Final report **Project UE4(03)01**

Investigating environmental justice in Scotland: links between measures of environmental quality and social deprivation

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LIST OF ACRONYMS, NOTATIONS AND TERMS

ANOVA	Analysis of Variance
AQS	Air Quality Strategy
BEN	Black Environmental Network
BGS	British Geological Society
CI	Gini Index of Concentration, a measure of equality within a distribution, calculated as the area between a Lorenz curve and a line of equal distribution.
CO	Carbon monoxide
COMAH	Control of Major Accident Hazard
COMEAP	Committee of Medical Experts on Air Pollution (DoH)
CRI	Chemical Release Inventory
CSO	Combined Sewer Overflows
Data zone	Spatial unit composed from output areas of the 2001 census, usually between 450 to 1000 population. Soon to be the default unit for area statistics in Scotland
Decile	A tenth - in our analyses deciles are population weighted, and initially contain an equal share of national population. Decile 1 is always the most deprived and decile 10 is always the least deprived.
DEFRA	Department of the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DoH	Department of Health
DVLA	Driver Vehicle Licensing Agency
DWI	Drinking Water Inspectorate
EJ	Environmental justice
EPA	Environmental Protection Agency (USA)
EPER	European Pollutant Emission Register
EPAQS	Expert Panel on Air Quality Standards
ESRC	Economic and Social Science Research Council
EU	European Union
FCS	Forestry Commission Scotland
FoE	Friends of the Earth
GIS	Geographic Information System
GLA	Greater London Authority
GQA	General Quality Assessment (water quality)
HSE	Health and Safety Executive
IMD	Index of Multiple Deprivation
IPC	Integrated Pollution Control

IPPC	Integrated Pollution Prevention and Control
LNR	Local Nature Reserve
Lorenz curve	The cumulative distribution of a variable
LULU	Locally unwanted land use (USA)
MAUP	Modifiable area unit problem
mg/m^3	Milligrams per cubic metre
NETCEN	National Environmental Technology Centre
NHEXAS	National human exposure assessment study (USA)
NIWT	National Inventory of Woodland and Trees
NO_X	Nitrogen oxides
NO_2	Nitrogen dioxide
NPFA	National Playing Fields Association
NPL	National Priority List (of USA contaminated 'superfund' sites)
NGO	Non-governmental organisation
ODPM	Office of the Deputy Prime Minister
OS	Ordnance Survey
PAN	Planning Advice Note
PM_{10}	Particles less than 10 microns in diameter
$PM_{2.5}$	Particles less than 2.5 microns in diameter
Quintile	A fifth - (see also decile)
SIMD	Scottish Index of Multiple Deprivation
SDC	Sustainable Development Commission
SEPA	Scottish Environment Protection Agency
SFVI	Social Flood Vulnerability Index
SIC	Standard Industrial Code
SME	Small and medium sized enterprises
SNH	Scottish Natural Heritage
SO_2	Sulphur dioxide
SOA	Super Output Area
SURPOP	Surface population (modelling)
STW	Sewage treatment works
TRI	Toxic Release Inventory (USA). See also CRI
TSDF	Transfer, storage and disposal facilities (USA)
ug/m^3	Micrograms per cubic metre
WGS	Woodland Grants Scheme

Project UE4(03)1 - Investigating Environmental Justice In Scotland: Links Between Measures of Environmental Quality and Social Deprivation

1 Executive Summary

1. The overall aim of this research project was to consider the extent to which communities of people in Scotland living at different levels of deprivation also live in proximity to factors affecting environmental quality. The presumption is often made that there is coincidence between poor environmental quality and deprived communities in Scotland. This project sought to develop an evidence base to explore this presumption and to help inform future policy directions.

2. The project involved a review of past research in the environmental equity field; a scoping and evaluation of data sets; and an analysis of 8 environmental topics against patterns of multiple deprivation throughout Scotland.

3. The results of this analysis provide an initial view of the spatial and social distribution of key aspects of environmental quality across Scotland, with a recognition that this analysis can only provide a relatively basic and initial exploration of complex social and environmental phenomena.

4. For each of the 8 environmental topics analysis was undertaken against the Scottish Index of Multiple Deprivation 2004. Use was also made of spatially precise household location data in order to estimate populations in proximity to environmental features. Patterns of clustering and differences between urban and rural populations were also examined where relevant.

5. The analysis showed the following:

- For *industrial pollution, derelict land* and *river water quality* there is a strong relationship with deprivation. People in the most deprived areas are far more likely to be living near to these sources of potential negative environmental impact than people in less deprived areas.

- For *landfills* and *quarries and open cast sites* the patterns of relationship between deprivation and population proximity are less distinct. At a national scale there is no evidence to suggest that deprived populations are more likely than others to live near to landfill sites. For quarries and open cast sites only when populations in rural areas are examined separately does a tendency against more deprived areas become evident.

- People living in deprived areas are less likely to live near to areas of *woodland*. However, for areas of new woodland the analysis shows that there has been a tendency in planting towards deprived populations, suggesting that policy may be redressing this overall imbalance

- For *green space*, the analysis showed that both the least and most deprived areas in Scotland have high percentages of people living near to a local designated wildlife site, indicating that there is no simple relationship. A more detailed exploratory analysis was also undertaken for Glasgow highlighting the complex issues involved in assessing environmental justice in relation to green space.

- People living in the most deprived areas are more likely to experience the poorest air quality than those living in less deprived areas. This was found to be true for four (nitrogen dioxide, PM_{10}, benzene and carbon monoxide) out of the five pollutants examined (the exception being sulphur dioxide). Exceedences of the nitrogen dioxide objective (annual mean) are strongly concentrated in the most deprived areas.

6. Recommendations have been made relating to the limitations of current environmental data sets for environmental justice analysis and the ways in which these may be overcome; approaches which can be taken to monitoring change in patterns of inequality over time; and priority areas for further research.

Key words: environmental justice, Scottish Index of Multiple Deprivation, air quality, industrial pollution, derelict land, quarries, forestry, green space, river water quality, GIS.

Project Partners: Scottish Executive, Scottish Environment Protection Agency, Scottish Natural Heritage, Forestry Commission

2 The Research Project

2.1 Aims and Objectives

The overall aim of this research project was to consider the extent to which communities of people in Scotland living at different levels of deprivation also live in proximity to factors negatively or positively affecting environmental quality.

The presumption is often made that there is a direct correlation between the locations of the areas of worst environmental quality and the locations of the most deprived communities in Scotland. There is a pressing need to investigate this correlation and develop a sound evidence base which can be used to plan future policy directions.

The research project has used a working definition of environmental justice similar to the one developed by Kevin Dunion, the Scottish Information Commissioner and former Chief Executive of Friends of the Earth Scotland. This working definition is made up of two elements:

1. the 'distributive justice' concern that no social group, especially if already deprived in other socio-economic respects, should suffer a disproportionate burden of negative environmental impacts;
2. the 'procedural justice' concern that all communities should have access to the information and mechanisms to allow them to participate fully in decisions affecting their environment.

The present research project relates to the first 'distributive' element of environmental justice. However the project has also considered the issue of equality of access to environmental goods.

The project was organised into two main stages. Stage 1 involved a review of past research in the environmental equity field; a scoping and evaluation of data sets which could potentially be used to investigate the relationship between environmental quality and social deprivation in Scotland; and the development of proposals to be used and applied in stage 2 of the project.

Stage 2 involved an analysis of 8 environmental topics set against patterns of social deprivation across Scotland. This was intended to provide an initial view of the spatial and social distribution of key aspects of environmental quality across Scotland, with a recognition that this analysis could only provide a relatively basic exploration of complex social and environmental phenomena.

2.2 Research Activities

2.2.1 Review of past research

The review of past research was conducted through an evaluation of the literature, including unpublished 'grey' sources. We were able to draw on a similar review recently completed for the Environment Agency (Mitchell and Walker 2003), but extending this work to (a) update to take account of recent research; and (b) extend the scope of the review to include a wider range of environmental variables, in particular, access to green space and woodland environments. We were also able to draw on a wide ranging review of the literature undertaken for DEFRA by the Sustainable Development Research Network (Lucas et al 2004).

The review is focused and bounded in the following ways:

- research undertaken in the UK is reviewed with any analysis for Scotland particularly highlighted. The more extensive literature from the USA is also drawn on to inform discussion of methodological issues;

- empirical studies examining the social distribution of environmental variables provide the main focus. A broader review of the meaning of environmental justice, political agendas and policy responses has not been undertaken, beyond some initial contextual discussion;

- empirical studies covering the areas included in stage 2 of the project also provide the main focus;

- common methodological issues for equity analyses are drawn out of the literature review and discussed in a separate section of the report.

2.2.2 Scoping and Evaluation of Data Sets

A long list of potential data sets to be used in Stage 2 of the project was identified at the initial steering group meeting. Some prioritisation of areas of analysis was indicated but the need to examine the scope for using a broader range of data sets was emphasised.

In order to evaluate data sets various data holders were contacted to obtain information on metadata, samples of data and in some cases full data sets. A list of parameters for each data set was then recorded and issues of coverage, scale, quality and usability examined.

Having reviewed the full range of data sets, we then excluded those which, for particular reasons, proved impossible or inappropriate to use in Stage 2. The methods of analysis which could be used for each data set were then examined and discussed at length in order to produce both proposals for which analyses should feature in Stage 2 and the methods of analysis that could be applied. After further discussion with the project steering group a set of 8 environmental topics and prioritised analyses to be undertaken for each of these were agreed. The 8 topics were chosen to reflect funding policy interests and to give a representative sample of factors thought by policy makers to be important in environmental justice issues. This outcome represented a preference for breadth rather than depth in the data analysis. At this stage of limited understanding, it was felt that there was a need for a view of broad patterns of relationship between deprivation and a range of environmental topics in Scotland, rather than an in-depth analysis of only a few.

2.2.3 Analysis of Data

The 8 environmental topics chosen for analysis were:

- Industrial Pollution
- Derelict Land
- Landfill
- Quarries and Open Cast Workings
- Woodlands
- Green space

- River Water Quality
- Air Quality

The methods used for analysis for each of these topics are discussed in general in section 5 and more specifically in each of the topic chapters. The choice of methods and extent of possible differentiation and sophistication in analysis reflects the preference for breadth rather than depth in the project as a whole. For this reason the limitations of the analyses have to be stressed and taken into account in the interpretation of results.

For each of the topics analysis was undertaken for the whole of Scotland using the Scottish Index of Multiple Deprivation (Scottish Executive 2004). The green space chapter (12) is to a degree distinct in providing more of a discussion of the range of issues involved in undertaking an environmental equity analysis for this topic and some initial exploratory data analysis.

3 UK Environmental Justice Research

3.1 Environmental Justice in the UK and Scotland

The relationship between the environment and social justice has become a new, wide-ranging area for policy attention in the UK.

- an increasing number of agenda-setting reports, reviews and position papers have made the case for integrating equity and justice into environmental management and policy in the UK, using a variety of definitions and conceptualisations of what this might mean (e.g. Jacobs 1999, Boardman et al 1999, Green Alliance 2000, Stephens et al 2001, Adebowale and Schwarte 2003, Foley 2004)

- the joint consultation document for the new UK Sustainable Development Strategy identifies environment and social justice as a potential priority theme for future policy attention and action (DEFRA 2004). This builds on the 1999 UK Sustainable Development Strategy which stated that '*everyone should share the benefits of increased prosperity and a clean and safe environment ….. Our needs must not be met by treating others, including future generations and people elsewhere in the world, unfairly*' (UK Government 1999) and the Scottish Sustainable Development publication 'Meeting the Needs…' (Scottish Executive 2002) '*Sustainable development is about combining economic progress with social and environmental justice…we should have regard for others who do not have access to the same level of resources, and the wealth generated'.*

- various government departments and agencies have begun to develop and explore the environment and social justice territory, with, for example, the Social Exclusion Unit undertaking work on transport and social exclusion; the Neighbourhood Renewal Strategy and Communities Plan pushing forward the environmental improvement of deprived areas; the Sustainable Development Commission (SDC 2002, 2003) focusing on the connections between regeneration, poverty and environment

- at a European level the obligations under the 1998 Aarhus convention on the environment, and associated principles of access to environmental information, public participation in decisions and access to environmental justice, are providing important drivers for further policy development.

Environmental justice has developed a particularly strong profile in Scotland. Friends of the Earth Scotland took up environmental justice as a major campaign theme in 1999 and have pursued programmes of work in a number of areas including community empowerment, activist education, fairness in the planning system and access to information (FoE 2003, Dunion 2004). A high profile speech by the First Minister Jack McConnell in February 2002 provided a high level political commitment to environmental justice, making the argument that concern for the quality of the environment should not be seen as a luxury of the privileged few, particularly as it is frequently those who are already carrying the burden of social deprivation who also live in poor quality environments:

> '*people who suffer most from a poor environment are those least able to fight back*', and '*I am clear that the gap between the haves and have-nots is not just an economic issue. For quality of life, closing the gap demands environmental justice too. That is why I said…that environment and social justice would be the themes driving our policies and priorities...*' (McConnell, 2002).

An agreement made in 2003 between between Labour and the Liberal Democrats 'A Partnership for a Better Scotland' placed environmental justice amongst the core priorities for the new term of government, with the goal of '*secur[ing] environmental justice for all of Scotland's communities*'. Several of the social justice targets listed in the agreement related to improvements to local environmental quality by addressing litter, abandoned vehicles, fly-tipping, flooding and public open space in new developments.

Environmental justice is now figuring far more centrally within the work of government departments and agencies in Scotland. The Scottish Executive now has environmental justice as a new crosscutting policy priority with a high level commitment made in its 2003 Policy and Financial Management Review. Protecting vulnerable communities and engaging effectively with the public are both stated as key objectives for the Scottish Environment Protection Agency in delivering environmental justice. Scottish Natural Heritage is also taking up environmental justice themes (SNH 2004a). Its 25-year Natural Heritage Futures (2002) vision for settlements is aiming to improve degraded landscapes and biodiversity close to where people live with access to local green space, greater involvement of communities in the care of their local environments and better access to environmental information. Other important initiatives include Making the Links: Greenspace and the Partnership Agreement (2004) produced by Greenspace Scotland in partnership with SNH, Communities Scotland & NHS Health Scotland with the aim of highlighting the value of green space to the social, economic and environmental well being of communities. Issuing concerning planning and environmental justice have also been recently examined (Scottish Executive Social Research 2004).

Despite this growing prominence for environmental justice in policy and local action, in the UK, and more specifically in Scotland, the evidence base analysing the relationship between the social characteristics of populations and their access to environmental quality is still at an early stage (Lucas et al 2004). In comparison to the USA, where the environmental justice agenda has stimulated a wealth of empirical research (Cutter, 1995; Sasz and Meuser, 1997; Bowen, 2002), we know comparatively little about which social groups experience better or worse environmental quality and access to environmental resources. The emergent UK environmental equity research field suggests that there are some significant inequalities in the distribution of various forms of pollution and risk, with lower income, deprived communities facing a greater environmental burden than other social groups. However, there may be significant differences between different parts of the country and there are major issues of methodology, causality and appropriate response, which currently complicate such analyses and the drawing of definitive and relevant policy conclusions. There is also a need to extend environmental equity research to other aspects of environmental quality, including access to environmental resources such as green space and woodland environments.

The following is a summary of equity research relevant to each of the environmental topics analysed in this project. The scope of review is largely restricted to the UK with any work specific to Scotland particularly highlighted. Where equity research does not exist a brief discussion of some of the relationship between environmental parameter and the well being of people is provided.

3.2 Industrial Pollution

Installations coming within the remit of the Integrated Pollution Control (IPC) regulations (now the Integrated Pollution Prevention and Control regulations) provide potential point sources of day-to-day polluting emissions to air, water and/or land with consequent potential health and amenity impacts. The exact scale and severity of health impacts is though often difficult to establish given the uncertainties and many confounding factors involved (Dunn and Kingham 1996). Environmental justice research in the USA has predominantly examined similar types of industrial facilities, and particularly the various forms of commercial/hazardous waste facility sites under the ambit of the Toxic Release Inventory. The total body of US research covers a wide range of scales of analysis (from purely local to national), environmental variables (some simply counting facilities, others attempting to take account of different levels or toxicity of emission) and social variables (ethnicity, class, income, age, population density). There has also been much debate about the conclusions that can reasonably be inferred from this research, with a particular focus on allegations of discriminatory siting practices.

There are a number of UK studies examining the spatial and social distribution of IPC sites in relation to various indicators of income and deprivation. None of these have included sites in Scotland, so the relevance of these studies may be limited.

- Two studies by Friends of the Earth (FoE) examined the locations of installations coming within the IPC regime in England and Wales, and subsequently levels of carcinogenic emissions from these installations in relation to indicators of income and deprivation. They found that 662 IPC sites were located in areas with an annual average household income of less than £15,000, with only 6 factories in areas where average annual incomes were greater than £30,000, a very different distribution to that which would be expected if factories were randomly distributed (FoE 2000). They also found that 82 % of carcinogen emissions from Part A processes (large facilities regulated by the Environment Agency) occurred in the most deprived 20 % of wards (FoE 2001). In both pieces of work, the limitations of the analysis, including the absence of any statistical tests of significance, are acknowledged. A further analysis examining only waste incinerator locations found a pattern of concentration in deprived areas for existing incinerators but a less clear bias for proposed new locations.

- A brief analysis by the Environment Agency (2002) examined the locations of IPC sites in England using a measure of number of sites per square kilometre within wards. In line with the FoE study, this found a strong relationship with the density of IPC sites increasing as deprivation increases.

- Wheeler (2004) included IPC sites in a complex analysis of environmental indices against various indicators of deprivation derived from the census. He found that an emission index constructed for IPC sites was consistently related to deprivation across four groupings of census wards - wholly urban, predominantly urban, urban-rural and wholly rural.

- The most substantial equity study of IPC sites by Walker et al (2003) was undertaken separately for England and Wales. It largely confirmed the findings of previous work for England and provided a more in-depth and differentiated analysis of patterns of site location, emissions and operator performance. This analysis concluded that for England there is compelling evidence of a socially unequal distribution of IPC sites in England. IPC sites are disproportionately located in more deprived wards. Wards in the most deprived decile provided the location for five times as many sites and authorisations and seven times as many emission sources as wards in the least deprived decile. Out of the 3.6 million estimated people living within 1km of an IPC site, there are 6 times more people from the most deprived decile compared to the least deprived. The research also found that IPC sites are also more clustered together in deprived wards, on average produce greater numbers of emissions and present a greater potential pollution hazard in deprived wards. They also produce more 'offensive' pollutants which are likely to have an impact on the day-to-day quality of life. In contrast to England the patterns of distribution of IPC sites in Wales showed a less distinct relationship to deprivation. The locations of sites in wards analysis showed no association with deprivation, although the population within 1km of an IPC site does exhibit some bias towards more deprived deciles (but not the *most* deprived) – suggesting that the distribution of sites and populations in Wales is particularly sensitive to the method of spatial analysis utilised. There is no evidence of a greater concentration of emission sources or of processes producing a greater pollution hazard in more deprived areas. Indeed the data for proximity to multiple sites and for levels of emissions of specific substances show a bias towards the less deprived, more affluent deciles. An explanation for the social pattern of site locations in Wales and the differences between England and Wales appears to rest in part with the geography of deprivation in Wales. The most deprived wards, particularly in the South Wales valleys, have few IPC sites – due to the particular industrial history of these areas.

3.3 Derelict and Contaminated land

There are a number of ways in which derelict land may have an impact on people and communities - both positive and negative. When derelict land is also contaminated there may be potential impacts on health (although often through extended and varied pollution pathways; DEFRA and Environment Agency, 2002). Hoke and Burghardt (2001) examined the role of derelict land in the Ruhr, Germany and discuss their role in spreading pollutants and soil-borne dust in urban and industrial areas. They suggested that the most significant factor was their contribution to PM_{10} particles in the air.

Derelict land may have a negative visual and aesthetic impact on the local area, contributing through this to a poor and stigmatised living environment. The presence of derelict land may also have an economic impact in deterring investors to the area. On the other hand, derelict land has been recognised in some circumstances as contributing positively to local biodiversity and having an important informal recreational value.

Contaminated land has featured in US equity studies through a focus on the high profile Superfund sites (largely old waste disposal sites which are identified as most polluted and a priority for clean-up investments; e.g Lavelle and Coyle 1992; Zimmerman 1993). Equity analysis of contaminated land in the UK has been limited by the lack of national and local databases of contaminated land parcels (although this is in the process of being addressed). No published equity research has been identified beyond the health work around landfill sites discussed above.

The Environment Agency estimates that there are 300,000 hectares of land in the UK contaminated to some degree by past industrial activity. Under current policy local authorities have to assess the risks that such sites pose and develop a remediation and targeted intervention strategy. Many local authorities have undertaken some analysis of population distributions in relation to contaminated land as part of their inspection strategies under part IIA of the Environmental Protection Act 1990. However, typically such analyses appear to be very basic, and limited to total populations within census areas. The health impact models on which guidance to local authorities are based are predominantly concerned with pathways that involve some form of direct use of the contaminated land (e.g. residence, growing of food, recreation) (DEFRA and Environment Agency, 2002) hence equity assessment following these exposure models would ideally go beyond simple measures of population proximity, and take account of patterns of access and useage.

3.4 Landfills

The health impacts of landfill sites have been controversial for some time. Epidemiological studies in Europe have suggested a link between elevated rates of birth defects and proximity to landfill sites (Dolk et al. 1998; Elliott et al. 2001a) but the strength of this evidence has been questioned. There are major limitations of knowledge about the environmental vectors involved in exposing people to potential health risks from landfill and the lack of explanation as to the excesses of various forms of ill-health that have been observed (Pheby et al. 2002). Elliot et al. (2001a: p363), for example, refer to human exposure via dispersion of contaminated air, soil and water (leaching, runoff), and also by animals and birds, but comment that '*evidence for any substantial exposures is largely lacking'.* The evidence base has been comprehensively reviewed and critiqued in a recent report for DEFRA (2003) which particularly notes that insufficient is currently known about chemical emissions from landfills. Given the uncertainties involved in epidemiological studies the Department of Health Advisory Committee on Toxicity report in 2001, concluded that it was not possible to draw firm conclusions on the health effects of landfills based on research to-date.

Other negative impacts of landfills include odour (most complaints), dust and noise (DEFRA 2003), impacts on house prices and, where old landfills are capped and built on, potential problems from methane releases and land instability. Positive impacts may be realised when landfills are restored and used for recreational uses or brownfield.

There are various pieces of research which have either directly or indirectly examined the distribution of landfill sites in relation to deprivation:

- Dolk et al. (1998), briefly observe in a study of 21 hazardous waste sites in five European countries, that there is no overall evidence that more deprived communities live near to landfill sites.

- Elliott et al. (2001a & b), in the largest UK study of associations between residence near landfill and birth outcome, noted that the area within two kilometres of landfill sites tended to be more deprived than the reference area used for comparisons (34 % in lowest Carstairs deprivation index tertile compared to 23 % in the reference area). They also note that the observed excess in birth outcome data is higher in deprived areas than in richer areas.

- An analysis for England by the Environment Agency (2002) used landfill site 'density' to examine the relationship between deprivation and proximity to a landfill site, concluding that there is a greater area of landfill sites in the most deprived wards compared to less deprived ones.

- Wheeler (2004) examined landfill sites for England and Wales together, differentiating between urban and rural areas. He found that the relationship between a 'landfill index' and deprivation varied between urban and rural wards, with 'complex associations' with deprivation components also identified. In wholly urban wards a weak trend towards landfills being found in less deprived areas was observed, whereas in predominantly urban, urban-rural and wholly rural wards the reverse relationship was identified.

- An economic study of house prices around landfill sites (Cambridge Econometrics *et al*. 2003) undertaken as part of a landfill tax review for DEFRA rather than for equity reasons, looked at over half a million sales of houses situated near 11,300 UK landfill sites, and found that those properties sited within half a mile of a landfill site suffer statistically significant disadvantages. The value of houses situated less than a quarter of a mile away from a landfill site were an average of £5,500 lower than the value of a similar house not situated near a landfill site. For those houses over a quarter of mile from a site but under half a mile, this value was an average of £1,600.

Of this existing research, only the last study of house prices included Scotland within its spatial coverage. The regional breakdown in that analysis found that the most marked effects were in

Scotland, where areas in closest proximity to a landfill site (less then a quarter of a mile) saw a fall in house prices of 41 %, much larger than for other regions and than the UK average of 7%. These results were used by FoE Scotland to make a claim of clear injustice:

> *'This truly shocking study underlines the appalling way in which Scotland has for years been dumping its rubbish on the doorsteps of some of its poorest communities. The most revealing aspect of this research is not that living near a dump reduces the price of your home, but how waste dumps are disproportionally clustered in areas of lower-income households. Through no fault of their own, these communities are having to suffer the double injustice of poverty and the threat to health that landfills may pose'(FOE Scotland 2003).*

Environmental justice campaigning activity by FoE Scotland has included supporting local campaigns against new landfill capacity for example in North Lanakshire (FoE Scotland 2003).

3.5 Quarries and Open Cast Workings

The nuisance and amenity impacts of living near to quarries and mines, particularly open cast rather than deep mining, are widely recognised (dust, noise, traffic). These will be variably experienced around different quarries depending upon the scale and nature of mining operations. However the health impacts through exposure to excess particulates have been more disputed. Recent research validated by the Committee on the Medical Effects of Air Pollution has shown that open cast coal mining was associated with a small increase in the mean concentration of airborne particles measured as PM_{10} (COMEAP 2000, Pless-Mulloli et al 2000). However, the respiratory health of children living in communities close to open cast sites was found to be 'very similar' to that of children living in communities distant from such sites. Some degree of elevation of GP consultations for eye and respiratory conditions was identified, but it was not possible to be certain that this elevation was due to open cast operations.

No equity-based studies examining the locations of quarries and mines in relation to social variables have been identified in the literature. Claims have been made in Scotland about the injustice of 'peripheral' communities bearing the burden of quarrying activity whilst the benefits are widely distributed to other parts of the country and beyond (FoE Scotland 2003). This brings additional dimensions to the analysis of equity and justice extending beyond the simple spatial distribution of extraction activities.

3.6 Green space and Woodland

Green space interacts with quality of life in a number of ways. The economic, social and environmental benefits of green spaces are outlined in several studies (Barker and Graf, 1989; Dover, 2000; Swanwick et al., 2001; Henwood, 2001; Urban Parks Forum, 2002; English Nature, 2003a, b, c, d; Urban Green Spaces Taskforce, 2002; Edwards and McPhillimy, 2003; SNH 2004b; CABE Space 2004, SNH 2004b) and include improving the quality of urban regeneration, promoting healthy living and preventing illness (including benefits in recovery from surgery and hospitalisation, Kaplan 1995; English Nature 2003c) and encouraging education and lifelong learning. Recent reviews of evidence by Henwood (2001), Pretty *et al.,* (2003) and Morris (2003) collectively cite over 200 studies that evidence the benefits of contact with nature, whether this be passive (e.g. sitting and enjoying the view) or active. However, there is almost no information available on the relationship between the overall level of green space provision in urban areas, the configuration of green space and their quality, on the one hand, and health parameters on the other.

Areas of woodland share many of the same relationships with quality of life as green space (Forestry Commission 2002a, b; Henwood, 2001; Tabbush and O'Brien 2002). Profiles of recreational, health, amenity and aesthetic value will vary however with type of woodland and access arrangements (Countryside Agency, 1999, Tabbush and O'Brien 2002). The Forestry Commission publication 'Health and well-being: trees, woodlands and natural spaces' (Tabbush and O'Brien 2002) provides synopses of presentations and workshop discussions from three expert consultations in Scotland, England and Wales in 2002. Findings include:

- contact with nature can extend a positive influence on the physical and mental health of humans, particularly in urbanised societies
- woodlands and green areas can provide an escape from stress
- woodlands also offer a locus for community action, a meeting place and a location that often forms an important aspect of local identity

There is considerable evidence that the use of green space and woodland is highly differentiated between different social groups (Comedia and Demos, 1995; Swanwick *et al.,* 2001; Urban Green Spaces Taskforce, 2002; University of Sheffield, 2002). Children primarily use green space for play. Disabled users of green space have received little attention in the literature, although they represent between 8-14% of Britain's population. Older people are underrepresented as green space users both in comparison with other age groups and in proportion to their presence in the residential areas surrounding the space. A number of other groups in society were also found to be underrepresented in their use of parks and green space (in proportion to their percentage of the total population) including ethnic minorities, women and 12-19 year olds. Particular deterrents to these groups include dog mess (all groups, especially woman and older people), poor access, toilets, seating and other facilities, and safety (people with disabilities), nothing to do (teenagers), vandalism and graffiti (all groups, especially older people and people with disabilities), racial issues (ethnic minorities).

Studies have shown that the majority of people travel to green space on foot (Llewelyn-Davies, 1992; Comedia and Demos, 1995). Poor access may keep people away from their local parks because they do not feel safe enough to journey to them on foot. Traffic and badly located green space means they are often too far or difficult for children to reach safely and as a result parents often do not let children go on their own (Urban Green Spaces Taskforce (2002). The English Nature report 'Accessible Natural Greenspace' points out that current standards over-estimate the distance young people are likely to range independently. The study suggests that the recommended 1,000 metres distance to a neighbourhood play area designed for 8-14 year olds is well beyond the permitted range of 11 year old girls, and also of many boys of the same age. Even the recommended distance of 400 metres to a local, equipped, play area is not within the permitted and accompanied ranges of some eight year old girls (English Nature 2003a). This emphasises the complex set of issues involved in analysing access to green space and that the actual use made of green space extends beyond simple questions of proximity.

The Forestry Commission (2002a, b) have explored the public use of, and attitudes towards, woodlands, particularly the level of use of woods and the profile of users. The two factors most mentioned as preventing the fuller use of woodlands are safety and woodlands abuse (such as littering and vandalism). Fears for safety, whether because of other people or from injury (particularly among elderly users) are deterrents to people using woodlands alone. Issues of social inclusion include teenagers who like woodlands as places in which to hide or get away from others. The report shows evidence that unemployed people who are economically and (often) socially disadvantaged use woodlands to escape the social pressures of their situation. Retired people are potentially an important category of woodland users but they are often anxious about their safety. Urban dwellers were less likely to travel more than two miles to visit woodland reflecting their principal mode of transport to green space: walking and cycling. The nature of rural areas suggests that access to public space (including green space) is easy. However, Smith and Barker (2001) find that rural childhoods are increasingly characterised by restricted spatial mobility. Access to public space for children in rural areas is limited by geographical isolation from other children, the privatisation of rural land and parents' fear of children's unsupervised use of public space. Other public attitudes to green space use and perception where covered by DEFRA (2001)

Environmental benefits of trees at a local level include trapping of pollutants and dust, reducing wind speed, stabilizing temperature and lowering temperature in urban areas (Stülpnagel et al 1990), and providing habitats to support biodiversity. There is an extensive body of literature on the relationship between trees and their links with local air quality, Beckett et al (1997) provides a review such studies. Findings include high levels of copper, iron and lead in leaf tissue in congested city areas (Alfani et al 1996), more lead and zinc particles were captured by rough leafed species (Fatoki 1987), particles accumulated throughout the growing season and were highest nearest motorway sources (Freer-Smith et al 1997). Impens and Delcarte (1979, cited in Beckett et al 1997) showed that interception of particles by vegetation was massively greater for street trees due to the proximity of traffic, and furthermore areas with the highest pollution concentrations where trees could be most effectively used were often the areas most lacking in urban greenery.

Both broadleaves and conifers have their advantages, broadleaves' main advantage is that they renew the leaves each year and so decrease the accumulated annual load of toxic particles. Conifers (except larch) keep their needles all year round and so continue to accumulate toxins (note that broadleaves still accumulate toxins on the bark and branches) making them more efficient at improving air quality, although this may cause prolonged damage in the longer term to the tree itself. On balance Beckett et al “suggest that future urban planting should focus on the increased use of conifers.” (1997)

Health benefits are increasingly being recognised by the provision of green gyms, managed walks and as place where people can exercise (see Interface NRM 2004 for an interesting evaluation of woods and health programmes in the West Midlands). Health benefits arise both from directly taking exercise within these areas, and also indirectly through the visual amenity in terms of mental well being. Such benefits should not be underestimated, significant differences in recovery times for patients have been noted between those who have a view of a green space compared to those with an internal room (see Kahn 1997 for a review) and work pioneered by Ulrich (e.g. Ulrich 1984, Ulrich and Lunden 1990, Ulrich et al 1991) over the last 20 years has had a significant impact on the design of new hospitals in several countries and our understanding of the role in green space in aiding recovery.

Taylor et al (2002) studied the role of views from high rise apartments and their impact on the self discipline behaviour of the children who lived there. Tests on concentration, impulse inhibition and delay of gratification improved the more natural a girl's view from home was. For boys there was no relationship, which the researchers suggested was due to the smaller amount of time spent playing in and around their home.

Kuo (2001) appraised the effects of nearby nature in reducing mental fatigue for residents in public housing projects in the USA. Residents living in buildings without nearby trees and grass reported more procrastination in facing their major issues and assessed their issues as more severe, less soluble and more long-standing than did their counterparts living in greener surroundings.

At a more fundamental level the biophilia hypothesis put forward by Wilson (1984) asserts that there is a fundamental genetic need for humans to experience nature or as “the connections that human beings subconsciously seek with the rest of life". The debate surrounding biophilia is covered in depth by Kahn 1997.

Several studies suggest that the value of woodlands and green spaces is reflected in the housing market via the pricing mechanism. Hobden et al (2004) examined house prices over 20 years in suburban Canada. They found that most types of green space increased the value of adjacent properties and that corridors in particular had a significant positive impact on adjacent property values.

Tyrvainen and Miettinen (2000) studied the sale of terrace houses in the district of Sale in Finland. They found two interesting results; firstly every 1km increase in the distance to the nearest forested area led to an average 5.9% decrease in the market price of the house. Secondly, dwellings with a view onto forests were on average 4.9% more expensive than dwellings with otherwise similar characteristics.

Tyrvainen (1997) used hedonic pricing methods to examine the role of urban forests, and their impact on house prices. Apartment sale data in a town in Finland (pop 48,000) was used with apartment characteristics, location and environmental variables to build a model. The main finding was that proximity of watercourses and wooded recreation areas as well as increasing proportion of total forested area had a positive influence on apartment prices.

Tajima (2003) examined the impact of a 15 year park and open spaces strategy in Boston, USA which found that proximity to urban open spaces had a positive impact on house prices while proximity to highways had a negative impact.

There are only two studies we have been able to identify which have examined the distribution of green space in relation to the distribution of population social characteristics.

- The Greater London Authority (GLA) (2003) has examined the value of green space in London by taking house prices as an indicator of how attractive different parts of London are and then asking to what extent house prices are affected by the amount of green space in the local area. GIS data was used to complement available statistical data. The spatial pattern of green space in each ward was examined against indicators such as deprivation, housing, crime and quality and public accessibility to the green space. The analysis found that the amount of green space in wards is the fifth most significant indicator in explaining the variation in average house prices. The first four indicators are level of income support, travel time to central London, average air quality and dwelling density. A 1 per cent increase in green space in a typical ward can be associated with a 0.3 to 0.5 per cent increase in average house price. They found that the best urban parks and green spaces in London are often surrounded by expensive and sought-after properties. The GLA scrutiny report (GLA 2001) on green space suggested that deprivation levels are often high in areas lacking green space with an indication that wards with a lower number of green spaces have more income support claimants and overcrowded households.

- The Urban Parks Forum assessment study (2001) showed that people in disadvantaged areas are most likely to be losing out on the benefits of good quality parks and green spaces. The report showed that in the 100 most deprived authorities, 40% of all parks were declining, and that figure rose to 88% for the parks already judged poor.

3.7 River Water Quality

River water quality as an environmental variable has a number of potential relationships with well being. Impacts on health most directly arise from recreational uses and there is a significant body of research directed at estimating the extent of illnesses associated with exposure to recreational water, and so identifying recreational water quality standards to protect public health (reviewed by Pruss 1998). These studies address both marine and inland surface waters, including controlled cohort studies for UK recreational waters (Fewtrell *et al*. 1992; Kay *et al*. 1994; Fleisher *et al*. 1998). Most studies address the microbiological quality (bacteria, viruses) of recreational waters, although a few studies address other parameters with health implications e.g. Phillip and Bates (1992), investigate the health risks to dinghy sailors of cyanobacteria exposure on UK reservoirs.

These studies distinguish between population groups in terms of use characteristics, with risk assessments specific to paddlers, swimmers, surfers, canoeists and sailors. We could find no literature addressing the health dimensions of recreational water quality (for the UK or overseas), that is specifically concerned with equity. This is not surprising, as epidemiological studies of recreational waters are based on controlled cohort investigations in which direct measurements of exposure are made. Thus there is no necessity to record demographic variables, such as socio-economic status, which are routinely recorded in other environmental epidemiological studies (to allow adjustment for confounding factors).

Other negative impacts from poor river water quality may include pets and other animals being made ill or killed through contact with polluted river water and vermin and local pest problems arising where water is still or stagnant (Battersby et al 2002).

Rivers and more importantly river corridors, also have important aesthetic and recreational values which include many of the positive benefits and access issues identified above for green space. Considerable effort has recently been put into improving riverside amenity and access arrangements for many rivers particularly in urban areas reflecting these aesthetic and recreational values, including programmes of river ecology restoration.

The one published UK study examining the social distribution of river water quality in England (Environment Agency 2002) used three different parameters to try and reflect the different aspects of the relationship with environmental quality. These were a measure of the modification of river habitats, chemical river water quality, and river aesthetic quality. When analysed against deprivation it was found that:

- River habitats were more likely to be modified (less natural) in the most deprived areas
- Rivers in deprived areas had a worse chemical water quality than in less deprived areas
- There was no relationship between aesthetic quality and deprivation

A simple analysis of overall river water quality against deprivation at a district level for England and Wales found that the percentage of rivers classified as 'not good' was biased towards those districts classifed as neighbourhood renewal districts (Brook Lyndhurst 2004). No equity analysis of river water quality has been identified for Scotland.

3.8 Air Quality

This is the topic for which the most substantial environmental equity evidence base exists in the UK. Most studies have investigated the relationship between air quality and *deprivation* and address a variety of pollutants, study areas (cities, regions, national), geographical units of analysis and analytical methodologies (Environment Agency 2002; King and Steadman 2000; Lyons et al. 2002; Pye et al. 2001; Wheeler 2004). This diversity means that some outwardly contradictory conclusions have been drawn with some city-level studies finding an inverse or absence of relationship with deprivation. However, the balance of evidence suggests that deprived communities are exposed to an above average burden of poor air quality. For example, Walker et al. (2003) examining patterns of five pollutants for England found that overall and for all pollutants, the most deprived wards are those with highest pollutant concentrations. For all five pollutants (except SO_2) the *least* deprived also experience concentrations that are above those for people of average deprivation, although the elevation above the average is much less than that of the most deprived. The relationship between poor air quality and deprivation was found to be particularly strong for peak pollutant values, including exceedences of standards with number of people in wards above pollution thresholds increasing progressively with increasing deprivation. Within this research a separate analysis for Wales did not find the same bias, with both the most and least deprived wards experiencing above average pollutant concentrations, with the highest concentrations in the *least* deprived wards.

Mitchell and Dorling (2004) in a study covering the whole of Britain found that levels of exposure to NO_2 vary markedly with age. Brainard *et al*. (2002) also investigated the relationship of air quality with age, finding no relationship for the city of Birmingham. They did though find that ethnic minority groups were exposed to the poorest air quality, but did not exclude the possibility of a confounding relationship between ethnicity and deprivation. However, working at the local authority district scale, McLeod *et al*. (2000) identified a positive relationship between minority ethnic groups and pollution in which the effect of deprivation is controlled through multi-level modelling.

The only study where some of the results are specific to Scotland is that carried out by King and Steadman (2000) which examined the distribution of NO_2 and PM_{10} for five cities including Glasgow. This tentatively found that better air quality was experienced by those in more deprived areas for Glasgow, whereas in London, Belfast and Birmingham the more deprived areas experienced poorer air quality.

4 Scoping and Evaluation of Data Sets

4.1 Collation of details on datasets

This is a crucial stage in the process of undertaking equity analysis and needs to be carried out as carefully and thoroughly as possible. It is rare to find data sets, which are not in some way problematic for reasons including issues of resolution, consistency, completeness or spatial referencing.

We therefore sought to thoroughly establish and evaluate the following information about each of 23 potentially useful datasets:

- Name and contact details
- Spatial Resolution
- Spatial Referencing (resolution, completeness, accuracy)
- Spatial coverage and completeness
- Temporal coverage
- Format and compatibility with other data sets
- Uses and Users of the data

There were problems involved in establishing this information for every data set and information for 21 sets was acquired. Whilst in some cases requested metadata and sample data sets were supplied very promptly, in other cases repeated requests needed to be made. Once initial metadata was obtained in some cases this proved insufficiently detailed, so additional information had to be sought.

4.2 Evaluation of data sets

Table 4.1 below details the information obtained on each environmental data set along with a summary evaluation of whether or not there are constraints preventing the data set from being used in Stage 2. It is important to note that at this stage we were only considering the qualities of the datasets themselves, <u>not</u> the form or content of equity analysis that could be undertaken with each data set.

Out of the 21 data sets reviewed we concluded that 14 were potentially useable. Datasets were rejected for a number of reasons including problems with spatial referencing, inconsistency, resolution and availability.

Table 4.1 Details of evaluated datasets

Name of Data Set	Data Holder and Contact	Spatial Resolution	Spatial Coverage and Completeness	Temporal Coverage	Format and Compatibility	Summary Evaluation	Potentially Useable (Y, N)
IPPC/IPC sites	SEPA	OS grid	Spatial locations accurate by end of August. Dataset complete.	2001-2, 2002-3, 2003-4	Excel - point data	List of all IPPC sites available (part A and partB/LAPC sites), but grid refs only reliable for annex 1 (EPER). Includes about 50 landfills.	Y
European Pollution Emission Register (EPER)	SEPA	OS grid	Scotland	2003-4	Excel - point data	Includes UK SIC codes and main activity. Emission data exists but many sites under reporting threshold and some issues over reliability.	Y
River Water Quality	SEPA		Scotland	2003	Excel, shape files in arcs for river sections.	Different parameters available. Not all river lengths are classified by all parameters.	Y
Sewer Overflows	SEPA	OS grid	735 sites but only 148 with validated grid reference		Excel - point data	Regional pattern to validation of grid references, not therefore a consistent sample. CSOs not consistently identified in the database. No record of how often an overflow occurs.	N
Environmental Complaints	SEPA		8000 in total. 3280 no spatial location	2001-2		40% without location. All records would need geo-coding by postcode. Issues in consistency of recording between regions.	N
National Inventory of Woodlands and Trees	Forest Research	1:25,000	Scotland.	1988, 1988-1995 1995-2001	Shape files - polygons	Has good differentiation of woodland types, includes polygons for different grant schemes, and areas of woodland with urban areas.	Y

Name of Data Set	**Data Holder and Contact**	**Spatial Resolution**	**Spatial Coverage and Completeness**	**Temporal Coverage**	**Format and Compatibility**	**Summary Evaluation**	**Potentially Useable (Y, N)**
Grant aided woodland area	FCS	OS Grid	Scotland	WGS 1,2,3	Sample data not provided.	Woodland Grant Scheme 3, includes scheme boundary, type of grant including some access data. May be useful if it can be tied directly to National Woodland Inventory above.	Y
Scottish Vacant and Derelict Land Survey	Scottish Executive	OS Grid	All of Scotland	Annual	Excel	A good dataset, but no spatial area of derelict land parcels, but size available.	Y
Quarries and mines	BGS BritPits Database	OS Grid	Scotland	2000	Excel	Coordinates of variable accuracy. 13 out of 1093 without coordinates. No polygon to show area. Some differentiation.	Y
Landfill sites	SEPA	OS Grid	Scotland		Excel - point data	Basic information indicating active/closed only. Uncertain degree of spatial accuracy in grid references.	Y
Local Nature Reserves	SNH	1:10,000	Scotland	Up to date	Shape file - polygons	Good dataset, although no information about access to the LNRs.	Y
National Nature Reserves	SNH	1:10,000	Scotland	Up to date	Shape file - polygons	No information on access to NNR	Y
Landscape Character Assessment	SNH	1:25,000 to 1:250,000	Scotland	2003	Shape file - polygons	Boundaries should be considered as 'fuzzy'. Descriptions are not consistent. Doesn't deal with urban areas. Urban green space does exist in the data but only large areas are picked out. Character assessments limited for assessing quality. Polygons very varied/complex shapes.	N

Name of Data Set	**Data Holder and Contact**	**Spatial Resolution**	**Spatial Coverage and Completeness**	**Temporal Coverage**	**Format and Compatibility**	**Summary Evaluation**	**Potentially Useable (Y, N)**
Land Cover Map 2000	Centre for Ecology and Hydrology		Scotland	2000	Shape file - polygons	For woodland NIWT is generally better except some of this goes down to 0.5ha for woodland. Not reliable for urban areas and issues with generalisation of the dataset from raster to vector. Doubts expressed about its accuracy.	N
Country Parks	SNH	1:10,000	Scotland	Up to date	Shape file - polygons	No information on access points in the dataset.	Y
Local plan data	SNH	1:10,000	Scotland	Up to date	Shape files - polygon, lines and points	108 plans to cover all of Scotland. Inconsistencies in recording of the data. Difficult data set to work with as overlapping polygons. Potential problems with working with master map at the national level	Y?
Regional Parks	SNH	1:250,000	Scotland	Up to date	Shape file - polygons	Scale too crude for analysis	N
Scottish Paths	SNH	1:10,000	Scotland	Mixed	Shape file - arcs	Not possible to use at national level, more feasible at local level. Path differentiation problematic.	Y?
Land use (Glasgow)	SNH	1:1,250, 1:2,500 Mastermap	Glasgow but looking to extend into other urban areas		Shape file - polygons	Potentially very good for detailed work in Glasgow for various topics – used within Glasgow green space study.	Y
Glasgow green space study	SNH	Master Map	Glasgow	2003 onwards	Shape file	Good quality of data available within this study.	Y
National Parks	SNH	1:10,000	Scotland	Up to date	Shape file	Two national parks only.	Y

Table 4.1 continued

Having collated information on each of the data sets initially identified as potential useable in the project, it was then necessary to consider how each of the data sets could be used in relation to each of the environmental topics also initially identified as within the scope of the project and the depth and meaning of equity analysis that can be undertaken. The factors taken into account at this point included:

- the meaning of environmental justice/equity in relation to each environmental topic
- the capacity of the data set to meaningfully address an environmental justice concern
- the quality of the data sets and complexities involved in using data where quality is limited
- the scope for differentiating the analysis by particular characteristics of the environmental topic
- the need and scope for targeting the analysis on particular spatial areas
- the amount of work involved in undertaking each analysis

Following discussion with the Steering Group for the project the 8 environmental topics were chosen and a profile of prioritised data sets and data analysis for each topic was agreed. These are discussed further in the sections 7 - 14 of the report

5 General Methodological Issues in Environmental Justice Research

Before considering the form and focus of analysis to be undertaken in the next stage of the project, it is first useful to consider some of the generic methodological issues that have emerged from a review of the literature. For a more detailed account see Mitchell and Walker 2003.

Whilst methodological questions have been aired at length in the US literature, only recently have academics started to thoroughly and critically appraise the body of empirical environmental justice research conducted over the past 20 years (Bowen 2003, Liu 2001). Overall, such appraisals have concluded that the evidence for environmental injustice in the USA is less substantive than often thought. Bowen (2002) reviews 200 US environmental justice studies conducted from the early 1980's to 1998, of which only 43 were considered properly empirical. Of these studies, ten were considered so flawed as to be considered entirely conjectural and not able to support any policy decisions, 16 were sufficiently well designed and documented to be judged accurate, but still contained notable flaws. The results of the remaining 17 sound studies were mixed and inconclusive. Thus Bowen argues that, contrary to popular opinion, there is little sound environmental equity research in the US, and concludes '*that a relatively small and very heterogeneous body of research hints or indicates (but by no means demonstrates) that, in some specific areas, some ostensibly identifiable groups in the population may in some instances live closer to some selected hazards. In short the evidence regarding disproportionate distributions is mixed and inconclusive*' (Bowen, 2002).

The reasons for this conclusion relate not to just to the limited body of empirical research, but also the manner in which it was conducted. Bowen notes that of the 43 empirical studies he reviewed, 40 examined proximity rather than risk. Proximity studies are relatively simple and cheap to conduct, and so have proved popular, but proximal location is nevertheless a poor substitute for a meaningful measure of actual exposure or better yet health effects where such impacts are of concern (it should be noted though that proximity studies may be far more appropriate where proximity to environmental goods such as green space is the focus). Thus Bowen finds that, on the basis of the research evidence, little or nothing can be said about geographical patterns of disproportionate distributions and their health effects on low income and minority communities. The evidence from proximity studies, he argues, is inconclusive and occasionally contradictory, and not of the size or quality required to meaningfully inform public policy and administrative decisions. A clear lesson from the US experience is therefore the need for any equity study to match method to objectives and claims, and to be precise about what is being analysed and with what uncertainties.

Drawing on such experience and our own involvement in equity studies, we can identify a series of key methodological complexities associated with equity studies:

- **data quality and availability**. Data is not collected specifically for the purpose of equity analysis, and equity studies must therefore draw on secondary data collected for other purposes. As appropriate data is a fundamental requirement, this can present problems, limiting the quality of analyses. As undertaken in this first stage of the project, a key task for equity research is therefore to attempt to use the best data available and to be fully aware of the limitations and uncertainties of any data sets that are used.

- **impact assessment**. Environmental equity studies address a variety of impacts such as physical health, safety and security, amenity and social and economic well-being. Many of the negative environmental impacts such as pollution and risk result from an impact chain that extends from location of environmental hazard through to emissions, dispersion, exposure, received dose and eventual effect on human or environmental system. Most environmental equity analyses address the start of this impact chain, addressing proximity to an identifiable hazard rather than exposure or health impact. Such studies often implicitly assume that higher exposure occurs with greater proximity to a hazard. However, even where an unequal distribution of proximity is found (e.g. more deprived groups close to hazardous facilities) this does not necessarily mean, for a range of reasons outlined below, that there is an elevated public health risk. Thus *ideally*, environmental empirical equity studies would address the later stages of the impact chain, where estimates of exposure or actual health effects are used as the basis for the equity assessment. Nevertheless, it should be stressed that proximity studies are still useful and are well suited to the identification of non-health equity impacts, such as the distribution of compliance with environmental legislation, the resource investment of regulatory bodies or economic impact on property values. Their application is also simple and economical. However, where health is the principal equity concern, alternative scientifically more rigorous approaches giving improved health impact estimates are clearly desirable, but typically unattainable. Such health impacts may also have to consider the perception of risk by the local population which may link to anxiety or psychological health effects. Similar considerations apply where the topic is access to an environmental resource such as green space. Simple measures of proximity fail to take account of the complex set of considerations which will limit access to each particular parcel of green space (as reviewed earlier) but still provide a basic indicator of *potential* availability and access.

- **selection of appropriate target population groups**; All environmental equity studies must identify the social or demographic group of concern, the people amongst who the distribution of environmental risk or benefit is measured. This decision has typically reflected policy or political concerns. There has been little debate in the UK as to which demographic characteristic should be addressed in environmental equity studies. Most studies have addressed distribution with respect to one or more deprivation indices, although a handful of studies have addressed age and ethnicity.

- **spatial analysis difficulties**; All environmental equity studies must select a geographic unit of analysis. However, many studies have selected geographic units without considering two important issues: how relevant the unit of analysis is to the environmental and health impacts under study, and how sensitive are the results of the study to the choice of unit? Whilst risk based studies are more powerful than proximity studies, both can provide meaningful information, so long as the spatial analyses are appropriately conducted (Maantay 2002). There is a challenging set of spatial issues raised here including:

    - *ecological fallacy* when results from analysis of large units do not hold true for smaller more refined units, but are assumed to do so.
    - *boundary problems* where the presence or absence of a noxious facility or land use in a geographical unit (e.g. ward, district, Local Authority) is the surrogate exposure variable. An obvious disadvantage is that households could be located very close to a noxious facility, say just across the street, but are located in a neighbouring geographical unit, and hence are not linked to that facility in the equity analysis. The boundary problem becomes less of an issue at finer geographical scales, but illustrates that proximity analysis can be a poor surrogate for exposure.
    - *geographical unit shape and size.* The geographical units of analyses most commonly employed in equity analysis are necessarily based upon administrative or census units

for which the required demographic data is available. These units have irregular shapes and sizes, hence common measures of proximity may be poor measures of distance to households (let alone exposure) in these areas. Buffer zones around particular spatial features can be used to in part address this problem, but raise their own methodological difficulties, such as how to determine the size of zone and what to buffer from (a point or an area).

- *Modifiable Area Unit Problem* (MAUP). This problem recognises that, for the same region, research findings can vary according to the geographical scale of analysis. Liu (2001) notes that many different scales have been used in US environmental justice studies, from state level to census blocks or less, and cites three studies in which scale issues have been investigated in equity analyses. These studies investigated the sensitivity of the social distribution of hazard from point facilities (Toxic Release Inventory and Transfer, Storage and Disposal Facilities sites) for up to five different scales, and found that identification of inequalities by income and particularly race were scale dependent.
- *Comparison areas*. A final spatial issue in equity studies concerns the selection of a comparison area. The conclusion of inequity is sensitive to choice of comparison area. If the study and comparison areas are not selected carefully, then the analysis will simply tend to confirm that there are differences in confounding factors between study and comparison areas. Issues of comparison are minimised however if 'whole country' analyses are undertaken.

- **assessing cumulative impacts**; Most environmental equity studies have analysed the distribution of different forms of environmental hazard on an independent and separate basis. This means that no account is taken of the total combined burden from different hazards in the same place. A number of studies (e.g. Bollin et al. 2002) have attempted to undertake an integrated analysis that takes some account of the cumulative burden of risk and have demonstrated the 'peaks' of accumulated inequity that can emerge. Such methodological approaches may be particularly relevant if spatially targeted policy responses are to be developed as a possible policy response.

- **statistical assessment of inequality**; Some studies draw conclusions about the nature of environmental inequity based on a visual comparison of mapped environmental and social distributions, but a more confident determination of association requires statistical analysis. A variety of statistical procedures, ranging from simple descriptive statistics to more complex multivariate analysis are used to determine the significance of association between the relevant distributions. Using a variety of univariate statistics, Greenberg (1993) demonstrates that the outcome of an equity assessment is sensitive to the statistical test applied, and hence the test should be selected carefully.

- **understanding causality**; In developing responses to environmental inequality, it can be helpful to have an understanding of how the inequality has arisen. This is important in terms of judging how 'unfair' the inequality is and in ensuring that measures taken to redress inequalities are appropriate and efficient. However, establishing cause and effect in social sciences is difficult due to the complexity of the processes involved, hence there is often significant uncertainty associated with causal explanations.

- **assessing injustice;** Having investigated an environmental cost or benefit, and determined that there is a significant inequality in its social distribution, it is then appropriate to ask to what extent is this inequality unfair, and what should be done about it? There are no technical answers to this question, rather it is a largely a matter of judgement, and clearly depends upon the views of those making the assessment and developing responses.

Deciding on appropriate responses to environmental inequality is further complicated by justice theory, which describes how benefits are distributed in society. There are several justice theories, each providing guidance on how benefits should be distributed so as to make a more equitable society (e.g. benefits can be distributed: equally amongst everyone; according to their merits or input; or according to their need). These ideas are presented in theories such as utilitarianism (maximise net benefit to society), egalitarianism (distribute benefits equally to all), contractarianism (improve conditions of least well off) and libertarianism (maximise freedom of choice and action).

Whilst this list of methodological complexities is substantial it is important to note that such complexity is not an uncommon feature of both environmental and social science research. The task is to find a pathway for undertaking meaningful analysis that is 'fit for purpose', operating within data and resource constraints, but with full recognition of the constraints integrated into the research design, and hence also recognised in policy development.

6 Methods of Data Analysis

As discussed in the last section there are a wide range of methodological issues to consider when investigating environmental justice and deprivation. The specific methodological issues which arise for each of the environmental topics in this project are discussed separately in their respective sections. However, there are aspects of the social deprivation data and the presentation of the results that are common to all of the analyses undertaken and these are discussed here.

6.1 Data Zone Population and the 2004 Scottish Index of Multiple Deprivation

The spatial units for the 2004 Scottish Index of Multiple Deprivation are the data zones which were produced at St Andrews University for the Scottish Executive (Flowerdew et al., 2004). Data zones are aggregations of 2001 census output areas and are designed to become the core geography for small area statistics across a wide range of policy sectors in Scotland. The criteria for the production of the data zone areas were:

"… in approximate order of importance:

1) approximate equality of population, between 500 and 1000 people;

2) compactness of shape;

3) approximate homogeneity of social composition;

4) existence, where possible, of some community of interest;

5) accordance with other boundaries of local significance; and

6) accordance with prominent features in the physical environment." (Flowerdew et al. 2004)

This application of these criteria resulted in 6505 data zones for Scotland with populations ranging between 431 and 2813 (however, only three data zones have a population above 1100). Data zones vary considerably in size and reflect the very concentrated distribution of population within Scotland, with over 80% of the population living in less than 2% of the area.

Table 6.1 Data zones size and associated populations.

Size of data zones (hectares)	Frequency	Total area (hectares)	Percentage area of Scotland	Total population	Percentage of the population
Less than or equal to100	5,277	125,883	1.61	4,125,374	81.50
100+ to 500	282	68,562	0.88	218,260	4.31
500+ to 5000	602	1,315,104	16.87	458,891	9.07
5000+ to 50000	318	4,428,377	56.80	239,992	4.74
50000+	26	1,859,142	23.84	19,494	0.39
Scotland	6,505	7,797,068	100	5,062,011	100

The 2004 Scottish Index of Multiple Deprivation (SIMD, Scottish Executive 2004) comprises of an overall rank obtained from six domains in the index (current income, employment, health, education skills and training, geographic access and telecommunications and housing). Note that the 2004 SIMD does not include a physical domain, though there are plans to introduce such a domain in updates to the index. If such a domain was included it would then be inappropriate to use the overall SIMD rank in studies such as this, instead some of the individual domains could be used. There is some variation in terms of the date of the data used to make up each domain although it is mainly for the year 2002.

The term multiple deprivation or deprivation used in this report is a technical one which records quantitatively a number of characteristics about the socio-economic structure of a population. Deprivation is a term commonly used today as the word poverty is both contested and seen as politically charged. Poverty is commonly thought of as a lack of economic resources and significantly this is a major part of the deprivation index. The income domain within the index of multiple deprivation is present as an “indirect measure of a major part of the main cause of deprivation” (Scottish Executive 2004). However deprivation in this case not only considers economic issues but also health and access to services, as such deprivation could be argued to be a more comprehensive term than poverty.

6.2 Creation of deciles

To examine the issue of environmental justice within a population we need to divide the population into groups so that we can determine the differences between them. In this study ten groups have been used containing equal populations, these are known as deciles.

In order to create data zone deciles the overall rank was used to place each data zone into a decile of equal population (See Table 6.2). Deciles of equal population are preferred to those of equal data zone count as the analysis then gives a population based distribution which is more meaningful for equity based studies. **In all cases decile 1 is the most deprived and decile 10 is the least deprived.** It is important to understand what these deciles represent. Essentially, decile 1 has the largest *concentration* of deprived people, while decile 10 has the smallest concentration of deprived people. Population weighted deprivation deciles of this form are often referred to using shorthand terminology but their precise definition needs to be remembered: in this way decile 1 is not 'the poorest 10% of the population', as some of the poorest people will live in pockets within less deprived data zones, nor is it 'the 10% most deprived data zones' as a population weighting has been applied.

Table 6.2 Population weighted deprivation deciles for data zones in Scotland

Decile	Population	Ranks	No. of data zones
1	505,775	1- 628	628
2	506,808	629 – 1,277	649
3	506,064	1,278 – 1,926	649
4	506,082	1,927, – 2,579	653
5	506,596	2,580 – 3,238	659
6	505,966	3,239 – 3,904	666
7	505,930	3,905 – 4,572	668
8	506,157	4,573 – 5,227	655
9	506,485	5,228 – 5,874	647
10	506,148	5,875 – 6,505	631

It follows that a population within a data zone and within a decile will vary in their characteristics; the index of deprivation provides a statistical measure for a group of people rather than a precise measure for every individual. Within area based studies this is a well known limitation referred to as the ecological fallacy which requires a caveat to be placed on any area based analysis. However it should be noted that the small population of data zones and approximate homogeneity of social composition will have helped to lessen this problem compared to ward analysis, for example.

6.3 Locating population using AddressPoint data.

For most of the analyses a buffer analysis has been undertaken which involves creating areas within specified distances of particular spatial features (e.g. within 600m of woodland). To then determine the deprivation characteristics of the population within that buffer area, it is desirable to take account of the distribution of population within the data zones that intersect with the buffer area. It may be for example that the part of data zone that falls within the buffer area in fact contains no population (a particular issue in the larger rural data zones), so to use the social characteristics of this data zone as part of the analysis would be nonsensical. Therefore to improve the spatial resolution of the analysis use has been made of the detailed spatial dataset (AddressPoint) which records every residence in Scotland. This is a point dataset that gives most locations to 1 metre accuracy.

The population figures used in this study are those reported in the 2004 Scottish Index of Multiple Deprivation and they are reported at data zone level. The population figures are taken from the 2001 census reported in the 2004 SIMD.

The datasets were processed in the following way:

- *Select residential addresses* – Residential address locations were taken from AddressPoint. Locations were deemed residential if they were 'non PO-Box and did not have an organisation name' and in addition they were not classified as demolished. There are approximately 2,330,000 residential addresses in Scotland that were used for this study.

- *Assign a population to each address location* – Each address location was assigned to the data zone that it fell within. Each data zone population was divided evenly across all of the addresses within it. This is important because the total population of the addresses must match the population reported in the SIMD. By assigning a data zone to each address the deprivation decile of each address is also known. This allows results to be reported by deprivation characteristics.

Populations were known for unit postcodes boundaries for 2001, but this data does not fully align with the AddressPoint data for 2003 as postcodes change over time.. Postcodes boundaries were not used to attach populations to AddressPoint because some unit postcodes did not have any AddressPoints within them. If postcodes had been used then some populations would not have been assigned to AddressPoints and the overall population of each data zones addresses would not have matched the reported SIMD population.

Whilst there is a theoretical advantage to using postcode boundaries populations they are limited by the time constraints of the data. Any difference between address populations using postcodes and address populations using data zones is likely to be extremely small for the following reasons:

a. The average figure produced by both will be similar, as 80% of households have between 1 and 3 people in them in Scotland.
b. The value attached to any one AddressPoint (regardless of which method is used), is obviously incorrect in reality (e.g. 2.2 people), but when aggregation of addresses occurs a population figure is produced which should reflect reality as closely as possible.

Spreading data zone populations evenly produces an average 'population per address' value. These populations were examined to determine whether they were sensible and this revealed a number of data zones with very high population per address figures. Examination of these data zones closely revealed a common problem. This was the presence of communal establishments with large populations that are represented as a single address location Such as: Armed Forces sites, Prisons and University Halls of Residence.

This problem was solved in the following steps:

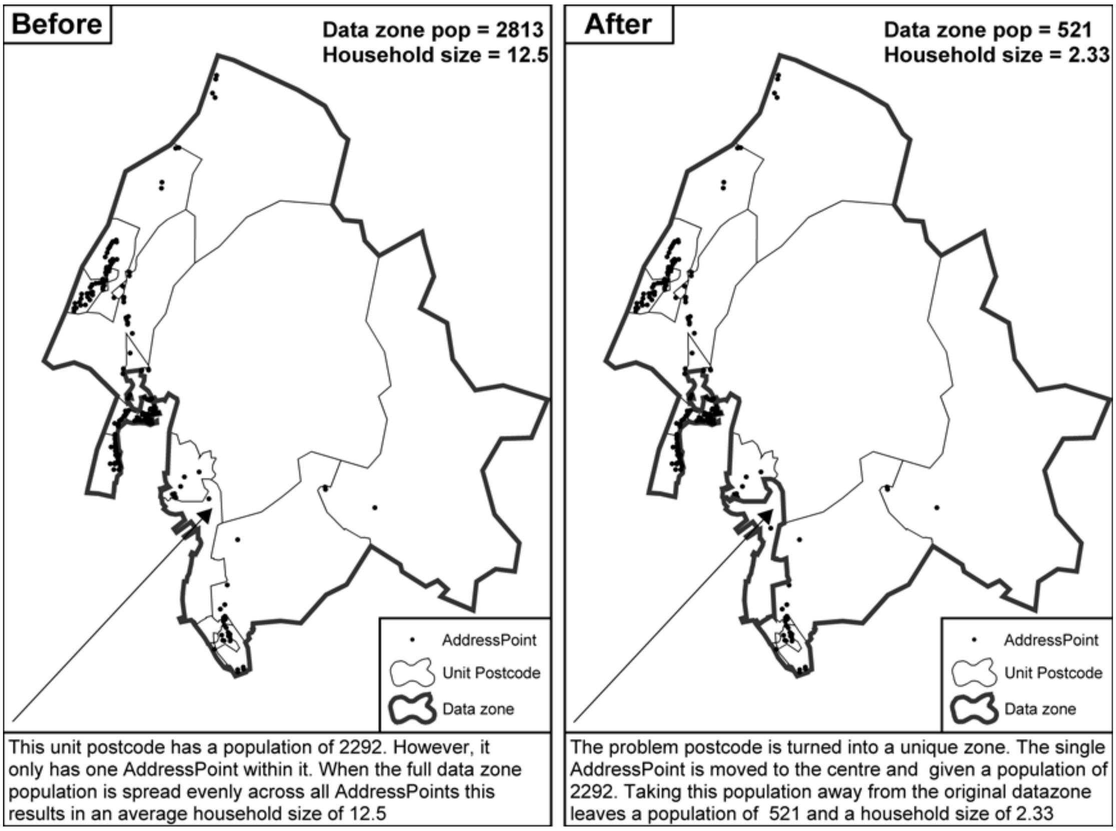
- Postcode boundaries with corresponding populations helped to adjust population figures. By looking at address information and postcode populations the location of the high density population within the data zone was determined.

- The solution was to create a new and unique zone using the postcode boundaries. The population of the postcode was assigned to the address location(s) within the boundary or if no address location was present the population was assigned to the geographic centroid of the postcode boundary.

- The population of the postcode was then subtracted from the population of the data zone that it falls within. The population per address within the rest of the data zone was then recalculated. This is important because the overall population for the data zone needs to remain the same.

Figure 6.1 gives an example of this process. This was carried out on any data zone with a population per address value greater than four. In total there were twelve data zones where this was the case and out of these, nine data zones were altered as we could identify individual features that had caused the high figures. Three data zones remained unchanged because it was not possible to determine whether the initial value was actually incorrect.

Figure 6.1 Example of an altered data zone



By carrying out the process of altering these data zones the high density population locations have been uniquely identified. The limitation of these locations is that they will experience edge effects in any buffer analysis because they are representing a large site with a large population as a single point. Thus a point could fall outside a buffer zone used in a possible analysis resulting in the population being missed out while in reality part of the site and associated population is actually within the zone. In contrast, a point could fall within a buffer zone resulting in all of the population being included while in reality part of the site is outside the buffer zone.

It is important to be aware of these limitations when looking at the results even though the population involved is only a very small percentage of the total population. However, this solution is far more acceptable than not identifying the locations and spreading the populations throughout a large area such as a data zone.

6.4 Spatial proximity measures

Many of the analyses in this report make use of proximity analysis i.e. what type of population lives within a set distance. The distance used is a Euclidean or "as the crow flies" distance. The usefulness of this compared to distance calculated along a route or network will vary depending on the environmental variable under consideration. For example, Euclidean analysis is the best option for the air quality data, but not the best possible option for access to woodland, as barriers may be in the way. The issue of distance and how it affects the analysis is discussed in each individual section. It should also be noted that proximity is often being used as a surrogate measure for other preferable but less quantifiable measures.

6.4.1 Distance selection for proximity studies

Distance has been selected in two main ways within the report

a. The use of set distances e.g. 1 and 4km which ties in with established zones used within planning by regulators (Environment Agency) e.g. for the sitting of polluting facilities. 1km is the most commonly used distance in impact assessments and 4km is thought to be the maximum distance of impact for airborne pollutants. The distances of 0.5 and 2km were also used to test for sensitivity due to the limitations of some of the datasets.

b. The second type of distance needed is essentially linked to our understanding of how people access green spaces and woodlands. We first have to consider how most people get to a woodland or green space. The research evidence shows that the overwhelming majority get there by walking (Dunnett et al 2002), this is also re-iterated in a range of standards proposed by different studies (see Table 6.3). After reviewing these studies the distance of 600metres was selected which is near the lower end of distances suggested. Once this walking neighbourhood distance was selected it was then also used within the derelict land and river water quality dataset analyses.

Table 6.3 Access standards for green spaces

Study	Criteria suggested	Comments
Barker and Graf 1989	A minimum standard of 0.5ha/km for green spaces in urban areas. An objective that schools should have access to a wildlife area within 10 minutes walk.	This includes distance and time criteria.
Box and Harrison 1993	Two minimum targets: 1. Natural green space of at least 2 hectares and within 0.5Km for urban residents. 2. Provision of a local nature reserve in every urban area at a minimum level of 1 hectare per thousand population. Also guidelines: At least one 20 ha site within 2 km of all residents. At least one 100 ha site within 5 km of all residents. At least one 500ha site within 10km of all residents	
Harrison et al 1995	Distance of 280 metres to accessible natural areas. Minimum size varies depending on purpose. Sites less than 2ha are fine for childs play. Sites of 2ha appear to provide areas with definable safe boundaries where children can play unsupervised.	After a review of children home range studies.
Barton 1995	Playing fields 800-1000metres Park or open space on the green network 800-1000m Major natural green space 2 – 5km	
Europa 1998	Proportion of population within 15 minutes walking distance of urban green areas (%)	Guideline for the assessment of 58 European cities
Cole and Bussey 2000	2 ha the minimum size of an urban woodland that people would visit regularly. Shape of woodland important in woods less than 5ha – blocks preferred to narrow belts. Walking distance of 5-6 minutes (100-400metres) suggested for parks beyond this frequency of use drops. Maximum walking time 15 minutes.	Open structure woods preferred. No difference between ancient woodland and plantation.
NPFA 2001	The Association recommends its use as a minimum standard per 1000 population of: 4 acres (1.6 hectares) for outdoor sport, including pitches and greens; and 2 acres (0.8 hectares) for children's playing space.	
Scottish Planning Advice Note 65 (PAN 65 2003)	"this [NPFA 2001] may act as a useful starting point, but it should not substitute for standards developed locally which take into account existing and desired quality, quantity and accessibility of open space."	
Handley et al 2003	More in favour of a localised figure depending on circumstances.	Updates and reviews Harrison et al 1995
Miller et al 2004	Neighbourhood park less than 400m Local park less than 600m City park less than 1500m	In the Aberdeen draft plan. Used network analysis for calculation of distances.
Woodland Trust 2004	Woodland Access Standard 500m to a 2ha or greater wood. At least one 20ha accessible wood within 4km	

6.5 Rural-Urban classification

Where appropriate and where resources allowed analysis has also looked at the rural/urban populations to aid understanding of the issue under consideration.

Postcode boundaries are allocated to one of 8 settlement type classifications in the Scottish Household Survey 2003 depending on criteria related to population and access (see Table 6.4). We used these boundaries to categorise AddressPoints as type 1 through to 8. Addresses located in settlement types 1 to 5 were then classified as urban and addresses located in settlement types 6 to 8 were classified as rural, following the convention adopted by the Scottish Executive. Table 6.5 provides a breakdown of the estimated urban and rural populations within each deprivation decile.

By using this urban-rural classification of AddressPoints results of analyses for several of the environmental topics could be reported as the proportion of the urban population affected or the proportion of the rural population affected for each deprivation decile. In addition, this allows a comparison between the urban and rural population split of an entire decile and the urban and rural split of an affected population within the decile.

Table 6.4 Classification of settlement type

Type	Description
1	Primary cities with a population of 125,000 or more
2	Urban settlements with a population of 10,000 or more
3	Accessible small towns: Settlements sized between 3,000 and 10,000 and within a 30 minute drive time of a town/settlement centre with a population of 10,000 or more.
4	Remote small towns: Settlements sized between 3,000 and 10,000 and between a 30 and 60 minute drive time of a town/settlement centre with a population of 10,000 or more
5	Very remote small towns: Settlements sized between 3,000 and 10,000 and over a 60 minute drive time of a town/settlement centre with a population of 10,000 or more.
6	Accessible rural: Settlements of less than 3,000 and within a 30 minute drive time of a town/settlement centre with a population of 10,000 or more.
7	Remote rural: Settlements of less than 3,000 and between a 30 and 60 minute drive time of a town/settlement centre with a population of 10,000 or more.
8	Very remote rural: Settlements of less than 3,000 and over a 60 minute drive time of a town/settlement centre with a population of 10,000 or more.

Table 6.5 Urban and rural populations of deciles

Decile	Total Population	Urban Population	Rural Population	Urban Population (%)	Rural Population (%)
1	505,694	498,301	7,393	98.5	1.5
2	506,819	475,296	31,523	93.8	6.2
3	506,079	464,795	41,284	91.8	8.2
4	506,088	428,663	77,425	84.7	15.3
5	506,603	375,266	131,337	74.1	25.9
6	505,988	330,739	175,249	65.4	34.6
7	505,892	300,667	205,225	59.4	40.6
8	506,178	349,527	156,651	69.1	30.9
9	506,459	418,923	87,536	82.7	17.3
10	506,162	471,308	34,854	93.1	6.9
Scotland	5,061,961	4,113,484	948,477	81.3	18.7

6.6 Statistical analysis

We have for some of our analysis calculated Gini Concentration Index (CI) values to provide a comparative statistical indicator of inequality. The CI is closely related to the simpler Gini coefficient which has been widely adopted as a measure of income and health inequalities (Wagstaff *et al*. 1991) and also recently applied to environmental equity research (Lejano *et al*. 2002. Walker *et al* 2003). To calculate a Gini coefficient, data are plotted as a Lorenz curve (cumulative distribution) and the area between the curve and a line of equal distribution calculated by integration.

Whereas a Gini coefficient is used to calculate the distribution of a variable across a constant unit (e.g. income by population), Gini CI values are used to investigate the distribution of a variable with respect to a second, usually socio-economic, variable (e.g. disease by socio-economic status). A modified form of the Gini calculation method is used, in which CI values range from 1 to -1. A value of zero indicates complete equality (e.g. in our application the proportion of the population within 600m of derelict land would be identical for all deprivation deciles) whilst values of 1 and -1 indicate extreme inequality in positive or negative relationships with deprivation.

The CI does not provide an indicator of the *significance* of inequality which will always be an ethical and political judgement and is best used in a comparative setting (see e.g. the comparison of different buffer sizes around EPER sites in section 7). It is useful to note however that values for income inequality in the UK over the period from 1979 to 2001 have ranged from 0.25 to 0.35 (Shephard 2003). Gini values for income inequality in the USA, by comparison, are currently around 0.45.

6.7 Methodological Limitations

Each of the analyses we have undertaken inevitably has limitations arising from the quality and resolution of source data sets, the spatial scale at which analysis has been undertaken and the complexity of real world environmental variables which can only partially be captured. The decision was taken by the project steering committee to cover a wide range of environmental topics within the research rather than to study a smaller number in greater depth and with greater sophistication. Consequently the results reported over subsequent sections need to be seen as a first view of relationships between environmental and deprivation variables in Scotland and in the discussion that follows we have sought to be fully open about the limitations of analysis and, where necessary, cautious with the conclusions that can be reasonably be made.

7 Industrial Pollution

7.1 Introduction

Industrial pollution is represented in this project by sites in Scotland which fall within the scope of the Industrial Pollution Prevention and Control (IPPC) Directive. Annex 1 of the Directive, as implemented by the Pollution Prevention and Control (PPC) Scotland Regulations (2000), defines a set of industrial activities and scales of activity which make it likely that potentially significant levels of polluting emissions (to air, water or land) will be produced. Encompassed within the Annex 1 IPPC category are the most substantial sources of pollution from industrial and related sources in Scotland. Each of the IPPC sites has to obtain permits to operate specified activities and undergo inspection by Scottish Environment Protection Agency (SEPA) field staff. The emissions made from each site are extremely diverse and may combine with pollution from other sources, including smaller scale businesses falling within the broader PPC regime, also regulated by SEPA, to influence overall air, water and land quality. The data available for the larger number of smaller sites was not available for this project, principally because of problems with the accuracy of site grid references.

In total there are 232 IPPC sites in the dataset for 2002 used in this project. Of these only 108 sites had 'reportable emissions' exceeding the thresholds laid down for reporting to the European Pollutant Emission Register (EPER). All 232 sites are used in the analysis but a distinction is made between those with reportable and non-reportable emissions. It should be noted that the reportable substances and emission thresholds for EPER have been set in relation to a number of considerations including impacts on climate change and the environment, rather than solely local impacts on human health. The occurrence of reportable emissions at IPPC sites does not therefore necessarily imply a higher level of impact on local people. The actual profile of local impacts from pollution emissions from IPPC sites will be highly diverse depending on a wide range of factors relating to both the type and level of emissions and their dispersion along pathways through the environment. It has not been possible to represent this diversity within the analysis in this project.

7.2 Data sources and methods

Data supplied by SEPA consisted of information on site location, industrial sector and whether or not each site had emissions at an EPER reportable level in 2002. Each site in the IPPC database has a grid reference which is usually positioned at the site entrance. SEPA has recently undertaken an accuracy check for each of these grid references, which should therefore be of good quality.

The approach taken to spatial analysis is to draw circular buffers around each site grid reference and then analyse the deprivation characteristics of the residential population within the buffer. This is superior to a method which simply takes the data zone that the grid reference falls within and uses this zone to characterise the deprivation characteristics of the population living near to the site. Data zones are of different shapes and sizes and grid references may fall close to the zone boundary so that populations proximate to the site are not recognised as such in the deprivation analysis (see discussion on spatial analysis issues in section 5).

Four types of differentiated analysis were undertaken:

a. Population Proximity Analysis

Ideally if the objective of analysis is to examine potential impacts on people living near to an IPPC site then a buffer would reflect the distribution of estimated potential impact. This could take the form of a risk contour, a plume grounding area for emissions from stacks, a visual impact area, or noise contour depending on the impact of concern (none of which are likely to be simple circles of fixed radius). However, such detailed and site-specific information on exposure patterns is complex and resource-intensive to produce and is unavailable on a national basis. For large sites with multiple emissions it would also involve taking account of many different forms and scales of exposure and potential impact. For this reason it is only possible to use a buffer *not* as a measure of actual exposure or impact, but as a way of *characterising* the deprivation profile of people living around the site.

The size of the buffer has then to be determined and in many equity studies this decision has been recognised as rather arbitrary (Liu, 2001). As in a previous project for the Environment Agency, our approach has been to explore the impact of varying buffer size by undertaking an analysis using four different buffer sizes; 500m, 1km, 2km and 4km. This range of buffer sizes was suggested as encompassing at 4km the greatest likely extent of impact from emission sources. The graduations below 4km then provide a range of alternatives for exploring the significance of buffer size on the results of equity analysis.

One of the limitations of the buffer analysis is that a circle will be drawn around the grid reference point, which for large sites may be some distance from actual emission sources. Ideally buffers would be drawn around each individual source or maybe around the entire site area, but the spatial information required to undertake far more involved analysis is not available.

b. Analysis by cluster of sites

This was carried out for the four different distances to discover which populations were living near to multiple IPPC sites. However, for conciseness results are only reported below for the 1km and 2km distances which show the most distinct patterns. It is important to note that a cluster of sites does not *necessarily* imply a greater level of overall pollution burden - a cluster of smaller sites may have less impact than one large site.

c. Analysis by industrial sector

The IPPC database included information on the industrial sector for each site enabling breakdown of patterns by industry.

d. Analysis by reportable emissions

In order to identify those with more significant emissions, analysis was broken down by whether or not the site had an EPER reportable level of emission in the 2002 database.

7.3 Results

Table 7.1: Population within 0.5km, 1km, 2km and 4km of an IPPC site by deprivation decile

Decile	Total Population in Decile	Popn within 0.5km	%	Popn within 1km	%	Popn within 2km	%	Popn within 4km	%
1	505,775	22,012	4.4	98,560	19.5	252,863	50.0	440,248	87.0
2	506,808	21,985	4.3	90,673	17.9	217,247	42.9	404,046	79.7
3	506,064	17,132	3.4	62,685	12.4	181,256	35.8	376,971	74.5
4	506,082	17,865	3.5	64,207	12.7	180,975	35.8	361,064	71.3
5	506,596	16,531	3.3	51,257	10.1	149,077	29.4	293,391	57.9
6	505,966	13,275	2.6	47,901	9.5	138,957	27.5	277,387	54.8
7	505,930	11,777	2.3	42,435	8.4	127,807	25.3	256,562	50.7
8	506,157	6,459	1.3	34,900	6.9	124,920	24.7	280,485	55.4
9	506,485	6,543	1.3	34,211	6.8	136,075	26.9	303,174	59.9
10	506,148	3,471	0.7	28,137	5.6	124,101	24.5	320,436	63.3
Scot	5,062,011	137,051	2.7	554,967	11.0	1,633,278	32.3	3,313,765	65.5
CI values			***0.26***		***0.22***		***0.13***		***0.08***

Figure 7.1: Percentage populations within 0.5km, 1km, 2km and 4km of an IPPC site by deprivation decile

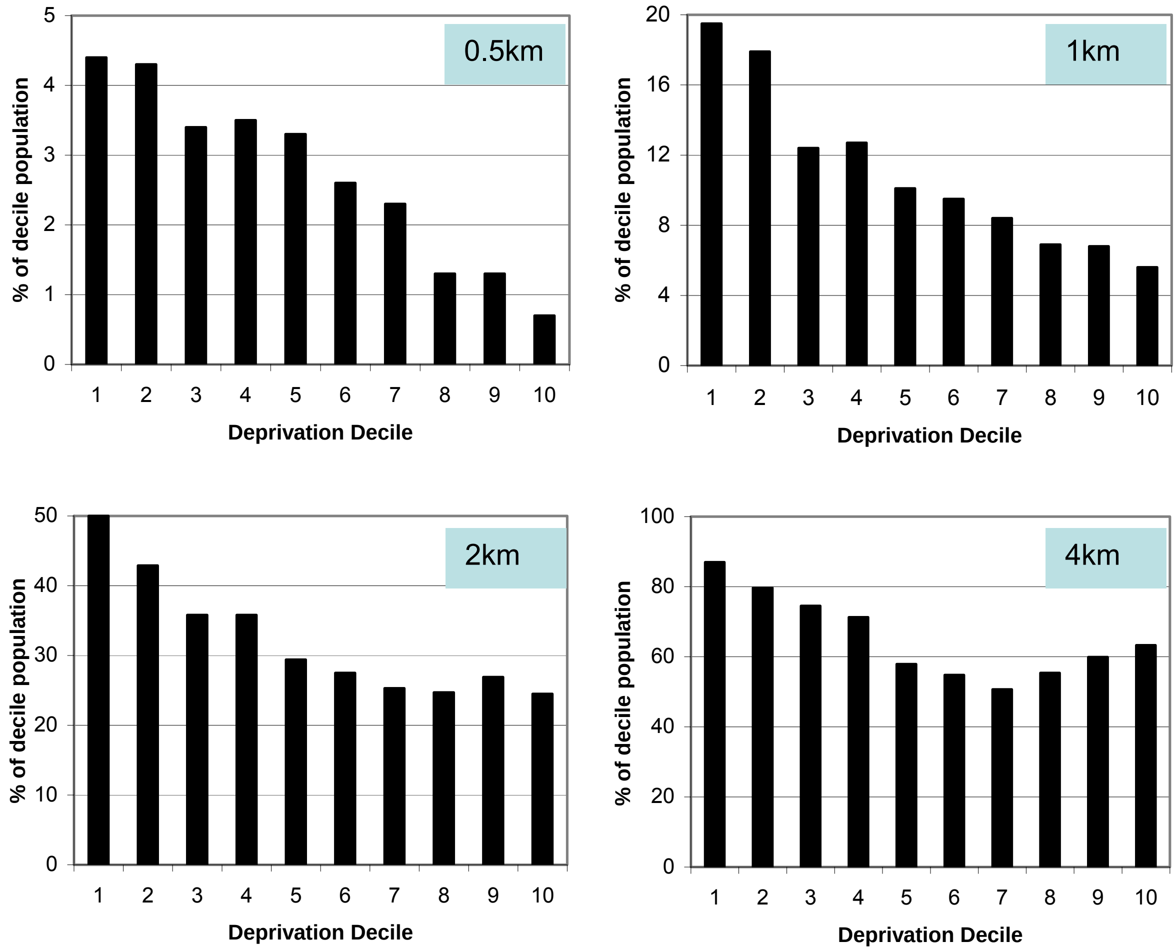


Table 7.2: Population within 1km of multiple IPPC sites by deprivation decile

Decile	Total Population in Decile	4 or more sites	%	3 or more sites	%	2 or more sites	%	1 or more sites	%
1	505,775	289	0.06	454	0.09	5,713	1.13	98,560	19.48
2	506,808	310	0.06	3,539	0.70	14,519	2.86	90,673	17.89
3	506,064	245	0.05	1,342	0.26	10,396	2.05	62,685	12.39
4	506,082	6	0.00	1,020	0.20	7,813	1.54	64,207	12.69
5	506,596	154	0.03	1,031	0.20	8,948	1.77	51,257	10.12
6	505,966	2	0.00	306	0.06	5,029	0.99	47,901	9.47
7	505,930	0	0.00	18	0.00	3,583	0.71	42,435	8.39
8	506,157	363	0.07	1,023	0.20	5,766	1.14	34,900	6.90
9	506,485	308	0.06	572	0.11	3,561	0.70	34,211	6.75
10	506,148	0	0.00	0	0.00	1,758	0.35	28,137	5.56
	5,062,011	1,677	0.03	9,306	0.18	67,086	1.33	554,967	10.96
CI Values			***0.13***		***0.32***		***0.23***		***0.22***

Note: columns are cumulative left to right; percentages are of the total population in each decile

Figure 7.2: Percentage population within 1km of multiple IPPC sites by deprivation decile

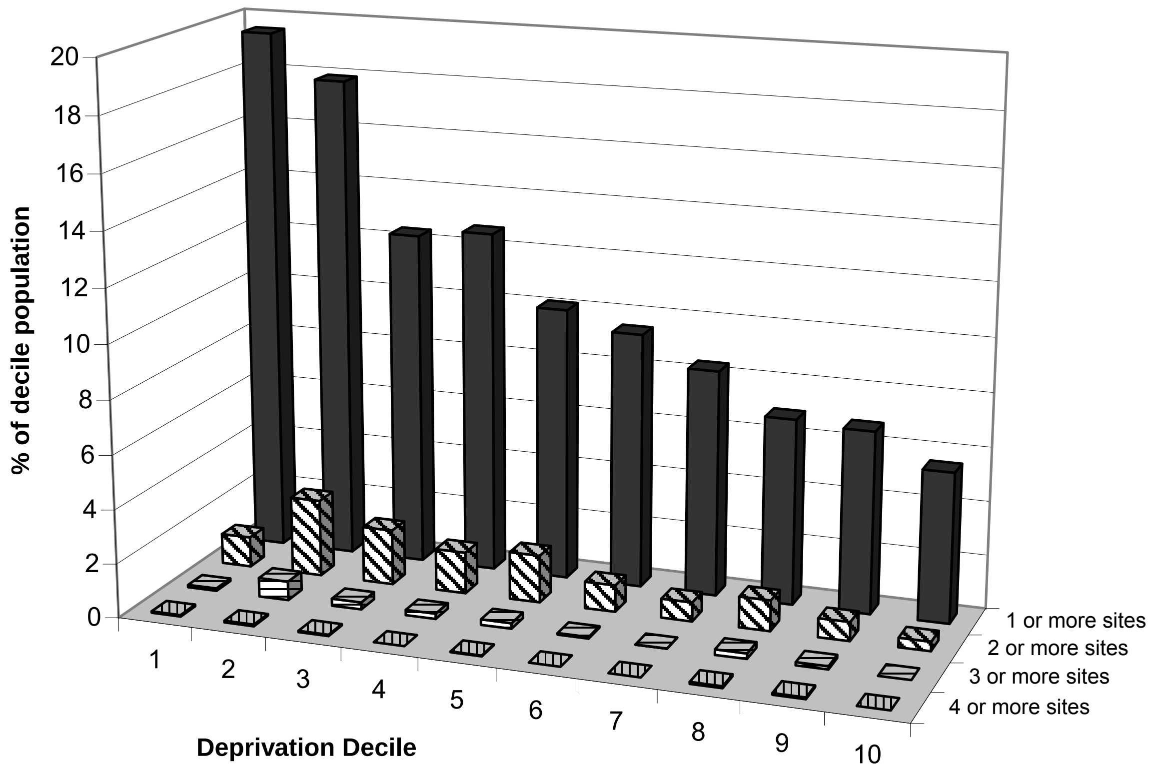


Table 7.3: Population within 2km of multiple IPPC sites by deprivation decile

Decile	Total Population	6 or more sites	5 or more sites	4 or more sites	3 or more sites	2 or more sites	1 or more sites
1	505,775	1,209	1,468	8,618	17,418	83,751	252,863
2	506,808	5,282	6,114	14,424	28,106	77,879	217,247
3	506,064	6,735	7,296	14,412	24,912	59,220	181,256
4	506,082	2,213	3,409	7,982	13,493	67,611	180,975
5	506,596	1,270	1,276	7,395	18,996	45,030	149,077
6	505,966	628	696	5,985	11,979	40,189	138,957
7	505,930	1,649	1,930	6,068	11,013	36,219	127,807
8	506,157	1,503	1,526	6,443	12,239	30,788	124,920
9	506,485	850	869	3,640	8,222	41,587	136,075
10	506,148	0	447	2,827	5,911	27,550	124,101
Scotland	5,062,011	21,338	25,031	77,793	152,290	509,824	1,633,278
CI Values		***0.33***	***0.32***	***0.22***	***0.21***	***0.20***	***0.13***

Note: figures are cumulative left to right; percentages are of the total population in each decile

Figure 7.3: Population within 2km of multiple IPPC sites by deprivation decile

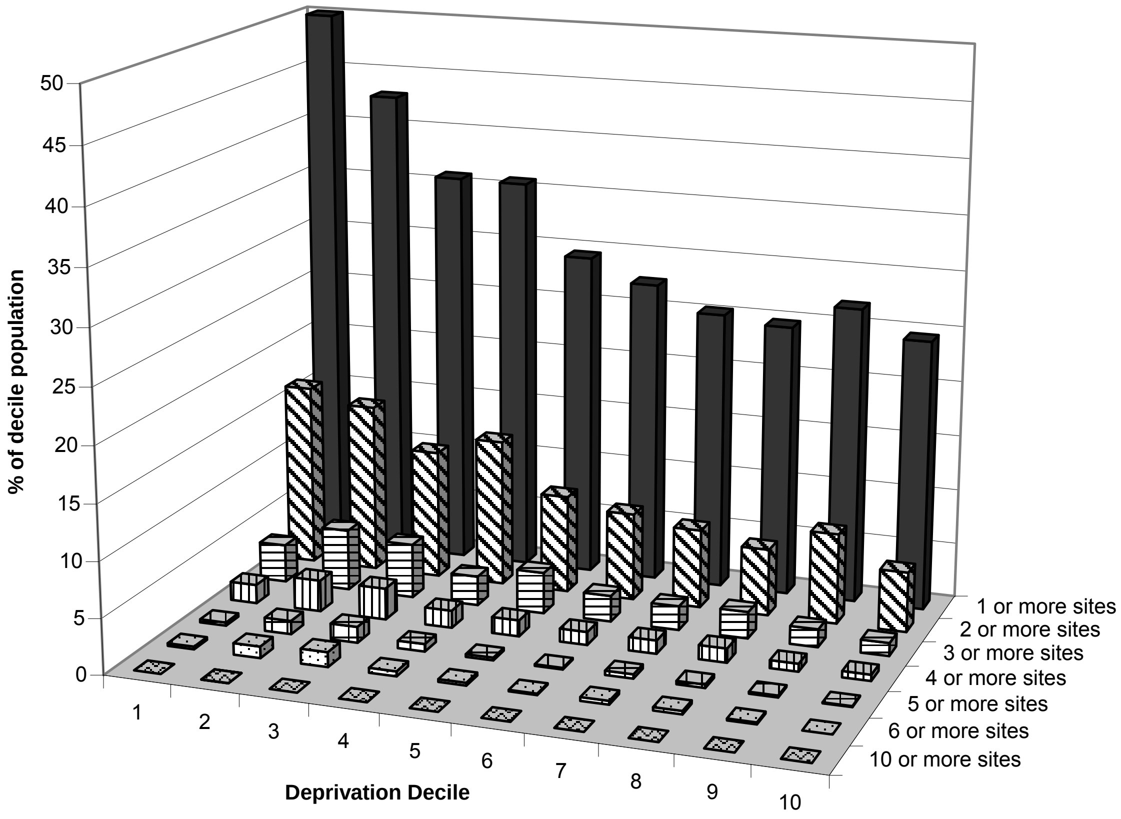


Table 7.4: Population within 1km of an IPPC site by industry sector and deprivation decile

Decile	Population within 1km of an IPPC site	Chemical	Energy	Metal	Mineral	Waste	Other
1	98,560	13,291	19,287	8,038	499	24,000	35,942
2	90,673	18,075	13,430	14,754	693	14,801	40,914
3	62,685	11,806	6,493	8,751	208	11,001	29,470
4	64,207	14,895	5,851	8,719	2,164	10,497	23,006
5	51,257	16,272	4,553	4,922	723	3,454	23,790
6	47,901	7,148	2,044	4,058	1,053	6,626	25,381
7	42,435	12,186	1,161	1,772	1,153	5,431	21,383
8	34,900	7,701	3,410	4,673	212	5,521	14,955
9	34,211	10,420	731	3,981	0	2,563	18,191
10	28,137	9,775	307	1,935	0	3,044	13,712
Scotland	554,967	121,569	57,268	61,603	6,706	86,939	246,744
CI Values		**0.10**	**0.51**	**0.28**	**0.18**	**0.36**	**0.18**

Note: the industry columns do not sum to the "pop within 1km of an IPPC site" column because a given population can be within 1km of more than one type of site.

Figure 7.4: Population within 1km of an IPPC site by deprivation decile and industrial sector

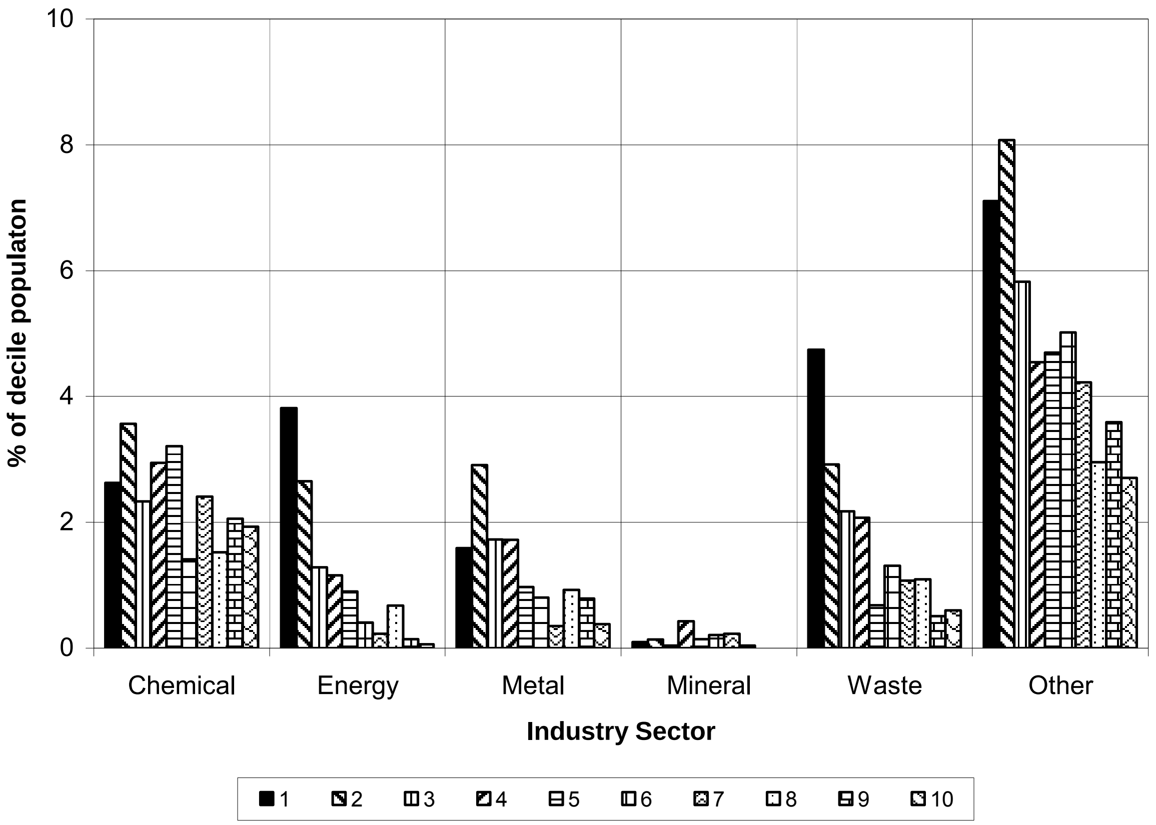


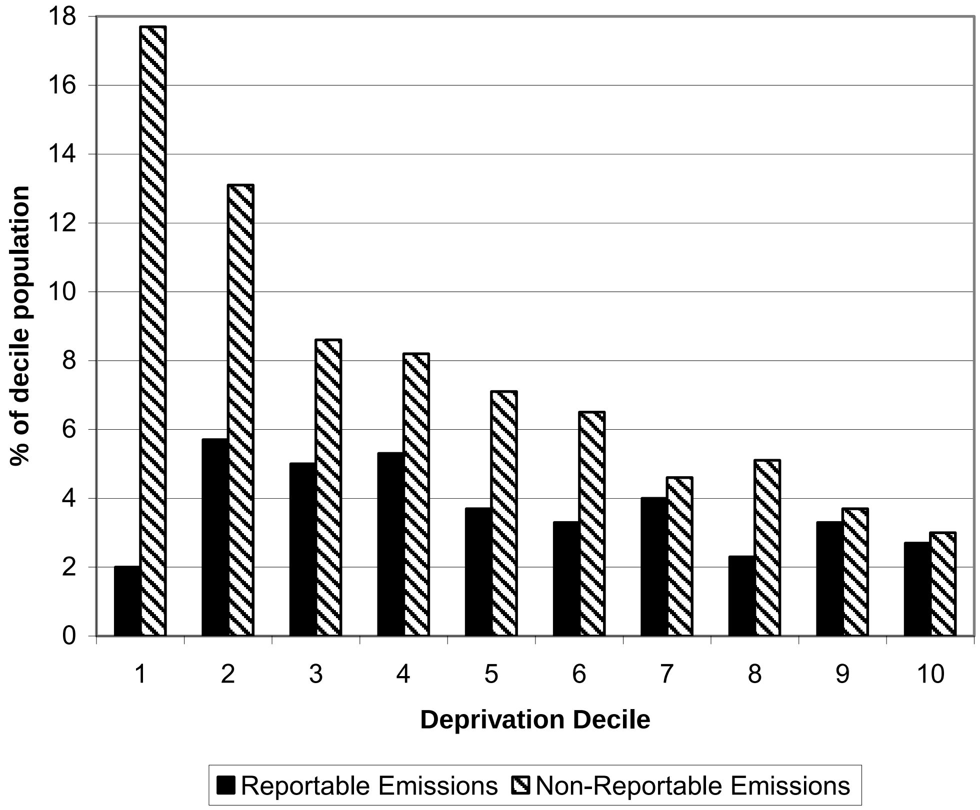
Table 7.5: Ratio of proportion of population within 1km of an IPPC site using decile 10 as a base by industrial sector (mineral uses decile 8 as a base)

Decile	Total Population	Population within 1km of an IPPC Site	Chemical	Energy	Metal	Mineral	Waste	Other
1	505,775	3.51	1.36	62.95	4.16	2.36	7.89	2.62
2	506,808	3.22	1.85	43.75	7.61	3.27	4.86	2.98
3	506,064	2.23	1.21	21.18	4.52	0.98	3.61	2.15
4	506,082	2.28	1.52	19.09	4.51	10.21	3.45	1.68
5	506,596	1.82	1.66	14.84	2.54	3.41	1.13	1.73
6	505,966	1.70	0.73	6.67	2.10	4.97	2.18	1.85
7	505,930	1.51	1.25	3.79	0.92	5.44	1.78	1.56
8	506,157	1.24	0.79	11.12	2.41	1.00	1.81	1.09
9	506,485	1.22	1.07	2.38	2.06		0.84	1.33
10	506,148	1.00	1.00	1.00	1.00		1.00	1.00
Scotland	5,062,011	1.97	1.24	18.68	3.18	3.16	2.86	1.80

Table 7.6: Population within 1km of IPPC site for EPER reportable and non-reportable emissions by deprivation decile

Decile	Population within 1km of an EPER Site	%	Sites with **Reportable** Emissions	%	Sites with **Non-Reportable** Emissions	%
1	98,560	19.5	9,885	2.0	89,487	17.7
2	90,673	17.9	28,945	5.7	66,494	13.1
3	62,685	12.4	25,091	5.0	43,294	8.6
4	64,207	12.7	26,899	5.3	41,336	8.2
5	51,257	10.1	18,955	3.7	35,993	7.1
6	47,901	9.5	16,444	3.3	32,880	6.5
7	42,435	8.4	20,007	4.0	23,123	4.6
8	34,900	6.9	11,622	2.3	25,816	5.1
9	34,211	6.8	16,587	3.3	18,778	3.7
10	28,137	5.6	13,715	2.7	15,042	3.0
Scotland	554,967	11.0	188,148	3.7	392,243	7.7
CI Values		***0.22***		***0.08***		***0.29***

Figure 7.5: Population within 1km of IPPC site for EPER reportable and non-reportable emissions by deprivation decile



7.4 Discussion

7.4.1 Deprivation and Proximity to IPPC Sites

For all of the buffer distances used to estimate numbers of people living near to IPPC sites there is a clear relationship between proximity and deprivation with the highest proportion of people in each case found within the most deprived decile (Table 7.1 and Figure 7.1). For the 500m buffer there are 6 times as many people in the most deprived decile living near to an EPER site when compared to the least deprived. For the 1km buffer nearly 20% of the population in the most deprived decile live near to an IPPC site, compared to only 6% in the least deprived i.e. the most deprived are three times more likely to be living near to an IPPC site than the least deprived. This proportional difference becomes lower as the buffer size increases (approximately 4 times for 1km, 2 times for 2 km) and the CI values accordingly decrease from 0.26 to 0.08. The relationship with deprivation for 500m and 1km buffers is strongly linear, whilst a curvilinear relationship emerges for 2km and 4km. Figure 7.6 maps the populations living within 1km of IPPC sites across the central belt of Scotland, highlighting those falling within the most deprived deciles 1 and 2. This highlights patterns of concentration of sites in deprived communities particularly in the Glasgow area.

7.4.2 Deprivation and proximity to multiple IPPC sites

The analysis of multiple proximity shows a disproportionate clustering of sites near to more deprived populations (Tables 7.2 and 7.3, Figures 7.2 and 7.3). However for both 1km and 2km buffers it is deciles 2 and 3 rather than the most deprived decile 1 in which most clustering is found. For both buffer distances the least deprived decile has the lowest population living near to multiple sites. CI values for proximity to clusters of sites are almost uniformly higher than for proximity to single sites, further demonstrating the disproportionate focus of site clusters on deprived populations.

7.4.3 Deprivation and proximity to IPPC sites in different industrial sectors

Differentiating by industry sector highlights some significant differences between industries (Table 7.4 and Figure 7.4). The energy and waste sectors both show a strong bias towards deprived populations (CI values of 0.51 and 0.36). The chemical, metal and 'other' sectors also show such a bias, but less strongly and consistently than for all sites. The ratio between least and most deprived decile (Table 7.5) particularly highlights the energy sector where there are 65 times more people in the most deprived decile, compared to the least deprived, living within 1km of an IPPC site.

One result in need of explanation is the difference between the strong pattern of inequality found for the IPPC waste sector and the lack of such a pattern in the landfill analysis discussed in section 9. This can be accounted for by the inclusion of incinerators and hazardous waste disposal sites in the IPPC waste category. These sites are largely urban whilst many of the landfills are peri-urban with relatively few people living near to them. This means that the relationship with deprivation found in the IPPC waste sector is particularly influenced by the larger populations near to the non-landfill sites.

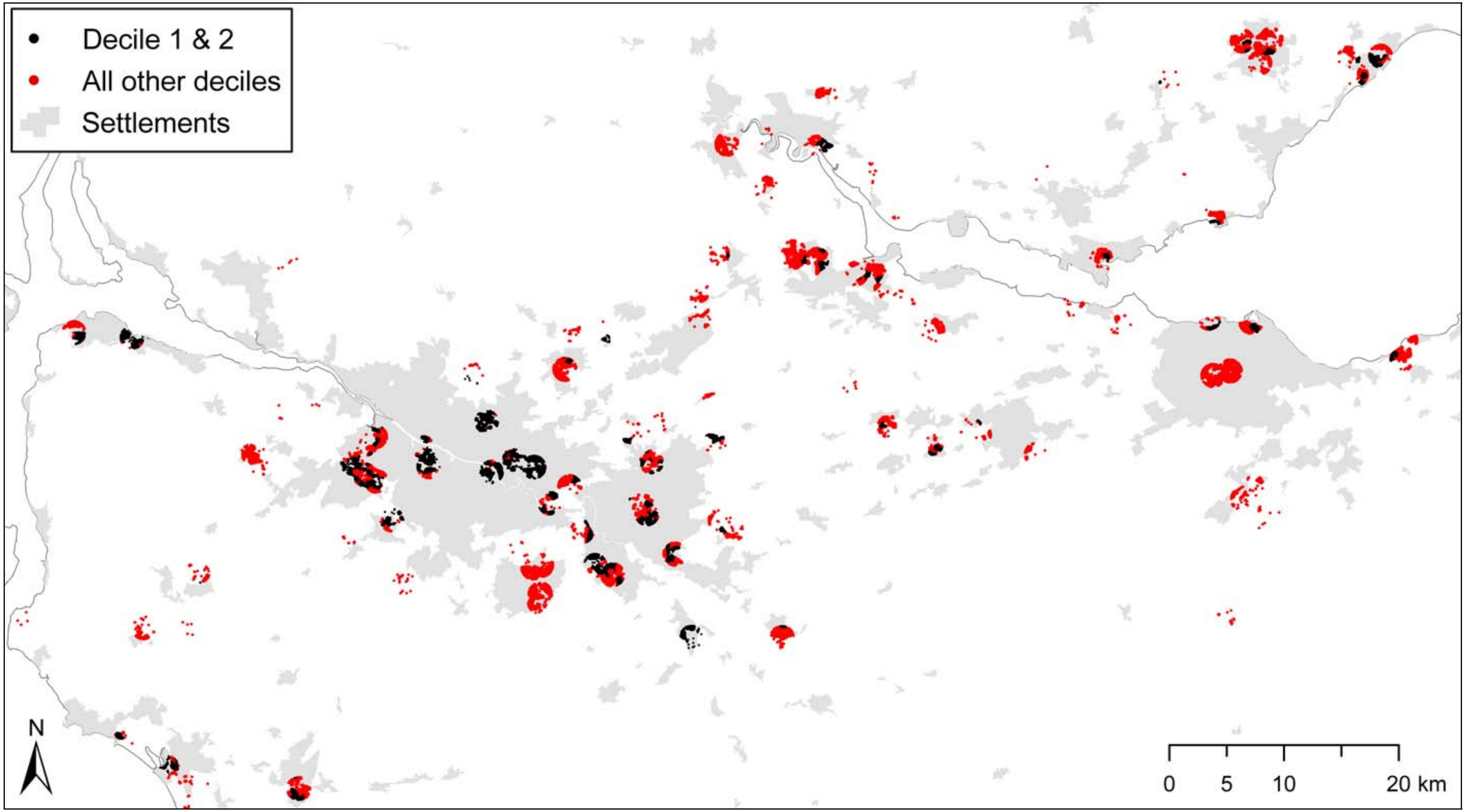
The numbers of people living near to sites in the 'other' category is quite striking with this category having the highest population within 1km in absolute terms (nearly 250,000 people). Scrutiny of the database here reveals that the sites with largest proximate populations are involved in 'textile pre-treating and dying', 'food production (treatment and processing)', 'milk treatment and processing' and 'surface treatment of substances, objects or products'. It is worth noting that many of these sites are included under IPPC because they predominantly present a threat to the environment rather than directly to human health, hence the high population levels may be seen as of less significance.

7.4.4 Deprivation and proximity to IPPC sites with EPER reportable and non-reportable emissions

This analysis provides a very basic indicator of the level of emissions that are being produced from the IPPC sites. Those sites with reportable emissions are over an emission threshold set in the EPER guidance. The analysis shows that sites with reportable emissions are less acutely biased towards more deprived populations (Table 7.6 and Figure 7.5). The highest populations are still to be found in more deprived deciles (deciles 2 and 3 rather than 1 though) and the lowest in less deprived deciles (8 and 10), but the proportional difference is not as high as for the overall pattern of IPPC sites and the CI value is much lower (0.08 compared to 0.22) This does *not* therefore suggest that the sites with reportable emissions levels are disproportionately found in deprived areas

.

Figure 7.6: Locations of IPPC sites and address points within 1km .



8 Derelict land

8.1 Introduction

There are a number of ways in which derelict land may have an impact on people and communities – both positive and negative (see section 3.3). When derelict land is contaminated there may be potential impacts on health and it can also have a negative visual and aesthetic impact on the local area, contributing through this to a poor quality and stigmatised living environment. The presence of derelict land may have an economic impact in deterring investors to the area. On the other hand, derelict land has been recognised in some circumstances as contributing positively to local biodiversity and having an informal recreational value. This multidimensional and complex relationship between derelict land and quality of life for individuals and communities needs to be borne in mind when interpreting the results in this section.

8.2 Data sources and methods

Data was provided from the Scottish Vacant and Derelict Land Survey for 2003 which is compiled from returns by local authorities. The definition of derelict land under this survey is as follows:

> "*… derelict land (and buildings) in urban and rural areas <u>includes</u>:*
>
> *a. land which has been so damaged by development or use that it is incapable of development for beneficial use without rehabilitation and;*
>
> *b. which is not being used for the purpose for which it is held or for a use acceptable in the local plan;*
>
> *c. land which is not being used and where contamination is known or suspected (even if treatment is required only for the buildings thereon)*"

The survey data does <u>not include</u> the following:

> *a. sites which cover less than 0.1 hectare; However, if several small contiguous sites of less than 0.1 ha. are regarded as a single site for redevelopment/refurbishment purposes, then a SINGLE combined entry for the aggregated area may be made, provided that this is at least 0.1 hectare;*
>
> *b. operational sites where rehabilitation would not be possible or appropriate within five years;*
>
> *c. land which is derelict through natural causes (for example neglected woodland/farmland, marshland or mudflats) and which appears to have blended into the landscape.*

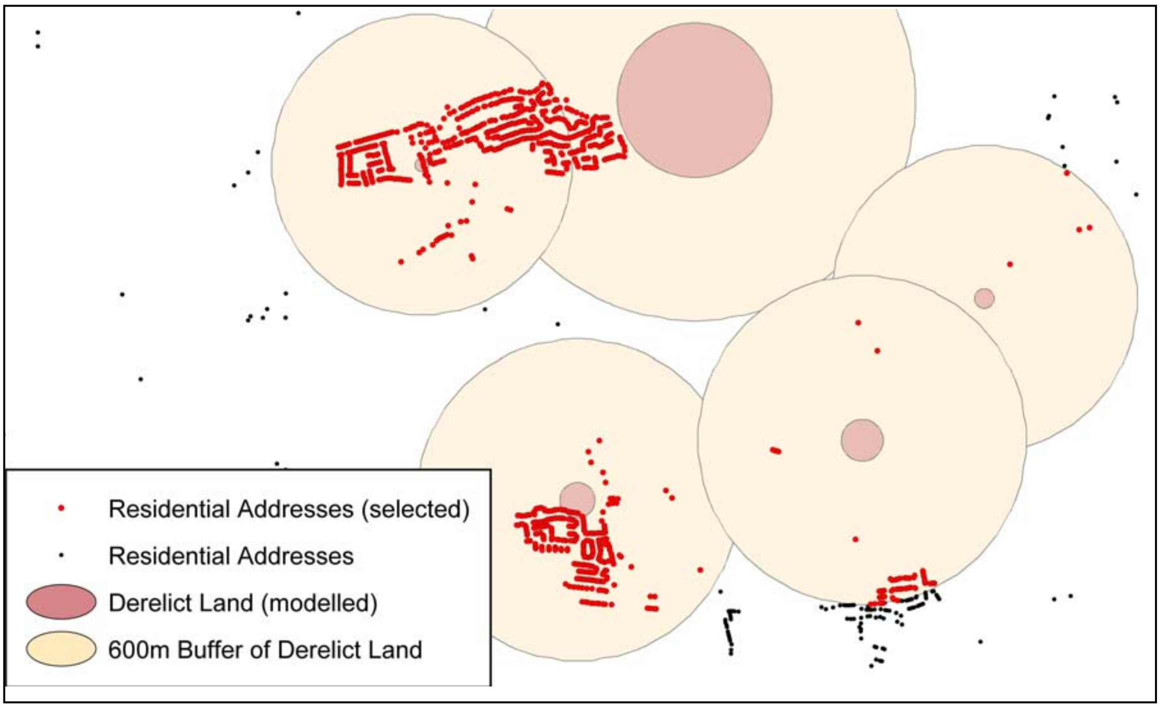
The database provides a centroid of the derelict land parcel and a figure for the total land area. It does not provide a polygon defining the exact shape of the parcel of land on the ground. In order to represent each derelict parcel the spatial area has therefore been modelled by calculating a circle around the centroid that equals the area size (see Figure 8.1 for an example). Use of this method is preferable to a simple point data source, but analysis would clearly be improved by accurately capturing the true extent of the derelict land under consideration.

The quality of the analysis possible is also limited by the lack of any differentiation between derelict sites in terms of the extent or severity of dereliction or contamination that exists. All sites have had to be treated equally apart from taking account of the size of land area.

The analysis calculates the population living within set buffer distances of the modelled derelict land making use of AddressPoint postcodes that have been coded by decile (see section 6 for further explanation) and a standard point in polygon analysis (see example in Figure 8.1). Note that we have included any population which falls within the modelled area of derelict land in the analysis.

An alternative approach was considered which would estimate the extent of derelict land within 600m of each household identified using AddressPoint data. However, whilst this would potentially give a better indication of the extent of dereliction experienced by each household, it was considered to be far too computationally intensive to be applied in this project.

Figure 8.1: Example of modelled derelict land area, 600m buffer and AddressPoints selected as within and outside of the buffer area



Four types of analysis have been undertaken:

a. Population proximity

Two distances have been used in the analysis of population proximity to derelict land to provide some degree of sensitivity testing - 1km and 600m. Section 6 discusses why the 600m distance was chosen for the woodlands analysis and it seemed sensible to also use this distance for the derelict land for two main reasons. First, it is being used to approximately define the distance people would walk around their neighbourhood. Second it would allow consideration of what would occur if derelict land was converted to woodlands or green space.

We would consider the results for the 600 metres buffer to be the more important, as the link between environmental quality and its effect will be stronger than at 1km. The distance calculated is Euclidean (straight line) rather than, for example, a route access analysis.

b. Age of sites

The survey provides information on the date the site was notified as being derelict. Analysis has also been carried out using the 600m buffer distance to examine the length of time the sites have lain derelict by decile. This allows us to know which groups have lived next to derelict land the longest and which group were most likely to live near land that has recently become derelict.

c. Cluster analysis of sites

Further analysis has been carried out on the 600m dataset to analyse the issue of overlapping buffers i.e. to examine who is most likely to be living near multiple derelict sites. It is important to note though that clustering does not necessarily imply a greater impact – as one large derelict site may be more significant in this respect than a cluster of small ones.

d. Urban-rural Classification: we have also used the urban-rural classification to explore differences in the relationships between urban and rural areas.

To give an indication of the number and area of derelict land sites involved, Table 8.1 provides a simple statistical breakdown by age of site. The highest proportion of sites by number and area is in the first date period of '1980 or earlier'.

Table 8.1: Number and area of derelict land sites in Scotland by date of notification

	Total	derelict land sites by date						
		1980 or earlier	1981-85	1986-90	1991-95	1996-2000	2001-2003	unknown date
Number of sites	1,875	459	288	246	249	251	175	207
% of sites	100	24.48	15.36	13.12	13.28	13.39	9.33	11.04
Area of sites	7,706.63	2,301.33	968.47	1,243.11	1,001.63	1,395.63	267.50	564.30
% of area	100	29.86	12.57	15.67	13.00	18.11	3.47	7.32

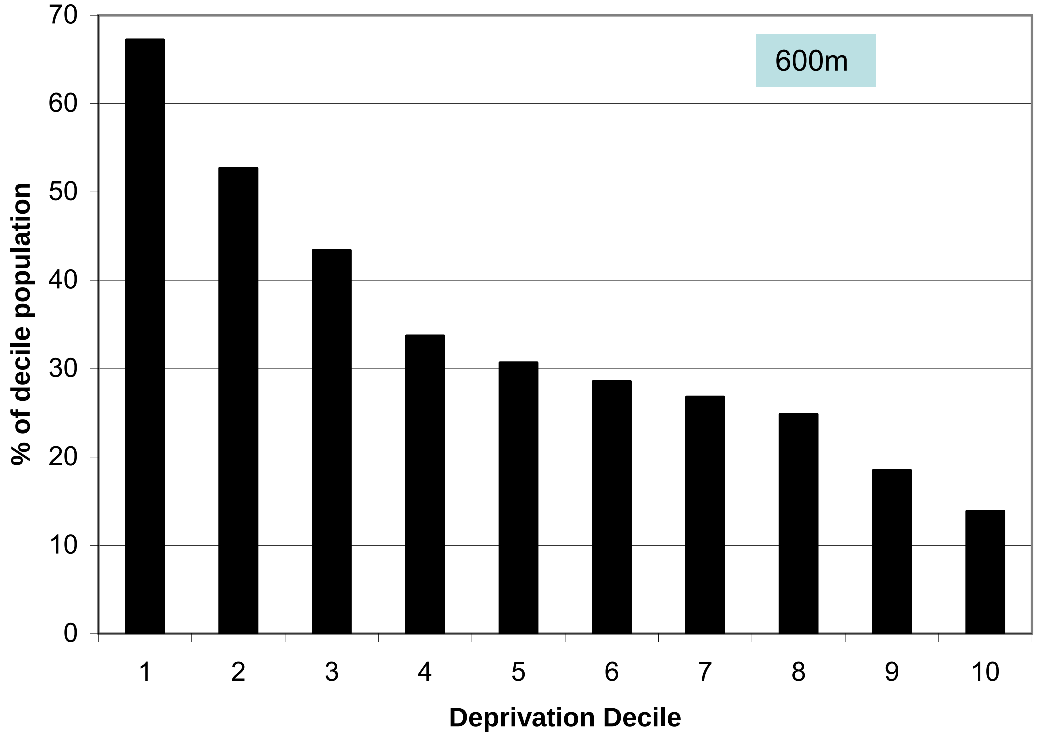
Note: site area is measured in hectares

8.3 Results

Table 8.2: Population living within 600m and 1km of derelict sites by deprivation decile

Decile	Total Population	Population within 600metres	%	Population within 1km	%
1	505,775	340,045	67.2	422,564	83.5
2	506,808	267,125	52.7	387,929	76.5
3	506,064	219,564	43.4	336,369	66.5
4	506,082	170,656	33.7	277,154	54.8
5	506,596	155,380	30.7	251,672	49.7
6	505,966	144,472	28.6	218,421	43.2
7	505,930	135,568	26.8	208,505	41.2
8	506,157	125,781	24.9	219,250	43.3
9	506,485	93,659	18.5	200,501	39.6
10	506,148	70,180	13.9	150,251	29.7
Scotland	5,062,011	1,722,431	34.0	2,672,615	52.8
CI values			***0.25***		***0.17***

Figure 8.2: Percentage of population living within 600m and 1km of derelict sites by deprivation decile



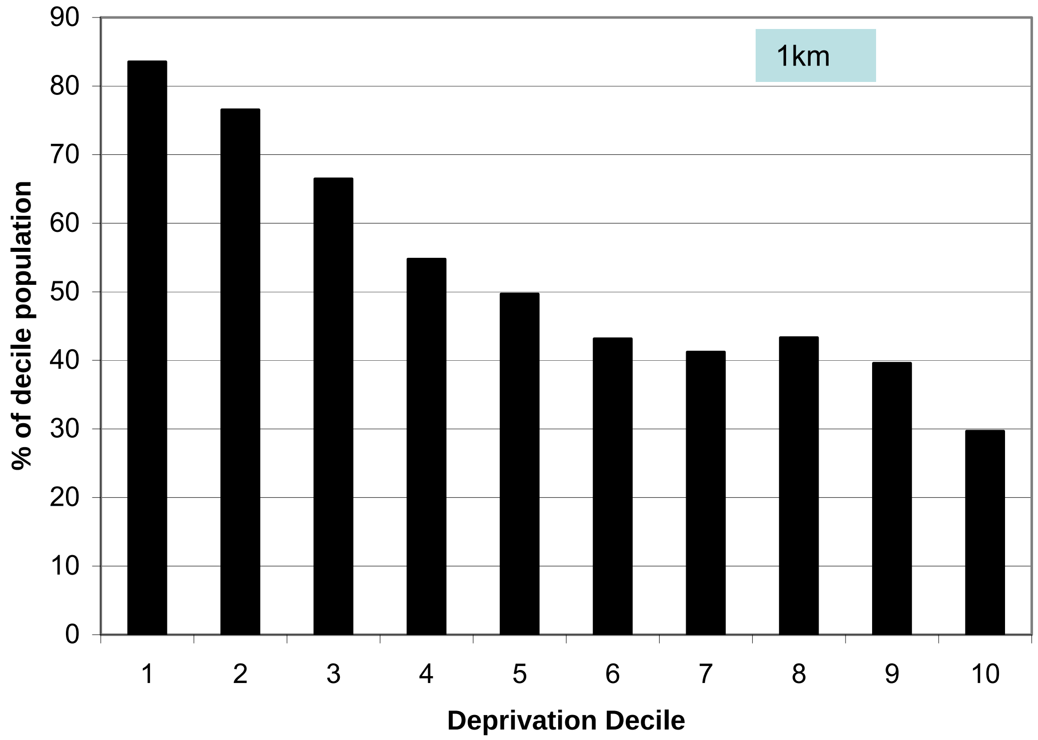


Table 8.3: Population living within 600 metres of a derelict site by deprivation decile and date of notification

Decile	Total Population	All dates	1980 or earlier	1981-85	1986-90	1991-95	1996-2000	2001-2003	unknown date
1	505,775	340,045	136,410	143,029	101,114	98,477	148,297	87,809	18,515
2	506,808	267,125	71,075	77,585	61,451	63,027	89,383	54,247	29,946
3	506,064	219,564	52,211	62,315	46,883	59,150	61,488	41,255	23,474
4	506,082	170,656	46,191	39,958	33,304	34,322	44,431	34,867	28,538
5	506,596	155,380	42,733	33,210	23,021	29,661	40,460	24,645	31,272
6	505,966	144,472	40,400	27,213	21,482	31,378	36,600	31,931	26,812
7	505,930	135,568	33,920	25,317	25,375	25,609	29,125	22,344	29,217
8	506,157	125,781	38,233	23,863	24,409	23,111	29,565	19,603	25,311
9	506,485	93,659	22,784	13,432	15,315	14,884	16,183	20,378	21,585
10	506,148	70,180	16,823	10,730	4,058	14,588	18,833	13,078	9,025
Scotland	5,062,011	1,722,431	500,782	456,651	356,411	394,206	514,365	350,156	243,693
Percentages									
Decile	Total Population	(%)	1980 or earlier (%)	1981-85 (%)	1986-90 (%)	1991-95 (%)	1996-2000 (%)	2001-2003 (%)	unknown date (%)
1	505,775	67.2	27.0	28.3	20.0	19.5	29.3	17.4	3.7
2	506,808	52.7	14.0	15.3	12.1	12.4	17.6	10.7	5.9
3	506,064	43.4	10.3	12.3	9.3	11.7	12.2	8.2	4.6
4	506,082	33.7	9.1	7.9	6.6	6.8	8.8	6.9	5.6
5	506,596	30.7	8.4	6.6	4.5	5.9	8.0	4.9	6.2
6	505,966	28.6	8.0	5.4	4.2	6.2	7.2	6.3	5.3
7	505,930	26.8	6.7	5.0	5.0	5.1	5.8	4.4	5.8
8	506,157	24.9	7.6	4.7	4.8	4.6	5.8	3.9	5.0
9	506,485	18.5	4.5	2.7	3.0	2.9	3.2	4.0	4.3
10	506,148	13.9	3.3	2.1	0.8	2.9	3.7	2.6	1.8
Scotland	5,062,011	34.0	9.9	9.0	7.0	7.8	10.2	6.9	4.8
CI Values		**0.25**	**0.30**	**0.41**	**0.37**	**0.33**	**0.37**	**0.30**	**0.06**

Figure 8.3: Percentage population living within 600 metres of a derelict site by deprivation decile and date of notification

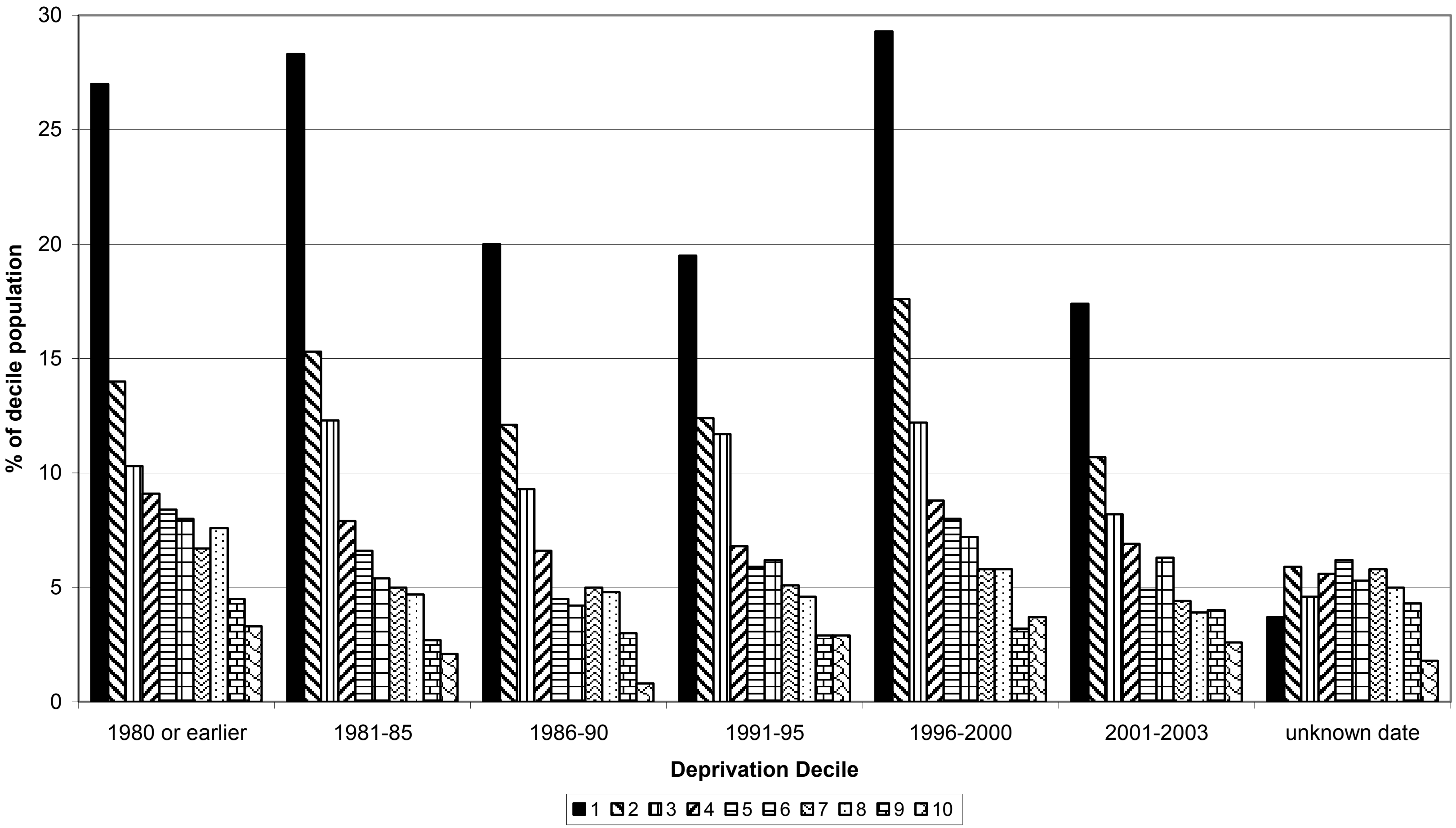


Table 8.4 - Population living within 600 metres of multiple derelict sites by deprivation decile

			Number of derelict sites and the population within each band						
Decile	Total Population	Population affected	11 or more	6 or more	5 or more	4 or more	3 or more	2 or more	1 or more
1	505,775	340,045	11,710	62,234	89,343	126,602	174,395	236,710	340,045
2	506,808	267,125	788	19,023	31,509	50,854	89,806	147,755	267,125
3	506,064	219,564	163	13,872	20,222	31,500	59,961	110,801	219,564
4	506,082	170,656	118	8,563	14,350	26,121	45,298	82,022	170,656
5	506,596	155,380	390	5,001	9,686	16,146	30,106	64,126	155,380
6	505,966	144,472	2	5,159	8,749	15,760	32,069	61,594	144,472
7	505,930	135,568	0	2,830	6,008	10,601	26,156	55,216	135,567
8	506,157	125,781	304	3,903	6,884	12,100	22,671	54,250	125,781
9	506,485	936,59	0	2,223	3,246	5,423	12,011	27,316	93,659
10	506,148	701,80	0	662	1,978	2,939	6,953	24,175	70,180
Scotland	5,062,011	1,722,431	13,474	123,470	191,976	298,046	499,426	863,966	1,722,431
Percentages									
Decile		%	11 or more	6 or more	5 or more	4 or more	3 or more	2 or more	1 or more
1	505,775	67.23	2.32	12.30	17.66	25.03	34.48	46.80	67.23
2	506,808	52.71	0.16	3.75	6.22	10.03	17.72	29.15	52.71
3	506,064	43.39	0.03	2.74	4.00	6.22	11.85	21.89	43.39
4	506,082	33.72	0.02	1.69	2.84	5.16	8.95	16.21	33.72
5	506,596	30.67	0.08	0.99	1.91	3.19	5.94	12.66	30.67
6	505,966	28.55	0	1.02	1.73	3.11	6.34	12.17	28.55
7	505,930	26.80	0	0.56	1.19	2.10	5.17	10.91	26.80
8	506,157	24.85	0.06	0.77	1.36	2.39	4.48	10.72	24.85
9	506,485	18.49	0	0.44	0.64	1.07	2.37	5.39	18.49
10	506,148	13.87	0	0.13	0.39	0.58	1.37	4.78	13.87
Scotland	5,062,011	34.03	0.27	2.44	3.79	5.89	9.87	17.07	34.03
CI Values		**0.25**	**0.82**	**0.60**	**0.56**	**0.53**	**0.46**	**0.36**	**0.25**

Note: This table also includes those people living near to just one site

Figure 8.4: Population living within 600 metres of multiple derelict sites by deprivation decile

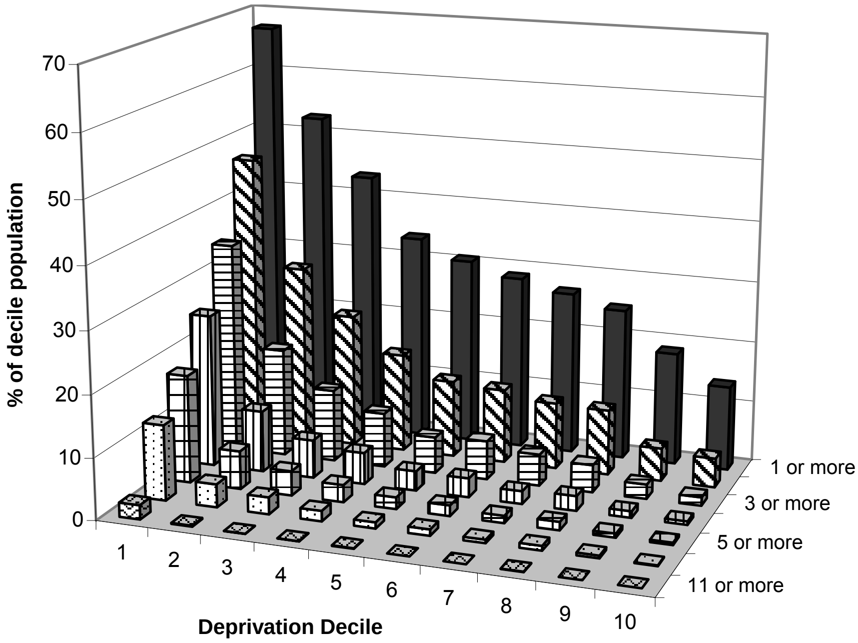


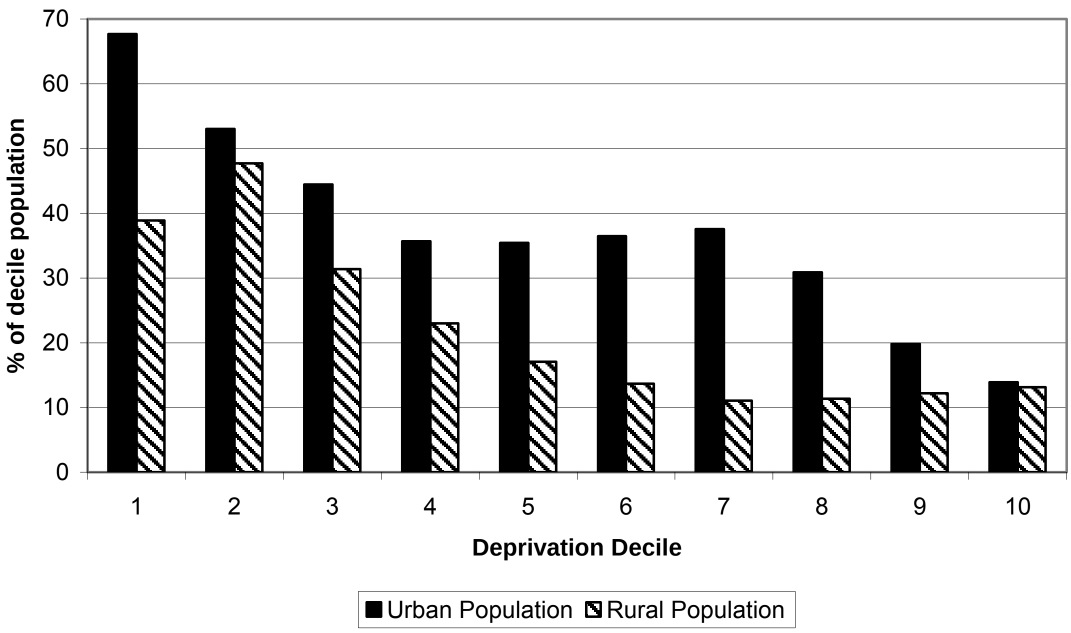
Table 8.5: Overall population living within 600m of multiple (two or more) derelict sites by deprivation decile

Decile	Total Population	Total living near multiple sites	Percentage of people living near multiple sites
1	505,775	236,710	46.8
2	506,808	147,755	29.2
3	506,064	110,801	21.9
4	506,082	82,022	16.2
5	506,596	64,126	12.7
6	505,966	61,594	12.2
7	505,930	55,216	10.9
8	506,157	54,250	10.7
9	506,485	27,316	5.4
10	506,148	24,175	4.8
Scotland	5,062,011	863,966	17.1

Table 8.6: Population within 600 metre of derelict land by urban and rural deprivation decile

Decile	Urban Population	Rural Population	Urban Population within 600m	Rural Population within 600m	% of Urban Population within 600m	% of Rural Population within 600m
1	498,301	7,393	337,172	2,873	67.66	38.87
2	475,296	31,523	252,092	15,033	53.04	47.69
3	464,795	41,284	206,613	12,951	44.45	31.37
4	428,663	77,425	152,856	17,800	35.66	22.99
5	375,266	131,337	132,983	22,397	35.44	17.05
6	330,739	175,249	120,543	23,929	36.45	13.65
7	300,667	205,225	112,876	22,692	37.54	11.06
8	349,527	156,651	107,978	17,803	30.89	11.36
9	418,923	87,536	82,995	10,664	19.81	12.18
10	471,308	34,854	65,615	4,565	13.92	13.10
Scotland	**4,113,484**	**948,477**	**1,571,724**	**150,707**	**38.21**	**15.89**

Figure 8.5: Percentage of population within 600 metre of derelict land by urban and rural deprivation decile



8.4 Discussion

8.4.1 Deprivation and proximity to derelict land

Those people living in the most deprived decile are most likely to be living within 600m of derelict land and there is a consistent pattern all the way through the deciles to the least deprived decile where people are least likely to be living near derelict land (Table 8.2 and Figure 8.2). 67% of people in decile 1 live within 600m of a derelict site compared to only 13.9% of people in decile 10. To express it another way, people in the most deprived areas are almost five times more likely to be living near to derelict land than people who live in the least deprived areas, and more than twice as likely as the averagely deprived area. The 1km analysis shows broadly similar patterns, although less extreme differences between most and least deprived deciles (a CI value of 0.17 compared to 0.25). This suggests that the analysis is not particularly sensitive to buffer size.

8.4.2 Deprivation, proximity to derelict land and date of notification

The pattern of bias towards deprived populations stays fairly consistently in place regardless of the date of notification (table 8.3, Figure 8.3). Both old and new derelict sites are found in proximity to substantially greater numbers of deprived people. 27% of people who live in decile 1 are living within 600m of a site that has been derelict for 23 years or more compared to only 3.3% of people who live in decile 10. People living in decile 1 also live near the most recently created derelict sites - 17.6% of people in decile 1 live near to a site that became derelict in 2001-3 compared to just 2.6% of people in decile 10. Therefore, those in the most deprived areas are over six times more likely than those in the least deprived areas to live near land that has recently become derelict.

With a few small exceptions the relationship between derelict land and social deprivation is straightforward; the more deprived the decile the greater the proportion of people living near to derelict land.

8.4.3 Deprivation and proximity to multiple derelict sites

Analysis was carried out to examine the deprivation characteristics of people living near to multiple sites (2, 3, 4, 5, 6-10 and 11-17 sites). The most deprived decile has the highest number of people living next to multiple derelict sites for every one of the groupings. 46.8% of people in decile 1 live near to multiple sites, compared to 12.45% of the average quintile and 4.8% in the least deprived decile (Table 8.5). Therefore, those people living in the most deprived areas are three times more likely to be living near to multiple sites than those in average areas and just under ten times more likely than those living in the least deprived areas. The bias towards deprived areas becomes more acute as the concentration of multiple derelict sites increases, as indicated by the steadily rising CI values from 0.25 through to 0.82 (Table 8.4). Nearly 12,000 people in decile 1 live near to between 11-17 derelict sites, whilst *no* people within deciles 7, 9 or 10 experience such a concentration of dereliction.

There is a clear correlation between deprivation and living near to multiple derelict sites**;** the greater the deprivation, the greater the population living near to multiple derelict sites.

8.4.4 Deprivation and proximity to derelict land in urban and rural areas

Proximity to derelict land is predominantly a feature of the urban population as shown by the absolute population numbers in Table 8.6. However, in proportional terms both the urban *and* rural deprived are substantially more likely to live near to a derelict site than people in less deprived deciles (Table 8.6 and Figure 8.5). For both urban and rural areas the highest population proportions are found in deciles 1 and 2, approximately three times as large as the proportions in the least deprived deciles.

The strong patterns found when examining the relationship between derelict land and deprivation shows that some degree of dereliction is a common and widespread feature of the local environment for deprived communities. This is likely to reflect a number of factors such as the historic concentration of industrial activity in urban and what are now more deprived areas; the processes of industrial change and decline that have been experienced; and the more attractive environment for new investment in 'better off' areas contributing to the avoidance of dereliction and availability of resources for clean up and regeneration.

9 Landfill

9.1 Introduction

Landfills have a range of potential impacts on the local environment. Health impacts may be of primary concern but are uncertain and strongly disputed (see discussion in section 3.4). Other negative impacts potentially include odour, dust and noise impacts on house prices and, where old landfills are capped and built on, potential problems from methane releases and land instability. Positive impacts may be realised when landfills are restored and used for recreational uses or brownfield development. The particular profile of local impacts will be highly variable between different landfill sites depending on their size, nature of operations, wastes taken and whether or not they are open or closed. This diversity has not been able to be represented in the following analysis, apart from differentiating between open and closed sites, which is a significant limitation on the conclusions which can be drawn.

9.2 Data sources and methods

Use was made of data supplied by SEPA for 2004. This listed 225 landfill sites in Scotland differentiating between those that are open (151), closed (73) and not yet open (1) (the latter site is excluded from the analysis below). Sites classified as 'closed' no longer take new waste, and may or may not continue to be monitored depending on the characteristics of each site. The data set provided no indication of the size of the landfill, the wastes taken or level of activity at the site. A grid reference was provided for each site which is usually positioned at the site entrance.

Information on the landfill site area was not available. As the data is a point data source there is no indication of the spatial extent of the landfill area – each site is represented by a point normally positioned at the entrance of the site, rather than an area, so a proximity analysis may not accurately represent those populations most affected by impacts that are felt close to the site boundary**.**

Three types of analysis have been carried out:

a. Proximity Analysis
To try to mitigate the problem of only having point source data we have carried out a sensitivity analysis by using a variety of buffer distances (500 metres, 1km and 2km) around the grid reference points. Caution should be applied to the 500m results as a large part of the buffer may be the actual site itself, and this may distort the overall results. A 2km distance has been used in most of the existing research examining correlations between site proximity and patterns of illness (see section 3.3). This analysis differentiates between open and closed sites

b. Site Status
The buffer analysis for 1km and 2km distances was also carried out separately for open and closed landfill sites.

c. Analysis by cluster of sites
A cluster analysis has also been carried out to see which populations live near multiple landfill sites. It is important to note however that clustering does not necessarily imply a greater impact - as one large active landfill may be more significant in this respect than a cluster of small inactive ones.

9.3 Results

Table 9.1: Population within 500m, 1km and 2km of a landfill site by deprivation decile

Decile	Total Popn in decile	Popn within 500m	%	Popn within 1km	%	Popn within 2km	%
1	505,775	2,929	0.6	12,508	2.5	54,597	10.8
2	506,808	1,407	0.3	11,369	2.2	66,246	13.1
3	506,064	2,081	0.4	10,631	2.1	58,617	11.6
4	506,082	609	0.1	9,069	1.8	55,376	10.9
5	506,596	1,338	0.3	12,038	2.4	60,904	12.0
6	505,966	1,173	0.2	8,999	1.8	58,868	11.6
7	505,930	3,031	0.6	12,650	2.5	54,650	10.8
8	506,157	2,486	0.5	17,878	3.5	74,876	14.8
9	506,485	1,346	0.3	7,807	1.5	58,754	11.6
10	506,148	503	0.1	5,500	1.1	54,095	10.7
Scotland	5,062,011	16,902	0.3	108,449	2.1	596,983	11.8
CI Values			**0.08**		**0.04**		**0.00**

Figure 9.1: Percentage of population within 500m, 1km and 2km of a landfill site in Scotland by deprivation decile

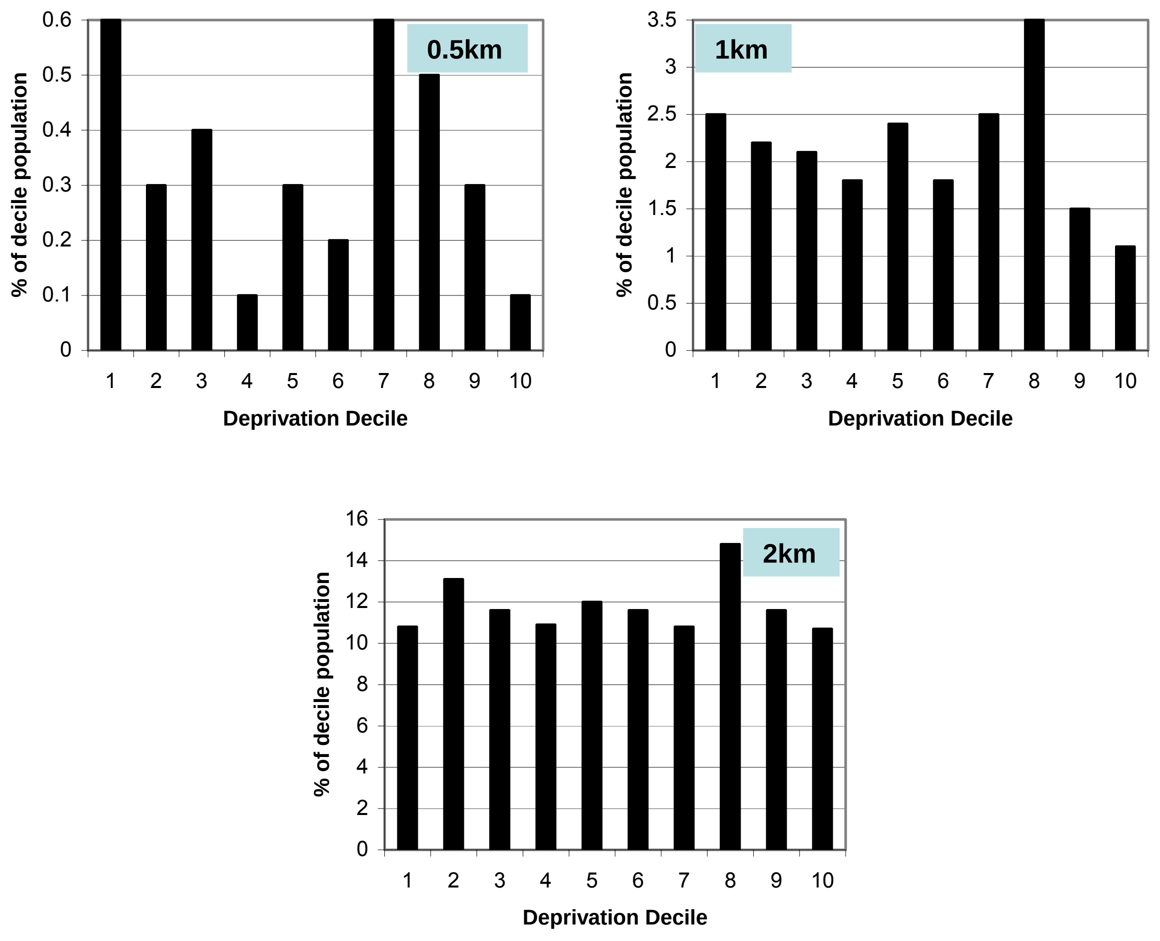


Table 9.2: Population within 1km of open and closed landfill sites by deprivation decile

Decile	Population within 1km of a Landfill	%	Open Site	%	Closed Site	%
1	12,508	2.47	6,604	1.31	5,916	1.17
2	11,369	2.24	5,809	1.15	6,020	1.19
3	10,631	2.10	8,485	1.68	2,145	0.42
4	9,069	1.79	6,636	1.31	2,433	0.48
5	12,038	2.38	5,918	1.17	4,571	0.90
6	8,999	1.78	5,930	1.17	3,113	0.62
7	12,650	2.50	8,463	1.67	3,914	0.77
8	17,878	3.53	11,895	2.35	5,043	1.00
9	7,807	1.54	3,506	0.69	4,146	0.82
10	5,500	1.09	4,295	0.85	1,211	0.24
Scotland	108,449	2.14	67,540	1.33	38,512	0.76
CI Values		**0.04**		**0.02**		**0.10**

Figure 9.2: Percentage population within 1km of open and closed landfill sites by deprivation decile

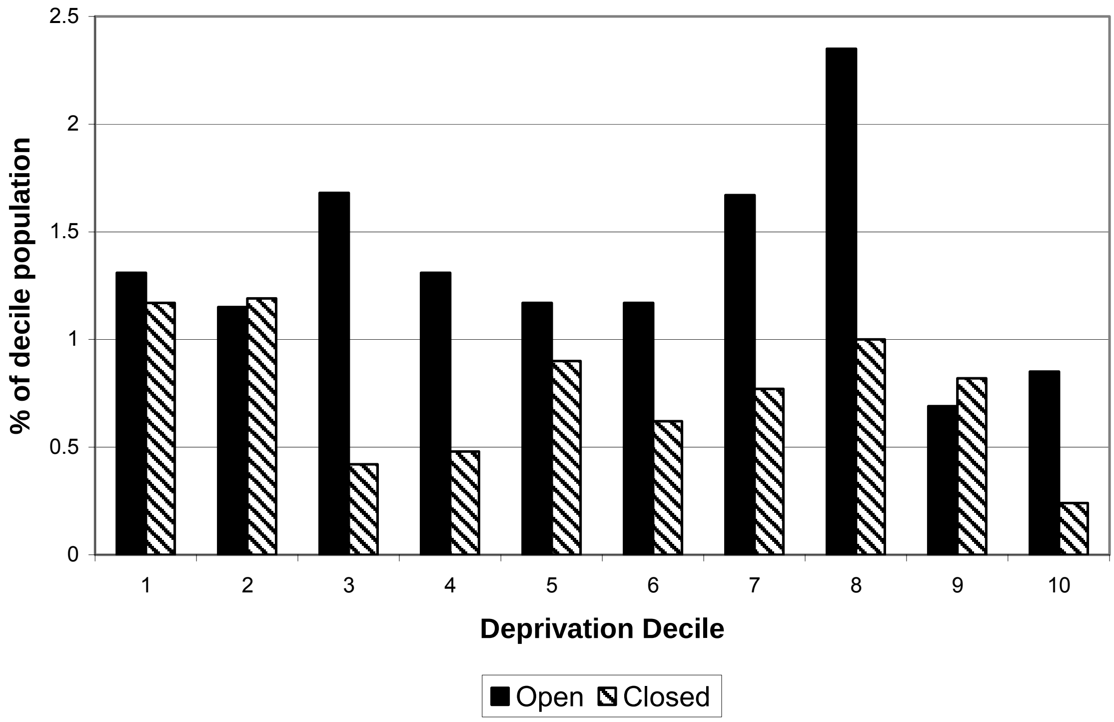


Table 9.3: Population within 2km of open and closed landfill sites by deprivation decile

Decile	Popn within 2km of a Landfill Site	%	Open Site	%	Closed Site	%
1	54,597	10.79	31,377	6.20	23,320	4.61
2	66,246	13.07	39,852	7.86	26,789	5.29
3	58,617	11.58	41,545	8.21	19,540	3.86
4	55,376	10.94	33,784	6.68	23,508	4.65
5	60,904	12.02	40,365	7.97	20,851	4.12
6	58,868	11.63	44,890	8.87	15,911	3.14
7	54,650	10.80	33,323	6.59	21,196	4.19
8	74,876	14.79	50,701	10.02	24,734	4.89
9	58,754	11.60	37,451	7.39	24,455	4.83
10	54,095	10.69	42,213	8.34	16,414	3.24
Scotland	596,983	11.79	395,501	7.81	216,719	4.28
CI Values		**0.00**		**-0.03**		**0.03**

Figure 9.3: Percentage population within 2km of open and closed landfill sites by deprivation decile

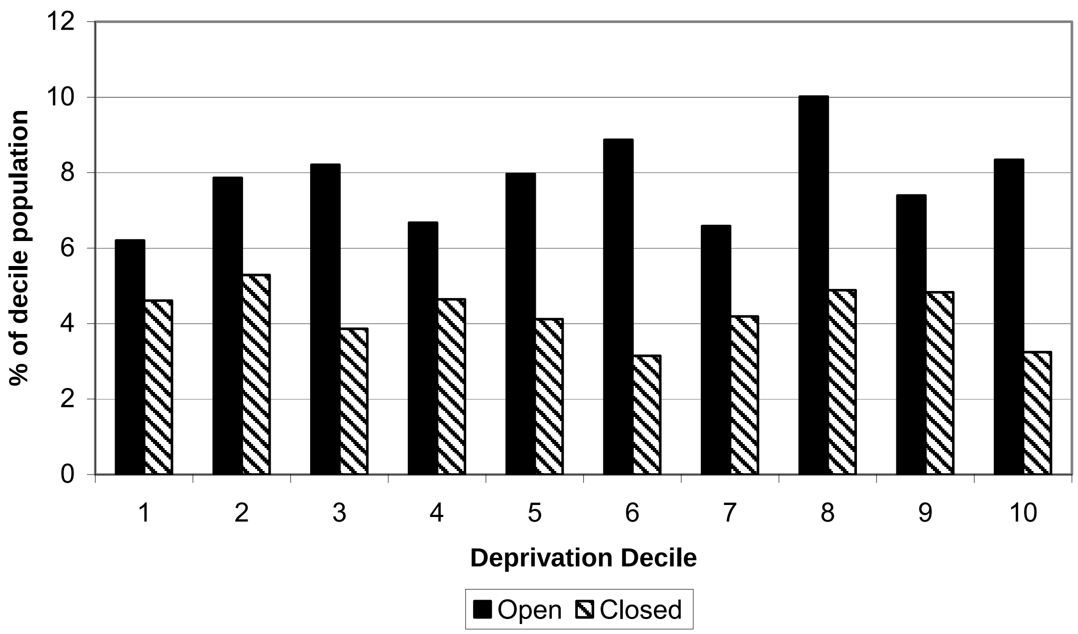


Table 9.4: Population living within 2km of multiple landfill sites by deprivation decile

Decile	Total Population	Population within 2km	Number of sites					
			3 or more	%	2 or more	%	1 or more	%
1	505,775	54,597	11	0.002	2,808	0.555	54,597	10.795
2	506,808	66,246	0	0	3,777	0.745	66,246	13.071
3	506,064	58,617	0	0	2,570	0.508	58,617	11.583
4	506,082	55,375	0	0	1,917	0.379	55,375	10.942
5	506,596	60,904	12	0.002	2,547	0.503	60,904	12.022
6	505,966	58,868	11	0.002	3,857	0.762	58,868	11.635
7	505,930	54,650	117	0.023	2,682	0.530	54,650	10.802
8	506,157	74,876	172	0.034	2,854	0.564	74,876	14.793
9	506,485	58,754	1,099	0.217	4,273	0.844	58,754	11.600
10	506,148	54,095	424	0.084	4,617	0.912	54,095	10.688
Scotland	5,062,011	596,983	1,846	0.04	31,900	0.63	596,983	11.79
CI Values				**-0.69**		**-0.04**		**0.00**

Figure 9.4: Percentage population living within 2km of multiple landfill sites by deprivation decile

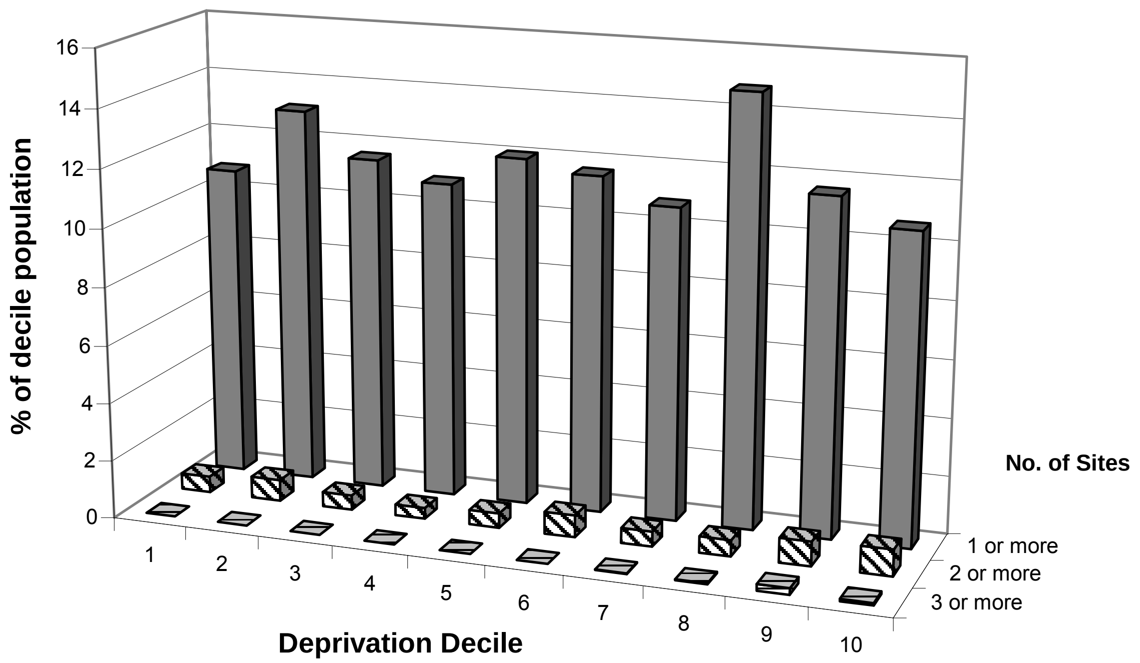
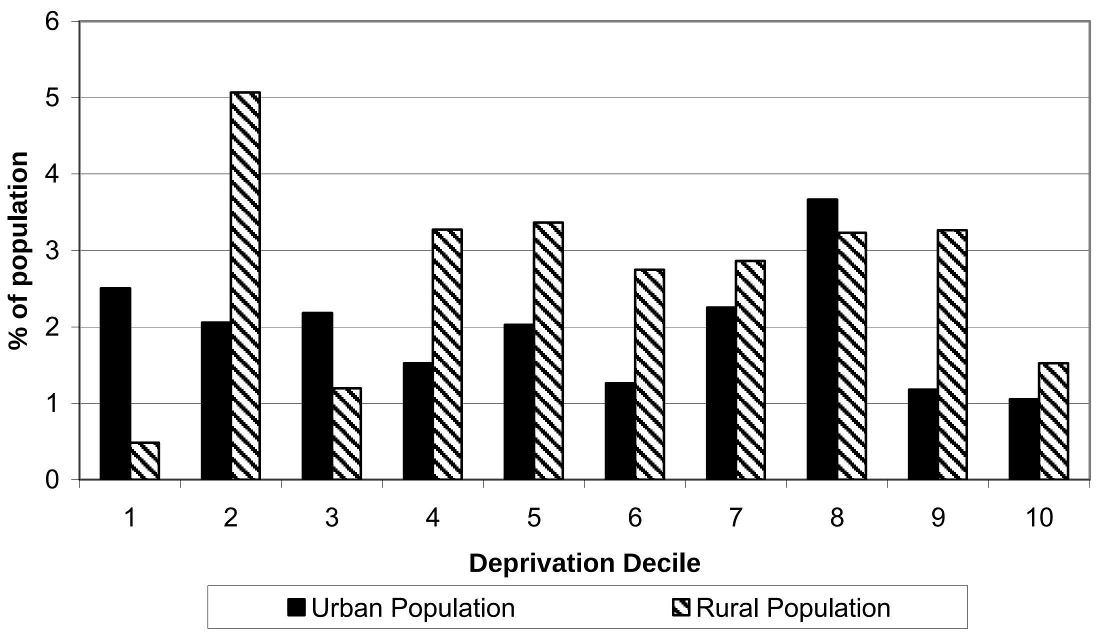


Table 9.5: Population within 1km of landfill sites by urban and rural deprivation decile

Decile	Urban Population	Rural Population	Urban Population within 1km	Rural Population within 1km	% of Urban Population within 1km	% of Rural Population within 1km
1	498,301	7,393	12,472	36	2.50	0.49
2	475,296	31,523	9,772	1,597	2.06	5.07
3	464,795	41,284	10,138	493	2.18	1.19
4	428,663	77,425	6,534	2,535	1.52	3.27
5	375,266	131,337	7,616	4,422	2.03	3.37
6	330,739	175,249	4,182	4,817	1.26	2.75
7	300,667	205,225	6,775	5,875	2.25	2.86
8	349,527	156,651	12,812	5,066	3.67	3.23
9	418,923	87,536	4,948	2,860	1.18	3.27
10	471,308	34,854	4,969	531	1.05	1.52
Scotland	4,113,484	948,477	80,217	28,232	1.95	2.98

Figure 9.5: Percentage of Population within 1km of landfill sites by urban and rural deprivation decile



9.4 Discussion

9.4.1 Deprivation and proximity to landfill sites

For landfill sites the patterns of relationship between deprivation and population proximity are difficult to characterise. There are few apparent simple or consistent relationships with deprivation. The buffer analysis distributes the populations in proximity fairly evenly over the deciles (Table 9.1 and Figure 9.1). For 500m the greatest proportion of population is found in the poorest decile but also within decile 7 (both at 0.6%). For the 1km buffer deciles 1 and 7 again have high and equal proportions of population living within this distance (2.5%) but the highest proportion is found in decile 8 (3.5%), a result which also holds for the 2km analysis (14.8%). However, across all of the buffer distances the least deprived decile consistently has the lowest proportion of population close to landfill sites. There is some sensitivity to buffer size in this analysis but all of the CI values are close to zero indicating little inequality in distribution.

At a national scale, therefore, there is no evidence to suggest that deprived populations are more likely than others to live near to landfill sites.

9.4.2 Deprivation and proximity to open and closed landfill sites

There are some small differences in the patterns between open and closed landfills (Tables 9.2 and 9.3; Figures.9.2 and 9.3). For closed sites using the 1km buffer, the poorest deciles 1 and 2 have the highest proportions of population and the lowest proportion is in decile 10. This suggests that there is more of a bias towards the most deprived deciles than for all sites, although decile 8 is again significant and the CI value of 0.1 does not suggest a bias as substantial as for other topics. For open sites the dominance of decile 8 also stands out followed by deciles 3 and 7 and the CI value is close to zero (0.02). For the 2km buffer these differences between open and closed are also found, but with much less strength and both CI values are close to zero indicating a relatively even distribution across the deciles.

9.4.3 Deprivation and proximity to multiple landfill sites

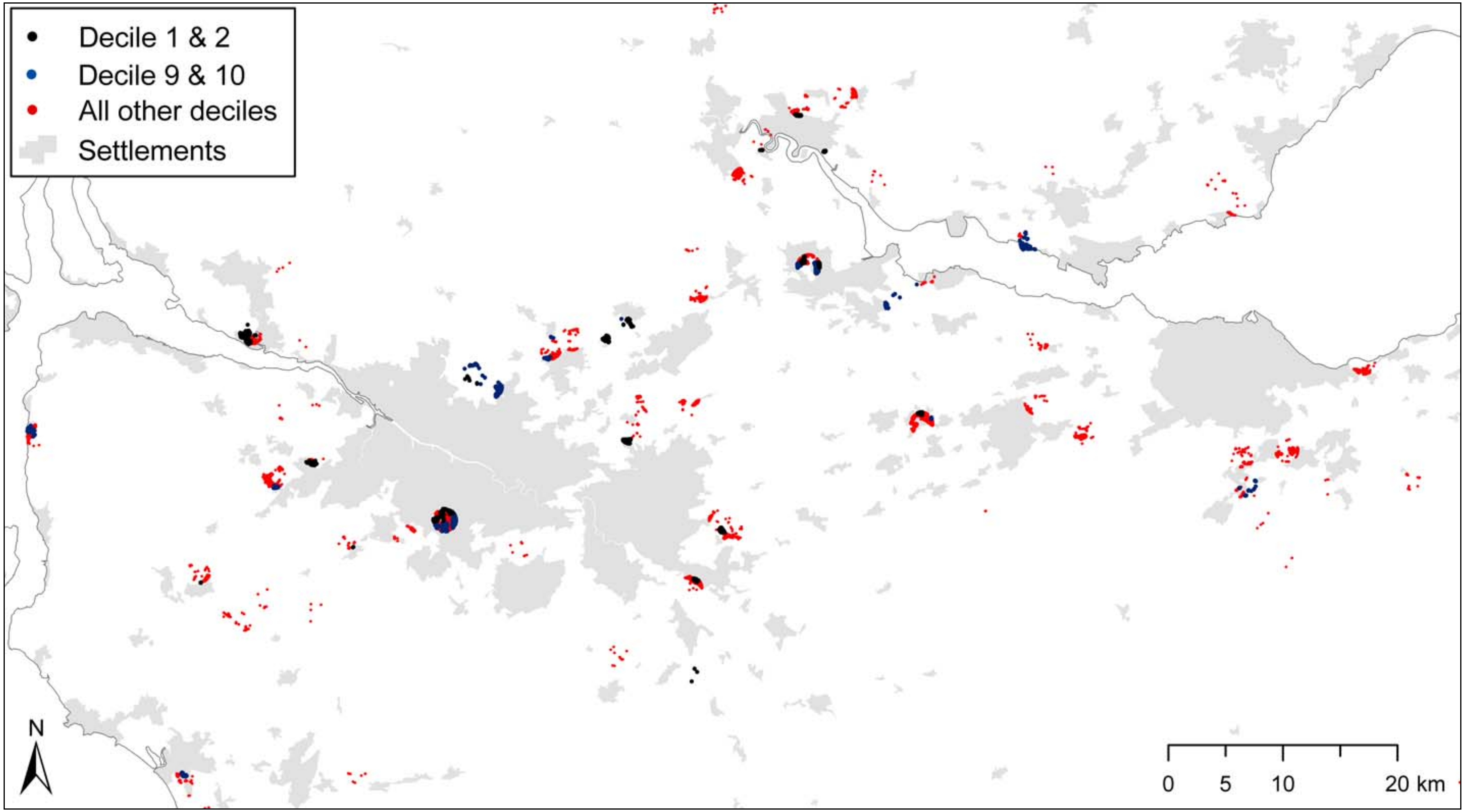
The level of clustering of landfill sites is generally low. The total numbers of people living within 1km of more than one site is only just over a 1000 and no people live near to more than 3 sites. For a 2km buffer size there are more people living near to multiple sites and the social profile of these populations is biased towards the least deprived deciles with negative CI values for proximity to both 2 or more and 3 or more sites (Table 9.4 and Figure 9.4). The highest proportions of people living within 2km of multiple landfills is found in the *least* deprived deciles 10 and 9, followed by deciles 7 and 1.

9.4.4 Deprivation and proximity to landfill sites in urban and rural areas

Separating out the analysis between populations in urban and rural areas shows no distinct or substantially different patterns to the overall analysis. For rural populations the proportion of population within a decile is highest for decile 2 (at 5%) suggesting some bias towards deprived rural communities, but the lowest proportion is found in decile 1 somewhat confounding this conclusion.

Overall our analysis has found no evidence to suggest that deprived people are more likely to live near to landfill sites or clusters of landfill sites. This may well reflect the largely peri-urban and rural locations of landfills and, as shown in Figure 9.6, the broad distribution of sites along the east coast and central belt of Scotland.

Figure 9.6: AddressPoints within 1km of landfill sites in Central Scotland



10 Quarries and Open Cast

10.1 Introduction

Quarries and open cast sites may impact on people in a number of different ways, including the contribution of dust and particulates to poor air quality, the localised generation of traffic and noise and other nuisance. After a quarry has come to the end of its economic life there are two main uses. One is an environmental good - the turning of the quarry into a recreation and/or wildlife area - and the second a conversion to a landfill site which is generally seen as an environmental bad. Clearly the profile of impacts generated by a quarry or open cast site and experienced by local people will depend on a number of variables including its level of activity and the size and nature of quarrying or mining operations being carried out. This diversity has only very partially been captured within the analysis in this section and this limitation therefore needs to be borne in mind when interpreting the results.

10.2 Data sources and methods

Data on quarries and mines was supplied by the British Geological Survey. Open-pit/surface workings were selected out of the dataset for analysis, these then being divided into the following types within the database:

Table 10.1 Definition of quarry and open cast types

Description	Definition
Active	Site at which minerals have been extracted within the last 12 months
Inactive	Site which has not been worked in the past 2 years but may be worked in the future
Historic	Historic building stone sites where no current activity
Ceased	Site at which there is assumed to be no further mineral extraction
Restored	Site has ceased producing minerals and has been restored
Special	Tourist mine, or other mineral operation, specify
Tipping	Site in use as a landfill
Yet to begin	Site permitted, but no operations have occurred at time of survey.

As shown in the Table below the majority of sites in the database have ceased operations, with only 33% in active operation.

Table 10.2 Profile of quarry types in Scotland

Status	No of Sites	%
Active	360	32.9
Inactive	87	8.0
Historic	1	0.1
Ceased	597	54.6
Restored	43	3.9
Special	0	0
Tipping	2	0.2
Yet to Begin	3	0.3
Total	1,093	100

The only spatial data provided in the database is a grid reference which locates the centre of the active working area of the quarry. No information is provided on the size, shape or extent of the quarry area. This has two important consequences. First, no differentiation is possible between major active quarries generating significant local impacts and those which are operating on a much less substantial basis. Second, populations potentially affected by these impacts can only be imprecisely identified by drawing circular buffers around the grid point. In practice a proportion of the buffer will fall within the quarry area, although to a variable degree from site to site.

The following three forms of analysis were carried out:

a. Population Proximity Analysis
Analysis of populations living within buffer zones was carried out using three different distances (0.5km, 1km, 2km) broken down by the BGS classification of type of site. Given the low numbers of quarry and open cast sites in the 'historic' and 'yet to begin' categories these have been excluded from the results reported below (very low populations were found in proximity to these sites in both cases)

b. Cluster Analysis
Cluster analysis was carried out for the 1km and 2km buffer distances to examine patterns of proximity to multiple quarry and open cast sites

c. Urban-Rural Analysis
Analysis of populations living within 1km of sites was carried out, divided between urban and rural populations

10.3 Results

Table 10.3 Population within 0.5km, 1km and 2km of quarries and open cast sites by deprivation decile

Decile	Total Population	Population within 0.5km	Population within 1km	%	Population within 2km	%
1	505,775		46,347	9.2	154,818	30.6
2	506,808		62,586	12.3	175,309	34.6
3	506,064		76,701	15.2	187,929	37.1
4	506,082		54,776	10.8	162,196	32.0
5	506,596		49,341	9.7	163,949	32.4
6	505,966		40,955	8.1	145,949	28.8
7	505,930		54,054	10.7	161,143	31.9
8	506,157		55,086	10.9	165,615	32.7
9	506,485		56,070	11.1	191,116	37.7
10	506,148		64,454	12.7	229,099	45.3
Scotland	5,062,011	0	560,370	11.1	1,737,122	34.3
CI Values				**0.0**		**-0.04**

Figure 10.1: Percentage population within 1km and 2km of quarries and open cast sites by deprivation decile

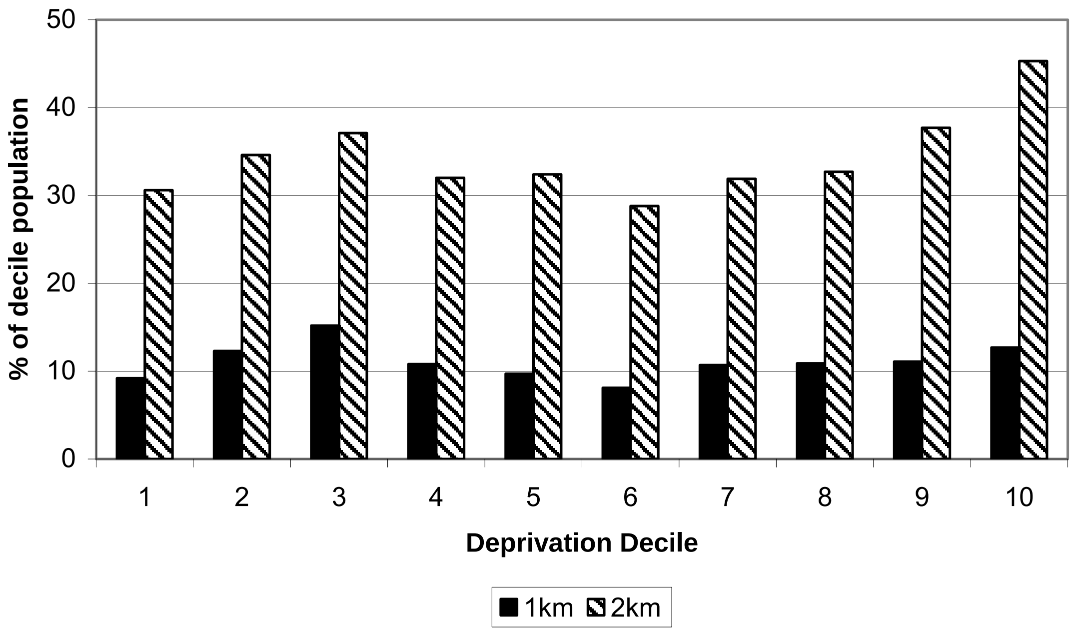


Table 10.4 Population within 1km of a quarry or open cast site by type of site and deprivation decile

Decile	Popn within 1km	Tipping	%	Restored	%	Inactive	%	Ceased	%	Active	%
1	46,347			893	0.18	173	0.03	43,874	8.67	2,488	0.49
2	62,586			280	0.06	211	0.04	55,341	10.92	9,062	1.79
3	76,701			1,172	0.23	1,614	0.32	64,222	12.69	11,847	2.34
4	54,776			2,178	0.43	2,747	0.54	43,979	8.69	11,040	2.18
5	49,341	7	0.00	594	0.12	2,473	0.49	37,874	7.48	8,702	1.72
6	40,955	78	0.00	149	0.03	2,211	0.44	29,632	5.86	9,389	1.86
7	54,054	2	0.00	552	0.11	2,318	0.46	41,220	8.15	10,970	2.17
8	55,086			194	0.04	1,589	0.31	42,727	8.44	11,268	2.23
9	56,070			634	0.13	2,397	0.47	44,468	8.78	10,461	2.07
10	64,454			336	0.07	257	0.05	55,920	11.05	7,782	1.54
Scot	560,370	88	0.00	6,982	0.14	15,990	0.32	459,257	9.07	93,007	1.84
CI Values			**-0.09**		**0.18**		**-0.09**		**0.02**		**-0.06**

Table 10.5 Population within 2km of a quarry or open cast site by type of site and deprivation decile

Decile	Popn within 2km	Tipping	%	Restored	%	Inactive	%	Ceased	%	Active	%
1	154,818		0.00	5,359	1.06	5,423	1.07	145,197	28.71	10,968	2.17
2	175,309		0.00	12,605	2.49	7,965	1.57	150,342	29.66	35,670	7.04
3	187,929	478	0.09	23,259	4.60	9,862	1.95	155,842	30.79	41,468	8.19
4	162,196	1,033	0.20	18,805	3.72	10,747	2.12	133,235	26.33	41,223	8.15
5	163,949	1,284	0.25	10,076	1.99	10,437	2.06	118,938	23.48	55,207	10.90
6	145,949	1,345	0.27	8,788	1.74	11,497	2.27	97,389	19.25	52,374	10.35
7	161,143	233	0.05	12,338	2.44	10,044	1.99	121,201	23.96	48,854	9.66
8	165,615	774	0.15	6,025	1.19	10,691	2.11	121,549	24.01	54,853	10.84
9	191,116	366	0.07	8,196	1.62	12,562	2.48	149,534	29.52	48,246	9.53
10	229,099		0.00	4,948	0.98	7,075	1.40	187,364	37.02	42,099	8.32
Scotland	1,737,122	5,512	0.11	110,399	2.18	96,303	1.90	1,380,592	27.27	430,962	8.51
CI Values			**-0.03**		**0.13**		**-0.05**		**-0.01**		**-0.11**

Note: figures may not sum as population may be within 1km of more than 1 site

Table 10.6 Population within 1km of multiple quarry sites by deprivation decile

Decile	Number of Sites											
	≥ 6	%	≥ 5	%	≥ 4	%	≥ 3	%	≥ 2	%	≥ 1	%
1	574	0.11	1,122	0.22	3,480	0.69	8,481	1.68	20,296	4.0	46,347	9.16
2	61	0.01	1,182	0.23	1,930	0.38	6,234	1.23	14,822	2.92	62,586	12.35
3	912	0.18	3,270	0.65	4,682	0.92	9,077	1.79	24,610	4.86	76,701	15.16
4	814	0.16	1,841	0.36	5,223	1.03	9,176	1.81	23,931	4.73	54,776	10.82
5	42	0.00	754	0.15	2,324	0.46	6,144	1.21	15,457	3.05	49,341	9.74
6	338	0.07	695	0.14	2,075	0.41	4,062	0.80	11,134	2.20	40,955	8.10
7	337	0.07	1,143	0.23	3,679	0.73	10,437	2.06	20,217	4.00	54,054	10.68
8	2,713	0.54	3,467	0.68	4,964	0.98	8,033	1.59	14,925	2.95	55,086	10.88
9	341	0.07	1,061	0.21	2,488	0.49	6,490	1.28	17,051	3.37	56,070	11.07
10	3,781	0.75	5,967	1.18	11,939	2.36	18,239	3.60	28,996	5.73	64,454	12.73
Scotland	9,912	0.20	20,504	0.41	42,783	0.85	86,371	1.71	191,439	3.78	560,370	11.07
CI Values		**-0.39**		**-0.20**		**-0.18**		**-0.10**		**-0.02**		**0.00**

Table 10.7 Population within 2km of multiple quarry sites by deprivation decile

Decile	≥ 10	%	≥ 6	%	≥ 5	%	≥ 4	%	≥ 3	%	≥ 2	%	≥ 1	%
1	251	0.05	8,406	1.61	20,275	2.35	27,557	1.44	59,626	6.34	87,484	5.51	154,818	13.31
2	804	0.16	13,158	2.44	19,977	1.35	30,825	2.14	50,033	3.79	89,846	7.86	175,309	16.86
3	1,946	0.38	21,644	3.89	34,066	2.45	47,444	2.64	64,040	3.28	101,542	7.41	187,929	17.07
4	2,122	0.42	20,883	3.71	28,221	1.45	35,155	1.37	46,875	2.32	84,687	7.47	162,196	15.32
5	384	0.08	11,185	2.13	17,129	1.17	26,237	1.80	42,365	3.18	75,025	6.45	163,949	17.55
6	409	0.08	10,364	1.97	15,372	0.99	22,458	1.40	34,595	2.40	63,620	5.74	145,949	16.27
7	1,016	0.20	12,621	2.29	20,893	1.63	28,662	1.54	45,733	3.37	86,685	8.09	161,143	14.72
8	454	0.09	12,441	2.37	21,001	1.69	29,449	1.67	44,390	2.95	77,119	6.47	165,615	17.48
9	0	0.00	17,198	3.40	25,539	1.65	39,430	2.74	63,650	4.78	109,117	8.98	191,116	16.19
10	15	0.00	38,411	7.59	55,436	3.36	74,787	3.82	98,677	4.72	143,602	8.88	229,099	16.89
Scot	7,400	0.15	166,311	3.14	257,908	1.81	362,005	2.06	549,984	3.71	918,728	7.28	1,737,122	16.17
CI Values		**0.25**		**-0.14**		**-0.10**		**-0.10**		**-0.06**		**-0.06**		**-0.04**

Note: populations are cumulative left to right

Figure10.2: Population within 1km of multiple quarry and open cast sites by deprivation decile

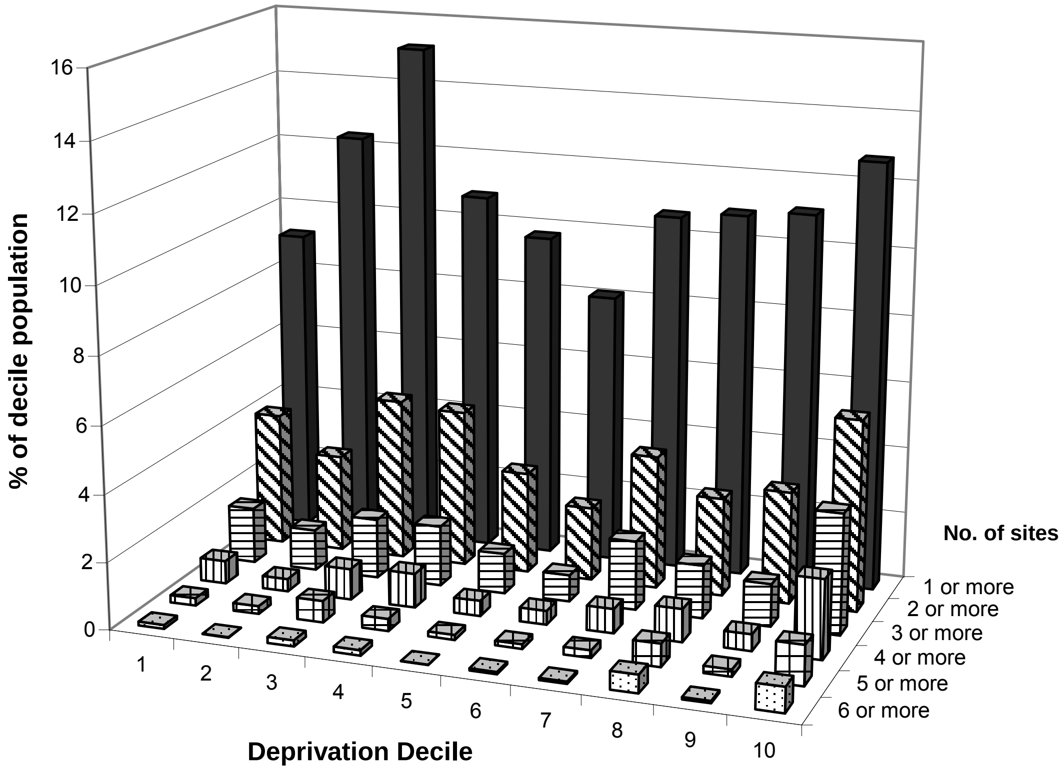


Figure 10.3: Population within 2km of multiple quarry and open cast sites by deprivation decile

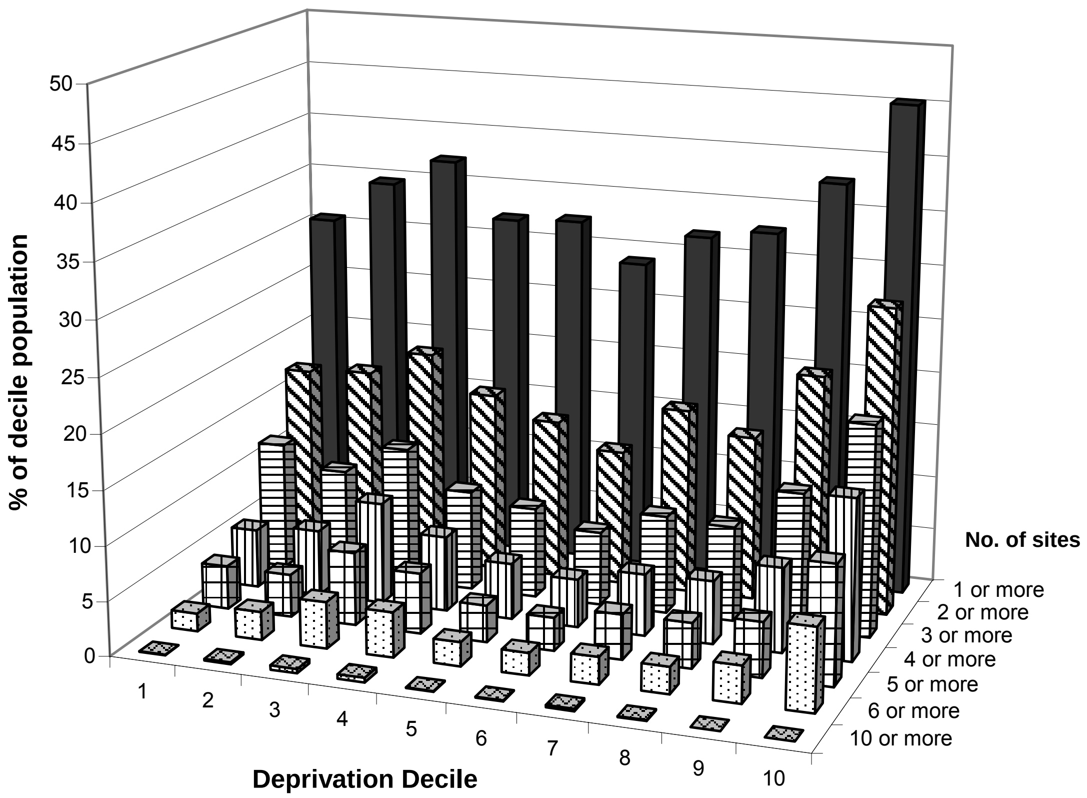
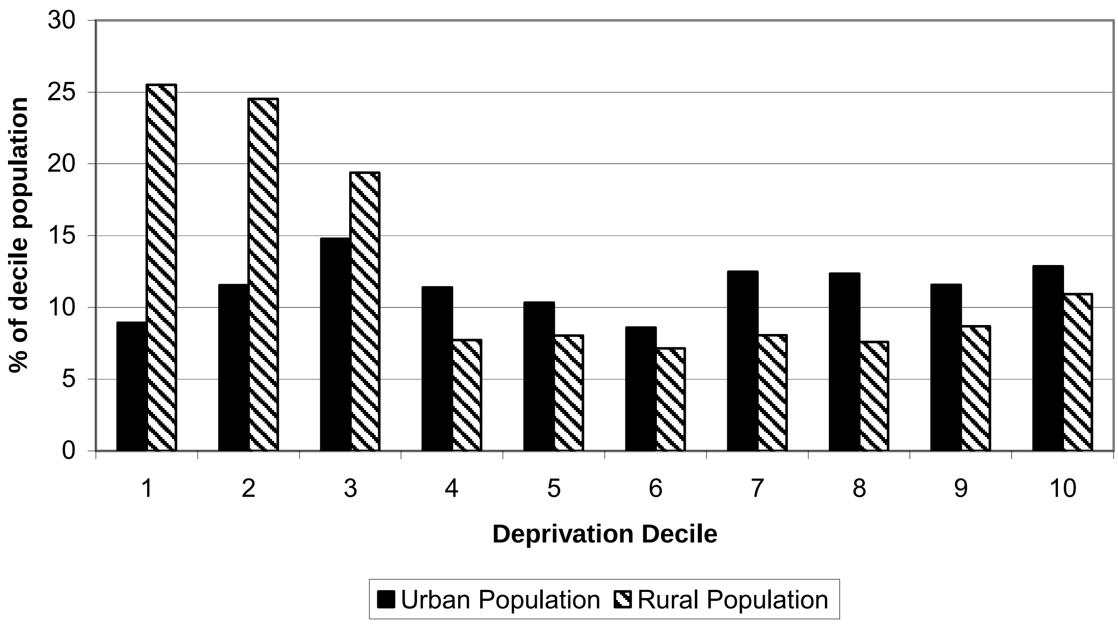


Table 10.8: Populations within 1km of a quarry by rural and urban deprivation decile

Decile	Urban Population	Rural Population	Urban Population within 1km	Rural Population within 1km	% of Urban Population within 1km	% of Rural Population within 1km
1	498,301	7,393	44,462	1,885	8.92	25.50
2	475,296	31,523	54,852	7,734	11.54	24.53
3	464,795	41,284	68,701	8,000	14.78	19.38
4	428,663	77,425	48,801	5,975	11.38	7.72
5	375,266	131,337	38,785	10,556	10.34	8.04
6	330,739	175,249	28,422	12,533	8.59	7.15
7	300,667	205,225	37,538	16,515	12.49	8.05
8	349,527	156,651	43,191	11,895	12.36	7.59
9	418,923	87,536	48,473	7,598	11.57	8.68
10	471,308	34,854	60,647	3,807	12.87	10.92
Scotland	**4,113,484**	**948,477**	**473,872**	**86,497**	**11.52**	**9.12**

Figure 10.4: Populations within 1km of a quarry by rural and urban deprivation decile



10.4 Discussion

Given the fact that the data is a point location and is located in the centre of the site, it is possible that the results of the 500m and 1km analysis are being distorted by large portions of some quarry and open cast sites being within the buffer area. This is particularly likely to be the case for 500m where no people were found to be living within the buffer area.

10.4.1 Deprivation and proximity to a quarry or open cast site

Table 10.3 indicates that around 11% of the population live within 1 km of a quarry or open cast site. However the majority of these sites are now closed and only around 2% of the population live within 1km of an active quarry or open cast operation (Table 10.4). Nationally there are 430,000 people living within 2 km of an active site and just over three times as many living near to a site where operations may resume (Table 10.5).

For all types of sites combined the profile of population proximity across the deciles shows little variation (Table 10.3). The percentage of the population within a decile that lives within 1km of a site ranges only between 9% and 15%, the CI value is zero and there is no distinct pattern to the variation. For the 2km buffer there is a similar lack of variability across most of the deciles although there is a peak towards the *least* deprived deciles 9 and 10, reflected in the negative CI value of -0.04. For the active sites (Table 10.5) the majority of deciles have values that are also very close together, apart from decile 1 which is much lower. This latter figure may be related to the fact that a large part of decile 1 is an urban population within Glasgow which has few proximate quarry or open cast sites (see Figure 10.5).

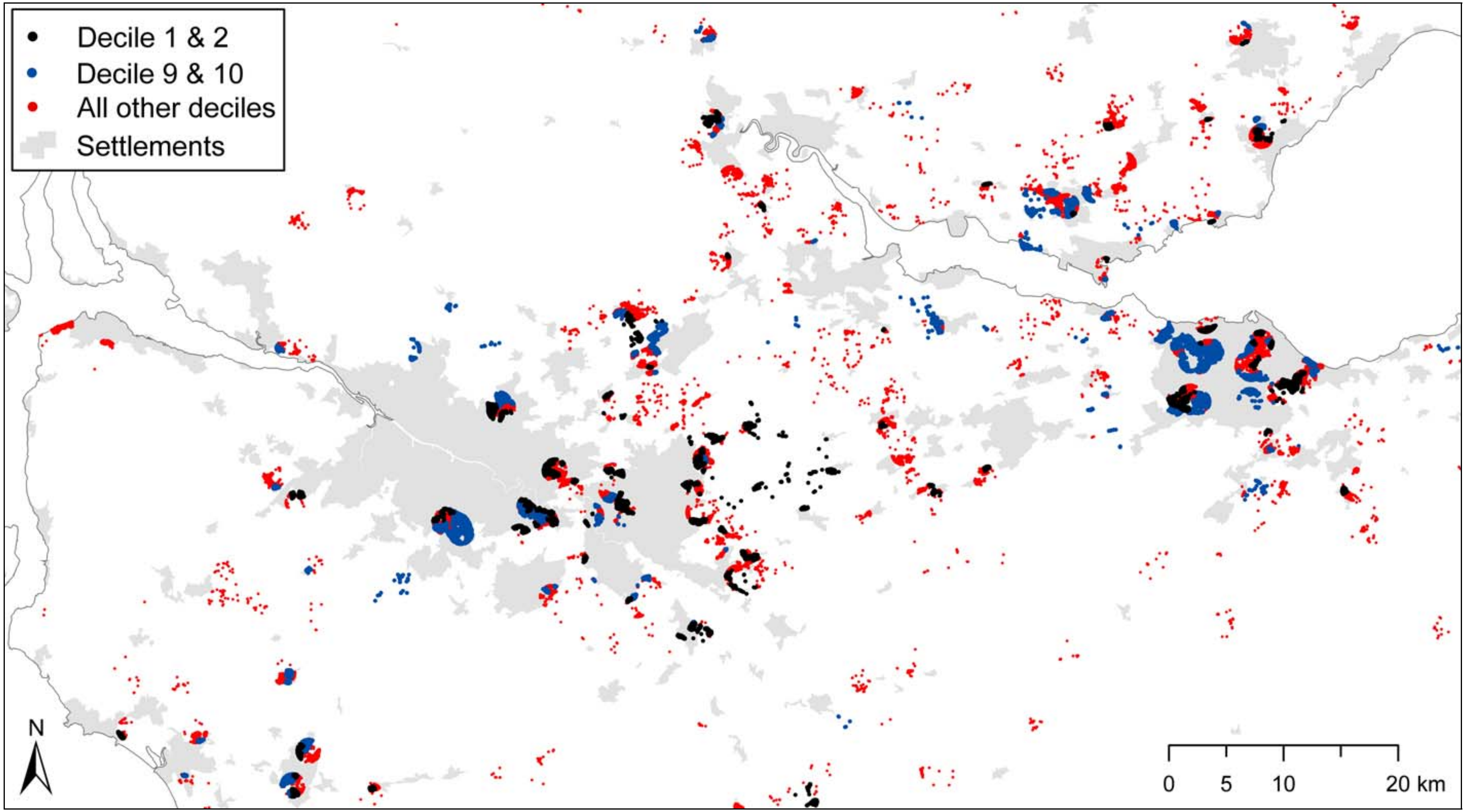
10.4.2 Deprivation and proximity to multiple quarries and open cast sites

The cluster analysis does show a fair degree of clustering of quarries and open cast sites in Scotland with people living within 2km of up to 10 sites. As the degree of clustering increases (Tables 10.6 and 10.7 and Figures 10.2 and 10.3) this tends to become concentrated in the least deprived deciles, with CI values steadily becoming more negative indicating an inverse relationship with deprivation.

10.4.3 Deprivation and proximity to quarries and open cast in urban and rural areas

The urban-rural analysis does show a different and fairly distinct pattern for rural deprivation (Table 10.8 and Figure 10.4). Whilst for the urban population a fairly even distribution is observed across the deciles, for the rural population the proportion of population that lives within 1km of a quarry or open site is distinctly higher in the most deprived deciles 1, 2 and 3. This proportional difference suggests that there is some bias towards the deprived rural population in the locations of landfills in rural areas.

Figure 10.5: AddressPoints within 1km of Quarries and Open cast sites in Central Scotland



11 Woodlands

11.1 Introduction

Currently in Scotland there are 1.3 million hectares of woodlands (Forestry Commission 2003) covering 17% of the country. This is the highest amount of woodland cover of the four countries in the United Kingdom, although broadleaf trees make up a smaller proportion (20%) of the overall total than in England or Wales. Woodlands produce a significant range of environmental, health, social and economic benefits to society (see section 3.6) as well as playing a role in many areas of urban regeneration. Within this study we have considered woodland to be a type of green space as is specified in Planning Advice Note 60 and so we make reference to both the woodlands literature and green spaces in general.

11.2 Data sources and methods

Although woodlands have many benefits, analysing a pattern between social deprivation and the role of woodlands is hard to do. Although the visual amenity aspects of some woodlands are considerable (for example open woodlands are generally viewed positively while blanket conifers are seen as negative) it is difficult to examine this link for the whole country at a small area unit. This limitation should be remembered when considering the following analysis.

We have examined the issue of physical proximity to woodlands as a resource for recreation, health benefits (both mental and physical), these uses are also ascribed to woodlands in NPPG11.

However, the issue of access and use of woodlands is important and warrants further discussion. It is important to realise the physical access to woodland or green space is only one of the determinants as to whether people will use it or not. The Comedia and Demos (1995) report found that elderly people, ethnic minorities, women and people with disabilities were under represented as users of parks and such findings are applicable to woodlands. Fears about crime in part caused by under funded and run down parks, lack of park attendants and poor management can all deter groups in general but especially women in the cohorts mentioned above (see Williams and Green 2001, Dunnett et al 2002 for reviews of these issues). Different levels of use of parks and woodlands also occur due to the design of the area itself, areas with open views are preferred, and providing seating areas are particularly important in encouraging use. When discussing the barriers to using green spaces Dunnett et al concluded "Most of these issues are resource issues that relate to the location, accessibility or environmental quality of urban green spaces and are therefore issues which could be overcome if the planners, designers and managers of these spaces could address them satisfactorily." (pg11 2002)

The analysis in this report is essentially looking at the population within proximity (not access) to woodlands. This in part helps account for the aesthetic and other benefits which do not require access.

When considering access to woodlands in Scotland we need to remember that the Land Reform (Scotland) Act 2003 gives a presumed right of access unless indicated otherwise. The implication of this is that any national analysis should, as a starting point, consider all woodlands in Scotland, even though some of the woodlands may be very difficult to access and the quality of the experience in woodlands for walking or cycling may vary.

However, after reviewing the standards relating to access (see section 6) we have chosen to examine the population that lives within 600 metres of woodlands that are 2 hectares or greater in area. The 600m distance falls at the lower end of a range of studies reviewed and the 2 hectare size fits with Box and Harrison (1993) and findings from Cole and Bussey (2000). These standards are applicable to the adult population. This criteria accounts for both the physical access, visual benefits and as a proxy for benefits identified in section 3.6.

The main source of data has been the Digital Woodland Map for Scotland which is an amalgam of several data sets. It includes the original land cover of Scotland (1988), Woodland Grant Schemes 1988-95 and 1995-2001, new Forestry Commission Planting between 1988 and 2001 and updates of woodland in urban areas. Forest parcels in the original classification were generally above 2 hectares in size (although woodland parcels that together made up a wood equal to or greater than 2 hectares were included) but subsequent updates have included parcels of all sizes up until March 2002 (the latest data was used for this project). This dataset has better spatial representation than some of the other topics in the report because it is a polygon dataset. However the processing of this complex polygon dataset takes a considerably longer time compared to the point sources and even the modelled derelict land.

The methodology uses the polygon dataset of the woodlands to first select parcels of woodland that are equal to or greater than 2 hectares. These polygons are then buffered to a distance of 600 metres. Use is then made of the AddressPoint data to carry out a point in polygon analysis and to provide a breakdown by social distribution. Given the size and complexity of the data set it was necessary to split the data into two parts to carry out the analysis and then bring the final results together.

Analysis has been carried out on all woodland and then the subset of new woodland. New woodlands under the Digital Woodland Map was classified as the following categories (Table 11.1)

Table 11.1 New woodland categories selected from the Digital Woodland Map

Feature code	Description
11	Young trees dated 31/03/95 New grants schemes
11	Young trees dated 31/03/00 and 31/03/01 New grants schemes 1995- 2002
7	Young trees dated 31/03/95 FC New Planting
7	Young trees dated 31/03/00 and 31/03/01 FC New planting 1995-2002

11.3 Results

Table 11.2 Population within 600 metres of all woodlands greater than 2ha by deprivation decile

Decile	Total Population	Population within 600m	Percentage (%)
1	505,775	279,526	55.3
2	506,808	295,599	58.3
3	506,064	278,761	55.1
4	506,082	295,125	58.3
5	506,596	309,638	61.1
6	505,966	318,299	62.9
7	505,930	329,484	65.1
8	506,157	324,354	64.1
9	506,485	328,782	64.9
10	506,148	331,848	65.6
Scotland	5,062,011	3,091,417	61.1

Table11.3 Population within 600 metres of new woodlands greater than 2ha by deprivation decile

Decile	Total Population	Population within 600 metres	Percentage
1	505,775	94,419	18.7
2	506,808	73,555	14.5
3	506,064	72,965	14.4
4	506,082	80,055	15.8
5	506,596	76,091	15.0
6	505,966	76,785	15.2
7	505,930	64,844	12.8
8	506,157	65,697	13.0
9	506,485	51,304	10.1
10	506,148	44,996	8.9
Scotland	5,062,011	700,712	13.8

Table 11.4 Population within 600metres of all woodland by urban and rural deprivation decile

Decile	Urban Population	Rural Population	Urban Population within 600m	Rural Population within 600m	% of Urban Population within 600m	% of Rural Population within 600m
1	498,301	7,393	272,982	6,544	54.8	88.5
2	475,296	31,523	271,572	24,027	57.1	76.2
3	464,795	41,284	248,123	30,638	53.4	74.2
4	428,663	77,425	250,066	45,058	58.3	58.2
5	375,266	131,337	220,383	89,256	58.7	68.0
6	330,739	175,249	191,631	126,668	57.9	72.3
7	300,667	205,225	181,535	147,949	60.4	72.1
8	349,527	156,651	208,018	116,336	59.5	74.3
9	418,923	87,536	263,375	65,407	62.9	74.7
10	471,308	34,854	306,742	25,106	65.1	72.0
Scotland	4,113,484	948,477	2,414,426	676,990	58.7	71.4

Figure 11.1 Percentage of population within 600 metres of all woodland by rural and urban deprivation decile

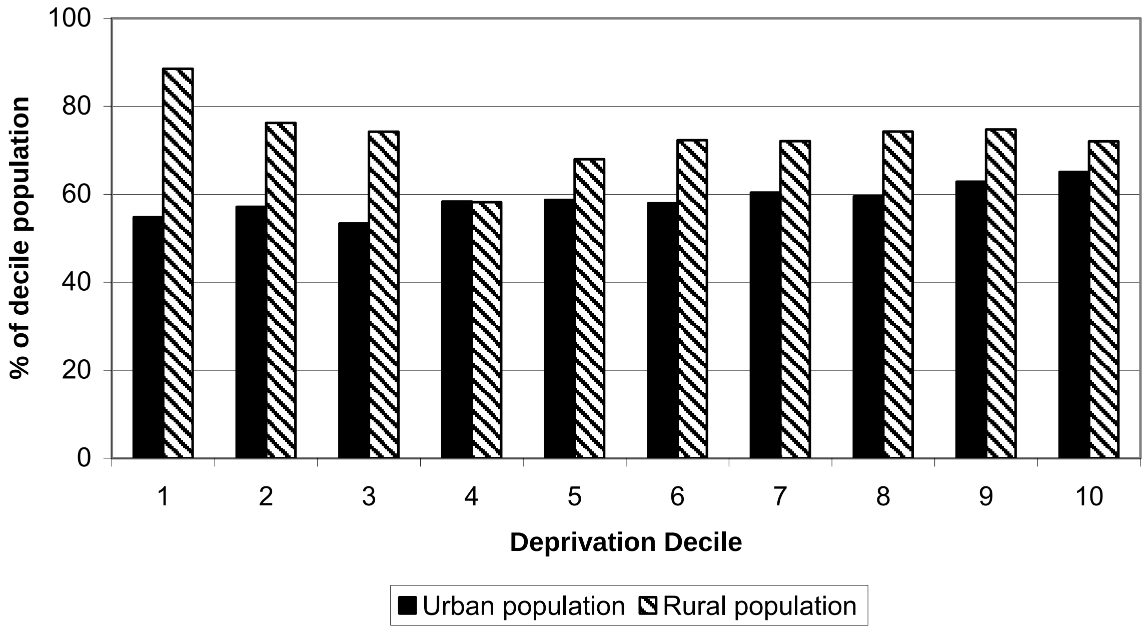
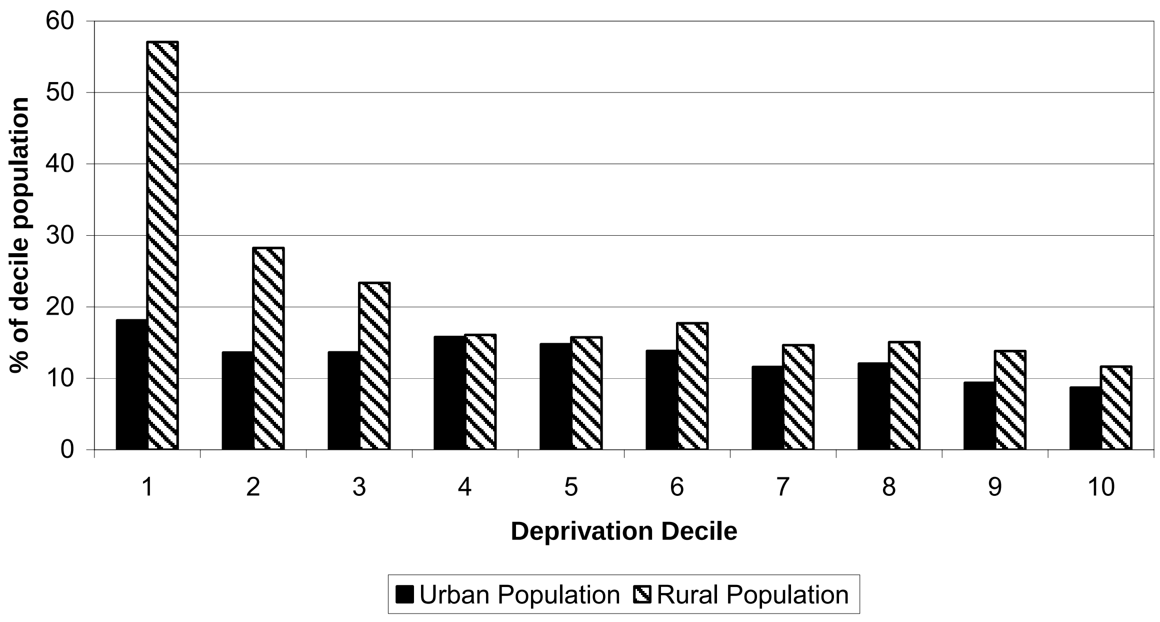


Table 11.5 Population within 600metres of new woodland by rural and urban deprivation decile

Decile	Urban Population	Rural Population	Urban Population within 600m	Rural Population within 600m	% of Urban Population within 600m	% of Rural Population within 600m
1	498,301	7,393	90,201	4,218	18.1	57.1
2	475,296	31,523	64,651	8,904	13.6	28.2
3	464,795	41,284	63,324	9,641	13.6	23.4
4	428,663	77,425	67,605	12,449	15.8	16.1
5	375,266	131,337	55,418	20,673	14.8	15.7
6	330,739	175,249	45,742	31,043	13.8	17.7
7	300,667	205,225	34,819	30,026	11.6	14.6
8	349,527	156,651	42,111	23,586	12.0	15.1
9	418,923	87,536	39,209	12,095	9.4	13.8
10	471,308	34,854	40,944	4,052	8.7	11.6
Scotland	4,113,484	948,477	544,024	156,688	13.2	16.5

Figure 11.2 Percentage of the within 600 metres of new woodland by rural and urban deprivation decile



Note
1. Decile 1 value for rural population is high but based on a very small rural population overall in decile 1

Table11.6 Population within 600 metres of all woodlands greater than 2ha by settlement type

Urban rural class	Total Population	Population in buffer	%
Primary cities	1,972,210	1,106,657	56.1
Urban settlements	1,472,539	882,518	59.9
Accessible small towns	525,202	345,375	65.8
Remote small towns	79,183	52,438	66.2
Very remote small towns	64,349	27,439	42.6
Accessible rural	662,430	489,999	74.0
Remote rural	141,428	113,812	80.5
Very remote rural	144,619	73,179	50.6
Scotland	5,061,961	3,091,417	61.1

Note
1.See table 6.4 for more details on categories

Table 11.7 Population within 600 metres of new woodlands greater than 2ha by settlement type

Urban rural class	Total Population	Population in buffer	%
Primary cities	1,972,210	264,728	13.4
Urban settlements	1,472,539	206,423	14.0
Accessible small towns	525,202	60,673	11.6
Remote small towns	79,183	3,755	4.7
Very remote small towns	64,349	8,446	13.1
Accessible rural	662,430	113,790	17.2
Remote rural	141,428	23,938	16.9
Very remote rural	144,619	18,959	13.1
Scotland	5,061,961	700,712	13.8

Note
1.See table 6.4 for more details on categories

11.4 Discussion

11.4.1 Deprivation and proximity to woodlands

People living in the most deprived deciles are less likely to be near to woodlands when considering all woodlands (Table 11.2). 55.3% of people in decile 1 live near to a woodland compared to 65.6% of people in decile 10. Deciles 1 through 4 all record values less than 60% while deciles 5 through 10 all record values above 60%. Conversely we can say that more than 40% of the population within Scotland do not live near to woodlands greater than 2ha.

The results of the new woodlands analysis are more positive (Table 11.3). Decile 1 has benefited most from the creation of new woodland with 18.9% of decile 1 living within 600 metres of new woodland. Such woodland is generally more likely to be accessible to the public than the general classification of all woodland as access was a condition for many recent grants over the last decade. Deciles 1 to 6 have benefited from new woodlands being planted in their areas, more so than deciles 7 to 10. This suggests that policy may have started to redress the unequal distribution of woodland overall between the deciles.

11.4.2 Rural/urban populations and proximity to woodlands

When the results of the urban/rural analysis are considered (Table 11.4, Figure 11.1) they show that the rural population overall has a greater proximity to all woodlands for every decile except decile 4 where the figures are effectively the same for the rural and urban population. The urban population in decile 3 records the lowest value (53.4) with decile 1 having the second lowest value at 54.8%. The rural population in decile 1 has the highest value of proximity to woodland at 88 %. However the results for decile 1 illustrate an important point when considering analysis of this data, namely that the balance between urban and rural population within deciles varies enormously. As such the absolute values and the percentage values need to be considered together in conjunction with Table 11.2 which contains the overall decile results. In the case of decile 1 the rural population comprises of less than 1.5% of the overall decile population. In deciles 6 and 8, it is the large rural population within these deciles with proximity to woodlands that increases the overall decile value; whereas in deciles 7, 9 and 10 it is the higher values in both the rural and urban populations which results in a higher overall percentage of population near to woodlands.

Examination of the population living near to new woodlands (Table 11.5, Figure 11.2) shows that in general it is the rural population which benefited disproportionately overall in terms of proximity to new woodland. The most deprived populations (decile1) in both rural and urban areas have benefited from the planting of woodlands near to them. For urban populations in decile 1 just over 18% is near to new woodlands while for the rural a figure of 57% is recorded. The next highest figures are recorded for the rural populations within deciles 2 and 3 at 28 and 23 % respectively (it should be noted that deciles 1 to 3 have small rural populations overall.) The population with the lowest values for proximity to new woodlands are urban populations within deciles 9 and 10 which are also the deciles with the largest values for proximity to existing woodland.

11.4.3 Settlement type and proximity to woodlands

There is a very wide variation in access to all woodlands by settlement type ranging from 42% in settlement type 5 to 80% in settlement type 7. However there is also a very wide variation in the total population within each settlement type and both percentage and absolute figures need to be considered in any analysis. Although there is no discernable pattern the results are worth presenting due to the large variation between settlement type.

New woodland by settlement type shows a much smaller range of values for the population with access. Settlement type 4 stands out as having a significantly smaller value than the other settlements for new woodlands.

12 Green Space

12.1 Introduction

This chapter provides a discussion of the issues involved in undertaking an environmental justice analysis for this topic and some initial exploratory data analysis.

A range of green space datasets were evaluated in section 4 and some further discussion of these is provided in this chapter. General issues about datasets and the requirements when carrying out environmental justice work are discussed in section 5 and recommendations concerning the availability and use of data in the future are discussed both here and in section 16.

12.1.1 Environmental justice and Green Space

Environmental justice is concerned with the relationship between people and the environment and in particular how the environment is socially distributed. As reviewed in section 3.6 there are many different ways in which green space is of relevance to people and their quality of life and therefore many different ways in which a green space environmental justice analysis may be framed, focused and carried out. Green space, for example, has impacts on issues of safety, recreation, health, education, play, community identity and economic vitality. Each of these could be the focus for an environmental justice analysis, either separately or in some combination, asking questions about:

- how the available green space positively and/or negatively impacts in different ways on different parts of society differentiated in terms of deprivation, age, gender, disability, ethnicity etc.. (questions of distributive justice)

- how decisions are being taken about green space provision and management, the fairness of decision-making processes and in particular who participates in discussion and decision-making (questions of procedural justice)

- how policy for green space is either directly or indirectly having an impact on the availability, quality and use of green space for and by different parts of society (questions of both distributive and procedural justice)

Researching each of these questions, for each of the forms of impact of green space on people and communities in Scotland, would be a substantial task, involving the application of different research methods, the collection or use of different types of data and undertaking analyses at different spatial scales.

The focus of this project is on analysing questions of distribution (the first bullet point above) in relation to patterns of deprivation. If this narrowing down of the breadth of potential analysis is followed, there are still a set of involved and interrelated issues to be addressed before a distributional analysis can be designed and carried out.

a. What specific type of green space is being analysed? Green space takes many different forms. Planning Advice Note (PAN) 65 entitled 'Planning and Open Space' identifies several broad types of green space (see Table 12.1). This illustrates that green space has a very wide definition and encapsulates a variety of quite different spaces. An analysis would ideally differentiate between the different types of green space rather than lumping all of these together, and focus only on those of particular interest to the questions being asked. For example, if the concern was how opportunities for green space based sport were distributed in relation to deprivation, then only those spaces falling within the 'sports areas' category would be included. If alternatively the concern was with how green space contributed towards the image and community identify of area and how this related to deprivation then several of the green space categories in Table 12.1 would need to be included in such an analysis.

Table 12.1 Types of Open Space

Type	Description
Public parks and gardens	Areas of land normally enclosed, designed, constructed, managed and maintained as a public park or garden.
Private gardens or grounds	Areas of land normally enclosed and associated with a house or institution and reserved for private use.
Amenity greenspace	Landscaped areas providing visual amenity or separating different buildings or land uses for environmental, visual or safety reasons i.e. road verges or greenspace in business parks, and used for a variety of informal or social activities such as sunbathing, picnics or kickabouts.
Playspace for children and teenagers	Areas providing safe and accessible opportunities for children's play, usually linked to housing areas.
Sports areas	Large and generally flat areas of grassland or specially designed surfaces, used primarily for designated sports i.e. playing fields, golf courses, tennis courts, bowling greens; areas which are generally bookable.
Green corridors	Routes including canals, river corridors and old railway lines, linking different areas within a town or city as part of a designated and managed network and used for walking, cycling or horse riding, or linking towns and cities to their surrounding countryside or country parks. These may link green spaces together.
Natural/semi-natural greenspaces	Areas of undeveloped or previously developed land with residual natural habitats or which have been planted or colonised by vegetation and wildlife, including woodland and wetland areas.
Other functional greenspaces	Allotments, churchyards and cemeteries.
Civic space	Squares, streets and waterfront promenades, predominantly of hard landscaping that provide a focus for pedestrian activity and make connections for people and for wildlife, where trees and planting are included.

(source PAN 65)

b. What qualities or characteristics of green space are of importance? This interacts with the question above, in that relevant characteristics will relate to the type of green space being examined. For example, where use of the green space is of concern, issues of accessibility (which itself has a number of dimensions) will be important and ideally factored into the analysis in a meaningful way. Where the contribution of green space to the image or aesthetic quality of an area is of concern, other characteristics related to the perceived attractiveness of different types of 'green' environments will be important to take into account

c. Which spatial scale is appropriate for the questions being addressed? Studies can be carried out at different scales from national through to local neighbourhood and can focus on different types of areas, such as urban or rural. Analyses at different scales can answer different types of questions. A national scale analysis can provide a view of the broad availability of green space for different communities, and address the fairness of that distribution in relation to levels of deprivation. Local analyses can look in far more detail at the particular context for parcels of green space, their connectivity, access routes and factors influencing the extent of their use by different social groups. A rural based analysis may be concerned far less with the general availability of green space (give that it will be pervasive) than with issues of access and the perceived quality of different types of rural environment and how these may vary in relation to patterns of rural deprivation.

Whilst these questions may be answered in an abstract way and an environmental justice green space analysis developed, the key practical question relates to the availability of data. As discussed in some detail in chapter 4, unless data sets include the information needed to undertake a chosen analysis, the research may not be viable or able to answer the questions initially posed. For example, if a data set does not include any information on the quality of green space (however that may be judged) then an analysis attempting to evaluate the contribution of the green space to the aesthetics of an area will be constrained in what it can conclude, or arguably even fundamentally undermined.

One key issue when considering the availability and suitability of data is the difference between land cover and land use datasets. Land cover is a description of the physical covering e.g. type of vegetation cover. Land use is a description in terms of its utility in an economic or planning sense. This differentiation is important for green space and woodland work as they can be subsumed within categories and merged with other classes. For example, derelict land may have woodland on it and is often a type of green space, but within the data set it may be recorded simply as derelict land.

Evaluation of a number of the existing green space data sets was briefly undertaken in chapter 4 and is developed further in the next section. This demonstrates the constraints which dataset characteristics can present and the difficulties involved in linking research questions to available data.

12.1.2 Further Evaluation of Green Space Datasets for Environmental Justice Analysis

A number of green space datasets were evaluated in section 4 with strengths and weaknesses for environmental justice analysis identified. As discussed below, two of these have been used for exploratory analysis in this project. However, to aid further development of environmental justice work, in particular by Scottish Natural Heritage, each of these datasets are considered at further length in this section in relation to the types of environmental justice questions which could be addressed.

Land Cover Map 2000

The focus of this dataset was the identification of broad habitats. 16 target classes (level 1) were identified and mapped, on average to an 85% accuracy level (although it is thought to be less accurate in Scotland). Within these classes (Level 2) 27 sub classes were identified. Within Level 3 sub class components are further identified. Level 2 and 3 habitat classes are less accurate than level 1. The data was originally in raster data format (with the inherent generalisations of that data model) and has since been converted to a vector format.

We were asked to consider the possibility of creating a semi-natural category from the dataset, to do this would require a merging of some of the level 2 data possibly using the “semi-natural & natural grasslands & bracken” category as a starting point. However given the level of inaccuracy in the dataset (an educated guess would suggest 20 - 25% at least), any use of this data would need to be supported either through the use of digital aerial photography or ground-truthing before further analysis was carried out. This suggests it may be possible to use it for a localised study if the accompanying resources were available.

There is a further limitation of the dataset in that within urban areas some types of green space have been merged into an overall 'urban' category. This is a problem as Scotland has a heavily urbanised population and most journeys to green space are on foot and over small distances. While it is possible to identify some classes as potentially useful e.g. broad-leaved / mixed woodland and possibly coniferous woodland, better datasets such as the National Woodland Inventory already exist.

The Land Cover Map 2000 is a good example of a dataset collected for a specific purpose and which superficially appears useful but which is of limited application when investigating environmental justice at a national level. Local scale analysis could in principle make use of this data to explore environmental justice questions in rural areas if combined with other local data. This is very much uncharted territory as environmental justice concerns have almost entirely been focused on urban areas and the prevalence of green space in rural areas can make questions of distribution appear irrelevant. Whilst provision of and access to green space for urban populations is undoubtedly the priority issue, as noted above there may be issues of access in rural areas depending on the nature of agricultural land uses and the provision of, quality and connectivity of footpaths and their suitability for different users. Such an analysis could make use of the land cover map to provide a background of habitat classes, but this also would need to be combined with detailed local data on other land characteristics and accessible route networks.

Landscape Character Assessments

This is a dataset which describes key landscape characteristics. It is used to give a broad, qualitative description of an area. The defined characteristics were not designed to aid the investigation of environmental justice or as a quantitative measure. Hughes (1997) identifies two spatial aspects of the dataset that would make them difficult to use for environmental justice:

a. “The individual map units are intended to be interpreted in accordance with the strategic nature of the study and the boundaries between them are therefore to be regarded as indicative positions rather than precise locations.”

b. “**The scale and level of detail at which these have been formulated should be stressed.** They are specifically intended to provide guidance at a strategic level, **and are therefore not necessarily directly and immediately applicable at the site specific level,** such as is required for the assessment of development proposals or the formulation of detailed planning policies. There may therefore be a need in many cases for a further level of analysis to be overlain” (Bold in original).

There are several other characteristics of the dataset that are obvious limitations for any quantitative study, such as the lack of coding in the database, the lack of quantitative data and the lack of any indicator of quality or evaluation.

Given these limitations it is hard to see how this data set could be used for environmental justice analysis. It does not provide useful information on green space in urban areas and for rural issues other data sets such as Land Cover are more appropriate.

Designated green spaces

Several datasets were identified in section 4 which given particular designations to areas of green space - local nature reserves, national nature reserves and country parks. These data sets are good quality in terms of the resolution of the data and the precision with which boundaries have been captured as polygons. There are two key issues for their use in exploring environmental justice. First, their location is clearly dependent to some degree on the intrinsic qualities of the environment. A simple proximity analysis which identified who lived within specified distances of these designated areas would not easily produce results which could then be acted upon by reconfiguring where such designated areas are located. This is particularly the case as designations become more unique and small in number (e.g. national nature reserves). On the other hand in terms of prioritising investment and management effort, particularly in making areas such as country parks accessible and attractive to populations who are not frequent users, and in setting up new country parks in areas of poor provision, such an analysis could be useful. Second, given this purpose it would be important to have information on access provision at the designated sites (which is not currently in the datasets), and ideally on access routes by different transport modes and on patterns of transport likely to be used by different social groups. This indicates again that a regional or local scale analysis is most appropriate which is able to capture and use more detailed local data. One way of approaching such a study could be to start from a focus on particular deprived communities and to consider what forms of designated green space are accessible to that population (see further case study discussion below).

Local Plan Data

Local plan data consists of an extraction of land use categories from the Local Plans for all the local authorities in Scotland. This data set has been used in an exploratory way in this project and is discussed further in the next section. Whilst there are problems with how the consistency with which the data has been collected and compiled it does provide a national data base of locally identified nature designations. We have undertaken a simple proximity analysis to provide an initial view of how these sites are distributed in relation to patterns of deprivation, but this analysis is restricted in what it can say about the realities of access to these sites, given the primary issue for an environmental justice study would appear to be the use of the sites by local people rather than simply their existence in the area. To improve upon this analysis information on the qualities of and access provision at each site would ideally be obtained and a route access analysis undertaken using information on path networks or if appropriate other forms of transport. This again suggests the need for local scale rather than national scale analysis.

A further focus for a study using the local plan data could be on educational use. The value of green space as an educational resource has been widely recognised and nature designations will be particularly significant in this respect. An analysis could for example examine the accessibility of green space near to schools with catchments having different profiles of deprivation. This could be based on simple proximity but would ideally involve analysis of route access by foot or school bus. It would be important for the necessary green space qualities for educational uses to be defined (e.g. size, quality, biodiversity) and further information to be recorded on each nature designation so that it can be judged against these criteria.

Glasgow Green Space Study

The Glasgow Green Space Study data set provides a far more complete and detailed view of the existence of green space across an urban area than any other of the data sets examined. It has been used for exploratory analysis in the project and is discussed further in the next section. Given its particular qualities it provides a city-level resource for beginning to explore some of the many varied environmental justice questions identified earlier.

For example, it is the only dataset which could begin to provide a view of how green space may be contributing in a broad way to the image or aesthetics of an area given that it attempts to be inclusive of many different types of green space. However, to produce an enhanced analysis in this respect the dataset would ideally separately identify further small areas of green space (from aerial photography, MasterMap or local authority data) so that for example, gardens and small stands of trees were included. In addition quality or characteristic ratings which reflect the perceptions and values that local people attach to different types of green space would also be needed. These could be obtained from preceding survey or focus group work.

Another example of how the Glasgow green space data could be utilised would be to make an assessment of the availability of green space for recreation and physical activity with linkages then through to impacts on health for different social groups. This would again require additional information to be collected on the green spaces in the city relating to access to the green space and the quality of physical activity opportunities that it provides.

A case study approach

Each of the data sets we have evaluated provide varying degrees of opportunity for environmental justice analysis, particularly, we suggest, if used at a local level and enhanced through additional data capture. One approach which could be used to enable the available data sets to be combined, explored and developed in an integrated way, would be for an environmental justice study to be intensively focused on case study areas. If a particular deprived community is identified (or a number of these) at neighbourhood level, an assessment could then be undertaken of the impact (negative and positive) of different types of green space (designated, general, accessible, private and so on) for that community. A range of green space impacts could be included within the remit of the work (physical activity, health, education, recreation, aesthetics) and detailed information on local usage, transport, access routes, perceptions, values and so on developed for that particular neighbourhood. Comparisons could potentially be made with a less deprived community and particular factors that make the difference between areas with good and poor green space provision identified.

12.2 Methods

As outlined in the discussion over preceding sections, environmental justice analysis for green space is involved and has many different possible purposes. To illustrate how studies can be undertaken, two of the available data sets have been used for exploratory analysis but without any of the enhancements discussed above. The limitations of the data and the conclusions that can be drawn from the analysis therefore need to be emphasised. Both of the datasets were initially prepared at Scottish Natural Heritage.

12.2.1 Glasgow Green Space Study

The Glasgow Green Space study dataset was created using digital aerial photography to classify the land use within Glasgow. It made use of the land classification system devised by the National Land Use Database and used for the ODPM in England.

When examining the links between deprivation and environmental quality at a local authority level it is not advisable to use the overall index of deprivation ranking as has been done for the national analysis. The values in the SIMD are a reflection of the national dataset, if Glasgow was to be divided into deciles based on the overall SIMD it would mean that areas that are very similar in terms of deprivation nationally would end up in different deciles for Glasgow. For example, deciles 1 to 4 and part of 5 for Glasgow would all come from decile 1 when examined on a national basis. The imbalance of data zones in Glasgow is illustrated in Table 12.2.

Table 12.2 Distribution of data zones using overall rank of SIMD 2004 in Glasgow

Decile	No of data zones	Cumulative
1	318	318
2	84	402
3	66	468
4	48	516
5	38	554
6	41	595
7	25	620
8	35	655
9	24	679
10	15	694

Instead we have made use of two of the sub domains of the Scottish Index of Multiple Deprivation: the income domain records the percentage of people who are income deprived and the employment domain which records the percentage of people who are employment deprived (note that these two domains **are** mutually exclusive). Use of actual scores would allow comparisons to be made between individual authority studies if they were carried out and would also allow a comparison over time regardless of any change in relative deprivation ranking.

The access distance for the Glasgow study had already been chosen before this study commenced and aligns with the recommend distance for children; as such this complements the work on woodlands, which used a distance for adults. The distance chosen was 300 metres and it has been calculated in two ways:

a. Use of a standard buffer i.e. a straight line distance i.e. does not take into account any barriers.

b. Calculation of a route access along a network of paths using a cost weighted distance analysis. This is currently both a very process intensive method and requires a detailed path network, it is very unlikely that it would be possible to replicate such an approach at a national level given the current technical and data limitations.

There is one other significant limitation within the analysis, populations living near to the edge of the city limits (i.e. within 300m) maybe near to green space within a neighbouring authority. However because we do not have land use data for neighbouring authorities some of the figures may be less than they should be.

The land use selected for the analysis was "outdoor recreation" which is overwhelmingly green space but also includes recreation facilities e.g. some stadiums, tennis courts etc. There is no indication of actual levels of access to the different parcels e.g. some may require payment.

12.2.2 Local plan data

The second dataset is an extraction from the Local Plans for all the local authorities in Scotland; there are 108 plans from 34 local authorities. This is a difficult dataset to use for a national analysis as there is no one consistent list of terms for different land uses; instead every local authority is free to come up with a term they think is best. Furthermore there is no coding system, which would link together different terms and make the local plan datasets easier to use. As such the same land use type is described by different terms and it is also possible that a single term could have been used in different ways between authorities.

Data was extracted for local nature designations under four broad headings; Sites of Importance for Nature Conservation (SINC), Local Nature Conservation Sites, urban wildlife sites, other wildlife sites. A full list of the variations on these four designations is shown in Table 12.3. However they have been treated as one category of green space in the analysis.

Table 12.3 Classification of local nature designations under local plans for Scotland

Text	Count
City-Wide Site of Importance for Nature Conservation	36
Designated Wildlife Sites	10
District Wildlife Site	88
Listed Wildlife Site	4
Listed Wildlife Sites	13
Local Designations (S.I.N.C)	211
Local Nature Conservation Area	80
Local Nature Conservation Sites	90
Local Site of Importance for Nature Conservation	36
Other Sites of Nature Conservation Importance	23
Other Sites of Wildlife and Scientific Value	55
Regionally and Locally Important Nature Conservation Sites	21
Scottish Wildlife Trust Sites	2
Site of Importance for Nature Conservation	162
Site of Importance for Nature Conservation, Features of Nature Interest to be Safeguarded	68
Site of Importance for Nature Conservation. Reference Number Included in Appendix D. Features of Nature Interest to be Safeguarded	20
Site of Importance for Nature Conservation. Reference Number Included in Appendix E. Features of Nature Interest to be Safeguarded	65
Site of Importance to Nature Conservation	78
Site of Interest for Nature Conservation	141
Site of Local Nature Conservation Importance	214
Sites of Importance for Nature Conservation	281
Sites of Importance for Nature Conservation (SINC)	13
Sites of Importance to Nature Conservation	28
Sites of Nature Conservation Value: Presumption Against Development	23
Urban Wildlife Site	54
Urban Wildlife Site to be Protected from Potentially Damaging Development	13
Wildlife Site	18
Wildlife Sites	17

12.3 Results

Table 12.3 Population within 300m (straight line) of green space greater than 2ha within Glasgow by income group

Income Deprivation (%)	Total Population	Not within 300m of Green space	Within 300m of Green space	Percentage not within 300m of Green space	Percentage Within 300m of Green space
0 to 25	274,419	74,311	200,108	27.1	72.9
25 to 50	237,829	41,843	195,986	17.6	82.4
50 plus	65,400	6,768	58,632	10.3	89.7
Glasgow	577,649	122,922	454,727	21.3	78.7

Note
1. Income deprivation provides the percentage of people in a data zone that are income deprived.

Table 12.4 Population within 300m (route access method) of green space greater than 2ha within Glasgow by income group

Income Deprivation (%)	Total Population	Not within 300m of Green space	Within 300m of Green space	Percentage not within 300m of Green space	Percentage within 300m of Green space
0 to 25	274,419	183,121	91,299	66.7	33.3
25 to 50	237,829	113,776	124,054	47.8	52.2
50 plus	65,400	25,278	40,122	38.7	61.3
Glasgow	577,649	322,174	255,475	55.8	44.2

Note
1. Income deprivation provides the percentage of people in a data zone that are income deprived.

Table 12.5 Proximity (straight line) to green space greater than 2ha for the top and bottom 10% of income data zones in Glasgow

Income deprived	Total Population	Not within 300m of Green space	Within 300m of Green space	Percentage not within 300m of Green space	Percentage within 300m of Green space
Top 10%	56,351	4,704	51,647	8	92
Bottom 10%	60,381	14,997	45,385	25	75
Glasgow	577,649	122,922	454,727	21	79

Notes
1. Top 10% are data zones with 51.4 to 71.1% of the population income deprived (check exact definition may be adult) 69 data zones
2. Bottom 10% are data zones with 1.5 to 6.7% of the population income deprived 69 data zones

Table 12.6 Proximity (route access) to green space greater than 2ha for the top and bottom 10% of income data zones in Glasgow

Income deprived	Total Population	Not within 300m of Green space	Within 300m of Green space	Percentage not within 300m of Green space	Percentage within 300m of Green space
Top 10%	56,351	21,248	35,103	37.7	62.3
Bottom 10%	60,381	39,353	21,028	65.2	34.8
Glasgow	577,649	322,174	255,475	55.8	44.2

Notes
1. Top 10% are data zones with 51.4 to 71.1% of the population income deprived (check exact definition may be adult) 69 data zones
2. Bottom 10% are data zones with 1.5 to 6.7% of the population income deprived 69 data zones

Table 12.7 Proximity (straight line) to green space greater than 2ha for top and bottom 10% of employment data zones in Glasgow

Employment deprived	Total Population	Not within 300m of Green space	Within 300m of Green space	Percentage not within 300m of Green space	Percentage within 300m of Green space
Top 10%	56,534	9,542	46,992	16.9	83.1
Bottom 10%	61,850	20,909	40,941	33.8	66.2
Glasgow	577,649	122,922	454,727	21.3	78.7

Note
1. Top 10% are data zones with 40.7 to 64.7 % of the population employment deprived
2. Bottom 10% are data zones with 2.4 to 7.6% of the population employment deprived

Table 12.8 Proximity (route access) to green space greater than 2ha for top and bottom 10% of employment data zones in Glasgow

Employment deprived	Total Population	Not within 300m of Green space	Within 300m of Green space	Percentage not within 300m of Green space	Percentage within 300m of Green space
Top 10%	56,534	27,106	29,428	47.9	52.1
Bottom 10%	61,850	45,376	16,475	73.4	26.6
Glasgow	577,649	322,174	255,475	55.8	44.2

Note
1. Top 10% are data zones with 40.7 to 64.7 % of the population employment deprived
2. Bottom 10% are data zones with 2.4 to 7.6% of the population employment deprived

Table 12.9 Population within 600m of local nature designated site(s) in Scotland

Decile	Total Population	Number within 600m of local nature designated site(s)	Percentage of people within the decile	As a percentage of all people within 600m of local nature designated site(s)
1	505,775	169,889	33.59	12.3
2	506,808	132,958	26.23	9.6
3	506,064	114,549	22.64	8.3
4	506,082	117,550	23.23	8.5
5	506,596	122,228	24.13	8.9
6	505,966	104,991	20.75	7.6
7	505,930	99,282	19.62	7.2
8	506,157	117,075	23.13	8.5
9	506,485	158,877	31.37	11.5
10	506,148	243,147	48.04	17.6
Scotland	5,062,011	1,380,547	27.27	100.0
			CI value	-0.06

Figure 12.1 Percentage of population within 600m of local nature designated site(s) by deprivation decile

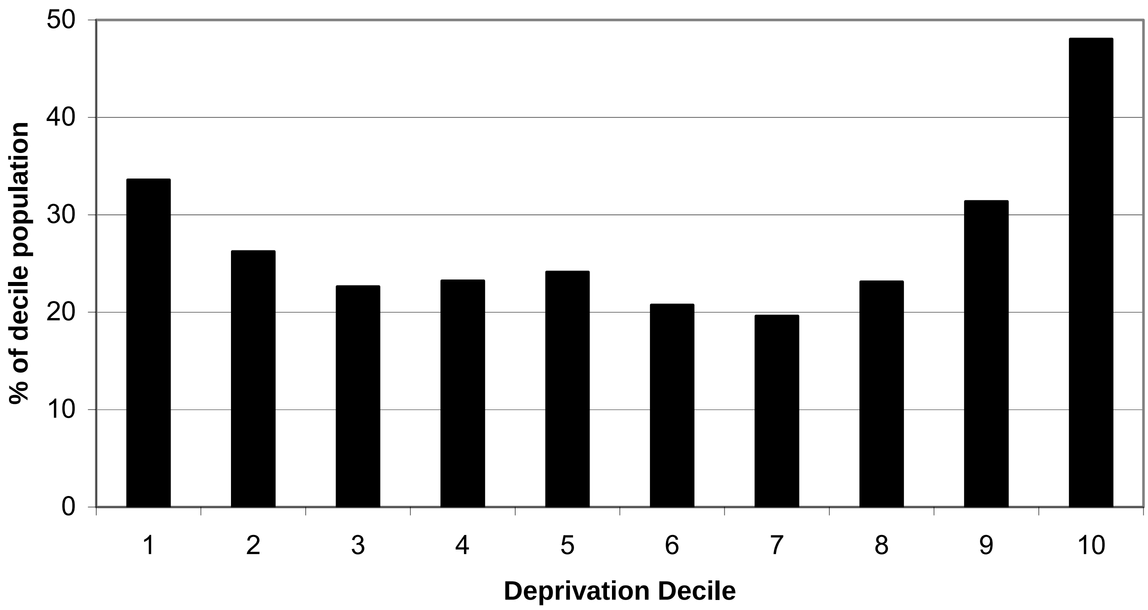
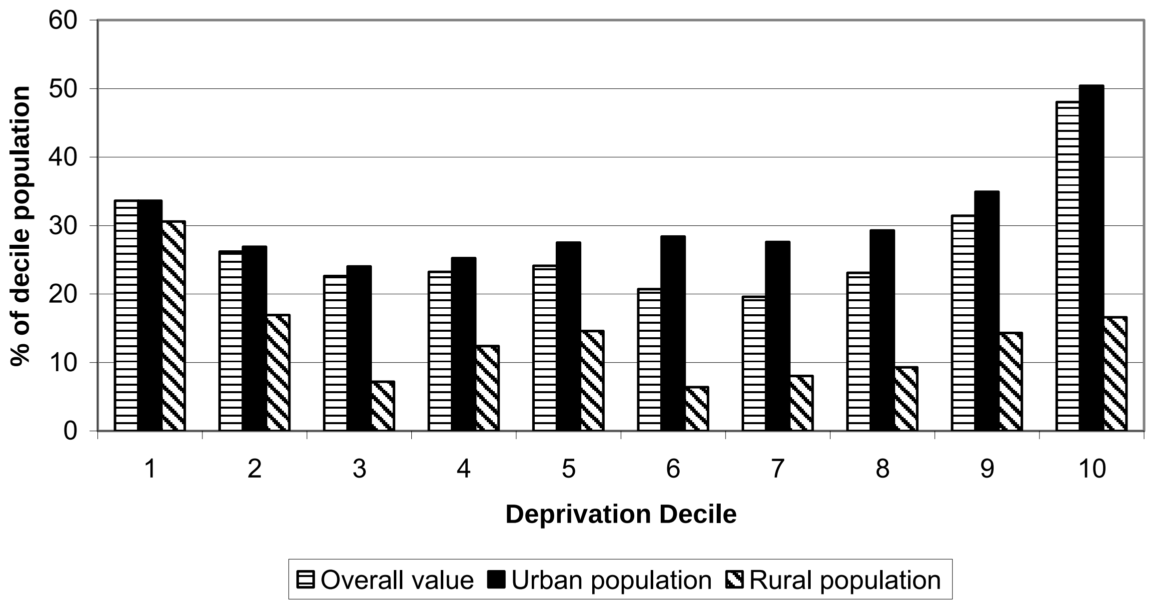


Table 12.10 Populations within 600m of local nature designated site(s) by rural/urban split and deprivation decile

Decile	Population near to local nature designated site(s)	Urban Population near to local nature designated site(s)	Rural Population near to local nature designated site(s)	Percentage of overall population near to local nature designated site(s)	Percentage of Urban Population near to local nature designated site(s)	Percentage of Rural Population near to local nature designated site(s)
1	169,889	167,627	2,262	33.6	33.6	30.6
2	132,958	127,631	5,326	26.2	26.9	16.9
3	114,549	111,595	2,954	22.6	24.0	7.2
4	117,550	107,977	9,573	23.2	25.2	12.4
5	122,228	103,011	19,218	24.1	27.5	14.6
6	104,991	93,790	11,200	20.7	28.4	6.4
7	99,282	82,948	16,334	19.6	27.6	8.0
8	117,075	102,491	14,584	23.1	29.3	9.3
9	158,877	146,363	12,515	31.4	34.9	14.3
10	243,147	237,349	5,799	48.0	50.4	16.6
Scotland	1,380,547	1,280,782	99,765	27.3	31.1	10.5

Figure 12.2 Percentage of population within 600m of local nature designated site(s) by rural urban decile



12.4 Discussion

12.4.1 Population within 300m of green space by income group for Glasgow

For both the straight line (Table 12.3) and route access (Table 12.4) method of calculating distance the most income deprived have greatest proximity to green space. There are however large differences in the values depending on which method has been used to calculate distance. For example in the least deprived income group (0-25% income deprived) the figure drops from 72.9% using a straight line to 33.3% using the route access method. The overall figure for Glasgow drops from 78.7% to 44.2%.

12.4.2 Population within 300m of green space by top and bottom 10% of income deprived data zones for Glasgow

It is worth noting that the bottom 10% of income deprived data zones in Glasgow are many of the most income deprived for all of Scotland. For straight line distance (Table 12.5) calculation 92% of the population are living within 300m compared to 75% for the least deprived income data zones. Using the route access method (Table 12.6) the most deprived areas have nearly twice as many people in proximity to green space than the least deprived (62% compared to 35%).

12.4.3 Population within 300m of green space by top and bottom 10% of employment deprived data zones for Glasgow

The most employment deprived data zones have greater proximity to green space than the least employment deprived areas. Using the straight line (Table 12.7) method 83% of those in the top employment deprived data zones are close to green space, and this drops to 66% using the route access method (Table 12.8). For the least employment deprived data zones the figures are 52% and 26%.

12.4.4 Overall comments on the Glasgow analysis

Firstly, there is a notably large difference produced between the straight line and route access method. Within Glasgow using the route access method 44% of the population is within 300m of green space. In fact the true figure is probably higher if account is taken the edge effect for population living on the outskirts of the city.

The higher values for the most deprived groups in Glasgow may well be a result of the decanting of the population through slum clearance to the outskirts of the city in the post war years (Cullingworth and Nadin 1994). Large council estates were often sited specifically to give access to green fields and cleaner air. It needs to be remembered that there is no indication in the data set of the quality of green space, its accessibility or its level of use. In recent decades (DLTR 2002) cuts in local authority funding have been especially large within recreation and outdoor departments. Authorities have often provided extensive, low quality, non specific green space with low maintenance costs as opposed to high quality green space with multiple uses. Other low grade green space may take the form of derelict land rather than managed spaces.

The analysis has not been able to take account of the issue of private gardens. Those in the more deprived areas tend to live at higher densities with terraces and flats which often have little or no private garden. Some of the least deprived also live in flats but there is also a larger amount of people living in detached and semi detached houses with larger gardens.

12.4.5 Population within 600m of a local nature designated sites

Decile 10 (Table 12.9) has the highest percentage (48%) of people living near to a designated wildlife site which is 15% more than decile 1, with the second highest value. Overall 27% of the Scottish population live within 600m (straight line distance) of a local nature designated site, with the exception of the two extreme deciles there is little variation between the deciles in terms of proximity to local nature designated sites, this is reflected in the low CI value of -0.06.

Within deciles (Table 12.10) it is the urban population that is much more likely to be living near to local nature designated areas than the rural population. In the case of deciles 3 to 10 the urban population is 2 to 3 times more likely to be living near to a local nature designated site than the rural population. The urban population in decile 10 has the highest proximity with half of the population living near to local nature sites, but this is an exceptional value as the next highest value occurs in decile 9 (again the urban population) at 34.9%.

It is useful to remember that the data originated from the local plan (see12.2.2.) and it may be that local authorities use designations as a tool to preserve green space in urban areas. The need for rural authorities to designate such sites is probably far less. Even so issues of access and quality would need to be considered in both rural and urban settings.

13 River Water Quality

13.1 Introduction

There are a number of dimensions to the relationship between river water quality and local 'quality of life'. There is no direct pathway by which poor river water quality has an impact on the health of those living nearby; however children playing in or near to the water or people swimming or engaged in water sports may be affected. Pets may also be made ill through contact with polluted river water, and vermin and pest problems in the local area may be worsened where water is still or stagnant. A poor quality river corridor can also detract from the aesthetic qualities of the local environment and fail to provide the quality of recreational resource that other rivers are able to. River water quality is therefore an issue for environmental justice both in terms of the distribution of negative impacts and the lack of access to a positive environmental resource. Given this complexity the general river water quality classification is unable to provide a meaningful and robust indicator of the range of potential impacts related either to the river water itself or the characteristics and condition of the river corridor. The results should therefore be taken only as a general and preliminary indicator, providing a basis for further analysis and to stimulate policy discussion

13.2 Data Sources and Methods

River water quality data was supplied by SEPA and provided a number of indicators of different aspects of the quality of river stretches.

Overall Quality Classification - there are 5 classes from A1 excellent to D seriously polluted

Biological Classification - this provides an indicator of the overall ecological health or biodiversity of the river stretch. There are 5 classes as before.

Aesthetic Classification - this has two assessed components which relate to the attractiveness of the river environment; list A contaminants such as faeces, toilet paper, and list B contaminants such as builders 'waste, furniture, road cones.' There are 5 classes as before.

Whilst ideally we might have used a number of these indicators in the analysis, the limited project resource available meant that a decision was taken to just use the overall quality classification and to focus within this on those river stretches classified as class C or D. Consideration was given to using the aesthetic classification to supplement this overall rating, but on scrutiny of the dataset this proved to be particularly inconsistent in its availability. The classes for the overall quality classifications are shown in Table 13.1 below.

Table 13.1: The river water quality classification scheme

Class	Description	Length (km)	% of total river length
A1	Excellent	6,815.2	26.8%
A2	Good	9,540.3	37.5%
B	Fair	2,373.8	9.3%
C	Poor	750.5	3.0%
D	Seriously Polluted	52.6	0.2%
U	Unclassified (assumed good quality	5,903.3	23.2%

Source: www.sepa.org.uk

The 'classification network' is built from the Digital River Network. This digitised network is based on 1:50,000 ordnance survey data. The DRN includes:

- all mainland and islands rivers with a catchment area of 10 km^2 or more. This is known as the "baseline network".
- mainland and islands stream stretches with a catchment of less than 10 km^2 have been excluded, except where they are the main source of a larger river, or they are substantially polluted (classified as fair, poor or seriously polluted) and have been monitored. These are added to the baseline network to give a "classification network".

The classification network is divided into river stretches whose start and end points are generally marked by confluences and/or points at which a significant pollutant input might be expected. Every stretch is assigned a monitoring point where chemical and/ecological surveys are taken and the aesthetic appearance recorded. The quality or “class” of a length of river is calculated from the monitoring point results. River lengths are assigned the quality of a downstream monitoring point. The final allocation of the quality class is based on the lowest class determined from the chemistry, ecology, aesthetic and toxicity assessments for the associated monitoring point. No attempt is made to assign zones of intermediate quality between stretches differing by more than one class.

Unclassified river stretches are mostly located in rural upland catchments. It is SEPA's intention that the extent of unclassified rivers will be progressively reduced to near zero by the time EU Water Framework Directive systems are in place in 2006.

By focusing only on the rivers classed as category C or D the analysis is examining only a very small proportion of the total river length in Scotland – only 3.2% falls within C or D.

It is important to acknowledge that this data provides a far from perfect measure of the amenity value of a river stretch. Such a measure would ideally take account of the overall environment of the river corridor and the accessibility of the river to the public.

Two analyses have been undertaken:

a. Population proximity analysis

A buffer analysis of river stretches classified as C or D was undertaken using distances of 600m and 1km from the centre line of the river. Applying these two distances provides some measure of the sensitivity of the analysis to buffer size, with 600m being the distance used in the green space and woodland analysis to reflect accessibility on foot. Results are reported which first estimate the numbers of people living in different deprivation deciles within 600m and 1km of all

C or D rivers, and second take out those people who live within these areas but who also live within 600m or 1km of rivers categorised as A or B. These people arguably are not disadvantaged in the same way as a better quality river is within reach. However such assumptions take no account of accessibility to the river and the results therefore need to be interpreted with some caution. A further limitation of the analysis is that no account is taken of river width. For a large river clearly a proportion of the buffer area will cover the river itself.

b. Urban-rural analysis

An analysis of the urban and rural distribution of the populations living within 600m and 1km of category C or D river stretches was undertaken.

13.3 Results

Table 13.3: Population within 600m and 1km of a river with overall water quality classified as 'C' or 'D' by deprivation decile

Decile	Total Population	**Population within 600m**	**%**	**Population within 1km**	**%**
1	505,775	129,752	25.7	195,259	38.6
2	506,808	88,247	17.4	147,688	29.1
3	506,064	83,760	16.6	144,211	28.5
4	506,082	79,393	15.7	130,345	25.8
5	506,596	70,623	13.9	110,360	21.8
6	505,966	67,010	13.2	104,306	20.6
7	505,930	61,453	12.1	91,357	18.1
8	506,157	57,022	11.3	87,664	17.3
9	506,485	61,778	12.2	97,848	19.3
10	506,148	67,799	13.4	112,504	22.2
Scotland	5,062,011	766,839	15.1	1,221,541	24.1
CI Values			**0.12**		**0.12**

Figure 13.1: Population within 600m of a river with overall water quality classified as 'C' or 'D' by deprivation decile

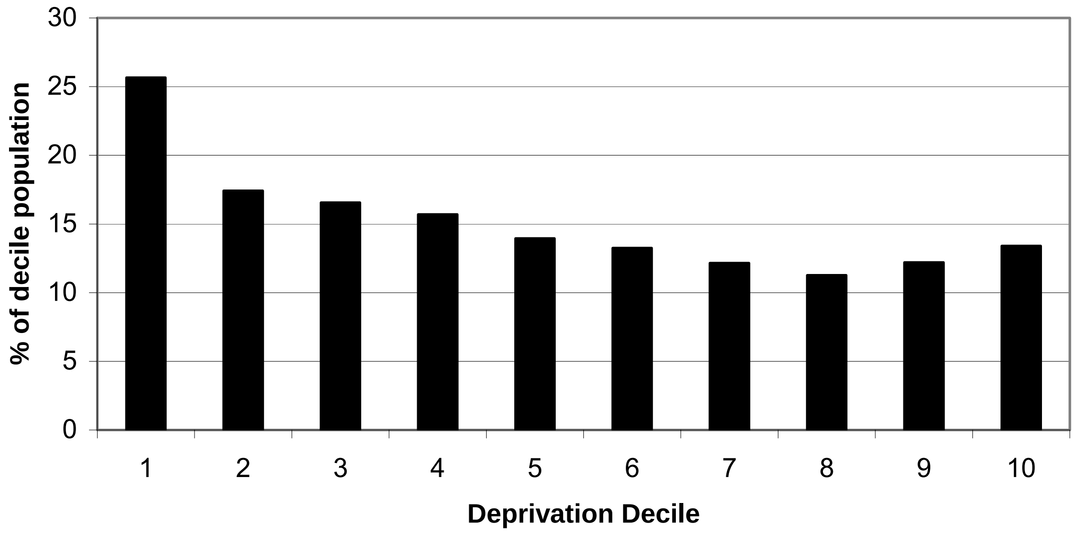


Figure 13.2: Population within 1km of a river with overall water quality classified as 'C' or 'D'

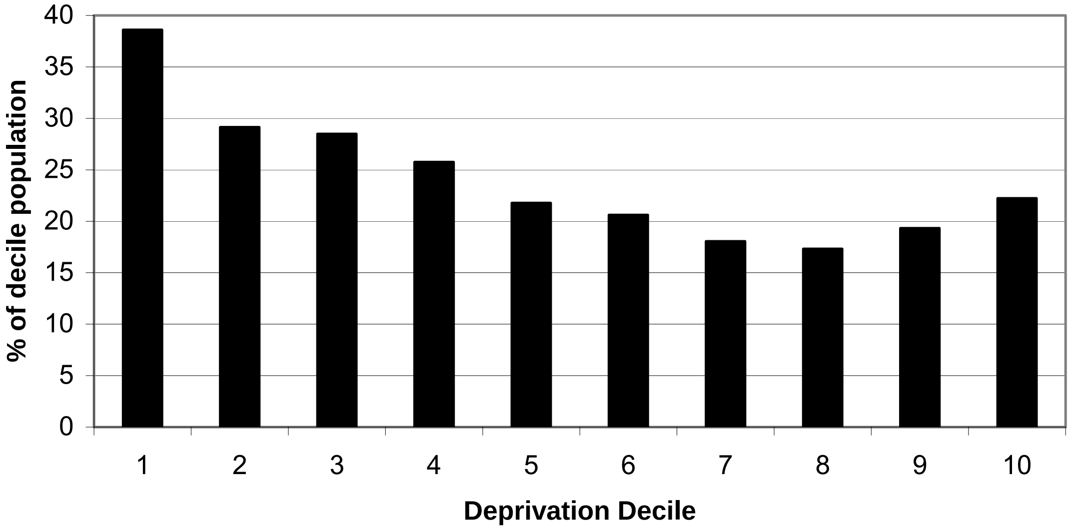


Table 13.4: Population within 600m of a river with overall water quality classified as 'C', 'D' or 'C and D'

Decile	**Population within 600m**	**C**	**%**	**D**	**%**	**C and D**	**%**
1	129,752	100,102	19.79	50,060	9.90	20,410	4.04
2	88,247	78,562	15.50	14,393	2.84	4,708	0.93
3	83,760	72,733	14.37	13,211	2.61	2,184	0.43
4	79,393	72,562	14.34	12,126	2.40	5,295	1.05
5	70,623	67,478	13.32	7,424	1.47	4,278	0.84
6	67,010	58,515	11.57	13,794	2.73	5,299	1.05
7	61,453	56,705	11.21	6,166	1.22	1,418	0.28
8	57,022	53,164	10.50	6,135	1.21	2,276	0.45
9	61,778	57,147	11.28	10,671	2.11	6,040	1.19
10	67,799	55,600	10.98	17,689	3.49	5,489	1.08
Scotland	766,839	672,568	13.29	151,669	3.00	57,398	1.13
CI Values			**0.10**		**0.24**		**0.24**

Table 13.5: Population within 600m of a river with overall water quality classified as 'C' or 'D' – excluding those who are also within 600m of a river classified as 'A', 'B' or 'Unclassified'

Decile	**Population within 600m**	**Population 'also' within 600m of a river(s) classified as A or B or Unclassified**	**%**	**Population 'only' within 600m of a river(s) classified as C or D**	**%**
1	129,752	34,183	6.76	95,569	18.90
2	88,247	33,899	6.69	54,348	10.72
3	83,760	30,711	6.07	53,049	10.48
4	79,393	30,750	6.08	48,643	9.61
5	70,623	20,490	4.04	50,133	9.90
6	67,010	21,265	4.20	45,745	9.04
7	61,453	24,349	4.81	37,105	7.33
8	57,022	21,176	4.18	35,847	7.08
9	61,778	29,560	5.84	32,218	6.36
10	67,799	19,888	3.93	47,911	9.47
Scotland	766,839	266,271	5.26	500,568	9.89
CI Values			**0.08**		**0.14**

Table 13.6: Population within 1km of a river with overall water quality classified as 'C' or 'D' – excluding those who are also within 1km of a river classified as 'A', 'B' or 'Unclassified'

Decile	**Population within 1km**	**Population 'also' within 1km of a river(s) classified as A or B or Unclassified**	**%**	**Population 'only' within 1km of a river(s) classified as C or D**	**%**
1	195,259	85,163	16.84	110,096	21.77
2	147,688	84,806	16.73	62,882	12.41
3	144,211	87,608	17.31	56,603	11.19
4	130,345	75,047	14.83	55,297	10.93
5	110,360	61,782	12.20	48,579	9.59
6	104,306	57,189	11.30	47,116	9.31
7	91,357	55,687	11.01	35,670	7.05
8	87,664	55,588	10.98	32,075	6.34
9	97,848	66,576	13.14	31,272	6.17
10	112,504	77,226	15.26	35,278	6.97
Scotland	1,221,541	706,673	13.96	514,869	10.17
CI Values			**0.06**		**0.21**

Figure 13.3: Population within 600m of a river with overall water quality classified as 'C' or 'D' – excluding those who are also within 600m of a river classified as 'A', 'B' or 'Unclassified'

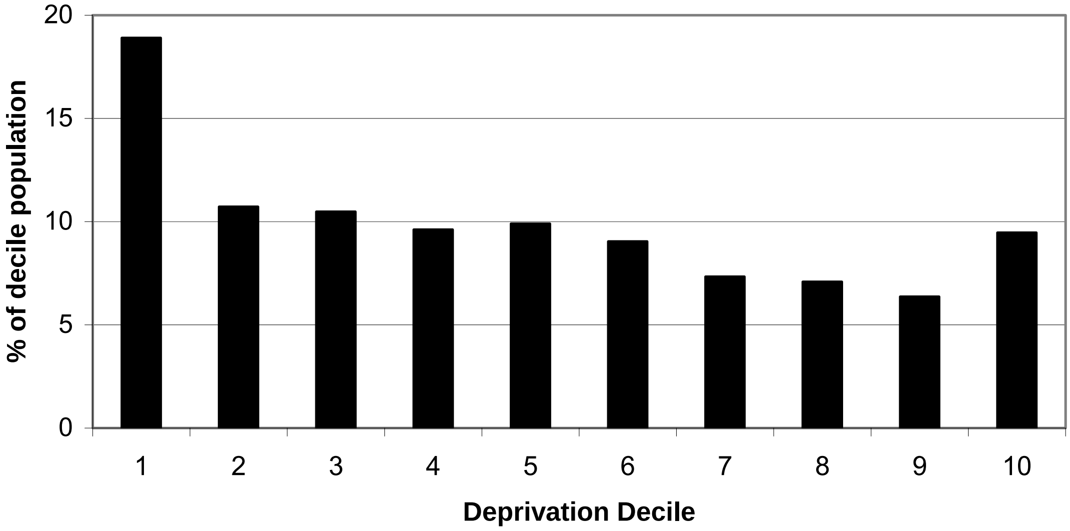


Figure 13.4: Population within 1km of a river with overall water quality classified as 'C' or 'D' – excluding those who are also within 1km of a river classified as 'A', 'B' or 'Unclassified'

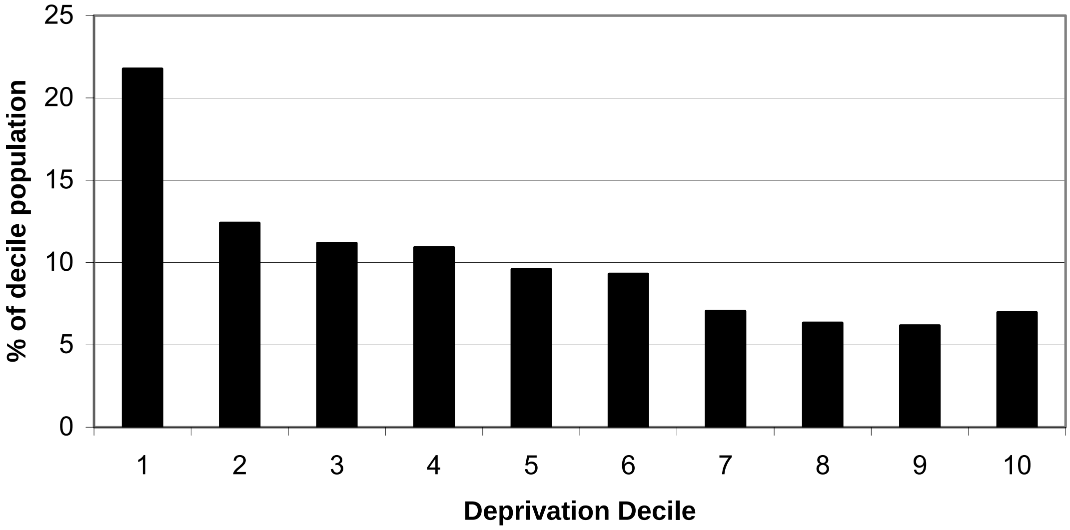
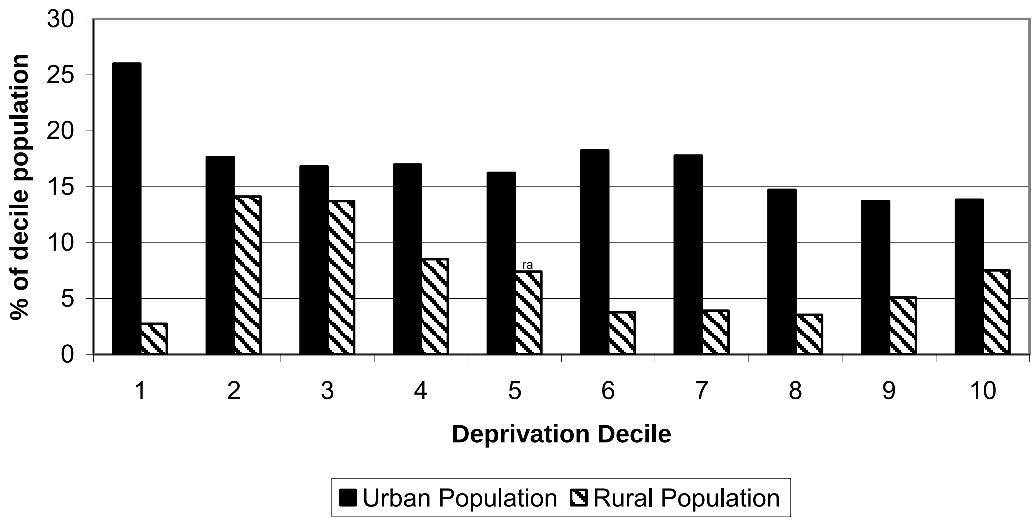


Table 13.7: Population within 600m of a river with overall water quality classified as C or D by urban and rural deprivation decile

Decile	Urban Population	Rural Population	Urban Population within 600m	Rural Population within 600m	% of Urban Population within 600m	% of Rural Population within 600m
1	498,301	7,393	129,549	204	26.00	2.75
2	475,296	31,523	83,795	4,452	17.63	14.12
3	464,795	41,284	78,102	5,658	16.80	13.71
4	428,663	77,425	72,801	6,592	16.98	8.51
5	375,266	131,337	60,899	9,724	16.23	7.40
6	330,739	175,249	60,378	6,632	18.26	3.78
7	300,667	205,225	53,398	8,055	17.76	3.92
8	349,527	156,651	51,464	5,558	14.72	3.55
9	418,923	87,536	57,330	4,448	13.69	5.08
10	471,308	34,854	65,185	2,615	13.83	7.50
Scotland	4,113,484	948,477	**712,901**	**53,938**	**17.33**	**5.69**

Figure 13.5: Percentage of population within 600m of a river with overall water quality classified as C or D by urban and rural deprivation decile



13.4 Discussion

13.4.1 Deprivation and proximity to poor quality rivers

There is a clear relationship between deprivation and proximity to class C or D rivers for both the 600m and 1km buffer distances (Table 13.3 and Figures 13.1 and 13.2). In both cases the highest proportion of population is found in the most deprived decile, with a decline through to deciles 9 and 10 where a small upturn is seen (more strongly for 1km than for 600m). 26% of the population in the most deprived decile live within 600m of a poor quality river compared to only 12% in decile 8. The relatively small difference in patterns found for the two buffer distances (and the identical CI values of 0.12) suggests that the analysis is relatively insensitive to buffer size. Taking out those populations that live within the buffer distances of both poor (C and D) and good (A and B or unclassified) quality rivers accentuates the bias towards the most deprived decile (Table 13.6 and Figures 13.3 and 13.4). There is a sharper drop between deciles 1 and 2 and less of an upturn in deciles 9 and 10 and the CI values are higher (0.21 compared to 0.12 for 1km).

13.4.2 Urban and Rural Deprivation and proximity to poor quality rivers

The population living within 600m of poor quality rivers is predominantly urban (Table 13.7). This is particularly the case for the most deprived deciles where the population is nearly entirely urban in any case. In proportional terms the poor quality rivers are biased towards both the urban and rural deprived (Table 13.7 and Figure 13.5). In rural areas the proportions of the deprived population in deciles 2 and 3 are nearly double those of any other decile. In urban areas decile 1 stands out more clearly with a relatively flat distribution across the other deciles.

The patterns found here are perhaps not surprising, as it would be expected that poorer quality rivers are found in industrial and urban areas where most of the sources of pollution and impact on river quality are to be found and most of the deprived population is concentrated. For these deprived populations there are potential negative impacts from living near to poor river water quality (although as discussed earlier some of these impacts relate to the use made of the river, rather than simple proximity) and the amenity resource that a nearby river could provide is potentially constrained by its poor quality classification. However, the lack of information on patterns of use and access and the limited ability of the general water quality classification to provide an indicator of amenity value need to be taken into account in interpreting these results.

14 Air Quality

14.1 Introduction

Significant improvements in air quality have taken place in recent decades, largely through technological innovation in emission control. However, throughout Western Europe, road transport has overtaken industrial processes and coal combustion as the main source of emissions, and rising mobility threatens to erode some of the past environmental improvements. To better address air quality in Europe, relevant legislation has been consolidated by the Air Quality Framework Directive (96/62/EC) and associated pollutant specific “daughter directives”. This legislation sets the framework for air quality management in member states, and is addressed in the the Air Quality Strategy for England, Scotland, Wales and Northern Ireland, for reasons of brevity it is referred to in this report as AQS. This has the primary objective to "make sure that everyone can enjoy a level of ambient air quality in public places which poses no significant risk to health or quality of life" (DETR, 2000:p12).

In 1998 the governments Committee of Medical Experts on Air Pollution (COMEAP) estimated that poor air quality in Great Britain was responsible for 'bringing forward' around 24,000 deaths each year (DoH, 1998). A further 24,000 admissions to hospital for respiratory illness related to poor air quality were also estimated, although the extent to which to these were brought forward or truly additional is unknown. In both cases, estimates related to particulates, sulphur dioxide and ozone only, pollutants for which reasonably certain estimates could be made, given current epidemiological knowledge. Estimates for other pollutants known to have implications for health were not included in the national estimate for total health impact due to inadequate data (CO) or uncertainty over the dose-response function relating ambient concentration to health impact (NO_2). However, using the best available epidemiological evidence, COMEAP suggested that nationally, NO_2 was responsible for an additional 8700 hospital admission for respiratory illness each year. A recent WHO report (2004), stated that the effects of chronic (long term) exposure for nitrogen dioxide included reduction in lung function and increased probability of respiratory symptoms.

Air quality standards are set with reference to scientific and medical evidence, and are designed so as to pose a minimum or zero risk to health. This is the approach adopted by the World Health Organisation in setting guidelines for air quality, and also EPAQS the government's expert panel on air quality standards. Note, however, that uncertainty exists in setting of standards, and that health impacts may still occur below the standard in some people. For example, WHO (2004:p8) notes that "Thresholds are in principle an appealing concept that has also been used in defining air quality policies such as justifying the numerical value of air quality limit values. Nevertheless, recent epidemiological studies in investigating large populations have been unable consistently to establish such thresholds, in particular for particulates and ozone. Rather they show effects at the level studied." This absence of a dividing line between levels of pollution that do and do not pose a threat to health is exemplified by the COMEAP disease burden study, in which the best available epidemiological evidence indicates that air quality dose-health response relationships are linear and through the origin.

Furthermore, note that air quality standards differ from the air quality objectives defined in the AQS. These objectives are aspirational targets (an ambient concentration limit over a defined averaging time for a specified year) that are set with reference to standards, and which also consider issues such as economic efficiency, practicability, technical feasibility and timescale for achievement. That is, whilst the AQS seeks to deliver air quality that is as close to the EPAQS benchmark standards as possible, objectives also consider implementation costs and feasibility.

Thus whilst air quality in the UK has improved markedly in recent decades, a significant disease burden attributable to air quality remains. Furthermore, even where air quality objectives are met, this does not imply the absence of a health impact: objectives are not equivalent to standards, and health impacts are assumed to occur at ambient concentrations below the limit values set by standards.

Recently, a number of studies have sought to identify the relationship between environmental quality (as air quality) and social deprivation (see section 3.8). These studies were initially conducted at the city scale, but proved of limited use in drawing conclusions about the national picture. Latterly, small area national studies have been completed (Environment Agency 2002; Mitchell and Dorling 2003; Walker *et al*. 2003) which demonstrate that deprived communities bear a disproportionate share of the poorest air quality nationally. Note however, that only Mitchell and Dorling included Scotland in any of these national analyses, and that their results were reported for Britain as a whole, rather than for its constituent countries.

14.2 Data source

The study looked at five atmospheric pollutants: nitrogen dioxide (NO_2), fine particulates (PM_{10}), sulphur dioxide (SO_2), carbon monoxide (CO) and benzene. These pollutants were chosen as they form part of the Air Quality Strategy (AQS) (DETR 2000) developed in response to the 1995 Environment Act and the EU Air Quality Framework Directive (96/62/EC). The objectives for Scotland which are relevant to this study are shown in Table 14.1. Other AQS objectives (e.g. for lead and 1,3-butadiene) are not addressed here as adequate national small area concentration data is not available.

Table 14.1 National Air Quality Objectives

Pollutant	Level	Measured as	To be achieved by
Benzene	16.25 $\mu g/m^3$ (5 ppb) 3.25 $\mu g/m^3$ (1.54 ppb)	Running annual mean	31 Dec 2003 31 Dec 2010
Carbon monoxide	11.6 mg/m^3 (10 ppm) 10.0 mg/m^3 (8.6 ppm)	Running 8 hour mean	31 Dec 2003 31 Dec 2010
Nitrogen dioxide	40 $\mu g/m^3$ (21 ppb)	Annual mean	31 Dec 2005
Particulates (PM_{10})	40 $\mu g/m^3$ 18 $\mu g/m^3$	Annual mean	31 Dec 2004 31 Dec 2010
Sulphur dioxide	350 $\mu g/m^3$ (132 ppb) not to be exceeded ≥ 24 times a year	1 hour mean	31 Dec 2004
	125 $\mu g/m^3$ (47 ppb) not to be exceeded ≥ 3 times a year	24 hour mean	31 Dec 2004
	266 $\mu g/m^3$ (100 ppb) not to be exceeded ≥ 35 times a year	15 minute mean	31 Dec 2005

The air quality data is the annual mean concentration of the pollutant for each $1km^2$ grid cell centroid in Scotland for 2001 (the latest available data) provided by the National Environment Technology Centre (NETCEN). Two of the pollutants do not have air quality objectives as an annual mean, SO_2 and CO. For SO_2 we use the WHO guideline for annual mean of 50 $\mu g/m^3$. There is no annual objective for CO but analysis has been reported to illustrate the variations between the deciles.

The pollutant concentration maps are based upon emissions recorded in the National Atmospheric Emission Inventory (Goodwin *et al.* 2000). The inventory provides an estimate of total pollutant emission in a base year for a 1 x 1 km grid, based upon estimated emission in over 140 secondary sectors and nine principal sectors: residential, services, industry, road transport, off road vehicles, shipping, rail, aviation, and other.

NETCEN calculate atmospheric concentrations from emissions by application of a dispersion box model. For secondary pollutants additional modelling is required. For example, in the case of oxides of nitrogen (NO_x), which are oxidised in the atmosphere to form NO_2 (the only nitrogen oxide for which an NAQS objective applies) the model applies a dispersion coefficient derived from regression of NO_x emissions in the vicinity of monitoring sites, against the difference between measured NO_x at the monitoring site, and background NO_x taken from a nearby rural site. Annual mean NO_2 concentrations are then calculated using non-linear functions relating atmospheric annual mean NO_x to annual mean NO_2 for geographical areas with characteristically different atmospheric chemistry (rural and urban areas). Note that road traffic is estimated to account for 50% of total UK NO_x emission, rising to 75% in urban areas (Goodwin *et al.* 2000).

The data upon which the box model functions are based were collected from 1990 to 1999 using the national automated monitoring network. Verification of the modelled concentrations using an independent set of measured data collected from 1996 to 1999 shows generally good agreement between observed and estimated concentrations (Stedman and Handley, 2001). Further details of the air quality modelling procedures are described in Stedman *et al.* (1997) and Stedman *et al.* (2001a; 2001b).

14.3 Method

Descriptive statistics were calculated for each data zone using a point in polygon analysis (i.e. an analysis of all points falling within a data zone). Data zones with no air quality data within their boundary were allocated air quality data from the air quality point nearest the data zone centroid (in all cases this is less than 500 metres away). Note that this modelled data addresses the annual mean only, and that there is no data for other averaging times (e.g. 8 or 24 hour mean). Data zones were used as the spatial unit for the analysis as air quality is continuous over the data zone - allocating air quality values to every AddressPoint in Scotland would have been very process intensive.

In correlating annual mean air quality with demographic data an assumption is made that an individual's exposure occurs entirely within the relevant data zone. Clearly this is a gross assumption and population movement (e.g. commuting), introduces a potentially significant bias in pollution exposure, a problem recognised in the air quality equity literature. The extent of this bias may differ between population groups depending upon their mobility. However, it is thought the effects of within-day population movement will be less significant when conducting a national scale analysis, as opposed to a more local study. Local studies tend to be of large cities within which population movement during the day due to commuting, travel to school and so on are greatest. Given the highly urbanised nature of Scotland, such daily movement patterns may have a significant effect on actual exposure; however analysis of the significance of this effect is beyond the scope of the current study. The current residential based equity analysis is also a clear prerequisite of any future study considering population movement.

In the following analysis data has been examined in four ways:

1. Data zone annual mean pollutant concentration by decile. This involves the calculation of a population weighted average using the mean annual value of each data zone within the decile.

2. Data zone mean exceedences by decile - This involves analysis of any data zone where the mean value exceeded the AQS objective value.

3. Distribution of data zones with the poorest air quality (irrespective of exceedence of objectives) using percentile statistics. This involves using the upper 10% of concentration values for a particular pollutant and examining the characteristics of the population within those areas. The rationale for this is that:

    - Meeting an AQS objective does not imply that there is no residual risk to health. Objectives are less demanding than health based standards, as they also consider the practicalities of achieving a standard, whilst a health risk remains even when standards are met (see 14.1 above);

    - Data zones may have average concentrations that meet the AQS objective, but individual points (smaller locations) that do not. People resident in these zones are more likely to be exposed to unsatisfactory air quality;

    - The equity implications of future revisions to standards and objectives may be better understood (as is the case for PM_{10}, reducing from 40 $\mu g/m^3$ now to 18 $\mu g/m^3$ in 2010.)

4. Distribution of data zones with the best air quality for PM_{10} and NO_2. This involves using the lowest 10% of concentration values for a particular pollutant and examining the characteristics of the population within those areas.

14.4 Results

Table 14.2 Distribution of mean air quality in Scotland

Decile	Nitrogen dioxide	PM_{10}	Sulphur dioxide	Carbon monoxide	Benzene
1	27.6	13.39	2.52	0.32	0.60
2	21.44	12.65	2.84	0.26	0.44
3	20.49	12.57	2.85	0.25	0.43
4	18.56	12.27	2.68	0.24	0.39
5	16.04	11.8	2.45	0.21	0.32
6	14.73	11.56	2.25	0.21	0.29
7	14.32	11.53	2.22	0.20	0.28
8	16.02	11.78	2.34	0.21	0.32
9	17.64	12.1	2.34	0.23	0.36
10	20.55	12.66	2.41	0.26	0.46

Note
1. All units are $\mu g/m^3$ except CO (mg/m3)

Figure 14.1 Annual mean values for deciles in Scotland

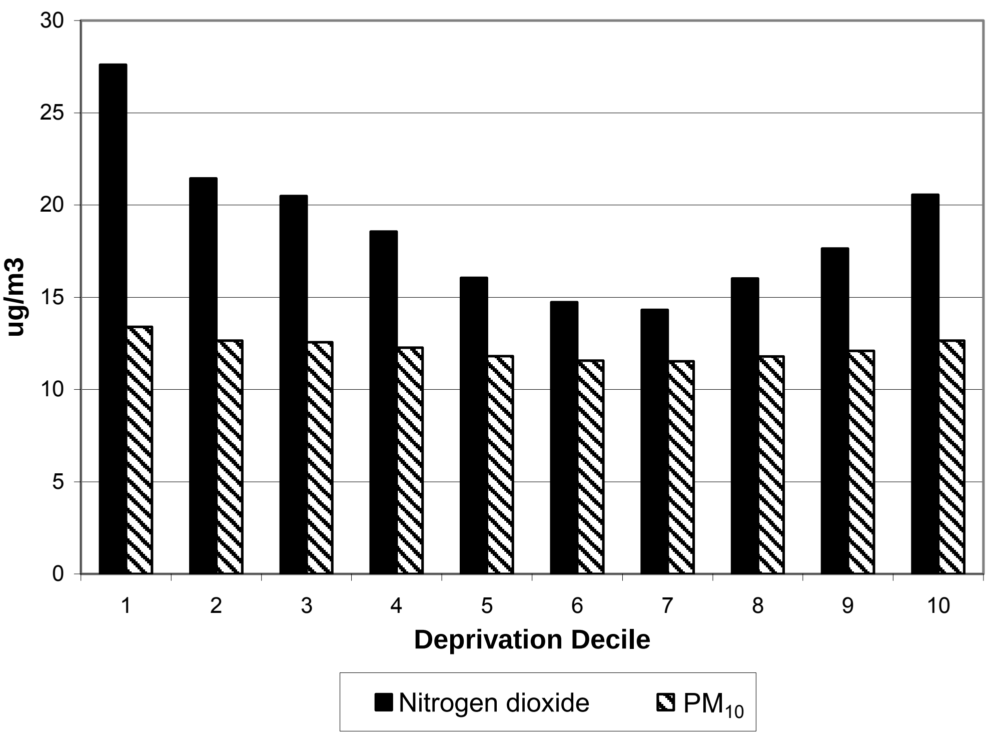


Table 14.3 Distribution of mean air quality in Scotland, standardised to mean deprivation

Decile	Nitrogen dioxide	PM_{10}	Sulphur dioxide	Carbon monoxide	Benzene
Most deprived (decile 1)	182	115	109	155	199
Median deprivation (deciles 5 & 6)	100	100	100	100	100
Least deprived (decile 10)	136	109	104	126	151

Notes
1. Median deprivation set to 100, (add deciles 5+6 divide by 2 and set the value to 100).
2. Divide the value of decile into the median value and multiply by 100.

Table 14.4 Distribution of data zone mean Nitrogen Dioxide exceedences (2001)
(CI value 0.6)

Decile	No. of Data zones	Population In Data Zones	Total population in Decile	Percentage within decile that experience mean annual nitrogen dioxide quality above the exceedence limits
1	34	29,751	505,775	5.9
2	13	11,295	506,808	2.2
3	11	8,269	506,064	1.6
4	10	8,947	506,082	1.8
5	6	4,779	506,596	0.9
6	7	6,187	505,966	1.2

Note
1. Deciles 7 - 10 have no data zones with average concentrations above exceedence values.
2. Annual mean standard is 40 $\mu g/m^3$ applied as a data zone average.
3. 69,228 people are in an exceedence data zone
4. 43% of all people living in an exceedence zone come from the most deprived decile 1.

Table 14.5 Distribution of data zones with highest mean Nitrogen dioxide values (2001).
(CI value 0.39)

Decile	Data zones	Population in Data Zones	Decile population	Percentage within the decile that are resident in data zones with the highest nitrogen dioxide concentration
1	235	193,674	505,775	38.3
2	89	70,622	506,808	13.9
3	73	58,235	506,064	11.5
4	51	43,259	506,082	8.5
5	40	32,062	506,596	6.3
6	43	35,260	505,966	7.0
7	33	26,255	505,930	5.2
8	38	32,421	506,157	6.4
9	32	26,343	506,485	5.2
10	18	15,974	506,148	3.2

Notes
1. Highest pollutant concentration defined as the top 10% of highest concentration values for Nitrogen dioxide. Value used greater than or equal to 30.78 $\mu g/m^3$
2. For example, this shows that 38.3% of people in decile 1 live in data zones where nitrogen dioxide is highest.

Table 14.6 Distribution of data zones with highest mean PM_{10} values (2001)
(CI value 0.22)

Decile	No. of Data zones	Population In Data Zones	Decile population	Percentage within the decile that are resident in data zones with the highest PM_{10} concentration
1	167	136,553	505,775	27.0
2	84	67,458	506,808	13.3
3	70	55,644	506,064	11.0
4	59	47,214	506,082	9.3
5	41	32,974	506,596	6.5
6	40	31,865	505,966	6.3
7	44	35,474	505,930	7.0
8	45	36,244	506,157	7.2
9	53	41,798	506,485	8.3
10	52	43,659	506,148	8.6

Notes
1. Highest pollutant concentration defined as the top 10% of highest concentration values for PM_{10}. Value used greater than or equal to 14.39 $\mu g/m^3$
2. For example, this shows that 27% of people in decile 1 live in data zones where PM_{10} is highest.

Figure 14. 2 Percentage of population in each deprivation decile living in data zones with the highest values for NO_2 and PM_{10}

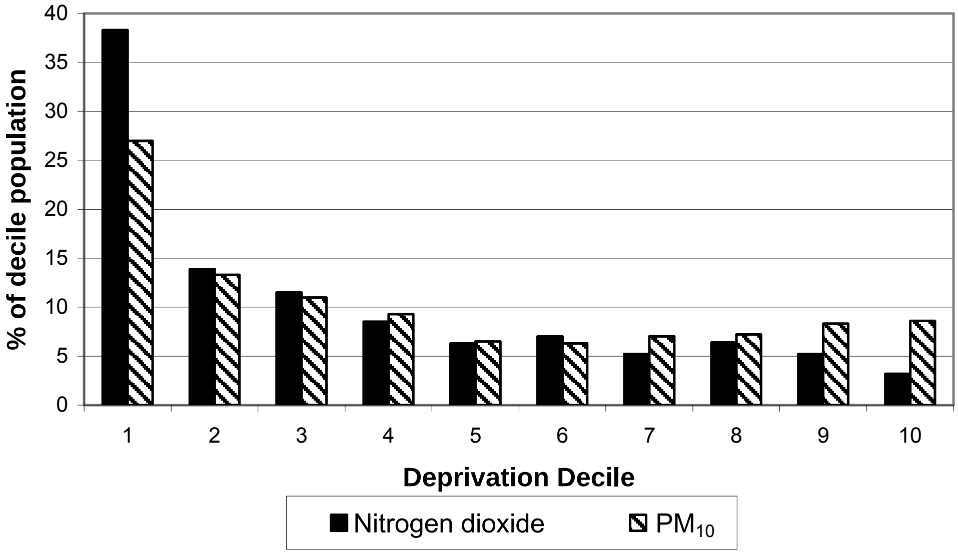


Table 14.7 Distribution of data zones with the highest mean carbon monoxide values (2001)
(CI value 0.27)

Decile	No of Data Zones	Population in Data Zones	Decile population	Percentage within the decile that are resident in data zones with the highest carbon monoxide concentration
1	211	174,719	505,775	34.5
2	74	59,121	506,808	11.7
3	59	46,861	506,064	9.3
4	50	41,655	506,082	8.2
5	36	29,136	506,596	5.8
6	40	32,549	505,966	6.4
7	35	28,528	505,930	5.6
8	42	34,665	506,157	6.8
9	51	40,534	506,485	8.0
10	50	42,853	506,148	8.5

Notes
1. Highest pollutant concentration defined as the top 10% of highest concentration values for carbon monoxide. Value used equal to or greater than 0.3648 mg/m^3
2. For example, this shows that 34.5% of people in decile 1 live in data zones where carbon monoxide is highest.
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Table 14.8 Distribution of data zone with the highest mean benzene values (2001)
(CI value 0.23)

Decile	No of Data Zones	Population in Data Zones	Decile population	Percentage within the decile that are resident in data zones with the highest benzene concentration
1	198	163,622	505,775	32.4
2	69	55,166	506,808	10.9
3	62	50,070	506,064	9.9
4	53	43,500	506,082	8.6
5	43	34,317	506,596	6.8
6	37	30,041	505,966	5.9
7	34	27,747	505,930	5.5
8	40	32,190	506,157	6.4
9	53	42,453	506,485	8.4
10	62	52,444	506,148	10.4

Notes
1. Highest pollutant concentration defined as the top 10% of highest concentration for benzene. Value used greater than or equal to 0.729 $\mu g/m^3$
2. For example, this shows that 32.4% of people in decile 1 live in data zones where benzene is highest.

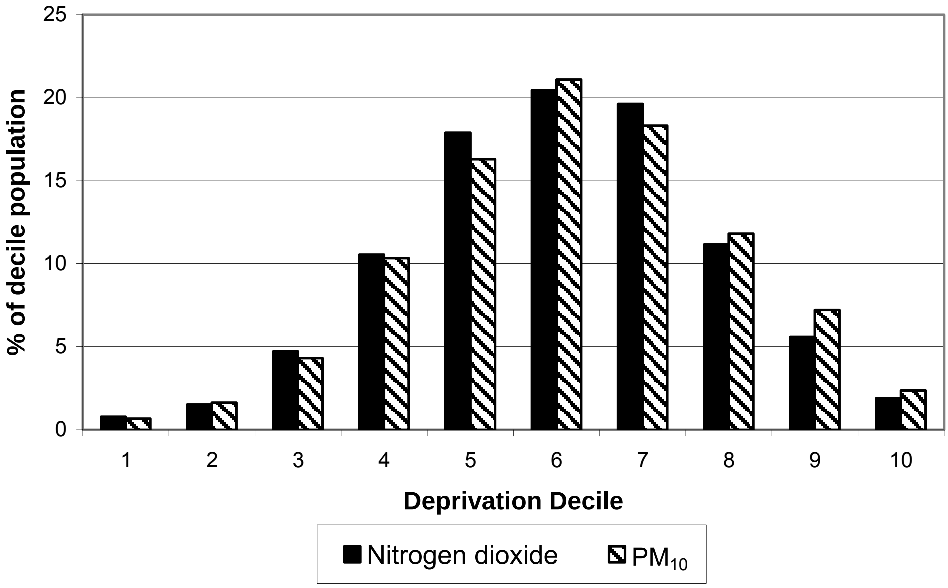
Table 14.9 Distribution of data zones with the highest mean sulphur dioxide values (2001)
(CI value 0.12)

Decile	No of Data Zones	Population in Data Zones	Decile population	Percentage within the decile that are resident in data zones with the highest sulphur dioxide concentration
1	37	29,113	505,775	5.8
2	99	73,899	506,808	14.6
3	104	77,408	506,064	15.3
4	90	69,653	506,082	13.8
5	77	61,228	506,596	12.1
6	56	43,541	505,966	8.6
7	52	39,470	505,930	7.8
8	58	44,139	506,157	8.7
9	42	32,372	506,485	6.4
10	35	27,602	506,148	5.5

Notes
1. Highest pollutant concentration defined as the top 10% of highest concentration for sulphur dioxide. Value used greater than or equal to 3.7979 $\mu g/m^3$
2. For example, this shows that 5.8% of people in decile 1 live in data zones where sulphur dioxide is highest.

Figure 14.3 Distribution of population with the lowest data zone mean values for PM_{10} and NO_2 (2001).

(CI value for PM10 - 0.31, CI value for NO2 – 0.11)



Notes

1. Lowest pollutant concentration defined as the bottom 10% of values for PM_{10} and NO_2. PM_{10} value used less than or equal to 9.98 $\mu g/m^3$, NO_2 value used less than or equal to 5.6 $\mu g/m^3$.

14.5 Discussion

14.5.1 Distribution of data zone mean air quality

The distribution of mean air quality (Table 14.2, Table 14.3) in Scotland shows that the most deprived decile has poorest air quality of all the deciles for four out of the five pollutants (the exception being sulphur dioxide). On average, people in the most deprived decile experience concentrations of nitrogen dioxide 1.8 times greater than concentrations experienced by people of average deprivation (Figure 14.1). Similarly, people in the most deprived decile experience benzene concentrations double that experienced by people of average deprivation, although these levels are significantly below the AQS objectives. Furthermore people in the most deprived decile experience above average concentrations for *all* pollutants including sulphur dioxide (Figure 14.1). The sulphur dioxide results are probably a reflection of the pollutant source as power generation is a major contributor and such facilities are often situated away from urban centres.

On average, the least deprived (decile 10) also experience above average concentrations although to a much lesser extent than decile 1. Nitrogen dioxide and benzene are again the two most significant pollutants at 26% and 51% above the concentrations experienced by people of average means. The relationship between pollutant concentration and deprivation is therefore curvilinear, with residents of both the most and least deprived data zones bearing a greater burden of pollution than data zones characterised by people of average deprivation. However, for all pollutants, it is the most deprived who carry the greatest burden of atmospheric pollution. This is consistent with similar analyses undertaken for England and Wales (see section 3.8).

14.5.2 Distribution of air quality objective exceedences

For those pollutants for which AQS annual mean concentration objectives exist (NO_2, PM_{10}, benzene), 2001 data zone mean concentrations only exceed the objective for NO_2 (Table 14.4). In all, 69,228 people in Scotland (1.36% of the total population) reside in a data zone where average NO_2 concentration is above the AQS annual mean objective. Of these people, 43% are found in the most deprived decile. No data zones in deciles 7 to 10 experience exceedences, and hence exceedences of the NO_2 standard are therefore seen to be strongly concentrated in the more deprived deciles. This is further illustrated by a CI value of 0.6.

14.5.3 Distribution of highest pollutant concentrations

Examination of the 10% of data zones with the highest pollutant concentrations (note that these may be within the NAQS objectives) reveals that the most deprived deciles disproportionately experience the highest pollution concentrations**.** For nitrogen dioxide (Table 14.5), someone living in decile 1 is twelve times more likely to be living in an area of higher pollution compared to someone in decile 10 and over five times more likely to be living in an area of higher pollution compared to someone of average deprivation. Furthermore, the lower two deciles account for 49.5% of people living in the most polluted data zones compared to just 7.9% of people living in the top two deciles.

For PM_{10} (Table 14.6) there is again a strong correlation between living in the more deprived deciles and experiencing the highest PM_{10} concentrations. People in decile 1 are three times as likely to experience the highest PM_{10} as those living in decile 10, with 27% of those living in decile 1 living in the most polluted data zones.

There is no annual mean national air quality standard for carbon monoxide. The results (Table 14.7) shows that while most of the decile values (deciles 3 to 10) are below the 10% level (at which each decile roughly experiences an equitable value) the most deprived decile make up a third of the population living in the most polluted areas.

The values for benzene are well below the required AQS objective and have already met the stricter objective for 2010. The pattern (Table 14.8) is very similar to that for carbon monoxide. In the most deprived decile a third of the people experience the highest levels of benzene.

Values for sulphur dioxide in Scotland are well below the WHO guideline of 50μg/m^3. The variation between the deciles is the lowest of all the pollutants. In general, the more deprived deciles have higher sulphur dioxide values, except for the most deprived decile where only 5.8% of that decile are experiencing the highest levels of sulphur dioxide.

Examination of the CI values indicates that the greatest inequality occurs for nitrogen dioxide (0.39). Benzene (0.23), PM_{10} (0.22) and carbon monoxide (0.23) share similar values with a low value for sulphur dioxide (0.12); all of these figures indicate a pollution bias towards the more deprived groups.

14.5.4 Distribution of lowest pollutant concentrations for PM_{10} and NO_2

Analysis was carried out for PM_{10} and NO_2 as these two pollutants show the largest variation in values and are the most significant in terms of overall concentrations and potential impact on health. Figure 14.3 illustrates a similar pattern for PM_{10} and NO_2 in that there is an unequal distribution of population in terms of where the best air quality occurs. Deciles 1 and 2 have the lowest proportion of population experiencing these levels, while deciles 9 and 10 also have low population values (but not as low as deciles 1 and 2). Deciles 6 and 7 have the largest proportion of population (approximately 20%) living in these areas. The CI value for PM_{10} is -0.31, and for NO_2 is -0.11 illustrating that the best air quality is to be found in the least deprived areas. This is to be expected, given the results reported above.

15 Summary of results

This project has provided an initial view of the spatial and social distribution of key aspects of environmental quality across Scotland. The results for each of the eight topics summarised below show that the common presumption that those already carrying the burden of social deprivation also live in the worst quality environments is to some degree borne out by the national-scale analysis that has been undertaken. However this is not universally the case and it has been repeatedly stressed that only a relatively basic exploration of complex social and environmental phenomena has been possible in this project. There are two general limitations which need to be remembered in considering the results summarised below:

- we have predominantly undertaken proximity analyses which indicate the numbers of people who live within specified distances of environmental features of various forms (sites, areas of land, stretches of river). Proximity, can however, only be a crude surrogate for the range and breadth of different types of negative or positive impact that may potentially exist in reality around each environmental feature

- we have only been able to take account of some of the ways in which the environmental features recorded in databases have different characteristics which influence the scale and nature of their environmental and social impact. For example for landfills, quarries and IPPC sites it was not possible to take account of the different size of sites (as data was unavailable) so that both small and very large sites were treated the same way in the analysis. Similarly in the green space and woodland analyses no account could be taken of the quality of the green space or woodland areas that had been mapped, which may be particularly significant to how these areas are viewed by local people

These considerations, again emphasise that the type of socio-spatial analysis undertaken in this project can only broadly characterize the deprivation characteristics of areas around environmental features, rather than provide a more robust view of who in practice experiences negative or positive impacts. As discussed in chapter 16 there are a number of ways in which this first view of patterns of distribution in Scotland could in the future be refined through further work.

Industrial Pollution

Industrial pollution was examined by analysing the proximity of populations to sites coming within the remit of the IPPC Directive. This showed a distinct bias in site locations towards deprived populations. The most deprived are three times more likely to be living near to an IPPC site than the least deprived. Sites were also found to be disproportionately clustered near to more deprived populations. Sites with higher reportable emission levels were *not*, however, found to be located closer to deprived populations than those with lower emission levels.

Derelict Land

The analysis for derelict land showed that people in the most deprived areas are almost five times more likely to be living near to derelict land than people who live in the least deprived areas. Those living in deprived areas are more likely to live near to long term derelict sites, 27% of people who live in the most deprived decile are living within 600m of a site that has been derelict for 23 years or more compared to only 3% of people who live in the least deprived decile. There is also a clear relationship between deprivation and proximity to multiple derelict sites - the more deprived the decile the greater the population living near to multiple derelict sites. Proximity to derelict land is predominantly a feature of the urban population, however, in proportional terms both the urban *and* rural deprived are substantially more likely to live near to a derelict site than people in less deprived deciles. With a few small exceptions the relationship between derelict land and deprivation is straightforward; the more deprived the decile the greater the proportion of people living near to derelict land.

Landfill

For landfill sites the patterns of relationship between deprivation and population proximity are difficult to characterise. There are few apparent simple or consistent relationships with deprivation and no evidence to suggest that at a national scale deprived populations are more likely than others to live near to landfill sites. Where landfill sites are clustered together there is a bias towards less deprived rather than more deprived populations. Differentiating between open and closed sites does indicate a small bias towards deprived populations for closed sites, but the pattern is not strong. Separating out the analysis between populations in urban and rural areas shows no distinct or substantially different patterns to the overall analysis.

Quarries and Open Cast

The relationship with deprivation for quarries and open cast sites is similarly difficult to characterise in a simple manner. When all such sites are considered the profile of population proximity across the deprivation deciles shows little variation. When clusters of sites are examined there is some bias towards these being located near to the *least* deprived populations. The urban-rural analysis, in contrast, shows a different and fairly distinct pattern for rural deprivation, with the proportion of the rural population that lives near to a quarry or open cast site distinctly higher in the most deprived deciles.

Woodlands

Proximity to woodland was examined through analysing populations living within 600m of areas of woodland over 2 hectares in size. This found that people living in the poorer deciles are less likely to live near to woodlands - the most deprived four deciles all record values less than 60% of the population living near to woodland while the remainder all record values above 60%. However, analysis focusing just on areas of new woodland found that the more deprived deciles have benefited more than the least deprived from new woodlands being planted in their areas. This suggests that policy may have started to redress the unequal distribution of woodland for populations living with different levels of deprivation.

Green space

Green space analysis has explored the use of highly detailed data just for Glasgow as well as analysing data from local plans on local nature designations at a national level.

For the national analysis the least deprived areas have the highest percentage of people living near to a local nature designation but the second highest value is in the most deprived decile, indicating that there is no simple relationship. Overall 27% of the Scottish population live within 600m of a local nature designation. With the exception of the two extreme deciles there is little variation between the deciles.

Within deciles the urban population is much more likely to be living near to a local nature designated site than the rural population.

River Water Quality

The river water quality analysis focused only on those rivers classified as poor quality or seriously polluted. This is only a very small proportion (3.2%) of the total classified river length in Scotland. There is a clear relationship between deprivation and proximity to these rivers. The highest proportion of population is found in the most deprived decile, with a decline through to the least deprived deciles where a small upturn is seen. 26% of the population in the most deprived decile live within 600m of a poor quality or seriously polluted river compared to between 11-15% in the least deprived deciles. In proportional terms these rivers are biased towards both the urban and rural poor.

Air Quality

The distribution of mean air quality in Scotland shows that the most deprived decile has the poorest air quality of all the deciles for four of the five pollutants examined (the exception being sulphur dioxide). Four of the five pollutants meet the Air Quality Strategy Objectives (the exception being nitrogen dioxide). However, note that even where air quality objectives are met, an absence of health impact cannot be assumed.

1.4% of the population in Scotland live in a data zone with NO_2 concentrations above the AQS annual mean objective. Of these people 43% come from the most deprived decile. Exceedences of the NO_2 annual mean objective are strongly concentrated in the most deprived areas.

For nitrogen dioxide someone living in decile 1 is twelve times more likely to be living in an area of higher pollution compared to someone in decile 10 and over five times more likely to be living in an area of higher pollution compared to the average person.

People in decile 1 are three times as likely to experience the highest PM_{10} values as those living in decile 10, with 27% of those living in decile 1 living in the areas with the highest PM_{10} values.

16 Recommendations for Monitoring Change, Data and Research

16.1 Purpose

This report has so far discussed the results of a 'snap shot' analysis of patterns of relationship between environmental parameters and multiple deprivation in Scotland. This section looks forward to consider how the research may be utilised and developed in the future and makes recommendations for future work. It has three objectives:

- to identify ways in which environmental data sets could be improved or extended in order to enable more sophisticated analysis in the future

- to consider how the data analysis could be repeated at regular intervals in order to monitor trends of change of change over time and relate these to policy objectives and targets

- to recommend further research to build upon the work undertaken in this project

The general methodological issues concerning investigation of environmental justice were dealt with in Chapter 5 are also relevant to the following discussion. Issues surrounding environmental justice and green space are covered in more depth in Ch 12.

16.2 Developing and Improving Data

This project has to some degree been dataset driven i.e. we have used existing datasets to investigate the issue of environmental justice. None of the datasets were designed or collected to aid the investigation of environmental justice, which in part explains the caveats we have had to attach to the analysis. A more substantial analysis could in principle be possible by first deciding which aspects of environmental justice were of concern and then collecting the relevant primary data (see section 16.3).

However improvements to our understanding of environmental justice may also be achieved by modifying and improving existing datasets. To aid how this may be achieved we first need to understand some of the methodological issues involved in any such analysis.

One of the main issues faced in undertaking the analyses in this report relates to the spatial types that are used to represent data in a GIS vector model. The three spatial types are points, lines and polygons (areas). All three of these were used in the research (e.g. points for landfill sites, lines for rivers and areas for woodland), but in several cases the spatial representation provided was a significant limitation on the quality of the analysis that could be undertaken. The main issue here is the use of points to represent what are in fact areas. This was the case for landfills, quarries, IPPC sites and derelict land (although areas were modelled around the point data in the latter case).

Point features are quick and easy to capture and can be supplied by the applicant of any licence/registration if needed in the form of a grid reference. The general problem with using points in this ways is that there is no automatic indication of spatial extent of the feature under consideration. A further problem for datasets we have examined include inconsistency as to the where the point is to be recorded from. Many datasets have used the front gate as the point to capture (almost certainly as a result of using the postcode to locate it); some have used the centre of the site. There are also some concerns about the level of accuracy of Ordnance

Survey grid references supplied by the public and inconsistencies in recording the precision of the spatial reference within individual datasets.

In general the centre of the site should be the preferred option for GIS analysis as:

(i) Sometimes area data is available and this can be modelled as a circle on the centre.
(ii) Buffer analysis is likely to be more correct if the centre of the site is used.

Polygon (area) features are more time consuming to capture and a higher level of technical ability is needed by the data collecting organisation, but the true spatial extent of the feature (e.g. the landfill or quarry site area) can be accurately captured. Whilst it is therefore theoretically desirable that polygon data is collected rather than point, there are a number of questions to consider in assessing the practical feasibility of this step.

- Does the organisation have access to detailed land parcel mapping e.g. MasterMap (as available to many public bodies under the pan-government Ordnance Survey (OS) agreement?
- What is the technical capability of the collecting organisation?
- How many items are in the dataset?
- How dynamic is the dataset? Are the features being collected likely to be long standing?
- Is the increase in spatial accuracy likely to have a significant impact on the results of a study if polygon (area) data is used over point data?

These considerations, and how they might play out for different datasets, can be illustrated by examining two datasets used in the study; landfill and derelict land. Landfill data, has been recorded only as a point feature with no other data such as size or age. There are 225 landfills in Scotland, most of which are long standing and are regulated by the SEPA. SEPA has access to Master Map data under the OS agreement. Given the small number of features involved, the long standing nature of the data and the fact that there is no existing size data for the landfill, it would suggest that this is a dataset that would benefit from being captured as polygons, first to precisely locate and delineate the landfills, but also as it could contribute to an increase in the accuracy of any further studies.

Derelict land data is collected by the Local Authorities; it is captured as a point data set, but with some estimation of land parcel size and a range of other data. There are sometimes hundreds of individual parcels within an authority with additions and deletions to the data set occurring within a one year time period. The local authorities have access to the PAN OS agreement however, given the large number of features involved, the level of change in the dataset and the fact that size data already exists; there would be less justification in expecting this data to be captured as a polygon dataset.

In addition to questions of spatial type there are other ways in which the datasets used in this study could be enhanced, particularly by the recording of additional attribute data so that different characteristics of environmental features can be taken into account. Table 16.1 details the specific recommendations related to each of the 8 environmental topics.

Such data improvements and their realisation would be facilitated by greater collaboration and data sharing across organisations and maximising the value and use of data through GIS within organisations. Collecting and maintaining data is one of the largest costs in establishing a GIS system. Collaboration on data collection and sharing between organisations would allow a more efficient use of resources.

Table 16.1 Recommendations for specific datasets

Dataset	Collected by	No of sites	Rate of update	Rate of change	Comments	Recommendations
Derelict land	Local authorities	1800 approx	Annual	Fast	Current system of recording as a point. Analysis could be repeated 'as is' without any changes to the data if monitoring over time is needed.	Further analysis should concentrate on attributes in the dataset such as contamination, ownership. Annual monitoring possible.
Air quality	NETCEN	1 km grid across Scotland	Annual	Slow	One of the best variables for examining environmental justice as there is a clear link to health through the National Air Quality Standards. Study can be repeated 'as is' if monitoring over time is required.	Investigate whether analysis could be done with shorter time measured data. Investigate whether other air pollutants are suitable for study. Annual monitoring possible.
Digital Woodland Map of Scotland	Forestry Commission	55K approx	Irregular	Medium	New 5 year project is starting to collect NIWT 2. If possible some recording of actual access capability/usefulness for recreation would be useful. No benefit in repeating study until updated digital data is available.	Consider recording access attributes and suitability for recreation in the new digital data set.
Landfill	SEPA	225	Annual	Slow	Currently a limited dataset. Need for other attributes to be collected e.g. spatial extent, type of waste, type of monitoring taking place. No benefit in repeating study until dataset improves.	Accuracy of recording of spatial location needs to be evaluated. Spatial extent of sites should be captured and new study carried out. Attribute data needs to be joined to the spatial dataset.

Industrial Pollution (IPPC)	SEPA	232	Annual	Slow	Spatial extent of site not captured. Could analyse by emissions types and levels and using other site characteristics data. No benefit in repeating study until dataset is improved. Part B sites could also be examined if grid referencing improves.	Spatial extent of sites needs to be captured. Quality check needed on data attributes in current data set.
Quarries	BGS	Approx 1000 but less than 400 active	Irregular	Slow	Working area of quarry will change through time, but capturing the extent of the quarry would allow calculation of worst case scenario. Furthermore as quarries are often used after their natural life has ended (e.g. nature reserve, landfill) may be efficient to capture now. Study is repeatable but would benefit from first capturing spatial extent.	Spatial extent of quarries should be captured. Attributes to add to the dataset could include noise and dust levels for individual sites if monitored.
Green space	Various	Tens of thousands	Irregular	Variable depending on type of green space	Capturing an accurate green space data set at the national level is likely to be extremely difficult if not impossible. While land cover can be captured (e.g. LCM 2000) this gives no indication of land use. Capturing of green space data will be best done at the local authority level. This could be done in conjunction with PAN 65. GIS analysis is particularly useful for PAN 65.	Local authorities to capture the spatial extent of green space. Further exploration of route access methods are needed for green space and access studies. Assessment of quality of green space needed as indicated in PAN 65
River water quality	SEPA	Thousands	Annual	Medium	Reducing the number of unclassified rivers would produce a more comprehensive study.	Annual monitoring possible to identify where improvements have been made

Table 16.1 continued

In addition to the specific recommendations in Table 16.1 there are a number of general recommendations coming out of the foregoing discussion:

R 1. Clear and consistent guidelines should be issued to all applicants who require licence authorisation from SEPA as to how to record the spatial location of their site or process. Other environmental organisations which award grants or funding for site specific projects should also consider the advantages of recording such information.

R 2. If point data is selected as the spatial type to be used then the centre of the site should be the location recorded.

R 3. Organisations should audit which datasets have actually been shared between organisations as a way of monitoring the effectiveness of data sharing. In particular data shared should be the in its most disaggregated form, and where possible made available in common GIS formats.

R 4. SNIFFER should consider the establishment of subgroup within the environmental justice cluster to examine technical issues surrounding data management, data creation and GIS.

R 5. Organisations such as SNH, SEPA and the Forestry Commission should organise internal data user groups composing of every day GIS and data users, if these do not already exist.

R 6. Organisations in Scotland should be encouraged to co-operate with the MAGIC initiative (www.magic.gov.uk) as a means of making meta data and data available. MAGIC aims "to act as the source of definitive information about environmental designations and schemes for the UK."

R 7. Organisations in Scotland should be aware of the "Scotland's Key Geographies" initiative by the Scottish Executive which will provide a definitive source for essential geographical data in Scotland.

R 8. SEPA should initiate a data collaboration group with the Environment Agency in England to exchange experience.

R 9. All organisations should explore possible links (including student placements) with universities running post graduate GIS courses (these include Edinburgh, Glasgow, Leicester, Leeds). This would allow them to achieve greater potential from their existing datasets and aid in the creation of new ones.

16.3 Monitoring change over time

One of the key purposes of undertaking environmental justice analysis is to make some assessment of the degree of inequality that exists, its fairness and need for policy intervention to address this inequality (see Mitchell and Walker 2005). Judgements of fairness and need for policy intervention are questions for discussion, debate and decision-making by policy making bodies, ideally in partnership with other stakeholders, and extend beyond the remit of this project.

However, assuming that such judgements are to be made there is then value in monitoring how patterns of inequality are changing over time. This could potentially serve a number of purposes, such as:

- to assess whether or not a specific policy intervention adopted in order to address an environmentally inequality, judged to be unacceptable or undesirable, is achieving its objectives

- to track whether or not a situation that is currently deemed to be acceptable is getting more or less unequal over time and therefore potentially in need of future policy intervention

If change over time is to be usefully assessed then decisions are needed as to how frequently such an assessment would be possible, appropriate or relevant. These decisions are influenced by a number of factors including the frequency with which data sets are updated, the stability of underlying geographies enabling or frustrating comparisons over time and the resources that are available to commit to monitoring change.

Several factors make the monitoring of change over time through repetition of the analyses in this project more feasible:

- The data zones used in this report are now the standard unit for small area analysis in Scotland, furthermore they were designed for long term monitoring in that their boundaries will not change.

- The Scottish Index of Multiple Deprivation is planned to be regularly updated every two years. This is more than adequate in terms of looking at relative deprivation as deprivation patterns are slow changing.

- Many of the datasets used in this report are collected on an annual or regular basis. It should be remembered that annual updates are unlikely to be needed for some environmental variables which are slow changing.

It needs to be considered as to whether or not the preliminary analysis provided by this project is sufficiently sophisticated and in depth to provide a useful baseline and to begin developing policy criteria and then monitoring change over time. We have emphasised the limitations of the analysis that has been possible within the scope of the project. It may be that a more sophisticated analysis needs to be undertaken for some of the variables - using improved data sets and with better differentiation between environmental characteristics - before policy responses are developed, performance criteria developed and trends of change over time monitored.

Recommendations for monitoring change over time are:

R 10. Factors to take account of in deciding which datasets can be used unmodified, which datasets need modification and the time span for monitoring are given in Table 16.1

R 11. If organisations wish to monitor other variables over time then consideration needs to be given to the creation of new data sets or geo-referencing some of the existing datasets.

R 12. Organisations such as SEPA, SNH, Scottish Executive and the Forestry Commission need to work with stakeholders to identify environmental inequalities which are deemed unacceptable and in need of policy intervention and monitoring.

R 13. Given the role of SEPA in terms of regulation and data handling we recommend the agency appoint a technical working group on environmental justice appraisal.

16.4 Future Research

This project represents the first time that an environmental justice data analysis has been undertaken at a national scale in Scotland. As emphasised in the introduction the approach has been to cover a broad range of topics, covering both environmental goods and bads, the trade-off being that the analysis could not be in-depth, but rather undertake a fairly basic approach to relating environmental topics to the SIMD data.

Recommendations for future research

R 14. That SNIFFER expands and develops the environmental justice area (UE4) programme to investigate the issues of ethnicity, gender, age and environmental justice in Scotland.

R 15. Research should examine differentiation within existing datasets as a means of investigating environmental justice issues - some of the datasets contain subcategories and characteristics of environmental features, e.g. emission levels from IPPC sites, derelict land contamination and ownership. Further more differentiated analysis should be carried out for some of these datasets to see if patterns of relationship with deprivation vary with characteristics or type of environmental feature.

R 16. Research should examine the effects of spatial distribution within environmental justice issues - there are various ways in which the spatial distributions revealed in this research could be explored in greater depth. This could include the identification of those places where the association between features and deprived populations is strongest to inform the targeting of policy. Another area which is generally very undeveloped in the environmental justice literature is the assessment of cumulative impacts of multiple environmental variables. This may reveal whether certain deprived communities experience a series of potentially interacting environmental impacts.

R 17. Research should be carried out at a range of spatial scales to address the issue of environmental justice - this report has largely examined environmental justice at the national level. However this does provide some limitations in terms of what can be achieved. Research can be carried out at number of scales, which may be a reflection of the purpose of the study, the data available or the scale of the environmental quality under consideration.

In this respect studies within a local authority are worth specifically commenting on as analysis could tie in with existing duties and data collection. Derelict land and green space are particularly relevant to local authority analysis as they are land parcel based and have a direct link to the planning system. Nationally collection of green space data is often difficult due to the range of green space types, the physical extent of it, and, if remote sensing data is being used, the range in reflectance values. However many green spaces (especially formal parks) should now be relatively easy to extract from Master Map and could be used in a fairly simple way to address PAN65 requirements at a local authority level. National organisations such as SNH or

SEPA could work in collaboration with local authorities to establish criteria and develop a toolkit to aid the investigation of environmental justice. Such a process would provide evidence and help to plan for sustainable development.

Local scale analyses will also be aided by the development of Local Land and Property Gazetteers contributing towards the National Land and Property Gazetteer. This will provide local authorities with an extremely accurate location of businesses and residences and thus population. This is particularly useful for proximity and access studies.

It may well be that for some environmental variables a two stage process of investigation is needed. Firstly, a national level analysis as carried out in this report that can be used to highlight hotspots or areas of concern. This would be followed by a more in- depth study which would examine the areas identified in more depth and at a smaller scale to better aid our understanding of how the environmental variable operates or is influenced at the local level.

R 18. Research should examine other environmental variables which have not been included in this study to aid our understanding of environmental justice - other environmental topics that could be examined include flooding, proximity to smaller scale IPPC sites and a wider range of waste sites, ambient noise levels. There is much more work that could investigate air quality issues, in particular ozone, which is known to have a health impact, and similarly $PM_{2.5}$ particles that are increasingly suspected of links with health impacts. Examination of air quality data held by local authorities including acute episodes of high pollution concentrations would also be a potential study topic.

R 19. Research should examine other social variables or cohorts of population to illustrate how environmental justice impacts differentially within society - this report has largely concentrated on overall deprivation as a means of examining environmental justice. Even within the most deprived areas some groups will suffer more than others. For example children suffer disproportionately from air pollution as their bodies are still forming and they are more susceptible. One starting point for investigating children and aspects of environmental justice would be the location of schools with respect to environmental good and bads. The Children's Health and Environment Action Plan for Europe (CEHAPE) run by the WHO and signed up to by British ministers provides the driver for such action. Other social variables to consider include ethnicity, gender, disability and household tenure.

One further alternative analysis worth considering is the use of house price information as an indicator of valued areas. This may provide a fairly rigorous method for establishing which environmental features are valued in economic terms.

R 20. Research should examine in greater depth the links between humans and the environment. Such research will need to consider issues surrounding exposure, vulnerability, causality, chronic and acute effects, this is particularly important with regard to any health impacts either positive or negative.

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