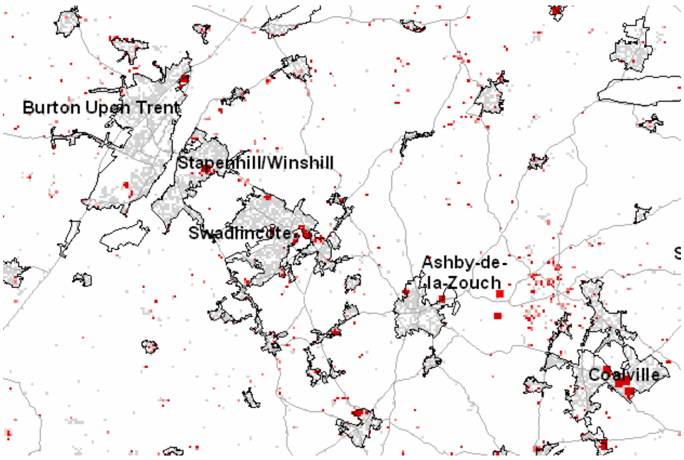
Appendix 1: Smoothing

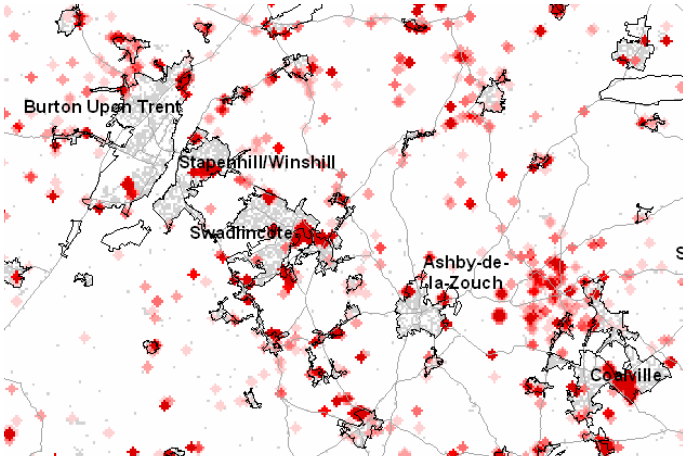
A1.1 The grids can be visualised in a number of manners to suit the particular need. Measured densities depend upon the scale at which they are measured. As areas are extended, for example, more areas of open space may be included and average densities will decline. Thus, different scales of generalization may be productively used for particular purposes. For example, while an 800 metre smoothing may be suitable for viewing an overall national view, identification of individual sites would not be possible. A large scale strategic view may be achieved by large scale smoothings (such as in the order of say three to ten kilometres).

A1.2 The following example illustrates different level of smoothings applied to the same LUCS data.

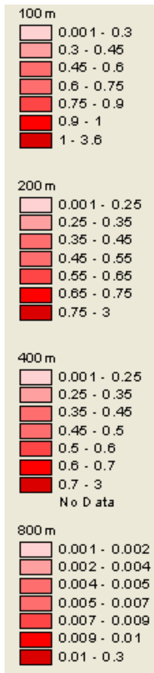
Figure A1.1: Various scaled smoothing applied to Lucsrulconr (developed / re-developed for built uses only on land that hasn't been previously developed for housing use only)

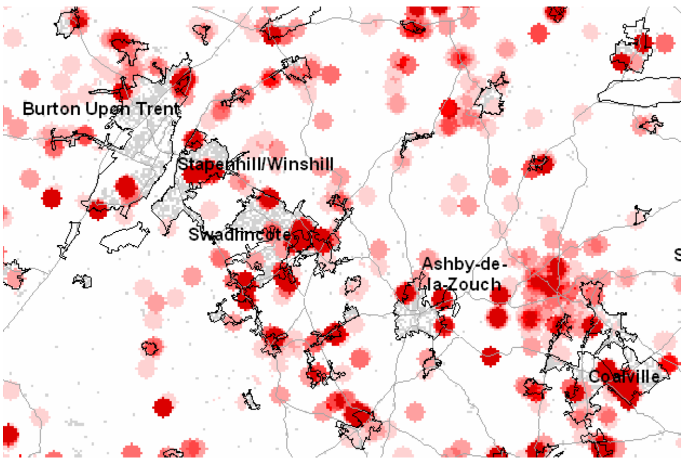


a) No smoothing applied

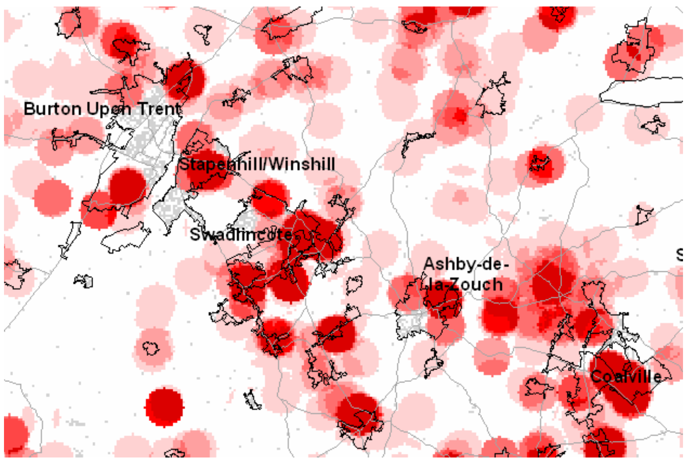


b)Smoothing at 200m





c) Smoothing at 400m

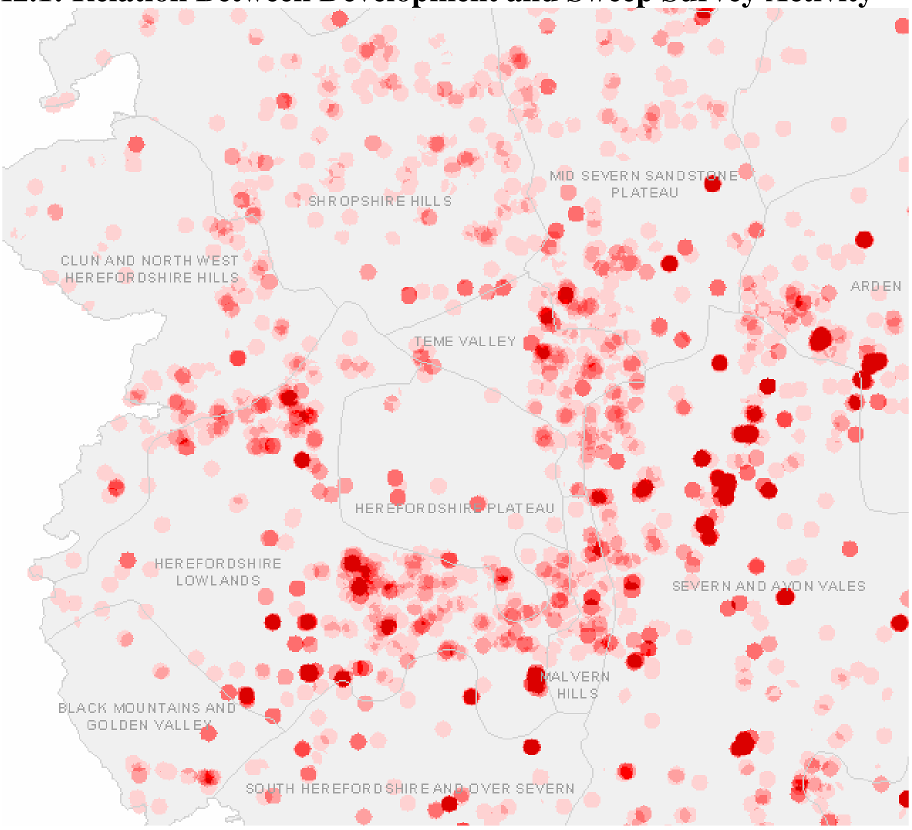


d) Smoothing at 800m

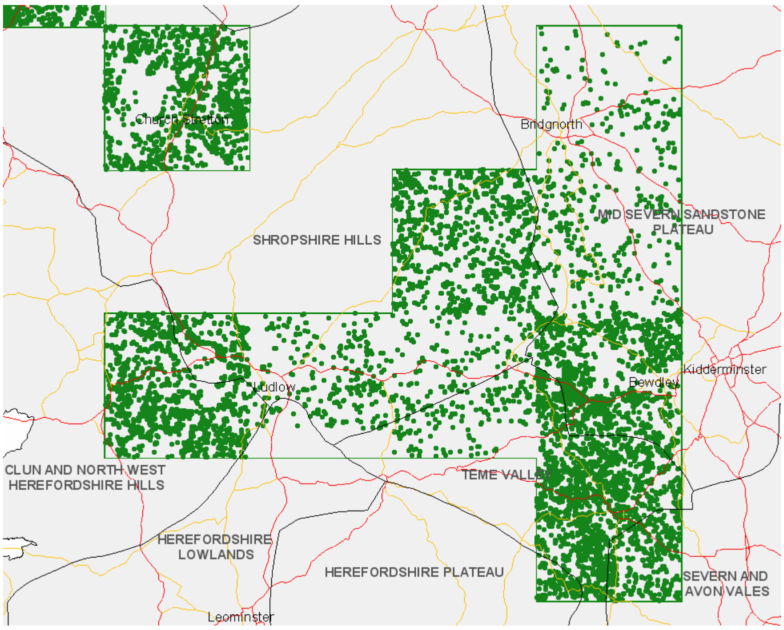
Appendix 2: Relationship between Units and Land Within LUCS, in Low-Density Areas

A2.1 This possibility seems strongest in the Herefordshire case. It seems likely that areas of land recorded as changing to residential use *may* be inflated through sweep survey evidence. Certainly there is an important relation between variation in the area of land recorded as passing to residential use and the intensity of sweep survey activity (see Figure A2.1).

Figure A2.1: Relation Between Development and Sweep Survey Activity



a) Apparent _| shape in the level of residential development

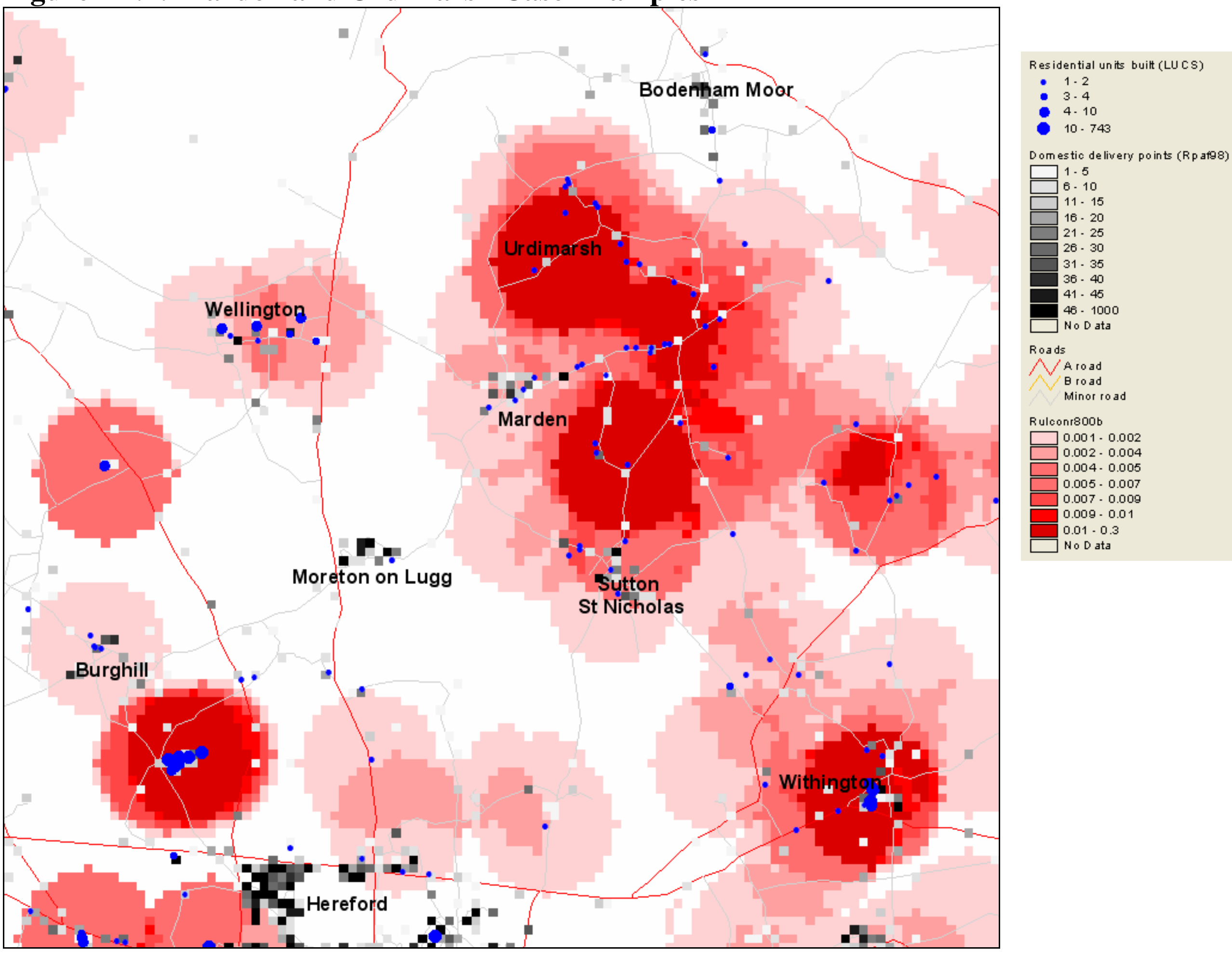


b) Differing intensities of sweep activity within the 10km2 swept blocks

A2.2 As suggested above, there is no clear evidence that the numbers of units built in this Herefordshire area is over-recorded. This would suggest that within sweep survey, either the curtilages of new properties are substantially over-estimated, land transfers from agricultural use to uses such as an ornamental garden, or that land is recorded as passing into residential use albeit without houses when the use is in fact of a different type.

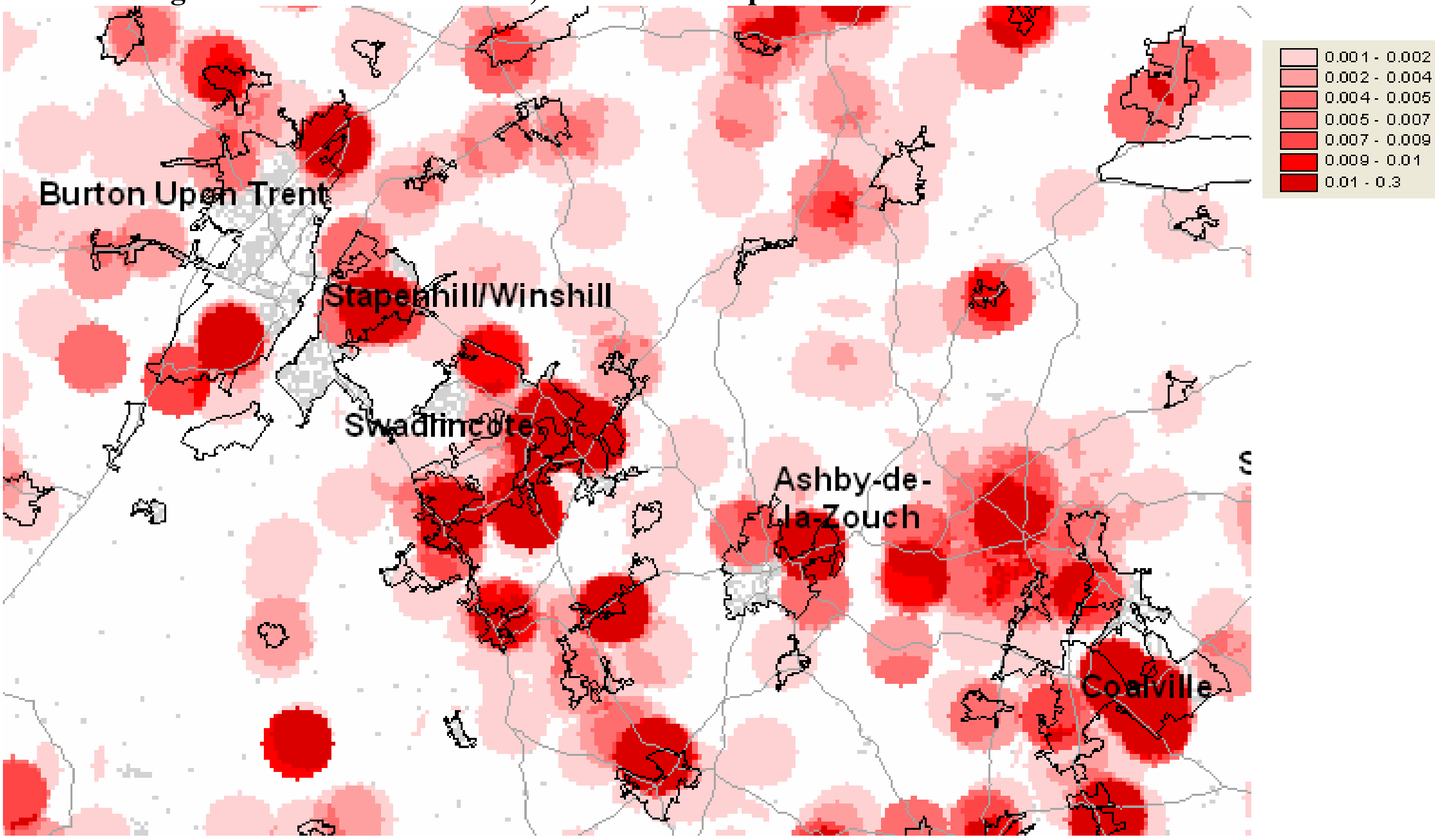
A2.3 Area *a* , around Marden in the Herefordshire Lowlands (see Figure A2.2), includes 13.22 hectares of land developed in associated with the construction of 35 dwellings (2.65 dwellings to the hectare). To the north of Marden, around Urdimarsh, six separate LUCS events together record the construction of one dwelling on 2.1 hectares.

Figure A2.2: Marden and Urdimarsh Case Examples

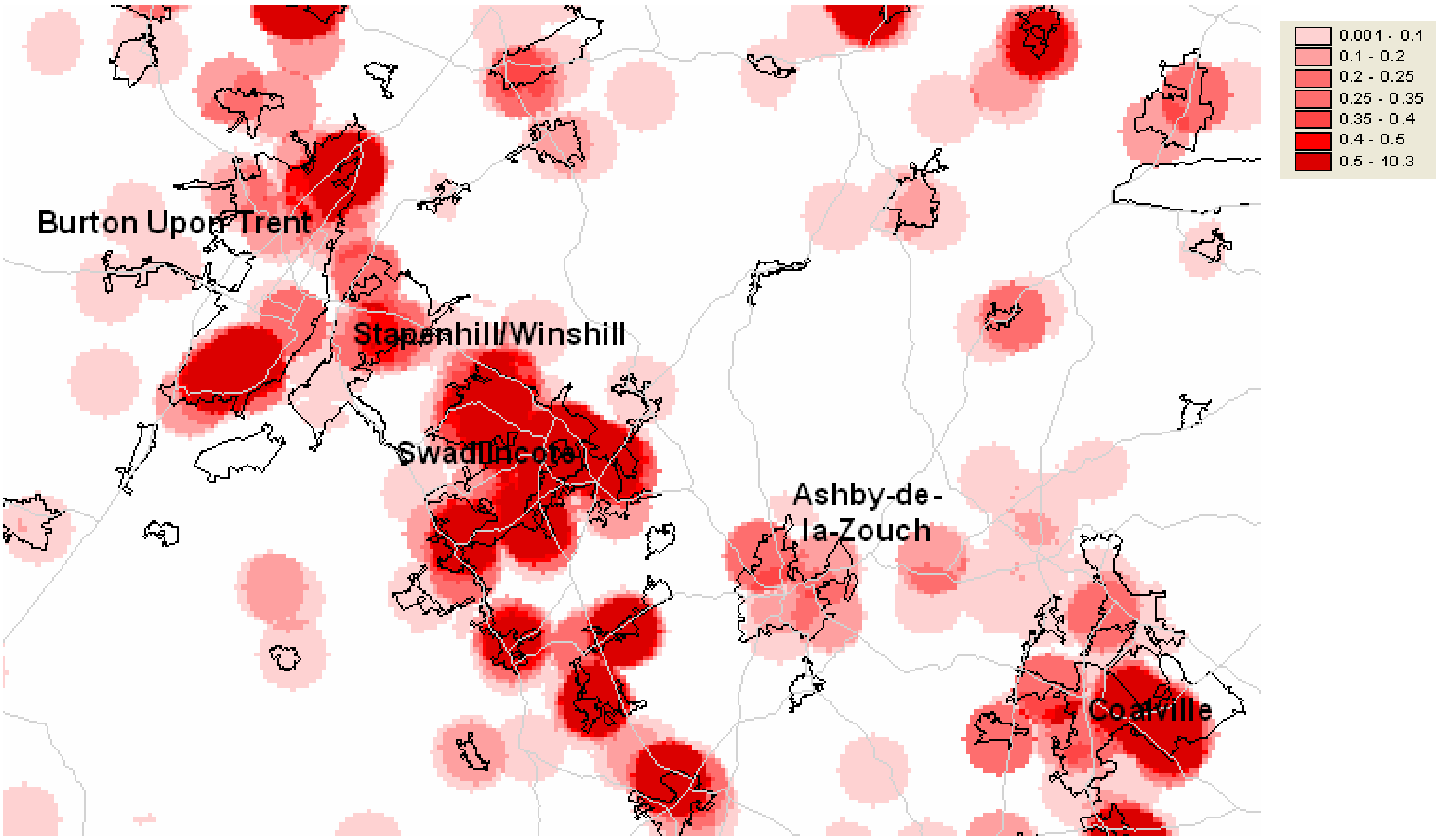


A2.4 This issue is also apparent in a number of different localities, most notably The Wash, Kerrier District of Cornwall, and an area to the north-west of Coalville. This last example is illustrated in Figure A2.3

Figure A2.3: Lucsrulconr800, Coalville Example



a) land



b) units

Appendix 3: On Reconciling PAF and LUCS

A3.1 This net change in dwellings recorded in PAF, say X, depends upon the number of dwellings built (in principle recorded in LUCS) and the number gained through conversion of existing property (net of allowances for demolitions and losses of units through amalgamation of properties):

$$X = B + C - D - A$$

where X is the net change in numbers of dwellings recorded in PAF,
B is the number of units built in the period 1998-2003
C is the total number of units gained through conversion of existing property
D is the number of demolitions in the period 1998-2003 and
A is the number of units lost through amalgamation of residential properties and change to non-residential use

A3.2 In this section, only X and B will be treated as directly observable, the other components being conflated into a residual, G, representing the net gain in dwelling units not involving new construction:

$$G = C - D - A$$

A3.3 In principle, G may be either positive (where the nature of demand for property prompts an increase in numbers of units through conversion), or negative (where demolition, amalgamation of properties or change to non-residential use predominates). Across England generally, the negative adjustments tend to outweigh the positive ones, the net change in dwellings over the period (614,000) appearing substantially less than the number of new units recorded in LUCS (808,000). Figure A3.1a captures place to place variation in G. It shows in shades of blue areas where losses of dwellings through amalgamation, demolition, or change to non-residential uses comfortably exceed upwards adjustment through conversion (where the residual is less than -0.03 units per hectare). Those areas depicted in shades of red are ones where net gains through conversion appear to augment the flow of new dwellings through new construction (generating values of G in excess of 0.03 units per hectare. To focus on the possibility of under-recording of new building at the urban fringe, Figure A3.1b masks out the urban domain. This figure focuses solely on areas where G exceeds 1 or is less than -1 units per hectare. This allows examination of those areas where there seems a real chance that new construction might be under-recorded. The differential tendency to net conversion is important in understanding any tendency to more intense property utilisation in the countryside, and is considered further in Section 3.

A3.4 For the present, concern is limited to using G to identify potential under-recording of new dwellings in LUCS. Any such under-recording would have the effect of inflating G (while any errors leading to recording excess units built in LUCS would depress its value). The possibility that LUCS under-records housebuilding activity in the rural domain, especially at the urban fringe is potentially important for understanding landscape change. It is potentially signalled where the net change in residential delivery points is substantially greater than the number of new dwellings started as recorded by LUCS.

A3.5 The possibility of under-recording might be assessed by forming an estimate of the maximum possible value of G, by means of a thought experiment. Recalling the components of G (in para A3.1), it is clearly possible that the number of demolitions in any locality would be zero. Similarly, it is possible that the number of losses of residential units to non-residential use would be zero. In such circumstances, the gap between the number of new dwellings started (as recorded by LUCS) and the net change in the number of residential delivery points must be accounted for by the net gain in residential units from conversion. This clearly is limited by the scale of the stock of dwellings at risk of conversion, in circumstances of most pertinence to the Countryside Quality Counts project (ie at the urban fringe) there will be a minimal number of dwellings potentially available to convert.

A3.6 Consider the maximum possible gain from conversion. Assume initially that at a maximum, one house in five is demolished and replaced by five houses. (This might be extremely high but plausible in a high demand area of villa-suburbs). If there were 100 houses in 1998, twenty might cease to be in single occupation, but their conversion to flats might yield 100 more units would be built, producing 180 units in total in 2003. This would allow net conversions to generate an 80% increase in the number of dwellings. In a suburb laid out in a yet more extensive manner, conversion of one property in ten would imply the loss of ten dwellings but if they were replaced by ten smaller units in each case, this would generate 100 dwellings producing a total of 190.

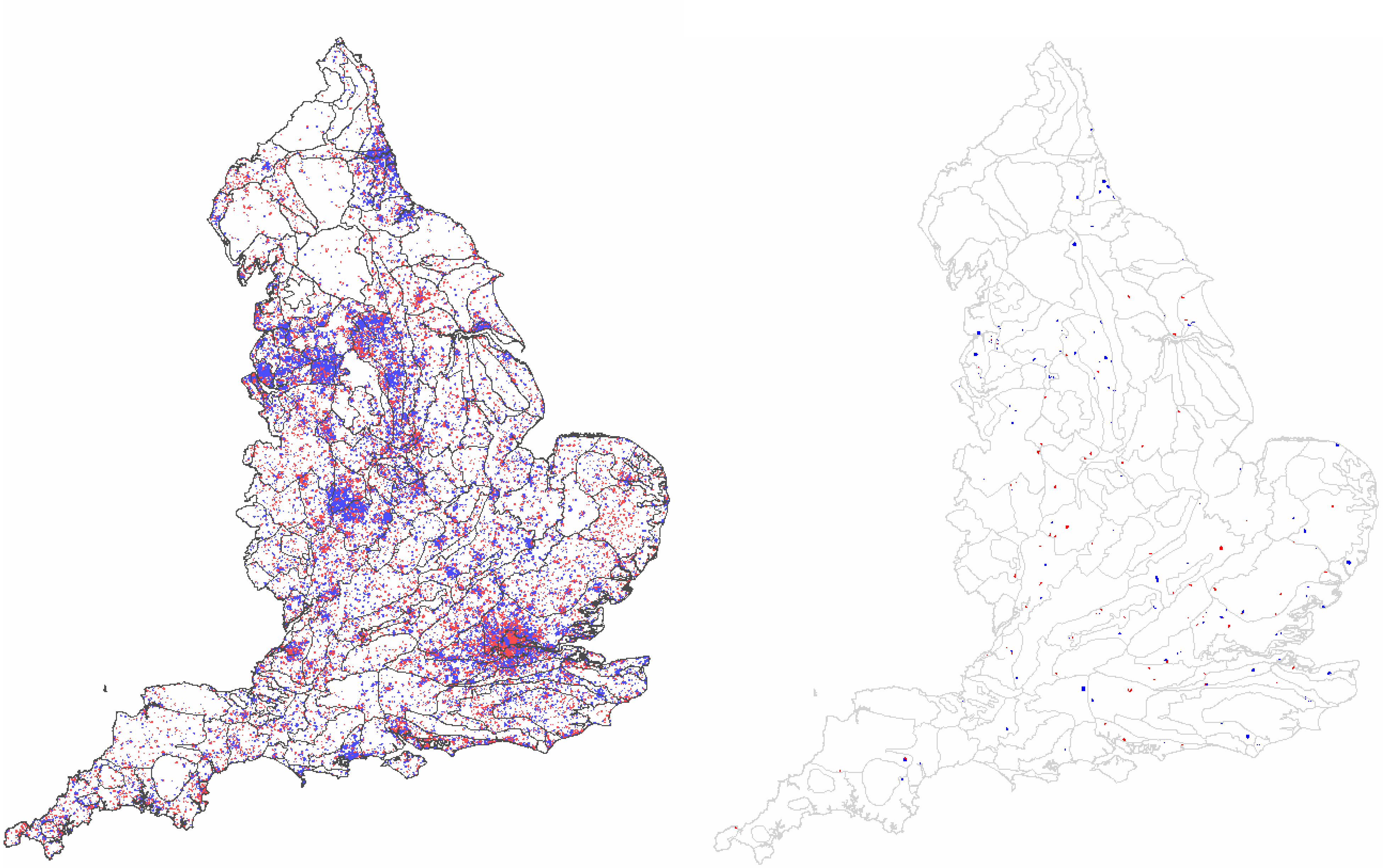
A3.7 More modestly, one might assume that one house in twenty were demolished and replaced by five smaller units. (Again this might be plausible in a high demand area of villa-suburbs). If there were a hundred houses in 1998, five would be demolished and twenty more would be built, producing a hundred and fifteen in total. This would allow net conversions to generate a fifteen percent increase in the number of dwellings.

A3.8 These two thought experiments imply quite different plausibility tests suggesting that an upper-limit on conversion might be either 15% or 90% of stock. Of course the fundamental principle that a stock of houses must exist to convert is the same for both cases. For present purposes, the greatest concern is at the urban fringe or beyond, where the existing stock of dwellings is very small. In fact, using a cut-off of either 15% or 90% serves to identify areas where new construction seems to be under-recorded in LUCS. Thus in Figure A3.2a, the areas highlighted are those within England's rural domain where new build appears under-recorded on a 15% conversion assumption, while Figure A3.2b shows those areas highlighted under a 90% conversion assumption. Locations where G is greater than 0.1 using the 90% cut-off (Figure A3.2b) are listed in Table A3.1.

Table A3.1 : Locations for cells greater than 0.1 using 90% cut-off

Name	Joint Character Area	Name cont.	Joint Character Area cont.
Bromsgrove	Arden	Chapeltown	Nottinghamshire, Derbyshire and Yorkshire Coalfield
Redditch	Arden	Stoke On Trent	Potteries and Churnet Valley
Shirley	Arden	Droitwich	Severn and Avon Vales
Cambourne	Bedfordshire and Cambridgeshire Claylands	Hardwicke	Severn and Avon Vales
Leighton Buzzard	Bedfordshire Greensand Ridge	Portishead	Severn and Avon Vales
Devizes	Berkshire and Marlborough Downs	Tewkesbury	Severn and Avon Vales
Bradley Stoke	Bristol, Avon Valleys and Ridges	Stone	Shropshire, Cheshire and Staffordshire Plain
Emersons Green	Bristol, Avon Valleys and Ridges	Wick	South Coast Plain
Cannock	Cannock Chase and Cank Wood	Chandler's Ford	South Hampshire Lowlands
Barton Le Clay	Chilterns	Fareham	South Hampshire Lowlands
Hemel Hempstead	Chilterns	Long Stratton	South Norfolk and High Suffolk Claylands
Heathcote	Dunsmore and Feldon	Braintree	South Suffolk and North Essex Clayland
Basingstoke	Hampshire Downs	Bury St Edmunds	South Suffolk and North Essex Clayland
Ledbury	Herefordshire Lowlands	Chelmsford	South Suffolk and North Essex Clayland
Beverley	Holderness	Harlow	South Suffolk and North Essex Clayland
Driffield	Holderness	Stevenage	South Suffolk and North Essex Clayland
Leyland	Lancashire and Amounderness Plain	Bollington	South West Peak
Liverpool	Lancashire and Amounderness Plain	Bracebridge Heath	Southern Lincolnshire Edge
Euxton	Lancashire Valleys	Ipswich	Suffolk Coast and Heaths
East Leake	Leicestershire and Nottinghamshire Wolds	Farley Hill	Thames Basin Heaths
St Georges	Mid Severn Sandstone Plateau	Fleet	Thames Basin Heaths
Telford	Mid Severn Sandstone Plateau	Epsom	Thames Basin Lowlands
Headington	Midvale Ridge	Bracknell	Thames Valley
Swindon	Midvale Ridge	Staines	Thames Valley
Mickleover	Needwood and South Derbyshire Claylands	Tedburn St Mary	The Culm
Tadworth	North Downs	Ely	The Fens
Sittingbourne	North Kent Plain	Hilton	Trent Valley Washlands
Northampton	Northamptonshire Vales	Witney	Upper Thames Clay Vales
Cheshunt	Northern Thames Basin	Witney	Upper Thames Clay Vales
Enfield	Northern Thames Basin	Haxby	Vale Of York
St Albans	Northern Thames Basin	Meltham	Yorkshire Southern Pennine Fringe
Watford	Northern Thames Basin	Brough	Yorkshire Wolds

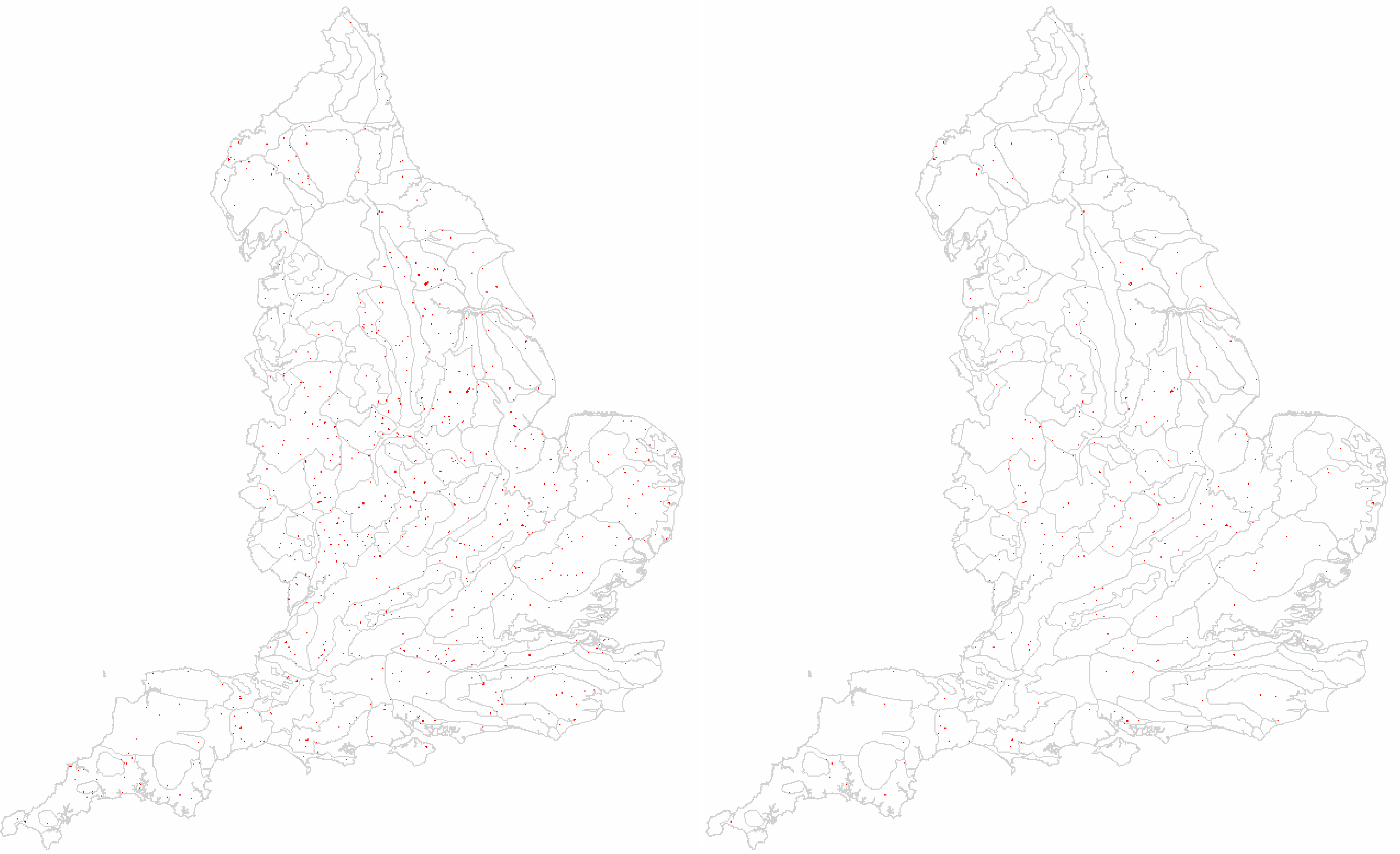
Figure A3.1: Place to place variation in G



a) G greater than 0.03 or less than -0.03

b) G greater than 1 or less than -1

Figure A3.2: Identifying areas where new construction seems to be under-recorded in LUCS



a) Greater than 0.1 using 15% cut-off

b) Greater than 0.1 using 90% cut-off

Appendix 4: Woodland Loss: Procedures and Progress

A4.1 Estimation of indicators of woodland loss on the basis of the Land Use Change Statistics (LUCS) forms a distinct block of work within the current project. LUCS provides unrivalled highly detailed information about land use change. Any use of LUCS, however, must take account of its origin as a by-product of Ordnance Survey's ongoing activity of updating basic scale maps. Usually survey activity is motivated by one of two imperatives; either by responding to built development under continuous revision or by programmed sweep (supported by Government).

A4.2 Woodland loss might be recorded under either circumstance. Some loss of woodland will be recorded in LUCS as part of OS's programme of continuous revision (where it arises from major road improvements for example). In the second case it would arise as a result of honouring commitments to government that map cover in 'rural' areas (ie those surveyed at 1:2500) should be revised within a five year period, while that of 'mountain and moorland areas' should be surveyed within a ten year period as part of programmed sweep survey.

A4.3 Not all woodland loss will be recorded in LUCS (even allowing for accidental oversight). Estimation of woodland loss involves considering three (conceptual) components. The first is that recorded under continuous revision. It will be assumed here that the timeliness of continuous revision is such that any change which should have been recorded under continuous revision will have been picked up by the second quarter of 2005, and so it will be treated as providing complete coverage of targeted change. (This assumption is considered further later). The second component is woodland loss recorded under sweep survey. This will be regarded (initially) as providing complete coverage of loss (other than that recorded in continuous revision) over the period from the beginning of 1998 until the time of the most recent sweep survey (where such survey has taken place)). The third component is unobserved change of a character that should be picked up in sweep survey. (It is assumed that it has remained unobserved simply because of the timing of programmed sweep survey. The third component must be estimated by reference to a rate of loss.

A4.4 The volume of sweep survey activity varies substantially from year to year in response to OS management decisions (as illustrated in Figure A4.1). Fortuitously, a particularly large volume of land use change records were generated as a result of OS sweep activity in 2004 implying that where sweep survey has taken place since 1998, all change in the period of interest is disproportionately likely to have been captured.

A4.5 More precisely, defining q_{cy} as the probability that a change in a given tile c taking place in a given year *goes unobserved,* the overall estimate of woodland loss in cell c in year y, is given as

$$L_{cy} = R_{cy}+q_{cy}\,W_{cy}r_{cy}$$

where

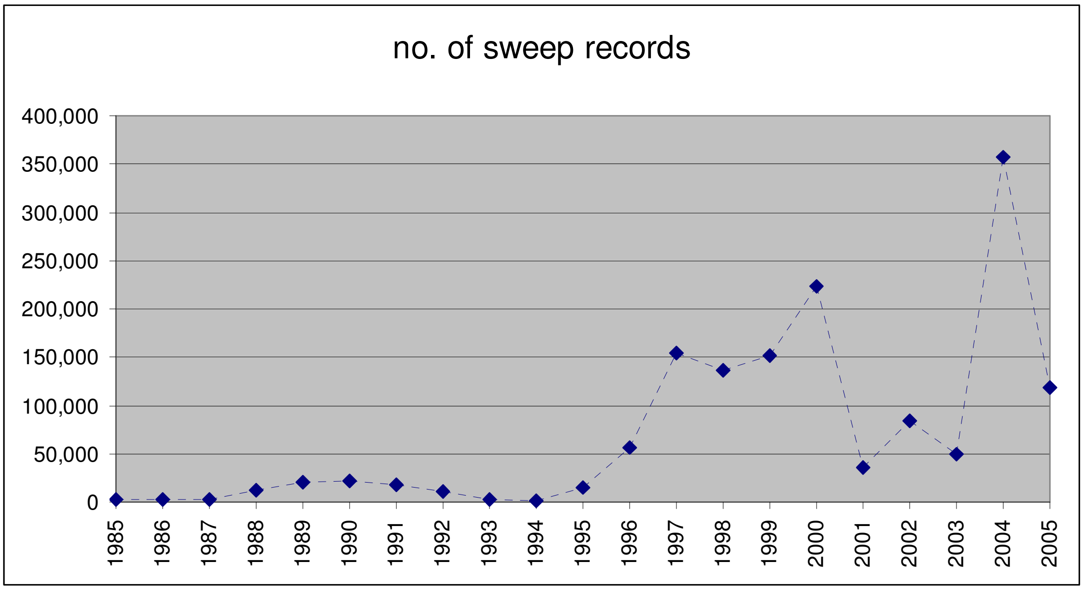
$$q_{cy}=1- p_{cy}$$

and

R_{cy}	is the loss of woodland in cell c in year y recorded within LUCS
q_{cy}	is the probability that woodland loss in year y goes unobserved before in the period up to 2004Wand
W_{cy}	is the stock of woodland in cell c in year y,
r_{cy}	is the estimated rate of unobserved woodland loss appropriate to cell c and year y
p_{cy}	is the probability that loss of woodland occurring in cell c in year y is recorded in LUCS

A4.6 Estimation therefore provides two related challenges. The first lies in estimating the probability, $p_{cy,}$ that change in any cell will have been recorded under sweep survey. This entails knowing when 10km blocks have been swept. The second is estimating on this basis rates of loss, r_{cy} that might be extrapolated to areas that have not been swept in the period between 1998 and 2003 or where sweep coverage occurred before 2004 (implying that the available information is incomplete. Following these estimations, absolute loss recorded under the continuous revision loss can be added in.

Figure A4.1: Sweep Survey Activity (by survey year)

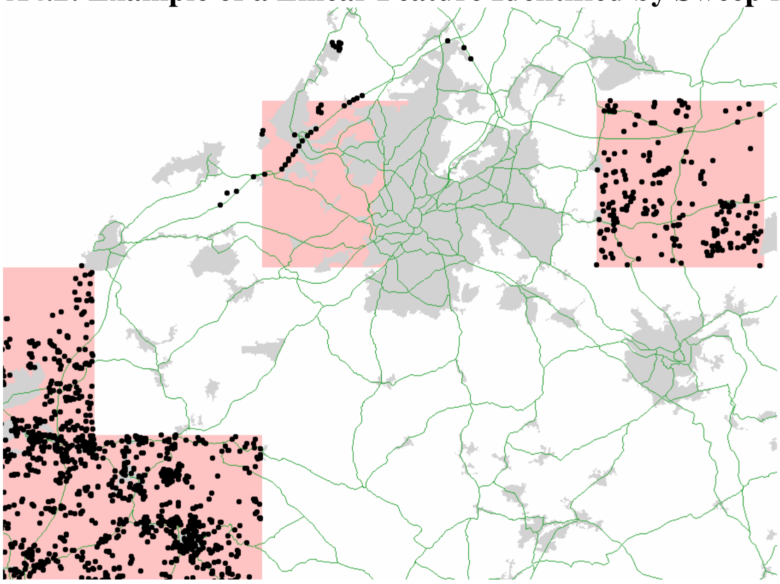


Estimating the Probability that Woodland Loss will be observed under Sweep Survey

A4.7 Sweep survey is undertaken covering 10km by 10km blocks. In principle, therefore, if there exists within LUCS one sweep-derived record for a block, it might be inferred that the whole block has been swept, and the date of the sweep will be apparent from the individual records. On this basis, the probability of any woodland loss being observed in a given hectare cell in a given year p_{cy} would be 1 if it was in such a block and zero otherwise. This suggests a simple procedure for estimating p_{cy}.

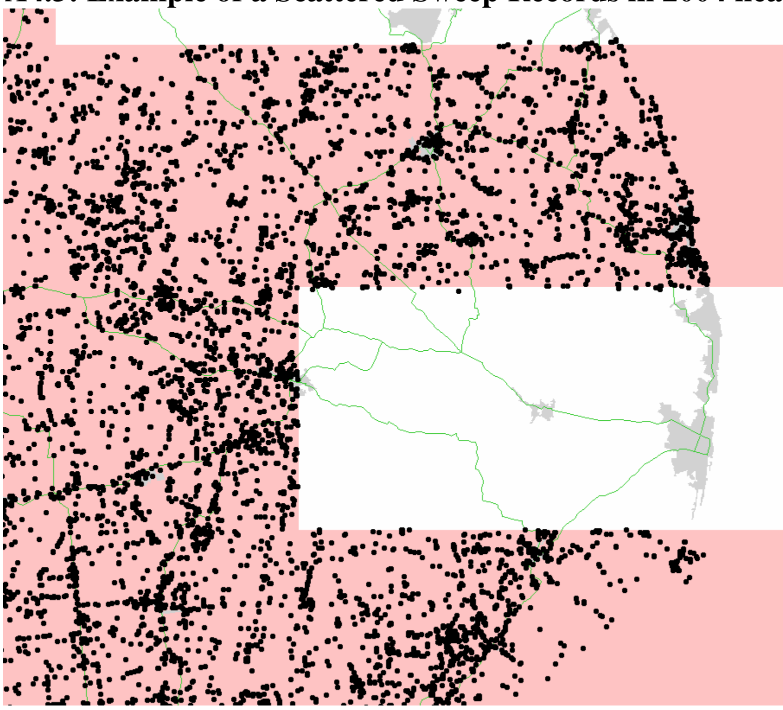
A4.8 In practice, the situation is more complex. It seems appropriate to modify the estimation procedure somewhat. Inspection of LUCS records flagged as collected under the sweep regime shows that they may not in fact be dispersed over 10km blocks as the principle implies. They may even follow the line of major road improvements (see Figure A4.2). (It thus seems likely that despite their coding that they have been generated under continuous revision). It would clearly be inappropriate to allow any such data to enter into estimation of unobserved loss.

Figure A4.2: Example of a Linear Feature Identified by Sweep in 2004 Near Bristol



A4.9 Inspection of the scatter of records generated under sweep survey reveals, moreover, that there is a tendency to capture further change in *areas which immediately abut swept blocks*. This presumably occurs because the limits of topographic features are not coincident with map sheet boundaries (see Figure A4.3). In contrast to the cases discussed in para, A4.8 these are presumably best regarded as genuinely arising from archetypal sweep survey.

Figure A4.3: Example of a Scattered Sweep Records in 2004 near Skegness

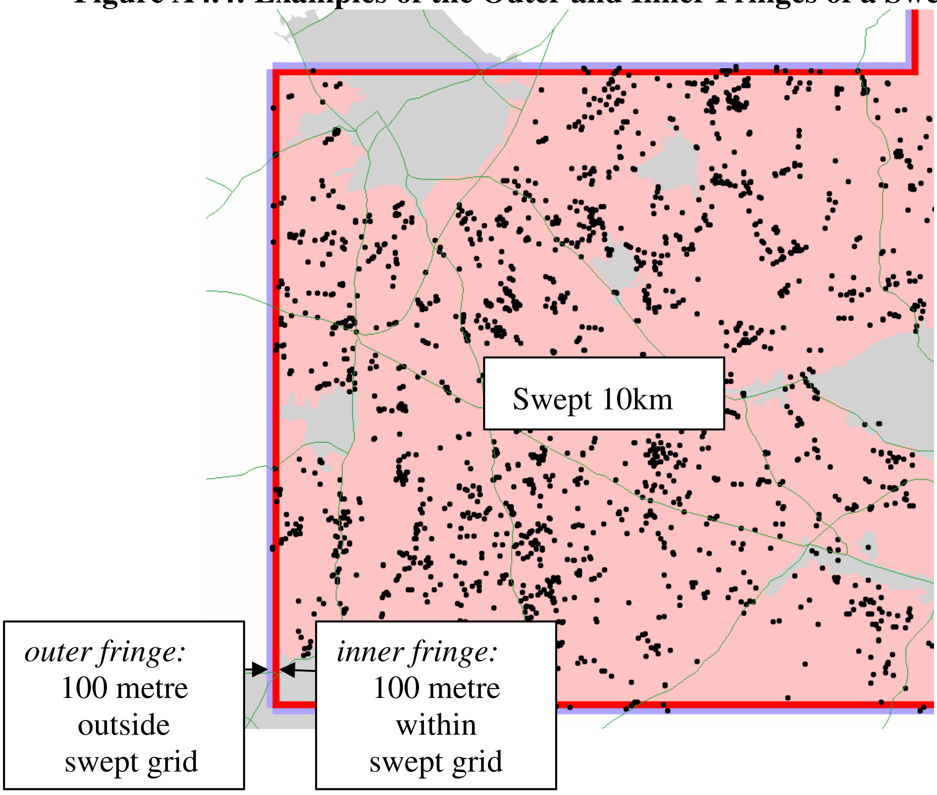


A4.10 Given the foregoing, it has seemed appropriate first to distinguish records recorded as generated under sweep from idealized or 'archetypal sweep' as described in para A4.7, and to reclassify LUCS data accordingly. (It should be noticed that 98.26% of records recorded as generated into sweep are treated as archetypal sweep; but the difference is far from trivial because of the spatial spread of the minority of records and their implications for probability estimation). The estimation principles set out in para A4.3 have therefore been applied using 'archetypal sweep' rather recorded sweep. Second, it seems important to take some account of the tendency for change to be recorded in areas that abut swept blocks, and to assign change in such cells some (non-zero) probability of being recorded.

A4.11 Given the remarks of para A4.9, there should be some relation between the size of a parcel whose use is changing, its distance from the swept block, and the probability of being recorded under sweep. Grids were therefore prepared to examine change firstly in the area within 100 metres of blocks subject to archetypal sweep, and secondly within 500 metres of such blocks. The overwhelming majority of sweep records (80.14%) found on the outer fringe of swept blocks fall within 100metres of the edge of the particular swept block. (This set of hectare cells immediately abutting (and outside) blocks swept in particular year is referred to below as the *outer fringe* for that year, see Figure A4.4).

A4.12 A simple expedient was therefore adopted for estimating probabilities of being recorded under archetypal sweep. To deal with the size relation a simple distinction was made between developed and undeveloped parcels (the latter tending to be larger). An undeveloped parcel is here defined as one changing to or from a use within the set {A,D,F,G,M,N,O,W,Y}. The total area of change recorded in such parcels in the outer fringe can be compared with the area recorded in what might be termed the *inner fringe* (the outermost hectare cells within swept blocks). Given the assumption that the probability of change being observed in a swept block is 1, the probability of being observed in the outer fringe can be estimated by the ratio of the area of change recorded in the outer fringe to the area recorded in the inner fringe. This yields a value of 0.252.

Figure A4.4: Examples of the Outer and Inner Fringes of a Swept Grid



A4.13 The probability that a change occurring between 1997 and year y (y<2004) within an undeveloped parcel will be recorded under sweep survey can therefore be estimated by considering the relation to the year of the most recent sweep of that cell. Denoting the year for which the estimate is required as y; denoting the year when cell c was last subject to sweep survey s_c and the year in which it last formed an outer fringe f_c, the probabilities p_{cy} can be estimated as:

$$p_{cy}= \begin{cases} 0.0 & y>s_c; y>f_c & \text{not swept} \\ 0.252 & y>s_c; f_c>y & \text{outer fringe} \\ 1.0 & s_c>y & \text{swept} \end{cases}$$

where p_{cy} is the probability that loss of woodland occurring in cell c in year y will be represented by one or more sweep records in LUCS. On this basis, hectare grids were constructed showing probabilities that woodland loss would be recorded under sweep for 1998, 1999, 2000, 2001, 2002 and 2003 referred to as P1998 to P2003 respectively.

Estimating *Rates* of Woodland Loss for Swept Areas and for Unobserved Loss

A4.14 Setting aside particular data difficulties which are considered below, estimation of the loss of woodland observed under archetypal sweep is straightforward. Using the grids P1998 to P2003, it is, moreover, immediately possible to generate a further set of grids -Q1998 to Q2002- showing the probability that woodland loss in cell c in year y will have gone unobserved (q_{cy}=1- p_{cy}).. It is necessary to estimate loss in these cells by applying estimated rates to the stock of woodland in each cell.

A4.15 The difficulty here lies in finding way of estimating appropriate rates. Four approaches at once present themselves. The first would attempt to understand the circumstances of woodland loss and to consider the probability that such circumstances would have occurred within a particular set of tiles. The second entails attempting to estimate a rate of loss as a geographic moving average calculated by reference only to tiles subject to archetypal sweep and imputing unobserved change in year y on the basis of ‘nearby’ change in the same year. The third approach would attempt to extrapolate rates of loss for a particular cell in year y on the basis of measures obtained sweep for the same cell. The fourth approach would involve some combination of the other methods. The following paragraphs consider their respective merits.

A4.16 The first approach involves an examination of the circumstances of woodland loss *observed under sweep survey* and the forces which motivate it. It appears that over the period since 1985, loss of woodland has tended to involve change of use to undeveloped uses (95.6% of the total) with agriculture predominant, as illustrated in Table A4.1. (Interpretation of this result should acknowledge that this is the rate of loss under sweep survey, and that change to built uses or transport infrastructure should be expected to be recorded under continuous revision). It should also be recognized that this deals with the *gross* loss of woodland reported rather than the net loss (thus while 44179 hectares were recorded under sweep survey as changing from woodland to agriculture, 58101 hectares changed gross from agriculture to woodland. This mix of uses to which land is put after woodland has been lost has remained relatively stable over time.

Table A4.1: Woodland Loss by LUCS Categories

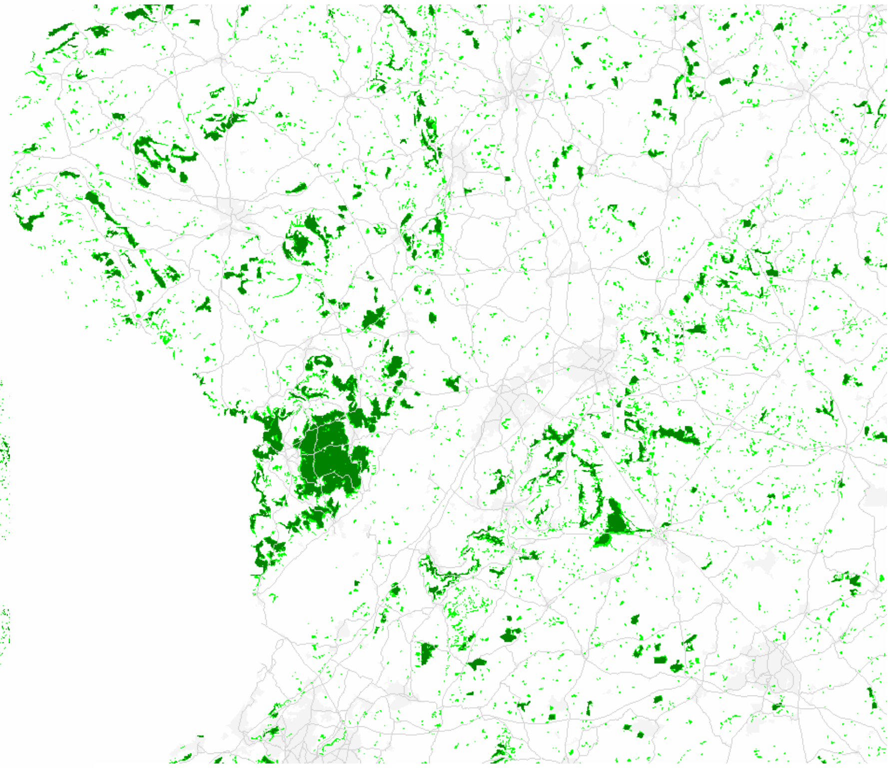
		Total hectares Lost	Percent of Total Lost
Agricultural Land	**A**	44179	70.2
Agricultural Buildings	**B**	564	0.9
Community Buildings	**C**	148	0.2
Defence	**D**	86	0.1
Rough Grassland and Bracken	**G**	9476	15.1
Highways and Transport	**H**	438	0.7
Industry	**I**	103	0.2
Offices	**J**	7	0.0
Retailing	**K**	25	0.0
Leisure and Recreational Buildings	**L**	325	0.5
Minerals	**M**	1083	1.7
Natural and Semi-Natural	**N**	2281	3.6
Outdoor Recreation	**O**	1493	2.4
Institutional & Communal Accommodation	**Q**	50	0.1
Residential	**R**	1129	1.8
Storage and Warehousing	**S**	66	0.1
Transport (other)	**T**	55	0.1
Utilities	**U**	68	0.1
Vacant Land Not Previously Developed	**V**	175	0.3
Water	**W**	973	1.5
Urban Land Not Previously Developed	**X**	16	0.0
Landfill Waste Disposal	**Y**	156	0.2
Derelict Land	**Z**	25	0.0

A4.17 As policy and financial support tend to favour change from agriculture to woodland rather than visa versa, it is difficult to identify exogenous pressures which would account for variation in the types of change evident in para A4.16. For this reason, it would seem unwise to attempt to estimate rates of woodland loss on the basis of analyses of their causes. Given that (despite overall trends) the prime cause of woodland loss is conversion to agriculture it would seem more appropriate to attempt to understand differences in rates of woodland loss by reference to geographic variation. At present, however, work on estimation of rates is suspended pending clarification of particular issues in connection with LUCS data.

Estimating Woodland Stocks

A4.18 Before rates can be calculated of course, it is necessary to draw information about stocks of woodland. For the purpose of this study rates woodland stocks were estimated using hectare grids prepared for work originally undertaken for the Department of Environment, Food and Rural Affairs (Defra). That work explicitly set out to explore the degree of consistency between the measures of woodland stock provided by Landcover Map 2000 (LCM), the National Inventory of Woodland and Trees (NIWT) and Ordnance Survey's Meridian (OSM) and to develop procedures for reconciling them. (This work is described further in Appendix Five). It generated a series of grids. These woodland grids are illustrated in Figure A4.5.

Figure A4.5: Woodland Stock Grids



a) for England b) for inset of Forest of Dean and surrounding area

A4.19 As indicated in para A4.4, very substantial sweep survey activity was undertaken for OS in 2004. Sweep records created in that year suggest that 19,488 hectares of woodland were lost (gross) between 2000 and 2003 in areas subject to archetypal sweep. The estimated stock of woodland as of 2000 in cells subject to sweep survey in 2004 amounts to 325,146 hectares implying a rate of gross loss of 5.99% over that period (or 1.50% per annum).

A4.20 Geographic variation in the rate of woodland loss between 2000 and 2003 implied by 2004 archetypal sweep survey is illustrated in Figure A4.6. This has been constructed by geographic averaging, generalizing both the component of loss recorded in LUCS and the woodland stock at the 2km scale. It should be noted that the computation underlying Figure A4.6 only takes account of either loss or stocks in cells which were subject to sweep survey in 2004. Cells not swept in 2004 are masked out.

A4.21 Figure A4.6 provides some suggestion of a degree of coherent variation in woodland loss with the south-west peninsular clearly showing lower estimated rates that much of the east of England. Construction of Figure A4.6 however, highlights significant problems with at least part of the LUCS data. Figure A4.7 identifies areas where the recorded loss of woodland in the period 2000-2003 exceeds the estimated stock in 2000, and the estimated stock exceeds 100 square metres. As the figure mapped is a geographic average, this implies that within a 2km radius of a particular cell there is at least 100 square metres of woodland for each hectare of land (i.e. in an area of 12.57km centred on the cell, the estimated stock of woodland is at least 12.57

hectares).

Figure A4.6: Smoothed Woodland Loss (2km) for 2004 Archetypal Sweep Survey

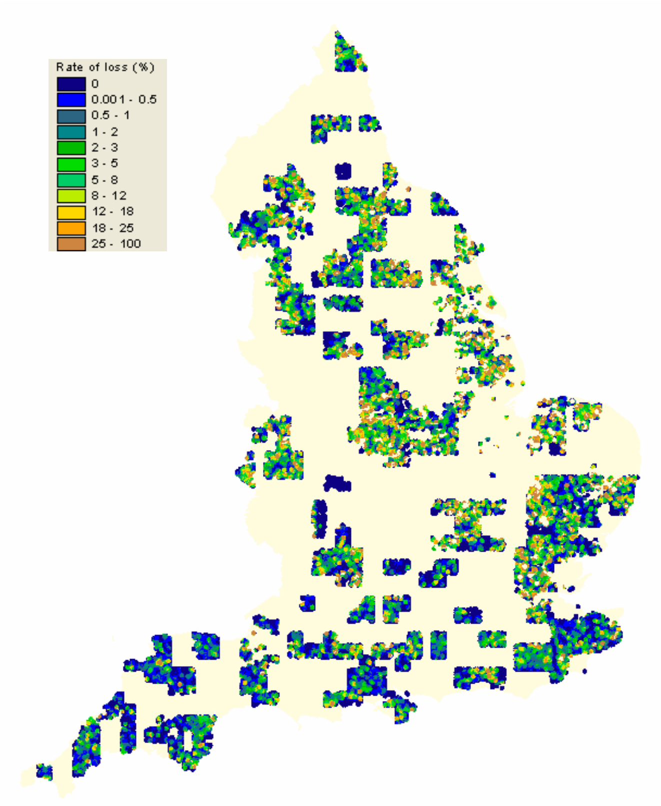
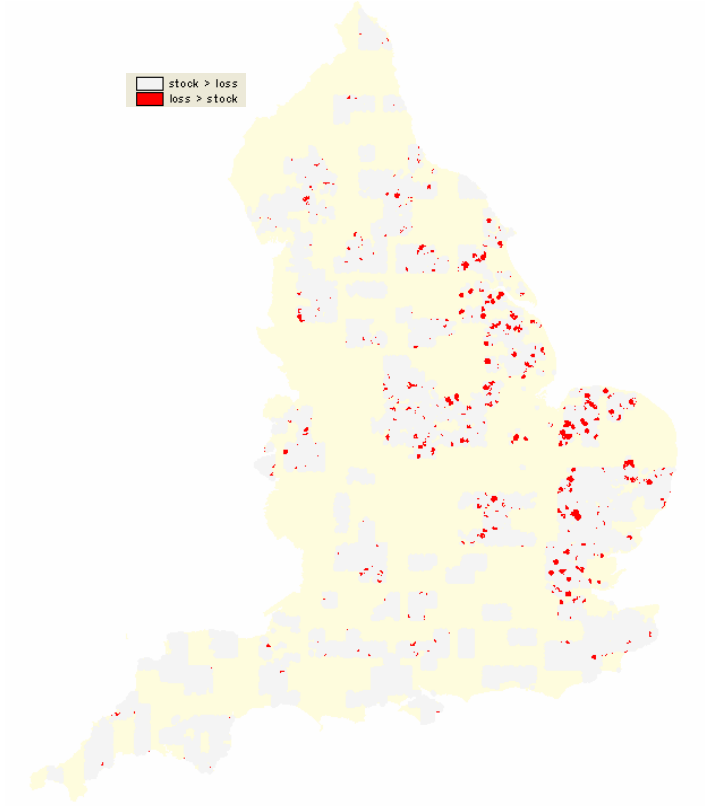


Figure A4.7: Smoothed Woodland Loss (2km) for 2004 Archetypal Sweep Survey, Areas Where Loss Exceeds Stock



A4.22 The areas shown in Figure A4.7 therefore appear to have quite implausible recorded losses even taking account of computational issues that might arise when both loss and stock were very small. The most obvious potential explanation is that the stock data are flawed. Detailed examination of particular areas, however, show that **none** of the woodland sources (ie NIWT, Meridian, LCM) indicate sizable stocks of wood in these situations. Moreover, examination of maps for 1985 at a scale of 1:10,000 does not indicate any woodland cover. This is illustrated in Appendix Six. The example in the appendix deals with an area of less than 5km square, to the north-east of Downham Market, where LUCS records in excess of 280 hectares of woodland loss but no significant stocks are recorded. It appears that it may have been possible to interpret air photographic evidence as suggesting the presence of woodland but this does not seem to have been reflected in map cover.

A4.23 While it would be possible to remove sites from the LUCS data where they are inconsistent with all three sources of woodland stock information, we are hesitant to do this. Doubt about the integrity of data removed must inevitably raise doubt about the integrity of data remaining. It would therefore seem wise to be clear about the circumstances in which such difficulties arise (having regard to OS's photo-interpretation arrangements) before considering estimation of rates of loss further.

Appendix 5: Previous Work on Woodland Grids (Stock)

A5.1 For the purpose of this study rates woodland stocks were estimated using hectare grids prepared for work originally undertaken for the Department of Environment, Food and Rural Affairs (Defra). That work explicitly set out to explore the degree of consistency between the measures of woodland stock provided by Landcover Map 2000 (LCM), the National Inventory of Woodland and Trees (NIWT) and Ordnance Survey's Meridian (OSM), and to develop procedures for reconciling them. The framework depends upon drawing out logical links between data items, and using these links to assess the attributes of tiles.

A5.2 Land Cover Map 2000 (LCM2000, Figure A5.1) is the first full survey of UK land cover at such spatial and thematic resolutions (Fuller *et al*, in press). Based on thematic mapping from remote sensing, it identifies 72 subclass-variants at a resolution of 25 metre tiles. Nevertheless, numerous problems remain with LCM2000 data, and estimates place its accuracy at about eighty-five percent (Fuller *et al*, 2003). Fuller *et al* (in press) firmly state that given the level of error, LCM2000 should not be used directly as supplied without understanding and accommodating the errors.

A5.3 Sets of rules were compiled in order to assist detection of errors, by utilising numerous other data sources. For the purpose of this project, however, the aim has been not simply to reduce error in LCM2000, but to add value by incorporating contextual information. For example, the occurrence of 'grassland' within an urban context may indicate the presence of a park rather than potential farmland.

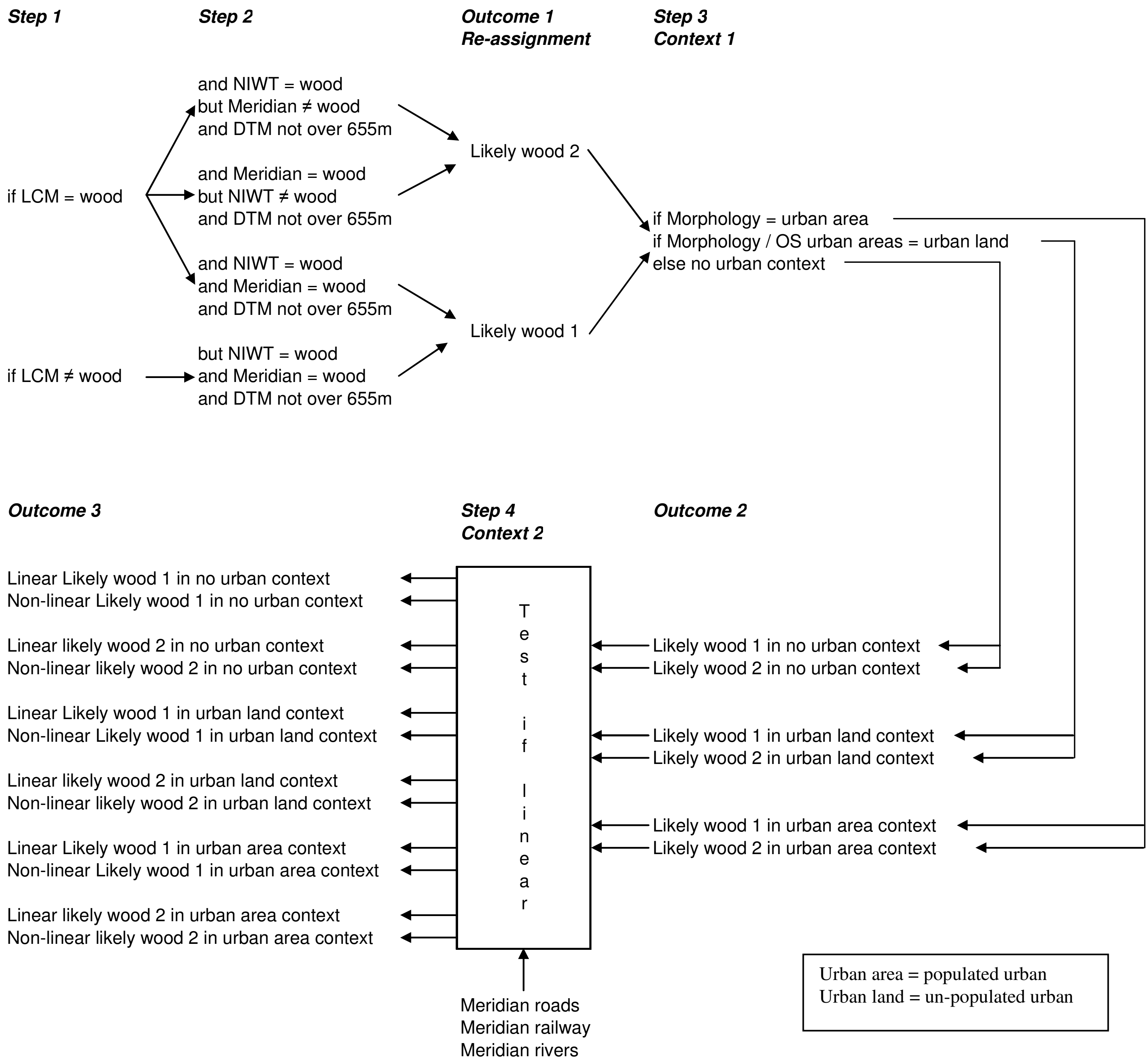
A5.4 Thus, it is not only possible to assign classes with a greater likelihood of reliability but it is also possible to add any number of relevant contextual information by the use of appropriate rules (as demonstrated within Figure A5.1). The re-assignment of the classes is obligatory but the contextual 'steps' are optional and any number or order could be undertaken.

A5.5 An example of the sort of proposed rules are as follows and illustrated in Figure A5.1: if LCM2000 states that a specific tile is woodland, and the National Inventory of Woodland and Trees, or Ordnance Survey Meridian data, state the area is woodland, then it's more than likely that the tile is woodland. However, if no additional sources indicate a presence of wood, and/or the tile is over 655 metres in altitude, then it's probably not wooded. Thus, woodland could be categorised into two classes of likelihood (likely wood 1 and 2) – based on an estimation of the probability of its existence. Thus, there is a greater reliability in the class 'likely wood 1' over 'likely wood 2'. Furthermore, unrealistic woodland (where disagreement between data sources was contested) can be removed.

A5.6 Also, value can be added by knowing if the wood is within a populated urban area or not, or along a linear feature, etcetera. The Natural Language Processing programming language Prolog was used to implement such rules. Sample Prolog rules for the re-assignment process are displayed within Box A5.1.

A5.7 A comparison of output of such Applied Rules, along with data from LCM2000 are illustrated in Figure A5.2 for the Cotswolds area. Woodland Outputs and comparisons are in Figure A5.3 for the Cotswolds area.

Figure A5.1: Rule Set for Woodland



Box A5.1: Example Re-Assignment Rules for Woodland

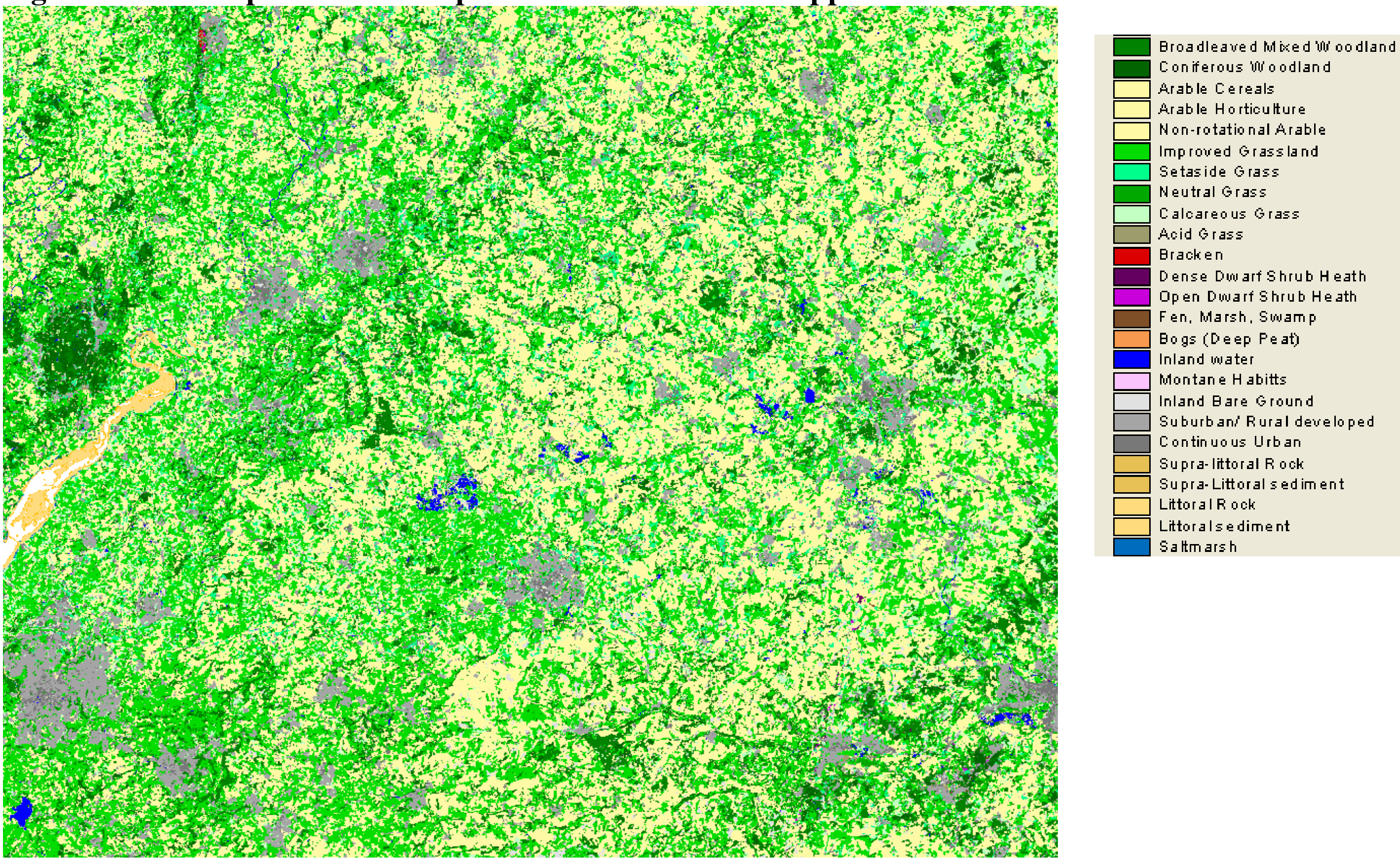
```
wood(Quad, likely2, urban_area):-
        q(Quad, lcm, wood),
        q(Quad, niwt, wood),
        q(Quad, dtm, <655),
        q(Quad, morphology, urban_area).

wood(Quad, likely2, urban_land):-
        q(Quad, lcm, wood),
        q(Quad, niwt, wood),
        q(Quad, dtm, <655),
        q(Quad, urban_no_pop, urban_land).

wood(Quad, likely2, not_urban):-
        q(Quad, lcm, wood),
        q(Quad, niwt, wood),
        q(Quad, dtm, <655).
```

```
wood(Quad, likely2, urban_area):-
        q(Quad, lcm, wood),
        q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655),
        q(Quad, morphology, urban_area).

wood(Quad, likely2, urban_land):-
        q(Quad, lcm, wood),
         q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655),
        q(Quad, urban_no_pop, urban_land).

wood(Quad, likely2, not_urban):-
        q(Quad, lcm, wood),
        q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655).
```

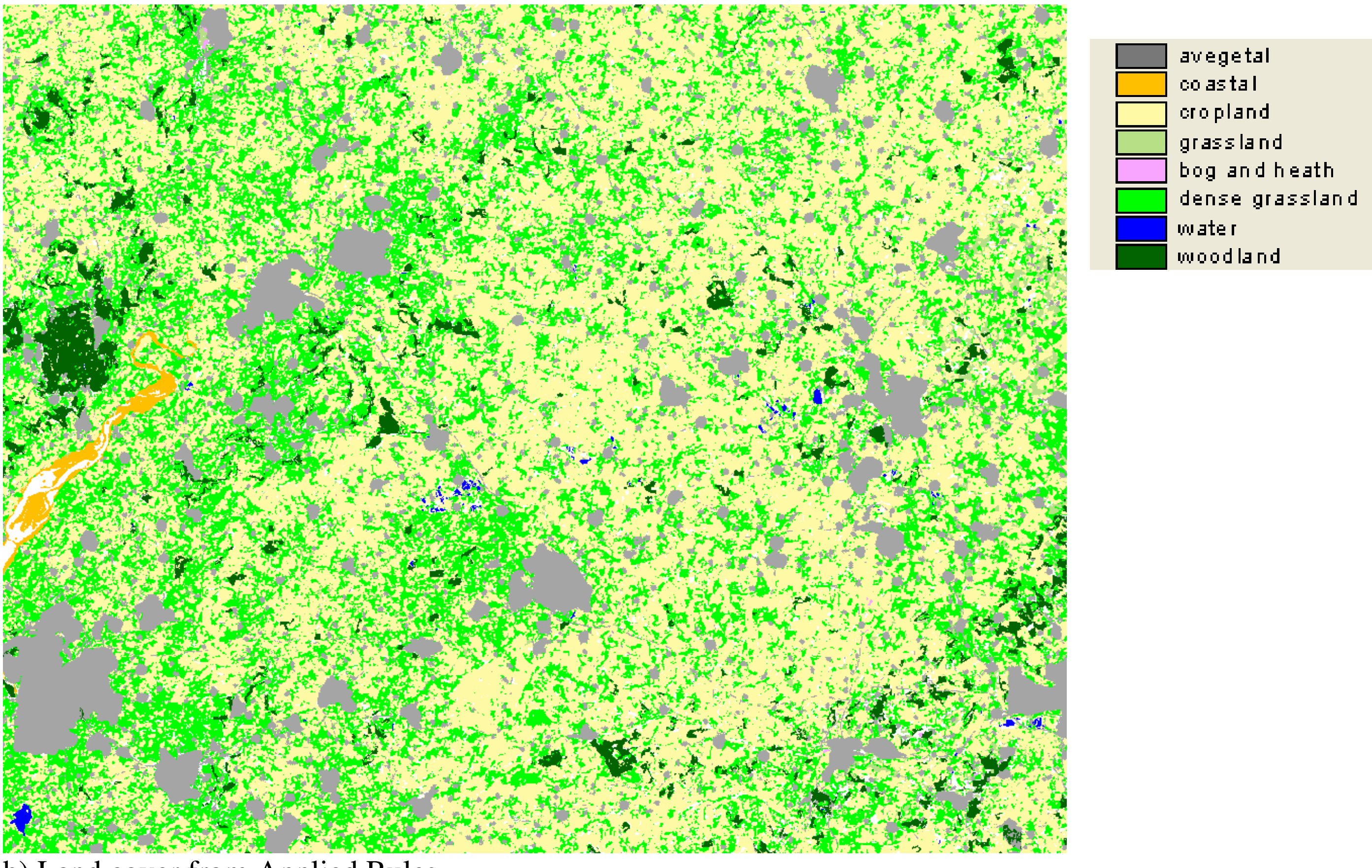
```
wood(Quad, likely1, urban_area):-
        q(Quad, lcm, wood),
        q(Quad, niwt, wood),
        q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655),
        q(Quad, morphology, urban_area).

wood(Quad, likely1, urban_land):-
        q(Quad, lcm, wood),
        q(Quad, niwt, wood),
         q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655),
        q(Quad, urban_no_pop, urban_land).

wood(Quad, likely1, not_urban):-
        q(Quad, lcm, wood),
        q(Quad, niwt, wood),
        q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655).
```

```
wood(Quad, likely1, urban_area):-
        q(Quad, niwt, wood),
        q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655),
        q(Quad, morphology, urban_area).

wood(Quad, likely1, urban_land):-
        q(Quad, lcm, wood),
        q(Quad, niwt, wood),
        q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655),
        q(Quad, urban_no_pop, urban_land).

wood(Quad, likely1, not_urban):-
        q(Quad, lcm, wood),
        q(Quad, niwt, wood),
        q(Quad, meridian_wood, wood),
        q(Quad, dtm, <655).
```

Figure A5.2: Comparisons of Output from LCM2000 and Applied Rules for the Cotswolds

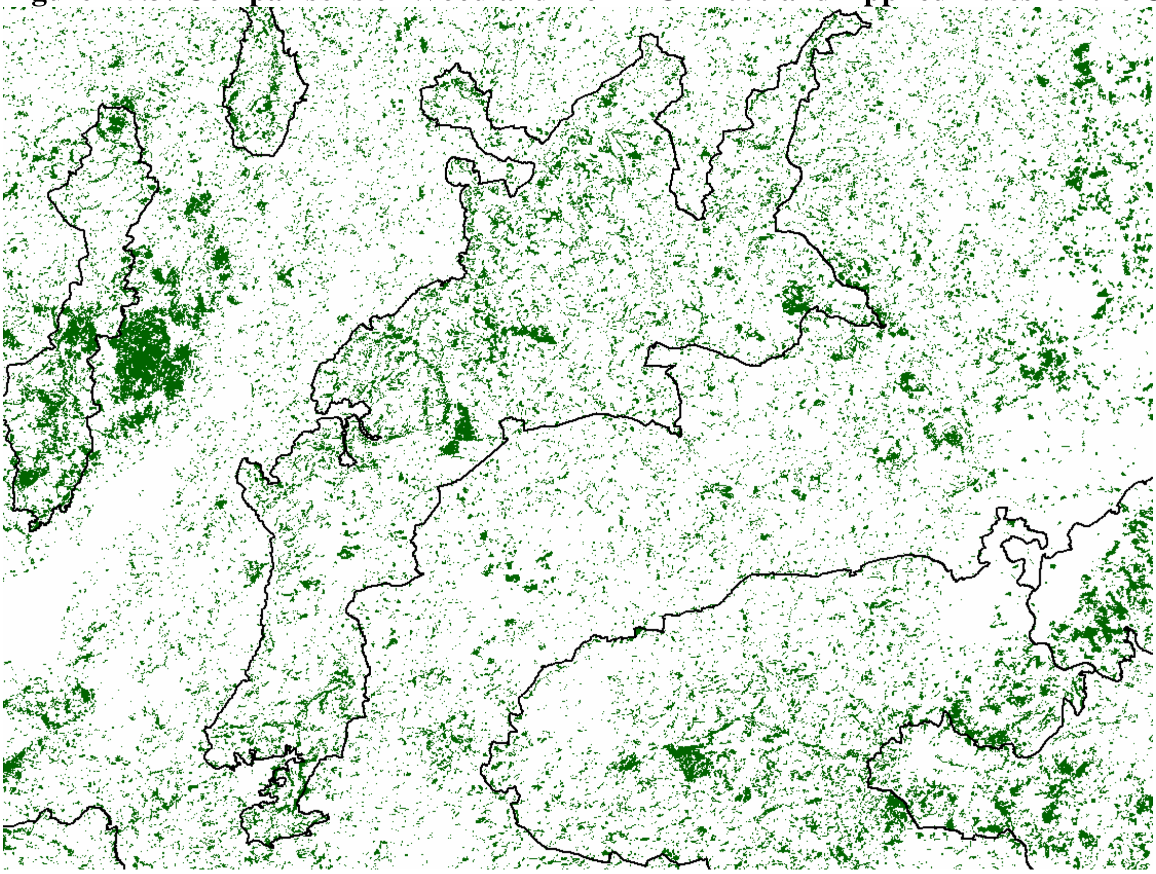


a) Land cover from Land Cover Map 2000

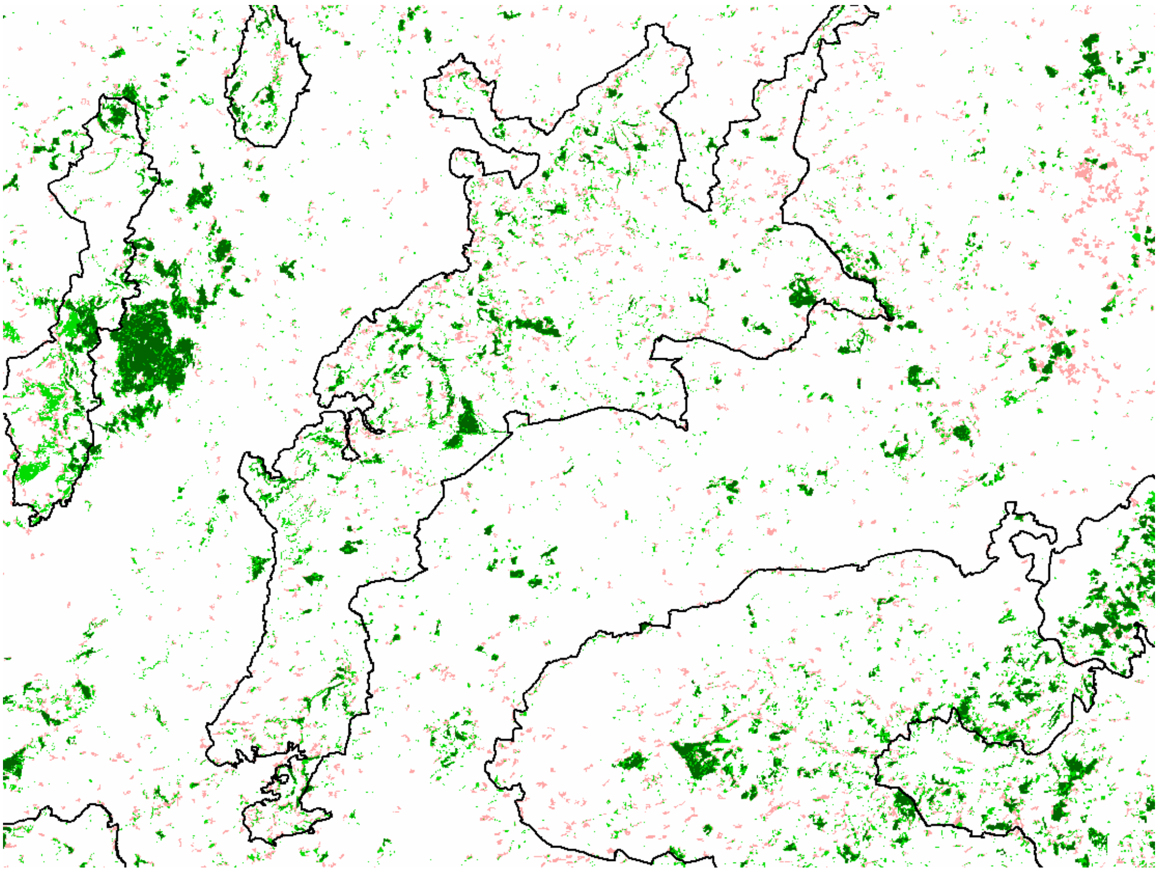


b) Land cover from Applied Rules

Figure A5.3: Comparisons of Woodland from LCM2000 and Applied Rules for the Cotswolds



a) Woodland from Land Cover Map 2000



Dark green:
Likely woodland 1

Light green:
Likely woodland 2

Red:
disagreement with Land Cover Map

b) Woodland from Applied Rules

Appendix 5 Bibliography:

Fuller, R.M., Cox, R., Clarke, R.T., Rothery, P., Hill, R.A., Smith, G.M., Thomson, A.G., Brown, N.J., Howard, D.C. and Stott, A.P. (2005) The UK land cover map 2000: Planning, construction and calibration of a remotely sensed, user-oriented map of broad habitats. *International Journal of Applied Earth Observation and Geoinformation* **7** (3), pp.202-216.

Fuller, R.M., Smith, G.M. and Devereux, B.J. (2003) The characterisation and measurement of land cover change through remote sensing: problems in operational applications? *International Journal of Applied Earth Observation and Geoinformation* **4** (3), pp. 243-253.

Fuller, R.M., Smith, G.M., Sanderson, J.M., Hill, R.A., Thomson, A.G., Cox, R., Brown, N.J., Clarke, R.T., Rothery, P. and Gerard, F.F. (2002) *Land cover map 2000: final report*. Huntingdon: Centre for Ecology and Hydrology.

Appendix 6: Exploration of LUCS Recorded Woodland Losses in Relation to Existing Woodland Stocks

A6.1 There are a number of areas (shown in Figure A4.7 in Appendix 4) that appear to have quite implausible recorded woodland losses even taking account of computational issues that might arise when both loss and stock were very small. The most obvious potential explanation is that the stock data are flawed. Detailed examination of particular areas, however, show that **none** of the woodland sources (ie NIWT, OS Meridian, LCM) indicate sizable stocks of wood in these situations. Moreover, examination of maps for 1985 at a scale of 1:10,000 does not indicate any woodland cover.

A6.2 The example in this appendix deals with one such area. It refers to a tract of less than 30km square, to the north-east of Downham Market, Norfolk, where LUCS records in excess of 1,000 hectares of woodland loss. Within this area there is a 5km square section were in excess of 280 hectares of woodland loss has been recorded within LUCS but no significant stocks are evident. This was also supported by the examination of detailed 1:2,500 scale maps for 1981, and 2004/2005 1:2,5000 OS Landline data, where again no evidence of extensive wood stocks were apparent.

Figure A6.1: Example of LUCS Recorded Woodland Losses Compared to Woodland Stock Sources (NIWT, Meridian, LCM), to the North-East of Downham Market, Norfolk

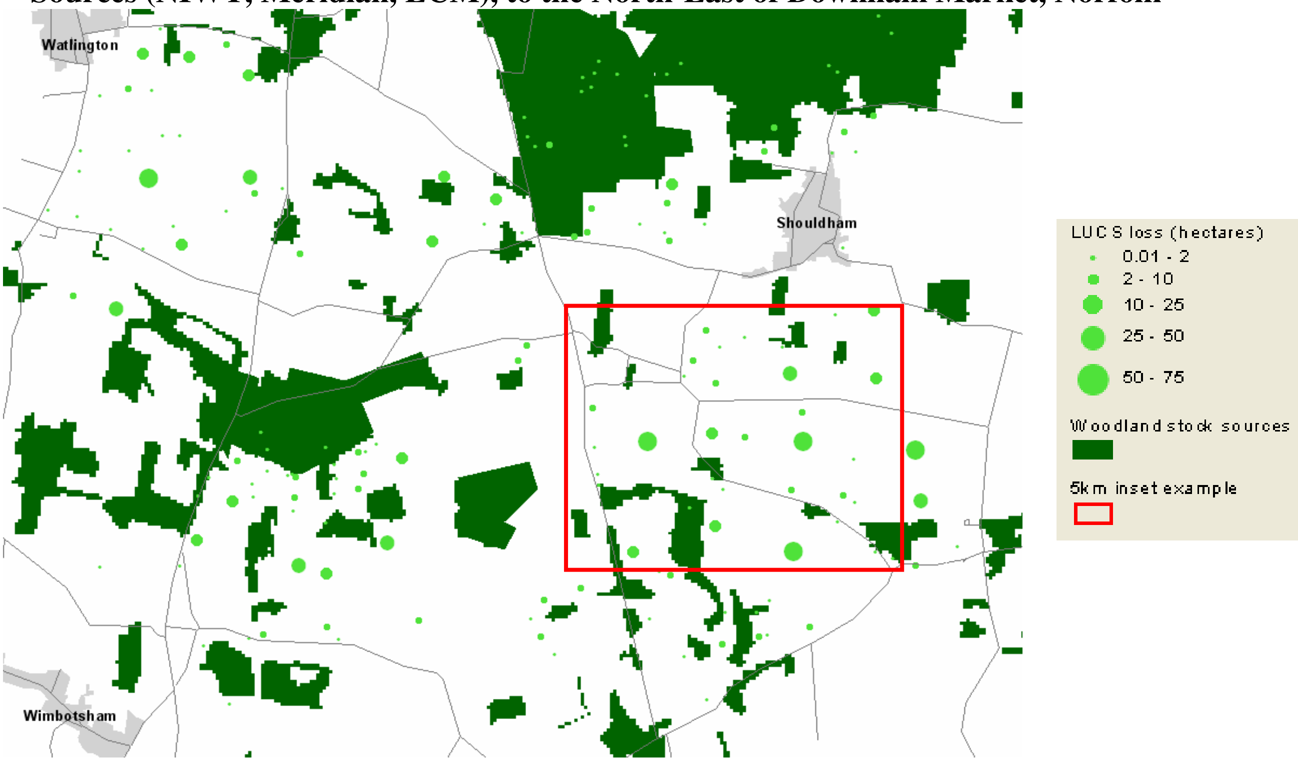


Figure A6.2: Example of LUCS Recorded Woodland Losses Compared to Current OS 1:25,000 Mapping, to the North-East of Downham Market, Norfolk

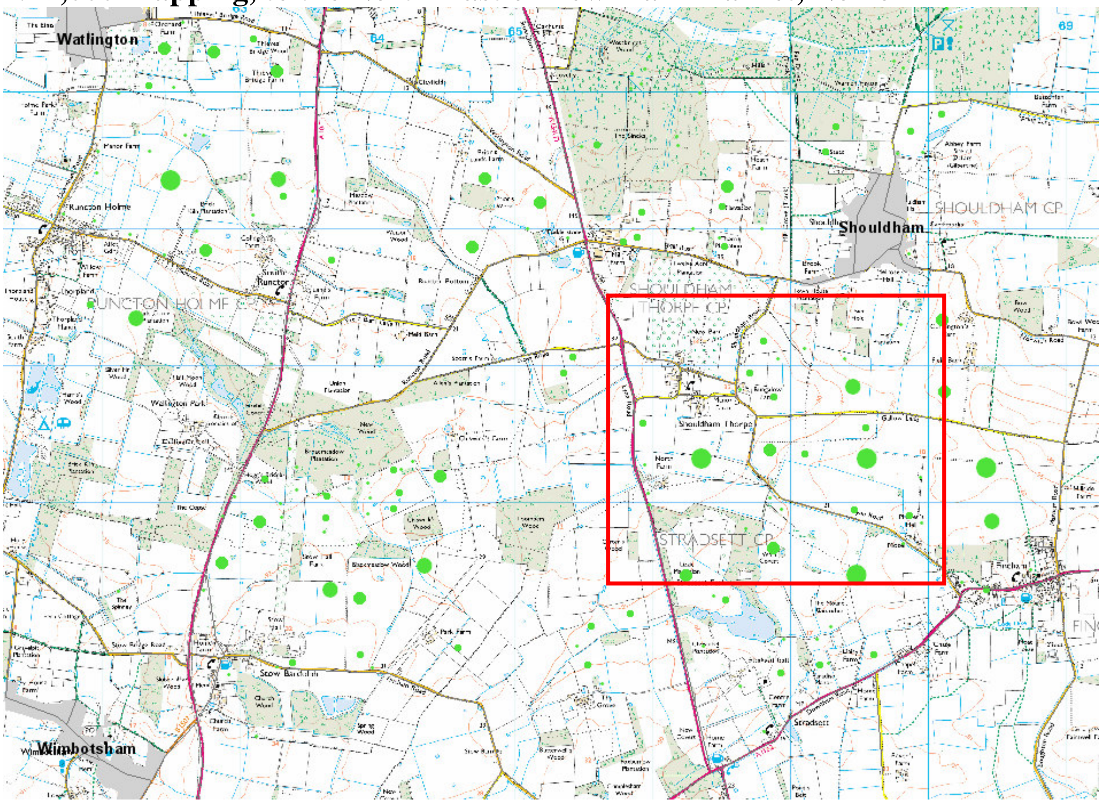


Figure A6.3: Example of LUCS Recorded Woodland Losses Compared to 1:10,000 1985 Scale OS Mapping, for the 5km Inset Between Shouldham and Fincham