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Trial measures of habitat (particularly woodland) fragmentation

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Summary

1. The various ways of describing habitat fragmentation were tested using map data (1:50,000 OS maps, Ancient Woodland Inventory maps, Phase I survey maps) and concentrating on woodland.

2. Three 'natural areas' were compared in terms of mean minimum inter-wood distances for all woods in two 5 x 5 km squares per 'natural area'. These varied from 138 m to over 3000 m.

3. The absolute minimum distance for each site from wood to wood was compared to the mean minimum distance based on the value for each quadrant. The mean quadrant value is potentially a more useful for estimating the general ease with which woodland species might spread through the countryside.

4. The same approach was adopted for patches of semi-improved grassland in two 3 x 3 km squares in Bedfordshire. The single minimum distance for each site was 126-438 m; the mean minimum based on values for each quadrant for each site was 443-1405 m.

5. A simple way of expressing the 'wildlife friendliness' of the countryside was tested based on the area of semi-natural habitat in a 5 x 5 km strip. 15 'natural areas' were compared using five 5 x 1 km strips per 'natural area in which the extent of ancient woodland and of all types of woodland were assessed.

6. The method was refined in a test on Phase I maps from Bedfordshire and Cumbria in that individual 1 km squares were recorded separately. This has potential for further development. In particular data held on the Countryside Information System could be used directly to calculate the index.

Preface

Habitat fragmentation is a major concern for those involved with nature conservation, particularly in the lowlands of England. The issues involved have been discussed and a series of research projects carried out since 1992 under the auspices of EN's Habitat Fragmentation Group.

One issue identified was the development of simple ways of describing habitat fragmentation. In March 1995 Penny Baalman, an Australian forester, joined us for three weeks and explored a number of different ways of measuring habitat fragmentation using map data of various sorts and concentrating on woods. This report summarises her findings.

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Introduction

Habitat fragmentation is a major issue in Nature conservation planning and management, particularly in the lowlands of England (Kirby 1995). In some areas destruction and degradation is still occurring and leads to increased habitat isolation; elsewhere a wide variety of new countryside initiatives are being proposed that it is expected should lead to reduced isolation and linkage of existing sites.

Simple measure of habitat isolation are needed at both site and landscape scales to provide

a. measures of the changes in fragmentation that are occurring; and

b. context for studies of species movement through the countryside.

The site-scale measure of isolation used was the minimum distance from one habitat patch to the next. Two ways of defining this were compared, either as the absolute minimum distance for a site or as the mean of four distances measured per site, one in each quadrant. These measures were calculated for woodland both ancient and recent in two 5 x 5 km squares in three natural areas. The method was also tested for semi-improved grassland patches in two 3 x 3 km squares in Bedfordshire.

The landscape-scale measure of fragmentation used was the area of semi-natural habitat in each kilometre square in a 5 x 1 km square strip. This was calculated using all semi-natural habitat in an upland (Cumbria) and lowland (Bedfordshire) landscape. It was then used to compare eight natural areas using woodland data only.

All the work was done from existing maps, either 1:50,000 OS maps, those produced for the Ancient Woodland Inventory (Spencer & Kirby 1992) or Phase I habitat maps (Wyatt 1991). Suggestions are made for how this work may be taken forward including measures that may be easily obtainable from other existing data sources.

Methods

Minimum inter-wood distances

Kirby and Thomas (1994) describe a method for comparing minimum inter-wood distances in different 'natural areas' (English Nature 1993) using randomly sampled woods in selected 10 km squares in each area.

These results are, however, based on only a small number of sites per natural area and on only the minimum boundary to boundary distance for each site. In this project we trialled a different type of assessment.

a. All woodland sites (both ancient and recent) in a 5 x 5 km square were considered and the minimum distance to the next site (either ancient or recent) calculated. This enables us to compare variability in inter-wood distances at a small scale as well as between Natural Areas.

b. As well as the absolute minimum inter-wood distance (boundary to boundary) for each site, the minimum boundary to boundary distance in each quadrant (NE, SE, SW, NW) was measured and the mean value per site calculated. If woods are regularly or randomly distributed these two values would be similar, although the mean quadrant value will always be higher than the absolute minimum value. However, if there is a tendency for woods to occur in linear patterns in a landscape, eg along valley sides or river systems, then there may be considerable variation between the values for different quadrants.

Three natural areas were compared using two 5 x 5 km squares from each (Table 1a). Initially samples from natural area 11 (Holderness Plain) were also to be used, but the two 5 x 5 km squares selected contained no woodland!

In each square a site was defined as a distinct area of ancient or recent woodland. The ancient woodland boundaries used were those defined on the 1:50,000 maps at the back of the relevant county ancient woodland inventory. Recent woodland (including any areas of ancient woodland too small to have been identified in the inventories) was any other area shown as woodland (ie shaded green) on the 1:50,000 Landranger OS maps.

The distance measured for each ancient site in each quadrant was that from its boundary to the nearest ancient woodland boundary and to the nearest wood of any sort (Figure 2a), ie the minimum colonization distance for an ancient woodland specialist and a species that can use any sort of woodland respectively. If recent woodland was immediately adjacent to the ancient woodland, eg the wood might have expanded beyond its former boundaries, this was recorded as zero colonisation distance; where the nearest ancient woodland in a quadrant was more than 15 km away this was given as the maximum value.

For recent woodland areas the distance to the nearest ancient woodland or to the nearest woodland of any sort was similarly measured. 'Sites' were often fragments of woods (Figure 2b). Thus what we are measuring is the minimum distance for colonization for a species from an ancient woodland or other woodland respectively.

Table 1: Natural Area, County and Kilometre squares sampled in the different parts of the project.

Natural Area		County	Kilometre squares
a.	**Minimum inter-wood distances**		
	24 Middle England	Northamptonshire	SP76(SW)
	24 Middle England	Cambridgeshire	TL35(SW)
	43 Low Weald	West Sussex	TQ12(SW)
	43 Low Weald	Kent	TQ74(SW)
	89 Cumbria Fells and Dales	Cumbria	NY32(SW)
	89 Cumbria Fells and Dales	Cumbria	SD29(SW)
b.	**Minimum inter-patch distances for semi-improved grassland in Bedfordshire**		
	24 Middle England	Bedfordshire	SP92(NE) central 3 x 3 square
	24 Middle England	Cambridgeshire	TL24(SW) central 3 x 3 square
c.	**'Wildlife friendliness' at landscape scale, woodland only (5 x 1 km strip)**		
	2 Border Uplands	Northumberland	NY97(SE), NY68(NE), NT81(SE), NT93(NW), NY87(SE)

	Natural Area		County	Kilometre squares
	9	North York Moors	North Yorkshire	NZ60(NW), SE79(SE), SE99(SW), SE58(SW), NZ81(SW)
	18	Trent Valley and Levels	Leicestershire	TM23(NE), TM24(SW), TM35(SE), TM46(NW), TM47(NE)
	27	Fenland	Lincolnshire	TF21(NE), TF12(SE), TF32(SW), TF35(NW), TF42(SE)
	28	East Anglian Southern Chalk	Cambridgeshire	TL34(SW), TL44(NE), TL54(NE), TL55(SW), TL65(NW)
	32	Suffolk Coast and Heaths	Suffolk	TM23(NE), TM24(SW), TM35(SE), TM46(NW), TM47(NE)
	38	London Basin	London	TQ17(NE), TQ18(SW), TQ36(NW), TQ37(NW), TQ48(NE)
	44	High Weald	East Sussex	TQ43(SE), TQ52(NW), TQ60(NE), TQ63(SW), TQ71(SW)
	47	Hampshire Chalk	Hampshire	SU32(NE), SU34(NE), SU52(SE), SU54(SW), SU63(SE)
	51	South Wessex Downs	Wiltshire	ST94(SW), SU03(NE), SU12(SE), SU13(SE), SU25(SW)
	59	Cornish Killas and Granite	Cornwall	SW53(SE), SW43(SW), SW96(NW) SX05(NE), SX36(SW)
	69	Greater Cotswolds	Gloucestershire	SP00(SW), SP11(NW), SP13(NE), S091(SE), ST89(SE)
	74	Hereford Plain	Hereford	SO34(NE), SO43(NW), SO54(NE), SO56(SW), SO65(SE)
	79	Mosses and Meres	Shropshire	SJ30(NE), SJ33(SE), SJ42(NE), SJ51(SE), SJ62(SW)
	87	Lancashire Plain and Valleys	Lancashire	SD33(NE), SD41(NW), SD52(SE), SD46(SE), SD73(SW)
d.	**'Wildlife friendliness' at landscape scale, all semi-natural habitats (5 x 1 km strip)**			
	24	Middle England	Bedfordshire	SP 95 25 - TL 0026
	24	Middle England	Cambridgeshire	TL 2042 - TL 2543
	89	Cumbria Fells and Dales	Cumbria	NY 3038 - NY 3539
	89	Cumbria Fells and Dales	Cumbria	NY 3135 - NY 3240
	89	Cumbria Fells and Dales	Cumbria	NY 3003 - NY 3504

The 5 x 5 km squares were selected at random within a given county section of the natural area. An east-west strip 5 x 1 km was then assessed across the middle of the square.

Minimum inter-patch distances for semi-improved grassland in Bedfordshire

Minimum inter-patch distances (by quadrant) were measured for semi-improved grassland in two 3 x 3 km squares in Bedfordshire (Table 1b). The patches considered were those shown on

Phase I habitat maps (1:10,000 scale) (Wyatt 1991). In this area there was virtually no other grassland other than highly improved agricultural or amenity grassland swards. Thus the inter-patch distances represent the best scope for colonization and spread of semi-natural grassland species in this landscape.

Assessment of 'wildlife-friendliness' at a landscape scale

For most species we do not know (nor are ever likely to know) their precise colonizing ability or their ability to spread through different types of habitat in the countryside. Thus precise inter-patch distances are not that useful as a measure of the general 'permeability' of a landscape to movement of a wide range of species. An alternative approach is to use simple measures of the total semi-natural habitat across a strip of countryside and the length of linear features in each square. A 5 x 1 km strip was adopted as a convenient 'standard' for this study.

A wide-ranging survey was tried measuring only woodland area (but separated into ancient semi-natural, ancient plantation and other woodland) in five strips in each of 15 natural areas (Table 1c). The estimates of woodland area were made from the Ancient Woodland Inventory and 1:50,000 maps using a dot-grid (100 points per 1 km square).

The method was refined in a trial using 1:10,000 scale Phase I habitat maps. Habitat area (and some linear features) were assessed separately for each 1 km square in the strip to provide three measures:

a. the extent of semi-natural habitat per square (estimated from a dot grid (100 points/km square);

b. the number of intersections between lines drawn across the middle of the square and linear features (high numbers being a positive feature);

c. the number of intersections between the lines and roads (a high number being a negative feature because they may act as barriers).

Two 5 x 1 km strips were recorded in Bedfordshire, a lowland landscape with little semi-natural habitat and three in Cumbria (Table 1d).

Table 2: Minimum inter-wood distances for selected natural areas

Location	5 x 5 km sq	No of ancient sites	No of recent sites	Inter-wood distances (in metres) (single minimum per site)			
Natural Area				Ancient to ancient	Ancient to any	Recent to Ancient	Recent to any
89	NY 32	3	6	350±160	67±17	975±423	516±319
	SD29	17	13	138±33	85±25	161±56	92±28
24	SP76	1	12	3000	50	1512±336	283±96
	TL35	4	32	662±360	100±67	1156±142	201±29
43	TQ74	11	21	322±154	195±70	707±85	261±44
	TQ12	0	54	-	-	1050±90	211±27

Location	5 x 5 km sq	No of ancient sites	No of recent sites	Inter-wood distances (mean quadrant value per site used)			
Natural Area				**Ancient to ancient**	**Ancient to any**	**Recent to ancient**	**Recent to any**
	NY32	3	6	6054±1547	1258±351	4797±900	1143±301
	SD29	17	13	861±156	566±73	873±180	603±89
	SP76	1	12	9387	2000	7641±638	1504±279
	TL35	4	32	3387±924	612±314	3196±350	663±52
	TQ74	11	21	1092±281	539±111	1531±87	744±75
	TQ12	0	54	-	-	2172±81	467±32

Results

Minimum inter-wood distances

Within the squares considered single minimum inter-wood distances, as expected, are much lower in Cumbria (NA89) than in Middle England (NA24). The Low Weald squares illustrate the need to get an adequate number of samples - one square has a low ancient-ancient woodland distance (322 m) whereas the other had no ancient woods in it. The distance from an ancient wood to any wood is much less than the ancient to ancient distance, implying a tendency for ancient woods to have recent woodland associated with them.

Recent to ancient wood distances are generally much larger than the ancient to ancient instance (the exception being SP76 which only contained one ancient wood and this biases the data).

The mean minimum distances for four quadrant are often much larger than the mean single minimum distance per wood. The two values will be closest where woods are abundant and spaced evenly through the landscape; they will diverge most where ancient woods are either in small clumped but generally scarce or arranged in strongly orientated patterns (Figure 1).

Thus in NY32 the mean single minimum distance (ancient to ancient wood) is not that different from that for the Wealden square TQ74 and both are less than for the Cambridgeshire square TL35. When the mean distances for all four quadrants are considered the position changes considerably: the Wealden square still gives the lowest value, the Cambridgeshire square comes next, the Cumbria square is much larger. In practical terms this means that for a species in the Cumbrian woods movement between site to site is much more constrained in terms of the direction in which it can occur easily and may be limited to within particular clusters of woods.

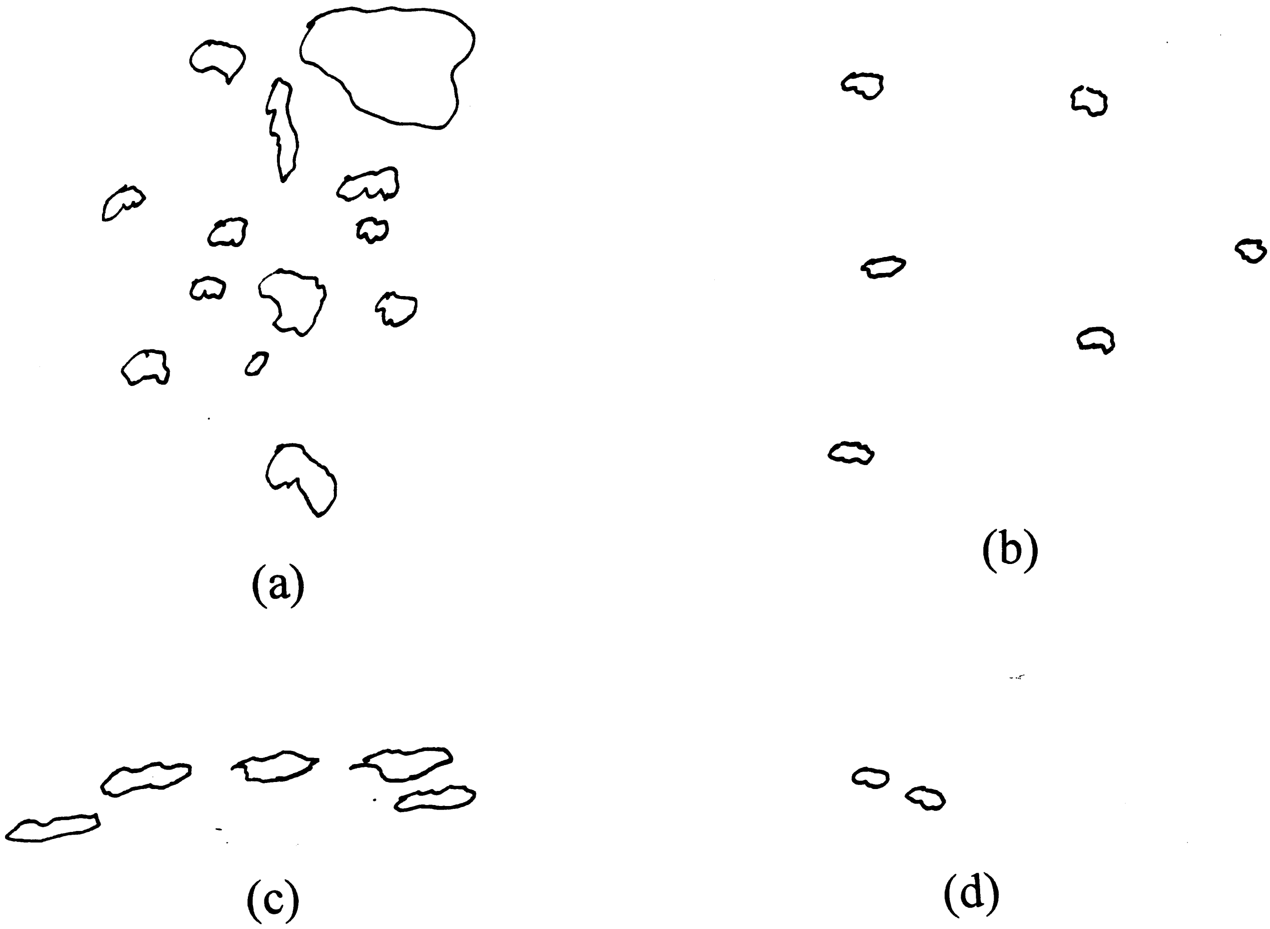

Figure 1: Illustration of ancient woodland patterns leading to high (a), (b) and low (c), (d) ratios for single minimum to mean for four quadrant differences.

Minimum inter-patch distances for semi-improved grassland

Although much of Bedfordshire is intensive arable in the two squares studied inter-patch distances are quite small (Table 3); certainly no worse than the isolation of ancient woods in much of England.

Table 3 Inter-patch distances for grassland in 3 x 3 km squared in Bedfordshire

	No of sites	Mean single minimum distance (M)	Mean of four quadrats Minimum distances (M)
Square TL24	4	438±129	1405_164
SP92	23	126±18.7	443±41

'Wildlife friendliness' for different woodland species in 5 x 1 km strips

Table 4: 'Wildlife-friendliness' of different landscapes for woodland species based on woodland area in five 5 x 1 km strips per Natural Area

	Mean area of		
	Ancient semi-natural woodland	**Ancient woodland**	**All woodland**
Natural Area			
Border Uplands (2)	0	0	109±78
North York Moors (9)	15±14	31±14	186±5
Trent Valley & Levels (18)	0	0	11±6
Fenland (27)	0	0	1±1
East Anglian Southern Chalk (28)	3±3	3±3	15±4
Suffolk Coast and Heaths	14±14	14±14	51±18
London Basin (38)	0	0	1±1
High Weald (44)	34±15	50±20	88±27
Hampshire Chalk (47)	23±11	37±13	56±13
South Wessex Downs (51)	12±8	31±20	59±26
Cornish Killas and Granite (59)	4±2	10±8	27±12
Greater Cotswolds (69)	17±8	20±10	48±20
Hereford Plain (74)	2±1	8±4	15±5
Mosses & Meres (79)	0	0	17±11
Lancashire Plain & Valleys (87)	2±1	2±1	18±8

The three columns in Table 4 illustrate differences in the relative permeability of the landscape for species with different degrees of dependence on woodland in general and on ancient or ancient semi-natural woodland in particular. For a species dependent on ancient semi-natural woods there is little to choose between the Border Uplands, Trent Valley, Fenland or the London Basin. For a woodland generalist the last two could be similarly hostile but the Trent Valley is rather more attractive and the Border Uplands have considerable potential. North York Moors and Suffolk Coast have similar amounts of ancient semi-natural woodland, but the opportunities for a species that can use any ancient woodland look rather better in the North York Moors.

'Wildlife-friendliness' as measured by all semi-natural habitat

The concept behind this measure is that the 'friendliness' or permeability of the countryside to movement of a wide range of species will be determined by local variations in the extent of semi-natural habitat. In Table 5 different situations are contrasted at the level of 1 km squares within a 5 x 1 km strip.

Table 5: 'Wildlife-friendliness' at the 1 km square level for selected 5 x 1 km strips in Bedfordshire and Cumbria

Location of strip		Order of 1 km square in strip				
		1	**2**	**3**	**4**	**5**
a.	**Area of semi-natural habitat**					
	NY33NW (horizontal)	0	0	1	0	9
	NY33NW (vertical)	100	100	33	1	1
	NY30SW (horizontal)	68	29	43	41	34
	SP92NE	16	19	5	26	1
b.	**Frequency of semi-natural linear features**					
	NY33NW (horizontal)	1	1	3	4	4
	NY33NW (vertical)	0	0	4	5	7
	BY30SW (horizontal)	4	6	3	2	4
	SP92NE	2	10	9	15	8
	TL24SW	4	2	7	2	6
c.	**Frequency of linear barriers (roads)**					
	NY33NW (horizontal	1	1	3	4	4
	NY33NW (vertical)	0	0	1	2	1
	NY30SW (horizontal	1	5	4	2	5
	SP92NE	4	0	0	0	0
	TL24SW	0	0	0	0	0

* Linear features within semi-natural areas were not counted

The strip across NY30SW in Cumbria comes out as the most 'friendly' strip (Table 5a). The vertical strip across NY33NW starts well (it is crossing the fells) but then moves into a highly intensive valley bottom which is potentially very hostile, as is the whole of the horizonal strip across this area. The two southern strips are not as 'friendly' as the best of the Cumbrian areas but what habitat there is reasonably evenly spread across the strip.

Table 5b and c illustrate the different frequencies of semi-natural linear features that might assist movement and roads that are likely to act as barriers in the strips.

Discussion

None of these measures tell us whether movement of species will actually occur between the patches or through the strips; or which species might move and which not. Nor do they help us decide whether the relationship between inter-patch distance or 'wildlife-friendliness' index and movement is linear or stepped with critical threshold values. However, there is a general presumption that reducing the degree of isolation of semi-natural habitat patches in the countryside and increasing the frequency of linear features connecting them is likely to be of benefit to nature conservation. In which case these sorts of measures may be helpful.

a. The single minimum patch-patch distance is appropriate where movement of a species with defined habitat requirements within a defined patch cluster is concerned.

b. The mean all-quadrant minimum distance for a particular patch type is more appropriate where the potential movement of a species with defined habitat requirements through the landscape generally is of interest.

c. The 'wildlife-friendliness' approach is useful where the focus is on opportunities for movement of a wide range of species, either within one broad habitat (eg woodland) or generally (all semi-natural habitats).

If this last approach is adopted we suggest data is collected on a 1 km basis, with either a 5 km (or perhaps 10 km) strip being adopted as the standard 'transect' for comparative purposes. This measure is small enough to be influenced by one or a few landowners; ie it should be able to pick up changes that are brought about by schemes such as Countryside Stewardship, new woodland planting etc. It also covers enough ground such that if several strips show a change than it probably represents a significant affect on the general landscape. One advantage of using 1 km squares as the unit is that it would be possible to get data already collected on the Countryside Information System to calculate the relative 'friendliness' of landscapes. Similarly the Ancient Woodland Inventory could provide data reasonably easily in this sort of form.

Others have identified the problems of trying to identify precisely the effects of habitat fragmentation and the value (or not) of linear features as wildlife corridors (eg Dawson 1994; Spellerberg & Gaywood 1993). Given these difficulties we suggest that robust (crude) measures such as we outline are likely to be as useful as anything else as measures of how landscapes differ in these respects.

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