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Routing out the Hot Spots: Towards using GIS and crime-place principles to examine criminal damage to bus shelters

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A.1 INTRODUCTION

This paper describes initial efforts to utilise GIS technology to cross reference crime data on one aspect of the public transport journey, bus shelter damage, with information on socio-demographic conditions, land use and infrastructure, covering the county of Merseyside in the North West of England. A GIS is used in conjunction with spatial statistical analysis to explore the nature, manifestation and patterns of damage to bus shelters. Evidence of clustering is found, and one fifth of all damage for a year is shown to occur at 2.5% of all bus shelters. The findings also suggest that particular neighbourhoods types, and certain characteristics of socio-demographic and physical environment, are more likely to experience shelter damage than others. This implies that bus shelter damage is related in a systematic and predictable way to known attributes of a shelter's location. This prompts discussion of the use of a combination of GIS and other crime mapping techniques developing our knowledge of the extent of, and the theoretical reasons underlying, crime and disorder on public transport.

Public transport crime, what is it and why does it exist? The police in the United Kingdom do not record incidents of crime and disorder on public transport systems as a separate category. This might imply that it is an area not worthy of research and further attention. However, recent findings by the then Department of the Environment, Transport and the Regions (DETR 1998) suggest that patronage on public transport could be increased by 3% at peak and 10% at off peak times if fear of crime and disorder on public transport journeys were to be reduced. These findings also highlight the importance of public transport use as a means of gaining access to health, leisure and other facilities, and thus in making a contribution to minimise social exclusion. Any attempt to reduce fear of crime on public transport requires a fuller understanding of both the nature and extent of crime and disorder on public transport, and environmental

characteristics that may help to explain this crime. These environmental features are likely to include land use, socio-demographic influences, and features of the physical infrastructure, such as the layout of buildings and the spaces between them. The techniques used in this paper have been applied to other areas of crime research (Bowers and Hirschfield, 1999, Johnson et al., 1997) Here, GIS is used in conjunction with spatial statistical analysis to explore the nature, manifestation and patterns of crime and disorder on public transport, and, in particular, criminal damage to bus shelters. In an attempt to offer some explanation for the spatial patterns identified, it is necessary to draw upon theoretical perspectives that relate crime in general to its environment. Some relevant theories are now highlighted, before the methodology and findings of this research are discussed in more detail.

A.2 THEORIES RELATING CRIME TO ITS ENVIRONMENT

Environmental criminology is concerned with describing and explaining the place and space of crime. Place of crime refers to the location of crimes. Space of crime refers to spatial factors that may help to explain the location of crime. The two core concerns of environmental criminology are to describe and explain the distribution of criminal offences, and to describe and explain the distribution of crime offenders (Bowers, 1999). This research paper concentrates on the former concern, where crimes happen. The spatial distribution of many offences (crime events) has been shown to be non-random (Eck and Weisburd, 1995) and attention has focussed on analysing when and where these crime events occur, and the environmental factors that may help to explain the occurrence of these incidents.

The three major theories of environmental criminology that are concerned with the distribution of crime events are routine activities theory (Cohen and Felson, 1979), the rational choice perspective (Cornish & Clarke 1986), and crime pattern theory (Brantingham and Brantingham 1993). Routine activities theory states that, for a criminal event to occur there must be a convergence in time and space of three factors. These are: a) the presence of a motivated offender; b) the absence of a capable guardian, and c) the presence of a suitable target. Whether or not these elements converge or coincide is a product of the routine activities (day to day movements) of potential victims and offenders.

A rational choice perspective suggests that offenders will choose their targets and achieve their goals in a manner that can be explained. This has its roots in economic theory, and seeks to explain the way in which crimes are distributed spatially by weighing up the potential cost of a crime (chance of apprehension, cost of journey) against its possible benefits (potential reward, ease to commit). The offender rationally chooses the situation with the highest net outcome. The development of these two theories led to a growing recognition that they were not necessarily mutually exclusive, and a combination of both theories may help to explain crime events. A significant development in this was the development of crime pattern theory. This argues that; '*crime is an event that occurs when an individual with some criminal readiness level encounters a suitable target in a situation sufficient to activate that readiness potential*' (Brantingham and Brantingham, 1993, p266).

This multidisciplinary approach to understanding crime contends that crimes are patterned, but these patterns are only discernible when crimes are viewed as

aetiologically complex, occurring within and as a result of a complex environment. Places are linked with desirable targets, and the situation or environment within which they are found, by focussing upon how places come to the attention of particular offenders.

Weisburd and Eck (1995) further emphasise the importance of place as essential to crime pattern theory. They discuss how theories of place and crime have merged, in order to develop a crime event theory. Here, crime is examined at the micro scale (individual or smallest levels of aggregation). Crime and its environment can be analysed at different levels of aggregation, from the individual (micro) to sub-population (meso) to population (macro) analysis. Given a set of high crime locations, a crime pattern theorist may focus upon why and how offenders converge at these locations, whereas a routine activity theorist would be concerned with explaining the movement of targets and the absence of possible guardians. Both theorists may produce valid explanations, yet these may be supportive or differ substantially, and even a combination of both may be useful in explaining the crime.

One final important concept is that of '*crime attractors*' and '*crime generators*' (Brantingham and Brantingham, 1995). A crime generator is an area that attracts large numbers of people for reasons other than to commit a crime. At particular times and places the concentration of victims and offenders in these locations produces an 'unexpected' opportunity for the offender to commit a crime. Shopping centres, sports stadiums and public transport interchanges are examples of this. Crime attractors are places that offenders visit due to knowledge of the area's criminal opportunities, such as bars and prostitution areas.

A.2.1 Crime on Public Transport

Applications resulting from the theories discussed above include situational crime prevention (Clarke, 1992), hot spot analysis (Buerger et al., 1995), opportunity theory (Barlow, 1993), and targeted policing (McEwen and Taxman, 1995). Although these have been applied to analyse crime and disorder in a number of areas, including domestic and commercial burglary, assault, theft and robbery (Brown et al., 1988, Ratcliffe and McCullagh, 1998, Jupp et al., 2000), there has been only a limited amount of research into crime and disorder on public transport. Pearlstein and Wachs (1982) provide evidence that crime on public buses is concentrated both in time and space. Levine et al., (1986) use results from survey and observational data to demonstrate that bus crime incidents tend to be high on routes passing through high crime areas. Block and Davies (1986) examined street robbery data in Chicago and found that, in low crime rate areas, crime was concentrated near rapid transit rail stations. La Vigne (1997) demonstrates how unusually low crime rates on the Metro, Washington DC's subway system, can be explained by reference to some aspect of its environment. A recent paper by Loukaitou-Sideris (1999) uses empirical observations, mapping and survey research to examine the connection between criminal activity at bus stops and environmental factors. 10 high crime bus stops were analysed along with four low crime 'control' stops. This empirical research indicates that environmental attributes and site conditions at bus stops do have an impact on crime levels, and that further research is required to better understand and measure this effect. It has been demonstrated that the environment plays an important role in the location of crime events on public transport systems. There does not seem to

have been any attempts to produce a systematic evaluation of the nature, extent, and causes of crime and disorder on public transport.

A.2.2 Crime Events

Central to the understanding of environmental criminological theories and their applications is the concept of a 'crime event'. An event is something that occurs (Barlow, 1993) and the theories discussed above all depict this event as a non-moving event at a particular time and location (a static event). When considering the public transport system, a 'whole journey approach' is needed (DETR, 1999). This incorporates all parts of the bus journey, including walking from destination point to a bus stop, waiting at a bus stop, travelling on a bus, transferring between stops, and travelling from bus stop to arrival point. In terms of the bus journey, there are three possible scenarios in which a crime event can occur.

i) Waiting at a bus, train or tram stop (the waiting environment).

ii) On board a mode of public transport (bus, train, tram).

iii) Transferring between stops on foot (departure point to stop, between stops, stop to destination point).

The first and third situations both describe a 'static' crime event. The middle possible scenario, however, implies the crime to be moving ('non-static'). Here the fundamental question arises: Can the existing theories of environmental criminology be applied or adapted to explain crime and disorder on public transport? The growth of new technologies has allowed increased sophistication in the mapping and analysis of crime data, particularly with the evolution of Geographical Information System (GIS). The challenge is to map the location of a crime event that occurs on a moving public transport vehicle. Ideally, a global positioning system would be used, but, at present, this is likely to prove expensive. If a crime were reported along a section of a route, this would demarcate where the crime event occurred (although not necessarily the movement of the crime offender). This could then be captured in a GIS as a 'static' event, at a unique time period, together with information about crime events at stops and stations, alongside information about the physical infrastructure, land-use, socio-demographic and other associated environmental features. This would allow existing theories of crime and place to be tested and either applied or adapted. The location of crime events could be represented as points (at stops) and lines (sections of a route).

One major advantage of a GIS is its ability to combine data from different sources, and for the spatial relations between these to be investigated. The use of a GIS as a framework for analysis opens up the possibility of carrying out a systematic evaluation of the nature and extent of crime and disorder on public transport and its juxtaposition with associated environmental characteristics. It is believed that this could lead to the development of an evidence base that would to enable management to make informed decisions about resource targeting and policy formulation, and to monitor and evaluate strategies that have been implemented. This research represents an initial attempt to develop a systematic approach capable of evaluating the nature, extent and causes of crime on public transport. It was noted earlier that the police in the UK do not record incidents of crime and disorder on public transport as a separate category. Indeed, the lack of available data that exists on the location of crime on buses restricts the spatial analysis that can be performed, since crime is reported specific to an entire route and not

pinpointed to a precise location. Bus shelter damage is recorded to individual stops with x-y co-ordinates, and hence this research examines data on bus shelter damage to pilot whether further research in this area is deemed appropriate

This study uses data obtained by Merseytravel, the Public Transport Executive Group (PTEG) for Merseyside. It relates to bus shelter damage on Merseyside for the year 2000. There were 3116 incidents of shelter damage recorded, costing approximately £400,000 in repairing the damage. In comparison police records of shelter damage for this period consist of only 8 incidents. This highlights both the problem of under-reporting and the lack of available data on crime and disorder on public transport.

This study will address the following questions:

- Is bus shelter damage concentrated at particular stops and areas?
- Do particular neighbourhoods suffer from raised levels of shelter damage?
- Do bus stops act as crime generators?

A.3 CHARACTERISTICS OF THE STUDY AREA

Merseyside is a metropolitan county situated in the North West of England, and is an area where public transport is particularly important as it is estimated that over 40% of the population do not have access to a car (1991 Census of Population). Merseytravel is responsible for co-ordinating public transport services on Merseyside and acts in partnership with bus and rail operators to provide local services. The deregulation of bus services in 1986 resulted in bus services being operated by a number of commercial companies. This adds difficulties in acquiring reliable and consistent data concerning crime and disorder on buses, since operators report information in a non-standardised fashion. Maritime and Aviation Security Services (MASS) also operate on a private contract as a rapid response service dedicated to buses on Merseyside. There are also two rail operators (First North West and Arriva) who are responsible for local rail services, with security provided by the British Transport Police (BTP) who police the rail network nationally.

A.4 DATA

The following section describes the data utilised in this research, highlighting its advantages and limitations

A.4.1 Bus Shelter Damage

Data on the number of incidents and cost of damage to bus shelters, for a twelve-month period (January to December 2000) were obtained from Merseytravel. Data fields indicated the date of an incident, the cost of an incident, and the type of incident. Incident types have been assigned to classification groups to include smashed panels, graffiti and other incidents of vandalism. Each bus stop is uniquely referenced with an X and Y co-ordinate to an accuracy of 1 metre. Bus stop type is also categorised to distinguish between bus posts (concrete posts), conventional displays (CDs which are two metal posts holding a single glass or plastic panels displaying timetable information) and bus shelters.

The major disadvantage of this data set is that it only indicates when an incident is reported, not when it occurred. It is assumed that events are reported up to 24 hours during weekdays and up to 62 hours at weekends after the event occurred. No indication of the time of day is given.

A.4.2 Census Variables and Geodemographics

35 selected variables from the 1991 Census of Population were extracted at Enumeration District (ED) level. The ED is the smallest unit of the census for England and Wales for which data is available. Geodemographics is a term used to describe the construction of residential units or neighbourhoods from the Population Census. Geodemographic classifications are based on the use of cluster analysis to assign each ED to a district cluster or area type based on variables reflecting their demography, social and economic composition, and housing type (Brown, 1991). This research uses the SuperProfile Lifestyle classification, based on data from the 1991 Census and other descriptive information from other sources such as the electoral roll and consumer surveys. For further information see Brown and Batey (1994). Britain's 146000 EDs were broken down into 160 SuperProfile Neighbourhood Types, a broader 40 Target Markets, and the most general classification of 10 SuperProfile Lifestyles (see Appendix A.1 for selected pen pictures of Lifestyles). Caution should be exercised in the interpretation of these descriptions which seek to highlight distinctive features of the Lifestyles based on an index table comparing the cluster means value of selected indicators with the corresponding national mean. Further caution is required in comparing data from 1991 with conditions in 2000, although no comparable contemporary information on social, demographic, economic and housing types exists. It is important to offset the limitations of such a classification with the insights they may provide for the analysis of crime and its relationship with its environment.

A.4.3 The Index of Local Conditions (ILC)

This area-based index of deprivation was produced at ED level using six indicators of deprivation from the 1991 Population Census (Department of the Environment, 1995). For the purposes of this research, the 2925 Merseyside EDs were ranked by their ILC score and then grouped into ten groups (deciles), each containing ten per cent of the Eds. Other indexes that could be utilised are the 1998 Index of Local Deprivation (ILD) and the 2000 Index of Multiple Deprivation (IMD). The former of these at ED level is also based on 1991 census variables and the latter is only available at ward level (www.regeneration.dtlr.gov.uk/98ild/).

A.4.4 Recorded Crime Data

Data on a number of crime types for the period January to December 2000 were obtained from the Merseyside Police's Integrated Criminal Justice System (ICJS). This data is known to be subject to a degree of under reporting (British Crime Survey 2000). The categories obtained include 'criminal damage', 'drugs related', 'robbery', 'other violence' and 'all recorded crime'. Data was also acquired for the same period for calls to the police from 'command and control' records. These are service calls to the police, not recorded levels of crime, and are subject to over-reporting. They have been used as an indication of demand from the public for police intervention, or 'formal social control' (Bowers and Hirschfield, 1999). The categories of incident for which call records were

provided are ‘disorder’ and ‘juvenile disturbance’. All these data sets were supplied aggregated to ward level, of which there were 118 covering Merseyside in 1991.

A.5 METHODOLOGY

All the data were compiled in a GIS system. Stop references were captured using their X and Y co-ordinates, whilst all other data were transferred using the point centroids of their respective Census ED or Ward level coverage. The GIS intersect command was used to join bus stops to the ED in which they were situated. This method enables a profile to be constructed of damage at each shelter with environmental variables (SuperProfile Lifestyles, selected census variables, % open space and % built areas, the ILC decile, and selected recorded crime and command and control data). The GIS program used was ArcView v3.1. This data was then exported into a statistical package (SPSSv10.0) to enable the further statistical analysis of the spatial data.

Analysis was undertaken to establish whether the point data relating to damage to bus shelters displayed evidence of clustering. CrimeStat v1.1 (www.udoj.gov/cmrc) was used to calculate both the Nearest Neighbour Index (NNI) and Ripley’s K statistic. The first of these measures tests if the distance to the average nearest neighbour is significantly different from what would be expected by chance. If the NNI is 1 then the data is randomly distributed. If the NNI is less than 1 the data shows evidence of clustering. A NNI result greater than 1 reveals evidence of a uniform pattern in the data. A test statistic (the Z-score) was also produced, the more negative the Z score the more confidence that can be placed in the NNI result. It is not a test for complete spatial randomness and only examines first order or global distributions. The Ripley’s K statistic compares the number of points within any distance to an expected number for a spatially random distribution. It provides derivative indices for spatial autocorrelation, and enables the morphology of points and their relationship with neighbouring points to be examined at the second, third, fourth and nth orders, thus enabling the identification of sub-regional patterns. In CrimeStat these values are transformed into a square root function (Lt) at 100 different distance bins. To reduce possible error rectangular border correction for ten simulation runs was applied.

ArcView was used for visual analysis, producing proportional circles of hot spot damage and comparing these with choropleth maps displaying related environmental characteristics aggregated to ED and Ward levels. The ‘hot spot’ function in CrimeStat produced statistical ellipses of hot spot clusters that were also displayed using ArcView. An important consideration is that the production of these visualisations is subject to user input, and modification of the classification ranges and inputs used produces different visualisations. In CrimeStat, three parameters, the probability a cluster was obtained by chance, the minimum number of points per cluster, and the number of standard deviations for the ellipse, can all be altered, resulting in different visualisations. The benefit of this type of analysis is that possible relationships can be visualised and demonstrated without, or prior to, employing statistical analysis.

Resource Target Tables (RTTs) compare the number of stops damaged with the total number of stops. Bus stop incidents are ranked in descending order of incident frequency at each stop. Cumulative counts of incidents as a percentage of all incidents are constructed, and cumulative percentages are calculated. These are compared with the corresponding cumulative counts and percentages of bus stops. This gives an indication

of the extent to which the incidents are concentrated at particular bus stops or groups of bus stops. An initial assumption in undertaking this analysis was that only certain types of stop (shelters and conventional displays) would be damaged. Thus, a separate RTT was constructed from which other stop types were excluded (notably concrete poles).

All bus stops were assigned to a particular ED using a GIS based operation and from this the number and cost of incidents of shelter damage could be cross-referenced with SuperProfile Lifestyle, ILC decile, and selected 1991 Census variables. In addition to this, the bus stops were also cross-referenced with a number of police recorded crime, and police command and control variables aggregated to Ward level. This data was exported from ArcView into a statistical package (SPSSv10), which enabled statistical analysis of the relationships between bus shelter damage and selected environmental factors. Two possible errors arise here. Using aggregated data (at ED and especially at ward level) increases the possibility of error due to the ecological fallacy (Martin and Longley, 1995). The ability of a GIS to adjust the levels of aggregation of data can result in further error attributed to the modifiable areal unit problem, whereby different aggregations can yield differing interpretations of the same data (Openshaw and Taylor, 1991). The Spearman's Rank Correlation was chosen as an appropriate non-parametric method for two-tailed bivariate correlation of non-normally distributed data. In addition to this the number of bus stops that suffered shelter damage in each SuperProfile Lifestyle were calculated, and compared with the frequencies of what damage would be expected on the basis of the number of stops in each lifestyle using Chi square analysis. This technique has previously been applied to burglary data (Bowers and Hirschfield, 1999)

To examine the temporal patterns of shelter damage, variations in cost were produced on a monthly basis for the whole of Merseyside. At present no information exists on hourly variations, and daily variation would be biased as incidents reported on the weekend (Friday p.m. to Mon a.m.) are reported as Monday. The data was split into the five districts of Merseyside, but to account for the disproportionate number of shelters in each district the rate of shelter damage per 100 shelters per month for each district was calculated. This was also compared with the rate for shelter damage pre month per 100 shelters for Merseyside.

A.6 FINDINGS AND DISCUSSION

Nearest Neighbour Analysis (NNA) and Ripley's K statistics were produced using CrimeStat to derive for evidence of clustering in the data. The Nearest Neighbour Index (NNI) calculated was 0.1346 and the test statistic (Z) value was -102.2862. This implies a very strong likelihood that the average nearest neighbour is significantly nearer than would be expected by chance, and that the global distribution of damaged bus shelters displays evidence of clustering. An important consideration is whether the distribution of shelters themselves is clustered. The NNI of all the shelters is 0.2278 implying that the location of shelters themselves is clustered. However the larger NNI value of all shelters compared to the damaged shelters implies the clustering of damaged shelters is over and above the clustered distribution of all shelters themselves. The L(t) values produced for the Ripley's K statistic using the Crimestat software are plotted against the distance bins between points (Figure A.1). This demonstrates that the L(t) increases up to a distance of

about 13km before starting to decrease again. This also provides evidence for clustering at some higher orders than first order clustering

A GIS was used to visualise the outcome of the hot spot analysis of the shelter damage. Figure A.2 shows proportional circles of hot spots, and compares them with first and second order Nearest Neighbour Hierarchical (NNH) ellipses produced in CrimeStat. The advantage of NNH clusters are they can be applied to an entire data set, but may still indicate small areas of clusters Only those points closer than expected by chance are clustered at the first level, before these clusters are re-clustered. Linkages between several small clusters and higher ordered clusters can be readily observed. The resulting images provide a method of portraying hot spots, depicting patterns that can be combined with other data within the framework provided by the GIS. The clustered distribution of shelter damage on Merseyside can be readily observed from this image

Figure A.3 shows a choropleth map of the SuperProfile Lifestyles in which the shading is restricted to the built-up areas with proportional circles of hot spot damage overlaid. This provides a visual representation of the possible relationship between bus shelter damage and Lifestyle, and suggests a very strong correlation between bus shelter damage and the areas of highest deprivation (the least affluent Lifestyle 'have-nots'). It also demonstrates the ability of GIS to cross-reference multiple data sets.

A number of methods of hot spot analysis exist (see for example Crime Mapping Research Centre, 1998; Chainey and Reid, 2002). These include different methods of visual interpretation, choropleth mapping, grid cell analysis, point pattern analysis and spatial autocorrelation. Techniques that could be applied to this data in the future include kernel density interpolation and methods utilising local indicators of spatial association (LISA) An example of this is provided by Ratcliffe and McCullagh (1998). These allow for local influences such as passenger flow numbers to be incorporated into the hot spot analysis.

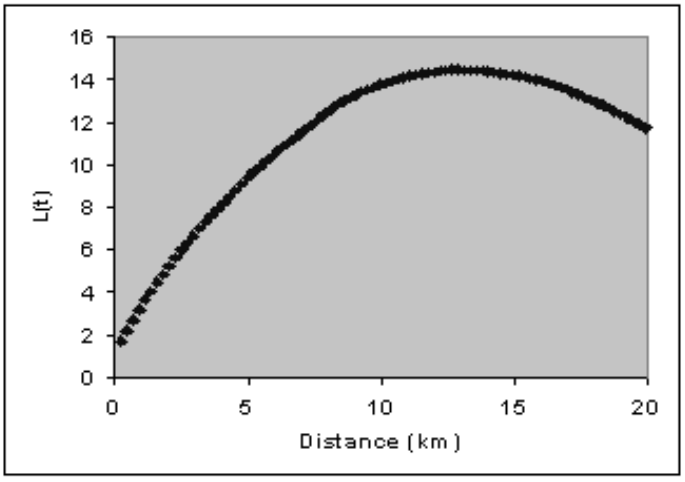


Figure A.1 L(t) values using Ripley's K statistic compared with the distance between points.

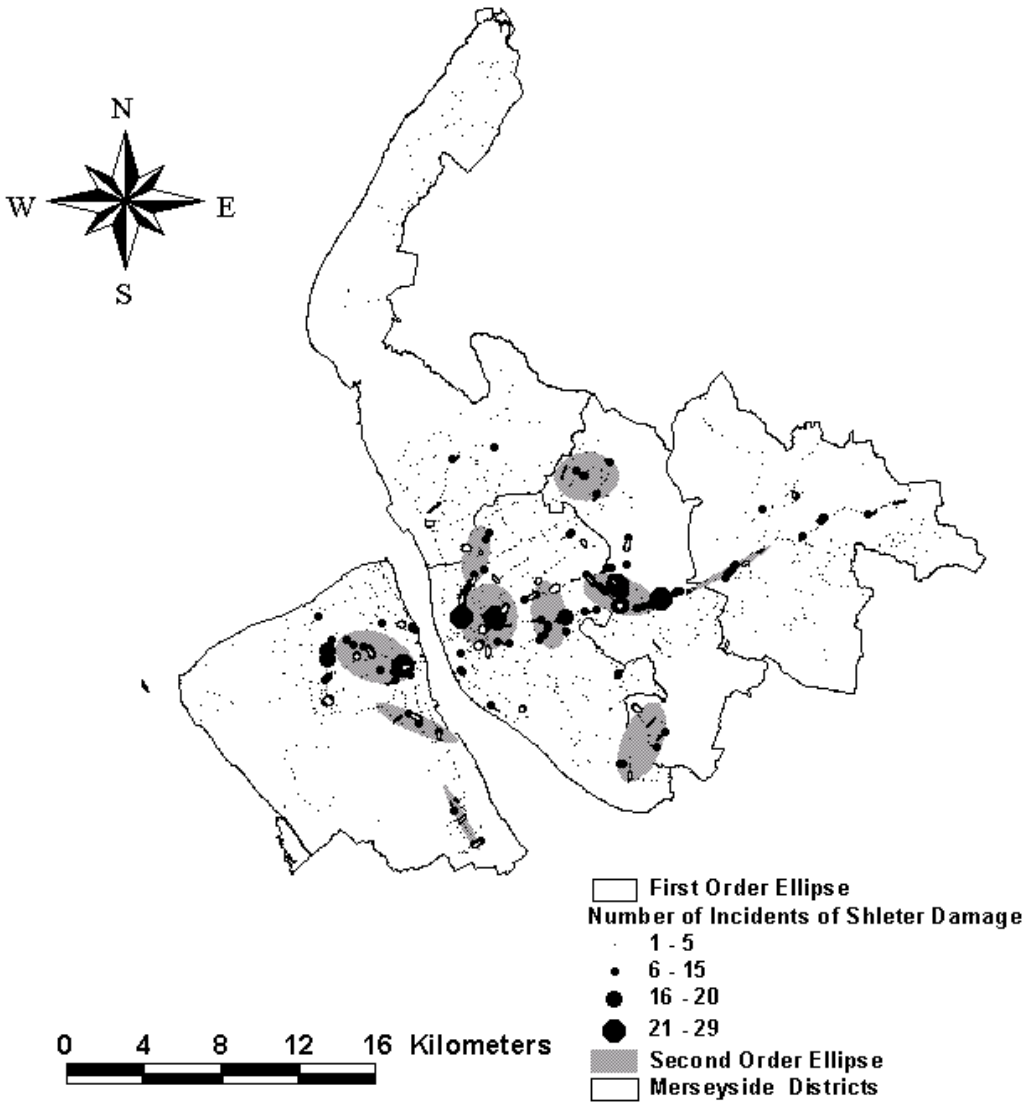


Figure A.2 Proportional Circles depicting incidents of bus shelter damage Jan to Dec 2000, with 1st and 2nd order Nearest Neighbour Hierarchical (NNH) Ellipses Overlaid.

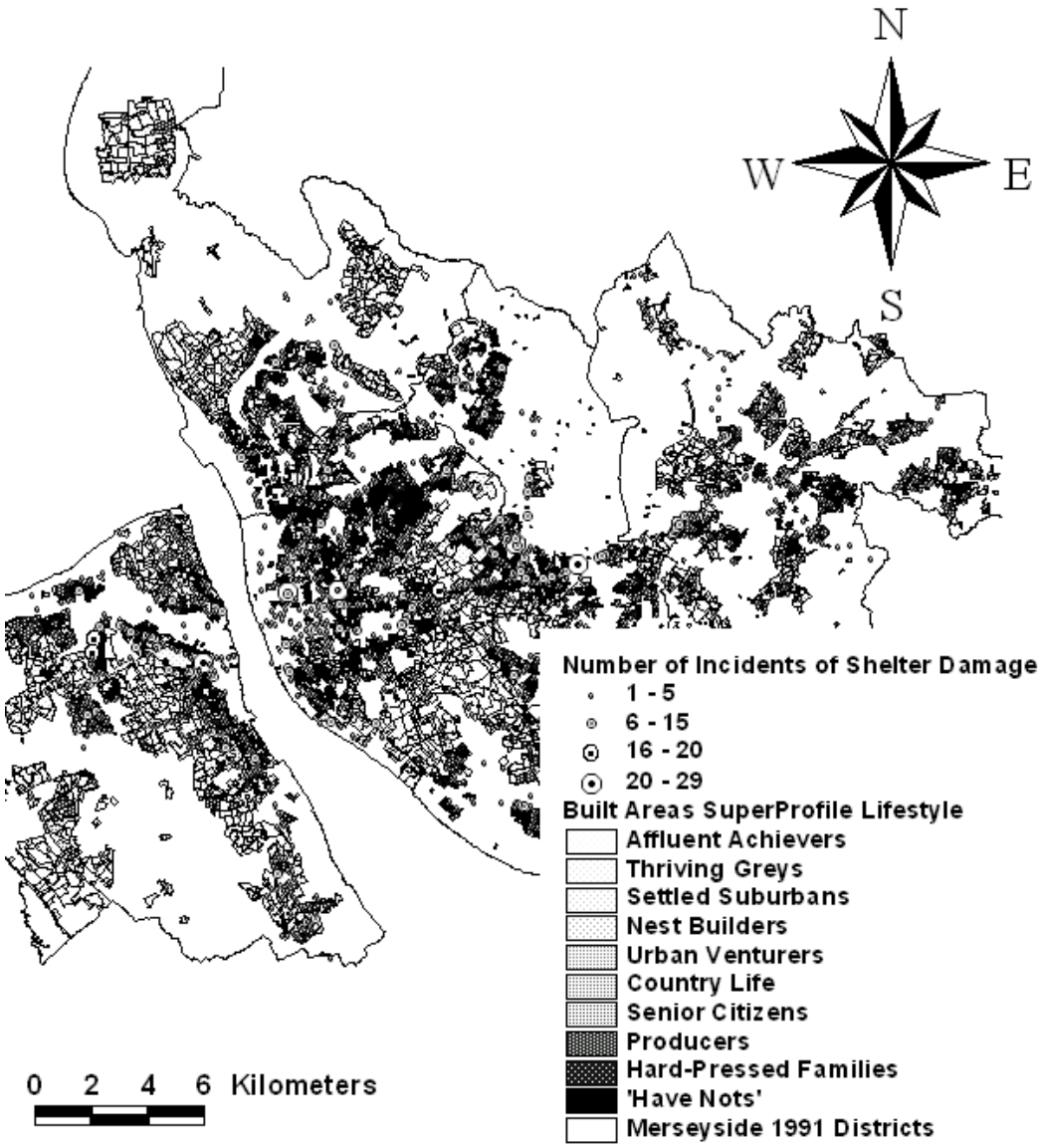


Figure A.3 Bus Shelter Damage Jan to Dec 2000 and SuperProfile Lifestyles for a section of Merseyside

Thus far the clustered distribution of bus shelter damage has been demonstrated, but the techniques applied provide no indication as to the extent to which incidents are concentrated at particular stops and or in particular areas. Resource Target Tables (RTTs) were produced to address this issue. An RTT was produced for all the stops on Merseyside (Appendix A.2). 20% of all shelter damage incidents occurred at 1% of all stops, 50% of all incidents at 5% of all stops and 100% of incidents at 25% of all stops over the year. In terms of targeting resources this implies that all of the damage occurred at one quarter of all the stops. However this includes all stop types including concrete poles, a type where it is assumed that little or no damaged can take place.

To allow for this a further RTT was constructed for shelters and conventional displays only, with the stop type 'concrete posts' excluded. (Table A.1). A concentration of damage is evident, with 20% of the damage occurring at 2.5% of all shelters, 50% of damage at 10% of all shelters and 100% of the damage at 58% of shelters. Therefore, one fifth of all damage occurred at 2.5% of all bus shelters, which in terms of volume equates to only 63 out of the 2556 bus shelters and CDs in Merseyside. The RTTs demonstrate that a concentration of shelter damage exists at particular stops and in certain areas and, when combined with a GIS, RTTs are a powerful tool in the identification and targeting of highly victimised stops.

Incidents per bus shelter	Number of bus shelters affected	Cumulative number of bus shelters	Cumulative number of incidents	Cumulative pecentage of bus shelters	Cumulative percentage of incidents
29	1	1	29	0.04	0.76
27	1	2	56	0.08	1.47
25	1	3	81	0.12	2.12
24	1	4	105	0.16	2.75
23	1	5	128	0.20	3.35
20	1	6	148	0.23	3.88
17	1	7	165	0.27	4.32
16	3	10	213	0.39	5.58
15	4	14	273	0.55	7.15
14	5	19	343	0.74	8.99
13	2	21	369	0.82	9.67
12	5	26	429	1.02	11.24
11	13	39	572	1.53	14.99
10	14	53	712	2.07	18.66
9	10	63	802	2.46	21.02
8	22	85	978	3.33	25.63
7	29	114	1181	4.46	30.95
6	33	147	1379	5.75	36.14
5	60	207	1679	8.10	44.00
4	89	296	2035	11.58	53.33
3	151	447	2488	17.49	65.20
2	290	737	3068	28.83	80.40
1	748	1485	3816	58.10	100.00
0	1071	2556	n/a	100.00	n/a

Table A.1 Resource Target Table for the Bus Shelter Damage on Merseyside, Jan to Dec 2000

The visual analysis suggests apparent relationships between criminal damage to bus shelters and its local environment, and further statistical analysis using bivariate correlations was deemed appropriate. This was to ascertain whether particular neighbourhoods or environmental factors display a degree of correlation with bus shelter damage. Appendix A.3 shows a detailed table of some selected results. It is evident from this that a positive correlation with the number of incidents of shelter damage is found for the percentage household lone parents, the percentage of an area open space, the percentage of youth unemployment, and the percentage of youths (age 15-25) in the area. All are significant at the 99% confidence level. These are possible indictors of a lack of capable guardianship and the presence of youths, and suggest they are important contributory factors to bus shelter damage. Interestingly, the percentage of male unemployment showed a negative correlation with incidents of bus shelter damage. This is possibly due to high unemployment as an indicator of low mobility. Clearly further analysis of these patterns is appropriate when attempting to implement crime reduction measures that design out crime. Examples of these include crime prevention through environmental design (CPTED) techniques (Pease, 1997).

Variables that provide information on passenger flows suggest there is a positive relationship between passenger numbers and bus shelter damage. Such a relationship is evident at the 99% confidence level for the following variables; the volume of passengers, percentage of households without a car, number of persons who travel to work on foot, and those who travel to work by car. Negative correlations are found between shelter damage and; the percentage households with one car, percentage home workers, percentage travel to work by car, and interestingly percentage travel to work by train, all significant at the 0.001 level. This adds weight to the claim that bus stops are crime generators. However, it is difficult to infer any causal relationships because data on other crime levels in the area would be required. The negative relationship with passengers using trains raises a number of questions. Does public transport facilitate, or displace crimes, for example? It is evident that information on damage to bus routes, train stations, train journeys and other mode of transport needs to be assembled and built into this system so that such issues can be explored more fully.

The police crime data supplied aggregated to ward level shows positive correlation with shelter damage, although this is a very generalised measure. Youths causing annoyance and recorded criminal damage displayed the most significant correlations with shelter damage. To understand this relationship further, crime would need to be analysed at finer levels of aggregation (at ED or using disaggregate data for example). This could be coupled with information about land use in the vicinity of individual bus stops, and local population levels as this may also vary by time of day. This could then provide further insight into whether bus stops act as crime generators, and, if so, for what types of crime and at what times of day?

The SuperProfile Lifestyle classification and the ILC both exhibit a positive relationship between levels of deprivation and levels of shelter damage, (significant at the 99% confidence level). To examine this further the number of damaged shelters that were located within each Lifestyle area were compared with the amount of damage that would be expected based on the number of shelters in each Lifestyle. Chi square analysis was used for this and the results are shown in Table A.2. The high positive relationship with ‘have-not’ areas is evident. ‘Hard pressed’ and ‘producers’ also experience greater than expected levels of shelter damage. In most affluent areas there is an under representation

of bus shelter damage. This suggests that there is a clear social gradient in the degree to which neighbourhoods are prone to shelter damage.

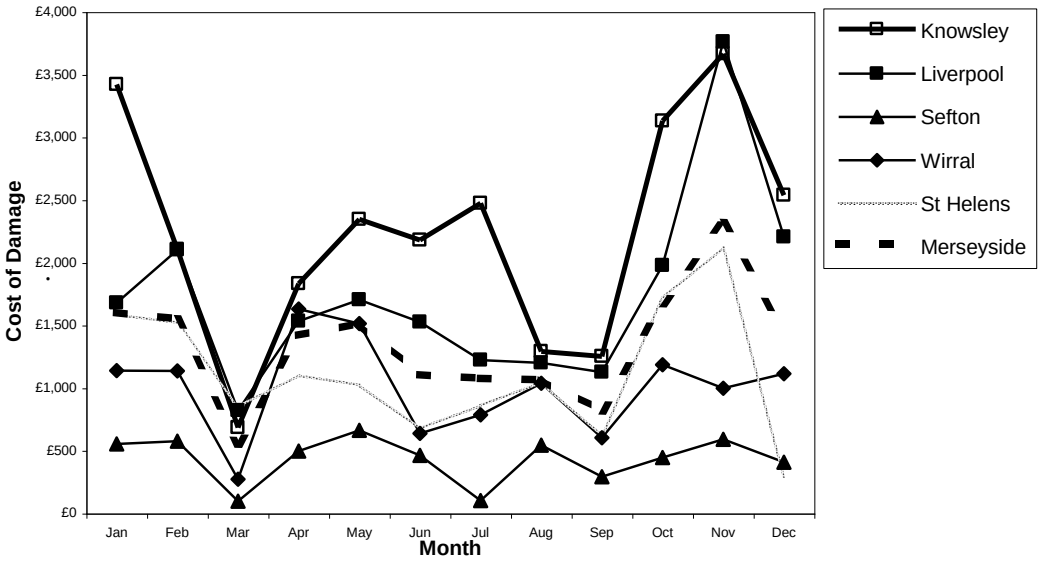


Figure A.4 Merseyside Shelter Damage 2000: Costs per 100 Shelters by District

Figure A.4 shows the cost of shelter damage per 100 shelters by month for 2000 for each of the 5 Merseyside districts. Although the district Liverpool, which contains the city centre, experiences a higher volume of incidents of shelter damage (Appendix A.4) the rate of damage per shelter is highest in Knowsley. A distinct peak in the damage occurs in October and November. This is probably attributable to Halloween, Mischief Night and Bonfire Night. In March and in the summer months a trough exists. One possibility is during school holiday's youths use buses and hence shelters less frequently, adding weight to the idea of shelters as crime generators. This data is only for one year, and hourly or daily variation plus comparisons with other years is desirable for future analysis.

Lifestyle	Number of damaged stops	Chi-square Value	Significance Level
Affluent Achievers	518	50.74(-)	0.001
Thriving Greys	617	34.71(-)	0.001
Settled Suburban	825	31.03(-)	0.001
Nest Builders	683	0.8(-)	ns
Urban Venturers	185	0	ns
Country Life	28	1.57(-)	ns
Senior Citizens	445	0.02	ns
Producers	769	9.09	0.001
Hard-Pressed	546	5.93	0.005
Have-Nots	1366	92.66	0.001

Table A.2 Correlation Coefficients for the Four Domains

A.7 CONCLUSION

This research has demonstrated the potential of the use of GIS, in combination with other techniques, to increase the knowledge of the nature and extent of criminal damage to bus shelters. It represents an initial attempt to develop a framework that should enable the identification of the levels and causes of crime and disorder on public transport. Such a framework should allow the testing of general theories of crime and disorder to see if they can be applied or adapted to explain crime on public transport.

This task could be improved by extending the range of data sets utilised in this research. For example information on crime on individual bus routes, distinguished by category and with information about time of day could usefully be added in the future. It is contended that this could then be combined with data relating to crime on other modes of transport. Data on land use at the individual stop level should also be associated. The understanding of crime on public transport systems could be further enhanced by adding more disaggregate contextual data on other crimes in the surrounding areas, and of local socio-demographic characteristics. Aspects of the physical infrastructure could be incorporated using OS landline data or aerial photographs.

This paper has presented preliminary evidence that damage at bus shelters is concentrated at particular stops and areas. Hot spot analysis, Resource Target Tables and GIS have been used to identify and target these 'high risk' stops and areas. There is evidence to suggest that particular neighbourhoods, socio-demographic influences and physical characteristics are more susceptible to shelter damage than others. Such areas include those in which high levels of deprivation are recorded, areas with large amounts of open space, and those with concentrations of youth populations. It is argued that this has implications for route planning and in tackling crime and disorder on public transport and is an area that warrants further research.

There is some evidence in support of the notion of bus stops as crime generators. It is possible bus stops act as generators of crime at certain times of the day and crime attractors at other times. This may also vary for different types of crime, for example criminal damage and robbery. Clearly further information on this is required. In summary this paper has demonstrated the importance of further research into crime and disorder on public transport. It suggests that bus shelter damage is related to its environment, and discusses how GIS and other crime mapping techniques can be combined to develop the knowledge of the extent of, and the theoretical reasons underlying, crime and disorder on public transport.

A.8 REFERENCES

Barlow, H. (1993). Introduction to Criminology. Harper Collins. New York

Block, R. and Davis, S. (1996). The Environs of Rapid Transit Stations: A focus for street crime or just a risky place? in Clarke, R. V. (Ed). Preventing Mass Transit Crime. Crime Prevention Studies Volume 6. Criminal Justice Press. Monsey, New York

Bowers, K. (1999). Crimes against non-residential properties: Pattern of victimization, impact upon urban areas and crime prevention strategies. Ph.D. thesis, the University of Liverpool.

Bowers, K. and Hirschfield, A. (1999). Exploring links between crime and disadvantage in north-west England: an analysis using geographical information systems. International Journal of Geographical Information Science. 13 (2) 159-184

Brantingham, P. & Brantingham, P. (1993) Environment, Routine and Situation: Toward a Pattern Theory of Crime, in Clarke, R. & Felson, M. (Ed). Routine Activity and Rational Choice. Advances in Criminological Theory Vol. 5. pp 259-294. Transaction Publishers. New Brunswick, New Jersey.

Brantingham, P. & Brantingham, P. (1995) Criminality of place: crime generators and crime attractors. European Journal on Criminal Policy and Research: Crime Environment and Situational Prevention. 3 (3) 5-26.

Brown, P. (1991). Exploring Geodemographics, in Masser, I. And Blakemore, M. (Eds). Handling Geographic Information : Methodology and potential applications. pp 221-258. Longman. London.

Brown, P. and Batey, P. (1994) Characteristics of Super Profile Lifetyle and Target Markets: Index tables, pen pictures and geographical distribution. Super Profile Technical Notes 2. (Liverpool: URPERRL, Department of Civic Design, University of Liverpool).

Brown, S., Colo, A., Lawless, D., Lu, X. and Rogers, D. (1998) Interdicting a Burglary Pattern: GIS and Crime Analysis in the Aurora Police Department, in LaVigne, N & Wartell, J. Crime Mapping: Case Studies. pp 99-108. Police executive Research Forum (PERF). Washington D.C.

Buerger, M., Cohn, E. and Petrosino, A. (1995) Defining the “Hot Spots of Crime”: Operationalising Theoretical Concepts for Field Research, in Eck, J. and Weisburd, D. (Eds.) Crime and Place: Crime Prevention Studies, Volume 4. pp 237-258. Willow Tree Press. New York.

Chainey, S. and Reid S. (2002). When is a Hotspot a Hotspot? A Procedure for Creating Statistically Robust Hotspot Maps of Crime in. Kidner, D.B et al. (eds.), Innovations in GIS 9: Socio-Economic Applications in Geographical Information Science. Taylor and Francis.

Clarke, R. (1992) (Ed). Situational Crime Prevention : Successful Case Studies. Harrow and Heston. New York

Cohen,L. & Felson, M. (1979). Social Change and Crime Rate Trends: A routine activity approach. American Sociological Review, 44, 588-608.

Cornish, D. and Clarke, R. (1986). The Reasoning Criminal : Rational Choice Perspectives on Offending. Springer Verlag. New York.

Crime Mapping Research Centre (1998) Hot Spots: An exploration of methods. www.udoj.gov/cmrc

Department of the Environment (1995). 1991 Deprivation Index. A review of approaches and a matrix of results. HMSO. London

Department of the Environment, Transport, and the Regions (1998). White Paper on the Future of Transport. HMSO. London.

Department of the Environment, Transport, and the Regions (1999). Young People and Crime on Public Transport. HMSO London.

Eck, J. and Weisburd, D. (1995) Crime Places in Crime Theory, in Eck, J. and Weisburd, D. (Eds.) Crime and Place: Crime Prevention Studies, Volume 4. pp 1-34. Willow Tree Press. New York.

Home Office Statistical Bulletin 18/00. The 2000 British Crime Survey . England and Wales.

Johnson, S., Bowers, K. and Hirschfield, A. (1997). New insights into the spatial and temporal ditribution of repeat victimization. British Journal of Criminology. 37 (2) 224-241.

Jupp, V., Davies, P. and Francis, P. (eds.) Doing Criminological Research. Sage.

LaVigne, N. (1997). Visibility and Vigilance: Metro's situational approach to preventing subway crime. Washington, DC: National Institute of Justice.

Levine, N., Wachs, W., and Shirazi, E. (1986). Crime at Bus Stops. A study of environmental factors. Journal of Architectural and Planning Research, 3(4), 339-361.

Loukaitou-Sideris, Anastasia. (1999). Hot Spots of Bus Stop Crime. The importance of environmental attributes. Journal of the American Planning Association, 65 (4), 395-411.

Martin. D. & Longley, P. (1995) Data sources and their geographic integration, in Longley, P. & Clarke, G. GIS for Business Service Planning. pp 15-32. Wiley and Sons. New York.

McEwen, T. & Taxman, S. (1995) Applications of Computerised Mapping to Police Operations, in Eck, J. and Weisburd, D. (Eds.) Crime and Place: Crime Prevention Studies, Volume 4. pp 259-284 Willow Tree Press. New York.

Openshaw, S. & Taylor, P. (1981). The modifiable unit areal problem, in Wrigley, N. & Bennett, R. (Eds). Quantitative Geography : A British View. pp 60-69. Routledge and Kegan. London.

Pearlstein, A., & Wachs, M. (1982). Crime in Public Transit Systems. An environmental design perspective. Transportation, 11, 277-297.

Pease, P. (1997) Crime Prevention, in Maguire, M., Morgan, R. and Reiner, R. (eds.) The Oxford Handbook of Criminology. Clarenden Press. Oxford.

Ratcliffe, J. and McMullagh (1998). Identifying repeat victimization with GIS. British Journal of Criminology. 38 (4) 651-662

A.9 APPENDICES

Appendix A.1 Super Profile Lifestyle Pen Pictures

A short description of each Lifestyle provides some idea of the distinguishing characteristics of these geodemographic groups based on the interpretation of an index

table comparing the mean value of a selection of variables for each cluster with the corresponding mean value for the country as a whole. Taken from Brown and Batey (1994). Lifestyles are alternatively numbered 1 to 10.

Lifestyle A : Affluent Achievers

High income families, living predominantly in detached houses. The Affluent Achiever typically lives in the stockbroker belts of the major cities, and is likely to own two or more cars, which are top of the range recent purchase and relied on for pursuit of an active social and family life. This type of person has sophisticated tastes. They eat out regularly, go to the theatre and opera and take an active interest in sports (e.g. cricket, rugby union and golf). In addition they can afford several expensive holidays every year. Financially aware, with a high disposable income, Affluent Achievers often invest in company shares and or/specialised accounts. They use credit and charge cards frequently, and are likely to private health insurance. Investments are followed closely in broadsheets such as the Financial Times, The Times and the Telegraph. Other magazines bought may include Hello, Harpers & Queen, and Vogue.

B: Thriving Greys

Generally older than Affluent Achievers, possibly taking early retirement, the thriving Greys are also prosperous. Their detached or semi-detached homes have been completely paid for, and children have grown up and left home. Therefore the greys have money to spare for investments or spending, on items such as a superior car. They eat out regularly, take one or two holidays a year, and are likely to play and enjoy going to the theatre. This group are also financially aware and may invest in the stock exchange, and /or purchase health insurance. The Thriving Greys read the broadsheets as well as more traditional magazines, such as Women's Realm and Woman and Home.

C: Settled Suburbans

Well-established families in generally semi-detached suburban homes. Settled Suburbans are employed in white collar and middle management positions, while in addition many wives work part-time. The lifestyle is fairly affluent, in that one or two package holidays a year may be taken, and the family can afford to purchase newer cars. They have taken advantage of government share offers in the past and often use credit cards. Many are mail order agents. Typical publications read include the Daily Mail, The Express, Ideal Home and Family Circle.

H: Producers

These more affluent blue collar workers live in terraced or semi-detached housing. Many are middle aged or older and their children have left home. The Producers work in traditional occupations and manufacturing industries, where unemployment has risen to a significant level. Most are well settled in their homes, which are either purchased or rented from the council. Leisure pursuits include going to the pub and betting on horse races. On TV, football and rugby league are the preferred sports. They do not spend money on cars and there is little planning for the future by way of financial investments. The Sun, The Mirror, and The News of the World are the most popular newspaper.

I: Hard – Pressed Families

Living in council estates, in reasonably good accommodation, unemployment is a key issue for these families. Most work is found in unskilled manufacturing jobs, if available, or on Government schemes. The parochial nature of this group is emphasised by an unwillingness or inability to either move home or go on holiday. The most popular leisure activities are betting and going to pubs and clubs. On TV, sports such as football and rugby league are watched. Tabloids, particularly The Sun, The Mirror and The Daily Record are the chosen daily papers.

J:'Have Nots'

Single parent families composed of young adults and large numbers of young children, living in cramped flats. These are the underprivileged who move frequently in search of a break. However, with two and a half times the national rate of unemployment, and with low qualifications, there seems little hope for the future. Most are on Income Support, and those who can find work are in low paid, unskilled jobs. There are very few cars and little chance of getting away on holidays. Recreation comes mainly from the television and the take up of satellite and cable TV is high. Betting is also popular, particularly greyhound racing. The Sun and The Mirror are the most popular newspapers.

Appendix A.2 Resource Target Table for all Shelter Types

Incidents per bus stop	Number of bus stops affected	Cumulative number of bus stops	Cumulative number of incidents	Cumulative percentage of bus stops	Cumulative percentage of incidents
29	1	1	29	0.02	0.76
27	1	2	56	0.03	1.47
25	1	3	81	0.05	2.12
24	1	4	105	0.07	2.75
23	1	5	128	0.08	3.35
20	1	6	148	0.10	3.88
17	1	7	165	0.12	4.32
16	3	8	181	0.13	4.74
15	4	11	228	0.18	5.97
14	5	15	287	0.25	7.52
13	2	21	369	0.35	9.67
12	5	26	429	0.43	11.24
11	13	39	572	0.64	14.99
10	14	53	712	0.88	18.66
9	10	63	802	1.04	21.02
8	22	85	978	1.41	25.63
7	29	114	1181	1.88	30.95
6	33	147	1379	2.43	36.14
5	60	207	1679	3.42	44.00
4	89	296	2035	4.89	53.33
3	151	447	2488	7.39	65.20
2	290	737	3068	12.19	80.40
1	748	1485	3816	24.55	100.00
0	4563	6048	n/a	100.00	n/a

Appendix A.3 Bivariate Correlation Results

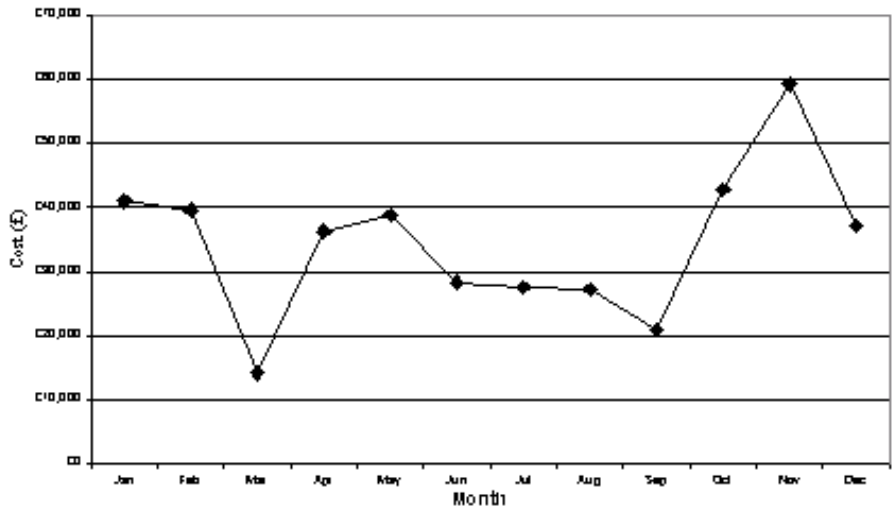
Potential Indicators of deprivation, lack of guardianship									
		Super Profile Lifestyles	**ILC Decile**	**Male Unemployment**	**Youth (16-19) Unemployed**	**% open space**	**% lone parents**	**%youths (15-24)**	**% young adults (25-44)**
Number of incidents of bus shelter damage	Spearman's rho	**.228	**.219	**-.07	**.145	**.242	**.165	**.077	*-.044
	Sig. (2-tailed)	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.038
	N	2925	2925	2925	2925	2925	2925	2925	2925

Indicators of passenger volumes									
		Passengers	**% household no car**	**% household 1 car**	**% Home workers**	**% Travel to work on foot**	**% Travel to work by car**	**% Travel to work by bus**	**% Travel to work by train**
Number of incidents of bus shelter damage	Spearman's rho	**.342	**.231	**-.207	**-.075	**.071	**-1.54	**.177	**-.083
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	.-001	0.000	0.000	0.000
	N	2925	2925	2925	2925	2925	2925	2925	2925

Indicators of other crime levels								
		Command and Control Youths Causing Annoyance	**Command and Control Disorder**	**Recorded Crime Criminal Damage**	**Recorded Crime Drugs**	**Recorded Crime Other violence**	**Recorded Crime robbery**	**Recorded Crime all crime**
Number of incidents of bus shelter damage	Spearman's rho	**.542	**.526	**.505	**.428	**.499	**.485	**.468
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N	118	118	118	118	118	118	118

**.Correlation is significant at the .01 level (2-tailed).
*.Correlation is significant at the .01 level (2-tailed).

Appendix A.4 (a) Merseyside Shelter Damage Jan – Dec 2000 (Cost per Month)



Appendix A.4 (b) Merseyside Shelter Damage 2000. Cost per District per Month