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Estimating the length of hedgerow in Suffolk

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Rob Parker

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Summary

This "Audit" of Suffolk's hedgerows is an analysis of a 2.52% semi-random sample, selected as a typical cross-section, with balanced representation from each of the 6 Natural Areas that make up the County. Aerial photography taken in 1995/96 was used as the basis for plotting the lengths of hedgerow in each of 24 tetrads. Field visits were then conducted to validate the plotting by confirming that lines of vegetation were actually hedges rather than rows of trees or bramble-filled ditches. The validated plot, made on an acetate overlay to a section of 1:10,000 map for each tetrad, was then measured. Hedges over 70% complete were counted at 100%, broken hedges between 30 and 70% complete were counted at 50%, and relict hedges of less than 30% were discounted. The results were expressed as kilometres of hedge per square kilometre.

Typically, one tetrad of agricultural land on the clay of the East Anglian Plain was found to contain about 16 kilometres of hedge, making a hedgerow density of about 4.0 km/km^2 normal in such areas. The highest density recorded in a single one-km square was 7.3 km/km^2 (near Saxmundham), whilst several tetrads were found to be almost devoid of hedges (on the coast at Minsmere, and in the Thetford Forest). The overall average of the 24 representative tetrads was found to be 3.621 km/km^2.

Simple arithmetic suggests that there is therefore 13,800 km of hedgerow in Administrative Suffolk, or 14,400km in the slightly larger area used for biological recording (Vice-counties 25 and 26). These figures provide a realistic baseline for the millennium.

The method used has been designed to allow further studies to ratify or adjust these figures, either by extending the cover to other tetrads, or by examining individual squares in greater detail. No attempt has been made to grade the quality of the hedges found, but this could also be done on a sample basis, and some possible approaches are suggested.

Introduction

Much has been written in recent years on the decline of hedgerows in the English countryside, but accurate measurement of existing stock has not been comprehensively undertaken. The best measurements for England and Wales were derived from an analysis conducted by the Institute of Terrestrial Ecology. This work was spread over several years and published for "The Countryside Survey 1990", with a supplementary "Hedgerow Survey 1993" (Barr 1993, Barr 1994). Whilst this contained estimates of total hedgerow by ITE's Land Classes, and for England as a whole, it did not seek to evaluate each county, partly because the sample size in each county was insufficient. Nonetheless, it is possible to extract a back projection from the Land Classes analysed on the computer information package that supports the survey, and this gives an expectation of 12,643km for Suffolk, comprising 11,400km complete hedge and 1,212Km relict hedge.

Other estimates available to the Suffolk Hedge Group included the result of the Suffolk Countryside Survey conducted in 1984/85: 10,598km of which 2040km were considered to be remnant hedgerow (Holborn & Parker 1986), and English Nature's "rough estimate" of 10-20,000km, of which 4-9000 may be ancient and/or species rich. (Sibbett 1998).
Several factors came together to suggest that the present was a good time to make a more accurate evaluation of Suffolk's hedge stock. Firstly, new legislation (The Hedgerow Regulations 1997) controls the removal of existing hedges, secondly the grants available since 1991 under the Hedgerow Incentive Scheme, and now through the Countryside Stewardship scheme, have already begun to reinstate relict hedges and to create new ones, and thirdly the publication of Suffolk's Biodiversity Action Plan commits the county to monitor its hedgerows. It was clear to the Suffolk Hedge Group that a more precise estimate of the existing hedge stock would be useful to underpin their work, to provide a baseline against which to assess the effectiveness of current grants and legislation.

Accordingly, an "audit" was undertaken by Rob Parker, working as an English Nature volunteer, and answering to the tasking of the Suffolk Hedge Group. Its aim was to use aerial photography to make an estimate of the quantity of hedge in the county, without regard to its quality.

Objective

The objective of the Audit was to estimate the hedge density in each of the 6 Natural Areas, and the total length of hedgerow in Suffolk.

The Suffolk Hedge Group

Some counties have formed their own "Hedge Groups" which are active in encouraging and practising good hedge management. They are made up of a forum of organisations and individuals whose aim is to foster support for hedge conservation through promoting management that optimises the value of hedges for farming, wildlife, landscape, archaeological and cultural purposes.

The Suffolk Hedge Group was founded in January 1995, following the example of the Devon group. Made up of farmers and representatives of conservation groups, the actions of the Suffolk group are concentrated on the East Anglian Plain natural area which includes most of

Suffolk, excluding the coast and the brecks. The Suffolk Biodiversity Action Plan for ancient or species-rich hedgerows has recently provided a focus for the group.

Over much of Suffolk, hedges are an important wildlife and landscape feature. The management of many hedges could be improved and some are still being lost. The group's vision for the future is more hedgerow planting and better management of existing hedges.

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Bury St Edmunds IP33 2BD
Tel: 01284 723042

Method

This section has been written in some detail to allow future hedgerow surveyors to copy the methodology for follow-on studies, or to make improvements where they can. In any event, it is necessary to give a full description of what has been counted, to allow validation of this study by other methods.

Selecting the Sample

Initially, the idea was to select a sample of just ten tetrads spread across the county from a random starting point. The starting point was chosen by English Nature at TL 7065-Kentford (see map), with recurrence every 10 Km, at TL8065 (Risby),TL 9065 (Thurston) etc. This gave an west-east run of 8 tetrads, which was extended to 10 by adding TL6065 (Exning) in the west and squeezing in TM4665 (Minsmere) in lieu of TM5065, which would have fallen in the sea.

Subsequently, two further west-east runs were added, in order to properly sample the north and south of the county, and to incorporate Fenland, Breckland and Broadland tetrads. It was necessary to deviate slightly from the precise west-east line to achieve this. Further additions were made at the specific request of the Suffolk Hedge Group to give overlap with the ongoing parish by parish Suffolk Hedgerow Survey -TM2448 (Gt Bealings), and to check the belief that hedgerow density might be at a maximum in the southern clay -TL 8550 (Shimpling).

The final result was a sample of 24 tetrads, representing 2.52% of the county, distributed as shown on the map, and covering all 6 Natural Areas in roughly the same proportion as for the county as a whole.

Representativeness of the sample

Balance of Land Type (and Land Use) in Sample.

Whether the sample fairly represents a microcosm of the County or not merits further analysis. The Countryside Survey of 1990 treats Suffolk as one homogenous landscape type. Indeed, at 99% "Arable"(Barr 1993), it is superficially presented as more uniform than any other county, and should perhaps be easy to estimate. In fact, Suffolk includes a good deal of variety beyond its 81% "Agricultural and Urban" (Beardall & Casey) or the satellite derived 56.6% "Tilled Land"(Sanford 1998)

Natural Areas
Suffolk has 6 terrestrial Natural Areas (Sibbett 1997), and the present audit shows variations in hedge density between them. Accordingly, it is important that the sample exhibits the same balance as the County as a whole. It does this reasonably well, although the smaller natural areas, at one tetrad each, are slightly over-represented:

Natural Area	% of Suffolk	% of Sample	
East Anglian Plain	58.5	56.3	(13.5 tetrads)
Suffolk Coast & Heaths	23.8	22.9	(5.5 tetrads)
Breckland	11.8	8.3	(2 tetrads)
The Broads	3.3	4.2	(1 tetrad)
The Fens	1.6	4.2	(1 tetrad)
East Anglian Chalk	1.0	4.2	(1 tetrad)

Coastline.
The 2.52% sample includes 2.5% of the Suffolk coastline (all in one tetrad).

Habitat Classes.
The following breakdown of Habitat Classes for the land area of 4044 sq km of Vice Counties 25 and 26 is derived from satellite data of 1989/90, and was provided by the Suffolk Biological Records Centre (Sanford 1998):

Coastal	0.8%	(Maritime habitat)
Grass	28.0%	
Heathland	1.7%	
Woodland	5.3%	(Conifer 2%, Deciduous/Mixed 3.3%)
Tilled Land	56.6%	
Developed	7.2%	
Bare Ground	0.9%	

Not all of these categories of habitat are directly related to hedge density, and this audit did not attempt to quantify all of them. However, the sample did include elements of each, and the breakdown which could be measured is discussed below.

Woodland, Road, Rail and Habitation.
Some man-made features which seemed likely to affect hedge distribution were measured from the aerial photography. The proportion of each tetrad occupied by woodland and by "habitation" (ie urbanised or developed) was measured, and is recorded on the individual tetrad maps in the Annex. Similarly, the length of public roads and railway (both active and disused) was recorded. The average of all 24 was:

Woodland	8.3%	
Habitation	2.52%	(Markedly less than the "Developed" figure above)
Roads	4.74 Km/tetrad	
Railway	0.4 Km/tetrad	

Judgement on Overall Representativeness
Overall, the sample contains a good geographic spread, a balanced representation of each Natural Area, the correct length of coastline, and a fair sample of each habitat type, albeit with a slight over-representation of woodland and an intentional under-representation of urban areas.

Map Preparation

A photocopy of the OS 1:10,000 map section covering each of the 24 sample tetrads was made, and an associated acetate sheet was prepared. The acetate was marked with a small number of ground features to assist in correlation with the photography. It was found that too much ground detail (e.g. all roads) whilst helping with initial orientation, actually hindered the operation by causing numerous distractions whilst plotting. The ideal plot comprised one unambiguous large road junction close to the centre of the tetrad, and one other feature near each corner. The precise edge of the tetrad is obviously important to ensure that hedges near the margin are correctly included or excluded.

Analysis of Aerial Photography

The photography used was taken in 1995 and 1996 for the Suffolk County Council, and is lodged in the custody of the County Map Service. It gives cloud free cover in colour and with good definition of the whole county. There is good overlap between frames from west to east and from north to south. In addition, but only for some areas, there is some overlap in time (e.g. Oct95 and Aug96), but this was not put to any analytical use. The difference between midday shots without shadow and late afternoon shots with clear shadows meant that some hedges were more easily seen than others, but generally no choice was available, and hedge alignment was equally significant.

Each frame covered an area of just over one tetrad, but it was usually necessary to consult 3 or 4 adjacent frames to give full cover of the tetrad selected for analysis. A small amount of distortion at the extremities of each frame led to imperfect matches between frames and against the OS 1:10,000 mapping. A sample frame is shown for interest on page 12; it is unusual in that it does cover the whole tetrad in one print, and that it shows a small smudge of cloud, but in respect of quality it is typical. It covers TM4065 (NE of Saxmundham), and can be compared with the corresponding plot (No.16) in the Annex.

Some hedges were easily identified from the photography, but most required the use of a magnifying glass to get the best view. Whilst stereo viewing was available for difficult stretches, it was not necessary as a general practice. The sections which could not be distinguished from hedges without a site inspection were as follows:

a. Walls covered in ivy or fences overgrown with bramble.
b. Lines of trees look the same whether there is a hedge underneath or not.
c. Ditches and dykes look like hedge shadow. In some cases, there was scope for erroneously counting a relict hedge along a ditch as a good hedge.
d. Roadside banks casting shadow.
e. Woodland edges may have hedgebanks concealed from above.
f. Recently planted hedges may not be dense enough to show. Post 1996 hedges were obviously not on the photography.

The acetate sheet was placed over the photography and a green pen was used to trace the line of every certain hedge. All boundaries that were possible hedges, i.e. in one of the above doubtful categories, were drawn in yellow on the acetate. Both green and yellow lines were drawn in water-soluble ink at the plotting stage.

Site Inspection

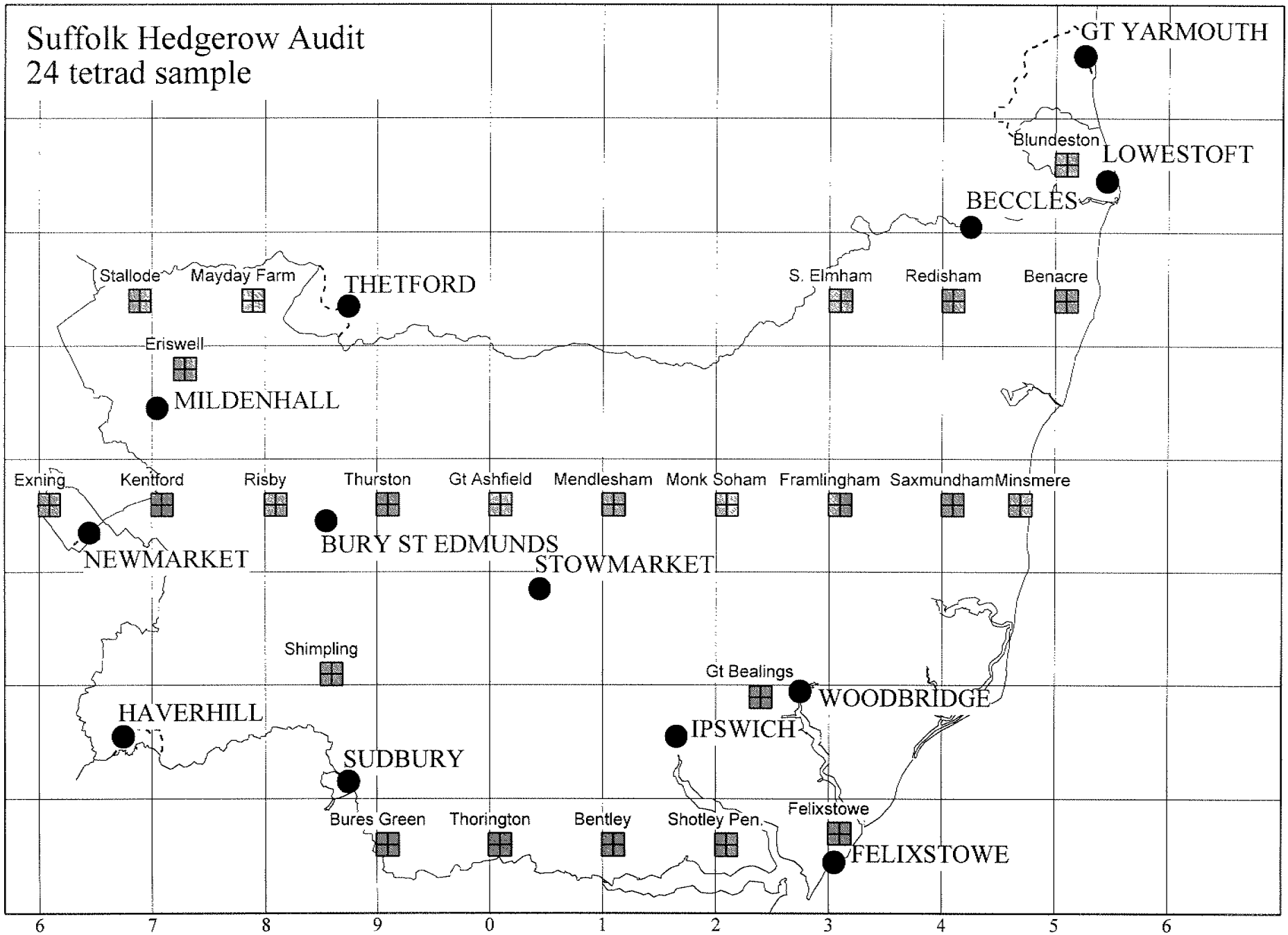
As soon as possible after the photographic analysis, a field visit was made to each tetrad. The purpose of this site inspection was to confirm that the green lines were indeed hedges, and to determine which of the yellow lines were also valid hedges. Two hours were spent in each tetrad, and this proved sufficient for the task, but was obviously insufficient for a survey of hedge quality.

Most of the checking was done by car from the roadside, using binoculars from suitable viewpoints, and walking to less accessible hedgerows. Priority was given to inspecting the hedges traced in yellow, particularly where these were long ones. Confirmed hedges were overwritten on the acetate with permanent green, in solid or dotted lines to represent solid or broken hedgerows. Any yellow lines that turned out to be rows of trees or ditches were deleted, but any sections that remained uninspected were left in yellow, (as were relevant boundaries and woods).

In practice, very few significant lengths of possible hedge were left uninspected, but occasional stretches were out of view because of topography, or were on private land, and could not be reached in the time available. The total never exceeded 0.5km, and was more usually only 1-200metres. The commonest difficulty was where edges of a wood were not all visible from the available perspectives.

When newly-planted hedges were spotted, these were added in solid green, but in practice this did not amount to many kilometres of extra hedge, as most plantings noted were gap fillers.

Tetrad: **16. SAXMUNDHAM**	Grid ref: **TM4065**	Hedge length: **19.0** km
Natural Area: **Plain**	woodland cover: **2%**	habitation cover: **0 %**
Land use: **Agriculture**	Air Photo: **848** date/time: **1Oct96/11:35**	road length: **3.1**km
Water features: **none**		railway length: **0.2** km
Remarks: **Air photo shows the record high hedge density in the SW quadrant, at 7.3km/sqkm. Habitation is limited to small farms 2Km NE of Saxmundham. Woodland cover at 2% is less than average. Photo quality is typical; size slightly exceeds tetrad boundaries. Print scale at 1:10,000 matches OS mapping.**		


Suffolk Hedgerow Audit
24 tetrad sample
GT YARMOUTH
Blundeston
LOWESTOFT
BECCLES
Stallode
Mayday Farm
THETFORD
S. Elmham
Redisham
Benacre
Eriswell
MILDENHALL
Exning
Kentford
Risby
Thurston
Gt Ashfield
Mendlesham
Monk Soham
Framlingham
Saxmundham
Minsmere
NEWMARKET
BURY ST EDMUNDS
STOWMARKET
Shimpling
Gt Bealings
WOODBRIDGE
HAVERHILL
IPSWICH
SUDBURY
Felixstowe
Bures Green
Thorington
Bentley
Shotley Pen.
FELIXSTOWE
0
9
8
7
6
5
4
3
6
7
8
9
0
1
2
3
4
5
6

Counting Rules

After the site visit, a fresh plot of the confirmed green line was made on a paper photocopy of the 1:10,000 map, and appears (in black and white) in the Annex. Each map shows the hedgelines detected by photographic analysis, and confirmed by field visit, being therefore a minimum for each tetrad. The total length of hedge was added, using a pair of dividers, and counting dotted lines at 50% of feature length. The counting rules used were:

Solid. Hedges that were solid, or better than 70% complete were plotted as solid lines.

Broken. Hedges that were broken, being 30-70% complete, were plotted as dotted lines, and counted at half-length.

Relict. Relict hedges with less than 30% intact (much more gap than hedge) were not counted. Plotting from the photography often made it possible to plot short stretches which could be counted individually.

Short. Hedges shorter than about 50m were disregarded at the photo analysis stage, except where an arrangement around a property seemed to amount to a worthwhile aggregation. Care was taken at the site visit stage not get into detailed plotting of garden hedges, although a village street was sometimes added in as a "broken" hedge.

Results

Hedge Density by Tetrad.

The individual tetrad maps showing hedge plots have been reproduced as an annex. Table 1 below summarises the results from the 24 separate samples, showing the total hedgerow count for each tetrad, and (dividing that by 4) the hedge density in the tetrad as a whole. High or low hedge densities are shown for individual one-kilometre squares only where they are extreme.

Table 1. The hedgerow density in each tetrad sampled.

	GRID	NAME	NATURAL AREA [Note]	HEDGE Km/Tetrad	HEDGE DENSITY Km/km^2		
					Highs	AVERAGE	Lows
1	TL6883	Stallode	Fen	5.00		1.250	0.80
2	TL7277	Eriswell	Breck	10.60		2.650	1.60
3	TL7883	Mayday Fm	Breck	0.30		0.075	0.00
4	TM3083	S.Elmham	Plain	19.40		4.850	
5	TM4083	Redisham	Plain	16.10		4.025	
6	TM5083	Benacre	Coast	16.10		4.025	
7	TM5095	Blundeston	Broad/Coast	14.90		3.725	1.80
8	TL6065	Exning	Chalk	20.90	6.80	5.225	
9	TL7065	Kentford	Chalk/Plain	16.90		4.225	
10	TL8065	Risby	Plain	16.30		4.075	
11	TL9065	Thurston	Plain	16.50		4.125	
12	TM0065	Gt Ashfield	Plain	11.40		2.850	1.20
13	TM1065	Mendlesham	Plain	18.00		4.500	
14	TM2065	Monk Soham	Plain	15.80		3.950	
15	TM3065	Framlingham	Plain	18.40		4.600	
16	TM4065	Saxmundham	Plain	19.00	7.30	4.750	
17	TM4665	Minsmere	Coast	2.20		0.550	0.00
18	TL8550	Shimpling	Plain	14.10	5.20	3.525	1.40
19	TL9035	Bures Green	Plain	17.00		4.250	
20	TM0035	Thorington St	Plain	16.50		4.125	
21	TM1035	Bentley	Plain/Coast	18.90		4.725	
22	TM2035	Shotley Pen.	Coast	10.70		2.675	
23	TM2448	Gt Bealings	Plain/Coast	20.50		5.125	
24	TM3036	Felixstow	Coast	12.20		3.050	2.25
		AVERAGE HEDGE DENSITY:				**3.621**	Km/km^2

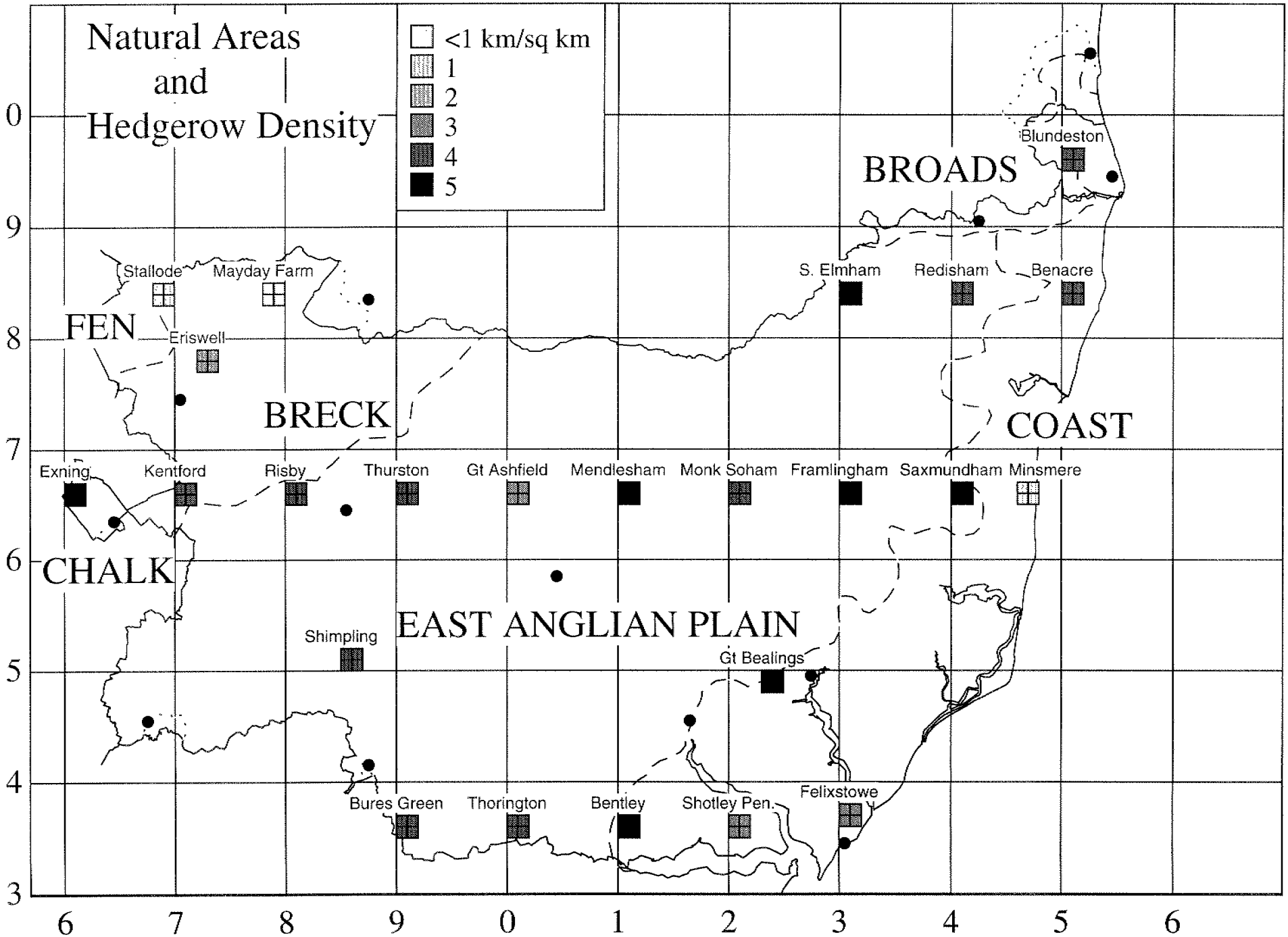
Note. The full titles of the Natural Areas (abbreviated above) are in Table 2 below.

Average Hedgerow density by Natural Area.

Table 2 gives the results rearranged into Natural Areas. Samples which overlap 2 areas have been excluded with the exception of Blundeston, which is the only Broadland sample.

Table 2. Hedgerow density by Natural Area.

SAMPLE No	NATURAL AREA	NAME	Hedge density km hedge/km^2		REMARKS
	EAST ANGLIAN PLAIN			**4.135**	58.5% of County.
4	Plain	South Elmham	4.850		
5	Plain	Redisham	4.025		
10	Plain	Risby	4.075		
11	Plain	Thurston	4.125		
12	Plain	Gt Ashfield	2.850		
13	Plain	Mendlesham	4.500		
14	Plain	Monk Soham	3.950		
15	Plain	Framlingham	4.600		
16	Plain	Saxmundham	4.750		
18	Plain	Shimpling	3.525		
19	Plain	Bures Green	4.250		
20	Plain	Thorington St	4.125		
	SUFFOLK COAST AND HEATHS			**2.575**	23.8% of County.
6	Coast	Benacre	4.025		
17	Coast	Minsmere	0.550		
22	Coast	Shotley Pen.	2.675		
24	Coast	Felixstow	3.050		
	BRECKLAND			**1.363**	11.8% of County.
2	Breck	Eriswell	2.650		
3	Breck	Mayday Fm	0.075		
	BROADLAND			**3.725**	3.3% of County.
7	Broad/Coast	Blundeston	3.725		
	FENLAND			**1.25**	1.6% of County.
1	Fen	Stallode	1.250		
	EAST ANGLIAN CHALK			**5.225**	1.0% of County.
8	Chalk	Exning	5.225		


Natural Areas
and
Hedgerow Density
<1 km/sq km
1
2
3
4
5
BROADS
Blundeston
S. Elmham
Redisham
Benacre
Stallode
Mayday Farm
FEN
Eriswell
BRECK
COAST
Exning
Kentford
Risby
Thurston
Gt Ashfield
Mendlesham
Monk Soham
Framlingham
Saxmundham
Minsmere
CHALK
EAST ANGLIAN PLAIN
Shimpling
Gt Bealings
Felixstowe
Bures Green
Thorington
Bentley
Shotley Pen.
0
9
8
7
6
5
4
3
6
7
8
9
0
1
2
3
4
5
6

Comparison of north and south Suffolk

Samples were taken as three separate West to East cross sections. Table 3 below reflects clearly the lower hedge densities of the Fen and Breck Natural Areas (which make up two fifths of the Northern cross section). There does not appear to be any significant north-south variation within the more homogenous agricultural area of the East Anglian Plain.

Table 3. North-south variation of hedge density

CROSS SECTION			AVERAGE
NORTH			
Fen, Breck	Plain	Coast	**2.845**
1.25, 0.075	4.85,4.025	4.025	
CENTRAL			
Chalk/Plain	Plain	Coast	**3.885**
5.225,4.225	4.075,4.125,2.85,4.5,3.95,4.6,4.75	0.55	
SOUTH			
	Plain	Coast	**3.765**
	4.25,4.125,4.725	2.675,3.05	

Note.
The above analysis incorporates only the 20 samples in direct West-East alignment, disregarding the 4 tetrads subsequently added for other reasons.

Statistical Analysis.

After the results had been assembled, statistical advice was very kindly given by Mr T H Sparks, the statistician working for the Institute of Terrestrial Ecology on earlier hedgerow analysis. Dr Alison Collins, an Open University lecturer and English Nature staff member also helped greatly. The estimates offered benefit from their guidance, and the following amplification is relevant:

Estimating Method. To treat all the results as a random sample is statistically acceptable, and simple arithmetic will give an estimate for the whole county with an accuracy that is dependant on the standard error for the sample. A more accurate result could, in theory, be obtained by stratifying the results by Natural Area averages.

Sample Purity. Because sample tetrads often fell across the boundaries of natural areas (ie Plain/Coast) they were not homogenous, and because of the limited size of sample from the smaller natural areas, it was not feasible to use the stratification method to derive a valid estimate for each Natural Area.

Standard Error. The overall standard error for the sample amounts to 1046km, which sounds large, but at circa 8% is not much worse than the National hedgerow length estimates, with 6% achieved from a sample of 508 squares (Barr 1994).

Confidence Level. In order to estimate the reliability of a sample mean in providing the true population mean, 95% confidence limits are attached to the sample mean. The true mean has a probability of 0.95 of falling within these limits (95% confidence limits are a convention widely used in ecology). A rough 95% confidence level for the sample mean is +/- 1.96 Standard Errors, and this has been used to give the working estimate for Administrative Suffolk
Where:
N = number of samples
x = value of individual sample
SE = Standard Error of the mean

And:

$$SE = \frac{\sqrt{\frac{\sum x^2 - (\sum x)^2/N}{N-1}}}{\sqrt{N}}$$

Estimates for total Hedgerow in Suffolk.

The official SCC area for Administrative Suffolk is 3802 Sq Km for 1999. Treating the 24 tetrads as a random sample from Administrative Suffolk (the simple arithmetic method) yields a hedgerow length estimate of:

13,800 Km with a confidence interval of 11,700 - 15,900

The 2224km^2 of East Anglian Plain yields an estimate of 9200km length of hedgerow, with a 95% confidence interval of 8,500 - 9,700 Km.(Based on the 12 tetrads of "pure" Plain).
The alternative method using the Natural Areas as strata resulted in a figure of 13,500, but was deemed statistically unsatisfactory in view of the presence of samples from mixed Natural Areas (eg. Plain/Coast) and the use of samples of just one tetrad from 3 of the Natural Areas. Two further projections were made using statistically acceptable methods with 4 strata: Breck, Plain, Coast and Miscellaneous, and these fell in the range 13-14,000km with a standard error of about 1000km.

The slightly larger area used for scientific recording purposes, Vice-counties 25 &26, adds a mixture of Breck and Broadland. If the extra is counted at a mean hedge density of those 2 natural areas (2.5km/km^2), the total of 4044km^2 yields an estimate of about 14,400 Km.

Refining the Results.

The accuracy of any future study could be improved by taking a larger sample including at least 2 tetrads from entirely within each of the Natural Areas. The benefit from adding extra tetrads to the results of this audit was likely to be disproportionately low compared to the effort required.