO (1990) and from "Highway Construction Details" (HMSO, 1987a).

Table 6

Road width specifications from "Highway Construction Details" , HMSO (1987a)

(All data in metres)

Road Type	'Overall width'	Margins	Total
MOTORWAY			
Dual 2 Lane	28.2	12	40.2
Dual 3 Lane	35.6	12	47.6
Dual 4 Lane	42.8	12	54.8
NON-MOTORWAY			
Rural all purpose(S2)	7.3	2	9.3

The meaning of overall width and margins can be seen in the diagrams in Appendix 1 which are highway cross sections A1 and A12 from HMSO (1987)

From Table 6 it can be seen that widening schemes involve an additional land take of 7.4 metres. 7.4 metres is the difference between a dual 2 lane motorway and a dual 3 lane motorway. The same figure is used as an estimate of land take when converting a dual 3 lane motorway to a dual 4 lane motorway.

The results of calculations of land take implied by the road programme in HMSO (1990) are shown in Table 7.

Table 7

Land take of the roads programme in "Trunk Roads, England into the 1990s"

Status of Road	Land take (km^2)
1	11.475
2	9.303
3	81.398
TOTAL	**102.176**

Notes:
All data from tables in HMSO (1990)
1 = Table 1, National Trunk Road Programme schemes completed 25.4.87-31.12.89
2 = Table 2, National Trunk Road Programme schemes under construction at 1.1.90
3 = Table 3, National Trunk Road Programme schemes in preparation at 1.1.90

Table 7 refers to England only. The total area of roads completed in the first row (11.47 km^2) is enough land for 30969 housing units. For all three categories of road the number of housing units that could be accommodated on the same area is 275875.

Whilst there is no such thing as national planning norm for the number of dwellings that can be accommodated on one hectare of land there is, nevertheless, a sound basis in

practice for making an assumption. This assumption is 27 housing units per hectare. The figure is based on detailed records of housing developments in Lancashire and Cumbria covering a large range of types (Brophy, 1994).

The Birmingham Northern Relief Road will, on the same basis, occupy enough land to provide 14472 housing units.

Why use housing as a metaphor for land take?

There is a problem with conveying the importance of the land take for road construction and transport uses. Very few people have a clear view of what given amounts of hectares, square miles, square kilometres, acres or square metres look like. On the other hand many people do have a clear view that 1.5% of something is not very much. The combination of these two factors gives the propaganda edge to those who would wish to see roads, airports, car parks and out of town shopping centres built. We could double the amount of land occupied by roads in Britain and still only have a small percentage figure to worry about.

It is common to convert areas into something else that can be more easily perceived and recognised. Football pitches are often used. The German study referred to above (UPI, 1993a) compares land take for road transport with land take for housing. Housing provides a powerful metaphor because everyone has a strong mental image of the amount of space occupied by a house.

Land take from rural uses of land for road construction (9600 hectares in the period 1985-1990) is second only to housing (23,300 hectares) (HMSO, 1994a, para 26.14). Both housing and transport can make unacceptable demands on a diminishing stock of green land, and there are many situations where neither housing nor new roads is acceptable. Nevertheless the combined pressures of housing and transport and the links through traffic generation effects between the two make a housing metaphor very useful indeed and one that will be readily understood by the wider public.

The 1994 review of the roads programme dropped 48 schemes or part schemes from those in various stages of preparation. The total land take of the dropped schemes was 6.83 km^2 or 8.3% of the total in category 3 of Table 7.

The road programme is a large pre-emptor of land in a situation where there are many competing uses for available land. Whilst it will always be possible to assert that roads "only" occupy approximately 1.5% of available land it is equally relevant to assert that the requirements of housing, industry, recreation, education and health care are very modest. The cumulative effect of lots of very "modest" demands is a total that is immodest and a total that puts significant pressure on sensitive landscapes, AONBs, SSSIs etc. Since transport's land requirements are large and growing it is quite correct to focus on their quantitative significance and on policies that can deliver accessibility, income and quality of life with drastic reductions in land take.

Sustainable transport planning and land use planning can deliver an effective and efficient transport system at much reduced levels of land take, thereby relieving the pressure, protecting habitat and giving way to housing and other developments where these can be planned to high environmental standards and to keep pace with changes in household composition.

LAND OCCUPIED BY ROADS

The data in Table 7 should be compared with estimates for the total land allocation for roads in Britain. TEST (1991) made an estimate of primary land take. The result was a total land take of 2592.854 km^2. This is shown below as Table 8. TEST make a distinction between primary land take and secondary land take. Primary land take is the amount of land actually allocated to road or rail routes together with associated verges and areas of exclusion. Secondary land take is a much wider category and includes the land used to provide the raw materials necessary for construction, (eg sand and gravel) and land allocated to vehicle manufacture, storage etc. Parking falls in the primary category but is not evaluated in the TEST study.

Table 8

Primary land take of the road and rail system in GB - 1988

Type	Total Length (Km)	Average Width (m)	Total Land-take (km^2)	% of GB Land Area
Surfaced Roads				
Motorway	2992	45.0	134.64	
Trunk/Principle	47419	23.0	1090.64	
Other	303904	4.5	1367.57	
Total	354315		2592.85	1.15
Railway Track				
Railway Lines	32628	6.0	195.77	
Sidings	5240	6.0	31.44	
Total	37868		227.21	0.01

Source: Test (1991)

The total land take for roads in Table 8 is calculated for Great Britain and according to TEST (1991, para 6.07) is equivalent to 1.15% of the total land area. No detailed regional or country breakdown is given so a comparison with the Department of Transport figure for England is not possible.

HMSO (1994b) gives more up to date figures on road length reflecting actual values at 1.4.93. These are summarised in Table 9

Table 9

Road length by road class by country

kilometres

	Trunk			Principal			Minor		All Roads
	Motorway	Built-Up	Non Built-Up	Motorway	Built-Up	Non Built-Up	Built-Up	Non Built-Up	
England	2,688.6	980.8	6,801.4	46.7	10,567.7	15,074.3	120,291.0	122,390.6	278,841.1
Wales	119.7	210.9	1,367.7	0.0	849.7	1,804.4	8,845.0	20,415.0	33,612.4
Scotland	254.1	216.1	2,652.5	31.4	1,270.9	6,335.5	13,561.5	27,701.3	52,023.3
Gt Britain	3,062.4	1,407.8	10,821.6	78.1	12,688.3	23,214.2	142,697.5	170,506.9	364,476.8

Source: Road Lengths in Great Britain 1993, The Department of Transport

An estimate of the total area given over to roads can be made from road length data multiplied by average road widths.
Road width data has to be inferred from a number of sources and is not available in published statistics.

For motorways a width of 47.6 metres is assumed. This is the width from boundary fence to boundary fence of a dual 3 lane motorway (see diagram in Appendix 1). Dual 3 lane is selected to reflect the dominant motorway type even though a considerable amount of widening to dual 4 lane is underway. The land set aside for motorways is not available for any other purpose or any form of public access other than the vehicular use for which it was designed. For this reason it is appropriate to take the total cross-section into account. Since the total cross-section consists of two thirds carriageway and one third marginal land of various kinds this is an important definitional issue.

For trunk roads and principal roads there is not a clear cut answer given the great variety of widths actually in place. HMSO (1987a) details two relevant standards:

- Urban all purpose roads with carriageway width of 14.6 metres excluding central reservation, footways and verges (Drawing A9)

- Rural all purpose roads with carriageway width of 7.3 metres excluding verges and hardstrips (Drawing A2).

For definitional purposes the non-carriageway parts of all purpose rural and urban roads have been excluded from the calculations. This is consistent with the motorway definition which includes these components. These margins are open to public access in a way that motorway margins are not.

The width assumption for all principal/trunk roads for area calculations is taken as the mean of rural all purpose/urban all purpose (14.6 + 7.3 ÷ 2 = 10.95).

The width assumption for minor roads is taken as the minimum for two way two lanes local distributor in residential districts. This is 6m (Architectural Press, 1979).

Width assumptions are summarised in Table 10

Table 10

Width Assumptions for calculating road land take

Road Type	Width in metres
Motorways (1)	47.6
Trunk/principal (2)	10.9
Minor (3)	6.0

Sources:

1 HMSO (1987a) Highway construction details, Drawing A1

2 HMSO (1987a) Highway Construction details, Drawings A2 and A9

3 Architectural Press (1979) New Metric Handbook, Recommended Carriageway widths, Table IV, p36, local distributor in residential district.

Table 11 summarises the calculations on land area allocated to roads in Great Britain . Road length is taken from table 9 and road width from table 10.

Table 11

Land allocated to roads in England, Wales, Scotland and GB

(Road length in km, area in km^2)

	Motorway		Principal Trunk Road		Minor Road		Area
	Length	Area	Length	Area	Length	Area	Total
England	2735.3	130.20028	33424.2	364.32378	242681.6	1456.0896	1950.6
Wales	119.7	5.69772	4232.7	46.13643	29260.0	175.56	227.39
Scotland	285.5	13.5898	10475.0	114.1775	41262.8	247.5768	375.34
GB	3140.5	149.4878	48131.9	524.63771	313204.4	1879.2264	2553.4

The amount of land allocated to roads in GB as at 1.4.93 was 2553.4 km^2.

The DoE (1993) survey referred to in Table 2 gives the total amount of land allocated to "continuous urban" and "suburban" as 15772 km^2 or 6.6% of the land area. Roads themselves, a proportion of which will be subsumed within the 15772 figure, account for 4400 km^2 or approximately 2% of the land area of GB.

The disparity between our figure of 2553.4km^2 and the DoE (1993) figure of 4400 km^2 is not surprising. The DoE figure is based on sample data with sampling error and takes into account all the components of the road system including all the land at intersections, within roundabouts and on roadside verges (Barr, 1994). Neither our calculations, nor those of the DoE take into account car parking or areas of hard standing reserved for car or lorry traffic.

Given the uncertainties and unreliability of the DoE (1993) estimates we prefer to conclude with our figure of 2553.4 km^2 (985.6 sq miles). This is 42% larger than the DoTs own estimate of 690 sq miles and very close to the 1000.8 sq miles calculated by TEST (1991)

SECONDARY LAND TAKE

The land occupied by roads in Britain does not represent the totality of land that is dedicated to road transport uses. The most obvious addition is parking but considerable areas are set aside for petrol stations, motorway service areas and all the service and ancillary activities associated with maintaining a car dependent society.

The space greedy nature of car dependency is often described by reference to the US situation:

> *"Up to 10% of the arable land in the US is taken up by auto infrastructure...about half of all urban space in the US is now devoted to auto-centred transport. In Los Angeles two thirds of land space is devoted to auto use ..... the average car (in Los Angeles) uses up to eight parking spaces daily, each located at different activities. In suburban New Jersey, developers are now required to build 3000 sq feet of parking space for every 1000 sq feet of commercial office space"*
>
> Freund and Martin (1993) page 19

TEST (1991) developed the idea of secondary land take to include the area devoted to providing the raw materials necessary for the construction of road and rail infrastructure. This would include all the land allocated to the mining and quarrying operations for raw materials used in making vehicles and in manufacturing steel and concrete (and making the cement) used in road construction. This approach is suggestive of a thorough life cycle analysis (LCA) which would take into account land take for these purposes throughout the world and link total land take to a passenger kilometre of car use in Britain. The resources for such an ambitious exercise are not available though there are no technical problems in its execution. The discussion of the vehicle's wider impacts on environment, society and development will continue to be deprived of this "ecological footprint" component.

A methodology

It is necessary to establish a logical framework for the collection of data and estimate of secondary land take. Pauen-Hoppner (1987) carried out her analysis of land take in Germany within a fourfold classification system (Table 12).

Table 12

German classification system for land take in the transport system

No.	Function	Examples
1.0	Travelling	Roads, areas set aside for drainage, noise protection etc
2.0	Parking	
	2.1 Outside	Private Car Parks Public Car Parks Street Parking
	2.2 In Buildings	Garages, Multi-storey
3.0	Service	Petrol stations, car repair, rest areas, police services, road maintenance
4.0	Sterile areas	Traffic islands, etc

Source: Pauen-Hoppner (1987)

Interestingly after producing this framework, Pauen-Hoppner decided that it was not possible to estimate the areas of categories 2.0 - 4.0. Similarly TEST (1991) concluded their opening remarks about secondary land take as follows:

> *"There is limited information available to allow an assessment of the scale of this type of land take in the UK"*
>
> TEST (1991) page 179

In this study we will follow the Pauen-Hoppner classification as far as possible.

PARKING

Parking takes up a lot of space. The Merry Hill shopping centre to the south of Dudley has 10000 car parking places and the NEC in Birmingham 15000. A standard parking bay is 4.8m x 2.4 m; 24 m^2 per place is assumed as a planning norm (Architectural Press, 1979). Applying this constant to Merry Hill results in a figure for car parking of 24 hectares and 36 ha for the NEC. The Merry Hill car park could provide housing for 648 housing units and the NEC, 972 housing units.

Since car parking requires aisles as well as bays and aisles are 6m wide calculations of land take based on bays alone are underestimates.

Off Street Car Parking

A major component of car parking provision is off street car parking provided by private contractors eg NCP or local authorities. This car parking is additional to that provided in purpose built shopping centres and super stores. Information on off-street car parking is not available in any central statistical source even though it is an important dimension of transport provision and an important determinant of the growth in car based trips (Topp, 1994). Burt and Sparks (1991) have calculated average levels of car parking provision in Great Britain. They give two sets of values:

> *..for "core" town centre areas an average level of provision between 2.2-3.0 places per 1000 sq feet of retail selling space.*
> *..for a wider town centre area an average level of provision of between 4.0-6.0 places per 1000 sq feet of retail selling space.*

The Burt and Sparks ratios do not differentiate between ground level parking and parking that takes place in underground or multi-storey car parks. They cannot be used, therefore, to make estimates of land take for car parking.

In order to make an estimate of ground level off street car parking we undertook a telephone and fax survey of local authorities to obtain numbers that specifically related to ground level parking. The results of this survey are tabulated in the appendices and made it possible to calculate an average ratio of car parking places to population of 210 places per 10,000 people.

This average ratio is then applied to the population of England to determine the number of car parking places supplied by local authorities in ground level car parks.

48.2M (Population of England, 1991 census) divided by 10000 x 210 = 1,012,200

1,012,200 car parking spaces at 24m^2 per space = 24.3km^2

Lothian Regional Council (1992) has conducted a survey of car parking provision in 16 cities in Great Britain. They found an average level of provision of 22.39 spaces per 1,000 population. This approximates very well to our survey results of 210 per 10,000 population.

NCP (National Car Parks Ltd) operate 600 multi-storey, surface and underground car parks in the UK. Their national guide (undated but sent in response to a July 1994 request) details all NCP provision. The total number of car parking spaces provided in ground level car parks (ie multi-storey and underground excluded) is 33922 for England. Scotland and Wales have relatively small numbers and are not included in this analysis.

At 24m^2 per space NCP provision for England can be calculated as:

33922 x 24 = 0.814Km^2

Underground and multi-storey car parking

For the purposes of our study underground car parks have been excluded. Multi-storey car parks have been included but only for their ground area. There are 3500 multi-storey car parks in the UK (Parking Review, May/June 1990). Each multi-storey car park should have a minimum ground area of 35m x 35m or 1225m^2 (Institute of Highway Engineers and Department of Transport, 1987). Clearly this minimum will be exceeded in many cases but for the purposes of this calculation the minimum is used.

The area occupied by multi-storey car parks in the UK is 3500 x 1225m^2 = 4.29Km^2.

Shopping provision

Shopping is increasingly car-oriented and the provision of parking at or near retail outlets an important consideration in planning and development at local authority level. TEST (1989) have documented the average number of car parking spaces by shop type and location. This information is contained in Table 13.

Table 13

Average number of car parking spaces by shop type and location

	LOCATION				
Shop Type	Out-of-Town	Urban, & Out-of-Centre	District Centre	Town Centre	TOTAL
Purpose Built Shopping Centre	5725	4098	890	857	1940
Retail Warehouse	1316	210	766	110	230
Superstore/hypermarket	382	333	423	498	456
TOTAL	2928	376	478	819	476

Source: "Trouble in Store?", TEST, 1989

The Advertising Association (1994) has documented the number of hypermarkets and superstores. These are defined as retailing units of more than 25,000 sq feet, with dedicated parking and removed from traditional shopping centres. The data refer to 1992 and are summarised in Table 14.

Table 14

Hypermarkets and superstores by country/regional grouping, and selling space and land take for car parking

Country	Number	Selling space	Car parking area	
	Open	000 (m^2)	(m^2)	(Km^2)
UK	776	2769.2	8492544	8.49
England	680	2434.2	7441920	7.44
Wales	28	97.2	306432	0.31
Scotland	48	176.4	525312	0.52
Northern Ireland	20	61.4	218880	0.22

The car parking area in Table 14 is calculated by taking the car parking space average per unit in Table 13 (456) and multiplying the total number of spaces by 24m^2. Thus 776 units in the UK at 456 car parking spaces per unit has a total car parking allocation of 353856 which at 24m^2 per space has a land requirement of 8.49 km2. The total for England (7.44 km^2) is 87.62% of the UK figure.

Business parks

Westside at Kings Langley offers 175000 sq feet of office space with 730 car parking spaces. The brochure extolling its virtues makes great play of its motorway location and excellent road links. Stockley Park in West London has a workforce of 4000, 85% of whom commute by car to their company provided car spaces adjacent to their offices. Chiswick Park, a planned business park near the M4 motorway will have 2100 car parking spaces. Table 15 lists a selection of business parks and their gross floor area.

Table 15

Business Parks listed in the TRICS database and Parking Review article (June 1993)

BUSINESS PARK	AREA (ha)	FLOOR AREA m^2	PARKING SPACES
Newbury BP	2.7	10561	568[1]
Reading BP	6.9	7573	407[1]
Lakeland BP, Allerdale	1.2	2120	116
Stockley Park, Hillingdon	-	31000	960
Uxbridge BP Denbridge Estate	-	16497	360
Broadwater Park, Hillingdon	-	32500	537
Carrington BP, Manchester	1.3	12077	500
Mole BP, Surrey	-	16000	700
Woking BP	-	23000	600
Southwater BP	4.0	16250	874[1]
Westside		16257	730
Chiswick Park		?	2100
TOTAL			**8452**

Note[1] Actual number not given. This number estimated from 1 : 18.58 ratio.
Source: TRICS Database, JMP Consultants, 1993 and Parking Review, June 1993.

Parking Review (June 1993) gives a parking space/floorspace ratio of 1:200 sq feet (1:18.58m^2). The total area of floorspace in Table 15 is associated with 8452 car parking spaces and a land take of 202848 m^2 or 0.20Km^2.

Brown (1993) has reviewed the development of business parks in the UK quoting the results of surveys by Applied Property Research. In 1993 the total office space in business parks was 67.7 million sq feet with another 65 million sq feet in the pipeline. 67.7 million sq feet produces a car parking requirement of 338,500. This in turn produces a land take of 8.12km^2.

Employment

The provision of car parking at a place of work represents a significant proportion of total car parking places in an urban area. Private non residential car parking (PNR) is a major source of concern for urban transport planners and those seeking to achieve a modal shift in the direction of public transport, walking and cycling.

This important area of transport policy is not covered by data sources. Occasionally planning documents describe the situation in a particular location. Lancaster has 3815 private spaces compared to a public off street total of 1715. Cambridge has 40000 PNR spaces of which 17000 are in inner Cambridge.

Hudson, Shoarian-Sattari and Kompfner (1993) carried out a large scale survey of parking in London and concluded:

"Off street parking information was more difficult to establish and our estimates are subject to some degree of uncertainty".

TEST (1984) have made an estimate of the number of firm provided parking spaces. Though very dated it can still be used to provide an estimate of land occupied by car parking for this purpose. As the estimate pre-dates the development of business parks we can assume that there is no double counting of car parking spaces between these two categories.

The TEST estimate is based on an analysis of data in the National Travel Survey documenting car drivers' journey to work ending with parking in a firm's or private car park paid by the firm: "This results in a national estimate of about 5 million parking spaces provided by the employer" (TEST, 1984, page 39). There is no way that this figure of 5 million can be disaggregated into sub-categories eg multi-storey, underground, ground level. It cannot, therefore, be used to quantify land take.

Five million spaces at ground level would require 120 km^2 of land.

Lothian Regional Council (1992) have conducted a survey of car parking which included private non-residential (PNR) parking. Their survey of 16 cities in Great Britain revealed 97,626 PNR places, an average of 6102 per city. We can use this average to make an estimate for PNR places for England. We will assume a cut off point for city size of 100,000. Our estimate will include only those urban areas in England with a population of greater than 100,000. There are 53 urban areas in England with a population of greater than 100,000 (OPCS, 1984). Thus we can calculate:

53 x 6102 = 323406 spaces = 7,761,744 m^2 assuming 24m^2 per space or 7.76 km^2

No data are available to identify the proportion of this total that is surface car parking as opposed to underground or multi-storey.

There are an additional 64 urban areas in England with a population in the range 50,000-99,999. These have been excluded from the analysis because the Lothian Region survey is biased towards larger urban areas (average size 37,1038) and it would not be appropriate to extrapolate to smaller sized areas.

London merits separate treatment and in any case is not part of the Lothian Region (1992) survey. The average number of PNR spaces per urban area in the Lothian Region survey was 6,102. Hudson, Shoarian-Sattari and Kompfner (1993) have produced data to show that central London has 43,464 PNR spaces. If we assume ground level parking this would occupy a land area of 43,464 x 24m^2 = 1043136m^2 or 1.04 km^2.

Given the use of multi-storey and underground car parking in Central London we cannot assume that the PNR total is ground level and no data are available to permit a disaggregation into different kinds of car parking.

No data are available on PNR spaces in London outside the central area defined by Hudson, Shoarian-Sattari and Kompfner.

Land take for employee parking at places of work is very difficult to quantify. We will carry forward the estimate of car parking space in English towns with a population greater than 100,000. This is an overestimate because of the problem of disaggregation into different kinds of car parks. We will not include any estimate of car parking space in central London because of the likelihood that a significant proportion will not be surface car parking and we will not include any estimate of employee car parking in outer London because there is no data. The overall result of these exclusions will be to underestimate land take for car parking.

Heavy Goods Vehicles

The 1992 statistical report "Goods Vehicles in Britain" (Department of Transport, 1992) gives the total HGV population as 415000. The IHT/DoT standard for the amount of space required for parking an HGV is 150-200m^2 for an articulated vehicle and 100-150m^2 for a rigid vehicle. We will assume that each HGV has at least one off-road parking place at its home base and that each HGV can be accommodated off-road at a potential destination. The area required for HGVs in GB is, therefore:

2 x 415,000 x 150 = 124,500,000m^2 or 124.5 km^2

Each HGV parking space is assumed to be 150m^2.

This is a crude estimate and almost certainly an underestimate but a useful guideline value nevertheless. Our study has not included land allocated for HGVs or containers at ports, on industrial estates, at specialised lorry parks and rest stops, at superstores or out of town shopping centres and at major centres of physical distribution and logistic activity eg sites owned and operated by TNT, Wincanton, TDG, Christian Salveson, McGregor Cory and Norbert Dentressangle.

Land take for activities wholly concerned with motor trades

Business Monitor (1991) lists the number of businesses active in Great Britain at that time in the motor trades. These are listed in table 16.

Table 16

Motor trades (SDA 27)

All Motor Trades	74,142
Retail Distributors	27,865
Wholesale Distributors	4,028
Repair and servicing	34,458
Petrol filling stations	7,791

Source: Business Monitor (HMSO, 1991)

Architectural Press (1979) gives enough information on standards, regulations and recommendations for retail outlets, wholesaling, repair and servicing and petrol filling stations to allow an approximate unit area to be determined. In all cases there will be an enormous variety of sizes in practice and conservative assumptions have been used here. Table 17 summarises the results of applying average size assumptions to a number of outlets in each class.

Table 17

Land take for businesses wholly involved in the motor trade

Type	Number	Unit Area m^2	Total Area Km^2
Retail distributors	27,865	150	4.18
Wholesale distributors	4,028	750	3.02
Repair and servicing	34,458	250	8.61
Petrol filling stations	7,791	507	3.95
		TOTAL AREA	**19.76**

Education

Education is an important journey purpose and is increasingly important as a traffic generator both for school trips and for higher education. The size and location of schools is an important variable in the sustainable transport equation and there is a very clear link between size, location and car dependency. Schools that are very large serve a large catchment area and have a higher proportion of staff and children who travel to school by car than in the case of smaller schools serving populations within walking distance.

In January 1993 there were 32997 schools in Great Britain (Walton, 1994). The number of parking places at schools is very variable indeed and for the purposes of this exercise we will assume 10 parking places per school. This is an extremely conservative assumption given the range of staff size at schools from under 5 to over 100. Car parking standards at schools recommend one space for every two staff plus additional space for visitors. In practice these standards will be difficult to produce and a proportion of schools parking will spill over onto nearby residential roads.

If we assume $24m^2$ for each parking space then the amount of parking on school grounds can be evaluated as:

$$32997 \times 10 \times 24 = 7919280m^2 = 7.9\ km^2$$

Universities are a particularly sensitive barometer of increasing car dependency and one that can be tracked through time by monitoring car parking land take.

The University of Lancaster was founded in 1964 on a green field campus site three miles south of the centre of Lancaster, beyond the edge of the built-up area in the countryside. The university has 1665 staff and a student population of 7100 (1992). The student total is expected to grow to 10000-15000 by the year 2000. A third of the students and two thirds of the staff commute by car. This level of car dependency is encouraged by a clear policy of preference towards car based access. This manifests itself through car parking space provision (2500 spaces) at a considerable cost to the university and no financial support to public transport. Travel to and from the University generates 3.5 million passenger kilometres pa and over 700 tonnes of pollutants. The projected increase in student numbers will create a demand, without a change in behaviour, for an additional 1480-3330 parking places (Armstrong et al, 1994).

There are 12 Universities in Britain that can be described as space extensive, campus based universities with generous levels of car parking. They are:

Bath, Essex, Exeter, Keele, Kent, Lancaster, Reading, Surrey, Sussex, Warwick and York.

We will assume an average level of car parking of 2500 spaces for this group. This produces a land take of $2500 \times 12 \times 24 = 720{,}000m^2 = 0.72\ km^2$.

There are 123 universities in Britain (1993) most of which, like Lancaster, have ambitious plans for expansion. Many are seriously constrained by space problems including those in central cities who were, until recently, in the Polytechnic sector and the 31 constituent schools of the University of London. Nevertheless all strive to provide parking for groups of staff (though sometimes not students) even when they are located near good bus and rail facilities (eg Salford, Aston, Manchester and Cardiff). Salford and Cardiff have their own railway stations and Aston is within easy walking distance of Birmingham New Street.

Universities are important because of their expansion plans and because of the low level of awareness of concepts of demand management and sustainability. They represent, therefore, an important source of extra travel demand for the future that in all likelihood will be fuelled by additional car parking provision, including multi-storey.

Current land take for car parking can be calculated by assuming an average of 500 spaces per University. This assumption is based on a survey of 22 universities attending

a course at Warwick University on car parking problems ("Mad Car Disease" 5-6 May, 1993). The course was led by John Whitelegg and the course participants provided details of their own institutions car parking numbers and transport policies. Further evidence on car parking provision in institutions of higher education was provided by a survey carried out by Kathy Ramsden of the Department of Independent Studies of Lancaster University in 1992. For non-campus institutions she found a wide range of provision: Bradford (1060); Coventry (300); Imperial College (650); Liverpool (1750); Oxford Brookes (370); Sheffield Hallam (200).

The number of Universities minus the campus universities is 111. Land take for car parking is calculated as follows:

$$111 \times 500 \times 24 = 1332000 m^2 = 1.33 km^2$$

Hospitals

Hospitals are characterised by large car parks and severe pressure on available space often leading to arguments about charging for visitors and patients (Parking Review, July/August, 1993). As hospitals have grown in size and complexity serving large hinterlands these problems have increased. Locational and organisational decisions within the health services rarely take on board questions of access and public transport and hospitals, like universities, are significant sources of traffic derived pollutants.

The reduction in the number of smaller hospitals over the last 20 years and the centralisation of facilities at fewer sites have both increased the amount of travel for health care and triggered the growth in car parking provision.

The Royal Liverpool Hospital added 1200 new spaces to its site in 1993. Addenbrooks has 2300 parking spaces for staff and visitors and Southampton General has 1800 parking spaces. Lancaster Royal Infirmary is a District General Hospital serving a catchment area of approximately 130,000 people and is on a congested city centre site with a mixture of new and 19th century buildings. Nevertheless it provides 583 car parking spaces, 80% of which are for staff and contribute to severe city centre congestion and demands for new roads to by-pass Lancaster City Centre.

Bolton infirmary, also in a crowded urban area, provides 725 car parking spaces.

407 hospitals are listed in the league tables for England produced by the government in June 1994. These are the main hospitals serving their district and regional catchment areas and it is assumed here that each has 900 car parking spaces. The figure of 900 is the average of all those hospitals contacted for this survey. They are listed with their car parking totals in the Appendices.

The amount of space occupied by car parking in English hospitals can be calculated as:

$$407 \times 900 \times 24 = 8791200 m^2 \text{ or } 8.79 km^2$$

Hospitals, like universities, have a responsibility to audit their "core business" in terms of environmental impacts, and space made available for parked cars is a keen indicator of the wider impact of organisational decisions. Adding extra car parking spaces in a long term incremental manner to "solve" perceived operational problems and satisfy staff demands for subsidised journey to work opportunities is a clear example of non-sustainable policies at work at the institutional level.

Residential

There are 23,298,374 physically separate households in Britain (OPCS, 1993). The breakdown into type of housing is shown in table 18.

In this study we shall assume that each detached house can accommodate two cars within its own grounds and each semi-detached house, one car. Terraced houses are assumed to have no space available for parking. In many parts of London and the South

East this is not the case. Terraced houses with small front gardens have had their front gardens removed and paved over to provide hard standing for cars. Semi detached houses originally designed to accommodate garden space around the sides have had this replaced by hard standing/car ports and many new developments have had dedicated areas of garaging built in addition to any land available for parking within the curtilage of the property.

The assumptions made in this study are, therefore, very conservative. They are not as generous as the findings of a large scale survey in Winter, Coombes and Farthing (1993) which reported 2 garage/parking spaces per house and in addition one visitor space for every 3-5 residential units.

Land take for domestic curtilage parking is shown in table 18.

Table 18

House types in Great Britain in 1991 and land take for car parking.

	Number	Land-Take km^2
Detached	4,637909	222.61
Semi-Detached	6,703921	160.90
Terraced	6,718,364	
	TOTAL	**383.51**

Source of house type data: 1991 census, CEN91 HAC, Housing and availability of cars, GB (OPCS, 1993)

Note
- parking space = $24m^2$
- space estimates have not included any allowance for drives or for garages which take more space than an open car parking space ($33m^2$ compared to $24m^2$ for the open space)

The amount of space allocated to cars in this minimalist assessment of land take is enough to provide for over one million new homes (1,035,477).

Recreational facilities

A large number of recreational facilities provide car parking for their staff and customers. Examples are listed in Table 19. Estimates of numbers of car park spaces have been obtained by telephone surveys and once again very conservative estimates have been inserted in Table 19.

Table 19

Recreational facilities in Great Britain

Type	Number	Car Spaces	Land-Take km^2
Football clubs	92	250	0.552
Sports grounds	2000-4000 (1)	50	3.6
Sports Centres	1200	25	0.72
Swimming pools	1200	25	0.72
Race courses	59 (2)	500	0.71
		TOTAL	**6.302**

Notes:
1. For this calculation N is assumed to be 3000
2. Race courses can have much larger numbers of spaces eg Aintree with 5000 car spaces

Airports

The growth in demand for aviation makes airports particularly important. The land requirements of aviation as a whole are not the subject of this report but it is worth noting in passing that forecasts of future growth in air travel are already fuelling a number of ambitious airport development projects that are very space greedy. These include:

1. The Manchester Airport second runway proposal has identified 231 hectares of land as being required for the development. All this land is green belt and much of it characterised by very attractive wooded and geomorphologically important features in the valley of the river Bollin
2. Terminal 5 at Heathrow would take 101 hectares. Heathrow itself occupies 1197 hectares.
3. Redhill Airfield, a proposal to develop an existing, lightly used aerodrome covering 191 hectares into a major airport with 2.5 million passengers pa, terminal buildings and car parking, a new motorway link from the M23 into the site and a 220 bedroom conference hotel and associated car parking. The whole site is in the Surrey green belt.

Airports are major traffic generators and in south east England centrally involved in the rising levels of traffic congestion that fuel the demand for widening of the M25 and M4.

Airports occupy large sites and have large areas devoted to car parking (Table 20)

Table 20

Selected airports: total site area and land take for car parking

Airport	Total site area (ha)	Car spaces	Land-Take (ha)
Heathrow	1,197	24,249	58.19
Gatwick	759	28,571	68.57
Stanstead	975	24,000	57.60
Luton	274	*	*
Manchester	607	14,280	34.27
East Midlands	*	3,960	9.50
Bristol	*	4,740	11.37
TOTAL	**3,812**	**99,800**	**239.5**

* data not available *Sources: Faxed survey; Airports Policy Consortium*

The land take for car parking purposes in these selected airports amounts to 239.5 hectares or 2.395 km^2. The airports covered in this sample account for 75.8% of the passenger throughput of UK airports. We assume that there is a constant relationship between passenger throughput and car parking provision at UK airports and therefore have factored up the land take for car parking to represent the total for UK airports:

$2.395\ km^2 \div 75 \times 100 = 3.19\ km^2$

SUMMARY OF SECONDARY LAND TAKE

Table 22 summarises all the components of secondary landtake (car parking) quantified in this report.

TABLE 22

Secondary Land-take - Summary

Type	Sub-type		Land-take km^2
Hypermarkets and supermarkets		UK England	**8.49** (7.44)
Multi-storey		UK	**4.29**
Off-street ground level Local Authority		England	**24.3**
NCP		England	**0.81**
Business Parks		UK	**8.12**
HGVs		GB	**124.5**
Motor Trades	Retail distribution	GB	4.18
	Wholesale distribution	GB	3.02
	Repair & servicing	GB	8.61
	Filling stations	GB	3.95
		TOTAL	**19.76**
Education	Schools	GB	**7.9**
	Campus Universities	UK	**0.72**
	Non-campus universities	UK	**1.33**
Hospitals		England	**8.79**
Residential	Detached	GB	222.61
	Semi-detached	GB	160.90
		TOTAL	**383.51**
Recreational	Football clubs	GB	0.55
	Sports Grounds	GB	3.6
	Sports Centres	GB	0.72
	Swimming Pools	GB	0.72
	Race courses	GB	0.71
		TOTAL	**6.3**
Airports		UK	**3.19**
Employment		England (excl London)	**7.76**

Total UK secondary land-take = 609.77Km^2.

LAND OCCUPIED BY ROAD TRANSPORT: REGIONAL AND COUNTRY DISTRIBUTION

Table 23 shows the area of land occupied by roads in each of the standard economic regions of England plus totals for England, Scotland, Wales and Great Britain.

Table 23

Road Lengths and Area by Economic Planning (Standard) Regions and by Country (length in km; area in km^2)

	Motorway W = 47.6		Trunk/Principal w = 10.9		Minor Road		
Region/ Country	Length	Area	Length	Area	Length	Area	Total Area
Northern	152.4	7.25	2895	31.55	20391	122.34	161.14
Yorkshire & Humberside	289.5	13.7	3375	36.79	25663	153.98	204.47
East Midlands	184.6	8.8	3965	43.21	24743	148.46	200.47
Eastern	315.7	15.03	4772	52.01	35665	213.99	281.03
South East	567.4	27.00	4917	53.59	33096	198.57	279.16
Greater London	59.8	2.84	1738	18.94	11588	69.53	91.31
South West	301.8	14.37	5035	54.88	42832	256.99	326.24
West Midlands	377.9	17.99	3600	39.24	26260	157.56	214.79
North West	486.2	23.14	3163	34.48	22441	134.64	192.26
England	2735.3	130.2	33424	364.32	242681	1456.08	1950.6
Wales	119.7	5.70	4232.7	46.13	29260	175.56	227.39
Scotland	285.5	13.59	10475	114.17	41263	247.57	375.34
Great Britain	3140.5	149.49	48132	524.63	313204	1879.22	2553.34

Source of road length data: HMSO (1994) Transport Statistics Report. Road Lengths in Great Britain, 1993.

CONCLUSION

The amount of land occupied by roads in Great Britain is 2,553km^2.

The amount of land occupied by roads in the UK is 2,848Km^2. The Great Britain figure represents 1.06% of the land area of that geographical unit and the UK figure 1.17% of the total land area including Northern Ireland.

Table 11 details the equivalent percentages for England, Scotland and Wales. Land take for roads in England represent 1.45% of the land area of England.

Our calculation for Great Britain is very close to that carried out by TEST (1991). Their total was 2592.85 km^2 and is considerably larger than a Department of Transport estimate of 1787.1 km^2 (690 sq miles).

Secondary land take has been calculated from a wide variety of sources which can only be amalgamated at the largest geographical scale which is at the level of the UK. This corresponds with the definitions used in the UK sustainable strategy document (HMSO, 1994a). The data shown in table 22 produce a UK land take of 609.77 km^2. Because of serious data deficiencies it is not possible to produce a reliable estimate for Great Britain or to disaggregate the many sources of data into individual countries.

Both land take for roads and secondary land take have been calculated on the basis of extremely conservative assumptions. Some important categories of land take, eg all the land occupied by motor vehicle manufacturing, is simply missed out altogether. The land devoted to sand and gravel extraction destined for road building has also been omitted. The final numbers are interesting but only measure one point in a steady progression to higher levels of land conversion and higher levels of car dependency justified by claims that only small amounts of land or small amounts of pollution and carbon dioxide are attributable to the transport sector. 'Small' in this context is used to down grade the importance and the seriousness of transport's contribution to non-sustainability.

A significant issue in land take has been omitted completely from this report. Our car dependency is based on global patterns of energy and raw material extraction and transport. Oil, bauxite, rubber, iron, rare minerals for catalytic converters and much more are required to feed car manufacturing and repair. A full audit of the car and its life time impact would require a map of its global footprint and this footprint is likely to get much bigger if predictions of alternative fuels come to fruition and we substitute fuels that began their life as crops for fuels that were extracted from under the ground or under the North Sea. The size of the global footprint might well exceed the amount of land allocated to the roads and secondary uses identified in this study.

The calculation of the size of the final land take reveals a process of land conversion that proceeds and accelerates in a large number of non-connecting policy areas and institutional responses to travel demand. The whole really is greater than the sum of the parts and the spread of car parking around universities, hospitals and airports demonstrates the close links between land take, higher levels of car commuting and the demands for more road space. Attention given to land take reveals the interdependencies of land take for road space and land take for car parking and auto-dependency. If land for car parking is reduced then the cycle can be interrupted and the demand for new road space dampened down as land uses adjust to different patterns of transport supply and better public transport, walking and cycling facilities are installed.

Land is a scarce and finite resource and green field developments to maintain auto-dependency a particularly inefficient user of land. Cars are only used for 2.8% of the time and then often by one person (UPI, 1993b). The rest of the time they are parked somewhere doing nothing. Allocating land to such inefficient uses is bad value for money and bad prioritisation given the many pressures on land in Britain in the 1990s.

Throughout this report reference has been made to housing units that could be accommodated on a given amount of land dedicated to car or lorry use. This has been done to emphasise the point that land is precious and that when choices have to be made between transport, housing, education, employment, recreation and health facilities we really must ensure that the land requirements of all these activities are compared one with another and with the remit of sustainable development. Where land can be conserved as it can by reducing the demand for transport then transport demands should have a lower priority than (say) health or education. Where universities, schools or hospitals need to expand then they can be encouraged to do so on land previously allocated to parking or on sites with no provision of new parking.

The total amount of space allocated to road transport uses (primary and secondary) in the UK totals 3,458km^2.

The UK car population in 1992 was 20.631 million. Dividing this total of cars into the total space produces a space requirement per car of 167.6m^2. This figure very much underestimates the true picture but is large enough to underscore the wider ramifications of car dependency in terms of land take. The result for Germany (UPI, 1993a) was 200m^2 per vehicle.

Forecasts of future levels of car ownership (BRF, 1993) indicate a low value of 30.160 million and a high value of 33.713 million in 2020. Applying 1992 space norms (ie 167.6m^2 per car) to the 2020 low estimate implies that we have to find an additional 9.529 million x 167.6m^2 space if we are to maintain current space standards. This space requirement totals 1,597Km^2. This amount of additional land is clearly not going to be found and the only conclusion, therefore is that conditions are going to get very much worse for everyone, including drivers, by the year 2020, as the space norm is literally and metaphorically driven down.

Increasing levels of car ownership and increasing number of trips exact a penalty in the form of increased land demands. Current levels of dissatisfaction with congestion and parking problems are likely to intensify as the pressure on facilities rises. Policy makers and politicians becoming accustomed to think in terms of air pollution and carbon dioxide emissions from transport sources need help to think through the land take implications of pursuing "business as usual" scenarios.

Land take must be taken seriously as an indicator of sustainable development and as a measure of the gross inefficiencies of the current system of funding and prioritisation in transport policy. If the primary and secondary land requirements of transport policies and road programmes were made explicit and were also published in association with forecasts of car ownership and travel demand then the alternatives to car dependency would emerge as much stronger policy options and far better value for money.

Land is at the centre of sustainable transport debates. The car-free residential suburb in Bremen-Hollerland will provide high quality housing, better community facilities, clean air and better play conditions for children (Glotz-Richter, 1994). It will need 30% less land than that needed for an equivalent size of development based on the usual norms for car parking, roads etc.

Land take is also an important European issue. The Trans European Road Network (TERN) proposed by the European Commission is based on a plan to "complete or upgrade" 12000 km of routes by 2002 (CEC, 1993). This plan has major implications for land take in all EU countries and serious consequences for rural areas and areas of ecological significance. It would be very appropriate to translate the TERN proposal into both primary and secondary land take estimates and subject this to both a conventional EIA (but for the whole network) and an SEA focusing on wider objectives including greenhouse gases, NOx reduction, ozone levels, acidification and land take.

There is a growing European recognition of the importance of land take for road transport uses and our study is the first in the UK to attempt the extremely difficult task of constructing a land take inventory that is comparable with work in other European countries. UPI (1993a) estimated that road transport (road space and parking) occupied 1.52% of the total land area of the pre-unification FRG. This is very close to the Great Britain figure calculated in our report. Pauen-Hoppner (1987) has produced an estimate of 5% for the same calculation but does not give enough detail for the source of the large discrepancy between his study and the UPI study to be identified. Metron (1989) carried out an extremely detailed inventory of road transport land take in Switzerland and calculated that all road space, parking space and other road transport related land uses occupied 1.76% of the total land area of Switzerland.

There is a clear consensus in those studies that have published enough data for an evaluation to take place that road transport land take is less than 2% of the total land area of the country. The range of values is not wide:

UK	1.42%
FRG	1.52%
Switzerland	1.76%

Reducing the land requirements for road transport is central to the achievement of sustainability and quality of life and there are no reasons why we cannot begin immediately to reduce transport's land take, develop alternatives to auto-dependency and do all this within existing transport budgets and on very short time scales.

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APPENDIX 1

HIGHWAY CROSS SECTIONS

NOT AVAILABLE

APPENDIX 2

CAR PARKING STANDARDS

IHT/DoT

NOT AVAILABLE

APPENDIX 3

HOSPITAL AND LOCAL AUTHORITY OFF STREET CAR PARKING

OVERLEAF

Hospital	No. of spaces
1. Addenbrookes	2,931
2. Barnsley	669
3. Battle	544
4. Bedford Hospital	550
5. Blackburn Queens Park	900
6. Blackpool Victoria Hospital	1,005
7. Blackburn Infirmary	240
8. Bolton Infirmary	725
9. Bournemouth	1,081
10. Broomfield	831
11. Canterbury	876
12. Chase Farm	1,041
13. Harold Wood	912
14. Huddersfield	815
15. Huddersfield Royal	700
16. Ipswich	1,558
17. John Radcliffe	2,243
18. King George	951
19. Lancaster RLI	583
20. Lewisham Hospital	280
21. Manchester, Christies	400
22. Milton Keynes General	1,000
23. Nelson	100
24. Newbury	105
25. Newcastle General	550
26. Oldchurch	650
27. Plymouth General	1,800
28. Rochdale Hospital	650
29. Royal Berkshire	1,057
30. Ruch Green	272
31. St Johns	379
32. Sutton	298
33. Walsall Hospital	1,500
34. Walsall Manor Hospital	1,500
35. Warrington	1,012
36. Whipps Cross	993
37. Withington Hospital	1,268
38. Wythenshawe Hospital	1,400

(From a total of 56 hospitals surveyed by fax or phone, 38 responded)

Local Authority Off Street (surface) Parking

Town/City	No. of spaces
1. Alston	74
2. Ampthill	195
3. Appleby	134
4. Ashtead	216
5. Bedford	851
6. Biggleswade	651
7. Blackpool	11,200
8. Bookham	92
9. Cheshunt	322
10. Claygate	149
11. Cobham	248
12. Cockermouth	574
13. Dorking	1,127
14. Dunstable	1,029
15. East Molesey	153
16. Esher	866
17. Flitwick	718
18. Guildford	1,722
19. Hersham	249
20. Hoddesdon	654
21. Keswick	876
22. Kirkby Stephen	89
23. Lancaster	1,715
24. Leatherhead	852
25. Leyton Buzzard	758
26. Long Ditton	59
27. Luton	1,102
28. Maryport	392
29. Oatlands	59
30. Oxford	1,818
31. Oxshott	32
32. Penrith	699
33. Runnymede	1,816
34. Sandy	219
35. St Johns	379
36. Stevenage	3,500
37. Surrey Heath	1,984
38. Thames Ditton	67
39. Three Rivers	986
40. Waltham Cross	838
41. Walton on Thames	1,204
42. Weybridge	584
43. Wigton	288
44. Workington	1,093