HEDGES and HEDGEROW TREES

Monks Wood Experimental Station

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ture Conservancy

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HEDGES AND HEDGEROW TREES

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Statements of opinion must be considered as personal to the participants and do not necessarily reflect the policy of the organization they represent.

FOREWORD

Symposia on various aspects of ecology and conservation have been held at Monks Wood Experimental Station regularly since 1965. These symposia have brought together staff of the Nature Conservancy, members of Government Departments and of Research Councils, and representatives of voluntary societies, especially in the Conservation field. The meeting held in November 1968 and reported in this volume followed this same pattern but drew even more widely from most of the bodies and groups concerned with the countryside. The subject - the present status of hedgerows and hedgerow timber in England and Wales - is one that has attracted much attention and concern in recent years and the primary objective of the meeting was to establish facts and promote mutual understanding. In this, it succeeded to a considerable degree.

In editing the papers for publication only minor alterations have been made to the authors texts, and the order of presentation followed at the Symposium has been retained. The free discussions, although a most valuable feature of the meeting, proved on analysis to be less suitable for publication because in many respects they repeated statements made more fully and precisely in the papers: they have consequently been severely edited, and are grouped for convenience at the end of Parts rather than after each individual paper.

Because over a year has elapsed since the meeting, a good deal of supplementary material describing recent events has been added at the end of the volume. This is a field in which developments are still taking place rapidly, and as a result much that is recorded here may have only transient authority. What is, perhaps, most important, and hopefully least transient, is the increasing convergence of thought and outlook among most Departments and groups concerned with the management of the countryside, and this volume is presented as one step along this road.

CONTENTS

INTRODUCTION: THE OBJECTIVES OF THE SYMPOSIUM

Dr. M. E. D. Poore, Director, Nature Conservancy

The removal of hedgerows and the decline in number of hedgerow trees have been controversial subjects in recent years. Much of the evidence was reviewed by the Merthyr Commission in 1955, but the controversy still continues.

The arguments are complex. They concern the economics and efficiency of arable farming; the effects of hedges on crops and stock by competing for light or nutrients, by providing shade, shelter, or protection from wind erosion, and by acting as reservoirs of pests or of beneficial species; the value of the hedges and trees as habitats of wild plants and animals in highly cultivated landscapes; and the contribution that they make to the beauty of the landscape - a beauty which has come to be thought of as characteristically English. The balance of all these factors undoubtedly varies from region to region, between one type of farming and another, and not all hedges behave in the same way.

In this symposium our first purpose is to establish facts; how fast have hedges been destroyed, how fast are they going now, and where and why. Secondly, we should agree what more we have to know and how to discover it. Finally, we should begin to discuss policy. Even if all the organisations represented at this meeting cannot yet agree a common policy, and even though our formal policies may indeed be appropriately considered at a later and rather different meeting, we can at least try to agree one thing: a common policy on the dissemination of the facts.

PART I: HEDGES AND HEDGEROW TREES

1. THE RATES OF HEDGEROW REMOVAL

M.D. Hooper

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The most commonly quoted average figure for the rate of hedgerow removal is 1.1 yards/acre/year. This was found from 29 sample areas, each roughly 200 acres in extent examined during the Common Bird Census recording for the British Trust for Ornithology between 1963 and 1966 (Williamson 1967).

Another average figure for the preceeding period 1946-1963, of 0.22 yards/acre/year, may be derived from our figures (Moore, Hooper & Davis 1967) but such averages obscure the very great variation of the rate in both space and time, and are in any case subject to the criticism that the sample are very small in relation to the 25,000,000 acres of improved farm land. To improve the accuracy of such estimates and remedy the deficiencies we have in progress studies of a number of sites within specific farming regions and we are taking into account changes in the rate with time.

This last point is of considerable significance as it has been suggested that hedge removal might cease on arable farms once the farm boundaries were reached thus leaving at least a proportion of the hedges. This proportion would, of course, vary with the variation in farm size that exists in the country. We have not found evidence to support this suggestion. On one of our largest study areas of 4,500 acres of general arable land in Huntingdonshire the rate has been:

	1946-1963	0.55	yards/acre/annum		
	1963-1965	5.1	"	"	"
	1965-1966	1.6	"	"	"
	1966-1967	0.8	"	"	"
	1967-1968	1.6	"	"	"
Average	1946-1968	1.08	"	"	"

Now a greater proportion of the original internal field boundaries remains than the external farm boundaries. These remaining hedges in fact show a very high degree of association with grazing as distinct from tillage rather than any association with farm boundaries.

This in turn suggests that rates of hedge removal may in fact vary with geographical variation in farm type. Using a farm type classification (e.g. see Church, Boyd, Evans & Sadler 1968) to order some of our study areas, the expected correlation appears very clearly, but there are exceptions, particularly in one general arable area in Norfolk:-

1. General Arable Areas (50-87½% total SMD on arable):-

2 samples	a)	1.93 yards/acre/annum
	b)	0.1 " " "

2. Mixed Farms:-

2 samples	a)	0.32 " " "
	b)	0.28 " " "

3. Dairying:-

2 samples	a)	0.1 " " "
	b)	o.01 " " " <u>net gain</u>!

This particular sample site (1.b in the above table) is in fact in an area where hedges are actively preserved as part of a game conservation policy. Thus the personal wishes of the landowner must also be taken into account. On three adjacent large estates of generally mixed farming (all over 1,000 acres) where we know the wishes of the landowner we have found:

Landowner interested in game and wildlife	=	no hedges removed
Landowner " in game only	=	50% " "
Landowner not interested in game or wildlife	=	93% " "

However, despite variation in the wishes of the landowners and regional variation, the average rate derived from 29 widely dispersed samples in the B.T.O. census was 1.1 yard/acre/annum. Our own most recent figure based on fewer but larger samples (sampling not yet complete) is o.54 yards/acre/annum over the period since 1945.

These figures imply that hedges are being removed from the country as a whole at a rate somewhere between 7,000 and 14,000 miles each year.* Even if the lower rate was assumed, should the process be maintained the last hedge in England would be grubbed up in the winter of 2049 A.D. Obviously this extrapolation should not be taken too seriously: it is useful chiefly to convey the scale. Half a yard per acre seems a small amount, yet over the whole country it represents a massive annual total of several thousand miles! But even so, this is only about 1 per cent of the total hedgerow mileage.

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* Note added in press

These figures have been re-examined since the Symposium, in consultation with officers of the Ministry of Agriculture, Fisheries and Food. A reappraisal of the position is given in Part V, page 94.

2. HEDGEROW AND PARK TIMBER AND WOODS OF UNDER ONE ACRE

G.M.L. Locke

Forestry Commission, Alice Holt Lodge

Scattered trees and small copses have become accepted as being an integral part of the scenery in many parts of the country and indeed in some areas they can give an impression of fairly dense woodland cover which is more apparent than real; in others, particularly in parts of Eastern England, they may form the major timber resource of the district. There is little doubt, therefore, that no matter how variable in occurrence these isolated trees and small woods may be they do contain a very substantial volume of timber and must therefore be taken into consideration in any assessment of national timber resources.

1938 Survey

There have been a number of surveys to measure the extent of this timber category, the first being in 1938, and the survey technique of measuring 16 acre strips, each one mile long and two chains wide, is the one which was adopted in this and in all subsequent assessments. The 1938 survey was confined to selected counties but there was a fairly even spread of sampling units over England and South Wales. In order to allow for possible variations in density, England and Wales were divided into different geographical regions, of similar geological and topographical type, and the density calculated separately for each region. Inspection of the mean volumes per tree appeared to show no consistent differences between the different regions or between the different species and all the volume measurements were therefore combined to give estimates of the mean volume per acre for each girth class.

In all 858 sample strips were measured and the size class distribution in England and Wales showed that 6 per cent of the volume was in trees of between 5 and 9¾ inches B.H.Q.G., 16 per cent in trees between 10 and 14¾ inches B.H.Q.G., and 78 per cent in trees of 15 inches B.H.Q.G., and over. The percentage proportions in terms of number of trees between saplings (trees under 5 inches B.H.Q.G.) and the three timber classes were 33 : 21 : 19 : 27. It is interesting to note that even thirty years ago some disquiet about the maintenance of the resource was being expressed for the report noted that very little planting or natural regeneration of hedgerow trees was taking place and that once the present stock of mature trees had been felled there would be much less timber of this nature in the country.

The survey was supposed to be confined to isolated trees and woods under 1/10th acre in size but it is apparent from the returns that this limit was not always adhered to and the results are not strictly comparable with those of later surveys. It was, however, clear that there was a preponderance of both volume and number of trees in the largest of the tree size classes and that the number of saplings, albeit one and a half times greater than the number in the class immediately above was probably barely sufficient to maintain the reserve at the lower level which was bound to result from the felling of the mature trees.

1942 Survey

The next survey was in 1942 when a sampling survey of all woodland resources was carried out to assess the rate at which the national stock of timber was being depleted by the heavy war-time fellings. For the hedgerow survey England and Wales were sub-divided into seven broad regions which reflected the various topographical, geological and climatic influences and the method of survey was essentially the same as in 1938, except that woods under one acre in extent were included in the assessment.

The volume was distributed between the three size classes of timber trees in the percentage proportions of 9 : 21 : 70 which after allowing for felling and recruitment agrees fairly closely with the 1938 figure. The analysis of the results of the 1942 survey did, however, cast some doubts on the assertion in 1938 that the mean volume per tree showed no consistent differences between regions or between species and it appeared that for a given girth there was a rise in volume from the North and West to the South and East which could be attributed to the improved growing conditions for hardwoods which form the bulk of the category. The estimated number of trees in the sapling class and in the three timber classes were in the percentage proportions 24 : 30 : 22 : 24 which, when compared with the 1938 results, showed a drop in numbers of both the largest size class and of saplings. The fall in the number of mature trees at a time of heavy felling was not unexpected but the fall in the number of saplings can probably only be attributed to the fact that recruitment of trees to the smallest timber class was taking place at a faster rate than recruitment to the sapling class.

1951 Survey

The next survey to be undertaken was in 1951 when 441 strips were measured to provide information for Conservancies and countries. The lower limit of the smallest timber class was raised to conform with measurement conventions then in force and became 6 - 9¾inches B.H.Q.G., instead of 5 - 9¾inches B.H.Q.G. When the results are compared with previous surveys the overall effect is to lower the percentage volume and number of trees in this class and to increase the number and thus the proportion of saplings. The results for England and Wales showed that the percentage proportions by volume in the three timber classes were 7 : 21 : 72 which, bearing in mind the reduction in girth range of the smallest class compares closely with the 1942 results. The number of trees by percentage in the four classes was - 42 : 19 : 19 : 20, which is a marked rise in the proportion of saplings. Part of this increase can no doubt be attributed to trees between 5 - 5^3 inches B.H.Q.G., no long being considered as timber trees but even after allowance for this fact it does appear that there had been an increase in the number of saplings in the nine year period.

1965 Survey

The last and most recent survey to be undertaken is the one carried out in conjunction with the 1965 sample census. On this occasion the sampling was confined to England South of a line from the Mersey to the Humber in which over 80 per cent of hedgerow and park timber occurs. In order to provide a direct comparison with the 1951 survey one third of the samples measured were the same as those measured in 1951 whilst the remaining two thirds were selected at random. It is therefore possible to compare the results of individual strips at two points in time.

Full analysis of the data has yet to be made but briefly the provisional results for the region concerned show the following pattern. First, the distribution of volume is in the proportion 10 : 22 : 68 which shows, in comparison with the 1951 results, a decrease in the largest class and an increase in the smallest whilst the distribution of number of trees is in the proportion 24 : 29 : 24 : 23 which is a reduction in saplings and an increase in all three volume classes.

Conclusions

The main inference which can be drawn from this and previous surveys is that trees are apparently being recruited to the lowest volume class faster than they are being recruited to the sapling class and that consequnetly a slow decrease in the total volume of the category is likely to take place unless the imbalance can be restored.

The picture is not, however, quite as gloomy as at first sight because a certain amount of redistribution of the resource is certainly taking place. For example it is known that in the South east of England quite a number of existing woods have been partially cleared for house building and as a result isolated trees and small copses now occur in place of the larger woodland blocks which existed previously. It also appears that in some areas trees are becoming concentrated in corners of fields rather than in the hedgerows themselves. The surveys which have taken place have been at a low sampling intensity and are not therefore comprehensive enough to enable really firm conclusions to be drawn for individual regions, nor can they isolate the changes that are taking place in one particular class of timber, e.g. hedgerow trees in agricultural regions as opposed to those in parks, gardens or small woods. It is clear, however, that the hedgerow and small wood category has undergone and is still undergoing a substantial change in its character and that the full impact of these changes can only be determined by regular assessments of the situation.

DISCUSSION - PART I

Rates of hedgerow removal

Dr. Hooper pointed out that the rate of hedgerow removal calculated by the B.T.O. was higher than his own, and would indicate an annual loss of nearly 2 per cent of the country's hedges. However he believed this to be biassed partly through sampling mainly from arable areas in the east and partly because of the period over which the observations were taken. His observations suggested that the rate was higher over the 1963-1966 period than before or since.

Mr. Williamson (B.T.O.) agreed that the rate of 1.1 yards per acre per annum might be on the high side as it was calculated from rate on 44 farms in the south, south-east and south-midlands. Mr. Cornwallis suggested that the variation between years might be random or possibly correlated with weather conditions but over a period on his own farm of 500 acres in Lincolnshire his rate also averaged out at a yard per acre per annum.

Dr. Poore asked what the range of variation in the rate was and Dr. Hooper replied that the observed range was from a slight increase in hedgerow mileage to a maximum loss of 5 yards per acre per annum.

Asked what were the main reasons for the loss and whether farm improvement grants were a significant factor, Dr. Hooper replied that it was his impression that the cost of maintenance of hedges was the major factor and that grants only played a part when extensive drainage schemes were implemented at the same time.

Changes in hedgerow timber and small woodlands

Mr. Locke was asked whether there were any details of how individual species were affected by the trends and whether ornamental species were excluded from the census. He replied that only orchards were excluded and ornamental species such as Laburnum were included. This made detailed estimates for individual species more difficult to extract from the data but there was certainly a decline in Oak.

In reply to other questions Mr. Locke indicated that mechanical cutting affected the sapling classes and that the increase in trees in corners of fields was caused by natural regeneration rather than planned planting up of such corners.

PART II HEDGES AND MODERN AGRICULTURE

3. LAND-USE CHANGES AND THE HEDGEROW

Professor J.T. Coppock

Edinburgh University

To write about the effects of land-use changes on the disappearance of the hedgerow is to attempt to make bricks without straw. Although there are many subjective impressions, no comprehensive examination of the relationship between hedgerow and agricultural land uses has ever been undertaken and, because of lack of data, no historical comparisons are possible for any large area before the late 1940s, when aerial photographs became widely available for the first time. Even the study of changes in field boundaries and of the relationship between length of boundary and land use, for which there is abundant material, has been neglected. It is, of course, possible to make estimates based on the assumption that boundaries which have been lost resemble those which survive, but this may be misleading for any large area; for the character of field boundaries often changes rapidly over quite short distances. And, since the data available for the assessment of even national changes in land use are themselves not very reliable, it follows that only very rough estimates are possible.

The age of hedges varies widely throughout the country. Some may be of great antiquity, some date from mediaeval times and others from the enclosures of the Tudor period and the hundred years after 1750. Few have been created since the mid-19th century, although hedge removal did not begin then; there seems to have been widespread field enlargement in the late 18th and early 19th centuries at the same time as new hedges were being planted in areas affected by Parliamentary enclosure. It is important to realise that what isbeing removed is very varied in origin and that the removal of hedges is now only on the scale on which it is taking place.

It is a truism that changes in the use of land are now occurring at a faster rate than ever before. In part, this is due to the rise in population, for there are now over five times as many people in Great Britain as there were in 1801 and more than twice as many as in 1871; it is also due to technological changes and to rising standards of living. The tractor, the bulldozer and the dragline excavator are but three of the tools now available for effecting landscape changes quickly, and such equipment has altered not only the speed of development,

N.B. Many of the figures given in this paper are rough estimates which should be treated with caution.

but also the scale of individual components of the land-use pattern, as is shown, for example, by the contrast between 18th century roads and modern motorways or between mediaeval brick-pits and those of the Oxford Clay belt between Bletchley and Peterborough. Technological change and greater affluence have also led to new kinds of use, such as water-gathering grounds, military training areas, airfields and refuse dumps, or to modifications in the character of existing uses, as with recreational land use. Most of these changes have helped to reduce the length of hedgerows in Great Britain.

Such developments are broadly of two kinds, those which result in the transfer of land from agriculture to other uses, and those which occur within the agricultural sector; the former tend to be highly localised and the latter widely diffused throughout the rural areas. Most of the land lost to agriculture has been taken by urban development or forestry, which now account for approximately 4.9 and 4.7 million acres respectively, or 9% and 8% of the land area of Great Britain; but their significance for the disappearance of the hedgerow is quite different, for whereas afforestation has largely been at the expense of rough grazings and has been concentrated in the uplands of the north and west, urban expansion has taken place mainly in the lowlands on land which was formerly in hedged fields. Changes within agriculture have largely been concerned with the shifting balance between grassland and arable land, and with changes in arable farming.

There are no accurate records of forest land before the censuses of this century, but it seems likely that before the first World War agriculture both lost land to forestry and gained land from it. In the 1850s and 1860s reclamation of woodland for agricultural uses was still taking place; for example, between 1856 and 1858 some 1900 acres of the recently disafforested Wychwood Forest in Oxfordshire were cleared of timber and converted into farmland. During the agricultural depression in the later years of the 19th century, on the other hand, some poor arable land and inconvenient fields were planted with conifers. However, the effects of such changes on the total length of hedgerow must have been small and it was not until the creation of the Forestry Commission in 1919 that major changes in the extent of land under woodland began to occur. Between 1919 and 1939 over a quarter of a million acres were afforested; since 1945 the Commission's forests have increased by over a million acres, though the transfer of private woodlands for replanting accounts for some 300,000 acres of these. On private estates, too, there has been quite large-scale afforestation for the first time since the 19th century, although some derelict woodland has also been reclaimed for agriculture. The total effects on hedgerows of all these changes cannot, however, be large, since the Forestry Commission, which has been the main agent of change, has been unable to acquire good agricultural land, both because of its cost and because of the need to secure the agreement of officials of the Agricultural departments before land is taken. These new woods have mainly been planted on the flanks of the uplands and most of the comparatively small acreage afforested in lowland Britain has been poor heathland, as in the Breckland and Cannock Chase.

Urbanisation, on the other hand, has been a major cause of loss of hedgerows. Unfortunately, there are no convenient records from which changes in the extent of urban land can be calculated, even at a national level, for, although it is possible to measure such changes by comparing successive editions of the Ordnance Survey maps, the dates of these differ widely over the country. Thus regional differences in the rate of loss, which are quite marked, can only be roughly estimated from population changes, especially for the 19th century when other sources of information are lacking.

It has been estimated that the urban area of Great Britain (that is, all land occupied by buildings, roads and associated open spaces) was some 2.2 million acres in 1900 and, on the basis of the rise of population from 20.8 million in 1851 to 37.0 million in 1901 and the widespread migration to the towns, the corresponding figure for 1851 was probably between 1.0 and 1.5 million acres. From 1927, change of occupancy data from the Ministry of Agriculture permit an annual estimate of change in England and Wales and show that the rate of transfer has been far from uniform; it was highest in the inter-war years when there was little planning control over urban development and the lower densities advocated in the Parker Morris report had been generally accepted. In the period 1934-8, the annual loss in England and Wales was some 60,000 acres and between 1925 and 1939 some 900,000 acres of agricultural land were transferred. In the postwar period losses to urban development have been at a lower rate, averaging about 41,000 acres in Great Britain in the 1950s. In all, the urban area seems to have increased by some 3½ million acres since the middle of the 19th century, largely at the expense of land in agricultural use, since little heath or woodland has been taken for urban development.

As the estimates for the 1950s indicate, the rate is not uniform throughout the country, averaging 5,000 acres in Scotland, compared with some 36,300 acres in England and Wales; and even the latter figure hides wide variations, for the percentage rate of urban growth rangedfrom 0.2% in Wales to 2.1% in London and southeast Ebgland. From the population estimates, it is clear that urban growth was more evebly spread in the 19th century, when the coalfield industrial towns were growing rapidly; thus the percentage growth in population between 1861 and 1921 was 110% in north England, 107% in Wales and 108% in metropolitan England. Since the 1920s, population growth has been fastest in the Midlands and south east England, which had 43.4% of the population in 1921 and 48% in 1961; an increase of 32.6% compared with 9.0% in northern England and -0.6% in Wales. These regional rates were, of course, resultants of depopulation from rural areas and growth in the large towns of each region; but there is no doubt that the bulk of urban development occurred in the south east and was therefore largely at the expense of hedged fields.

Not all this land will have been cleared of hedges. On some housing estates, they have been retained as boundary fences and they may also survive where fields have been sufficiently large to accommodate playing fields and sports grounds. On the other hand, the influence of urbanisation on agricultural land extends beyond the urban fence, for there is quite commonly a zone of blight around the large towns where much land is either awaiting development or is in semi-agricultural use, and hedges are neglected and fields run down.

Agricultural land has also been taken for mineral working, especially gravel digging and open-cast mining for coal and iron ore. The volume of minerals extracted from the ground has been rising steadily since the early 19th century and was dominated by deep-mined coal until the 1920s. Since then coal's share has been declining, both absolutely and relatively, and now accounts for less than half the weight of all minerals extracted, while the share of sand, gravel and limestone for concrete making has been rising sharply. Since deep-mining requires land only for pit-head gear, washing plant and for tip-heaps, the loss of hedged fields must be quite small. By contrast, the raw materials of the civil engineering industry are generally worked open-cast in relatively shallow pits in the river valleys of Lowland Britain and quickly affect large areas of agricultural land. The working of iron ore along the Jurassic outcrop and open-cast coalmining, begun during the second World War and now being phased out, have also made important contributions. In the 1950s the acreage of land used for mineral working was averaging about 12,000 acres a year in England and Wales, most of it agricultural land. Not all this land is permanently lost to agriculture, for about three quarters is restored after working, and the total area of derelict land in England and Wales is estimated at about 112,000 acres. Land worked open-cast for coal must be restored after the coal has been extracted, and between 1942 and 1958 an estimated 110,000 acres were returned to other uses. The scale of open-cast mining of iron ore has been smaller and it was not until the establishment of the Ironstone Restoration Fund in 1951 that any serious attempt was made to restore the land which had been worked. Some planning consents for other minerals also specify that land must be restored to use after it has been worked, but the value of many of the materials of the civil engineering industry is often too low to bear the cost of reclamation. However, restoration has little relevance for the conservation of hedgerows, for even where the land is restored to agricultural use, it is generally laid out in rectilinear fields, separated by post and wire fences, and the hedgerows are not replanted.

Other changes of use have also reduced the extent of hedgerows. Some land for recreation has already been included in estimates for losses through urban development, but there have also been extensive transfers in the countryside. Other land has been taken for military purposes, especially during the second World War; much of this was moor and heath, but large areas, totalling over 250,000 acres were cleared for airfields, mostly on fairly flat agricultural land in lowland areas such as

Lincolnshire and East Anglia; and, as with open-cast mining, even where such land is restored to agricultural use, the hedgerows do not return. Some valley bottom land, often in hedged fields, has also been flooded to provide new reservoirs; and although the acreage is small, it probably has greater significance than in areas where hedgerows are abundant.

While it is impossible to say accurately how much land has been diverted from agricultural uses, it is certain that most of the land lost to those uses was formerly agricultural land. The significance of such losses for the conservation of the hedgerow will depend greatly on the character of each agricultural landscape and in particular on the size of fields and on the nature of field boundaries; thus, the spread of London into north Middlesex, where fields were small and lined with hedges, has led to proportionately much greater losses than the eastward spread of Liverpool. At a very rough estimate, perhaps four million acreas of lowland agricultural land have been taken since 1850, more than half since 1920. If G.M.L. Locke's estimates of the length of hedgerows per square mile are taken as a guide, these various developments have accounted for the loss of about 100,000 miles of hedgerows. This is very much less than the scale of losses on the remaining agricultural land suggested by the Monks Wood Sample Survey.

It is thus not the loss of hedgerows arising from the transfer of land to other uses which is causing concern, but that resulting from changes within the 45 million acres of remaining agricultural land; and it is changes in agricultural practice rather than changes in the use of agricultural land <u>per se</u> which have posed the most serious threats to the survival of the hedgerow. Changes in the pattern of land uses, although they are in part related to these changes in practice, are chiefly important as indicators of the probable regional incidence of new practices and hence of the threat of hedgerow removal; and even for these conclusions to be drawn, relationships between field enlargement, hedge removal and land use must be assessed which, although perhaps self-evident, have not yet been demonstrated by any valid statistical procedure. Once again, moreover, an attempt is being made to match two parameters whose locations are known not only imprecisely, but with different degrees of imprecision; for, while the generalised distribution of land-use changes can be examined in fair detail from the agricultural returns, that of field sizes and types of field boundaries is based mainly on general impression.

Three related changes in farm organisation are primarily responsible for the pressure to remove hedges and are expressed, if somewhat indirectly, in land-use patterns, viz. increasing mechanisation of farming, increasing size of farm and increasing specialisation, both by farms and by area; the rising proportion of agricultural land, in owner-occupation is perhaps also a contributory factor. Their effects have been felt mainly in the past thirty years and with special force in the last decade when farmers, squeezed between rising costs and land values and a diminishing labour force, have been under increasing pressure to adopt the most efficient form of farming.

Mechanisation is generally considered to be the most important of these changes, in part perhaps because it is the most obvious in its effects. Mechanisation first began on any scale during the first World War and by the early 1920s there were perhaps 20,000 tractors. By 1939 this number had risen to about 56,000, confined almost entirely to eastern England, but it increased more than eightfold from the outbreak of the second World War to the 1950s. There has been little change since, but the stability is illusory; for the available horsepower has been steadily rising as replacements are made with larger and more powerful machines. Measured in relation to the crops and grass acreage, tractors are now fairly evenly distributed; but those in the west are as much general purpose tools for haulage and even personal transport as instruments of tillage. Combine harvesters provide a better index, since it is above all the development of mechanised cereal growing which has led to thre removal of hedges. The number of combine harvesters began to increase rapidly only in the postwar period and shows a similar pattern of outward diffusion in rates of adoption from the south and east to the north and west; but though the number of combines per thousand acres of cereals is highest in the west, in absolute terms they are far more numerous in eastern arable counties. Moreover, a higher proportion of those in the west and north are small machines and much of the relatively small acreage of cereals in these areas is still cut by reaper-binders, which outnumber combines by 2 to 1. Other implements, such as beet and potato harvesters, are even more markedly concentrated in eastern counties.

The effects of increasing farm size are less direct, working through a general enlargement of the scale of operation and offering greater opportunities for rationalisation of farm layouts; moreover, it seems that, as a general rule, field sizes is directly related to farm size, with small farms tending to have a smaller average size of field and a higher proportion of small fields. Evidence about changes in farm size is not very satisfactory and is complicated in the period before the second World War by the reclassification of land as rough grazing, leading to an apparent decline in the number of large farms. It is reasonably certain that the statistical data understate the extent to which large farms are coming to dominate the agriculture of eastern counties. If the area in farms of over 300 acres is taken as an index, there has been a marked increase since the 1930s and the share of land in crops and grass occupied by such large farms rose from 25% to 35% by 1965; moreover this change has been most marked in counties where the proportion was already high, exceeding 15% in most of East Anglia and being less than 10% in most western counties. How far the increase in owner-occupation is related to this trend is uncertain, but owner-occupation does remove any restraint on the removal of hedges that might be exercised by a landlord conscious both of their contribution to amenity and of their value to wildlife.

The trend towards specialisation is indicated by the rising proportion of individual crops and of classes of livestock which are to be found on a small proportion of holdings and in a decrease in the number of enterprises per farm; but it is most easily seen in its regional expression and in the sharpening of the contrast between an arable east and a pastoral west. It is true that, in a sense, this tendency began much earlier in the retreat from the high farming of the 1870s and its effects are complicated by events during the two World Wars; but it is particularly characteristic of the period since the second World War .

In the modern period, the early 1870s marked the peak of arable farming, although the agricultural statistics almost certainly understate the true position. Arable farming and cereal growing were widely practised, although they were subordinate to grass farming in western counties. Although the question has never been properly investigated, it does seem that, even under then-standards of technology, grass fields were generally smaller than arable fields; there are even some advantages in small size in livestock farming, whereas the few studies which have been made show that operating costs in arable farming are appreciably higher on small fields. In the following 50 years, however, the acreage of arable land steadily declined, reaching its nadir in 1938 and becoming progressively concentrated in eastern counties; with this decline, any pressure to enlarge fields was weakened and, even in the remaining arable areas, both landlords and farmers lacked the resources to engage in the large-scale removal of field boundaries. During this period, neglect rather than removal seems to have been the rule.

Although arable farming became progressively concentrated in eastern counties in this period, regional specialisation was by no means universal and dairying became widely adopted, especially in the 1930s after the creation of the milk marketing boards. In the postwar period, however, both livestock and arable farming have shown a marked regional segregation. Dairying and sheepkeeping have declined in importance in eastern counties so that, despite an increase in numbers nationally, there are now fewer grazing livestock in these counties than in the 1930s; similarly, despite a considerable increase in the acreage of land under crops other than grass, the proportion of agricultural land under tillage is now lower in western counties than prewar and is higher in eastern counties even than at the peak of the wartime ploughing campaign. Because of fewer livestock, there is less need for stock-proof fencing; at the same time, increases in the size of tillage implements and in the scale of operation have, together with the availability of grants which reduce the cost of hedgerow removal, increased the incentives to enlarge fields. Insofar as fields are bounded by hedgerows in such areas, it is here that the pressures to remove hedges are strongest.

Of course, this summary picture is a gross over-simplification. Greater tractive power has made it easier to cultivate some of the heavier soils in midland England, and the proportion of tillage here is higher than in 1939. The effects of the two World Wars and of the great expansion in ley farming since 1944 must also be taken into account. The first World War probably had little effect on the rate of hedgerow removal; for mechanisation was little advanced and, although the area of arable land increased by one and a half million acres, this did not restore the losses of the preceding 50 years. During the second World War, the acreage of ploughed land increased by six million acres, although the total acreage was still less than in the 1870s; on the other hand, mechanised farming was widely adopted and in many western and midland counties more land was cropped than during the 1870s. This situation did not last long and immediately after the end of the War farmers began to lay land down to grass, the arable acreage began to decline steadily, and fell below the prewar level in western counties. However, in recent years, the total acreage has begun to rise again as a result of the expansion of tillage in eastern counties.

What significance these developments had for hedgerow removal is not known, although a comparison of the field sheets of the first Land Utilisation Survey and the aerial photographs taken immediately after the second World War could provide some indication. It seems reasonable to suppose that the flow and ebb of this wave of cultivation must have led to the removal of some hedges in areas which are now mainly grass. The situation is complicated by the widespread adoption of ley farming, which has blurred the once-sharp distinction between arable land and permanent grassland and which results in a large acreage coming under the plough from time to time. The acreage of such temporary grass is now 1.8 million acres higher than in 1939.

Whatever the effects of such changes, it seems quite clear that the incentives to enlarge fields and remove hedges have become progressively strengthened in eastern counties; but the effectiveness of these incentives will depend on the existence of hedges to be removed. There have never been many hedges in the Fenland, the area of most intensive arable farming, nor have they been numerous on the chalk downs and in the Cotswolds, two of the major areas of large-scale cereal growing.

It is impossible to predict accurately trends in land use or in hedge removal. Losses to non-agricultural uses will continue on a larger scale and, although government policies of restraining growth in the favoured areas of the south east and encouraging it elsewhere may have some effect, it is likely that much of this development will take place in the Midlands and south-east England. Changes on the remaining agricultural land will depend both on government policy and on developments in agricultural technology. Trends towards the enlargement of farms and the rationalisation of farm layout can be expected to continue, with government help, and any increase in incentives to cereal growing, such as would come from restrictions on imports or from entry into the European Economic Community, would certainly accentuate the trend to field enlargement. Similarly, adoption by British dairy farmers of the practices of Wisconsin dairymen, whose stock is kept mainly in yards, would certainly remove the need for stock-proof fencing; indeed, the general tendency for farming to go under cover is already working in this direction. Since there is comparatively little scope for increasing either the proportion of land in cereals or the extent of ploughed land in those areas which now specialise in cereal growing, any general incentive to increase the acreage under tillage or under cereals counl lead only to a widening of the area within which large-scale removal of hedgerows is taking place.

What this paper illustrates, apart from the inadequacy of our land-use records, is the need for a factual basis for any discussion about hedges and land-use. At least, I can claim to have made some small contribution in this respect, for one of my first academic assignments was to organise a land-use survey of the Chilterns in 1951, in the course of which we recorded the location and character of field boundaries over an area of 1300 square miles. We have recently carried out a similar survey in 200 square miles of Roxburghshire. These can be used as datum points from which fairly accurate assessments of change in relation to land-use can be made. The Countryside Commission's proposed sample survey of randomly chosen kilometre squares will also provide valuable information.* In the meanwhile, we can sample successive editions of large-scale Ordnance Survey map, especially those that can be related to land use, to establish regional differences in the scale of field boundary changes; for, used with care, this information could provide a fair indication of the changing pattern of hedgerows in most lowland areas.

* Since this was written it has been decided not to proceed with the Changing Countryside Project. See page 99.

4. FIELD SIZE AND MACHINE EFFICIENCY

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Many hedges have been grubbed out over recent years, generally on the grounds of increased workable acreage and improved field machinery efficiency in better shaped, larger fields. These points can be considered on a factual basis relative to shape and size, though other results of hedge removal - loss of shelter, removal of weed and pest sources, etc., are dependent almost entirely on local conditions.

Added Workable Acreage

The extra acreage released for cropping is directly related to the area originally covered by the hedge together with any headland rendered inaccessible for cultivation, and depends accordingly on overall width and total length removed. To gain one acre of land would necessitate the removal of 110 chains of a 6' wide hedge, or 220 chains of a well-trimmed 3' hedge. If removed by contract, the annual charge of the cost of removing such a hedge could be equivalent to a rental of £70 per acre on the area cleared. If effected by farm staff during slack periods, the cash cost would, of course, be greatly reduced and the annual charge become negligible.

Given a constant area, the shape of a field has very little effect on the area lost to cultivation due to the presence of a hedge, apart from in an exceptionally long and narrow field. A hedge covering a 6' strip of ground would prevent cultivation of a 3' strip round the adjacent fields and Table 1 shows the effect in three field shapes, i.e. square, or rectangular with sides in 2:1 and 5:1 ratio.

Table 1. Area Lost on 3' Headland Strip

Field Size in acres	Square		Rectangular (2:1)		Rectangular (5:1)	
	%	Acres	%	Acres	%	Acres
5	2.6	.128	2.7	.136	3.5	.176
10	1.8	.182	1.9	.193	2.4	.244
20	1.3	.258	1.4	.274	1.7	.344
30	1.0	.315	1.1	.333	1.4	.423
40	.9	.364	1.0	.388	1.2	.488
50	.8	.410	0.9	.435	1.1	.550
100	.6	.580	0.6	.610	0.8	.770

The percentage difference between the shapes becomes progressively smaller as field acreage increases, though the actual acreage difference will increase. The difference due to shape ranges from .05 acres in a 5 acre field to .19 acres in a 100 acre field, and can be ignored in most cases.

Maintenance saved

All types of hedge or fence need repair and the annual cash saved will depend on the type of original boundary, and the geographical situation of the holding.

FIELD MACHINERY

Well maintained field machinery will cover the greatest acreage per hour when travelling at its maximum forward speed compatible with required quality of work, and at full working width with a minimum out-of-work time on turning, loading and unloading and travelling between fields. Any reduction in this out-of-work time must increase output. Hedge removal will reduce the number of turns necessary whether cultivating in an up and down manner or round and round. However, field machinery that carries materials for distribution, or collects a load, must also be loaded or unloaded and row length, or distance between corners, will determine the effective load that can becarried without excessive travelling to and from the loading or unloading point.

Corners

The number of corners to be turned in a field depends on row length or distance between corners in round and round patterns. Three factors control the percentage of time spent in cornering (Table 2):-

1. Skill of operator in reducing time per turn to a minimum.
2. Length of travel between turns.
3. Speed of machine in work.

Table 2. Percentage working time lost with turns of .20 and .60 mins.

	Turn of .20 min. in rows of				Turn of .60 min. in rows of			
	100 yd.	250 yd.	500 yd.	750 yd.	100 yd.	250 yd.	500 yd.	750 yd.
1 m.p.h.	5.5%	2.3%	1.2%	.75%	15%	6.5%	3.5%	2.5%
2 m.p.h.	10.0%	4.5%	2.4%	1.5%	27%	12.5%	6.5%	4.5%
3 m.p.h.	15.0%	6.5%	3.5%	2.5%	35%	17.5%	9.5%	6.5%

It will be noted that of these three factors speed in work has the greatest effect on the percentage of time lost. It must be emphasised that these figures refer to "Working time" only. If other factors are considered such as loading the combine drill, the suggested out-of-work time may drop by approximately a quarter when related to total time in the field.

Loading and Unloading Time

In such operations as combine drilling of cereals, the proportion of out-of-work time taken up in loading the hoppers will depend to a great extent on the acreage covered by one load. The actual time spent physically handling the materials will remain relatively constant, but extra travelling time per acre to the loading point will be incurred if the machine carries a smaller load. The load distributed by an particular machine is affected by row length. If the material supply is sited on one headland the effective load of the machine must be a multiple of the quantity distributed on one complete bout. If both headlands carry material depots, or if loading can be arranged in the centre of the field the effective load will be multiple of the quantity required for one row length (equal to two half rows if loading centrally).

Overlap of distributed materials

If the rate of application (seed, fertiliser, etc.) is at an optimum under a given set of conditions, the extra material applied on overlap on the headland must be wasted and the amount of this wasted material is directly related to the length of overlap per row and row length in the field. With a 3' overlap at each end of rows 100 yards long, which may be considered excessive, the area covered twice amounts to only 2% of the total. In an operation such as combine drilling of cereals where seed and fertiliser may cost £7 per acre, this represents a cash wastage of 2s. 9d. per acre. Increasing row length does not give a linear reduction of this wastage. Doubling row length to 200 uards reduced the loss to 1% or 1s.4½d., a further increase to 300 yards gives a reduction to .65% or 11d. Reduction of overlap length has a more marked effect. A skilled driver would reduce the length of overlap to less than 18" which in 100 yard rows amounts to 1%.

COSTS AND RETURNS

Once the original investment in the cost of clearing the hedge has been made, there will be no further charge apart from interest on the capital which may be fractional where farm staff has performed the clearance. Cash Returns would be expected from four sources:-

1. Gross Margin from the extra workable land.
2. Saved cost of maintenance on the original hedge.
3. Reduced non-working time of field machinery saving <u>direct</u>

costs of machine operation.

4. Saving of cost of material wasted on overlap.

Even at a high cost of hedge removal it is considered that these accumulated savings would at least equal the annual charge on the original investment, particularly in very small fields. However, bearing in mind that most of the savings made by removing hedges do not go up in proportion to the acreage made available in one unit and that further difficulties may be encountered as row length becomes excessive, there appears to be little advantage in greatly exceeding a row length of 500 yards. This indicates a square field of approximately 50 acres which would allow field machinery to work efficiently in both directions. Field acreage may also be increased however, to allow any one crop to be grown as one unit (dependent on rotation) to reduce changeover time between parcels of land.

5. PHYSICAL EFFECTS OF SHELTER

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I have extended my paper somewhat in order to look briefly at the agricultural and horticultural implications of the physical effect of wind and shelter on the crops and livestock being produced in this country.

The ill effects of wind and the need for shelter, particularly for livestock and their masters, have long been appreciated and there were extensive plantings of shelter belts during the nineteenth century and earlier. Many of these belts can still be seen in the more exposed hilly and mountainous districts of the country although they are less in evidence in the lowlands where the remains of forests and woodlands are still in existence and have some effect on the meso-climate of the farmlands of these areas.

Hedge plantings

In the lowlands hedges were planted in the successive periods of the enclosures mainly to define the boundaries of properties and of individual fields and to prevent the movement of livestock. In the less favoured parts of the country dry stone walls or stone faced earth banks were used and in a few areas the necessary drainage channels served the same purposes. Shelter was not then a major consideration and it was only in exposed districts, often near the coast where wind sensitive horticultural crops were grown, that hedges were planted to reduce the effects of wind. The horticultural districts of Cornwall, Scilly, the Wirrall, South Hampshire and West Sussex come to mind as having examples of this type of sheltering hedge.

Shelter studies

The appreciation of the need for shelter was carried by the settlers who were extending agriculture, and therefore human habitation, into the large relatively flat areas of the United States, Canada and other newer countries. It was in these countries and in Russia where the first studies of the effects of wind and shelter on crops, livestock and people were made and early publications such as those by Bates (1911) stress the ill effects of wind, particularly in the extremely cold winters of those new lands, and make recommendations as to how to plant and grow living shelter.

In the past twenty five years or so more intensive studies have been undertaken in those and many other countries including the British Isles. Studies of the meteorological records in fact suggest that these islands are among the windiest of any of the well-populated countries in the world (Gloyne, 1965).

The literature of this subject of wind and shelter in agriculture and horticulture has been reviewed in recent years by Caborn (1957, 1965), Jensen (1954), Kreutz (1952), Marshall (1967) and others. It would seem that we are perhaps arriving at a stage when a great deal is known about the behaviour of wind, its effects on many crops, the effects of shelter on both climate and on vegetation but at the same time are finding it more profitable to transport produce from areas in favoured climatic situations than attempt the costly task of providing shelter in less favoured areas.

Behaviour of wind

Wind is of course air moving under pressure over the surface of the earth. At heights above the earth which are only of interest to airmen the airflow is relatively speedy and consistent. Over the sea the wind is similarly relatively steady but close to the surface of the land the direction and speed of wind is varied by the surface obstructions over and around which the air must pass. Mountains, hills, buildings, forests, hedges and other obstructions change the direction of the wind both laterally and vertically and at the same time cause changes in speed by impeding and accelerating the flow of air over and around them. Thus wind speeds on the crests of hills or at the ends of buildings or shelter belts are often higher than in the open while lower speeds are experienced lee of such obstructions.

Some reduction may be experienced to the windward of such shelter where a cushion of air can be built up which throws the oncoming air over and around the obstruction.

The amount of such variation in speed and direction depends on the solidity or degree of permeability of the obstruction and on the angle of the face of the obstruction to the oncoming air. Sloping hillsides and even shelter belts presenting a sloping surface to the wind will send the air up the slope at an increasing pace and where the slope on the lee side is less than about ten degrees the wind will then continue down that slope at about the same speed. Gently sloping land surfaces thus disturb the flow of air but provide relatively little shelter (Gloyne, 1965, and Hogg, 1961).

Living and artificial windbreaks

The effects of living or artificial windbreaks grown or erected to provide shelter have been studied in detail both as to the immediate effect on wind speed and direction and the effect on the micro- or meso-climate of the affected area. All of the many studies have shown that the alteration in wind speed depends on the height, length and permeability of the windbreak. When wind blows towards a windbreak placed at right-angles to the wind direction its speed is reduced at up to about 5H to windward and 20H to leeward where H is the height of the barrier. Slight reductions in wind speed have been reported at greater distances at up to 10H to windward and 30H to leeward but the effective reduction is only experienced at considerably shorter distances. Windbreaks of 10H or more in length are needed to provide shelter of this order if the wind direction remains at or near to right-angles but lengths of 20H or more are needed to provide similar shelter for winds varying up to 45^{o}, if the end effects are not to be felt over the leeward area.

Types of windbreak

The permeability of the windbreak has an important effect on the wind-speed and direction. Solid or near-solid barriers tend to create areas of low pressure on their lee side down into which the wind will blow more or less vertically and even back towards the barrier thus causing turbulence and eddying often with greater damage than that caused by the original and obstructive wind. Open windbreaks allow the penetration of much of the moving air and thus cause smaller reduction of wind speed. Those with a permeability of forty to fifty per cent where the aperture and solid portions are small as in the coir netting used by hop growers, the one inch lath fences used by flower growers in Cornwall and a hedge or shelter belt where movement can be seen but objects are distinguished with difficulty, provide the maximum shelter with the minimum turbulence. Thus a permeable barrier of at least 20H in length will affect the wind speed over some thirty times the height of the barrier. Since however the amount of reduction of wind speed is very limited to windward and beyond some 15H to leeward the area effectively sheltered is contained within a rough rectangle the length of the shelter, if 20H or more in length, by 15H in depth. The maximum reduction occurs at about 3-8H to leeward where speeds of less than 40% of the original can be measured.

The effect of this reduction in wind speed is reflected in the air and soil temperatures and the evaporation and humidity. As a result the growth of plants within this more effectively sheltered area can be altered. None of these climatic factors is significantly altered beyond about 10H to leeward and it is at 4H that temperatures of up to ten to fifteen per cent above the exposed areas and evaporation rates of some 75% below have been recorded.

We thus arrive at a rather smaller area of effectively sheltered land than is suggested by the minimal reductions in wind speeds at up to 10H to windward and 30H to leeward and it is better to regard the sheltered areas as extending no more than to 10H to windward provided the length of the windbreak is at least 20H.

Field sizes

Let us then relate these figures to likely sizes of hedges and areas of land. Ignoring the maximum sheltered area of 10H to windward and 30H to leeward which are but slightly affected and the most heavily sheltered area of 10H to leeward only I will use the area of 20H to leeward and 5H to windward for my examples. A trimmed hedge 6 ft high will affect wind speeds some 10 yds (6ft x 5H) to windward and 40 yds (6 ft x 20H) to leeward. Since, in this country, damaging winds can blow from all quarters it is necessary to have hedges on all sides of every field to be sheltered if an effective but not maximum reduction in wind speed is desired. This implies having fields 50 yds square or just over ½ acre in size with 6 ft hedges on all sides. A proposition entirely unacceptable to present day agriculture.

Since crop responses can only be measured within shorter distances of windbreaks even smaller fields, or taller hedges, are necessary in order to provide effective shelter, for susceptible crops in exposed situations. This situation is known empirically by the Scillonians whose hedges of Pittosporum crassifolium, and other species, are as much as 15 to 20 ft high and often no more than 3 to 4 H apart.

If hedges of up to 20 ft high could be allowed and maintained at that height the above mentioned minimum amount of shelter would then be provided on fields of 166 yds square or some 5½ acres in area.

Extending our attention for the moment to shelter belts a well grown but semi-permeable belt of trees 50 ft high around a square field would provide the minimum shelter on no more than 400 yds square or something over 30 acres in size.

Subsidiary effects

Other effects of windbreaks include the shadows produced on the north side of those orientated east-west and the less persistent shadows to the west before noon and to the east in the afternoon by those running north-south. These shadows have some effect on the soil and air temperatures and they also reduce plant growth in the low light conditions. It is suggested that the effects of these conditions on plant growth are limited to some 1-2H from the shelter.

Horticultural crops

Many studies have been made of the effect of wind on crops and these effects can perhaps be divided into the direct and indirect. Direct damage caused by breaking, bruising, chafing and drying the aerial part of the plants which directly affect the appearance of the crops. Such crops such as flowers, fruit and some salads and vegetables can in such circumstances be rendered useless or so reduced in value as to be unprofitable to the grower. Indirect effects follow the lowered temperature of the air and soil and loss of moisture from soil and plant in exposed situations. These may delay maturity and also cause loss to the grower in that the price may be lowered as a result of the delay in marketing.

Plant behaviour

Studies by Whitehead (1965) have shown that plants produce markedly different patterns of growth in the presence of wind. Those exposed to wind having reduced areas of leaf, shorter internodes, decreased proportions of shoot to root, a decrease in stomatal size but increase in the numbers of stomata and in general a similarity to plants grown in xerophitic conditions. Plants transferred from windless to windy conditions exhibit far more damage when winds occur and in extreme situations die more rapidly but except in extreme situations those grown throughout their life in wind-swept situations grow to maturity without harm although exhibiting the various different characters described above. Thus crops produced from seed sown in the open are less likely to be affected by wind than some of the more delicate horticultural crops which are raised under glass and planted in the open.

Agricultural crops

There have been fewer studies of agricultural than horticultural crops but in general those such as cereals show very little variation in yield between those in windy and sheltered situations. They are however liable to lodging close to shelter belts and other windbreaks particularly where they have produced weaker stems in low-light conditions and where accelerated or turbulent winds occur near the shelters. Harvesting may thus be made more difficult and this may also be delayed by the slower drying of the crop shaded and unexposed conditions. Yields of root crops are similarly unaffected except where the earliness of the crop is the important criterion as with early potatoes. Then the improved climate produced by shelter from wind permits earlier growth and leads to the earlier maturity of marketable crops.

Livestock

When we turn to shelter for livestock the evidence is far from adequate and the situation more complex. For not only are the animals themselves affected by wind and shelter but in many instances the food on which they graze can also be affected. Apart from the untested evidence of the shelter provided in the nineteenth century and earlier, research that has been undertaken suggests that the provision of shelter for sheep is as uneconomic as it is for agricultural crops. Sheep appear only to seek shelter at the time of birth of their lambs. Lambs seek shelter but in doing so may suffer because they are separated from their mothers and consequently get less milk than if they have no shelter and continue to suckle. Sheep enclosed and thus provided with shelter from wind lose less wieght than those in an exposed situation if the diets of both are less than adequate. With an adequate diet the gains in weight are similar in both conditions (Miller, 1968; Winfield, 1967).

Conclusion

On the evidence available there is ample justification for the provision of shelter in even relatively sheltered areas of this country in order to produce high value horticultural crops. Even in this section of the industry however the economic effects of the mechanisation of production, the lowered costs of transport and the improved storage methods may make it more profitable to grow crops in naturally sheltered and otherwise favoured situations rather than add to the cost of production both in the provision of shelter and by limiting the size of machinery by creating small fields as a result of providing shelter.

The value of shelter for vegetables which do not depend on earliness or outward appearance for their value and for the generality of agricultural crops is far more problematical. In general the balance seems to be in favour of larger fields and no shelter against the smaller partially sheltered fields of the immediate past.

Where livestock is concerned there are some doubts about the real value of shelter unless full and complete environmental control is provided by housing the animals for the whole of their lives or at least during the more inclement parts of the year.

The maintenance or planting of shelter belts and hedges in most of the English countryside seems therefore to depend on other factors than those of modern, economic agriculture.

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6. BIOLOGICAL EFFECTS OF SHELTER - INTERRELATIONS BETWEEN HEDGE AND CROP INTERVERTEBRATE FAUNAS

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SUMMARY

An account is given of the ways in which crop invertebrate faunas are influenced by the presence of hedges. The influences are complex, but for convenience are divided into four categories.

1) Shelter effect.

2) Hedges as overwintering sites.

3) Seasonal movement by insects exploiting the changing availability of food in hedges and crops.

4) Flower feeding.

A distinction is drawn between the more easily observable local effects on crops due largely to the shelter effect of hedges, and the role which hedges have in the life cycles of many insects, which may disperse from the hedges over wide areas.

It is suggested that widespread removal of hedges could considerably reduce the diversity of crop faunas, but the effect of such loss of diversity is not known.

INTRODUCTION

The aims of this paper are to describe what is known about the ways in which hedges influence and contribute to the invertebrate fauna of arable crops, to assess whether there is any evidence that their presence contributes to the stability of crop faunas and to suggest the direction which further research on this problem should take.

Reviews of the influence of uncultivated land on crop insects have quite recently been provided by van Emden (1965a) and Lewis (1965a). These reviews refer to many types of uncultivated land and crops. Here the rather more specific problem of hedges and arable crops is considered.

THE HEDGE FAUNA

The hedge fauna can reasonably be described as an impoverished woodland or woodland edge fauna. That is to say the majority of hedge species also occur in these habitats. This is illustrated (Table 1) by a survey of the invertebrates of a fifty yard length of a well grown hedge (unpublished work by the author). The survey was made in 1967/8 using a number of different sampling techniques. The hedge has a variety of shrub species, with hawthorn Crataegus monogyna, spindle Euonymus curopaeus and blackthorn Prunus spinosa dominant. It is close to Monks Wood and because of this and its varied shrub composition is probably richer in invertebrate species than most hedges.

Table 1. A division of part of the fauna of a mixed hedgerow into woodland and open ground species.

	Woodland species	Open-ground species
Oniscoidea (woodlice)	6	2
Opiliones (harvestmen)	11	2
Carabidae (ground beetles)	16	7
Miridae (capsid bugs)	13	3
Totals	46	14

The woodland species of these four taxa total forty-six species, compared with one hundred and forty-one recorded in Monks Wood. All of these groups are well worked in Monks Wood and were selected partly for this reason. Thus the fifty yard length of hedge contained approximately a third of the species recorded in Monks Wood in these taxa. The proportion varied in the different taxa: the majority of the Monks Wood Oniscoidea and Opiliones were present in the hedge, but much fewer of the Miridae and Carabidae, many of which have rather specialised habitat requirements. The work of Tischler (1948), who made a very exhaustive survey of the fauna of two hedge types in Germany, also shows that the nucleus of the hedge fauna is of woodland or woodland edge species.

In agricultural areas the woodland component of the hedge fauna is largely restricted to hedges, while the open habitat component consists, at least in part, of species from the adjoining fields which have 'overflowed' into the hedge. This is shown in the case of two species of Trechus (Carabidae), T. obtusus and T. quadristriatus samples by pitfall traps (Pollard, 1968a). T. obtusus, a woodland species, was virtually confined to the hedge, while the field species T. quadristriatus occurred in the hedge to a limited extent. Similar separations of hedge and field species recorded by Thiele (1964) led him to conclude that there was little evidence for interaction between hedge and crop faunas. It is hoped to show here that this is not the case and that hedges influence the fauna of crops both by their physical presence and by playing an essential role in the life cycles of many members of the crop fauna.

PHYSICAL INFLUENCES

Much of our knowledge of the influence of shelter on crop insects is from Lewis (1965b,c, 1966a,b) and Lewis and Stephenson (1966) working with artificial barriers at Rothamsted. This work has shown that many groups of weak flying insects are deposited in the relatively calm air in the lee of shelter and that other, stronger flying, groups tend to congregate in this area of calm air. Aphididae probably come into the former category, Syrphidae the latter, although this will depend on the species concerned, their flight speed and the strength of the wind.

In some instances the deposition of pests in the lee of shelter has led to severe crop damage in the area close to the shelter. Examples given by Lewis (1965b,1966a) include infestations of lettuce root aphid Pemphigus bursarius on a lettuce crop, and another aphid Myzus persicae in a turnip crop, resulting in infection with turnip mild yellow virus which is transmitted by M. persicae. It is reasonable to suppose that farm hedges influence insect deposition and activity in much the same way as do these artificial barriers, and indeed many pest distributions resembling those found by Lewis are recorded in the literature of agricultural entomology (Lewis 1965a).

Also familiar to the agricultural entomologist is the use of dense hedges as temporary shelter for pests. The classic case is that of the carrot fly Psila rosae, the larva of which feeds underground on the developing carrot. The adult fly shelters in hedges during windy weather and on calm days moves into the crop to lay its eggs. This behaviour results in larger numbers of eggs around the edges of hedged fields than in the centre.

Not only is the flight of insects directly influenced by the presence of shelter, but there may also be indirect effects on the crop fauna through the influence of shelter on the crop environment. The distribution of the predacious anthocorid bug Anthocoris nemorum in several crops has been shown to be related to the presence of hedges (Pollard, 1968b). It was considered that this was due, at least in part, to the influence of shelter on the crop microclimate. It is logical to suppose that the majority of the crop fauna will find the sheltered edge of a field either more or less favourable than the centre as the microclimates of the two areas differ. Such edge effects are unlikely to extend very far into the field, probably not further than ten to twenty times the height of the hedge.

HEDGES AS OVERWINTERING SITES FOR INVERTEBRATES

As in the other aspects of hedgerow entomology discussed, the early research on the overwintering of insects in hedges was done by agricultural entomologists whose starting point was naturally the study of crop pests.

Numerous instances have therefore been cited of pest species which overwinter in hedges. Many pests which overwinter as eggs, larvae or pupae do so in the crop environment, but virtually all which overwinter as adults move away from the crop to hedges or other sheltered sites (Tischler, 1950). The recommended control for some of these species has been to spray around the edge of the crop as the insects move away from the hedges in the spring, as for example in the case of the cabbage seed weevil (Ceutthorrhynchus assimilis. Overwintering crops, such as cereal stubble undersown with clover provide alternative but inferior overwintering sites for some of these species (Tischler, 1968).

Overwintering in hedges is true not only of pest species, but also of much of the crop fauna which overwinters in the adult stage. In a study of species overwintering in a hedge-bottom and the adjoining ploughed field (Pollard, 1967), hibernating adult Coleoptera and Thysanoptera were found almost entirely in the hedge (Table 2)

Table 2. Numbers of overwintering Coleoptera and Thysanoptera taken in emergence traps (30 in each habitat) 8th March - 21st May, 1965.

	Hedge-bottom	Field
Coleoptera	91	2
Thysanoptera	219	10

A number of these species, particularly weevils, flea beetles and cereal thrips have been recorded as crop pests, many others have not. One of the common predacious ground beetles of arable fields Agonum dorsale overwinters in hedges and moves out into crops in the spring to breed (Pollard, 1968a). Crops provide habitats suitable for many insects only between crop emergence and harvest, and therefore life cycles involving seasonal movement to and from crops are of frequent occurrence.

OTHER SEASONAL MOVEMENTS BETWEEN HEDGES AND CROPS

Hedgerow shrubs all come into leaf early in the spring, have a quite short period of rapid growth and flowering, and during the rest of the summer produce relatively little new growth. They therefore carry large invertebrate faunas in the spring during the period of rapid growth. This is the time when maximum numbers of individuals and species occur. The maximum number of individuals of plant feeding species on hawthorn and blackthorn, sampled by cutting samples and sorting in the laboratory was in both cases in May (unpublished work by the author). This is well before the fauna of arable crops reaches its maximum.

Some plant-feeding species take advantage of this changing availability of food, first in hedges, then on crops; notable amongst these are some of the aphids which are amongst the most serious of our crop pests. A very well known example is that of _Aphis fabae_, which feeds in the spring on spindle before dispersing to its summer hosts which include beans and sugar beet, and there are many other similar examples.

The relationship between woody plants and crop aphids has long been recognised, but it has not been widely realised that many predators also exploit this changing food supply by producing an early generation on shrubs and a later one on arable crops. Some of these predators also utilise the early growth and insect faunas of some of the biennial and perennial herbaceous plants of the hedge bottom, particularly the nettle, _Uritca dioica_, which has a very rich fauna.

One example of a predator with this type of life cycle, _Anthocoris nemorum_, has been described by Pollard (1968b) but it is equally true of other common predators such as the coccinellids (ladybirds) _Adalia bipunctata_ and _Coccinella septempunctata_, the syrphids (hover flies) _Syrphus ribesii_ as well as species of _Platycheirus_ and _Melanostoma_, and the neuropterans (lace-wings) _Micromus variegatus_ and _Chrysopa_ spp.

This list includes some of the most abundant predators found in crops, and this is perhaps not very surprising as these are the species which most efficiently exploit the two commonest habitats in agricultural areas, hedges and crops.

FLOWER FEEDING

Many insects, crop pests, predators such as syrphids, and also parasites feed as adults on the pollen and nectar of flowers. In some species flower-feeding has been shown to be essential for the maturation of the ovaries (Schneider, 1948). In arable areas hedges provide a succession of flowering plants where there are otherwise few flowers and these hedgerow flowers may well be very important to some insect species. The succession of flowers may also be important for pollinating insects and so the pollination of crops such as field beans, but there is little evidence available.

What evidence there is suggests that on a local scale the presence of flowers around the edge of a crop is unlikely to affect the distribution of a crop pest or its predators and parasites within the crop. This is probably because flower feeding normally occurs before the insect is ready to search for oviposition sites or between periods of egg laying. Movement of flying adults after flower feeding is likely to be over such a wide area that a local effect of flowers is lost (Chandler, 1968). This hypothesis is supported by the work of Thorpe and Caudle (1938) on the behaviour of a hymenopterous parasite _Ephialtes ruficollis_.

DISCUSSION

The problem of the scale of an effect, mentioned in the preceding section is one that recurs in hedgerow work. A distinction can be made between the local effects, such as the deposition of insects in the lee of shelter and the modification of the crop microclimate, and the role which hedges play in the life cycles of crop insects which may move over long distances. These latter effects are very difficult to demonstrate experimentally, but not necessarily less important.

It is possible to draw up lists of pest species and 'beneficial insects' which make use of hedges, and put them on either side of a balance sheet, but such lists, compiled from numerous isolated examples, are of little use in deciding whether hedges are harmful or beneficial generally.

It is usually assumed by ecologists that a diverse community is more stable than a simple one, and there is evidence of a general nature which supports this. It is however much too facile to apply this general hypothesis to the specific problem of hedges and arable crops.

The next logical step for research is for intensive studies on the development of infestations of individual species of crop pests. One approach would be to compare the progress of a pest population in sheltered and open parts of a single field, to investigate the local influence of hedges, as van Emden (1965) did with edge vegetation composed of exotic trees and open verges; another approach would be to compare the progress of pest infestations of the same species in well hedged and poorly hedged farmland, although there would be considerable experimental difficulties involved in this. The basis of the problem lies in the population dynamics of individual species and will only be answered by such intensive studies combined with a knowledge of the various ways described in this paper, in which hedges influence the crop fauna.

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DISCUSSION: PART II

Land use changes and the hedgerow

Major Gape suggested that the fundamental factor underlying change was the price of the land. With land costing £300 per acre efficiency in farming was absolutely necessary. Increasing yields with decreased costs must be achieved. Hedges took up space and were expensive to maintain hence they would disappear from expensive land.

Field size and machine efficiency

Mr. Edwards pointed out that over half a farmer's costs were labour costs in men and machines and the main factors in field size were the length of the row and width of the machine. Dependant on other factors mentioned in the paper efficient field sizes might vary between 20 and 50 acres. Questioned on this maximum of 50 acres, Mr. Edwards indicated that such a figure depended on the machinery. It could be said that the optimum was a 500 yard row length which might give a 100 acre field in certain circumstances.

The estimate, of the cost of removal being equivalent to a rental of £70 per acre, was based on actual costs of removal which could vary between £2 and £10 per chain of hedge.

Shelter

Mr. Shepherd emphasized that shelter appeared to be commercially profitable only with crops in which appearance or timing was important. With livestock the absence of shelter could be compensated for by extra feeding. This could be cheaper, hence from a commercial point of view there was no general agricultural reason for retaining hedges.

Mr. Shepherd agreed that little work had been done on the influence of shelter upon crop yield in England.

Where wind erosion was a problem it seemed likely that changes in tillage methods would be more efficient than planting hedges.

Asked if he agreed with Mr. Shepherd over the effects of shelter on crop yields and wind erosion, Dr. Pollard replied that shelter could increase crop yields and help prevent erosion but that the cost of providing shelter might outweigh the profit in the increased yield and be more expensive than alternative methods of preventing erosion.

PART III WILDLIFE CONSERVATION AND THE HEDGEROW HABITAT

7. THE CONSERVATION OF PLANTS

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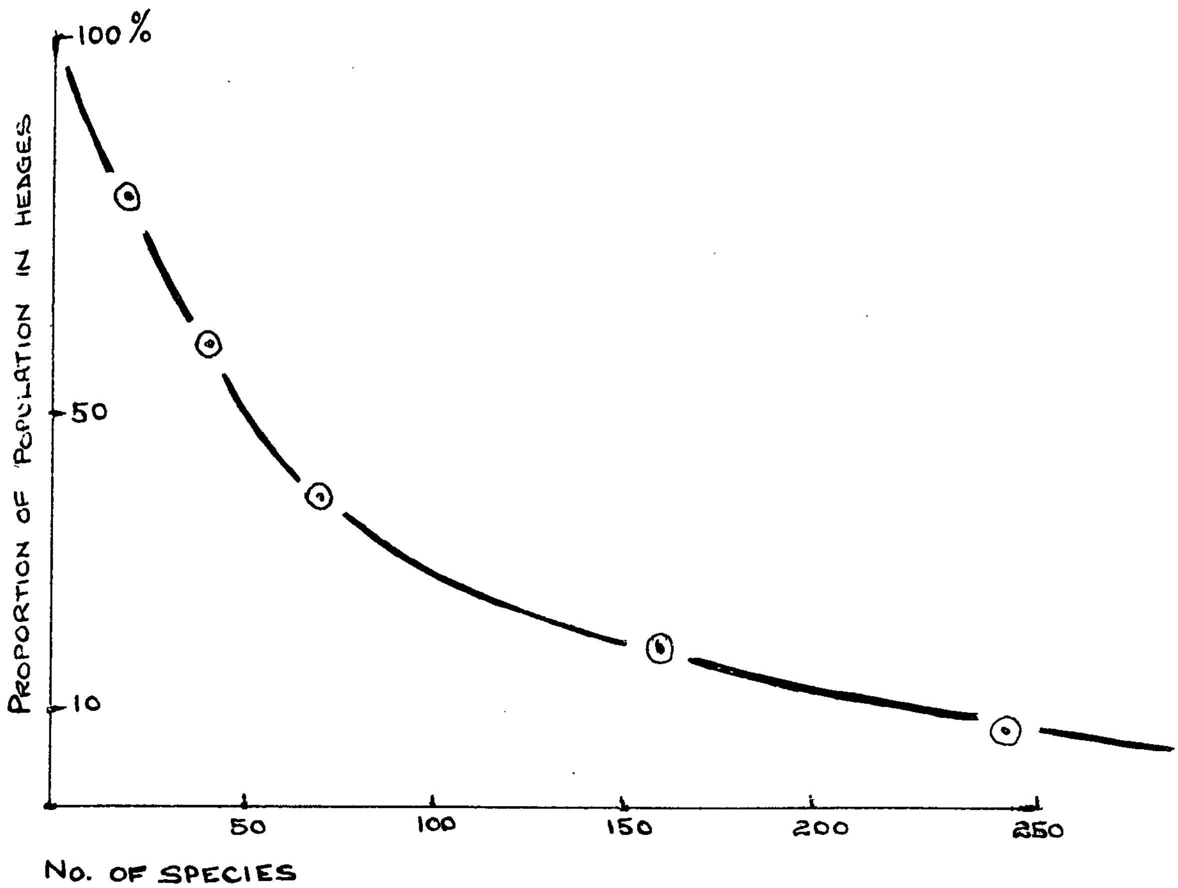
About a third of our native plant species have been recorded, at some time or another, as occurring in hedges but only about 250 species occur sufficiently frequently to be regarded as hedgerow plants. In considering the significance of hedges for the conservation of these species we must take into account their occurrence in other habitats. This is known in very general terms only as shown in the diagram.



Hence the removal of hedgerows will affect the total population of 20 species of plant very seriously, a further 20 species quite seriously and, say, another 30 or 40 species to a marked extent.

Whether this is of importance to the conservation of plants in a wider context also depends upon the relative abundance of individuals of these species. For example, Tamus communis and Ulmus procera are so very much more abundant in a number of habitats than, say, Berberis vulgaris that, although a large proportion of their individuals occur in hedges, hedgerow removal may not be as significant for these species as for Berberis. In fact the removal of hedgerows is unlikely to make any species extinct unless it be one of the"microspecies" of Rubus, Rosa or Ulmus.

In a few cases the removal of hedgerows might lead to the extinction of a species within a limited area such as an English county. This applies to species such as Astragalus glycophyllos, Vinca minor or Sorbus torminalis which are local, or to species common enough in one area but rare in another like Solidago vigaurea which is rare in the south east or Viburnum lantana which is rarer in the north.

The main plant species found in hedges are apparently common enough in a number of habitats and although removal of all the hedges in the country might cut the total population by two-thirds or three-quarters, one would still not have to travel very far to see an example, say, of Oak, Ash or Thorn.

This cut in population of some 75% is, however, most serious not for the conservation of the plants themselves but for the animals dependent upon them. This point will be dealt with more fully by Dr. Moore in the next paper but it must be emphasised that the biological significance of these ordinary everyday plant species is quite extraordinary. For example, the mean number of species of moths feeding on any one species of plant (Stokoe & Stovin, 1948) is about six but Quercus robur is a food plant for 114 species, Crataegus monogyna for 87 and Prunus spinosa for 57 species. Even the less "appetising" hedgerow species can support numbers well above the average: Ulmus procera has 34 species, Corylus avellana 24, Fraxinus excelsior 18 and Rosa canina 13 species of moth. It must be remembered that the plants in a hedge are, as are plants in any habitat, the primary producers. Nor should it be surprising that the production of these every-day plants is exploited by so many organisms, for these plants are representatives of the woodland which is the natural climax vegetation of the British Isles.

This is another reason for regarding the conservation of hedges as important. Hedges are miniature woods. The habitat notes in many floras bear this out. In the Warwickshire check list (Readett, Hawkes & Cadbury, 1965) 131 species are noted as occurring in both hedges and woods as against 48 species in woods but not hedges.

At the moment there might appear to be sufficient woodlands of all types for the destruction of hedges to be unimportant but there are reasons to doubt this. Economic forces tend to make woodland a profitable land use only on the very poorest soils but hedges occur on almost all types of soil. Economic reasons are also advanced for the swing to exotic species which is in a few quarters so pronounced that the Oak is now regarded as a weed.

The Nature Conservancy does of course have some woodland but of the impressive total of a quarter of a million acres of National Nature Reserves under ten per cent is in fact woodland.

Hedges are not only miniature woods; being linear they tend to habour plants more characteristic of other habitats. Taking the Warwickshire figures again as our example, there are a further 99 species found in hedges but not in woods and for only about half these is the hedge the only habitat noted. Thus hedges are a very variable habitat.

This in turn leads to another important factor for their conservation; hedges are important in education. Hedges are generally available to junior schools and over half our secondary schools do in fact use them in fieldwork (Anon, 1963).

Diversity in hedges also brings us to yet another point for consideration. We have found, contrary to expectation, that management does not seem to affect the shrub complement of a hedge. Apart from the overriding influence of a planter's personal preferences we can identify only two major factors affecting the diversity of a hedge: soil type and age. The soil type determines which species can occur within a hedge. For instance, Dogwood and Spindle are found in hedges on calcareous soils while Holly and Blackthorn are more common on other soil types. The age of the hedge seems to determine the number of the possibles which do occur. There is a correlation between age and number of species of shrubs such that in a 30 yard length of hedge each shrub species indicates 100 years in the life of that hedge. A hedge with 5 different species of shrub will be about 500 years old, one with 10 species about 1,000 years old. Now hedges with 10 species in 30 yards are not uncommon; these hedges are out commonest archaeological remains of the Saxon period and should therefore be preserved for historical reasons if not for the conservation of plants.

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8. THE CONSERVATION OF ANIMALS

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Introduction

Most of Britain is agricultural land. The patterns of distribution and of population numbers of most wild plants and animals in Britain are determined by past and present agricultural practices. The hedgerow is a characteristic feature of most British agricultural environments; those responsible for conservation in this country need to know

1) the ecological nature of the hedge flora and fauna

2) the overall effects of the removal of hedges from the countryside.

This paper is complementary to Dr. Hooper's on the botanical aspects of the problem and Dr. Pollard's on the biological effects of shelter. I shall put most emphasis on the larger hedge animals because more is known about these organisms, because their total populations tend to be smaller than those of smaller species and so are under greater threat, and because there is greater public interest in them.

The hedgerow habitat

All hedges contain two basic elements - a strip of woody scrub bordered on both sides by herb layers in which grass species are abundant and usually predominate. Hedges may or may not contain a bank, a ditch or hedgerow trees. They share many features with woodland edges. They provide food, cover and features essential for reproduction. The micro-climate of the hedge is very different from that of the open habitats bordering it: hedges provide shelter from the wind, and sheltered by them are areas which are warmer than the surrounding land - points of particular importance to poikilothermic animals.

Like a river or stream, the hedgerow has more edge relative to its area than do most habitats. When numerous, hedges provide a network of grassland and scrubland which link scattered woods and larger grasslands together.

The Ecological Nature of the Hedgerow Fauna

The ecological origin of British mammals, birds and butterflies found in hedges is given in Table I.

Table I. Number of species breeding in hedges/

Total number of species from the habitat type found in Britain.

Taxon	Habitat: Open country	Scrub	Woodland	Houses
Mammals (less bats)	3/3	-	17/24	1/1
Birds	4/14	17/18	43/54	1/5
Butterflies	7/22	1/1	15/31	-

As one would expect, hedges contain both 'open country' and 'woodland' elements, and, since the original vegetation of Britain was mainly woodland the woodland element predominates. These generalisations probably hold for most other groups, see for example Dr. Pollard's figures in Paper No. 6.

Of the birds found in hedges, 17 species nest on the ground 22 in bushes and 35 in trees; of the latter 17 nest in holes in trees.

The larvae of 20 butterfly species found in hedges feed on herb layer plants, 3 on shrubs and only 2 on trees.

In addition, many other species use hedges but do not breed in them, e.g. migrant Fieldfares and Redwings which feed in them, and swallows and dragonflies which hunt in the shelter provided by them.

Some hedgerow species spend most of their lives in the hedge (e.g. the Bank Vole), whereas others are only partially dependent upon it.

The Significance of the Hedgerow Fauna as a Proportion of the total British population.

The hedgerow habitat is declining in Britain, in some areas rapidly. (Moore, Hooper and Davis, 1961 and Paper No. 1). The full ecological and hence the conservation significance of this event can be assessed only if we know the relative numbers of animals found in different habitats including hedges. The relevant data are largely missing. A tentative attempt is made here to describe the dimensions of the problem. Table II shows the proportion of the terrestrial species of certain groups which are known to occur in hedges (date from Ford, 1945; Southern, 1964; and Moore, unpublished).

It is concluded that a very significant proportion of our total terrestrial species breed in hedges, but none or very few are confined to this habitat.

Table II.

Taxon	Number of species: Total British lowland terrestrial species	Total breeding in hedges	Commonly breeding in hedges	Confined to hedges
Mammals (less bats)	28	21	14	0
Reptiles	6	6	1	0
Birds	91	65	23	0
Butterflies	54	23	15	0
Mecoptera	4	3	3	0

The insect fauna of hedges depends largely on available food plants. Some shrubs and trees support many more species than others, see Table III (from Southwood, 1961).

Table III. <u>The numbers of insect species on various deciduous and coniferous forest trees in Britain</u>

Species	Number of insect species
Oak (Quercus)	284
Willow (Salix)	266
Birch (Betula)	229
Hawthorn (Crataegus)	149
Poplars (Populus)	97
Apple (Malus)	93
Pine (Pinus)	91
Alder (Alnus)	90
Elm (Ulmus)	82
Hazel (Corylus)	73
Beech (Fagus)	64
Ash (Fraxinus)	41
Spruce (Picea)	37
Lime (Tilia)	31
Hornbeam (Carpinus)	28
Larch (Larix)	17
Fir (Abies)	16
Holly (Ilex)	7

It will be noted that the commonest hedge plant, the hawthorn, and one of the commonest hedgerow trees, the oak, both support exceptionally large numbers of species.

Reasonably accurate figures for numbers of insect species supported by the hedgerow habitat are not available. If hedgerows near Monks Wood are typical, the number of adult butterflies supported by hedgerows in Britain may lie between the values 10,000,000 and 250,000,000. If the overall density of Hedge Brown butterflies (Maniola tithonus) - one of the most characteristic hedgerow species - is reckoned as one tenth of the highest population observed in Huntingdonshire, the total hedge population of this species may be about 9,000,000 adult insects. Its total woodland population is probably much less, perhaps about 2,000,000 adult insects.

Thanks to the B.T.O. Common Bird Survey and studies in progress at Monks Wood, much more reliable estimates can be made of bird populations in hedges. If it is accepted that hedges support on average one pair of birds per 100 yards length of hedge, about 10,000,000 birds breed in hedges. The conservation significance of the destruction of a large proportion of this population varies between species; estimates have been made below of two woodland species, see Table IV.

Table IV.

Species	Acreage of suitable habitat in forests	Acreage of suitable habitat in nature reserves	Miles of hedges suitable for species	Estimated no. of pairs in forests	reserves	hedges
Nightingale	500,000	3,500	0	25,000	200	0
Whitethroat	2,500,000	10,000	500,000	800,000	3,000	300,000

(Note Population density of Nightingale in suitable habitat assumed to be 0.05 per acre
" " Whitethroat in forest " " 0.3 "
" " Whitethroat in hedges " " 2.4 "
Williamson, 1964; Moore et al, 1964, and unpublished; Anon, 1962)

It is concluded that for woodland species like the Nightingale the destruction of hedgerow will have no effect unless it causes increased predation when birds move from one wood to another. In the case of the Whitethroat a large proportion of the species is found in hedges and large-scale hedge destruction would seriously affect the total population. If the present trend from hardwoods to conifers in State forests were extended to small woods as well the effect would be even more serious.

Conclusions

A very large proportion of the British land fauna is found in hedges, yet few if any species are known to be confined to that habitat. If hedges were eliminated from the British agricultural landscape it would greatly reduce the populations of many vertebrate and invertebrate species.

If the destruction of hedges coincided with a large scale change in British woodland from hardwoods to conifers many woodland species would be at risk.

While an increasing number of farmers get rid of hedges a small but increasing number make corner plantings. Preliminary studies on the bird populations of these show that on an acreage basis they support lower densities of birds than do hedges; nor are corner plantings large enough to support many woodland species. Nevertheless they are to be welcomed in a country which has a deciduous woodland fauna and an unusually small amount of deciduous woodland.

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9. CONSERVATION OF GAME

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Twenty-five years ago habitat could be largely taken for granted in game conservation. Open canopied hardwood coverts were ideal for pheasants and the agricultural pattern of well-distributed crops interlaced with hedgerows suited both the pheasants (Phasianus colchicus) and the partridges (Perdix perdix, Alectoris rufa). The wholesale destruction of this habitat has had a devastating effect on the partridge, and pheasant numbers depend increasingly on the hand-reared bird. Large-scale private re-afforestation since the war has initially benefited the pheasant by providing excellent nesting cover, with shelter and a variety of natural food from the seeds and fruits of "weed" species growing with the young trees. However, much of the planting has been with conifers which, when the tree canopy closes, tend to produce woods that are cold, draughty and devoid of all natural food and ground cover. In agriculture, block farming patterns and the constant search for heavier yielding dense crops, coupled with the removal of hedgerows, make for an impenetrable summer jungle alternating with bleak winter conditions.

Modern game conservation has a constant struggle to compensate for these changes and the preservation of the hedgerow is one of its most important tasks. We have studied its value to the partridge in some detail, particularly in north-west Norfolk, where comparatively high densities of partridges can still be found.

While it would be foolish to suggest that the hedges of north-west Norfolk had been made for the benefit of game, yet no one can deny their importance to the well-being of the partridges. Indeed, it was a fortunate chance that strong winds and light soils necessitated the erection of windbreaks for the benefit of crops and stock. For without these hedges it is highly unlikely, under modern farming conditions, that breeding densities would be as high as they are today.

Paired partridges dislike being made aware of their immediate neighbours; and in March, when much of the corn may be sown, there is little to obstruct even a partridge's view at 9 inches above ground level - except the nearby hedge. Partridge pairs may spend the whole day separated by a relatively short distance - so long as a hedge is between them and the pairs remain invisible to each other.

Later on, towards the end of April, hedges will be supplying an even more essential feature in the partridge's environment - a suitable nesting site. Often before the ley-grass is high enough to provide cover, the growth on the hedge-banks will give adequate protection. And later still, during the incubation period, the herbage on the dry earth-bank will not become so lush that the incubating partridge is smothered by a mass of vegetation. To a partridge, the amount of cover for nesting is indeed a critical factor, and too much or too dense cover is almost as undesirable as no cover at all. Just the right amount, so that the sitting bird can see without being seen, is what the average partridge requires, and it is these conditions which the majority of typical Norfolk hedges provide to perfection.

When the eggs have hatched, the dry, sheltered, gently sloping banks, clad with a variety of plants and an even greater variety of insects, provide oases of food and shelter in what may be, due to the widespread use of herbicides and insecticides, a relative desert.

From a keeper's point of view these hedges possess many advantages. Not only do they provide an easy framework on which to plan his predator control, by means of strategically sited tunnel-traps for taking rats and other ground predators, but they also make nest finding a relatively easy matter. In unkeepered country, nesting loss experienced by hedge-nesting partridges might well be high, but where predators are controlled and nests found, protected and "managed", the advantages of hedge-nesting are very great.

What are the characteristic features that distinguish these hedges? Essentially they consist of a man-made bank, along the crest of which hawthorn (Crataegus monogyna) has been planted. At the base, these banks average a little over two yards wide (about 7 ft) and slope gently upwards to a two-foot wide crest which is usually from two to two and a half feet above the level of the adjoining fields.

Of course, some hedges appear to be more frequently nested in than others, and if we examine in a little more detail a few of the most popular nesting hedges, the following facts emerge. Of average width (7 ft) and height (2-2½ ft) the banks support a strong growth of Barren Brome grass (Bromus sterilis). Distributed among this grass are clumps of the Common Nettle (Urtica dioica), and it would be difficult for a partridge selecting a hedge-nesting site to avoid using these plants as a source of cover. It was found that rather more than half the nests observed depended for their cover on these two plants alone. The hawthorn bushes themselves gave protection to many nests, while brambles (Rubus spp.) - usually sparsely growing - gave some early protection to approximately a quarter of the nests studied. Bryony (Bryonia dioica), a common hedgerow plant giving a profusion of relatively early growth, was in no case relied on for the main source of cover, and its occasional appearance trailing over a nest-site appeared to be accidental. Several other plants, such as the Bladder Campion, Cleavers, Chervil, Houndstongue and Meadow-grass, occurred in the vicinity of some nests, but there was no indication that any selection had been practised. Needless to say, the bank vegetation is entirely natural, and purely fortuituously provides the partridge with just the kind of nesting cover it requires. During the incubation period the well-drained bank, with the hawthorn roots taking some of the goodness from the soil, provides an adequate but not too lush cover for the sitting birds. On the average the grass and other vegetation around the nest in early May (during the laying period) was about six inches; by the end of May it had grown to about sixteen inches but was still sufficiently open to give the sitting birds glimpses of the outside world.

The position of the hedge can influence choice of a nest site. Some years ago on an estate in north-west Norfolk, where nests maps had been kept for several years and where the hedges ran mainly east-west and north-south, it was found that on southerly slopes hedge direction (north-south or east-west) exerted no influence on nest density, but on slopes facing north a definite preference seemed to be shown for hedges running north-south. On southerly slopes, some preference for the north side of east-west hedges was shown, while on northerly slopes the reverse was the case. On northerly facing slopes, the eastern side of north-south hedges appeared to be preferred, but on southerly slopes no such preference could be detected. No doubt, side of hedge and slope of the ground affects the growth of the vegetation, but sitting partridges may be just as uncomfortable in a site that is too sheltered and warm as in a very exposed one. But the typical Norfolk hedge can satisfy the most particular partridge's nest requirements.

Where no woodland is present the hedgerow is just as important to the pheasant as it is to the partridge. Even where there _is_ woodland a large proportion of the pheasant stock will disperse to the fields in March and April, subsequently nesting in the hedges. On arable farms with no woodland, pheasants will concentrate in cover crops such as sugar-beet, kale, mustard, etc., when stubbles are ploughed in. When these crops are harvested, the hedgerow is their only refuge for food and shelter.

If the present rate of hedgerow destruction continues we can foresee serious consequences. The steady decline of the grey partridge (_Perdix perdix_) may accelerate to a disastrous landslide. In America, the Wisconsin Conservation Department has shown that the loss of hedgerow cover was directly related to the reduction of bobwhite quail (_Colinus virginianus_) on a study area of 4,500 acres. The population fell from a "high" of 433 quail in 1933 to _nil_ in 1959! When there was one mile of hedgerow to 450 acres, the quail population averaged 23 birds per mile. When this ratio dropped to one mile of hedge per 650 acres, the quail population disappeared completely.

Admittedly a partridge is not so dependent on hedgerows for nesting as a bobwhite quail, but notice should be taken of this warning, for if we destroy the hedges - even if the partridges do not disappear - we shall certainly drive them into the grass crops to nest, where we shall probably cut them to pieces with the mower.

So far the release of reared birds has failed to arrest the decline in partridge stocks. Where the wild bird has been unsuccessful it is perhaps not surprising that the reared bird should fare no better, but further research may show how these birds may best be utilised. Reared red-legged partridges (Alectoris rufa) on the other hand can give shooting recoveries as high as those from reared pheasants and the rearing and releasing of this species is likely to increase.

As a result, shooting will have to rely more and more on the hand-reared bird, both partridge and pheasant, and the cost will rise accordingly. The majority of shooting men in this country rely on the wild bird for sport and the man who enjoys a Saturday walking hedgerows with a spaniel, or driving out small spinneys and pieces of kale with a few friends, will be very hard hit.

It is often difficult to persuade a landowner that the agricultural gain from removing a hedgerow should be balanced against the loss to game (as well as other wildlife). Nevertheless, where sport is concerned, the facts speak for themselves.

Shooting supports a considerable industry, with an annual turnover in labour and materials estimated to be in the region of £20 million. Far from being in decline, there is an ever-increasing demand for shooting land and the rents of sporting rights have risen to a point where £1 per acre is quite usual for a productive shoot. And yet one frequently sees this potential (which incidentally represents a capital value of approximately £15 per acre) being thrown away by the wanton destruction of hedgerows in favour of marginal gains to the farm income. Ironically this affects the pocket of the landowner who is not interested in shooting, but could let the sporting rights for cash - and he is the man who can rarely be persuaded to retain "unprofitable" hedgerows!

In a recent study we took a 1,000-acre local farm as an example and calculated the effect of increasing its 30-acre fields to an average size of 60 acres. The existing hedges are 9 ft across (7 ft as in Norfolk hedges, is quite sufficient for gamebirds) and the removal of the requisite number would have resulted in a gain of 3.7 acres. There can be few farms where this would increase the income, before tax, by more than £60 per annum and any additional profit to offset the deterioration of the sporting rights must come from the more efficient use of machinery. It is fairly obvious that in many instances it is not efficiency that is looked for but mere convenience.

In addition it should be remembered that although the retention of hedges can reduce income before tax, the cost of reared birds in compensation comes out of nett income after tax!

If hedges had to be hand-trimmed, today's high labour costs would make it virtually impossible to keep them. Fortunately the tractor-mounted cutter has largely solved this problem. The principal argument we have heard against hedges is that they are reservoirs for couch or twitch grass (*Agropyron repens*). However, this can be controlled efficiently by fallowing the headland once every three or four years. A rotovator is the best machine for this purpose and 1,200 yards of headland (on both sides of a hedge) can be treated for the loss of 1 acre of production. A useful side effect of this process is that the bare strip by the hedge provides a useful sunny area for gamebirds to dust and dry their chicks in showery weather. The absence of natural "drying-out" areas on a modern farm with dense crops is thought to account for much heavier weather casualties to chicks than in the past.

In our opinion, arresting the process of hedgerow destruction, together with other activities damaging to wildlife habitat in general, can only be achieved by the combined efforts of all interested parties.

In conclusion we would mention that, during a three-year course at one well-known agricultural college, no time at all - not even one hour - can be spared for any outside subject such as game, wildlife, forestry, etc! Any subjects such as these are channelled to groups of students who are particularly interested - in their spare time. In other words, preaching to the initiated. It is not surprising, therefore, that the young farmers of today are primarily technicians and not countrymen. To prevent further destruction it must be demonstrated to them that wildlife is important (and even valuable to farming!) and not just a passing curiosity.

SUMMARY

The replacement of open-canopied hardwood coverts with conifer plantings and varied crop distribution with block farming has resulted in a very serious deterioration in gamebird habitat. For pheasants, this has been partially offset by an increase in reared and released birds, but so far similar methods have failed to arrest the decline in the grey partridge. High breeding densities in both the common and red-legged partridge depend on an adequate hedge distribution and the typical Norfolk hedge provides many of the partridge's requirements. In the U.S.A. the disappearance of the bobwhite quail has accompanied hedge destruction in certain areas. In England the high value of a productive shoot is often unrecognised and marginal increases in profit achieved by hedge removal may be offset by decreases in the value of the sporting rights. It is essential that young farmers hould be made aware of the value of maintaining habitat suitable for game and wildlife.

10. THE VALUE OF HEDGEROWS TO PARTRIDGE POPULATIONS

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The partridge (Perdix perdix) in Great Britain is a species that is almost entirely dependent upon agricultural land. Because of this, its populations are likely to react most rapidly to changes in the agricultural environment as progress is made towards more intensive and efficient production and more complete exploitation of the available land surface.

Of the traditional features of the countryside, hedgerows have for long been recognised as of particular importance to partridges, primarily as nesting sites. In 1948, Blank (1961 and unpublished) found that on a well hedged area of north Norfolk (37 yds of hedge/acre), where there was little alternative cover and where an estimated 90% of all nests were located, only 2% were not in hedgerows. On a study area in Hampshire between 1950-57, 63% of all nests found occurred in field boundaries, predominantly hedgerows (Huband, in prep.), despite a smaller length of hedgerow (24 yds/acre) and the presence of considerable amounts of alternative cover in the form of woodland edge, clear-felled woodland, plantation, copse and rough downland (Table 1). The proportions of nest found in different types of cover remained relatively constant even when a very high proportion of all possible nests was found (87%) which suggest that these figures are probably not greatly biased by searching techniques.

Research into the detailed relationship between partridge populations and environmental factors such as crop and cover distribution is at present being undertaken by the author (Huband, 1966). The programme includes a study of the nesting habits of partridges on chalk farmland in north Hampshire, where there is relatively little hedgerow cover (13 yds/acre). This too demonstrates the dependence of partridges upon field boundaries (Table 2). Nearly 90% of all nests found occur in linear arrangements of permanent cover such as hedgerows, belts and fencerows. Almost half (48%) are associated with hedgerows although the latter tend to be unevenly distributed over the areas.

Under all these circumstances it is obvious that hedgerows form the most important single category of nesting cover for partridges.

A detailed investigation of the exact position of partridge nests in relation to hedgerow structure provides interesting information about the factors influencing the selection of nesting sites. Although 65% of all hedgerow nests are to some extent dependent for cover on the shrub layer of the hedge less than a third (27%) are closely associated with it (i.e. with shrub cover less than 2 ft above the nest)* Under 10% of the nests occur at or near the centre of hedgerows, and those that do are in relatively open conditions as far as cover from the shrub layer is concerned. A quarter (24%) of all nests occur on the verges of hedgerows and are totally independent of direct shrub cover and a further 24% of nests are situated in gaps in the hedgerow where they are only slightly influenced, if at all, by the shrub layer. Another 13% are associated with small outgrowths of the hedge such as suckers and trailing branches, rather than the line of the hedgerow itself.

In general, partridges nest in the hedgerow verges rather than the hedgerow bottoms. The width of the verge to some extent determines the location of the nest in relation to the overshadowing shrubs, but the width of the hedge appears to be of little importance. So far there is no distinct indication that different types of hedgerow management permanently affect the nesting potential of hedgerows. The immediate cover of almost all nests comes predominantly from the herb layer which is largely composed of a variety of grass species and stinging nettles (Urtica dioica). It is not yet clear whether the presence of the shrub layer is of direct importance in nest site selection or whether it is the interaction between shrub layer and herb layer, producing the right cover conditions at the right time, that is the critical condition.

Apart from providing nesting cover, hedgerows fulfil other functions which have an obvious effect upon partridge distribution. In the present study, at relatively low population densities, more than 70% of all sightings of partridges occur within 50 yds of a field edge, irrespective of whether the boundary is a hedgerow or a fence. This edge effect is particularly noticeable in early spring after the formation of breeding pairs, when there is a minimum of cover. At this time, under equivalent crop conditions, the density of partridges associated with hedgerows is more than twice that associated with fencerows (Table 3). In part this may be due to the relative seclusion that an intervening barrier, such as a hedgeprovides for "territorial" birds on either side of it. Since aggressive behaviour in partridges appears to be usually triggered off by visual contact (Jenkins, 1961), a hedgerow provides effective separation which would have to be provided by spatial adjustment in more open situations. Other reasons for the attractiveness of hedgerows may include its use as escape cover from predators e.g. Hen Harrier (Circus cyaneus), physical shelter and, in some cases, a food source.

* These figures agree fairly closely with those found by Blank for Norfolk hedgerows, which were 75% and 35% respectively for "some overhead shrub cover" and close association.

The destruction of any field boundary, except possibly in the case of very small fields, will therefore reduce the partridge carrying capacity of the land, first because of the edge and barrier effects mentioned above and secondly because of the loss of nesting cover. As far as hedgerows are concerned, the effect will depend upon whether the hedge is simply cut down to avoid maintenance cost or whether the land is incorporated into the farmed area. In the former case the strip remains available for nesting although at a reduced potential; in the latter case the loss is total.

The great advantage of hedgerows, as far as partridge management is concerned, is that it is an economic way of providing the cover that the bird requires, since it is the length of edge rather than the area that is important. Even on the present study sites which are relatively poorly hedged and where 87% of the total area is under crop production, hedgerows occupy less than 2% of the total area and yet contribute over 13,000 yds of cover or nearly 15 miles of edge per 1,000 acres.

TABLES

1. The distribution of nests of partridges (Perdix perdix) on a Hampshire study area, 1950-57. (Acreage; 925 acres)

Year	March Pair Census	Likely(1) Breeding Density	Nests found(2) No.	Nests found(2) %	Location of nests (%) Field Boundary	Field	Copse	Wood (3)	Rough Downland
1950	106	117	73	62	60	10	10	15	4
1951	119	126	110(4)	87	69	8	9	9	2
1952	153	170	81	48	70	7	6	10	2
1953	163	182	98(5)	54	58	8	6	17	6
1954	149	163	104	64	56	6	13	13	7
1955	106	128	74	58	65	1	12	12	8
1956	137	145	87	60	72	2	8	1	9
1957	160	168	109	65	60	11	16	5	6
Average	137	150	92	61	63	7	10	10	5

(1) Adjusted to allow for border pairs.
(2) Does not include early losses or second nests.
(3) Wood - includes woodland, clear felled woodland and plantation.
(4) Includes 5 nests with no recorded location.
(5) Includes 1 nest with no recorded location.

2. Nest distribution of partridges (<u>P. perdix</u>) on poorly hedged chalk farmland, 1968.

LINEAR COVER		No.	BLOCK COVER	No.
Hedgerows		46	Plantation	3
Fencerows		27	Clear felled wood	1
Belts	(a) Tree	5	Grassland/Scrub	1
	(b) Scrub	5	Gardens etc.	4
	(c) Grass	2	Field	2
		85		11

3. Density of partridge pairs (<u>P. perdix</u>) in relation to field boundaries. (All pairs within 50 yds of edge)

Crops adjoining boundary	Length of boundary / pair (yds)	
	Hedgerow	Fencerow
Grass / Grass	160	390
Grass / Plough	250	480
Plough / Plough	690	1640
Sown / Sown (cereals)	650	1370
Overall	437	895

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DISCUSSION: PART III

Hedgerow floras and faunas

Dr. Hooper said that very few rare species of plant were confined to hedges. The chief reason for conservation of hedgerows must, therefore, be as an example of a deciduous woodland habitat of importance in education and of some historical interest. This could lead to a positive suggestion in that old hedges such as Parish Boundary hedges were richest in species. Parish boundaries were often farm boundaries so the prevention of the removal of these should cause the minimum agricultural loss and the maximum conservation gain.

It was agreed that the loss of hedgerows would cause declines in wildlife and discussion centred on possible alternative habitats such as corner plantings, suburban gardens or disused railways and canals. It was suggested that linear scrubs were ideal for most bird populations and where they were less than ideal changes in behaviour of the species might compensate for the loss of hedgerow.

At this point Mr. Edwards asked what a hedge was as various ideas seemed current. What for example, was the best width or height? Dr. Moore replied that for birds a tall wide hedge was best. Dr. Hooper suggested that for plants a narrow well managed hedge was quite adequate.

Game

The speakers suggested that conservation of game was largely a question of personal choice but all too often when the answer was affirmative, the three departments of farm, forest and game enterprises were treated in separation. Given a reasoned balance, game could provide an economic return.

Asked what field sizes, types of hedge, shelterbelt or woodland would provide a shooting rent of £1 per acre, Mr. Gray replied that field size was not as important as urban nearness but no woodland should be more than 10 acres of unbroken extent and a good game spinney need take no more than ½ an acre.

Mr. Skilbeck suggested that the separation of inter-related enterprises was the result of educating technicians who thought it immoral to sacrifice farming to sport.

GENERAL DISCUSSION: PARTS I - III

Dr. Holdgate as Chairman, summarized the first day by suggesting that the fact of declines had been established although details remained to be filled in. It had also been established that, in general, there were sound economic reasons behind these declines although again there were a few queries that could be raised over the benefits of shelter. As these trends continued, marked declines in wildlife could be expected but so far economic values could be put upon game alone.

Dr. Moore suggested that it was difficult, if not impossible, to value wildlife, but Mr. Gray suggested that at least heads, binoculars or books could be counted.

Mr. Cornwallis indicated that as far as counting heads went, there were in fact far fewer farmers than was often supposed. There were only 20 to 30 thousand men to be influenced.

Mr. Workman suggested that as poorer agricultural land was better for wildlife, some areas could be set aside for this alone, Mr. Williamson challenged this premiss and said the richest loam soils were best for wildlife. Professor Coppock suggested that a spatial separation of agricultural and amenity land use might be possible but Colonel Floyd replied that purely commercial returns of something usually thought of as amenity were not fully appreciated. Four miles of hedgerow elm could be worth £20,000 at any one time.

Mr. Boote finally suggested that the real problem was to translate wildlife, amenity and aesthetic values into values which could be appreciated by those who took the decisions.

PART IV HEDGES IN THE LANDSCAPE

11. THE EVALUATION OF HEDGES AND SHELTER

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The factors which affect an economic evaluation of hedges and shelter are :-

i.	value of land for agriculture
ii.	" " timber
iii.	" " shooting
iv.	" " shelter
v.	" " visual amenity
vi.	" " conservation of flora and fauna.

It is possible, in general, to express i. and ii. in fairly precise monetary terms. Adjustments to the market price may be necessary, if you wish to consider national interest, as opposed to the value to an individual owner, but there is no very great difficulty in doing this (Department of Education and Science, 1966). Shooting values can also be fairly easily determined, from letting prices.

That leaves us with three factors which are less easy to determine:-

shelter, visual amenity, wildlife conservation.

The value of shelter is related mainly to agricultural land values and agricultural practices, though it may also affect the "amenities" of an area by making it less bleak. These factors have been covered by previous speakers, but it might be worth pointing out here that, if shelter could raise the productivity of a field by as little as 5%, this could (assuming for the moment that the cost of providing the shelter is nil) raise the profit margin by a very significant amount (up to 50%?).

My own view on this matter is that we <u>must have</u> some sort of shelter-woods and hedgerows in agricultural areas in order to safeguard our scenery and wildlife resources, but thatthis can probably be accomplished without any harm to the agricultural interest, and it may even be of considerable benefit to agriculture.

The value of visual amenity is something which is less easily related to any direct financial index. It is, however, necessary to do this if it is to be compared on the same footing, as the other values being considered.

A short paper which I wrote fairly recently (1967a) sets out a basis for comparing the amenity value of one tree with another and one woodland with another, according to their prominence, proximity to centres of population, etc. The whole system is then tied in to monetary values on the basis of a limited number of examples where money has been involved.

I have also attempted a similar exercise for the valuation of wildlife resources, which is to be published next Spring (Helliwell, 1969). This, again, is intended to be a means of provoking thought and discussion rather than a clear-cut method of evaluation.

Once one accepts that wildlife resources <u>have</u> a value, and that some are more valuable than others, it should be possible to rationalise this and say <u>why</u> some resources are more valuable than others. In doing so, it is necessary to isolate the separate components which constitute this value, and then to place monetary values on these.

The basis values of wildlife resources stem from :-

i. Production (venison, berries, fish, etc.)
ii. Potential production (breeding material for cultivated plants and domestic animals, and biological control of pests.)
iii. Education (primary and secondary schools, undergraduate students, and research students).
iv. Recreation (amateur naturalists, photography, contribution to "character" of a locality, etc.)

The main factors which influence these values are :-

a. Scarcity (locally and nationally)
b. Accessibility
c. Diversity

The importance of each of these factors varies, according to the factor being evaluated (e.g. accessibility is of great importance for education areas, but less so for reserves of genetic material), and some additional factors will be important under certain heads (e.g. the number of conspicuous flowers, when evaluating recreational areas).

Whilst it is necessary to consider the various factors involved separately, their net values may not always be a simple summation of their individual values.

The quality of the scenery may affect the value of shooting rights, for example. (Obviously, people will be more willing to pay for shooting in pleasant surroundings than in dismal surroundings.) Similarly, the letting of caravans in a pleasant area of countryside may assist in maintaining the value of agricultural land by providing a little more profit for the farmer.

The questions of diversification of seasonal demands on labour, the availability of capital, and the skill and knowledge of the landowner will also complicate the general picture to some extent.

I would like now to give a couple of hypothetical examples, very briefly, in order to provoke discussion and attempt to crystallise the views of the meeting as to what emphasis should be given to the various aspects discussed by our several speakers.

A. <u>Planting a shelterbelt system, on an area of 1,000 acres of good flat arable land in the English midlands.</u>

COST		
Loss of land to agriculture 50 acres at £300	=	£15,000
Cost of fencing and establishing shelterbelts 50 acres at £160	=	£ 8,000
total cost		£23,000
BENEFIT (to the community at large)		
Value of standing timber produced before replanting required, discounted at 5% interest back to present day	=	£ 2,750
Value of shelter to agriculture, say 3% increase on gross return of £150 per acre per annum after 10 years and 5% increase after 15 years, discounted back to present day	=	£83,025
Value of visual amenity to the community at large. £5,760 after 15 years, discounted back to present day.	=	£ 2,880
Shooting value. 5/- per acre per annum over the whole estate.	=	£ 5,000
Conservation of flora and fauna.	=	£ 1,250
total benefit		£94,905

Net benefit £71,905

Net discounted revenue per £100 discounted investment	=	£ 413

B. <u>Retention of hedgerows on land worth £200 per acre.</u>

Assuming that all fields are square and that hedges have no measurable sheltering affect, the only appreciable benefit (excluding, for the moment, questions of stock-fencing, etc.) is likely to be as a refuge for wild plants and animals.

There may be a visual amenity value in many cases, but this will vary even more than the aminity value of trees and woods, as it is more dependent upon the landscape pattern created than on the hedgerow itself. There may also be some value as shelter to stock, and as nesting areas for partridge.

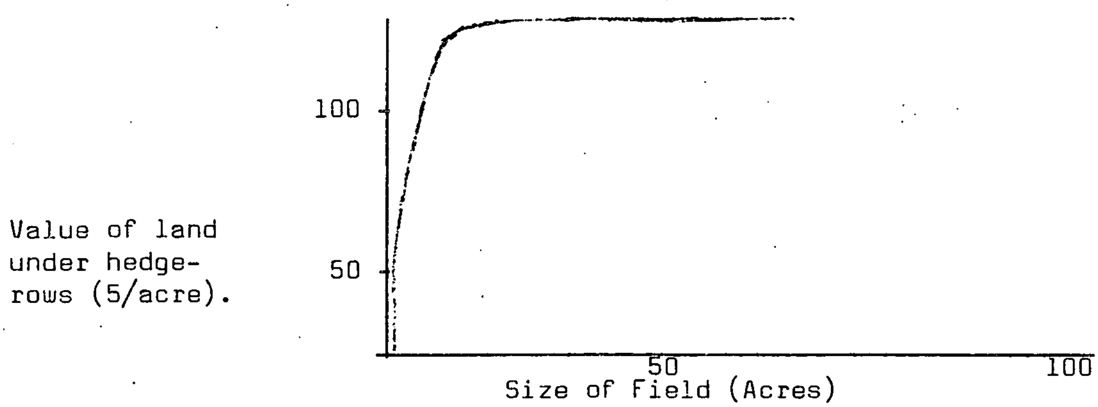
Under the heading of wildlife conservation, there will be little value from direct production, or as a reserve of genetic material for breeding, in most cases. There may be some value for educational purposes if there is a primary or secondary school very close by; and some value to local naturalists and the public in general, if there is a footpath alongside. In remoter areas, however, the only appreciable values are likely to stem from

1) the maintenance of populations of wild plants and animals in the areas as a whole (the more extensive the habitat the greater the variety of species likely to be found within it and the more stable will be the numbers of any one species,)
2) possible benefit to agriculture by "biological control" of pest species.

This last factor is difficult to evaluate. Where agriculture is at a very intensive level it is likely that such control of pests is not sufficiently effective to avoid the need to take measures such as spraying to protect crops. This will vary to some extent from crop to crop, of course. At one extreme, it is rarely necessary to take special measures to control pests in forest crops, even when they are intensively managed; and at the other extreme, one does not expect to get very much benefit from hedgerow species in controlling pests in a market garden.

In general, however, it is fair to say that the more diverse the wildlife of an area the less chance there is of any one species becoming a pest, and, in so far as hedgerows contribute to such diversity, they will have some value in this respect.

Under these circumstances, the situation shown in this graph is likely to be the case :-



i.e. it would be difficult to justify the retention of hedgerows dividing fields less than 20 acres in extent unless they were especially rich in species, or had some especial value for education, amenity, shelter, etc. Even in larger fields, it may be difficult to justify their retention if the cost of maintenance is high and the cost of removal is low, except where there are special factors involved or in areas where there are no alternative wildlife habitats (making hedges correspondingly more valuable).

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12. LANDSCAPE AND AMENITY

Miss Brenda Colvin
P.P.I.L.A.

Our landscape is a National Resource: other speakers have referred to the difficulty of evaluating it. We cannot say how many £.s.d. good landscape may be worth per acre, but we can be certain that it is not the least of our natural resources and that it is not expendable, to be used up and spent like minerals in the soil, but one whose value we can enjoy while it continues to grow.

I think we have to regard fine landscape as an invaluable asset.

Although I was unable to be present at yesterdays session, I have read the papers circulated and have been much impressed by the research undertaken into the various values - the balance sheets drawn up and the attempts to evaluate even the amenity. But although so much has been learned of the immediate economics of removing hedges and hedgerow trees, we are clearly a long way from being able to assess with scientific precision the ultimate effect on the general ecology - if we include in that the quality of human life in future generations - or the long term results of the drastic alterations we so rashly make with our new-found powers. We use the new space-age technology and power rather like a child playing with a machine gun.

My fear is that before we have time to learn how to apply the controls, we shall have lost the hedges and the plants and other forms of life depending on them. Before we learn the result of our actions, not only in regard to hedges but in matters of atmospheric and water pollution, humanity may tip the balance in favour of short term economy to the point of no return.

We seem to be aiming at a monoculture of humanity at the expense of all other forms of life except those we can exploit for immediate gain. This must inevitably lead to a lower quality of human life and may even destroy it, since we are dependent on clean air and water andon <u>all the biological balance</u> that has hitherto maintained these.

The simple instincts which, under natural conditions, ensure survival of a species - and amongst these we should include vision and visual appreciation - are not yet lost to man.

By refinement and cultivation and training of the inborn senses, humanity reaches new depths of appreciation which find their expression in art.

Today the landscape is man controlled and man-made. A good landscape is a work of art. I think we fail to realise how much of what we have was consciously planned with good appearance well up among the priorities of good husbandry. Consciously or unconsciously however, traditional farming practice, at least from the 18th century up to recent times, has given this country some of the richest landscape in the world, and this, I think, was because varied but balanced econcmy was essential on each estate and each farm.

It is that variety of land use, that balance between cultivation, woodland and pasture on each property that has made our typical landscape.

Today the need for that kind of variety and balance no longer exists. Quicker profits can be made by other means - for example by 'factory' farming.

So that the countryside might become a vast industrial estate with concrete and wire and cables replacing grass and hedges. I hardly think that the only sufferer would be the tourist trade.

Until we can evaluate the wider and longterm issues more thoroughly than as yet, I feel we should use our inborn sense of values - our natural love of fine landscape - as a kind of thermometer, the instrument by which we can <u>see</u> whether our actions are lowering or raising the quality of life. I realise that to make this suggestion here, to scientists skilled in precise evaluation, is to become a Daniel in the lion's den. But I suspect that some of the lions may feel as I do - and I trust that before I am torn to pieces you will let me come down to hedges and hedgerow trees as we can see them in the landscape.

I referred before to the value of variety and diversity in landscape. This points to variety in the size of open spaces - pasture or arable - contrasted with woodland and spinney. The hedge lines are a linking network, or web, defining the open spaces and relating them to tree groups.

Wind shelter belts are a major feature of our landscape. Their elimination would be an immeasurable loss to the visual scene - apart from practical considerations. I think the groups are more important than the individual trees in the hedge, though the hedgerow trees contribute greatly to the scene. Let us remember that hedgerow trees plant themselves at no expense to us - we have only to protect them from the hedge clipper. In regard to these, I can see no objection to felling mature hedgerow timber if a proper succession of "hedgelings" can be assured.

The spinneys, shelter belts and scattered woodlands are important in the scene by reason of their distribution. Visually their loss cannot be compensated for by large blocks of forest in distant places, whatever the acreage figures. The small tree groups distributed amongst the fields and farms emphasize the variations of land form and lend much to the beauty of the farmland.

The size and pattern of the fields, variable according to the type of agriculture, gives each region individuality. But within each area variation in the field size is more interesting than equality. There are parts of the West country where too many fields are too small for visual satisfaction. Monotony and repetition always make dull landscape.

I am constantly impressed by the lovely effect of farm groups whose buildings in themselves may lack architectural merit, but which please because their widely varying shapes - each depending on its function - are so closely and logically related to one another. The sheltering trees around the group contribute to this sense of good relationship, linked as they nearly always are by hedge lines to the fields beyond. They seem to symbolize the relationship of man to nature.

Landscape often symbolizes sound relationships, and I believe that it reflects the underlying condition of the ecology - just as a glossy coat indicates the condition of a cow.

The whole of life on this planet may be seen as an organism of which we humans are just a part. In spite of our sense of isolated superiority, humanity is dependent on the rest of nature through his lungs and stomach.

The quality of his life depends on the health of the whole, and its health is now, for the first time in history, within his control: men have been responsible for some very bad mangy patches in the past, but our activities are now having a worldwide effect.

Research - more and more research into ecological science is needed in order to guide our actions. But meanwhile - for the sake of decent human life we can at least make better use of our eyesight - our natural love of landscape and our appreciation of beauty in our surroundings.

13. THE LINDSEY EXPERIMENT

J. D. Leefe

Project Officer,
Lindsey Project for Improvement of the Environment

1. LINDSEY PROJECT FOR IMPROVEMENT OF THE ENVIRONMENT

This project is really the brain-child of the Secretary of "The Countryside in 1970", Mr. R. E. Boote, who of course is well-known to most of you.

The aims of the project include the collection of information on countryside matters, liaison with the Lindsey County Council Countryside Committee, promotion of co-operative projects by voluntary bodies for achieving a high quality environment and the promotion of measures for long-term liaison and co-operation between voluntary bodies and public authorities over environmental issues.

The main sponsors are "The Countryside in 1970" Conference, Lindsey County Council, Lindsey and Holland Rural Community Council and the Carnegie United Kingdom Trust. In addition, the Countryside Commission and National Council of Social Service are represented on the Steering Committee, which is under the chairmanship of Mr. W. E. Lane, Clerk of the Lindsey County Council, in a personal capacity.

Work commenced on 1st September, 1967 and will terminate in 1970, when a report will be presented to the third conference of "The Countryside in 1970", this report forming part of the U.K. contribution of European Conservation year.

In the first year, strenuous efforts have been made to establish contact with voluntary organisations and public authorities at both county and national level and useful liaison has also commenced with a number of Universities and educational institutions interested in environmental problems. Firm links have been established with the Lindsey Countryside Committee, the Cheshire Countryside Officer and the Dartington Amenity Research Trust. Information is also received regularly from the Kesteven Countryside Committee.

The field of activity has included :-

(i) <u>Trees</u>

A tree survey, by voluntary effort, has been organised on a parish basis in the Isle of Axholme Rural District Area (N. W. Lindsey). Articles have been prepared on tree planting for farmers and published in the Lindsey Farming Bulletin. An article on village tree planting has also been published in the Autumn issue (1967) of "The Village".

A trees seminar for farmers, landowners, land agents, foresters and naturalists was held recently at the Lindsey College of Agriculture and aroused further interest in the subject. A summary of the proceedings will be issued. Support and encouragement has also been given to courses on tree planting and maintenance which are held at the College. An exhibition was provided for the Lincolnshire County Show.

Visits have been made to Ministry of Defence property (mainly airfields), villages and farms in Lincolnshire to encourage and give preliminary advice on tree planting. Detailed advice is provided, where necessary, by the County Forestry Officer including plans and he is also able to arrange for labour, on a payment basis, if required.

(ii) <u>Buildings</u>

In March 1968, the Lincolnshire Historic Buildings Joint Committee was formed with representatives from the C.P.R.E. (Lincs. Branch), Lincolnshire Local History Society, Lincolnshire Association (Heritage Panel and Museum), Lincolnshire Society of Architects and Lindsey Project for Improvement of the Environment.

This is a very active committee and a buildings survey is being organised at present to ascertain how many older buildings exist in the County, particularly the smaller ones which are not listed. Local correspondents are being recruited to carry out the survey work.

A working party has also been formed to assist the Countryside Committee with the "Countryside Treasures" registration scheme and the project is helping with this work as well.

(iii) <u>Recreation</u>

The Lindsey Countryside Recreational Survey is at present surveying and analysing present recreational facilities in Lindsey and trying to assess future demands.

Lindsey P.I.E. puts forward ideas for possible picnic sites, country parks, nature reserves, etc., which have arisen from various contacts that have been made as a result of other activities.

(iv) <u>"Eye-sores" and "face-lifts"</u>

Several possibilities for using army personnel for removing "eye sores" have been exploited, with some success. A scheme is already in existence for community effort by the army, which has the title "M.A.C.C." (Military Aid to the Civil Community). The main difficulty seems to be obtaining trade union clearance but a financial contribution may also be required and a form of indemnity has to be signed, absolving the army from claims for damages.

Refuse tips are a useful field of study and some work has been carried out.

Village "face-lifts" can provide opportunities to youth organisations for community service and this theme is being developed, in conjunction with the Lindsey Standing Conference of Voluntary Youth organisations. This example of liaison and co-operation brings me to my main brief.

2. LIAISON AND CO-OPERATION

By word definition, the title of this section of my talk might also be rephrased as "maintaining connections to ensure joint operations", and I believe that this aspect of our work in the field of conservation is most important.

The Durham County Planning Officer, Mr. J.R. Atkinson, in a paper "New land for Old" given at the recent C.P.R.E. Conference held at Newcastle, said of derelict land:-

"People will continue to regard derelict land as a separate, finite problem which exists in isolation and which can be solved in isolation. This is quite wrong". He then went on to say "Reclamation only makes sense if it is tackled as an integral part of a general strategy of upgrading and improvement". Is this not true of all conservation problems? What catastrophes may ensue if we all press on in our own fields of activity "putting things right". The keen, but uninformed forester who fells a decayed stump of a tree for appearance and possibly hygenic purposes, is not aware that he may be destroying an absolute supermarket for the bird population. Or the farmer with a tidy mind may spray all the nettles on his farm with a herbicide, to the great detriment of butterflies and moths. In my own case, a great desire to demolish old bunkers on airfields as a matter of urgency remained unabated, until a zoologist friend pointed out that they might have become favourable habitats for bats, possibly rare species.

How then can we ensure that liaison is maintained between farmers, foresters, naturalists, industrialists, public authorities, etc.? First, I think, we have to distinguish between two levels of action, namely at national level and at county level.

At national level, I think it is true to say that much spade-work has been done, particularly through the "Countryside in 1970" Conference and also at meetings such as today's symposium. It is at county level that further efforts are required, if all who use the countryside are to understand the problems of conservation and the need for liaison and co-operation.

At this level both local authorities and voluntary organisations can play their part, the former through Countryside and Planning committees; the latter through public meetings and study groups, provision for cross-representation on each other's executive committees and possibly through the establishment of a county standing conference on countryside matters.

It was, of course, the "Countryside in 1970" who advocated that County Councils should appoint Countryside committees, with co-opted representatives of local bodies expert and active in countryside activities (see report of Study Group No. 5 Review of Legislation III 2). The following paragraph is of interest:

"We see Countryside Committees becoming concerned with the implementation of policies for tree planting, landscaping, establishment and maintenance of local nature reserves and other measures of nature conservation, ascertainment and protection of countryside treasures, provision of open spaces for various forms of recreational and other public enjoyment, rights of way and the like."

The activities of such a committee obviously tie-in with the Countryside Act 1968 and would seem essential for most counties, possibly coupled with some sort of county forum at which all parties interested in the use of the countryside can be represented, as mentioned earlier. In Cheshire, for instance, the Cheshire Community Council has established a Rural Committee on which a number of organisations such as the N.F.U., Parish Councils Association, Footpaths Society, etc., are represented. The atmosphere is less formal than the Countryside Committee and any ideas or suggestions put forward are debated fully by most of the members attending. Any ideas which prove generally acceptable are passed on to the County Council, the Countryside Officer forming a link between the two committees and also providing me with a lead to my last point, the role of the 'catalyst'.

3. THE ROLE OF THE 'CATALYST'

I must preface this section by saying that the views expressed are my own and not necessarily those of my Steering Committee.

Having spent just over one year on the project gathering information and ideas and trying to stimulate action, it has become fairly apparent to me that some sort of catalyst is required, at county level, if conservation policies are to be widely discussed and adopted. The title of 'Countryside Officer' is one possibility and a number of such appointments have been made, mainly as members of a planning department which may or may not be a good thing.

My catalyst needs to act as a liaison officer between voluntary organisations and local authorities in the county; to develop a working relationship with all Government departments and Public Authorities operating in the county, particularly the Nature Conservancy and Countryside Commission, to assist the local authorities with the development of recreational facilities and to advise on Countryside matters generally and to lecture widely to both the general public and specialist bodies including school-teachers' associations, so that conservation policies hammered out nationally can become known and adopted at county level.

The type of person to be recruited would vary widely, but basic requirements appear to be an overall interest in the field of conservation and a willingness to work with all kinds of people, at all kinds of hours! A specialist qualification might be an advantage providing status in at least one field of conservation. Employment could be offered by the County Authority or it might be possible to devise some form of independent status, e.g. secondment to a County Authority from the Countryside Commission, expenses being met jointly. A neutral status seems vital, at least from my own experience, if all views are to be ascertained andall interests served impartially.

CONCLUSIONS

Perhaps too much crust from the Lindsey P.I.E. and not enough meat, but at least I hope you now have some idea of the aims and activities of the project. I also hope that you will agree that 'liaison' and 'co-operation' are important words in the field of conservation. I shall be most interested to hear your views on the idea of a countryside 'catalyst'.

14. THE CHANGING COUNTRYSIDE PROJECT AND THE COUNTRYSIDE ACT

Miss Judith Hartley
Countryside Commission

There is some evidence that we are at present losing more hedgerows and hedgerow trees than we are replanting. This paper attempts neither to explain this trend nor to comment on its implications for the functioning or appearance of the countryside, but describe the sections of the new Countryside Act which may be capable of being used to influence the trend and some work the Countryside Commission is doing to improve the information available on such changes.

Before the Countryside Act was passed, in August 1968, there was already a great variety of legislation affecting the removal, maintenance and planting of hedgerows and hedgerow trees. Among this was Town and Country Planning legislation, including the Civic Amenities Act amendments, on Tree Preservation Orders, and the National Parks and Access to the Countryside Act provisions. Hedges and hedgerow trees are rarely mentioned as such, but reference to trees, as opposed to woodland or forestry, can often be interpreted to cover hedges too; many County Councils have applied Tree Preservation Orders to hedgerow trees, while the National Parks and Access to the Countryside Act of 1949, which gives local authorities amenity tree planting powers, which may qualify for up to 75% grants in National Parks and Areas of Outstanding Natural Beauty, defines trees as including bushes, shrubs, flowers and grass. In contrast to this approach to tree conservation, Ministry of Agriculture grant regulations refer specifically to hedgerow removal and replanting.

The White Paper "Leisure in the Countryside", published in February 1966, outlining the proposed countryside legislation, recog- that, "Changes in agricultural practice and the continuing emphasis on increased efficiency in farming are together making for a striking change in the face of the countryside because of the loss of trees and hedgerows, particularly noticeable in lowland England, which for generations has characteristically been a country of small fields, scattered woods and hedgerows. Changes there must be, but the losses can be made good by new planting. The Government will therefore ask local authorities to embark on an extensive programme of tree-planting in the countryside, not in the main in large woodlands but in small woods, clumps and rows."

Section 34(1)8 of the new Countryside Act relates to this point in the White Paper, by extending the grants for local authority tree planting for amenity purposes from National Parks and Areas of Outstanding Natural Beauty to all the countryside of England and Wales. Section 5 of the Act also allows for the work to be grant aided when done by private landowners where this is thought preferable.

Additionally the new Act provides powers for grants to be paid for the establishment of recreation areas in the countryside, such as country parks and picnic sites, which must often include tree or shrub planting of various kinds. One imagines that the Nature Conservancy may use its new power under Section 15 to make management agreements on Sites of Special Scientific Interest for the protection or planting of hedgerows and hedgerow trees. The Forestry Commission is, in Section 24, given the power to acquire land for amenity afforestation but the phrasing of this part of the Act suggests that this is intended for the planting of woodlands and not for isolated trees.

This new countryside legislation incorporates wide permissive powers for central and local government to encourage the protection and planting of trees, bushes, shrubs, flowers and grass in rural England and Wales, and also a general amenity clause: "In the exercise of their functions relating to land under any enactment every Minister, governmental department and public body shall have regard to the desirability of conserving the natural beauty and amenity of the countryside". However, these powers are only permissive; nothing definite has to be done as a duty; everything depends on the resources, of money, staff and initiative available. The Countryside Commission has begun to prepare policies for the spread of its slender finances between all the kinds of schemes it is allowed to help and guidance can be expected on the relative priority that will be given to hedgerow and hedgerow tree provisions. They must also explore the possibilities of conflict or overlap of policies with the Ministry of Agriculture, the Forestry Commission and other grant-aiding bodies.

In Section 2(2) of the Countryside Act the Commission are given a duty to "Keep under review all matters relating ..... the conservation and enhancement of the natural beauty and amenity of the countryside....", and even before the Ace was passed they had begun work on this part of their responsibilities with what is now known as the Changing Countryside Project.

The Commission's first concern was the lack of factual information on rates of removal of hedgerows and hedgerow trees. It seemed generally accepted that these were decreasing over the countryside as a whole and that there were wide regional variations in this trend, but neither Ministry of Agriculture grant accounting nor the few isolated surveys and historical studies made by the Nature Conservancy and others, provided a clear picture of what was happening. Other landscape features were also known to be changing and unrecorded; Ministry of Agriculture Annual returns and the two national land use surveys gave only an approximation to some of this information. Urban land uses do not always have an urban appearance, nor is the land use definitely of roads a satisfactory landscape category, for this may include both tarmac and wide grass verges.

It was decided that the Commission ought to develop an entirely visual classification of these landscape features thought liable to change, and then gather information in these categories periodically, to record the changing appearance of the countryside. Objective definitions of the following features were prepared (some revision of this list may be made in the future):

Built-up areas, buildings;

Built-up areas, hard surfaces;

Inland water;

Sea;

Broad-leaved woodland;

Coniferous woodland;

Mixed woodland;

Young plantations and orchards;

Bare ground, heaps;

Bare ground, holes;

Bare ground, flat areas;

Grassland;

Ploughed land;

Other cropland;

Scrubland;

Low rough vegetation, herbs;

Marshland;

Heathland;

Bracken areas;

Pylons and poles;

Other tall features;

Isolated broad-leaved trees;

Isolated coniferous trees;

Boundary broad-leaved trees;

Boundary coniferous trees;

Fences;

Walls;

Low hedges;

Tall hedges;

Earthbanks.

The next step in the Project was to find the best way of getting information on how the amounts of these features per unit area were changing. Interpretation of existing sources of data and the use of periodic air surveys were considered, but it soon became apparent that field recording would be necessary.

Complete field survey of England and Wales every few years was obviously out of the question and it was decided that a regional picture should be sought by sampling. Provision of information for units of about 750 square kilometers was estimated to need a random sample of the order of ten thousand kilometre squares. Discussions with educational agencies suggested that school-children might take on the work on this scale, and various voluntary organisations, such as the Women's Institutes, also expressed a strong interest in participating. It was thought that a visual survey would give a versatile basis for a great variety of school projects, the standard instruction handbook and base maps which the Commission would provide encouraging many teachers to attempt field studies with their classes for the first time.

The fieldwork was, consequently, designed to be within the capabilities of the average secondary school-child, and a series of tests of the accuracy of their work were carried out in the summers of 1967 and 1968. In the second of these pilot surveys a sufficiently large sample was taken for the characteristics of the data to be estimated and the size and type of sampling programme needed in a full national survey will be deduced from these estimates by Dr. Yates, F.R.S., who is employed as statistical adviser during the preparatory stages of the project.

The Commission has been consulting farming interests and many other agencies and individuals, including the Forestry Commission and the Nature Conservancy, at various stages during the preparation of the project. A detailed organisation scheme and publicity programme are being prepared for the full survey and an educational consultant is collecting together schemes of work based on the survey, designed both to encourage participation and the emphasise the opportunity this fieldwork provides to show children the need to exercise care in the countryside.

It is hoped to finish preparatory work early next year and if the Countryside Commission then decides to initiate this project on a national and recurring basis, the first full survey will probably take place in 1970. This is expected to provide, amongst other things, reasonably accurate figures for the average lengths of low hedges and of tall hedges, and the average numbers of coniferous and of broad-leaved scattered hedgerow trees, per square kilometre. These figures will apply to any area of 750 square kilometres or more in extent, in England and Wales. It is hoped that this form of montoring the changing amounts of hedgerow and hedgerow trees will provide the factual basis needed to assess the effectiveness of Government policies and initiate productive research in this field.

Handbooks prepared for the pilot survey carried out this summer can be obtained free of charge from the Research Section of the Commission at 1, Cambridge Gate, London, N.W.1.

N.B. Please see page 99.

DISCUSSION: PART IV

Mr. Tandy as Chairman, summarized Mr. Helliwell's attempt at a cost benefit analysis and Miss Colvin's plea for landscape to be regarded as a valuable natural resource. Professor Coppock pointed out that the landscape was a result of past use and if it was to be frozen we must decide on how much we are prepared to pay and how much the farmers might want.

Miss Colvin was asked what landscape design she would suggest to combine intensive agriculture and wilderness areas, to which she replied that a network web of trees and hedges would suit both, with the size of the cells of the web dependent on use, with some degree of emphasis on local characteristics in particular areas. It was suggested that this reply could appear to be a conditioned reflex to the network already in existence and perhaps there might be some underlying principle of a landscape preserving elements of a pre-human climax vegetation.

Mr. Darke said it was in the national interest to have a scientific approach to farming and he for one thought teaching aesthetics in agricultural colleges inappropriate. False precision could arise from familiarity in cost benefit analyses and final decisions could be made on inaccurate data. Nevertheless, there appeared to be a case for financial aid for spinneys and copses.

Mr. Cornwallis then suggested that the basic issue was not being squarely faced. Prevention was the wrong attitude. Hedges were removed because they were no longer useful and cost money to maintain.

The question of whether or not shelter was a benefit was raised again and it was suggested that this was a first priority for further research.

RESOLUTIONS

The following resolutions were agreed in the final discussion.

1. <u>Addressed to N.E.R.C. (Nature Conservancy)</u>

That the Nature Conservancy should examine areas where facts were lacking, draw up a priority list for further research, and ensure that such research was carried out and the results disseminated.

2. <u>Addressed to the Countryside Commission</u>

That the Commission press on with their plans for putting their Changing Countryside Project onto a permanent national basis, so that there may be a continuing objective measurement of the changes in the mileage of hedgerows in different parts of the country.

3. <u>Addressed to Department of Education and Science and various Councils for Environmental Education</u>.

That environmental education at all levels be made aware of, and take into account, the various topics discussed at the Symposium.

4. <u>Addressed to Ministry of Agriculture, Fisheries and Food, and Department of Agriculture and Fisheries Scotland</u>

That the ministers concerned be invited to reappraise their policies, with a view to their reformulation in the light of the discussion at the Symposium.

5. <u>Addressed to Ministry of Housing and Local Government</u>

That those departments and organisations concerned with rural planning and amenity be invited to take into account the views expressed at the Symposium in future discussions of policy.

6. <u>Addressed to the National Farmers' Union, County Landowners Association</u>

That these organisations be invited to consider the formation (or promotion) of local groups to review this Symposium's conclusions in planning management and future development of agriculture.

PART V: DEVELOPMENTS SINCE THE SYMPOSIUM

FURTHER INVESTIGATIONS (ARISING FROM RESOLUTION I)

Since the Symposium, officers of the Nature Conservancy have collected additional information about the rates of hedgerow removal, and have discussed their data with officers of The Ministry of Agriculture, Fisheries and Food, who have collected statistics about the extent hedgerows have been uprooted with the aid of a grant. The Conservancy's Land Agents have also investigated the relative costs of hedgerows and of other fence types.

1. The rate of hedgerow removal.

During and immediately after the Sumposium it appeared likely that the Countryside Commission's Changing Countryside Project would provide accurate information on rates of hedgerow removal and further sample surveys by the Conservancy were therefore held in abeyance. By August 1969, however, it appeared that this project would not provide reliable data. In the same month M.A.F.F. officers published the results of their own appraisal, which led to an estimate of under 1,000 miles of hedgerow removed each year. Of this, some 500 miles were removed under grant aid.

The divergence between this figure and the estimate of 7,000 miles a year given by M.D. Hooper in the Symposium was so large that discussion between the organisations were held to establish the cause of the variation. From these it was apparent that the rates of removal estimated by both groups was in substantial agreement over most of the country. Recalculation of the estimates, and elimination of as many errors as possible with the limited samples available, still left the Conservancy's estimate three times as large as the Ministry's. It was agreed that although the two surveys had been made over different periods of time (1946-62 for the Conservancy and 1957-69 by the Ministry) this alone was unlikely to explain the difference.

It was agreed that at present the best overall estimate was that on average a total of about 4,500 miles of hedgerow have been removed in each year between 1946 and 1962. As stated by M.D. Hooper in the Symposium, if correct, this figure represents only about 1 per cent of the total mileage of hedge in England and Wales. The figure could, however, be in error by as much as 50 per cent, and officers of the Nature Conservancy agreed to survey a further series of sample areas in the arable region of England in order to bring down the margin of uncertainty: officers of M.A.F.F. have agreed to help them. This work is now progressing and the 21 sample areas analysed so far indicate an average rate between 1946 and 1962 of 1600 ($\pm$ 350) miles of hedge lost each year from the approximately 6 million acres of arable land alone.

The current M.A.F.F. figure of 750 miles of hedge removed from England and Wales each year under grant aid is a reliable one. Hence farmers in arable regions must remove a much greater mileage of hedgerow without grant aid than with it. If the rate of 1,600 miles per annum in arable areas remained constant throughout the period 1946 to 1962, it might be suggested that farmers removed at least three times as much hedgerow without grant. However, a small number of samples taken by the Conservancy suggest that the rate on arable land between 1946 and 1954 was 800 miles a year, between 1954 and 1962, 2,400 miles a year and between 1962 and 1966 rose to 3,500 miles a year. (This latter rise would explain the high rate observed by the British Trust for Ornithology, reported on page 9). The rate between 1966 and the present appears to have fallen to about 2,000 miles a year. These variations in time, as well as those from region to region, make caution even more essential in interpreting any suggested average national total. If the estimate of 4,500 miles removed per annum is valid, however, it would imply that for every farmer receiving a grant for hedgerow removal, about five acted without grant aid.

2. The costs of hedgerows and other fences.

During the symposium, several figures for the costs and benefits of hedges were mentioned but there seemed to be little agreement among the participants. The Conservancy agreed that some figures should be provided as a basis for further discussion.

The costs given below are based upon estimates of costs of fences provided by the Conservancy Land Agents in various parts of the country. These costs are those prevailing in 1968 and show considerable variation between areas and even within areas for specific sites. The figures must, therefore, be used as a rough guide only.

A. Erection costs.

Rabbit fencing	6/- per yard
Woven wire	8/- to 10/- per yard
High Tensile wire	6/- to 11/- per yard
Post and rail a) 2 rails	12/- to 15/- per yard
b) 4 rails	18/- to 30/- per yard
Hawthorn Hedge	12/- per yard

B. Maintenance costs.

Fences of all types require periodic inspection and routine repairs which might cost 1d. to 6d. per yard annually.

Hedges

to cut and hay	£4 to £14 per chain
hand trimming	12/- to £4 per chain
mechanical cutting	£5 to £15 per mile

Estimates of the frequency of cutting and laying necessary varied between seven and twenty-five years. Provided the hedges were trimmed annually, the costs of hand trimming were thought to be of the order of 15/- per chain and mechanical trimming about 1/6 per chain.

C. Length of life.

Fences were expected to require complete renewal at between 15 and 25 year intervals. Hedges, assuming regular management, were expected to last indefinitely.

Conclusion.

As a crude comparison it seems reasonable to suggest that a yard of fence might cost 16/- for each 20 years of its existence while a yard of hedge would cost nearer to £1 for its first 20 years but only 6/- for each subsequent period of 20 years, assuming it was laid once in each period and regularly trimmed mechanically.

Hence all new boundaries may be expected to be fences rather than hedges in the interests of flexibility of management. Only if one can be sure the boundary will still be required in 40 years time is planting a hedge justified in terms of direct costs.

On the other hand, if a good hedge already exists, there is little point in replacing it with a fence. Even if the hedge is overgrown it might still be cheaper to renovate it rather than replace it.

3. Review of Past and Current Research

Symposium Resolution I required the Nature Conservancy to examine areas lacking in facts and list the further research that was necessary. In view of the disagreement on the degree which hedgerows conferred an economic benefit through the effects of shelter on crops and stock, it was decided that this should be examined first. The literature on shelter effects has therefore been reviewed. In addition a system has been devised for storing information on hedgerow topics in such a manner as would allow both the stored information to be easily available and gaps in research effort to be readily seen.

Shelter effects on crops have been reviewed by Jensen (1961), Line (1962) and Marshal (1967). It seems generally accepted that shelter will increase yield in a wide variety of crops. The increases found vary from place to place but are distinctly greater in areas with a continental climate than in areas with an oceanic climate. Marshal concludes that in East Anglia with a relatively continental climate, there might be a sufficiently high incidence of dry seasons to justify the provision of shelter but that in general the use of shelter has only a limited potential use in Britain.

This seems a sound conlcusion since it must be remembered first that no crop yield can be expected within a horizontal distance of twice the height of the shelter and, second, that an increase may be expected only within the zone distant between twice and twelve times the height of the shelter, on the lee side. Hence, an average increase in yield of 20 per cent over this area is necessary before shelter can be justified in terms of land use even without taking into account the costs of erecting and maintaining the shelter.

On the Russian steppes increases in grain yields from the use of shelter average out at 28 per cent (Smith 1929) but in Denmark, where conditions more nearly approach those of eastern England, the average increase in grain yield is only 17 per cent (Anderson 1943).

A number of situations have been found where the increase more than compensates for the loss, for example, in a grass/clover mixture in Denmark (Flensborg and Laussen 1941) but shelter also produces a number of adverse effects, particularly delays in ripening of cereals (Olbrich 1949), which can make the potential increase in yield unharvestable.

Mr. Shepherd's conclusion that shelter is not a commercial proposition for agricultural field crops is certainly supported by this evidence. In the case of horticultural crops, there is however, evidence of shelter being extremely valuable and work is now in progress on types of shelter at Rosewarne Experimental Horticulture Station, and on increases in yield at the Scottish Horticultural Research Institute.

With stock the situation is more complex as a two part system of plant and animal is under consideration. The grass component is currently being investigated in the Department of Agriculture at Bangor and the Hill Farming Research Organisation at Edinburgh. The general conclusions so far seem to be the same as for crops; increases in yield can occur but are largely offset by the decreases and costs of providing shelter.

Positive effects of shelter on live weight gains of animals have been reported (e.g. Stockler & Williams 1949) but recent studies at Bangor on pregnant ewes indicate no direct benefit from shelter in terms of live weight changes or lamb birth weights. Such work is continuing at Bangor but again, the general conclusion drawn is that shelter for stock is an uneconomic land use (Miller 1968).

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THE CHANGING COUNTRYSIDE PROJECT (RESOLUTION 2)

During the year following the Symposium, the Changing Countryside Project has been evaluated further. It was agreed that the survey had considerable educational value, that there were few problems over access and that the Commission's staff could adequately produce and distribute material. But the information produced by surveyors was extremely inaccurate. Successive modifications of the Survey instructions through three pilot runs failed to reduce errors to a reasonable level and in August 1969 the Commission decided they should not take the project further.

A brief report on the third pilot survey is available from Miss J. Hartley free of charge, and a full account of the research will be published early in 1970. Work on other methods of monitoring landscape changes and on other ways of introducing children to the countryside will continue as two separate lines of study under Mr. A.A.C. Phillips and Mr. A.C. Jones respectively.

ENVIRONMENTAL EDUCATION (RESOLUTION 3)

In 1969 the Department of Education and Science prepared an exhibit on hedgerows which was shown at various centres in conjection with the British Association of Young Scientists.

Details of a school project on hedgerows prepared by the Nature Conservancy have been sent by the D.E.S. to all schools in the country as part of the educational programme for E.C.Y. 1970.

The circular states:-

> "National Rural and Environmental Studies Association/ Nature Conservancy Hedgerow Project for Schools."

Most British farmland is still very rich in wildlife, largely because of its hedgerows. But many hedges are now being removed for economic reasons. The Nature Conservancy is surveying the distribution of different types of hedgerow, their management and the kinds of shrub in them. Research so far indicates that the older a hedgerow, the more species of shrubs, and thus the more wildlife, it is likely to contain.

"Schools can help in this work, and an information leaflet is available which includes a record sheet and suggestions for follow-up work. The project not only offers an introduction to systematic recording but can also provide the basis for more sophisticated geographical, biological and historical studies."

"Further information can be obtained from Monks Wood Experimental Station, Abbots Ripton, Huntingdon."

REAPPRAISAL OF POLICIES (RESOLUTION 4)

Following the Monks Wood Symposium, the M.A.F.F., N.C., R.S.P.B., B.T.C., S.P.N.R., N.F.U. and C.L.A., jointly organised a confrontation between farmers, agricultural advisors and conservationists at Silsoe, Bedfordshire, on 11th - 13th July 1969. The people who attended walked a 400 acre farm and prepared a series of alternative management plans for different types of economic husbandry and for various compromises to allow preservation of game and conservation of wildlife and amenity. The meeting did much to improve mutual understanding, and was extremely successful. In a major speech made on January 21st, 1970, the Minister for Agriculture, Mr. Hughes said

> "I intend to introduce more emphasis on the opportunities for conservation in the training of my advisory services. New courses designed to achieve a broader understanding of conservation management and its relationship with farming practices are already being planned. As a result, advisers will be more easily able to suggest to farmers and others in what way and at what cost conservation interests can be safeguarded.
>
> I think too that it would be useful if my Agricultural Executive Committees in each county were to take the initiative by bringing together representatives of farming and conservation interests, perhaps by forming a group in every county. These groups could consider how best to promote an understanding of the problems by whatever means they might think appropriate, such as the conference and demonstrations to which I have already referred. Secondly, I propose to organise a series of regional demonstrations and conferences. These might take the form of the very successful Silsoe weekend. I am sure that these steps will be welcomed by all those who have a real interest in the future of the countryside."

Two conferences of this type have already been held - one for Cambridge and the Isle of Ely organised by the Agricultural Land Service, and one for Norfolk, Suffolk and Essex organised by the National Agricultural Advisory Service. A further ten conferences are being planned for 1970. The Cambridgeshire N.A.A.S. have published a pamphlet entitled "Tree planting on the Farm" which was produced in co-operation with the County Planning Department, the A.L.S. and the Nature Conservancy. The East Midland (Lindsey) N.A.A.S. also published a pamphlet with the same title in December 1968.

RURAL PLANNING AND AMENITY (RESOLUTION 5)

The Countryside Commission is actively pursuing policies that closely accord with the views expressed at the Symposium. Under the Countryside Act, 1968, "every Minister, Government Department and public body" is instructed to "have regard to the desirability of conserving the natural beauty and amenity of the countryside" and there is much evidence (for example in the Minister of Agriculture's speech quoted above) that Departments are taking this instruction very seriously indeed.

FORMATION OF LOCAL GROUPS (RESOLUTION 6)

A large number of local events in which such bodies as the N.F.U. and C.L.A. are active participants are planned for 1970 as part of European Conservation Year.

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Mr. T.H. Blank, Eley Game Advisory Station.
Miss N.A. Bonnar, Nature Conservancy (H.Q.).
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