Wildlife Habitat Changes
in Lowland Scotland

by

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DECLARATION

I hereby certify that this thesis has been composed by myself from the results of my own work, except where stated otherwise, and that it has not been submitted for any degree other than that of Master of Philosophy in the University of Edinburgh.

Carol L Crawford
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CHAPTER 1 INTRODUCTION

1.1 OBJECTIVES

The main object of this study was to put post-war wildlife habitat changes, measured in the NCC sponsored 'Lowland Agricultural Habitats (Scotland) Air Photo Analysis of Change' project, into perspective.

This thesis is divided into three main sections. In the first section the above project is outlined and the results presented. In the second section an attempt is made to put the main results into historical perspective by comparing them with changes in earlier periods. In the third section the ecological implications of the changes are considered.

In the first introductory chapter the reasons for undertaking the work will be presented.

1.2 BACKGROUND

Changes occurring in the countryside since the last war have precipitated fear that remaining habitats have been irrevocably altered.

A series of Sites of Scientific Interest (SSSIs) have been selected by the Nature Conservancy Council (NCC) to encompass the best examples of our natural habitat types. Their combined total area is only about five percent of the total land area of Britain. This is seen as the absolute minimum area which must be reserved to hold representatives of all our flora and fauna. The criteria for the selection of these sites must therefore include such variables as fragility and rareness.

In addition the designation of a site as a SSSI does not ensure its conservation: in 1977 it was estimated that 100 out of the total of 3900 SSSIs were lost; a rate of four percent per year (Goode 1981).

Over 80% of the land area of Britain is under agricultural management. It is within this area that the majority of our wildlife exists. Habitats such as woods, marshes and grassland are refuges for all our typical and common flora and fauna. A combination of factors renders such habitats at least a luxury, often a waste, and even a liability to the landowner and many have been put to more productive land uses. This process has been facilitated by farmers being exempted from planning control under the terms of the 1947 Town and Country Planning Act.

Coupled with concern over wildlife has been a resistance to the 'new', more functional, agricultural landscapes which are replacing the more pleasing 'traditional' landscapes. This resistance often seems to be founded more on aesthetic, even emotional grounds, than ecological reasoning.

1.3 CHANGES

Both subjects for concern have arisen following the loss of semi-natural elements in the countryside, such as copses, meadows, hedgerows, ponds and marshes. The ecological diversity of these ensures refuge for an array of wildlife. Their presence provides structural diversity in farmed areas, thus enhancing landscape appearance.

Further to individual habitat loss, the network of wild areas becomes more tenuous and the residual fragments may be less viable. This has been termed the 'island dilemma' (Diamond 1975).

Thus the 'sum is greater than the parts' argument seems to hold here from both the nature conservation and amenity points of view.

Much attention has been focussed on hedgerow loss; it has become, perhaps, the symbol of this particular movement of environmental concern. Yet, in Scotland at least, many of the hedges are comparatively young. They were planted around 200 years ago; part of an earlier agricultural revolution which also radically altered the countryside. The old mediaeval agricultural system with large open fields divided into 'rig and furrow' (equivalent of English strip system) was replaced by a patchwork of smaller fields enclosed by hedges. 'Improving' landlords enriched this landscape with woodland and parkland often for sport or amenity rather than any 'productive' function.

In addition hedgerows remaining in Scotland are often neglected. The original management practice of laying, which serves to keep the hedge thick and stock-proof is rarely practised now in Scotland. Relic hedges are likely to be gappy and 'repaired' with fencing. Most are only clipped and this does not encourage basal growth to fill the gaps. A recent study of hedges in East Lothian (Taylor and Tozer 1979) suggested that many remaining interfield hedges were less well managed than those beside roads. In addition roadside hedges were often composed of a mixture of species, which provided better habitat for wildlife, whereas interfield hedges were mostly single species (hawthorn).

1.4 THE CAUSES OF CHANGE

1.4.1 Land-use Changes

It has been government policy since the second World War to support agriculture. This followed the decline of arable agriculture since the second-half of the 19th century when it became possible to import cheap grain. Although there was a revival of support for farmers during the first World War, arable agriculture declined again in the inter-war years. It took another major war to alter the governments attitude.

The government has tried to increase the country's level of self sufficiency since the second World War. A report in 1975 stated that it was necessary for agricultural production to increase by 2½%/year to improve the country's balance of payments. (NCC 1977). These aims together with a desire for cheap food have made agricultural subsidies the norm. The consequences are intensification of agriculture on existing farmed areas and reclamation of land for wildlife habitats.

The British countryside had, on the whole, reached a 'climax' of deciduous woodland before man's arrival. Since Neolithic times the natural forest has been cleared for agriculture, for fuel, and for security. Many of the woods left today were in fact replanted by the improving lairds of the 18th and 19th century. The establishment of the Forestry Commission in the early years of the 20th century has also helped redress the losses. However, much felling was necessary in the war years.

For the above reasons and because timber is another important resource, forestry has, like agriculture, been encouraged by the government. Woodland covers 8% of the land area of Britain and it is aimed to increase the proportion of the land occupied by forests to 20%. The main problem for nature conservation interests is that it is more economically viable to plant the faster growing coniferous species. These are mostly non-indigenous and less hospitable to the native flora and fauna associated with deciduous woodland. Forestry, like agriculture, was exempted from the planning restrictions of the 1947 Town and Country Planning Act. However most of this afforestation was believed to be occurring in the upland area and not in the lowland farming area.

The third major cause is urbanisation. Towns have grown since the war. One of the reasons for this is the employment of labour saving technology in farming which has pushed much of the remaining rural population into the towns. There has been spread of industry round settlement areas and now urban influence is spreading further into the countryside. Nature conservation was not high on the government's list of priorities in the immediate post-war years. In fact it still is not; the 1977 Government funding to NCC was £7 million whereas the Ministry of Agriculture Food and Fisheries (MAFF) paid out £540 million in agricultural grants alone (Moore 1980). Much has been achieved in the nature conservation field by voluntary effort.

1.4.2 Technological Advances

These tend to facilitate increased production and render some semi-natural habitats unecessary. For example, the advent of piped water marked the demise of the farm pond, and the new larger agricultural machinery which has replaced horse-drawn implements requires larger fields to manoeuvre in, making boundary removal preferable. Other advances in the post-war years include plant-breeding, development of pesticides and greater availability of fertilisers.

Hedges were initially established as stock barriers but trends towards intensive livestock production indoors and greater arable production in the fields tend to render them superfluous.

In some places agriculture has become more of a business than a livelihood. In others the demise of the estate and the advent of the owner occupier heralded a drive towards more intensive production, often at the expense of the semi-natural habitat, for livelihood alone. The estate-holders were more inclined to afford non-productive areas.

Many of the new methods are clearly less sympathetic towards wildlife than the old methods. In fact grants are more likely to be awarded if the farmer or forester can show his land to be utilised more efficiently.

1.5 EVIDENCE OF CHANGE

Although it was accepted that changes were occurring, there was little systematic quantitative evidence for the country as a whole, to back this up. Smaller studies had been made, often of only one habitat type, in a parish or county.

For example in one parish in Huntingdonshire there was a 90% reduction in hedges between 1945 and 1965 with no evidence of change between 1840 and 1940 (Pollard, Hooper and Moore 1975). It is possible that this was initially an area with a greater than average density of small fields. A 23% hedge loss for the post-war years has been suggested by Moore (1980) for England as a whole. In another parish in Huntingdonshire 50% of all ponds were lost: NCC (1977). Seventy percent of Norfolk and Suffolk Breck heathlands have been lost (Moore 1980). In Wiltshire 47% of the remaining chalk downland was ploughed up between 1937 and 1971 (Goode 1981). However grasslands and heathlands have been artificially maintained. If grazing pressure were removed they would revert to scrub and finally woodland. Goode (1981) reported NCC findings that 30% to 50% of all ancient semi-natural woodland in Britain has been lost since 1947 which is roughly equal to all woodland lost in the preceeding four centuries.

The actual effects of such changes on wildlife are even more difficult to gauge. As an example downlands are seen as providing habitat for some of those species prevalent between the end of the last ice-age and the growth of deciduous woodland. Before the advent of chalk grassland such species had become confined to coastal areas and clearings in the woods.

Because woodland was the dominant vegetation type before man's clearances, most of our flora and fauna are adapted to it. It is also the most diverse habitat both structurally and biologically. It has been estimated that 70% of birds found on farmland require trees and bushes in which to feed or nest (NCC 1977).

Primary woodlands are therefore seen as the most valuable habitats. Although secondary woodlands (established after other land use) are also valuable it would take a long time for them to regain the diversity of primary woodlands and it is thought certain species might never re-establish themselves (NCC (1977) paragraph 28).

As a whole 10% of our flora is confined to the following habitats:- woods, pastures, hedges, ditches and ponds.

There are a few figures for individual species. For example Moore (1980) reported that with the loss of wetlands since the war three or four species of the 41 British dragonflies have become extinct. It is known that none were lost between 1800 and 1965. Changes in the insect kingdom are difficult to document because the full extent of their distribution and abundance is as yet unknown.

We know that species have become extinct at other periods in the past but we have little evidence that extinction rates are increasing. The recording of species is comparatively recent; beginning in the 17th century, and systematic country-wide recording is a 20th century innovation.

British extinctions might be offset by species introduced from other countries. For example, since 1600 twenty species of flowering plants have been lost from the British flora of 2300 species. However it has been estimated that 700 of these species were introduced (Green 1981). Many aliens seem to be able to adapt to the new conditions brought about by man's changes. However there is a fear that such species are the less exacting 'weed' species to which less value is attached. They may be by nature more adaptable or aggressive and, in the absence of natural control, out-compete native species. Alien flora probably supports less of our native fauna than the native flora does, but time may change this.

1.6 REASONS FOR THE STUDY OF HABITAT CHANGES

It is clear that the situation is far more complex than the following statements from the Friends of the Earth (FOE) booklet 'Paradise Lost' would have us believe:

> Britain's present habitats have evolved over the last 10,000 years... 'Paradise Lost' shows how our natural habitats are being turned into food and timber factories.... Britain's traditional countryside is gradually changing for the worse.

The introduction to the controversial 'The Theft of the Countryside' (Shoard 1980) contains the following rather biased passage:

> Although few people realise it, the English landscape is under sentence of death. Indeed, the sentence is already being carried out. The executioner is not the industrialist or the property speculator, whose activities have touched only the fringes of our countryside. Instead it is the figure traditionally viewed as the custodian of the rural scene - the farmer.

Such simplifications and exaggerations draw public attention and support for the conservation movement, but overstatement of the case may defeat the purpose. This study aims to build a truer picture by sifting through the scientific evidence, the exaggerated statements and the emotive outcries associated with the subject of wildlife habitat change.

Change is a natural part of any ecosystem and could be considered to be the driving force of evolution. The main fear is that the changes which have been occurring in the post-war period are of a far greater rate and scale than in previous periods and that as a result of this native species do not have time to adapt.

The NCC is required by law to 'Take account of actual or possible changes'. The impetus for such work was provided by their publication 'Nature Conservation and Agriculture' which focusses on the changes which may be occurring. Whilst allowing that the available evidence was 'circumstantial and fragmentary' the following statements are to be found in this document:-

> The rate and extent of change in the last 35 years have been greater than at any similar length of time in history.
>
> All the factual evidence suggests that Britain faces a serious reduction in wildlife if present trends continue.

These are fairly alarming statements to have arisen from scientific appraisal.

1.7 REASONS FOR A COMPREHENSIVE STUDY OF WILDLIFE HABITAT CHANGES IN LOWLAND AGRICULTURAL SCOTLAND

If the evidence for the rest of Britain was seen as piecemeal and random, then there was virtually no evidence for Scotland. In addition the English habitat types are different: downlands are not a feature of the Scottish landscape, hedges and lowland heaths are less common.

In 'Nature Conservation and Agriculture' it was recognised that the situation is very different in Scotland. Only 22% of the land area is suitable for intensive agriculture (grades A+ -C) by Department of Agriculture and Fisheries for Scotland classification, whereas in England and Wales 70% is in grades 1-4 (MAFF Agricultural Land Classification of England and Wales (1974)). In one sense it was felt that the problem could be less because a much smaller area was involved. On the other hand the problem could be more acute because the remaining wildlife supported by a smaller area of habitat are under a far greater threat in the event of its reduction.

It was felt that the changes in Scotland might have been less obvious because of the undulating nature of the physiography of the lowland agricultural area. The variation in land forms serves to mask landscape changes and to diversify the view. In the flat plains of east England changes are all too obvious.

An earlier study of a lowland area of Midlothian (Crawford 1978) showed that hedgerow removal there over the last 30 years had only been about 15%. One of the conclusions that was drawn was that the nature of the land forms had provided far less opportunity for field enlargement than in England.

This study also revealed other differences in the Scottish landscape such as an 111% increase in conifer woodland between 1957 and 1968 often at the expense of grassland habitats. Although non-coniferous woodlands had decreased by 30% over the period 1947 to 1974 this was not as a result of agricultural development.

What had not been recognised in previous studies of changes was that there are gains as well as losses in semi-natural habitat. There were fairly large gains in grasslands and scrub-type vegetation when felled areas and old mineral workings were 'left to nature'. However, it is thought by research scientists that such areas would take centuries to regain as much nature conservation interest as the primary habitats. (e.g. NCC (1977) paragraph 28).

Little evidence was found for the reclamation of grassland to agriculture. It may have been that all potential areas had already been reclaimed, because most of the remaining old grassland was in the steep-sided valleys which could not be cultivated.

In addition there was little evidence of further fragmentation of wildlife habitat. The main conclusion was that the situation was far more complex than had been thought initially. Because this was only one area of a District, more evidence was needed before drawing conclusions about trends in the rest of Scotland.
In a pilot study for the future NCC project Langdale-Brown and Weyl (1978) working in North-East Fife found quite different changes from those in Midlothian. For example there was a greater decrease in improved grassland. There was also a net decrease in scrub whereas this habitat had increased in Midlothian.

1.7.1 The NCC Project - Lowland Agricultural Habitats (Scotland) Air-Photo Analysis of Change

In 1978, the NCC, recognising the need 'to improve the quantitative basis of its policy Statements', initiated this project. The main objective was to determine wildlife habitat changes which had occurred in the lowland agricultural area of Scotland in the post-war period. It was felt that statistically reliable data would give far greater weight to discussions with other government departments responsible for controlling land-use in Scotland. Indeed the results were quoted in the political lobbying preceding the 1981 Wildlife and Countryside Act. The survey was contracted out to Edinburgh University Department of Forestry and Natural Resources where a team led by Dr Ian Langdale-Brown carried out the research. The author of this thesis was a member of that team.

Fourteen habitat types were identified and changes which had occurred between them since the late 1940's measured. This was done by comparing early post-war aerial photographs with more recent ones.

The results do not show a picture of straightforward losses to agriculture which the NCC had anticipated, but rather one of losses and gains to each habitat type. For example, with scrub the gains are often equal to or greater than the losses, though there is an overall net loss. With deciduous woodland the losses do exceed the gains. Perhaps the most surprising change is an overall loss in the area of agricultural land. Much of this has been turned to non-agricultural land uses such as housing and road building. The increase in conifer woodland is of far greater magnitude than was expected in the lowlands. Much of this was at the expense of deciduous woodland but grassland categories have also been planted with conifers. Afforestation and urbanisation are obviously as significant forces in the lowland agricultural area of Scotland as agriculture itself.

1.8 STRUCTURE OF THE THESIS

The main object of this thesis is to put into perspective the post-war wildlife habitat changes identified in the above project. The work is divided into four sections with the following subsidiary objectives.

1.8.1 Section 1

In the first section the NCC project will be outlined. This will be followed by an appraisal of the results, exploring the differencies between Districts and culminating in the extraction of the most significant changes. In the discussion the limitations of the methods will be considered and the results compared with those obtained in other studies.

1.8.2 Section 2

The impetus for the second section comes from the statement made in 'Nature Conservation and Agriculture' (1977) that the 'rate and extent of change in the last 35 years have been greater than at any similar length of time in history'. The section begins with a review of vegetation changes from late glacial times to the present day concentrating on the main periods of change and their causes. This is followed by evidence of habitat change in lowland Scotland derived from maps and other material published at the time of change. Estimates of change between 1760 and 1947 are presented for East Lothian.

1.8.3 Section 3

It is generally believed that the replacement of deciduous woodland with conifer species leads to a loss in the value of the habitat for wildlife. Yet many of the deciduous woodlands in the study area were planted by the 'improving' landlords of the 18th century and are of less value for wildlife than primary woodland.

Likewise hedgerow removal is often thought to be disastrous for wildlife yet those that remain in Scotland are often neglected. They are of less value for wildlife than well maintained examples.

In this section the 'ecological value' of those habitats most involved in change will be considered. Limited field evidence for the floristic value of Lothian habitats will be presented. This will be supplemented with more general information about the habitat value from the literature.

1.8.4 Section 4

In the final section the conclusions of the previous three sections: the main changes of the last 30 years, their scale compared to past changes, and the effects of such changes on wildlife, will be considered. Then comment will be made on the significance of post-war wildlife habitat changes in the Lowland area of Scotland.

SECTION 1 LOWLAND AGRICULTURAL HABITATS (SCOTLAND) AIR-PHOTO ANALYSIS OF CHANGE

CHAPTER 2 METHODS

2.1 INTRODUCTION

This section outlines the 'Air-photo analysis of change' project and summarises the most significant results. There will be three chapters:

2) Methods.
3) Presentation of results and discussion.
4) Discussion: Summary of findings, comparison with the other results, other changes not identified by the project. Conclusion - the most significant results.

The survey was commissioned by the Nature Conservancy Council 'to determine the abundance of the main wildlife habitats in lowland Scotland and to estimate the extent of the changes which have occurred over the last 30 years'. The work was carried out at the Department of Forestry and Natural Resources, Edinburgh University, by the following team:-

Ian Langdale-Brown	- Organisation and Supervisor
George Jolly	- Statistical Design
Jackie Muscott	- Computing Supervisor
Susan Jennings	- Computing and Air Photo Interpretation
Carol Crawford	- Air Photo Interpretation

Towards the end of the project (Autumn 1980) two more members were added to the team to help complete the photo-interpretation.

The study area; Lowland Agricultural Scotland was defined using the last Ordnance Survey (OS) 1 inch to 1 mile series, as that area below the extensive moorland boundary. The original remit had been 'land below the 1000 foot contour' but moorland was found to extend below this level.

The method chosen as most appropriate was a comparative air-photograph technique. There is complete aerial coverage of Scotland for the immediate post-war years, flown by the RAF as a training exercise. This was compared with more recent aerial photographs, mostly taken by the Ordnance Survey for purposes of map updating.

For reasons of time and economy only a sample of this cover was examined. Strict sampling techniques were adopted. Randomisation was a prerequisite for the statistical tests used to determine the precision of sample estimates. In the event the volume of data needed to achieve acceptable precision was so great that computer packages were used for its analysis.

Habitats on the air photographs were classified into fourteen types and changes between the two dates of photography assertained.

A fuller account of the methods used is to be found in the report of Survey to the Nature Conservancy Council entitled 'Lowland Habitats (Scotland) Air-Photo Analysis of Change' by Langdale-Brown, Jennings, Crawford, Jolly and Muscott (1980).

2.2 SELECTION OF AIR PHOTOGRAPHS

The quality and availability of the RAF cover was checked in a preliminary survey - Garwood (1978). At the same time the extent of recent Ordnance Survey Cover was determined. The former was found to be adequate but as the work progressed it was found necessary to supplement the recent Ordnance Survey coverage with photographs flown by commercial companies.

A 10% sample of the survey area was used. This percentage was found adequate after a pilot study of Berwickshire in which the reliability of the results generated by 20% and 10% samples was compared.

The survey area was stratified, strata being the lowland agricultural area of each local authority District. The sample from each stratum was taken in two stages. The first stage sampling units were the recent sorties. Sorties are blocks of photographic cover flown at different dates between 1965 and 1979. The sorties were selected on the basis of those which together gave optimum cover of a District. Where possible the most recent sorties were chosen to give a longer interval in which to estimate the changes. Smaller sorties were avoided for they were often flown to update specific features such as new road alignment.

The total lowland agricultural area of a District was estimated from the OS 1 inch: 1 mile maps.

The second stage units were the photographic frames. To enable the photographs to be interpreted stereoscopically, two adjoining prints were acquired to achieve the necessary overlap. A minimum of three such triads were chosen from each sortie. Their selection was further refined by dividing each primary unit (sortie) into sets of 100 consecutive frames and selecting the same proportion from each.

A useable sample frame contained less than one-third of another sample frame, of another District, or sea, or of extensive moorland, or a combination of these.

The best matching early frame was selected from the 1946-1956 RAF cover housed in the Scottish Development Department Air Photograph Library, with its adjoining two prints. The secondary sample units then were actually the common area on recent and early sample frames. Due to differences in scale and orientation they were rarely completely coincident.

2.3 HABITAT CLASSIFICATION

The Nature Conservancy Council initially proposed the following list of 13 habitat types:

1) Deciduous woodland
2) Mixed (coniferous and deciduous) woodland
3) Scrub
4) Hedges (with or without trees)
5) Dwarf shrub heath

6) Permanent grassland
7) Wetland (bog and fen)
8) Open water (including impoundments)
9) Salt-marsh
10) Dune and dune slack
11) Improved grassland (leys)
12) Arable land
13) Non-agricultural land (including land occupied by buildings, mineral workings, roads, etc.)

These were tested out in the pilot study of Berwickshire and certain revisons made.

Coniferous woodland was found to be an important sub-type and a separate category was created for it. It was also necessary to separate felled areas from the other woodland categories: in the early photographs it was impossible to tell which woodland type had been cleared and in the recent photographs what kinds of woodland, if any, such areas would be replanted with. The other new category was 'lines of trees'. It was felt that they were different in nature to hedges and that as landscape features they were frequent enough to warrant a separate category.

There was much confusion over the grassland types. Even in the field it was often difficult to distinguish permanent grassland from improved grassland. These problems were mostly solved by defining these types very carefully. The improved grassland type was modified to eliminate leys. Because leys have been completely reseeded they are closer in nature to, and very difficult to distinguish from, arable land on aerial photographs. These problems are discussed more fully in Chapter Four of the report.

This revised classification ensured that habitats of greater conservation interest were separated from those of less interest e.g. permanent grassland has never been altered by management whereas surface draining or cutting is possible on improved grassland, which does not alter the habitat as drastically as the ploughing and reseeding of the ley. Every area of the photograph can be assigned to one of the following habitat classes on the basis of characteristics visible on the photographs.

1) Deciduous Woodland
2) Coniferous Woodland
3) Mixed Woodland
4) Felled Areas
5) Scrub
6) Dwarf Shrub Heath
7) Permanent unimproved grassland
8) Improved rough grassland
9) Wetland
10) Open Water
11) Agricultural Land
12) Non-Agricultural Land
13) Hedges
14) Tree Lines

The definition of these habitat types and description of their characters follows. Colour prints and sample air photographs are provided, as detailed below, to help illustrate the classes. A fuller description of photographic characters is to be found in the report cited above.

1 <u>Deciduous Woodland</u> (Figures 2,6)
Habitat dominated by deciduous trees, coniferous trees constituting less than 25% of the canopy. May be of mixed age with open or closed canopy. Found in lower areas, in gullies or on steep slopes.

2 <u>Coniferous Woodland</u> (Figures 3,24)
Usually an even-aged block dominated by coniferous trees planted in rows. Here broadleaf trees contribute less than 25% of crown area. Continuous canopy, except with young plantations. Generally found in higher situations. Includes some young plantations whose constitution is uncertain.

3 <u>Mixed Woodland</u> (Figures 2,24)
Communities dominated by a mixture of deciduous or broad leaved trees each contributing more than 25% to the crown cover. Mixed age, open or closed canopy and in lower lying locations.

Figure 1: View of the lowlands. A composition of agricultural land; woodland and hedge; and settlement - from the uplands. (Perthshire from the Ochil Hills, December).

Figure 2: Deciduous woodland. Bluebells (Hyacinthoides non-scripta) can be used as an indication of a site which has been continuously wooded. (Dalkeith Estate, Midlothian, May).

Figure 3: Coniferous woodland. At this Sitka spruce (Picea sitchensis) plantation, the denseness of the canopy has led to the exclusion of most other plants except a few mosses and lichens. The accumulating litter may be a contributory factor. (Bush Estate, Midlothian, July).

Figure 4: Mixed woodland, open water. A mixture of coniferous and deciduous trees borders an ornamental lake. (Penicuik Estate, Midlothian, May).

4 Felled Areas (Figures 5,24)

Areas cleared of woodland whose origins and future are uncertain. Usually composed of grassland-type vegetation, dwarf-shrub heath or scrub together with dead wood. Often located next to woodland.

5 Scrub (Figures 6,8,9)

Medium height vegetation consisting of bushes, shrubs and occasional trees which may be interspersed with grassland. The density of this woody vegetation varies from continuous thicket to dispersed bushes. Common species are *Ulex europeus*, *Cytisus scoparius*, *Rubus fruticosus*, *Crataegus monogyna* and young *Betula pendula* or *B. pubescens*. Located on knolls, in gullies, on felled areas left to regenerate, and on wasteland. Commonly forms mosaics with grassland or associated with woodland.

6 Dwarf Shrub Heath (Figure 7)

Low-medium vegetation dominated by *Calluna*, *Empetrum*, *Erica* and *Vaccinium* species with mosses and lichens. Often interspersed with grassland. Found near moorland and on abandoned lands.

7 Permanent Unimproved Grassland (Figure 8)

Grassland with no signs of improvement:- surface treatments, drainage or agricultural activities. Located on remote, inaccessible areas such as hill tops and slopes of gullies where topography prevents the use of farm machinery. Often associated with scrub or dwarf shrub heath. Sheep may be present.

8 Improved Rough Grassland (Figures 8,9,10)

Grassland communities with some 'improvement' such as drainage or mowing but not recent ploughing or reseeding. Drainage lines, walls and animal tracks may be discernable. Found in less remote situations with gentler topography and better access than unimproved grassland.

9 Wetland (Figures 9,10)

Variable habitat; blanket bog, fen, flush, moss, marsh and carr. Areas which are seasonally or permanently waterlogged. With wetland flora. Found in depressions and other low lying land. May be interspersed with open water.

Figure 5: Felled area. In this clear felled area, coarser species such as Rose-bay willow -herb (Epilobium augustifolium) and bramble (Rubus fructicosus) are predominant. Rabbit-proof fencing has been erected in the foreground preparatory to the next planting. (Dalmeny Estate, Edinburgh District, November).

Figure 6; Scrub/woodland network. Areas of woodland, hedges, tree-lines and scrub. The scrub growing on the knoll in the centre of the picture was much frequented by livestock. (near Gatehouse of Fleet, Galloway, March).

Figure 7: <u>Dwarf Shrub Heath/Scrub/Grassland</u>. In the heathland/scrub area there are places where dwarf shrub heath predominates and in others a mosiac of the two types can be seen. (West Lothian).

Figure 8: <u>Grasslands</u>. On the far bank an area of improved rough grassland has been fenced off, probably preparatory to tree planting as on the near bank. The subsequent relief from grazing leads to a sharp distinction between it and the seeded pasture. Above the road other areas of rough grassland, possibly permanent grassland, can be seen together with scrub. (near Dundrennan, Galloway, March).

Figure 9: Improved Grassland/Scrub/Wetland. The area on either side of the stream is a mixture of these three types with grassland predominant. On the slopes scrub has spread, and in the valley leading off to the right, some trees had colonised the scrubland. The foreground area of rough grassland would be classified as non-agricultural land. (Ochiltree, West Lothian, July).

Figure 10: Wetland and Parkland. In the foreground is an area of Juncus dominated wetland which could be distinguished from an air photograph. The rest of the area illustrates parkland: pastureland and open woodland laid down by the 'improving landlords'. (Dalmeny Estate, Edinburgh District, November).

10 Open Water (Figures 4,8,24)

Ponds, lakes, reservoirs, rivers, streams and canals. In lowest situations, often separated from adjacent land by a bank.

11 Agricultural Land (Figures 6,8,11,13,24)

Land used intensively for arable crops or stock rearing including grass leys. Plough lines and tractor tracks may be visible. In fields bounded by walls, fences or hedges. Always occupies most of the flatland on the photographs.

12 Non-Agricultural Land (Figures 11,12,14)

Built up areas (housing and industry), roads, railway lines (and verges), mineral workings, urban and rural wasteland, parkland and recreation areas.

13 Hedges (Figures 6,13,25,26)

Shrub or tree species growing as a barrier between fields. May include mature trees. This category includes 'linear scrub', irregular lines or bushes along rivers, roads and railways.

14 Tree Lines (Figure 14)

Lines or trees along field,wood and road boundaries with no hedge beneath.

2.4 AIR-PHOTO INTERPRETATION PROCEDURE

The terms 'early' and 'recent' have been used throughout to denote the two dates of photography:

Early refers to 1946 - 1954 air survey.

Recent refers to 1965 - 1979 air survey.

First the air photographs were prepared. This involved:

a) delineation of the area common to the early and recent air photographs upon the recent photograph.

b) baselining - to aid stereovision.

c) scaling with the 6 inch: 1 mile or 1:10,000 Ordnance Survey maps, so that habitat areas can be measured accurately.

Following this photo-interpretation proceeded in the following stages:

1) Classification of each area on the recent aerial photographs into one of the twelve aerial classes described above. These areas were outlined with wax pencil, and the two linear classes (hedges and tree lines), were marked with a different coloured wax pencil.

Figure 11: Agricultural Land. The ripening grain crop is evident to the fore of this picture in a fairly typically sized East Lothian field. In the background open cast coal mining has commenced since the date of the last aerial photograph (1975). One randomly selected hedge which it was intended to survey lies beneath the spoil. (Adniston, East Lothian, June).

Figure 12: Non-agricultural Land. This is the site of an abandoned air field used in the war. The runway is still mostly unvegetated but some colonisation is occurring e.g. by stone crop (Sedum spp). (near Greendykes Farm, East Lothian, June).

Figure 13: Hedges and Agricultural Land. Hedges divide the fields in this area of farmland. Trees remain in hedgerows and even in the centre of the near field. (Ochiltree, West Lothian, August).

Figure 14: Roadside Tree-line. (near Ochiltree, West Lothian).

2) The interpreted recent photographs were then compared with the early photographs. Changes between the two were marked on the recent air photographs to avoid the problems of having two different scales.

An example of such interpreted photographs has been shown for an area near Gorebridge. (Figures 15A and 15B)

3) Checking of any 'problem' areas of the ground: There were some areas which could not be allocated to one of the habitat classes on the basis of aerial photo-interpretation. All of these areas were identified on the ground. The information gained was also used to improve the subsequent photo-interpretation.

4) The area of each habitat type on a photograph frame was estimated with a dot grid. A ten dots/centimetre grid was superimposed, the dots falling on each class counted, then multiplied up to scale giving the areas in hectares. The area of the largest habitat type on a frame (usually agriculture) was established by subtracting the total of the other areas from the total frame area. Hedge and tree-line lengths were estimated using a Map Measurer.

5) Changes were estimated in the same way, measurements being made on the recent photographs. They were recorded in a two-way table on the basis of:- From Habitat type X to Habitat type Y. Examples of data recording sheets are to be found in the report.

6) The data for the individual frames were then transferred to Sortie Summary Sheets. These facilitated the transfer of data to the punchcards by which the raw data is fed into the computer.

2.5 DATA PROCESSING

A computer package developed at the Rothamstead Experimental Station was employed to facilitate the manipulation of raw data. This is called Rothamstead General Survey Package (RGSP). Chapter 5 of the report gives more details of the package. Computer analysis of the data proceeded in four stages.

1) <u>Initial checking</u>
To ensure all the data from the primary and secondary sampling units (sorties and individual frames) were present.

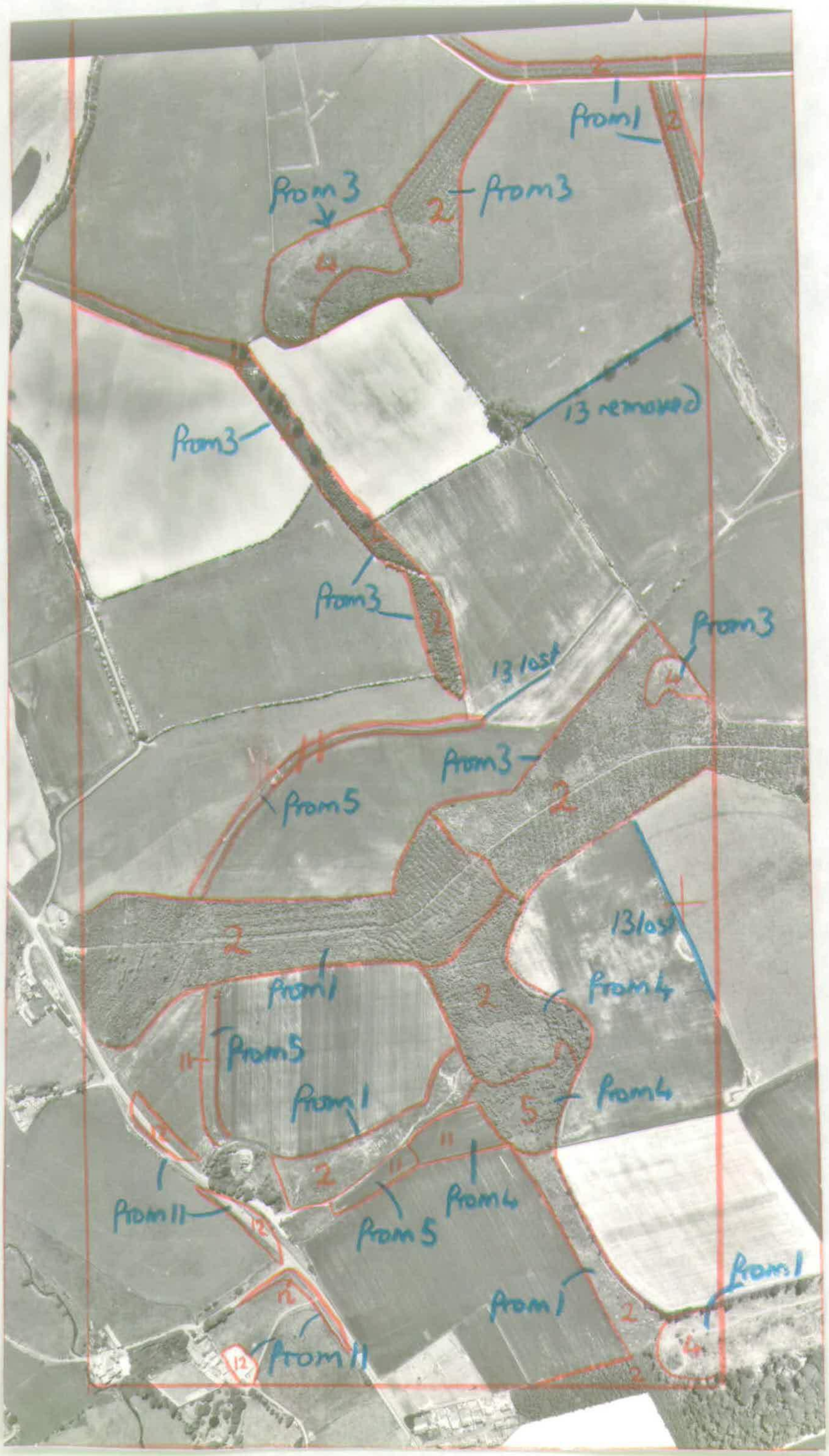

Figure 15A: Air photo-interpretation: Recent (1974). Areas which have undergone change since 1947 are marked in red with old type marked in blue.

Key: 1 = deciduous woodland, 2 = coniferous woodland, 3 = mixed woodland, 4 = felled areas, 5 = scrub, 11 = agricultural land, 12 = non-agricultural land, 13 = hedge. (near Gorebridge, Midlothian).

Figure 15B: Air photo-interpretation: Early (1947)
This portrays the habitats present in 1947.

Key as Figure 15A.

2) Generation of results

At the time of print selection the total area of each stratum (District) and of each sortie was estimated (using a ten dots per centimetre grid on maps of scale one inch: one mile). With the primary and secondary sampling fractions known, individual frame data was multiplied to give a District estimate. Values for the whole Region were calculated by combining the District totals. The estimates for each habit include:

i) Early and recent extent.
ii) Losses and gains in extent.
iii) Net changes.
All above are also expressed in relative terms.
iv) Breakdown of change: interchange of losses and gains.

3) Generation of Annual Changes

The spread of dates of the early photographs - 1945 to 1954 and of the recent photographs - 1965 to 1979 means that the actual time interval varies. In order to make change results more strictly comparable they have been expressed as average annual estimates. The annual extent of change was calculated separately for each secondary sampling unit. However it must be noted that the rate of change may not have been constant over the whole time interval.

4) Indication of statistical significance of results

Every result generated is an estimated mean. The statistical validity of the estimates is shown by the following information:

i) Variances (V): the sum of two kinds of variation in the raw data.
   (a) of sorties within strata and frames within sets of 100 frames
   (b) of frames

These can be used to predict what second stage sampling intensity is required. In the pilot study of Berwickshire variances were calculated for both 10% and 20% samples and the 10% sample was shown to be adequate.

ii) Standard error (SE) this shows the precision of the mean. It is equal to V

iii) 95% Confidence Limits (CLs) These show the reliability of the estimates i.e. probability is less than 5 in 100 that the true

value lies outwith this interval
95% CLs = Estimate ± 2SE
They assume an approximately normal distribution of the estimated mean.

The distributions of the individual gains or of the individual losses, which combine to make net change, are more likely to be skewed for both must by definition be positive. Alternative confidence limits are therefore calculated based on the assumption that the square root of the estimate is normally distributed.

$$\text{'Transformed Limits'} = \left(\sqrt{\text{estimate}} \pm \frac{\text{SE of estimate}}{\text{estimate}} \right)$$

CHAPTER 3 RESULTS

3.1 ORGANISATION OF RESULTS

Full copies of the computer print-out may be consulted at NCC headquarters. The survey covers all the Local Authority Regions south of the Highland fault line and all but the wholly urbanised Districts within them:-

BORDERS REGION	Berwick
	Roxburgh
	Ettrick and Lauderdale
	Tweeddale
LOTHIAN REGION	East Lothian
	Midlothian
	West Lothian
FIFE REGION	North East Fife
	Kirkcaldy
	Dunfermline
CENTRAL REGION	Falkirk and Clackmannan
	Stirling
DUMFRIES AND GALLOWAY REGION	Annandale and Eskdale
	Nithsdale
	Stewartry
	Wigtown
STRATHCLYDE REGION	Lanark
	Kyle and Carrick
	Cumnock and Doon Valley
	Cunninghame
	East Strathclyde
	West Strathclyde
TAYSIDE REGION	Perth and Kinross
	Angus

Regions north of Tayside were not surveyed because of time limitations. Urban Districts excluded were City of Dundee, City of Edinburgh, City of Glasgow, Bearsden and Milngavie. Clydebank, Dumbarton and Inverclyde had to be excluded because there was insufficient photographic cover.

The preceding list of Districts includes three combined Districts. The sampling criteria could not be met within the individual local authority Districts because they were too small. These are:

Falkirk and Clackmannan:	Falkirk District and Clackmannan District
East Strathclyde:	Strathkelvin, Cumbernauld and Kilsyth, Motherwell, Monklands and Hamilton Districts
West Strathclyde:	Renfrew, Eastwood, Kilmarnock and East Kilbride Districts

The computer print-out for each District or Region is presented in four sets:

Set 1) Hedge and Tree-line Results
2) Habitat Extents and their Net Change
3) Breakdown of Habitat Changes
4) Average Annual Changes

Every estimate is presented with four pieces of statistical information which are a guide to its statistical validity: Variance, Standard Error, and Upper and Lower 95% Confidence Limits (CL).

The NCC criterion for a net change was that it should be detectable with 95% statistical confidence i.e. that the 95% confidence interval should not include zero. A 'real change' is any change of more than 10% which meets the above criterion. The test habitats were scrub, permanent unimproved grassland and hedgerow.

A complete list of the tables in the print-out within each of the four sets follows:

Set 1 **HEDGES AND TREE LINES** (All lengths in Kilometres)

Table Number	
1	Early lengths of hedges and tree-lines
2	Recent lengths as % of early length
3	Recent length
4	Loss in length as % of early length
5	Loss in length
6	Gain in length as % of early length
7	Gain in length
8	Net change in length as % of early length
9	Net change in length
10	Annual loss in length as % of early length
11	Annual loss in length (km/yr)
12	Annual gain in length as % of early length
13	Annual gain in length (km/yr)
14	Annual net change in length as % of early length
15	Annual net change in length (km/yr)

Set 2 **HABITATS EXTENTS AND NET CHANGES** (Areas in hectares)

Table Number	
16	Early areas of habitat types as % of total LAA
17	Early areas of habitat types
18	Recent areas of types as % of LAA
19	Recent area of each type
20	Net change to each type as % of early area of that type
21	Net change to each type in area
22	Annual net changes in areas as % of early areas of types
23	Annual net change in areas (ha/yr)

Set 3 **BREAKDOWN OF HABITAT CHANGES**

Table Number	
24	Loss in area as % of early area
25	Gain in area as % of early years
26	Interchange: Two-way table of individual losses and gains to each habitat type expressed on basis of from Donor Type A to Recipient Type B. Includes total losses and gains in area of each type.

Set 4 AVERAGE ANNUAL CHANGES

Table Number	
27	Annual loss in area to each type as % of early area
28	Annual gain in area to each type as % of early area
29	Annual Interchange. As Table 26 but of annual individual losses and gains with totals for each in ha/yr.

To ease perusal of all the results in this thesis, the results have been condensed into tables which show the results of all the Districts and Regions together.

3.2 THE STATISTICAL RELIABILITY OF THE RESULTS

Every estimate in every table (listed in Section 3.1) of the computer print-out has been presented with four pieces of statistical information (detailed in Section 2.5) which can be used to indicate the reliability of that estimate. In order to reduce the presentation of these results to more manageable proportions only the 95% confidence limits have been used here to give a guide to the reliability of the estimates. These are the parameters within which the true result probably lies, i.e. one can have 95% confidence that the mean estimate lies within this interval. The width of this interval has been used to judge whether the result is reliable or not. Two classes of reliability have been recognised: 'more reliable' and 'less reliable'.

1) A 'more reliable' result is one where the difference between the upper and lower confidence limit is less than twice the estimated mean.
2) A 'less reliable' result is one where the difference between the upper and lower confidence limit is greater than or equal to twice the estimated mean. These are marked with an asterisk (*) throughout.

'Less reliable' results are discounted and not included in the discussion for the whole survey area. However if nearly all the results for a habitat type are 'less reliable' then they can be considered, as the results of the 10% sample area, to give a rough indication of changes to that habitat type in the whole survey area. More interest has been shown in estimated changes of greater than 10% in the discussion of the results.

Finally the statistical information was only presented for the Districts and Regions. The reliability of estimates for the whole survey area must be based on the estimated reliability of the District and Region results.

It is recognised that these criteria are arbitrary. However in view of the great mass of results involved they allow a fairly rapid assessment to be made of their reliability.

(N.B. The criterion used to indicate a 'more reliable' estimate is in effect the same criterion that was applied by NCC to define an 'acceptable' net change. An 'acceptable' net change was any 'real' net change (a 'real' change is any change of greater than 10 %) which could be detected with 95% statistical confidence i.e. for which the confidence interval did not include zero. To meet this criterion for a net gain the difference between the lower confidence limit and the estimate must be less than the estimate.)

There are two main reasons why a result will be deemed 'less reliable'. The first is that the raw data is over-variable. The second is that the sampling intensity was not sufficient to take account of all the variability. The results will be more reliable in Districts of larger area and with a large number of secondary sampling units. Table 1 presents this information. In the next section a comparison is made between the reliability of the results generated by two different sampling intensities.

3.2.1 Comparison of Results Generated by 10% and 20% Samples of Berwick

In the pilot study of Berwick two sampling intensities were used to determine an acceptable intensity of sampling for all the other Districts. The results generated by 10% and 20% samples of Berwick are presented here to show the effect of doubling the sampling density. On the basis of these results the 10% sampling density was selected.

Table 13A shows early and recent areas and areas of change generated by the two depths of sampling. Table 13B shows these same estimates for hedges and tree-lines. The tables show how the two sampling intensities do yield quite different estimates of the same attributes though all but one are of the same order of magnitude. With the estimates of net change

TABLE 1: Local Authority Districts or Regions, their areas, and sample frames for each

LOCAL AUTHORITY DISTRICT OR REGION	AREA OF DISTRICT OR REGION IN HECTARES	NUMBER OF SAMPLE FRAMES
Berwick	66930	35
Roxburgh	64356	31
Ettrick and Lauderdale	59323	29
Tweeddale	21744	10
BORDER REGION	212353	105
East Lothian	55167	21
Midlothian	28697	17
West Lothian	27239	13
LOTHIAN REGION	111103	51
North East Fife	73714	31
Kirkcaldy	25006	13
Dunfermline	28242	8
FIFE REGION	126962	52
Falkirk and Clackmannan	36263	16
Stirling	49053	22
CENTRAL REGION	85316	38
Annandale and Eskdale	63530	30
Nithsdale	67745	31
Stewartry	70747	28
Wigtown	73116	34
DUMFRIES AND GALLOWAY REGION	275138	123
Lanark	49198	31
Kyle and Carrick	57439	28
Cumnock and Doon Valley	30465	17
Cunninghame	28659	17
East Strathclyde	59851	35
West Strathclyde	86939	46
STRATHCLYDE REGION	312551	174
Perth and Kinross	145626	69
Angus	99720	48
TAYSIDE REGION	245346	117
Whole Survey Area	1368769	660

TABLE 13A: A comparison of areal results for Berwick District (in hectares) generated by 10% and 20% samples

Habitat	10% Sample Early Area	20% Sample Early Area	10% Sample Recent Area	20% Sample Recent Area	10% Sample Net Change	20% Sample Net Change
Deciduous Woodland	1917.1	1824.3	1454.4	1313.4	-462.6	-510.9
Coniferous Woodland	885.2	854.2	2125.8	2171.2	1240.6	1317.0
Mixed Woodland	1011.6	762.8	650.4	492.2	-361.2*	-270.5
Felled Areas	480.1	531.4	180.1	167.8	-300.0	-363.6
Scrub	739.0	701.4	730.9	655.0	- 8.1*	- 46.4*
Dwarf Shrub Heath	324.0	551.6	18.2*	64.0*	-305.8*	-487.6
Permanent Unimproved Grassland	913.1	1171.1	641.5	929.1	-271.7	-242.0
Improved Rough Grassland	2634.9	2693.3	2078.2	2116.2	-556.7	-577.1
Wetland	225.5	340.8	245.9	351.2	20.4*	10.4*
Open Water	178.7	142.4	174.6	136.1	- 4.9*	- 6.4*
Agricultural Land	54870.1	54726.6	55732.8	56050.6	862.7	1327.1
Non-Agricultural Land	2750.6	2633.1	2897.2	2483.2	146.6	-150.0*

TABLE 13B: A comparison of linear results for Berwick District (in kilometres) generated by 10% and 20% samples

Feature	10% Sample Early Length	20% Sample Early Length	10% Sample Recent Length	20% Sample Recent Length	10% Sample Net Change	20% Sample Net Change
Hedges	1794.8	1884.7	1410.0	1461.7	-384.8	-423.0
Tree-lines	570.0	490.0	357.1	330.3	-212.9*	-159.7

* Less reliable results

the direction of the change is the same in both 10% and 20% estimates except with the non-agricultural land where the estimates of net change are almost the same in terms of size but the 10% estimate is a net gain and the 20% one a net loss.

It can be seen that four of the 20% areal net change estimates are 'less reliable' compared with five of the 10% sample. Net changes in mixed woodland and dwarf shrub heath are now 'more reliable' but that in non-agricultural land is less reliable. The net change in tree-line length is also less reliable in the 20% sample results. This suggests that the 10% sample result did not represent net change to non-agricultural land and tree-lines. The other three less reliable estimates of scrub, wetland and open water from the 10% sample remain so at the 20% level. However these changes are less than 10% of the previous area and so less important.

A better idea of changes in precision induced by greater sampling intensities may be obtained by showing the width of the confidence intervals. In most instances the 20% results can be predicted within narrower limits than the 10%. Table 14A illustrates this for net changes. The difference between upper or lower confidence limit and the mean has been expressed as a percentage of the mean. It can be seen that in nine of the areal changes and both linear changes precision improves. One of the results in which this does not occur - wetland is less reliable, still and another is non-agricultural land, already mentioned above. In all the habitat extent results (not illustrated) there is an improvement in precision but these involve larger areas and are therefore less likely to be variable than net changes. This project was most concerned with change which is why the focus is on net changes in Table 14.

In summary, for Berwick, a doubling of the sampling intensity increases the number of more reliable results from eight to ten and reduces the width of the confidence interval by between 15% and 40% in eleven habitats. (There was a high improvement in scrub but this result is still

TABLE 14A: A comparison of the precision of areal estimates generated by 10% and 20% samples of Berwick, by comparing the width of their 95% confidence intervals

Habitat	10% Sample		20% Sample		% Change in CL %
	% Net Change	CL%	% Net Change	CL%	
Deciduous Woodland	-24.1	45	-28.0	53	-18
Coniferous Woodland	140.1	53	154.2	43	+19
Mixed Woodland	-35.7	112	-35.5	91	+19
Felled Areas	-62.5	83	-68.4	70	+16
Scrub	- 1.1	1480	- 6.6	222	+85
Dwarf Shrub Heath	-94.4	116	-88.4	71	+39
Permanent Unimproved Grassland	-29.8	95	-20.7	65	+32
Improved Rough Grassland	-21.1	98	-21.4	77	+21
Wetland	9.0	206	3.1	525	-155
Open Water	- 2.3	158	- 4.5	138	+13
Agricultural Land	1.6	78	2.4	50	+36
Non-Agricultural Land	5.3	93	- 5.7	315	-239

TABLE 14B: A comparison of the precision of linear results generated by 10% and 20% samples of Berwick, by comparing the width of their 95% confidence intervals

Feature	10% Sample		20% Sample		% Change in CL %
	% Net Change	CL%	% Net Change	CL%	
Hedges	-21.4	27	-22.4	22	+19
Tree-line	-37.4	115	-35.6	67	+42

$$CL\% = \frac{\text{Upper 95\% confidence limit - estimate}}{\text{estimate}} \%$$

not very reliable). Thus a doubling of the sampling intensity i.e. a doubling in cost of air photographs, and person hours would not have been compensated by a commensurate degree of precision.

3.3 HEDGE AND TREE-LINE RESULTS

Estimates for hedge and tree-line lengths and changes in length have been shown in Tables 2 to 7. Less reliable results are marked with an asterisk*.

3.3.1 Reliability of Hedge and Tree-Line Results

As Table 2 shows all hedge results except for the net change in Tweeddale can be detected with 95% statistical confidence. This net change is less than 10% and so less serious. Estimates for net changes in tree-line length are less reliable in five Districts. The sources of the unreliability have been further explored in Table 3 which gives the confidence intervals for the individual gains and losses which make up net change.

TABLE 3 Confidence Limits for Estimates of Losses, Gains and Net Changes in Hedge and Tree-Line Lengths where Net Change cannot be detected with 95% statistical confidence (kilometres)

DISTRICT AND NET CHANGE	LOSS, CONFIDENCE INTERVAL (km)	GAIN, CONFIDENCE INTERVAL (km)	NET CHANGE CONFIDENCE INTERVAL (km)
Tweeddale HEDGE	15.5-(30.0)-49.2	5.1-(21.6)-49.4*	-38.2-(-8.4)-21.3
Berwick TREE-LINE	38.3-(212.9)-528.9*	0.0	-458.2-(-212.9)-32.4
Midlothian TREE-LINE	2.1-(17.7)-48.7	0.0-(1.9)-7.7*	-39.4-(15.8)-7.8
Kirkcaldy TREE-LINE	4.1-(44.0)-126.3*	0.0	-105.1-(-44.0)-17.1
Wigtown TREE-LINE	2.1-(10.5)-25.4*	0.0	-22.2-(-10.5)-1.2
East Strathclyde TREE-LINE	10.6-(25.9)-48.0	1.0-(7.6)-20.2*	-39.7-(-18.3)-3.0

TABLE 2A Early and Recent Hedge Lengths (kilometers) and Net Change as a Percentage of Early Length.

Local Authority District or Region	Early Length (km) (EL)	Recent Length (km)	Net change as % of EL
Berwick	1794.8	1410.0	- 21.4
Roxburgh	1133.6	882.7	- 22.1
Ettrick and Lauderdale	990.0	794.6	- 19.7
Tweeddale	175.0	166.6	- 4.8*
BORDERS	4093.4	3253.9	- 20.5
East Lothian	1337.9	1042.2	- 22.1
Midlothian	327.9	283.1	- 13.6
West Lothian	565.2	514.6	- 8.9
LOTHIAN	2231	1839.9	- 17.5
NorthEast Fife	853.5	528.1	- 38.1
Kirkcaldy	471.8	307.4	- 34.8
Dunfermline	640.2	491.5	- 23.2
FIFE	1965.5	1327.0	- 32.5
Falkirk and Clackmannan	794.3	508.9	- 35.9
Stirling	963.8	669.8	- 30.5
CENTRAL	1758.1	1178.7	- 33.0
Annandale and Eskdale	2543.1	1942.0	- 23.6
Nithsdale	1284.1	1001.4	- 22.0
Stewartry	1299.9	1002.0	- 22.9
Wigtown	1812.9	1393.4	- 23.1
DUMFRIES AND GALLOWAY	6940.0	5338.8	- 23.1
Lanark	705.2	523.0	- 25.8
Kyle and Carrick	2095.9	1695.0	- 19.1
Cumnock and Doon Valley	900.9	745.1	- 17.3
Cunninghame	1071.7	936.8	- 12.6
East Strathclyde	1810.6	1329.1	- 26.6
West Strathclyde	2701.7	2096.4	- 22.4
STRATHCLYDE	9286.0	7325.4	- 21.1
Perth and Kinross	1517.8	1129.1	- 25.6
Angus	676.8	435.5	- 35.6
TAYSIDE	2194.6	1564.6	- 28.7
WHOLE SURVEY AREA	28468.6	21828.3	- 23.3

Tweeddale District is unusual in having a fairly large hedge gain as well as a loss but the confidence limits for the gain are much wider than those for the loss and it must be there that the variability lies. This result is now discounted. There are two reasons for the unreliability of tree-line estimates. In Berwick, Kirkcaldy and Wigtown where there have been only losses in hedge length, the losses must be inherently variable. In Midlothian and East Strathclyde there have been both losses and gains. The gains are more unreliable in nature as a whole than the losses and the combination of the losses and gains will lead to a very unreliable estimate of net change.

In Table 4 the net changes in tree-line length have been calculated again for Regions excluding the above unreliable estimates. Exclusion of Tweeddale from the hedge results would alter the net loss in the Borders by only a half percent and would not alter the results in the whole survey area at all.

TABLE 4 Estimates for Net Change in Tree-Line Length as a percentage of early Tree-Line Length (EL) for Regions and for the whole Survey Area excluding the unreliable data in Table 3

LOCAL AUTHORITY REGION	NET CHANGE AS % OF EL
Borders	- 18.9
Lothian	- 11.2
Fife	- 21.5
Central	- 21.0
Dumfries and Galloway	- 19.1
Strathclyde	- 7.1
Tayside	- 10.4
Whole Area	- 14.4

Generally the Regional estimates have narrower confidence intervals than the District estimates. To illustrate this, the confidence limits for one set of data: net changes in hedge length, have been set down in Table 5. This is likely to be the most variable data set presented, in view of the combination of positive and negative elements, but it is also the data set of most interest. The confidence interval has been expressed firstly as a percentage of the early area and secondly in order to make the results comparable, as a percentage of that estimate of net change.

TABLE 5: 95% Confidence Limits (CLs) for Net Change in Hedge Length expressed as a Percentage of Early Hedge Length (EL) and of the Estimate of Net Change

Local Authority District or Region	Net Change and C.Ls as % of EL	Confidence Interval as % of EL	Confidence Interval as % of Estimate
Berwick	-27.1-(-21.4)-(-15.7)	6.4	30
Roxburgh	-29.2-(-22.1)-(-15.1)	7.1	32
Ettrick and Lauderdale	-32.8-(-19.7)-(- 6.6)	13.1	66
Tweeddale	-21.8-(- 4.8)- 12.2	17.1	356
BORDERS	-25.0-(-20.5)-(-16.0)	4.5	18
East Lothian	-36.7-(-22.1)-(- 7.5)	14.6	66
Midlothian	-23.4-(-13.6)-(- 3.8)	9.8	72
West Lothian	-12.5-(- 8.9)-(- 5.4)	3.5	39
LOTHIAN	-26.4-(-17.5)-(- 8.6)	8.9	51
North East Fife	-56.8-(-38.1)-(-24.4)	13.7	36
Kirkcaldy	-69.0-(-34.8)-(- 0.6)	34.2	98
Dunfermline	-36.1-(-23.2)-(-10.3)	12.9	56
FIFE	-21.5-(-32.5)-(-43.4)	11.0	34
Falkirk and Clackmannan	-51.4-(-35.9)-(-20.4)	15.5	43
Stirling	-40.6-(-30.5)-(-20.3)	10.2	33
CENTRAL	-41.9-(-33.0)-(-24.0)	9.0	27
Annandale and Eskdale	-30.3-(-23.6)-(-16.9)	6.7	28
Nithsdale	-29.3-(-22.0)-(-14.7)	7.3	33
Stewartry	-31.2-(22.9)-(-14.6)	8.4	37
Wigtown	-30.9-(-23.1)-(-15.4)	7.8	34
DUMFRIES AND GALLOWAY	-26.8-(-23.1)-(-19.3)	3.8	16
Lanark	-37 -(-25.8)-(-14.7)	11.2	43
Kyle and Carrick	-24.1-(-19.1)-(-14.1)	5.0	26
Cumnock and Doon Valley	-24.3-(-17.3)-(-10.3)	7.0	40
Cunninghame	-15.8-(-12.6)-(- 9.3)	3.3	26
East Strathclyde	-34.1-(-26.6)-(-19.1)	7.5	28
West Strathclyde	-27.1-(-22.4)-(-17.6)	4.8	21
STRATHCLYDE	-23.7-(-21.1)-(-18.5)	2.6	12.3
Perth and Kinross	-35.4-(-25.6)-(-15.8)	9.8	38
Angus	-47.2-(-35.6)-(-24.1)	11.6	33
TAYSIDE	-36.4-(-28.7)-(-21.0)	7.7	27

In every Region but Lothian the 95% confidence interval is narrower than any of the District intervals. One can state with some confidence that the percentage of hedgerow removal over the study period lies between 20% and 27%.

From this table it can be also deducted that the data for Lothian is the least reliable and that the data for Strathclyde is most reliable. The most unreliable District after Tweeddale is Kirkcakdy with West Strathclyde results best. There is some variation in reliability within Regions, as might be expected, notably in Fife and Lothian. On the whole the data seems fairly reliable.

Tree-line results are more variable and less reliable than the hedge data. This is already apparent in that five Districts estimates of net change are less reliable compared to only one of the hedge estimates. Table 6 shows the confidence intervals for the seven Regions. These are always wider than the corresponding hedge results. The confidence intervals for the Districts in the most reliable Region, Strathclyde, are also shown to demonstrate their variability. The true value of net change in tree-line length for the whole survey area probably lies between -12% and -20%.

3.3.2 The Hedge Results

The most obvious deduction to be made from Table 2A is that in every District or Region there has been a reduction in hedge length. Present hedge lengths in the whole lowland area are estimated to be only three-quarters the length in the early post-war periods. There is however much variation in the proportion of loss, between Districts and Regions. Of the Regions, Lothians has lost least: 17.5% and Central and Fife most: 33%. The Districts range of loss is from 9% in West Lothian to 38% in North-East Fife.

Also on Table 2A it can be seen that Strathclyde has the greatest length of hedges at both dates of photography and Central Region has least. Of Districts Tweeddale supports least and West Strathclyde most.

TABLE 6: 95% Confidence Limits (CLs) for Net Change in Tree-line Length expressed as a percentage of Early Tree-line Length (EL) and of the Estimate of Net Change, for all Regions and the Strathclyde Districts

LOCAL AUTHORITY DISTRICT OR REGION	NET CHANGE AND CLs AS % OF EL	CONFIDENCE INTERVAL AS % OF EL	CONFIDENCE INTERVAL AS % OF ESTIMATE
BORDERS	-43.5 - (-26.0) - (- 8.6)	± 17.5	± 67
LOTHIAN	-17.5 - (-11.5) - (- 5.5)	± 6.0	± 52
FIFE	-34.6 - (-23.8) - (-13.1)	± 10.8	± 45
CENTRAL	-27.4 - (-21.0) - (-14.6)	± 6.4	± 30
DUMFRIES & GALLOWAY	-24.1 - (-17.5) - (-10.9)	± 6.6	± 38
Lanark	-17.0 - (-11.6) - 6.1	± 5.5	± 47
Kyle & Carrick	-14.4 - (- 9.2) - 4.0	± 5.2	± 56
Cumnock & Doon Valley	-12.7 - (- 9.1) - 5.5	± 3.6	± 40
Cunninghame	- 5.7 - (- 3.4) - (- 1.0)	± 2.3	± 68
East Strathclyde	-16.0 - (- 7.4) - 1.2	± 8.6	±116
West Strathclyde	- 4.8 - (- 3.6) - (- 2.3)	± 1.3	± 36
STRATHCLYDE	- 9.0 - (- 7.1) - (- 5.2)	± 1.9	± 27
TAYSIDE	-14.7 - (-10.4) - (- 6.1)	± 4.3	± 41

West Strathclyde in fact supports more hedgerow than the whole of Lothian, Fife, Central and Tayside Regions put together. Table 7A shows the lengths of net change. Overall there was a net loss of 6440km. There was again great variation in losses between Regions and Districts. The greatest hedge length loss was in Strathclyde, not surprisingly as it has the greatest initial length and the least length lost was in Lothian: one of the Regions with the lowest initial length. Of Districts, West Strathclyde (again with the greatest length of hedges) has lost most. This is greater than the total length of hedgerow in some Districts e.g. in West Lothian and Kirkcaldy. The smallest length lost was in Midlothian, which had the second lowest initial hedge length.

However, it is perhaps meaningless to consider the lengths of hedgerow loss in this way. They are very likely to be influenced by the size of the District or Region. The largest and smallest Regions, Strathclyde and Central, support the greatest and least length of hedgerow respectively. A large length of hedge loss does not mean a large proportion of hedge lost e.g. in Strathclyde the proportion of loss is less than average. Similarly in Central there is one of the lowest lengths of hedge loss but this a third of the early length; the largest proportion of hedge loss.

It is more meaningful to consider the density of hedges in a Region and to compare the losses to this. Baird and Tarrant (1973) in their study of hedgerow removal in Norfolk suggests that the greatest losses occur in areas with smaller fields and a greater initial density of hedges, where there would be greater necessity for boundary removal preliminary to field rationalisation. District hedgerow densities have been presented in Table 8A to test the hypothesis for Lowland Scotland.

Strathclyde Region has in fact the greatest hedge density at both dates in addition to the greatest hedge length, despite having the largest area. This was almost 30m/ha at the early period and is now 23.5m/ha.

TABLE 7A Losses, Gains and Net Change in Hedge Length over Study Period in kilometres

Local Authority District or Region	Net Change (km)	Loss in Length(km)	Gain in Length (km)
Berwick	- 384.8	384.8	0.0
Roxburgh	- 250.9	250.9	0.0
Ettrick and Lauderdale	- 195.4	195.4	0.0
Tweeddale	- 8.4*	30.0	21.6
BORDERS	- 839.5	861.1	21.6
East Lothian	- 295.7	295.7	0.0
Midlothian	- 44.7	44.7	0.0
West Lothian	- 50.5	58.2	7.7
LOTHIAN	- 390.9	398.6	7.7
North East Fife	- 325.4	355.9	30.5
Kirkcaldy	- 164.4	166.2	1.8
Dunfermline	- 148.7	163.6	14.9
FIFE	- 638.5	685.7	47.2
Falkirk and Clackmannon	- 285.4	300.6	15.2
Stirling	- 293.9	293.9	0.0
CENTRAL	- 579.3	594.5	15.2
Annandale and Eskdale	- 601.1	607.6	6.5
Nithsdale	- 282.8	282.8	0.0
Stewartry	- 297.9	297.9	0.0
Wigtown	- 419.5	439.6	20.1
DUMFRIES AND GALLOWAY	-1601.3	1627.9	26.6
Lanark	- 182.3	187.4	5.1
Kyle and Carrick	- 400.9	400.9	0.0
Cumnock and Doon Valley	- 155.8	156.3	0.4
Cunninghame	- 134.9	138.1	3.2
East Strathclyde	- 481.5	485.1	3.6
West Strathclyde	- 605.4	605.4	0.0
STRATHCLYDE	-1960.8	1973.2	12.3
Perth and Kinross	- 388.6	397.7	9.1
Angus	- 241.2	243.6	2.3
TAYSIDE	- 629.8	641.3	11.4
WHOLE SURVEY AREA	-6640.1	6782.3	142.0

TABLE 8A Early and Recent Hedgerow Densities and Net change in Density in Metres per hectare

Local Authority District or Region	Early Length x 1000 area m/ha	Recent Length x 1000 Area m/ha	Net change in density m/ha
Berwick	26.8	21.1	- 5.7
Roxburgh	17.6	13.7	- 3.9
Ettrick and Lauderdale	16.7	13.4	- 3.3
Tweeddale	8.1	7.7	- 0.4
BORDERS	19.3	15.3	- 4.0
East Lothian	24.3	18.9	- 5.4
Midlothian	11.4	9.9	- 1.5
West Lothian	20.8	18.9	- 1.9
LOTHIAN	20.1	16.6	- 3.5
North East Fife	11.6	7.2	- 4.4
Kirkcaldy	18.9	12.3	- 6.6
Dunfermline	22.7	17.4	- 5.3
FIFE	15.5	10.4	- 5.1
Falkirk and Clackmannan	21.9	14.0	- 7.9
Stirling	19.6	13.5	- 6.0
CENTRAL	20.6	13.8	- 6.8
Annandale and Eskdale	40.0	30.6	- 9.4
Nithsdale	19.0	14.8	- 4.2
Stewartry	18.4	14.2	- 4.2
Wigtown	24.8	19.1	- 5.7
DUMFRIES AND GALLOWAY	25.2	19.4	- 5.8
Lanark	1.4	1.1	- 0.3
Kyle and Carrick	36.5	29.5	- 7.0
Cumnock and Doon Valley	29.6	24.5	- 5.1
Cunninghame	37.4	32.7	- 4.7
East Strathclyde	30.2	22.2	- 8.0
West Strathclyde	31.1	24.1	- 7.0
STRATHCLYDE	29.7	23.4	- 6.3
Perth andKinross	10.4	7.7	- 2.7
Angus	6.8	4.4	- 2.4
TAYSIDE	8.9	6.4	- 2.5
WHOLE SURVEY AREA	20.8	15.9	- 4.9

Tayside Region with one of the lowest lengths, has the lowest density at both dates from 9m/ha to 6.5m/ha. The density of hedges in Strathclyde was almost three times that in Tayside. The mean density for the whole survey area was 21m/ha. The range of densities for Districts was even wider. The District densest in hedges (Annandale and Eskdale; 40m/ha) has 30 times more than the least (Lanark 1.5m/ha). Annandale and Eskdale has also one of the longest lengths of hedgerow in the early period and Lanark least: 1.4m/ha with one of the shortest lengths and more recently the mean density fell to 16m/ha, Cunninghame with the most: 33m/ha and Lanark still with least: 1m/ha.

The relationships between hedgerow length and density are further explored in Table 9. The two Regions with the greatest density of hedges have also the greatest length (Dumfries and Galloway and Strathclyde) and those two Regions with the lowest density, Fife and Tayside, are amongst those with the lowest length. Such relationships may reflect differences in agricultural practice. In more northern Regions stone walls may be more common, or the land may be flatter with greater scope for large fields. In the two western Regions there is a greater proportion of land under grass and stock-rearing than in the east and hedges may still have some function.

These relationships hold many of the Districts too. All but one of the Districts with longer than average hedgerow length have also a great hedge density. Only in Perth and Kinross may the long length of hedgerow be attributed to the size of the Districts, it being the largest District. However only half the Districts with a low hedge length have also a low density of hedges: Tweeddale, Midlothian, North-East Fife, Lanark and Angus. The other four have a more average density. Some Regions and Districts are more average in these respects e.g. Border Region and Stewartry District.

Finally to test the hypothesis that the greatest proportions of hedgerow removal occur where there was the greatest initial hedgerow density, the early densities of the Table 8A must be compared with the present net change of Table 7. These comparisons are also summarised in Table 9. The evidence here appears to negate the hypothesis. The two Districts with the greatest proportion of hedgerow removal,

TABLE 9: Summary of the Hedgerow Length, Density and Net Change % in the Local Authority Districts and Regions

Size Data Set	Greater than Average	Average	Less than Average
REGIONS: Early Hedge Length	Dumfries & Galloway Strathclyde	Borders	Lothian Fife Central Tayside
REGIONS: Early Hedge Density	Dumfries & Galloway Strathclyde	Borders Lothian Central	Fife Tayside
REGIONS: Net Hedge Loss	Fife * Central Tayside *	Borders Dumfries & Galloway Strathclyde	Lothian
DISTRICTS: Early Hedge Length	Berwick Annandale & Eskdale Wigtown Kyle & Carrick East Strathclyde West Strathclyde Perth & Kinross	Roxburgh Ettrick & Lauderdale East Lothian Stirling Nithsdale Stewartry Cumnock & Doon Valley Cunninghame	Tweeddale Midlothian West Lothian North East Fife Kirkcaldy Dunfermline Falkirk & Clackmannan Lanark Angus
DISTRICTS: Early Hedge Density	Berwick East Lothian Annandale & Eskdale Wigtown Kyle & Carrick Cumnock & Doon Valley Cunninghame East Strathclyde West Strathclyde	West Lothian Kirkcaldy Dunfermline Falkirk & Clackmannan Stirling Nithsdale Stewartry	Roxburgh Ettrick & Lauderdale Tweeddale Midlothian North East Fife Lanark Perth & Kinross Angus
DISTRICTS: Net Hedge Loss	North East Fife * Kirkcaldy Falkirk & Clackmannan Stirling Lanark * Angus *	Berwick Roxburgh East Lothian Dunfermline Annandale & Eskdale Nithsdale Stewartry Wigtown West Strathclyde Perth & Kinross	Ettrick & Lauderdale (Tweeddale) Midlothian West Lothian Kyle & Carrick Cumnock & Doon Valley Cunninghame

* Hedgerow loss most critical due to low initial length and density of hedgerow

North-East Fife and Angus, are amongst the least dense as regards hedgerows. In fact, as Table 9 shows, none of the Districts with either a high initial hedge length or density have a high proportion of hedgerow removal. The six Districts with the highest proportion of hedge removal all have either an average or low density. As well as North-East Fife and Angus; Kirkcaldy, Falkirk and Clackmannan, Stirling and Lanark fall into this category. In those Districts with both short length and low density of hedgerows the changes are the most serious of all. The Districts where hedges appear safest, where there was high initial density and a low proportion of loss, are Kyle and Carrick, Cumnock and Doon Valley and Cunninghame. The rest of the District changes may be graded for seriousness, between the extremes, using Table 9.

Table 7A also shows the losses and gains which go to make up the net change. The gains are very small compared to the losses but occur in all Regions and many (14) Districts. Only in Tweeddale, discounted on grounds of unreliability, do the gains appear to be of the same order of magnitude. Elsewhere they never exceed 10% and for the whole survey area gains work out at only half a percent. This was probably gain due to the spread of linear scrub along disused railway lines, and at other non-agricultural sites. Gains then are for the most part insubstantial, not only far less than the losses but new habitats occurring in new places where they would not provide habitat for species displaced by hedgerow removal. Finally as Table 10 shows, the gains are mostly unreliable. The picture is very much one of losses.

The annual changes in hedgerow length in Table 11 puts the figure on a truly comparative basis but the picture is the same. The greatest annual loss occurs in Strathclyde - 80 kilometres per year, and the least in Lothians, 15 km/yr. West Strathclyde and Annandale and Eskdale are the Districts with the greatest annual loss in length: 25 km/yr and Midlothian and West Lothian have the lowest annual loss: 25 km/yr. Fife and Central Regions lose the greatest proportion, 1.8% and 1.7%/yr and the two Lothian Districts above and Cunninghame lose the lowest proportion. In the whole survey area 282 km/yr are lost which is exactly 1%/yr.

TABLE 10: Reliability of Gains in Hedge and Tree-Line Length

LOCAL AUTHORITY DISTRICT OR REGION	Gain in Hedge Length	Confidence Interval	Gain in Tree Length	Confidence Range
Ettrick & Lauderdale	-	-	0.8	0.0 - 3.2*
Tweeddale	21.6	5.1 - 49.4*	1.7	0.0 - 5.8*
BORDER	21.6	5.1 - 49.4*	2.5	0.3 - 6.9*
Midlothian	-	-	1.9	0.0 - 7.7*
West Lothian	7.7	2.3 - 16.5	2.3	0.5 - 5.4*
LOTHIAN	7.7	2.2 - 16.4	4.2	0.9 - 10.0*
North East Fife	30.6	15.0 - 51.5	-	-
Kirkcaldy	1.8	0.0 - 6.1*	-	-
Dunfermline	14.9	4.9 - 30.4	-	-
FIFE	47.3	27.4 - 72.3	-	-
Falkirk & Clackmannan	15.2	3.1 - 36.7*	4.6	0.8 - 11.7*
CENTRAL	15.2	3.0 - 36.6*	4.6	0.8 - 11.7*
Annandale & Eskdale	6.5	2.3 - 13.0	1.4	0.0 - 5.8*
Wigtown	20.1	2.0 - 56.9*	-	-
DUMFRIES & GALLOWAY	26.6	6.0 - 61.9*	1.4	0.0 - 5.8*
Lanark	5.1	1.0 - 12.5*	0.7	0.0 - 2.7*
Cumnock & Doon Valley	0.4	0.0 - 1.7*	1.7	0.0 - 6.3*
Cunninghame	3.2	0.3 - 8.9*	-	-
East Strathclyde	3.6	0.6 - 9.1*	7.6	1.0 - 20.2*
STRATHCLYDE	12.3	3.8 - 25.6	10.0	0.2 - 34.2*
Perth & Kinross	9.1	2.3 - 20.3	19.9	1.7 - 57.8*
Angus	2.3	0.4 - 5.9*	-	-
TAYSIDE	11.4	3.9 - 22.8	19.9	1.7 - 57.8*

* LESS RELIABLE RESULT

TABLE 11 Annual net changes in length in kilometres per year and as a percentage of the Early Length (EL) for Hedges and Tree lines.

Local Authority District or Region	Hedges Annual net change km/yr	Hedges Annual net change as % of EL	Tree-Line Annual net change km/yr	Tree-Line annual net changes as % of EL
Berwick	- 16.9	- 0.9	- 9.0*	- 1.6
Roxburgh	- 12.3	- 1.1	- 2.9	- 0.8
Ettrick and Lauderdale	- 7.6	- 0.8	- 2.8	- 0.8
Tweeddale	- 0.4*	- 0.2	- 1.6	- 0.9
BORDERS	- 37.2	- 0.9	-16.3	- 1.1
East Lothian	- 11.1	- 0.8	- 1.4	- 0.4
Midlothian	- 1.7	- 0.5	- 0.7*	- 0.6
West Lothian	- 1.9	- 0.3	- 1.1	- 0.6
LOTHIAN	- 14.7	- 0.7	- 3.2	- 0.5
North East Fife	- 15.4	- 1.8	- 5.2	- 1.0
Kirkcaldy	- 6.0	- 1.3	- 1.6*	- 1.3
Dunfermline	- 7.0	- 1.1	- 1.2	- 0.9
FIFE	- 28.4	- 1.4	- 8.0	- 1.1
Falkirk and Clackmannan	- 10.7	- 1.4	- 3.2	- 1.0
Stirling	- 14.0	- 1.4	- 4.1	- 0.8
CENTRAL	- 24.7	- 1.4	- 7.3	- 0.9
Annandale and Eskdale	- 25.8	- 1.0	- 1.8	- 0.7
Nithsdale	- 11.7	- 0.9	- 2.9	- 0.9
Stewartry	- 12.0	- 0.9	- 2.5	- 0.7
Wigtown	- 20.2	- 1.1	- 0.5*	- 0.3
DUMFRIES AND GALLOWAY	- 69.7	- 1.0	- 7.7	- 0.7
Lanark	- 7.3	- 1.0	- 1.8	- 0.5
Kyle and Carrick	- 16.6	- 0.8	- 1.0	- 0.4
Cumnock and Doon Valley	- 5.8	- 0.6	- 0.6	- 0.3
Cunninghame	- 5.7	- 0.5	- 0.1	- 0.1
East Strathclyde	- 19.7	- 1.1	- 1.0*	- 0.4
West Strathclyde	- 25.0	- 0.9	- 5.5	- 0.3
STRATHCLYDE	- 80.1	- 0.9	- 5.5	- 0.3
Perth and Kinross	- 16.2	- 1.1	- 3.6	- 0.4
Angus	- 11.2	- 1.7	- 2.2	- 0.5
TAYSIDE	- 27.4	- 1.2	- 5.8	- 0.4
WHOLE SURVEY AREA	-282.2	- 1.0	-53.8	- 0.7

3.3.3 Tree-Line Results

In Table 2B it can be seen that the overall length of tree-lines in a District is one quarter to one third that of the hedge length. In only one District does the early tree-line length exceed the initial hedge length and that is in Tweeddale where the data has already been identified as unusual and unreliable.

Strathclyde Region, as with hedgerows, supports the greatest length of tree-lines and Fife and Lothians least (see Table 12). Of Districts Perth and Kinross had most and Cunninghame least.

Using the corrected Regional estimates of net change in Table 4 it can be seen that there has been an overall net loss of just over 14%. This is almost 10% less than the net hedgerow loss. Strathclyde Region has lost the lowest proportions:- 7.1% and Fife Region most:- 22%.

With Districts, excluding the five less reliable Districts, the greatest loss occurs in Falkirk and Clackmannan: 27% and the lowest in Cunninghame: 13%.

As with the hedgerow situation there have been gains as well as losses in many Districts; these are shown in Table 7B. Again these are mostly fairly small (all less than 10% of the early length) and as can be seen from Table 10 every result is less reliable.

The overall net loss of tree-lines is over 1000km but this is only one sixth of the hedgerow net loss (Table 7B).

As with hedgerows, tree-line densities have been calculated for all Districts and these are shown in Table 8B. The early overall mean density of tree-lines is 5.7m/ha which is about one quarter that for hedgerows. The range of densities for Regions is from 4m/ha in Dumfries and Galloway to 10m/ha in Central Region. More recently the mean density for the whole survey area has fallen to 4.8m/ha with a range of 3m/ha to 8m/ha for the same Region as before. The early Districts range of densities is from 1.9m/ha to 10.4m/ha. More recently the range is 1.8m/ha to 8.6m/ha.

TABLE 2B Early and Recent Tree-line Lengths (Kilometres) and Net change as a percentage of Early Length (EL)

Local Authority District or Region	Early Length	Recent Length	Net Change as % of EL
Berwick	570.0	357.1	- 37.4*
Roxburgh	383.3	323.4	- 15.6
Ettrick and Lauderdale	341.2	271.5	- 20.4
Tweeddale	178.3	137.3	- 23.0
BORDERS	1472.8	1089.3	- 26.0
East Lothian	342.1	311.3	- 9.0
Midlothian	121.2	105.3	- 13.0*
West Lothian	184.7	156.6	- 15.2
LOTHIAN	648.0	573.2	- 11.5
North East Fife	496.7	388.0	- 21.9
Kirkcaldy	124.5	80.5	- 35.4*
Dunfermline	127.2	101.5	- 20.2
FIFE	748.4	570.0	- 23.8
Falkirk and Clackmannan	308.9	224.6	- 27.3
Stirling	510.4	422.6	- 17.2
CENTRAL	819.3	647.2	- 21.0
Annandale and Eskdale	253.0	215.7	- 14.7
Nithsdale	309.2	237.4	- 23.2
Stewartry	338.2	275.6	- 18.5
Wigtown	140.3	129.8	- 7.5*
DUMFRIES AND GALLOWAY	1040.7	858.5	- 17.5
Lanark	369.7	326.8	- 11.6
Kyle and Carrick	256.2	232.5	- 9.2
Cumnock and Doon Valley	188.5	171.4	- 9.1
Cunninghame	71.7	69.3	- 3.4
East Strathclyde	247.3	229.0	- 7.4*
West Strathclyde	653.8	630.5	- 3.6
STRATHCLYDE	1787.2	1659.5	- 7.1
Perth and Kinross	846.7	763.8	- 9.8
Angus	455.2	402.7	- 11.5
TAYSIDE	1301.9	1166.5	- 10.4
WHOLE SURVEY AREA	7818.3	6564.2	- 16.0

TABLE 7B Losses, Gains and Net Changes in Tree-line length over Study Period (kilometres).

Local Authority District or Region	Net Change (km)	Loss in Length(km)	Gain in Length(km)
Berwick	- 212.9*	212.9	0.0
Roxburgh	- 60.0	60.0	0.0
Ettrick and Lauderdale	- 69.6	70.5	0.8
Tweeddale	- 41.0	42.7	1.7
BORDERS	- 383.5	386.1	2.5
East Lothian	- 30.8	30.8	0.0
Midlothian	- 15.8*	17.7	1.9
West Lothian	- 28.1	30.4	2.3
LOTHIAN	- 74.7	78.9	4.2
North East Fife	- 108.7	108.7	0.0
Kirkcaldy	- 44.0*	44.0	0.0
Dunfermline	- 25.7	25.7	0.0
FIFE	- 178.4	178.4	0.0
Falkirk and Clackmannan	- 84.3	88.9	4.6
Stirling	- 87.8	87.8	0.0
CENTRAL	- 172.1	176.7	4.6
Annandale and Eskdale	- 37.3	38.6	1.4
Nithsdale	- 71.9	71.9	0.0
Stewartry	- 62.6	62.6	0.0
Wigtown	- 10.5*	10.5	0.0
DUMFRIES AND GALLOWAY	- 182.3	183.6	1.4
Lanark	- 42.8	43.5	0.7
Kyle and Carrick	- 23.7	23.7	0.0
Cumnock and Doon Valley	- 17.1	18.8	1.7
Cunninghame	- 2.4	2.4	0.0
East Strathclyde	- 18.3*	25.9	7.6
West Strathclyde	- 23.3	23.3	0.0
STRATHCLYDE	- 127.6	137.6	10.0
Perth and Kinross	- 82.9	102.8	19.9
Angus	- 52.5	52.5	0.0
TAYSIDE	- 135.4	155.3	19.9
WHOLE SURVEY AREA	-1254.0	1296.6	42.6

TABLE 8B Early and Recent Tree-live Densities and Net Changes in Density in metres per hectare.

Local Authority District or Region	Early length x 100 area m/ha	Recent Length x 1000 area m/ha	Net change in density m/ha
Berwick	8.05	5.3	-3.2
Roxburgh	6.0	5.0	-1.0
Ettrick and Lauderdale	5.8	4.6	-1.2
Tweeddale	8.2	6.3	-1.9
BORDERS	6.9	5.1	-1.8
East Lothian	6.2	5.6	-0.6
Midlothian	4.2	3.7	-0.5
West Lothian	6.8	5.8	-1.0
LOTHIAN	5.8	5.2	-0.6
North East Fife	6.7	5.3	-1.4
Kirkcaldy	5.0	3.2	-1.8
Dunfermline	4.5	3.6	-0.9
FIFE	5.9	4.5	-1.4
Falkirk and Clackmannan	8.5	6.2	-2.3
Stirling	10.4	8.6	-1.8
CENTRAL	9.6	7.6	-2.0
Annandale and Eskdale	4.0	3.4	-0.6
Nithsdale	4.6	3.5	-1.1
Stewartry	4.8	3.9	-0.9
Wigtown	1.9	1.8	-0.1
DUMFRIES AND GALLOWAY	3.8	3.1	-0.7
Lanark	7.5	6.6	-0.9
Kyle and Carrick	4.5	4.0	-0.5
Cumnock and Doon Valley	6.2	5.6	-0.6
Cunninghame	2.5	2.4	-0.1
East Strathclyde	4.1	3.8	-0.3
West Strathclyde	7.5	7.2	-0.3
STRATHCLYDE	5.7	5.3	-0.4
Perth and Kinross	5.8	5.2	-0.6
Angus	4.6	4.0	-0.6
TAYSIDE	5.3	4.8	-0.5
WHOLE SURVEY AREA	5.7	4.8	-0.9

If the initial tree-line densities are compared with the initial tree-line length, patterns are less clear cut than with the hedgerow results (see Table 12).

Relationships are also unclear between density and proportion of tree-lines loss. Of Regions, Borders has a high loss as well as high initial density and length, a situation which never occurred with hedges and Central has a high density and loss. Only Dunfermline District is as critically affected as some of the Districts were with hedgerow loss, and in East Strathclyde and Cunninghame tree-lines are safest.

If Tables 9 and 12 are compared it can be seen that all the Regions and most of the Districts with a high proportion of hedge loss had also a high proportion of tree-line loss.

Finally net annual change should be considered. In Table 11 it can be seen that the overall net annual loss in tree-lines is estimated at 54km/yr. This and the Regional estimates will be unreliable for reasons discussed in Section 3.3.1. It would have been too complicated to recalculate them, as % net change was recalculated in Table 4, because of the varying periods of photography. The net annual percent loss was 0.7%/yr; a lower rate than hedgerow loss (1%/yr). Of Districts the greatest reliable net annual loss was 1% in North-East Fife and Falkirk and Clackmannan. The lowest annual proportion of hedge loss was 0.1% in Cunninghame and West Strathclyde. North-East Fife and Cunninghame also lost the greatest proportion of their hedges annually.

3.4 AREAL HABITAT EXTENTS

3.4.1 Reliability of areal estimates

In Appendix 1 the total area of each habitat type is shown and the less reliable data marked. Regional areas are shown in Table 15. Of the early results the most unreliable of the twelve habitat types out of 24 Districts are:

TABLE 12: Summary of Tree-line Length, Density and Net Change % in the Local Authority Districts and Regions

	Greater than Average	Average	Less than Average
REGIONS: Early Tree-line Length	Borders Strathclyde	Dumfries & Galloway Tayside	Lothian Fife Central
REGIONS: Early Tree-line Density	Central Borders	Lothian Fife Strathclyde Tayside	Dumfries & Galloway
REGIONS: Net Tree-line Loss	Borders Fife Central	Dumfries & Galloway	Lothian Strathclyde Tayside
DISTRICTS: Early Tree-line Length	Berwick North East Fife Stirling West Strathclyde Perth & Kinross Angus	Ettrick & Lauderdale Roxburgh East Lothian Falkirk & Clackmannan Annandale & Eskdale Nithsdale Stewartry Lanark Kyle & Carrick	Tweeddale Midlothian West Lothian Kirkcaldy Dunfermline Wigtown Cumnock & Doon Valley Cunninghame East Strathclyde
DISTRICTS: Early Tree-line Density	Berwick Tweeddale West Lothian Falkirk and Clackmannan Stirling Lanark West Strathclyde	Roxburgh Ettrick & Lauderdale East Lothian North East Fife Kirkcaldy Nithsdale Stewartry Cumnock & Doon Valley Perth & Kinross Angus	Midlothian Dunfermline Annandale & Eskdale Wigtown Kyle & Carrick Cunninghame East Strathclyde
DISTRICTS: Net Tree-line Loss	(Berwick) Ettrick and Lauderdale Tweeddale North East Fife (Kirkcaldy) Dunfermline * Falkirk and Clackmannan Nithsdale	Roxburgh Midlothian West Lothian Stirling Stewartry Lanark Perth & Kinross Angus	East Lothian Annandale & Eskdale (Wigtown) Kyle & Carrick Cumnock & Doon Valley Cunninghame East Strathclyde West Strathclyde

* Tree-line loss most critical due to low initial length and density of tree-line

TABLE 15A: Early Areas of Habitat Types in each Region

Local Authority Region	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric.	Non-Agric.
BORDERS	7864.5	6057.8	3946.6	2182.2	1586.5	1090.4	1990.6	9802.3	1519.2	1522.8	161841.1	12948.2
LOTHIAN	7384.3	1400.8	2103.9	270.4	1178.5	445.9*	900.4	3836.1	680.5	413.6	83415.9	9072.7
FIFE	5471.8	2520.8	335.3	349.1	1557.7	790.2	1150.1*	7512.9	2020	799.2	94830.7	9624.3
CENTRAL	5557.1	1362.9	1376.1	1121.1	1009.4	218.9	2.7*	1403.3	1700.2	2366.2*	59322.0	9876.1
DUMFRIES & GALLOWAY	10529.9	7105.8	2157.7	2184.3	2946.7	437.8	565.5	10008.8	12066.6	2974.7	210582.0	13578.3
STRATHCLYDE	13109.0	3950.1	637.8	1687.7	3346.9	1091.5	10.2*	7018.3	10469.5	3357.6	225388.1	42483.9
TAYSIDE	14513.5	8410.1	1265.2	1775.2	2934.5	1895.3	0.0	4515.4	1321.2	2165.3	191690.3	14859.8
WHOLE SURVEY AREA	64430.1	30808.3	11822.6	9569.8	14560.2	5970.0	4619.5	44097.1	29777.2	13599.4	1027070.3	112443.3

* Less reliable estimate

TABLE 15B: Recent Areas of Habitat Types in each Region

Local Authority Region	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric.	Non-Agric.
BORDERS	6417.7	9521.3	3315.6	1631.4	1844.3	256.1	1443.6	8130.1	1592.5	1509.4	162304.2	14386.7
LOTHIAN	6257.0	2893.8	2269.7	747.5	1110.4	172.4*	857.8	2373.9	648.1	370.4	82362.6	11039.2
FIFE	3837.8	6499.7	871.3	998.5	1487.8	29.9	91.2*	4033.4	1784.4	735.2	93017.0	13575.9
CENTRAL	4672.4	2646.9	1311.8	975.6	1143.2	111.8	2.7*	1160.2	1656.8	2352.6*	55190.6	14091.2
DUMFRIES & GALLOWAY	8385.0	13091.4	3448.2	1530.3	2808.8	44.5	518.2	6165.8	10530.2	2948.3	212027.2	13639.8
STRATHCLYDE	12059.3	6586.9	581.0	1249.0	3203.8	905.6	10.2*	4361.6	8377.4	2950.8	218166.5	54099.2
TAYSIDE	11593.3	13395.1	2026.9	1609.8	2506.7	817.7*	0.0	1901.4	1029.0	2164.5	192192.6	16108.9
WHOLE SURVEY AREA	53222.3	54634.6	13824.5	8742.1	14105.0	2338.0	2923.7	28126.4	25618.4	13031.2	1015260.7	136940.9

* Less reliable estimate

Dwarf Shrub Heath: 17 Districts less reliable
Permanent Unimproved Grassland: 12 Districts less reliable
(8 Districts 0)
Wetland: 6 Districts less reliable
Open Water: 6 Districts less reliable

In the other habitat types at least one District result is unreliable and only data for agricultural land and deciduous woodland are wholly more reliable.

Three out of seven Regional estimates of permanent unimproved grassland are less reliable and one out of seven for both dwarf shrub heath and open water are less reliable. Similarly with the recent results:

Dwarf Shrub Heath 17 Districts less reliable
Permanent Unimproved Grassland: 11 Districts less reliable
(8 Districts 0)
Open Water: 6 Districts less reliable
Mixed Woodlands: 5 Districts less reliable

Here only with agricultural land are all the results more reliable. With Regions again three dwarf shrub heath estimates are less reliable and three of the permanent unimproved grassland estimates, and one of the open water results.

It is also clear that in some Districts there are more less reliable results than in others. For the recent data, the most unreliable Districts are:

West Lothian: 7 estimates less reliable
Dunfermline: 5 estimates less reliable
Tweeddale: 4 estimates less reliable

These are the Districts with the lowest number of secondary sampling units: 13, 8 and 10 frames respectively (Table 1). Only in Lanark and East Strathclyde are all the estimates more reliable. Even West Strathclyde and Angus, with over 45 prints each, have two less reliable estimates. Most of the Regional data, except those for the Borders and Dumfries and Galloway include one or two less reliable estimates. Likewise with early results:

West Lothian: 7 estimates less reliable
Dunfermline: 6 estimates less reliable
Cunninghame: 5 estimates less reliable
Cumnock and Doon Valley: 4 estimates less reliable

Wigtown and Angus have three less reliable results each but more than 35 sample photographs. Thus as might be expected there is a correlation between the number of sample units and the reliability of the data. In the smaller Districts the number of secondary sampling units may not have been sufficient to take account of all the variability. With the larger Districts where there are still less reliable estimates the reason must lie in the variability of certain habitat types such as dwarf shrub heath and permanent grassland.

Of the whole of the 24 Districts and 12 habitats i.e. 288 results for each date there are 230 more reliable estimates at the early date and 233 more recently.

This approach in drawing attention to results which cannot be predicted with 95% confidence does mask the width of the confidence intervals for the other figures. These have been shown in Appendix 1, expressed as a percentage of the mean estimate in order that the results can be more easily compared.

Two broad conclusions can be made about this data. Firstly, that the confidence interval for the Regional estimates is lower than that for District estimates as it was with the linear features. Secondly, that the estimates for some Districts and for some habitat types are more reliable than others. Taking the data in Appendix 1 for both dates of photography together, the reliability of the habitat types can be ranked as follows:

Decreasing reliability of results. ↓

Agricultural Land
Non-Agricultural Land
Deciduous Woodland
Scrub
Coniferous Woodland
Felled Areas
Wetland
Improved Rough Grassland
Mixed Woodland/Open Water
Permanent Unimproved Grassland
Dwarf shrub Heath

3.4.2 Area Results

Appendix 1C shows these early and recent habitats areas as proportions of the total Lowland agricultural area. From this it can be seen that agricultural land is always the largest type in a District or Region and at 75% of the whole survey area, an order of magnitude greater than the proportions of the rest of the habitats. The second commonest habitat type is non-agricultural land: 8% of the early survey area and the third commonest is, perhaps surprisingly, deciduous woodland: 5% of the whole survey area. However more recently, coniferous woodland replaced deciduous woodland as the third commonest type. The least frequent types in the whole survey area are dwarf shrub heath and permanent grassland. The properties of habitats vary very much from District to District especially with the lesser types.

A series of diagrams have been drawn to 'illustrate' such subtle differences in the proportions of habitat types between Districts and Regions. Both the early and the recent situation have been portrayed, but for the purposes of comparing Districts and Regions, only the early results have been referred to:

Diagram 1

These piecharts focus on the varying proportions of agricultural and non-agricultural land at the early date of photography. For this purpose all the remaining habitats have been grouped together as 'Other' habitats. In any case their proportions are often too small to portray alongside agricultural land whereas collectively they are of a similar order of magnitude. In addition these areas might be considered as distinct from agricultural and non-agricultural land in not being devoid of wildlife interest. The data used in these piecharts is presented in Table 16.

Diagram 1A Regional Proportions

75% of the whole survey area is under agricultural use but within this area the proportion varies from 70% in Central Region to 78% in Tayside Region.

The mean area of land under non-agricultural use is 8% with a range from 5% in Dumfries and Galloway Regions to 14% in Strathclyde Region.

The mean proportion of land occupied by Other habitats in the whole survey area is 17% and the range of values is narrow compared to that for non-agricultural land; from 14% of Strathclyde Region to 19% of Central Region. The proportions of Other habitats in the remaining Regions lie within 1% of the mean value for the whole survey area.

One conclusion that can be drawn from these charts is that the Regions with the greatest proportion of agricultural land do not have the lowest are of Other habitats. There seems to be more correlation between the proportions of agricultural land and non-agricultural land. The Regions with the most land under agricultural use: Dumfries and Galloway and Tayside have the lowest proportion of non-agricultural land and the Regions with the least agricultural land have the most non-agricultural land: Central and Strathclyde. There does not seem to be any consistent relationship between either of these two land uses and Other habitats e.g. Central Region and Dumfries and Galloway Regions have more land under Other uses than the other Reions but are quite opposite each other as regards their proportions of agricultural and non-agricultural land.

Diagram 1B District Proportions

Range in proportions of:-
Agricultural land: 62%(East Strathclyde) - 83% (Wigtown)
Non-Agricultural land: 3%(Roxburgh) - 23% (East Strathclyde)
Other habitats: 12%(West Lothian, Wigtown, Cunninghame, West Strathclyde and Angus) - 25% (Stewartry)

TABLE 16: Early and Recent proportions of Agricultural Land (Agric.), Non-Agricultural Land (NA) and 'Other' Habitat Types as percentages of Lowland Agricultural Area (LAA).

Local Authority District of REGION	Early Agric. as % of LAA	Recent Agric as % of LAA	Early NA as % of LAA	Recent NA as % of LAA	Early 'Other' as % of LAA	Recent 'Other' as % of LAA
Berwick	82	83	4	4	14	12
Roxburgh	80	81	3	3	18	17
Ettrick & Lauderdale	68	67	11	13	20	20
Tweeddale	70	70	8	9	22	21
BORDERS	76	76	6	7	18	17
East Lothian	76	77	5	5	19	18
Midlothian	78	75	6	9	17	16
West Lothian	71	68	17	21	12	11
LOTHIAN	75	74	8	10	17	16
North East Fife	77	78	6	7	17	16
Kirkcaldy	72	63	8	17	20	20
Dunfermline	70	71	13	15	17	14
FIFE	75	73	8	11	18	16
Falkirk & Clackmannan	70	61	17	27	13	12
Stirling	69	68	9	8	23	24
CENTRAL	70	65	12	17	19	19
Annandale & Eskdale	77	77	4	5	18	18
Nithsdale	74	74	7	7	19	19
Stewartry	72	72	3	3	25	24
Wigtown	83	84	5	5	12	11
DUMFRIES & GALLOWAY	77	77	5	5	19	18
Lanark	75	75	9	11	15	14
Kyle & Carrick	75	77	8	9	17	14
Cumnock & Doon Valley	80	81	5	7	15	12
Cunninghame	73	72	15	17	12	11
East Strathclyde	62	54	23	32	15	14
West Strathclyde	72	68	16	20	12	11
STRATHCLYDE	72	70	14	17	14	13
Perth & Kinross	76	77	6	6	18	18
Angus	81	81	7	8	12	11
TAYSIDE	78	78	6	7	16	15
WHOLE SURVEY AREA	75	74	8	10	17	16

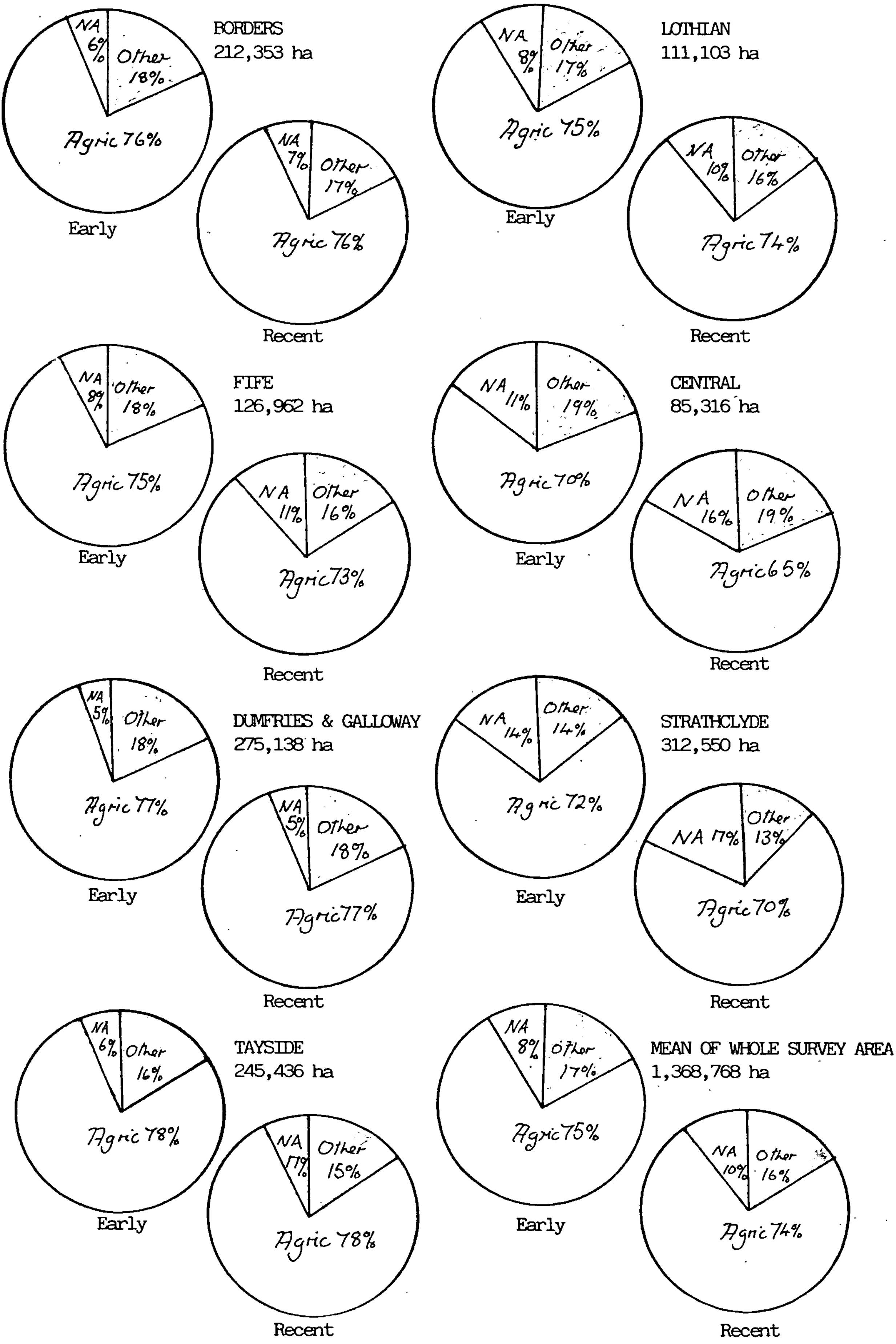

Diagram 1A: Early and Recent proportions of Agricultural land, Non-agricultural land and 'Other' habitat types in Regions.

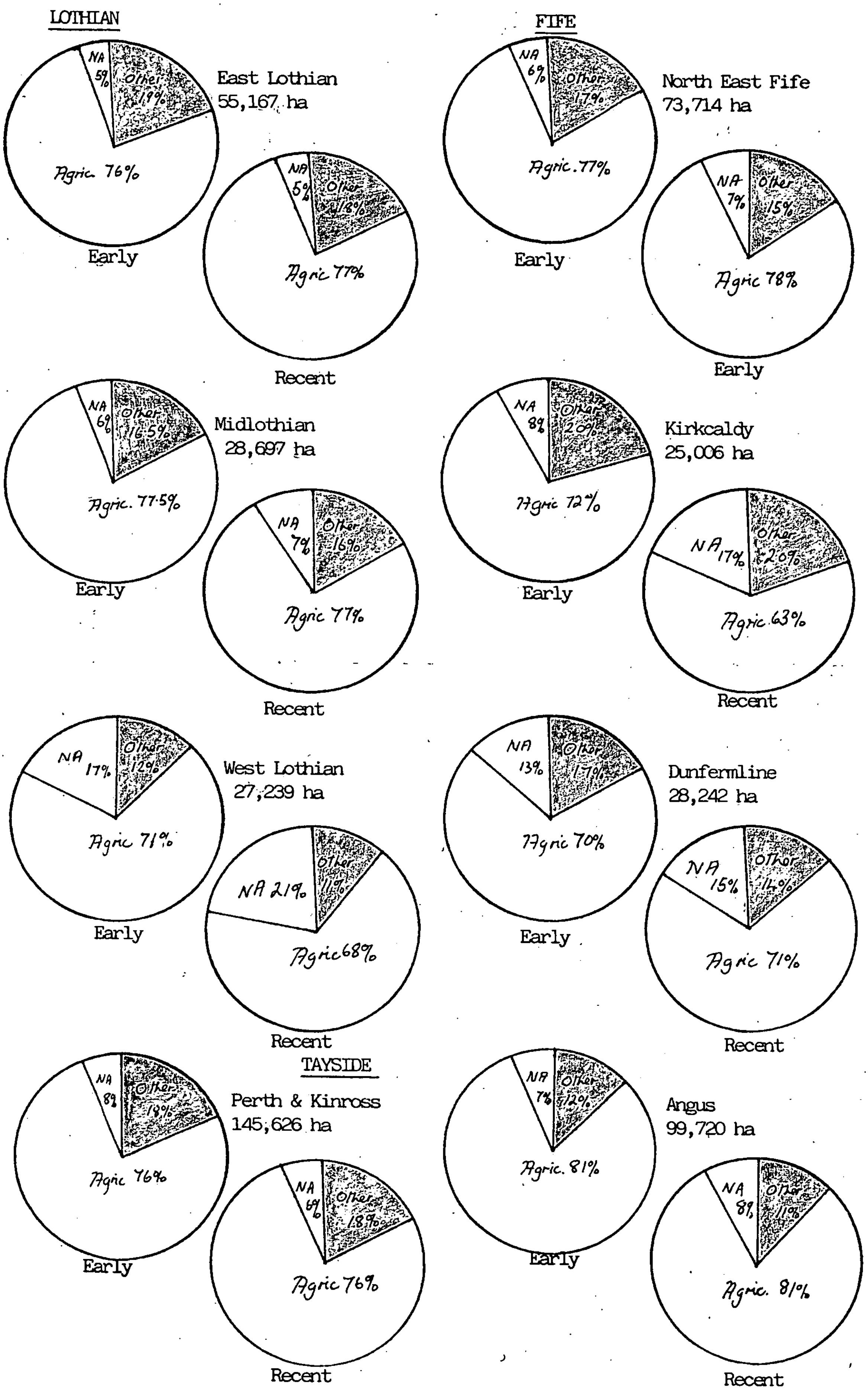

Diagram 1B (i): Early and Recent proportions of Agricultural land, Non-agricultural land and 'Other' habitats in Lothian, Fife and Tayside Districts.

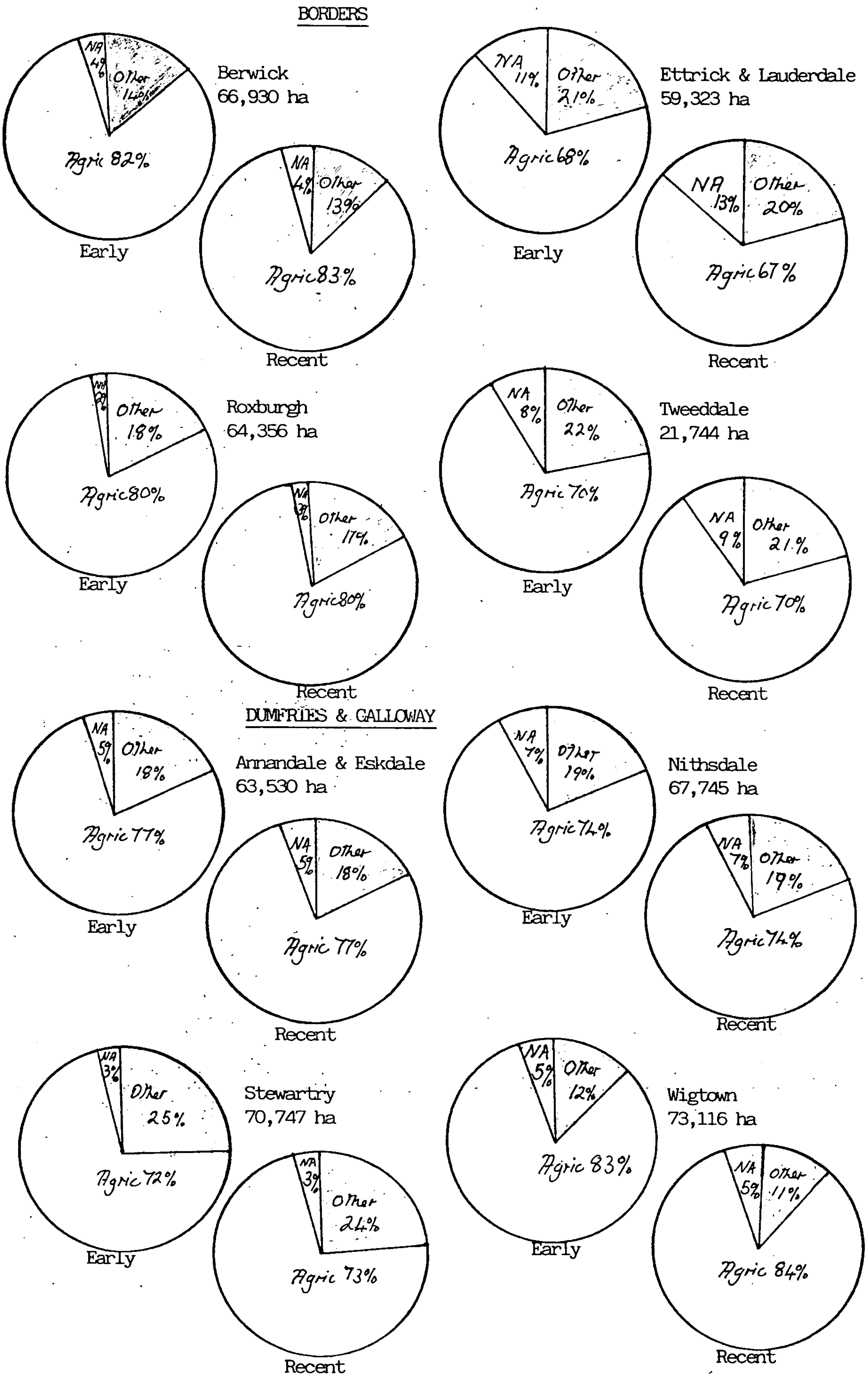

Diagram 1B (ii); Early and Recent proportions of Agricultural land, Non-agricultural land and 'Other' habitats in Borders and Dumfries and Galloway Districts.

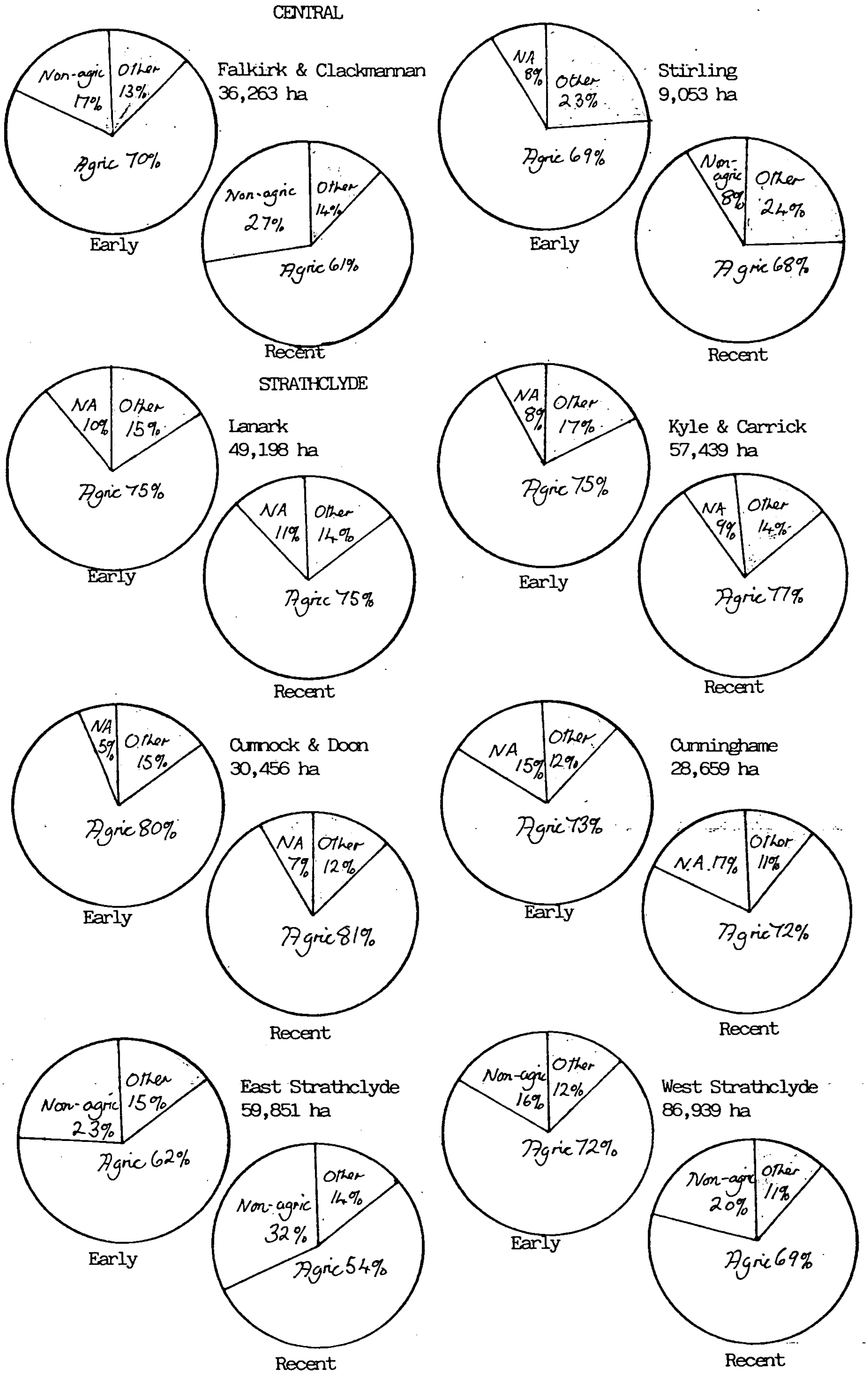

Diagram 1B (iii): Early and Recent proportions of Agricultural land, non-agricultural land and 'Other' habitats in Central and Strathclyde.

The spread of values is again greater with Districts than with Regions. The range in values for the proportions of agricultural land and non-agricultural land are the same but the range was narrower for the Other habitats, despite the greater overall mean, than that of non-agricultural land.

It is clear that within the Regions there was some variation in District proportions when compared with Regional proportions. For example one of the lowest (Wigtown) and the highest (Stewartry) proportions of Other habitat types both occur in Dumfries and Galloway Region.

The preliminary classification proposed for Regions also encompasses most of the Districts. Every District with a greater than average proportion of non-agricultural land has low proportion of agricultural land. These Districts are: West Lothian, Dunfermline, Falkirk and Clackmannan, Cunninghame, East Strathclyde and West Strathclyde. Likewise all the Districts with a greater than average proportion of agricultural land have a low proportion of non-agricultural land. These are Berwick, Roxburgh, Midlothian, North-East Fife, Annandale and Eskdale, Wigtown, Cumnock and Doon Valley, Perth and Kinross, and Angus.

The first of these categories will hence forth be called 'Industrial' Districts and the second 'Agricultural' Districts.

Five of the six Industrial Districts have a low proportion of Other habitats, the exception being Dunfermline which has an average amount. None of the Agricultural Districts have also a high proportion of the Other habitats. However there is a relationship between a high proportion of Other habitats and agricultural land. The five Districts with the highest proportions of Other habitats have also a low proportion of agricultural land. They are: Ettrick and Lauderdale, Tweeddale, Kirkcaldy, Stirling and Stewartry. These Districts will henceforth be termed 'Wildlife Conservation' Districts.

The four Districts so far unclassified may be termed 'Average' Districts: East Lothian, Nithsdale, Lanark, and Kyle and Carrick.

In Borders Region, on the whole Average; Berwick and Roxburgh Districts are Agricultural, and Ettrick and Lauderdale and Tweeddale are Wildlife Conservation Districts.

In Lothian again on the whole Average, West Lothian is Industrial, Midlothian Agricultural, and only East Lothian Average.

In Fife, the third Average Region, Dunfermline is Industrial, North-East Fife Agricultural and Kirkcaldy a Wildlife Conservation District.

Dumfries and Galloway is one of the two Agricultural Regions and has two Agricultural Districts: Annandale and Eskdale and Wigtown and also a Wildlife Conservation District in Stewartry whilst Nithsdale is an Average District.

Strathclyde, the other Industrial Region has three Industrial Districts: Cunninghame, East Strathclyde and West Strathclyde, one Agricultural District in Cummnock and Doon Valley and two Average Districts : Lanark and Kyle and Carrick. Only in Tayside, the second Agricultural Region do both Districts: Perth and Kinross, and Angus, fall into the Regional Category.

Thus the Regional results must be seen as means which do not reflect the proportions of habitats in all their Districts.

Diagram 2

These histograms portray the proportions of other habitats i.e. habitats of Wildlife Conservation interest in each District or Region. As well as comparing total proportion of these habitats, and the total proportion of the habitats at the two dates of photography in each District or Region, they also illustrate the relative proportions of the types of Other habitats in every Region or District. The ten individual Other types have been collated into four groups, to ease the assimilation of this information. The four groups are:

Woodlands:- deciduous, coniferous, mixed woodland and felled areas.
Scrub:- This type is found in association with all the groups therefore cannot be categorised with any one group.

Grassland and Heathland:	- dwarf shrub heath, permanent unimproved grassland and improved rough grassland,-this group will be abbreviated to 'Grasslands' in future discussion.
Freshwater Wetlands:	wetland and open water,-this group will be abbreviated to 'Wetlands' in future discussion.

In this section only the early proportions are considered.

It is important to recall that some of the habitat results are less reliable as described in Section 3.4.1. However it is impossible to estimate the true value of such results with the information available and so such results have been included in order to convey a more complete picture.

Individual habitat proportions are to be found in Appendix 1C.

Diagram 2A Regional Proportions of Habitats of Wildlife Interest.

The final columns in the chart depict the early proportions of the Other habitat groups within the whole survey area i.e. the mean of the District or Regional proportions. Woodlands occupied the largest proportion; on average 8.5% or half the area of the other habitats. Its proportion was in fact greater than the combination of the remaining groups, in four Regions: Borders, Lothians, Central and Tayside and it occupied the largest proportion of any groups in all but Fife Region.

Grasslands occupied the next highest proportion: 4.0% (this was the largest habitat group in Fife), followed by Wetlands 3.2% and lastly scrub 1.1%. There was again much variation in the proportions between the Regions:-

Range of Woodlands proportions: 6.2% (Strathclyde) - 11% (Central)
Range of scrub proportions: 0.8% (Borders) - 1.2% (Fife, Central and Tayside)
Range of Grasslands proportions: 1.9% (Central) - 7.4% (Fife)
Range of Wetlands proportions: 1% (Lothian) - 5.5% (Dumfries and Galloway)

Although the pattern made by the relative proportions of these habitat groups in each Region is unique, some generalisations can be made: Borders, Lothian and Fife Regions were similar in having a greater

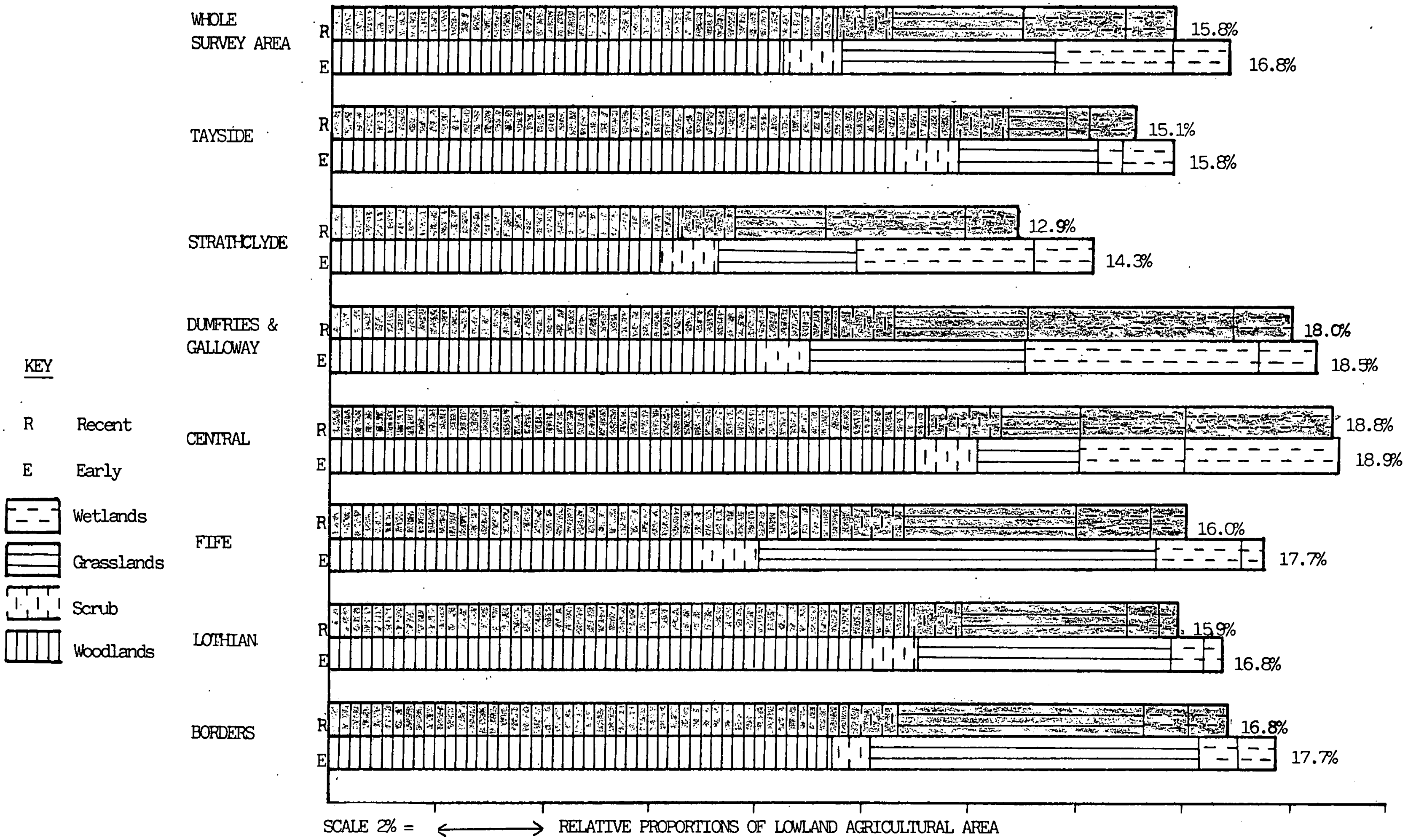

Diagram 2A Regional Proportions of 'Other' Habitat Groups.

than average proportion of the area of wildlife interest under Woodlands, the three greatest proportions of Grasslands, and low proportion of Wetlands.

Dumfries and Galloway, Strathclyde and Central Region were similar in having the three highest proportions of Wetlands, and in having lower proportions of Grasslands than in the first three Regions. As regards Woodlands, the three Regions differ; Dumfries and Galloway and Strathclyde have less than half their area under Woodland respectively but Central had the greatest proportion of Woodlands.

Finally, Tayside Region was quite unique in having a very high proportion of Woodlands, but a low proportion of Grassland and Wetlands.

Diagram 2B and 2C District Proportions of Habitats of Wildlife Interest.

Within Districts, there was again much deviation from the mean values in the final column of Diagram 2A:-

Range in Woodlands proportions: 3.8% (Cunninghame) - 12.9% (Midlothian)
Range in proportion of scrub: 0.3% (Tweeddale) - 1.6% (Stewartry and North East Fife)
Range in Grasslands proportions: 1.1% (Falkirk and Clackmannan and Cunninghame) - 8.8% (North East Fife)
Range in Wetlands proportions: 0.4% (East Lothian) - 8.8% (Stewartry)

Scrub was present in every District but never exceeded 2% of the whole area.

The classification of Regions proposed at the end of the last section, on the basis of the relative proportions of Grasslands, Woodlands and Wetlands does not encompass all the Districts. Generalisations are even more difficult to make except to say that the west coast Districts, as might be expected on climatological grounds, have more Wetlands than the east coast Districts.

Stirling and Kirkcaldy had also a greater proportion of Wetlands than the mean of 3.2%. This might be expected in the cases of Stirling District which is located in the western central part of Scotland but not in the case of Kirkcaldy which is distinctly east coast. In all other Districts Wetlands increase with westerliness e.g. the other more central Districts: West Lothian, Dunfermline, Falkirk and Clackmannan, Perth and Kinross and

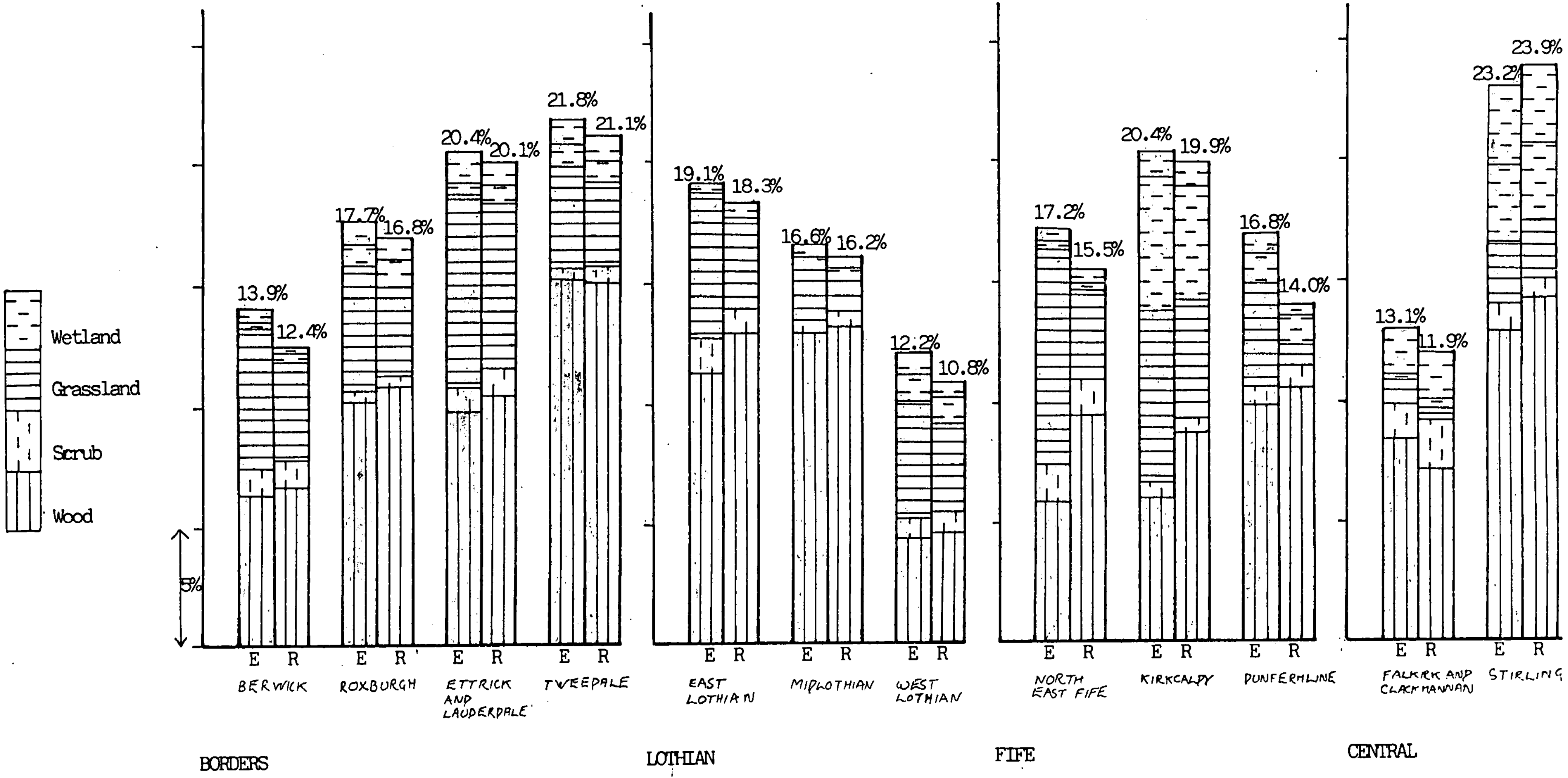

Diagram 2B: District Proportions of 'Other' Habitat Types in Borders, Lothian, Fife, Central Regions.

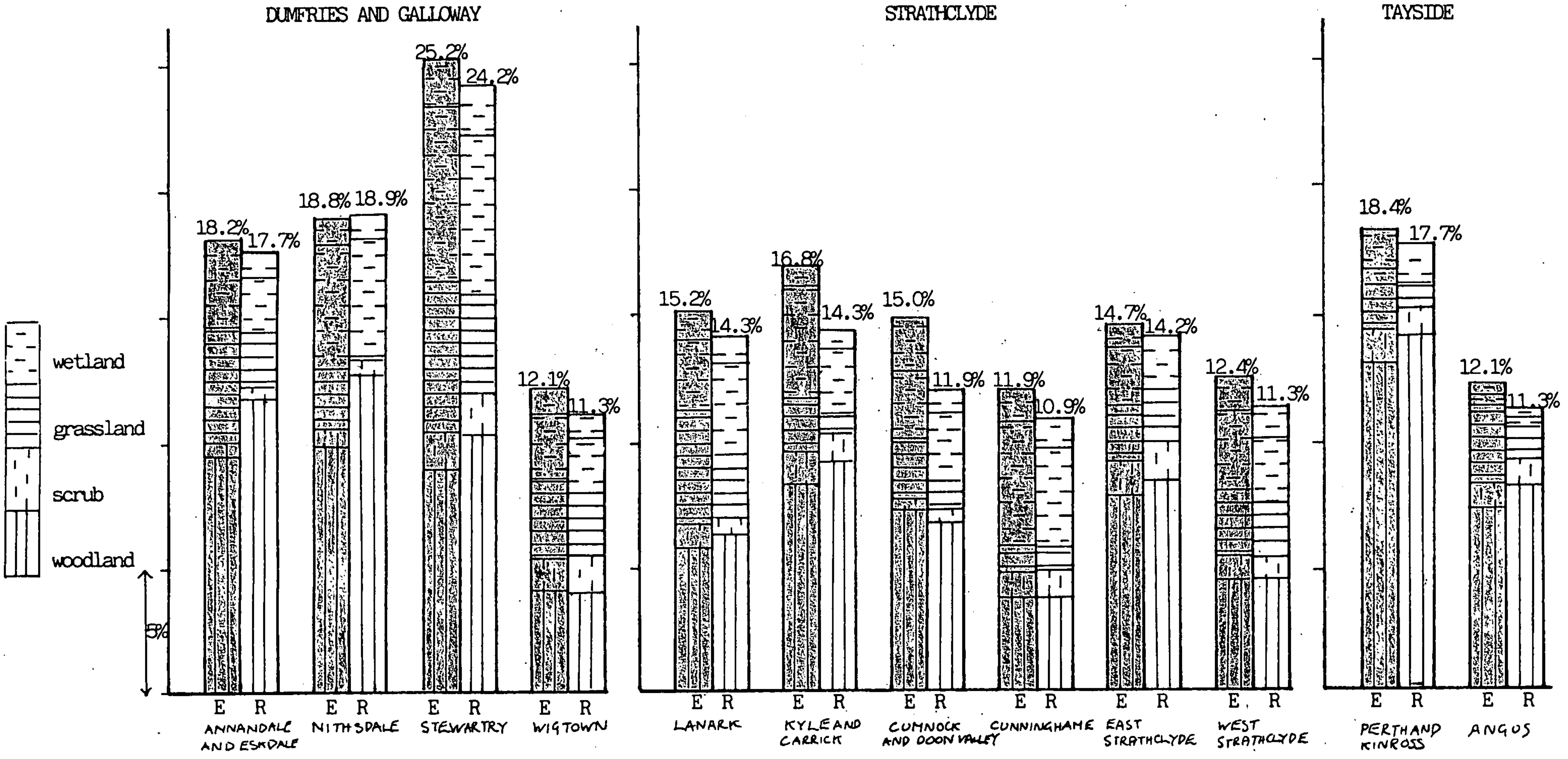

Diagram 2C: District proportions of 'Other' Habitat Types in Dumfries & Galloway, Strathclyde and Tayside Regions.

Tweeddale have more Wetlands than east coast Districts.

Neither the proportion of Grasslands nor that of Woodlands is consistently related to the proportion of Wetlands.

Woodlands occupied a larger area than the Other groups combined in four Regions; this occurred in nine Districts. It occupied the largest proportion of groups in the Other area in all Regions except Fife and in all but four Districts: West Lothian, North East Fife, Kirkcaldy and Cunninghame.

Grasslands occupied the greatest proportion in all these last few Districts except Cunninghame where Wetlands were commonest. The area of Grasslands exceeded the area of Wetlands in most Districts except for seven in the west half of the country: Stirling, Stewartry, Nithsdale, Kyle and Carrick, Cumnock and Doon Valley, Cunninghame and West Strathclyde.

These diagrams serve to illustrate the myriad of patterns possible in the proportions of wildlife habitats in the Districts. For example in Perth and Kinross, and Midlothian, Woodlands was most predominant and other habitats much less common. In Kirkcaldy there were almost equal proportions of the three main groups and in Cunninghame; Wetlands have achieved predominance. Again one could reflect on how the Regional proportions are really no more than means of the District figures, especially in Lothian, Fife, Dumfries and Galloway, Central and Tayside.

Proportions of Individual Habitat Types within the Habitat Groups

The area of Fresh Water Wetlands on charts 2A - 2C has been further subdivided. The near portion shows the proportion of wetland and the farther that of open water. For the whole survey area there was a mean of 2.2% wetland and 1% open water. The Regional range of values was as follows:

Proportion of wetland 0.5% (Tayside) - 4.4% (Dumfries and Galloway)
Proportion of open water 0.4% (Lothian) - 2.8% (Central)

In four Regions: Lothian, Fife, Dumfries and Galloway and Strathclyde, the area of wetland was greater than the area of open water. In the Borders Region the proportions were equal and in Central and Tayside Regions the areas of open water were far greater.

There was even more variation between the Districts of these Regions:

Range in the proportion of wetland:	0.2% (Falkirk and Clackmannan) – 7.1% (Stewartry)
Range in the proportion of open water:	0.1% (East Lothian) – 3.4% (Stirling)

In all but six Districts the proportion of wetland was again the greater of the two.

<u>Diagram 3</u> portrays the proportions of the individual Woodlands and Grasslands types.

<u>Diagram 3A</u> Regional Proportions

The chart on the near half of the page portrays Regional proportions of the Woodlands types. For the whole survey area the mean proportions were: 4.7% deciduous woodland, 2.2% coniferous woodland, 0.9% mixed woodland and 0.7% felled areas. The range in values were as follows:

Proportion of deciduous woodland	3.7% Borders) - 1.9% (Lothian)
Proportion of coniferous woodland	1.3% (Lothian and Strathclyde) - 1.9% (Tayside)
Proportion of mixed woodland	0.2% (Strathclyde) - 1.9% (Lothian)
Proportion of felled areas	0.2% (Lothian) - 1.3% (Central)

In all Regions deciduous woodland occupied the largest proportion of Woodlands and in four Regions: Tayside, Fife, Central and Lothian, the proportions of deciduous woodland exceeded that of the other types combined. In five Regions coniferous woodland occupied the second largest proportion of the Woodlands area. However in Central and Lothian Regions the proportion of mixed woodland was larger.

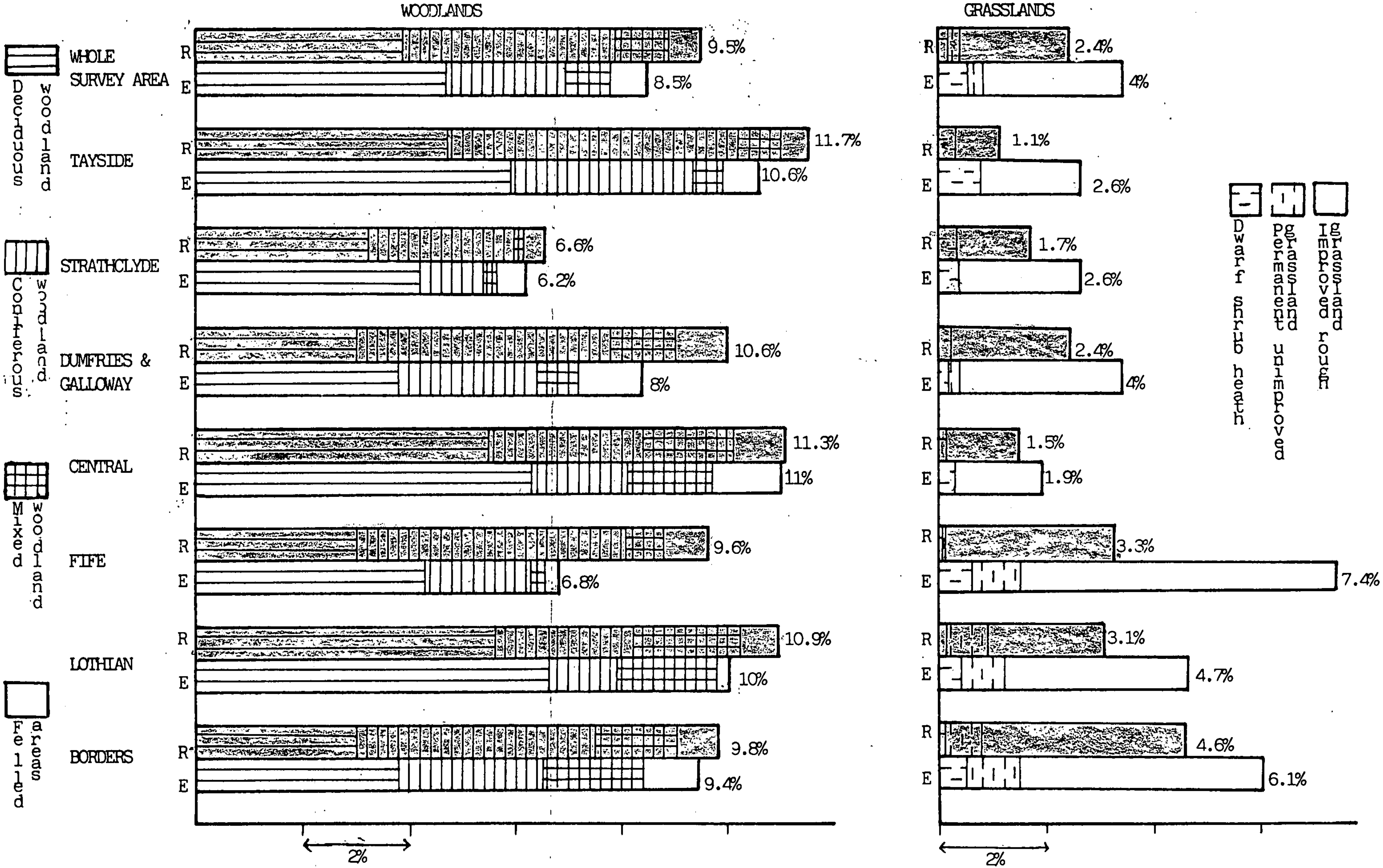

Diagram 3A: Regional Proportions of Individual Woodlands and Grasslands types.

R Recent E Early

The chart on the far side of the page illustrates the early proportions of the Grasslands types. For the whole survey area the mean proportions were 0.4% dwarf shrub heath, 0.3% permanent unimproved grassland and 3.2% improved rough grassland.

Proportions of dwarf shrub heath varied from 0.2% in Dumfries and Galloway to 0.8% in Tayside.

Proportion of permanent unimproved grassland varied from 0% (Central, Strathclyde and Tayside) to 0.9% in Borders and Fife Regions.

Proportion of improved rough grassland: 1.6% (Central) - 5.9% (Fife)

The most obvious deduction to be made from the graph was that improved rough grassland was not only the most common of the Grassland and Heathland types but that it always occupied an area greater than the other two types combined. Proportions of dwarf shrub heath and permanent unimproved grassland never exceeded 1%, and in three Regions the latter type is absent. Where permanent grassland was present, the area exceeded that of the dwarf shrub heath except in Dumfries and Galloway where proportions were equal. Thus the mean situation does not occur in any Region.

<u>Diagram 3B</u> District Proportions of Woodland Types

There was again much deviation from the survey mean: Range in proportion of deciduous woodland:- 2.7% (North East Fife and Lanark) - 8.5% (Midlothian)
Range in proportion of coniferous woodland:- 0.1% (Cunninghame) - 7.3% (Tweeddale)
Range in proportion of mixed woodland: 0.0% (Dunfermline) - 2.9% (Midlothian)
Range in proportion of felled areas:- 0.0% (West Lothian) - 2.2% (Stirling)

Unlike the situation in the Regions, deciduous woodland did not always occupy the largest area. In the four Districts the proportion of coniferous woodland was greater. However in fourteen Districts the proportions of deciduous woodland exceeded that of other woodland types combined.

Coniferous woodland occupied the second largest proportion of the woodland area in 14 Districts and in 6 Districts the area of mixed woodland exceeded that of coniferous woodlands.

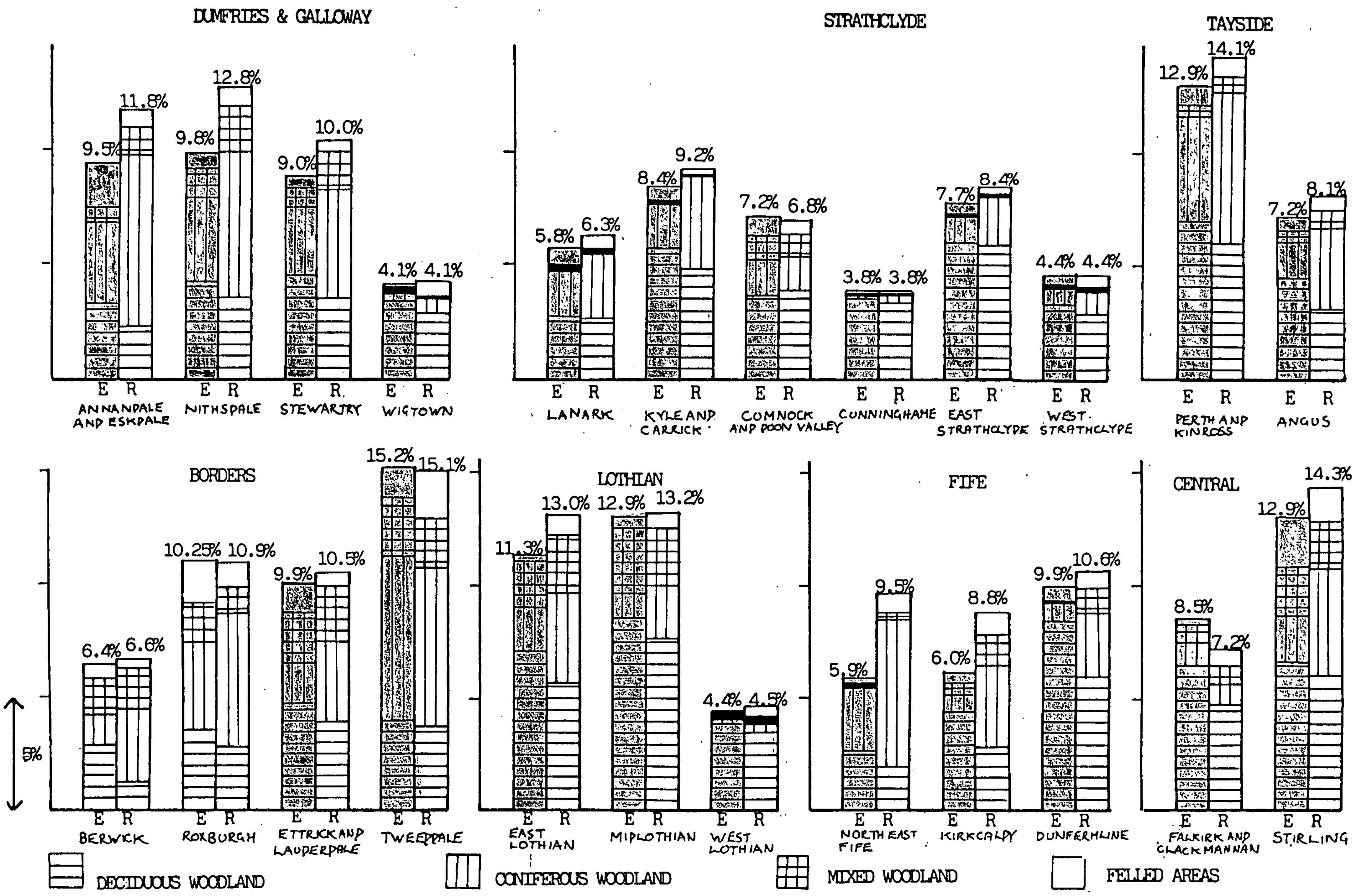

Diagram 3B: Early and Recent District Proportions of Woodland types.

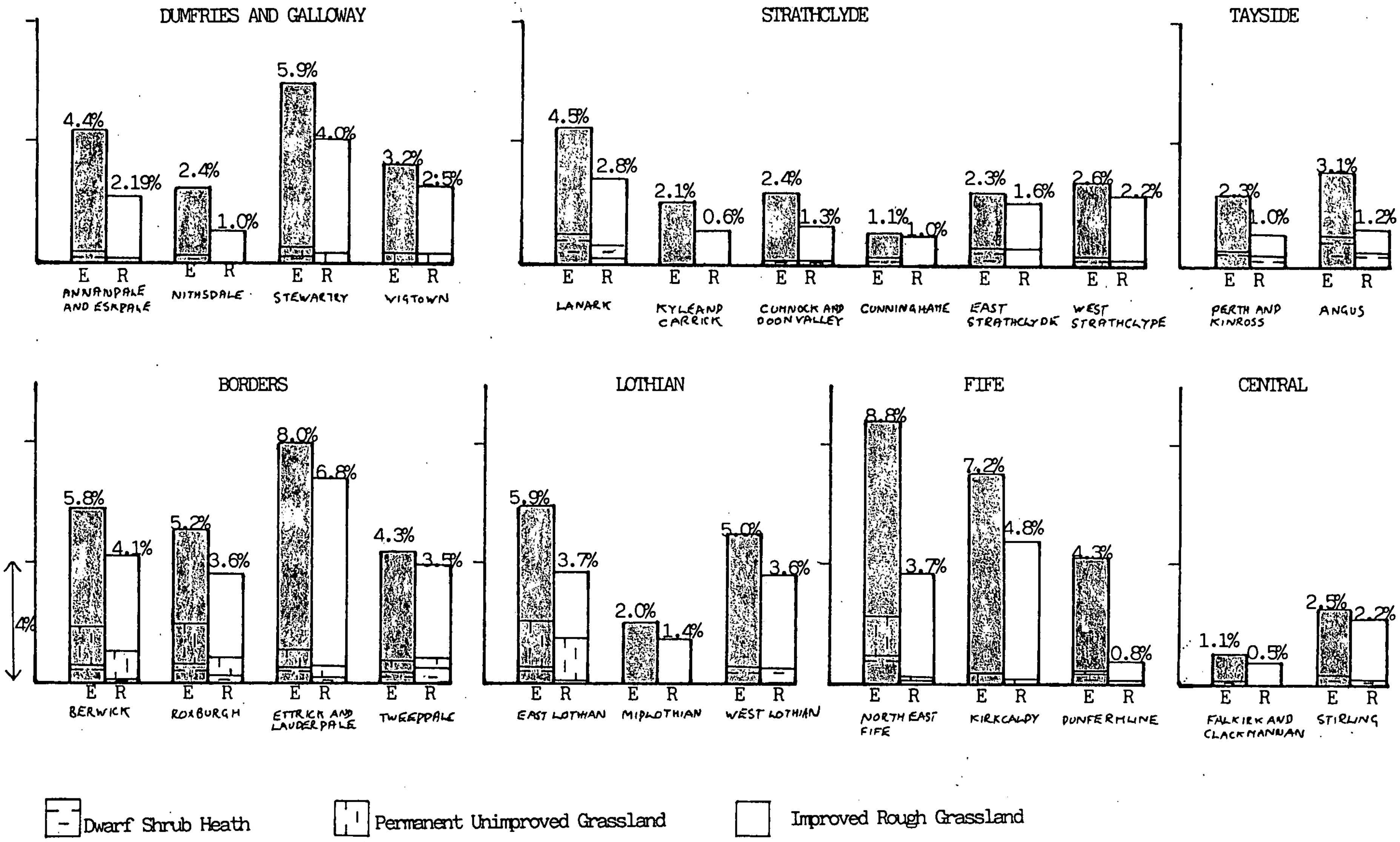

Diagram 3C: District proportions of Grassland and Heathland Types.

TABLE 17: Early and Recent proportions of Other Habitat Types in the Whole Survey Area and the frequency with which each occupies the largest proportion of the total 'Other' habitat area.

Habitat Type	Early Mean proportion %	Districts where predominant	Regions where predominant	Recent Mean proportion %	Districts where predominant	Regions where predominant
Deciduous Woodland	4.7	12	4	3.9	12	3
Coniferous Woodland	2.2	2	-	4.0	7	4
Mixed Woodland	0.9	-	-	1.0	-	-
Felled Areas	0.7	-	-	0.6	-	-
Scrub	1.1	-	-	1.0	-	-
Dwarf Shrub Heath	0.4	-	-	0.2	-	-
Permanent Grassland	0.3	-	-	0.2	-	-
Improved Grassland	3.2	7	2	2.0	1	-
Wetland	2.2	3	1	1.9	4	-
Open Water	1.0	-	-	1.0	-	-
Total	16.7	24	7	15.8	24	7

Diagram 3C District Proportions of Individual Grassland and Heathland Types

Range in proportion of dwarf shrub heath ; 0% (Midlothian, Kirkcaldy, Wigtown and Kyle and Carrick) - 1.1% (Angus)
Range in proportion of permanent unimproved grassland : 0%(Midlothian, West Lothian, Falkirk and Clackmannan, Stirling, Nithsdale, all Strathclyde and Tayside Districts) - 1.6% (East Lothian)
Range in proportion of improved rough grassland: 0.8% (Cunninghame) - 6.8% (Ettrick and Lauderdale)

As in the Regions, the most striking illustration in these charts is the predominance of improved grassland in all Districts. The proportion of the other two types may be considered minor, exceeding 1% in only a few Districts whereas the proportion of improved grassland rarely fell below 1%. The other types achieved their greatest proportions in the east coast Districts. As in the Regions the area of permanent grassland, where present, exceeded that of heathland but it is absent from thirteen Districts.

A summary of the importance of the Other habitat types is given in Table 17. This shows the mean proportion of each type in the whole survey area, and the number of Districts and Regions where the type was predominant. Overall then at the early period, deciduous woodland was the most important Other habitat type followed by improved grassland.

3.5 THE CHANGES

3.5.1 The Reliability of Net Change Data

The Net changes to each habitat type in the post-war period are summarised in Table 18. Only the Regional results are shown and the full District results are to be found in Appendix 2A. In both less reliable data are marked with an asterisk (*). Net change has been expressed in terms of area (hectares) and as a percentage of the early area of that habitat type.

TABLE 18: Net Change to each Habitat Type in each Region in area (hectares) and as a percentage of Early Area

Habitat / Region		Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land
BORDERS	ha	- 1446.9	3463.4	-630.9	-550.8*	257.8*	-834.3	-547.2	- 1672.1	73.3*	-13.6*	462.9*	1438.4
	%	- 18.4	57.2	- 16.0	- 25.2	16.2	- 76.5	- 27.5	- 17.1	4.8	- 0.9	0.3	11.1
LOTHIAN	ha	- 1127.2	1492.9	165.8*	477.2	- 68.1*	-273.4*	- 42.6*	- 1462.2	- 32.4*	-43.2*	- 1053.3	1966.5
	%	- 15.3	106.6	7.9	176.5	- 5.8	- 61.3	- 4.7	- 38.1	- 4.8	-10.4	- 1.3	21.7
FIFE	ha	- 1633.9	3978.9	536.0	649.4	- 69.8*	-760.3	-1058.9*	- 3479.6	-235.5*	-64.1*	- 1813.7*	3951.5
	%	- 29.9	157.8	159.9	186.0	- 4.5	- 96.2	- 92.1	- 46.3	- 11.7	- 8.0	- 1.9	41.1
CENTRAL	ha	- 884.7	1284.1	- 64.3*	-145.5*	133.8*	-107.0*	0.0	- 243.1	- 43.5*	-13.5*	- 4131.4	4215.2
	%	- 15.9	94.2	- 4.7	- 13.0	13.3	- 48.8	0.0	- 17.3	2.6	0.6	- 7.0	42.7
DUMFRIES % GALLOWAY	ha	- 2144.8	5985.7	1290.4*	-653.8*	-137.7*	-393.4	- 47.3*	- 3843.0	-1536.4	-26.6*	1445.3	61.6
	%	- 20.4	84.2	59.8	- 29.9	- 4.7	- 89.9	- 8.4	- 38.4	- 12.7	- 0.9	0.7	0.4
STRATHCLYDE	ha	- 1049.6	2636.8	- 56.8*	-438.7*	-143.0	-186.0	0.0	- 2657.4	-2092.2	-406.7*	- 7221.6	11615.3
	%	- 8.01	66.8	- 8.9	- 26.0	- 4.3	- 17.0	0.0	- 37.9	- 20.0	-12.1	- 3.2	27.3
TAYSIDE	ha	- 2920.1	4985.0	761.9	165.4*	-427.8*	-1077.6	0.0	- 2614.0	-292.3*	- 0.8*	502.4*	1248.9
	%	- 20.1	59.3	60.2	- 9.3	- 14.6	- 56.9	0.0	- 57.9	- 22.1	- 0.0	0.3	8.4
WHOLE SURVEY AREA	ha	-11207.8	+23826.3	+2001.9	-827.7	-455.2	-3632.0	-1695.8	-15970.7	-4158.8	-568.0	-11809.6	+24497.6
	%	- 17.4	+ 77.3	+ 16.9	- 8.7	- 3.1	- 60.8	- 36.7	- 36.2	- 14.0	- 4.2	- 1.2	+ 21.8

* Less reliable estimate

From Appendix 2A it is clear that there are a large number of less reliable results at the District level. And even at the Regional level there are many less reliable estimates. Table 19 provides a summary of reliability of results for each habitat type. It distinguishes 'real' results: those where net change has been greater than 10% from the rest of the results and shows how many of these are more reliable. From this it can be seen that just over half of the Regional estimates of net change fall are more reliable, and most of these are greater than 10%. However only about one third (88) of the 273 Districts results are reliable although again the majority may be considered to be real changes. The results for mixed woodland, felled areas, scrub, dwarf shrub heath, wetland, open water and agricultural land are particularly unreliable. Between them there are only 30 more reliable net changes out of a possible 155 estimates. These figures can be compared with the analysis in Section 3.4.1. There a total of 230 out of 288 District estimates were more reliable.

The source of this greater variation, compared with that for total areas, may lie in the nature of the net changes. Firstly they are far smaller than the total areas,and secondly they are not unidirectional, being combinations of gains and losses. The second point is neatly demonstrated with the Central Region estimates of net scrub change. Both District results are more reliable:- in Falkirk and Clackmannan a net gain in area of 55%, in Stirling a net loss of 24%, but the Regional net change:- a gain of 13%, is less reliable. In most Regions there was a greater proportion of more reliable results than less reliable results compared with the District results; i.e. so long as change is unidirectional, Regional results are usually more reliable than District results. Another example of this occurs in hedgerow results: nearly every single estimate of net change was more reliable, and here the changes were unidirectional, mostly losses; where there were gains they were of a lower order of magnitude.

If only more reliable net changes are considered then only with the habitats of deciduous and coniferous woodland, improved rough grassland and non-agricultural land are there enough results to draw satisfactory conclusions. However it may be that the individual gains and losses which make up the net changes are more reliable, and it is only the combination of the two which, by increasing the variation, renders the net change less reliable.

TABLE 19: Numbers of 'Real' Results (Change 10%) and 'More Reliable' Results for each Habitat Type within Regions and Districts

Habitat / Data	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land	Total
Number of 'more reliable' District results	15	14	3	9	3	5	2	13	3	2	6	13	88
Number of 'more reliable' District results >10%	13	14	3	9	3	5	2	13	3	0	2	10	77
Total number of Districts with changes	24	24	23	24	24	23	11	24	24	24	24	24	273
Number of 'more reliable' Region results	7	7	3	2	0	5	1	7	2	0	4	6	44
Number of 'more reliable' Region results >10%	6	7	3	2	-	5	1	7	2	-	0	5	38
Total number of Regions with changes	7	7	7	7	7	7	4	7	7	7	7	7	81

Table 20 shows the individual gains and losses for every Regional net change. These have again been marked with an asterisk if the results are less reliable, using the criteria in Section 3.2. The gains and losses which make up the District net changes are shown in Appendix 2B. If Table 20 is compared with Table 18, the most obvious difference is in the number of more reliable results. Out of 77 Regional results with both gains and losses, 65 have both more reliable, i.e. 84% of the Regional gains and losses are more reliable, whereas only 44 out of 81, or 54% of net changes are more reliable.

In Table 21A there is a summary of the reliability of the Regional gains and losses for each habitat type. If this is compared with Table 19 it can be concluded for which habitats where net changes were less reliable, the source of this unreliability was in combining the individual gains and losses: this occurs with mixed woodland, scrub, wetland, open water and agricultural land. In some instances where net change was less reliable, the individual gains or losses are themselves less reliable, for example in dwarf shrub heath and permanent unimproved grassland.There are a few instances when the net change was reliable but either the gain or loss was less reliable. In all these cases, the smaller of the two results was the less reliable one and was usually an order of magnitude less.

If Appendix 2B is perused it can be seen that many more of the individual Districts gains and losses are more reliable compared with the District net changes. Table 21B summarises the reliability of these results and should be compared with Table 19 (net changes). Whereas only 88 of the 273 Districts net changes were more reliable, or 32%, 190 of the 248 results, where there were both gains and losses, or 77% were more reliable.

In summary over one half of the Districts and Regions with less reliable net changes have more reliable gains and losses. In the other half the variability is inherent in the gains and/or losses.

There is a more detailed consideration of the statistical reliability of the net changes in each habitat, in the next section. However in

TABLE 20: Gains and Losses to each Habitat Type expressed as a percentage of the Early Area in the Regions

Habitat Region		Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land
BORDERS	gain %	2.6	69.6	11.4	66.1	37.2	3.0*	2.3*	5.5	9.3	0.6	1.5	13.3
	loss %	21.0	12.4	27.4	91.4	21.0	79.5	29.8	22.6	4.5	1.4	1.2	2.2
LOTHIAN	gain %	9.4	125.3	34.1*	252.2*	43.6	0.0	2.7*	2.3	11.4	0.6*	1.4	25.8
	loss %	24.7	18.8	26.2	75.8	49.4	61.3*	7.4	40.4	16.1*	11.1	2.6	4.1
FIFE	gain %	5.7	177.0	167.5	273.4	35.9	0.0	0.0	3.6	10.4	1.7	3.0	47.7
	loss %	35.6	19.1*	7.7*	87.4	40.4	96.2	92.1*	50.0	22.0	9.8	4.9	6.7
CENTRAL	gain %	8.9	135.2	13.4	80.5	57.4	16.4	0.0	14.5	25.4	0.8*	1.6	47.5
	loss %	24.8	41.0	18.1	93.4	44.1	65.3	0.0	31.8	28.0	1.4	8.6	4.8
DUMFRIES & GALLOWAY	gain %	10.5	104.4	80.8	65.1	34.7	0.0	2.7*	5.9	13.5	3.3	2.2	10.8
	loss %	30.8	20.2	21.0	95.1	39.3	89.9	11.1	44.3	26.2	4.2	1.5	10.3
STRATHCLYDE	gain %	11.1	82.6	20.5	55.7	41.0	29.0	0.0	4.4	11.5	2.2	2.6	30.6
	loss %	19.1	15.8	29.4	81.7	45.2	46.0	0.0	42.2	31.5	14.3	5.8	3.3
TAYSIDE	gain %	9.7	70.9	76.4	77.4	31.1	10.4*	0.0	10.6	8.3	2.7	1.8	15.2
	loss %	29.8	11.7	16.2	86.7	45.7	67.3	0.0	68.5	30.5	2.8	1.6	6.8*
WHOLE SURVEY AREA	gain %	8.8	94.0	40.0	80.7	38.1	9.7	1.8	5.6	13.9	2.0	2.0	26.7
	loss %	26.2	16.5	23.3	89.3	41.2	70.6	38.6	41.8	26.0	6.0	3.2	5.0

* Less reliable estimate

TABLE 21A: Number of 'More Reliable' Gains and Losses to each Habitat Type within Regions

Habitat Data	Decid. Wood.	Conif. Wood.	Mixed Wood	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land	Total
Regions with 'more reliable' gains	7	7	5	7	7	2	0	7	7	5	7	7	68
Regions with 'more reliable' gains >10%	2	7	5	7	7	2	-	2	5	0	7	7	51
Regions with 'more reliable' losses	7	6	6	7	7	6	3	7	6	7	7	6	75
Regions with 'more reliable' losses >10%	7	6	6	7	7	6	3	7	5	2	0	1	57
Regions with both gains and losses 'more reliable'	7	6	5	7	7	2	0	7	6	5	7	6	65
Regions with both gains and losses 'more reliable' which had 'less reliable' net changes	-	-	2	4	7	1	0	-	4	5	3	1	27
Total Number of results	7	7	7	7	7	4	3	7	7	7	7	7	77

TABLE 21B: Number of 'More Reliable' Gains and Losses to each Habitat Type within Districts

Habitat / Data	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land	Total
Districts with 'more reliable' gains	20	21	11	18	24	3	0	14	13	8	22	20	174
Districts with 'more reliable' gains >10%	17	21	7	18	24	3	-	4	9	0	0	16	119
Districts with 'more reliable' losses	24	14	13	19	21	6	3	18	15	14	20	16	183
Districts with 'more reliable' losses >10%	22	10	13	19	21	6	2	18	13	2	1	2	129
Districts with both gains and losses 'more reliable'	20	14	57	14	22	2	0	10	12	6	20	13	190
Districts with both gains and losses 'more reliable' which had 'less reliable' net changes	8	4	5	9	19	1	0	2	10	8	14	3	83
Total Number of Results	24	24	22	23	24	11	4	24	23	21	24	24	248

most of the section the net change per se will be examined. It is possible to judge the reliability of the habitat changes for the whole survey area by assessing the number of more reliable District results. The individual gains and losses are also then considered per se and not only for the light they shed on the validity of the net changes. The figures expressed in Table 20 and Appendix 2B are percentages; an idea of the order of magnitude of the area involved has already been gained from the net change results in Appendix 2A. Finally the percentages of loss and gain for the whole survey area have been calculated using only more reliable results.

3.5.2 The Main Changes

Summary of Tables and Diagrams referred to below in order of appearance:

Table 15	Early and Recent Areas of Habitat Types in Regions
Appendixes 1A & 1B	Early and Recent Areas of Habitat Types in Districts
Table 18	Area of Net Change and % Net Change in Regions
Appendix 2A	Area of Net Change and % Net Change in Districts
Table 19	Reliability of Net Changes
Table 20	Percentage Gains and Losses to each Habitat Type (Regions)
Appendix 2B	Percentage Gains and Losses to each Habitat Type (Districts)
Table 21	Reliability of Gains and Losses
Table 17	Overall Importance of Other Habitat Types
Appendix 1C	Early and Recent Proportions of Habitat Types in Regions and Districts
Diagram 3A	Proportions of Woodland and Grassland Habitat Types (Regions)
Diagram 3B & 3C	Proportions of Woodland and Grassland Habitat Types (Districts
Diagram 2A	Proportions of Other Habitat Groups (Regions)
Diagram 2B & 2C	Proportions of Other Habitat Groups (Districts)
Table 16	Early and Recent Proportions of Agricultural Land, Non-Agricultural Land and Other Habitat Types
Diagram 1	Piecharts of Table 16

3.5.3. Net Changes in Woodlands

1. Net Changes in Deciduous Woodland

In the whole Survey area the area of deciduous woodland changed from 64430ha to 53222ha: a fall of 17%. There was considerable variation between Regions in the proportion lost, ranging from a loss of only 8% to 30%.

All the Regional net changes are more reliable but only 15 of the District results are. Thirteen of these 15 results are greater than 10%. The range of net losses is 7% to 35%.

If the individual gains and losses are considered, it can be seen that for the nine less reliable net changes, there is only one instance where either the individual gain or the loss is less reliable: West Lothian. A higher proportion (five out of nine) of these less reliable net changes are less than 10% compared to more reliable ones.

A consideration of net change alone masks the fact that the picture is not wholly one of loss - there are gains as well. In addition the area of loss of deciduous woodland is greater than that suggested by net change. Losses to mature deciduous woodland may represent a greater loss in value than would be compensated for by gains of young woodland.

Moreover the gains may be in different places from those lost and will not provide immediate alternative habitat for species displaced when the woodland was felled. These points should be borne in mind for all twelve habitats under consideration.

Thus in the survey area as a whole 26% of the early area of deciduous woodland has been lost and the gain from other habitat types is 9%. The range of losses in Regions is from 19% to 36%. The range of gains is from 3% to 11%. The Regional gain is greater than 10% in only two Regions.

In the Districts, the range of loss is from 7.5% to 40%. Only two Districts are less than 10%. The range of gains is from 0.9% to 20%. The gains exceed 10% in only seven of the 24 Districts.

In every District except one, the losses exceed the gains. In Lanark there is a very small net change which completely masks the fact that there was both a gain and a loss of around 20%, but this District seems to be unusual. Overall then the picture is one of loss (losses are on average three times the gain) but it is encouraging that there are gains, albeit small, in every District. However there are doubts as to whether these gains will be equal in nature conservation value to the losses.

From Table 17 it can be seen that in the early period, deciduous woodland was the third commonest type and the most common of the Other habitat types in the whole survey area, and in most Regions and Districts. Now however it is the fourth commonest habitat type and the second most common Other habitat type. The area of coniferous woodland is now slightly greater than the area of deciduous woodland. This seems to be less because deciduous woodland has decreased than because coniferous woodland has increased by a very large amount. It is interesting that deciduous woodland is still the commonest habitat type in 12 Districts at the recent date. This is probably because the area of improved rough grassland, the second commonest type at the early date, has decreased by a greater percentage.

2. Net Changes in Coniferous Woodlands

In the whole survey area the area of coniferous woodland has risen from 30808ha to 84635ha or by 77%. In some Districts and Regions the area has more than doubled: e.g. Lothian Region 106% increase, Fife 158% increase, and in at least eight Districts. Range of Regional net gain: 57% to 158%.

All the Regional results are more reliable but only 14 of the District results are. Net changes in more reliable Districts are all greater than 10%. Range of District net gains: 46% to 340%. The second highest increase is 140%. It is interesting that Kirkcaldy, the District with the largest net gain in coniferous woodland was also the District with the largest loss in deciduous woodland.

If the gains and losses making up the ten less reliable net changes are observed (Appendix 2B) there are only four instances where the individual gain or loss is more reliable. In the other Districts the variation must occur between the sample frames.

If the individual losses and gains are considered per se, the gains seem even more dramatic with an area equivalent to 94% of the early area being planted in the whole survey area. In four of the Regions, the gain is greater than 100%. The complete range of gains is from 70% to 176%. There is much more variation in the Districts with increases as low as 25% and as high as 485%. In eleven of the 21 more reliable Districts the increase was more than 100%. However as in deciduous woodland the situation is not completely one-sided. The mean loss is 16.5% which although being less than one-fifth of the gain is still fairly substantial when compared with gains and losses in other habitat types. In all Regions the loss was greater than 10% with a range from 12% to 41%. Ten of the District results are less reliable. Of the remaining 14, ten are greater than 10%. The range of District losses is from 3.5% to 41%. In every District except two the gains exceed the losses. The distribution of gains and losses seems random: Districts with high net gains do not always have high net losses i.e. there is little evidence that the differences between Districts were caused by higher forestry activity in one District compared to another.

The overall net increase in coniferous woodland and increases in Districts and Regions are illustrated in Diagrams 3A and 3B. Overall coniferous woodland has risen from being the fifth largest type overall to the third largest. Of Other habitats this type was initially the third commonest (along with wetland) but it is now the commonest in the whole survey area. However it is only the commonest Other type in four of the seven Regions and in seven Districts. The net gain in the area of coniferous woodland is not only the largest net gain (relative to the earlier area) of any of the twelve habitat types but also the largest net change. The net increase of 23826ha is the second largest increase in terms of area.

3. Net Changes in Mixed Woodland

Here the situation is less clear cut compared to that of deciduous woodland and coniferous woodland. In the whole survey area the amount of mixed woodland has risen from 11823ha to 13824ha a net increase of 17%. However the majority of the Districts estimates and half the

Regional results are less reliable. Even if the results are considered as those of a 10% sample it is not easy to draw conclusions. Although the net change is greater than 10% in 16 Districts, in half the Districts there was a net gain and in half a loss.

Of the six more reliable Region and District results, four suggest a net gain and two a net loss. These net gains are far larger than the net losses.

If the individual gains and losses are considered there are still as few as five Regions and five Districts where both results are more reliable. If gains and losses are considered separately there are six Regions and thirteen Districts where losses are more reliable and six Regions and eleven Districts where gains are more reliable. Some conclusions may be drawn from these results.

The mean loss for the six Regions under consideration was 23% and in all Regions the loss was greater than 10%. The range of Regional losses is in fact narrow: 16% to 27%. The more reliable District losses are also all greater than 10% with as much as 55% lost.

The mean gain for the six Regions was 40%. Regional estimates were again all greater than 10% but the range is far wider: from 11% to 176%. This pattern is repeated for the more reliable District estimates: range from 10% to 1293%.

In the five Regions where both estimates are more reliable the gains exceed the losses in two Regions. Of the five Districts gains exceed the losses in only one District. It has been noted that the overall loss is lower and the range in losses narrower whereas overall gain is larger and the range wider. It is only where the gains are very large that they exceed the losses and this occurs in a minority of instances.

In conclusion, although the area of mixed woodland has increased overall, this situation is not emulated in all the Districts and Regions where the results are statistically more reliable. However this difficulty in drawing clear conclusions is not serious because overall mixed woodland is one of the more minor habitats: initially it was ninth largest and is now eighth largest. However it is an important type in some places. At the early period the area of mixed woodland was larger than that of coniferous woodland in five Districts. This is illustrated in Diagrams 3A and 3B. Now however coniferous woodland predominates.

4 Net Changes in Felled Areas

In the whole survey area the amount of felled areas fell from 9570ha to 8742ha i.e. there has been an average of more planting and/reclamation than felling. However as in mixed woodland results many of the individual Districts and Regional results are less reliable. Only two Regional results and nine District results are more reliable. And again, as in the mixed woodland, some of these results suggest a net gain and some a net loss. Although the overall net loss is 8.6% (less than the 10% required for a 'real' change) all the more reliable results are greater than 10%. The two more reliable Regional estimates, are both gains: 176% in Lothian and 186% in Fife. Of the District results there was a net loss in five of the Districts and a net gain in four. The range is from-62% in Berwick to +53% in North East Fife.

A consideration of the individual gains and losses clarifies the situation because the majority are more reliable. The mean gain and mean loss for the whole of the survey area are very large and an illustration of the limitations of considering only the net change. The overall gain was 81% and the overall loss 89%. The range in values of Regional gains was from 56% to 273%. Of the 18 Districts with more reliable gains the range was from 25 % to 274%. Losses in felled areas in the Regions ranged from 75% to 95%. In all 19 Districts had more reliable losses and these ranged from 58% to 106%. Two conclusions can be drawn from these results: firstly, in every District there are both losses and gains of more than 20% in the area of felled woodlands: secondly, that as in the mixed woodland changes, the range of losses is narrower than the range of gains though overall means are similar. Furthermore, in only two Districts losses exceed 100% whereas in five Districts the gains exceed 100%.

All seven Regions had both more reliable gains and more reliable losses. In five Regions the losses exceeded the gains. Of the 14 Districts with both gains and losses more reliable, in ten the losses are greater.

Thus although gains and losses are sizeable in all Districts, in most cases the losses are larger. The extent of this loss is fairly consistent through the Regions but felling i.e. gains are more variable in nature. There are more instances of really large gains than there are of losses and it is in those instances as with mixed woodland that gains exceed losses. On the whole the area of felled woodland has decreased. However not only was this habitat type the smallest in extent on both occasions, it is really a transitional category. It is by nature changeable; the impression gained from the aerial photographs themselves, is that only a few areas identified as felled at the early date were still felled at the more recent date. One cannot really comment on the seriousness of the greater area of reclamation than felling without knowing which categories have gained from this loss. The main importance of this category lies in reflecting the changes within the woodland area and its losses to the other habitat groups. These points will be considered further in Section 3.6.

Woodland: Summary of Net Change

From diagrams 3A and 3B it can be seen that the area of woodland actually increased over the whole survey area, in every Region and in nearly every District. Only in Tweeddale did the total area decrease whilst in the west coast Districts of Wigtown, Cunninghame and West Strathclyde the area remained the same. In the whole survey area the losses in deciduous woodland were almost equalled by the gain in mixed woodland. There was also a loss in the felled area therefore the reason for this increase in the woodland area lies almost wholly in the increase in coniferous woodland. At the earlier date deciduous woodland occupied the largest proportion of the woodland area in the whole survey area and all Regions. Now coniferous woodland is almost equal in extent to deciduous woodland over the whole survey area and exceeds it in four Regions: Borders, Fife, Dumfries and Galloway and Tayside. This pattern is repeated in the Districts - in about half the Districts coniferous woodland dominates the woodland area.

Areas of mixed woodland and felled areas are less significant than coniferous and deciduous woodland relative to the whole woodland area.

3.5.4 Net Changes in Scrub

The net change results for this habitat type are similar to the last two habitat types in being amongst the least reliable. Moreover, the overall change suggested by these results is extremely low at -3%. However this category is larger in extent than the last two: early area 14560ha, recent area 14105ha, and so is worthy of consideration. In addition almost every single District gain or loss is more reliable i.e. the cause of the variation lies almost completely in the combination of gains and losses.

A first glance at the net change data suggests a greater sampling intensity was necessary as there were only three Districts where the results were more reliable: Tweeddale, Falkirk and Clackmannan, and Stirling. In the first two of these Districts there were large net gains: 87% and 55% respectively and in Stirling a net loss of 24%. None of the Regional results were acceptable.

However in every single Region both the individual gains and losses are more reliable. The mean gain was 38% with a range of 31% to 57%. The mean loss was 41% and the losses ranged from 21% to 49%. In Districts every single gain is more reliable ranging from 13% (Berwick) to 114% (Tweeddale). It is interesting that these extremes of the gain range both occurred in one Region. Only two of the District loss results were less reliable. More reliable District losses range from 15% (Berwick) to 60% (Annandale and Eskdale). In Districts there were slightly more instances where the losses exceeded the gains. Again all gains and losses exceed 10%. The magnitude of losses is not generally correlated with that of gain. It is once more necessary to point out how little a net change of -3% reflects the picture of changes in this habitat type. Although the net changed area is the lowest of any habitat type at 455ha, a total area of over 11,000ha has been involved in scrub changes. Wildlife will be disrupted by both types of changes - for example, when scrub is removed there is a loss of suitable habitat for birds and when grassland succeeds to scrub interesting flowering plants may be lost.

In summary the gains and the losses almost balance each other in terms of area and so the net change is low. Although it is perhaps meaningless to consider net changes alone, a slight reduction in the total area of scrub is indicated. The individual gains and losses are all fairly substantial and cannot be ignored in an appraisal of scrub change. Not only are the effects of the gains and the losses different, they are spatially isolated i.e. gains will not necessarily provide alternate habitat for species affected by the losses.

In the same way that felled areas represent a transitional type within the woodland area, scrub is a transitional type between grassland types and full woodlands. However the origin of the felled areas is artificial whereas scrub arises naturally. Scrub gains may be important in indicating the degree to which land is being left free of man's influence.

3.5.5 Net Changes in Grasslands and Heathlands

1. Net Changes in Dwarf Shrub Heath

The early area of this habitat type was 5970ha which had dropped to 2338ha by the more recent date; a fall of 61%. However nearly all the District results are less reliable. The Regional results, of which only those from Lothian and Central need be discounted, show a range of net loss from 17% to 96%. The more reliable District results indicate losses of 35% to 98%.

If the individual losses are considered, 17 of the District losses are still less reliable but only one Regional result is. The mean loss is 70% with a Regional range of 46% to 96%. Most of the areas involved in the Regional losses are very small, less than 100ha but because the total area of dwarf shrub heath is low - amongst the lowest of all habitats - the proportion lost is relatively large compared with a similar change in one of the commonest habitat types. The same might be said of the seven more reliable District losses which range from 28% to 98%.

Dwarf shrub heath has not only undergone losses; there have been small gains in eleven Districts and four Regions. In the survey area as a whole the mean gain was estimated at 9.7%. However results are less reliable in eight Districts and two Regions. The remaining District gain results are 21% in Stirling, 17% in Lanark and 32% in East Strathclyde. In Central Region there was a gain of 16% and in Strathclyde Region 29%.

On the whole the District results are unreliable. This is not surprising considering that the estimates of early and recent extent of this habitat were the most unreliable of all habitats (Section 3.4.1). This variation is because of the low number of heath areas encompassed in the sample area. These ranged in size from small regenerating patches on wasteland to large areas in the vicinity of the moorland boundary. However the Regional results are more reliable and suggest a large loss in most Regions. This is serious because there is so little of the habitat left. There are small gains but they are on average one-sixth of the losses and cannot be considered to compensate for them.

2. Net Changes in Permanent Unimproved Grasslands

The loss of this habitat is slightly less dramatic than the loss of dwarf shrub heath. It has changed from being the rarest to the second most rare category whereas dwarf shrub heath changed from being the second most rare to the rarest. The initial area was estimated to be 4620ha and this has fallen to 2928ha, a drop of 37%. However whereas dwarf shrub heath is still present in nearly every District, permanent grassland is already absent from eight Districts and one whole Region. A further complication is added to these results in that in the first Districts covered before definitions were clarified and expertise in identification gained, some areas may have been allocated to this category in error. Later in the survey the interpreters may have erred more on the side of caution and permanent grassland may have been included in improved rough grassland. The Region to be surveyed last is the one from which permanent grassland is absent (Tayside). Notwithstanding this the fact that one-third of the Districts appear to be without permanent grassland is in itself fairly serious but at least no other District has been added to this category in the post-war period.

Again many of the results are less reliable even at the Regional level. The estimates of early and recent extent of permanent unimproved grassland were the second most unreliable so this is not surprising. There are only two more reliable District estimates of net change both of which are losses: 30% in Berwick and 34% in Roxburgh. The only more reliable Regional estimate is that for the Borders Region - a net loss of 27%. The individual gain and losses results are also unreliable, but the losses are mostly larger. Gains in permanent grassland are extremely unlikely, but there are some. These may be errors especially as they occur in the earlier Districts surveyed. These gains are all less reliable. Only one of the individual District losses is more reliable apart from those of Berwick and Roxburgh and that is a 7% loss in East Lothian.

The main conclusions about changes to permanent grassland have to be based on the results for the 10% sample area. An individual loss in area of 39% with a small gain of 2% results in a net loss of 37% which is less serious than in dwarf shrub heath. However losses are considerably larger in the sample area of some of the Districts and Regions, the highest being a 96% net loss in North East Fife and a 92% loss in Fife as a whole. In some ways the situation is more serious than in dwarf shrub heath in that the habitat is already extinct in places.

As regards total extent it was one of the rarer and least reliable types. Rarity and unreliability are probably closely related; the main conclusion to be drawn is that the depth of sampling here was not sufficient to cover all the variability.

3. Net Changes in Improved Rough Grassland

This habitat is about ten times more extensive in area than that of permanent grassland. At the early date it covered 44097ha but now covers only 28126ha, a drop of 36% overall. The reliability of the results is about the same as for the coniferous and deciduous woodland i.e. in 13 Districts and all seven Regions the estimates are more reliable. In all of these there is a net loss of more than 10%. The net losses in the Regions ranges from 17% to 58%. The range of District net losses is from 19% in West Strathclyde to 70% in Kyle and Carrick, both interestingly in the same Region.

If the individual gains and losses are considered, 14 of the gains are more reliable and 18 of the losses are more reliable and there are now ten Districts with neither a more reliable gain or loss. Of the eleven less reliable District net changes, both gains and losses are more reliable in two Districts; Stirling and Stewartry. In the others the losses themselves are too variable.

The individual mean loss is 42% with a range of Regional losses of from 22% to 68%. The range of District losses that are more reliable is from 23% to 72%. There are also gains in every District though they are usually of an order of magnitude less than the losses and only exceed 10% in three Districts and two Regions. The range of Regional gains is from 2% to 14% and the range of District gains from 3% to 17.5%. In the Districts where both gains and losses are more reliable the losses always exceed the gains.

Overall then there has been a marked loss in the area of improved rough grassland. In fact the net loss to this habitat is the largest reliable net loss of all habitats in terms of loss relative to the early area (though in the 10% sample area dwarf shrub heath and permanent grassland have lost greater proportions of their early area) and in terms of area; the reduction of 18446ha is the largest area lost from any habitat type. There is a small net gain, estimated to be about one tenth of this loss. Again new areas of a habitat are likely to be spatially separate from, and of less value than, the areas lost. At the early date improved grassland covered the second largest area of any Other habitat type in the whole area and covered the largest area in seven Districts and two Regions. More recently it has become only the third commonest Other habitat type overall, and only the largest in one District. This loss is substantial and must be considered to be one of the major changes.

4. Summary of Net Changes in Grassland and Heathlands

Diagrams 3A and 3B show how the total area of Grasslands and Heathlands decreased over the survey period in the whole survey area and in every District and Region. This decrease is far larger than the Woodlands increase in most areas. The Region most severely affected by this decrease is Fife, particularly the Districts of North East Fife and Dunfermline, where over half the former area was lost. Three Districts now have less than 1% of their total lowland area under grassland; these are Dunfermline, Falkirk and Clackmannam, and Kyle and Carrick. The initial proportion of this habitat group was generally less in the west coast Regions; the decreases may be more serious there. The relative proportions of the three habitat types to each other remain similar at both dates though the small areas of permanent grassland and dwarf shrub heath may be disappearing at a faster rate than improved grassland.

3.5.6 Net Changes in Freshwater Wetlands

1. Net Changes in Wetland

At the early date wetland covered 29777ha and now covers 25618ha - a drop of 13%. However many of the net changes in the Districts and Regions are less reliable. Only the results for three Districts and two Regions can be used in an appraisal of net change. In all of these there was also a net loss. All three of these Districts are in Strathclyde Region; there was a loss of 4.3% in Kyle and Carrick, 20% in Cumnock and Doon Valley, 17% in West Strathclyde and 20% in the Region as a whole. In Dumfries and Galloway there was a smaller loss: 13%.

Fortunately the individual gain and loss results were more reliable; overall there were twelve Districts and six Regions in which both gains and losses were more reliable. Together they suggest a loss of 26%. In six Regions and fifteen Districts the losses were more reliable. The Regional range of losses was from 4.5% to 31%. The Borders was the only Region with a loss of less than 10% and only one of the more reliable District loss estimates was for less than 10%. The maximum loss incurred by any District was 48%. Perhaps surprisingly, there have also been gains to the area of wetland in every District. The overall gain was estimated at 13% and only two of the Regional estimates were less than 10%. All the Regional gains are more reliable, these range from 8% to 25%. In all but two of the fifteen Districts where both gains and losses are more reliable, the losses exceed the gains, Finally it is worth considering the net change results for the 10% sample area to clarify the picture. In nine Districts there was a net gain and in fifteen a net loss. Four of the net gains are greater than 10% and eleven of the net losses are.

On the whole the picture is one of loss. The net loss is itself fairly substantial at 13% but the actual area of wetland which has been lost is double this. This is because there are also gains, which are overall only half the extent of the losses, but do exceed the losses in a few Districts. Overall this habitat initially occupied the third largest proportion of the Other habitat area, being equal in extent to the area of coniferous woodland and was the major Other habitat in three Districts and in one Region. More recently, with the large increase in the area of coniferous woodland it has become the fourth commonest Other habitat type but is still the major Other habitat in four Districts. Though common in some Districts, it is extrememly rare in other Districts and there the losses will be more serious.

2. Net Changes in Open Water

The total area covered by open water is fairly small, however this is because the individual units, e.g. rivers and ponds are small, for it is a habitat type present on nearly every photograph. The initial area was estimated to be 13599ha and this fell by 4% to 13031ha.

Again the net change results are very unreliable with only two District results more reliable and no Regional results more reliable. These results are a loss in North East Fife of 8.5% and a loss in West Strathclyde of 2%. In the 10% sample area only four of the District results and none of the Regional results were greater than 10% so the change is fairly insignificant

More of the individual gain and loss results are reliable but there are still as few as six Districts where both are.

In fourteen Districts and in all seven Regions the individual losses are more reliable. There is overall an estimated loss of 6% with a Regional range of 1% to 11%. Only one Region and two Districts had losses of more than 10%. The lowest District loss was 0.2% and the greatest 26%.

Fewer of the gains are more reliable: in eight Districts and again in seven Regions. Overall they suggest a gain of 2% with a range of 0.5% to 3.3% in the Regions and 0.2% to 8% in the Districts i.e. all are less than 10%. In the six Districts where both results are more reliable there were losses in two Districts, gains in two Districts and no change in two Districts.

Thus for the whole survey area there are not enough results to draw conclusions about the main direction of the change, but it can be said that the change is minor. The results for the 10% sample area suggest a small loss. In the survey area as a whole this type occupies the fourth lowest proportion of any habitat type but it is in fact equal in extent to mixed woodland and scrub. It does not seem to be as seriously affected by change as those two types.

3. Summary of Net Changes in Freshwater Wetlands

Diagrams 2A - 2C portray the relative proportions of the two habitat types at the two dates of photography. In the survey area as a whole and in all the Regions, the total extent has altered very little. In addition the proportions of the two habitat types remain the same: there was twice as much wetland as open water. In some of the Districts, especially those on the west coast, there have been more notable differences but again only to the total proportions of both types, the relative proportions of each remaining similar.

3.5.7 Summary of Net Changes in Other Habitat Types

Diagrams 2A -2C portray the relative proportions of the four Other habitat groups and the net change to them.

In the survey area as a whole, in all Regions and in every District except Stirling, the total area of Other habitats has decreased. The total proportion of Woodland has actually increased, the amount of Freshwater Wetlands decreased by a lesser amount than this increase, and so the main reason for the overall decrease appears to be decrease in the area of Grasslands and Heathlands.

However it is worth recalling that although there has been a small increase in the area of woodland this is mostly due to an increase in the area of coniferous woodland. There is good evidence for a fall in the area of deciduous woodlands, Although all the Grassland types have decreased, the limited evidence suggests dwarf shrub heath and permanent grassland are more seriously affected being smaller in extent. However the well substantiated decrease of 36% in the area of improved grassland is of major importance in that it represents the largest area of any habitat type (15971ha) to be lost.

Within the Districts the picture is fairly similar i.e. in most the reduction in the area of Grasslands is the most serious feature. However in the west coast Districts where Grasslands are often less common than on the east coast, the Wetlands types often suffered a greater decrease.

3.5.8 Net Changes in Agricultural Land

Although estimates of the early and recent extent of agricultural land were amongst the most reliable, estimates of net change are amongst the least reliable. The reasons for this again appears to be that there are gains and losses of similar extent.

This is by far the largest habitat type: the early area was estimated at 1027070ha and the more recent area at 1015261ha. Overall there has been the smallest net change relative to the early area: a net loss of 1.2% but this represents 11800ha which is actually larger than the area of deciduous woodland lost and second only to the loss in area of improved grassland.

The four more reliable Regional results for net change range from -7% to +0.7%. The changes in the six more reliable Districts range from -14% to +1.6%. Only two of these ten results are greater than 10%.

Most of the individual gain and loss results are more reliable. The results for the 22 Districts and all seven Regions with more reliable gains suggests an overall gain of 2%. The range of Regional gains was from 1.4% to 3%. There is a slightly wider range of District gains from 0.9% to 5.5%. Losses are more reliable in 20 Districts and all Regions. These results suggest an overall loss of 3% with a Regional range of from 1.2% to 8.6% and a range of District losses of from 0.3% to 14.8%. Only two Districts changed by more than 10% in all the gain and loss data. Although the remainder of the changes are small in terms of the percentage they are extremely large in terms of area, so cannot be discounted.

In all Regions and 20 Districts both gains and losses are more reliable. In the Regions the losses exceed the gains in four instances and in the Districts in ten instances. In summary there are both gains and losses in the area of agricultural land. Although in exactly half the Districts and Regions there has been a net gain and in the other half a net loss, in the areas where there has been a net loss the losses are of far greater extent than the net gains and so overall the area of agricultural land has decreased. This result was completely unexpected in the light of the NCC's main objective of measuring the gains to agricultural land from wildlife habitats. However although the losses in the total agricultural area exceed the area of gains by nearly 12000ha the gains are themselves sizeable. If the estimated gain in area of 21479ha was all at the expense of habitats of wildlife interest this would be serious. This will be studied further in Section 3.6.

3.5.9 Net Changes in Non-Agricultural Land

This was the second largest habitat type at both dates of photography. The post-war area was 112443ha and this rose to 136941ha over the survey period, an increase of 22%.

The results are mostly reliable with more precise estimates in 13 Districts and all but one Region. Net gain in the Regions ranged from 8.4% to 43%. Only one Regional gain was less than 10%. Net gains in the Districts ranged from 4% to 66%. Altogether three estimates were less than 10%.

However the change is not unidirectional; there have also been losses in every District. The individual loss and gain data is again more reliable than the net change data. Reliable losses were recorded in sixteen of the Districts and six Regions and overall suggest a loss in area of 5%. District losses range from 1% (Berwick, Stewartry) to 15% in Nithsdale and Regional losses from 2% in the Borders to just over 10% in Dumfries and Galloway. However losses of greater than 10% occurred only in two Districts, the other one being Dunfermline.

The individual gain results suggest an area of land equal to 27% of the early non-agricultural area has been gained. All the Regional results are more reliable and greater than 10%: they range from 11% to 48%. Twenty of the District gains are reliable ranging from 2% to 68%. Only four gained less than 10%, all were Agricultural Districts.

In the thirteen Districts where both gains and losses are more reliable the gains are larger in all but two Districts. Overall there has been a large gain in non-agricultural land in terms of both absolute and relative areas. This gain of 24498ha is the largest areal gain to any of the 12 habitat types, larger even than the gain in coniferous woodland. However the picture is not completely one-sided, areas have been lost from non-agricultural land. In total this area is less than one fifth of the gain and in most Districts less than 10% of the early area. It does however represent a fairly sizeable area and if this has not been all reclaimed to agriculture it may represent new habitats for wildlife.

3.5.10 Summary of the Net Changes in the Area of Agricultural Land, Non-Agricultural Land and Other Habitats

Diagram 1 portrays the relative proportions of agricultural land, non-agricultural land and Other habitats at the early and recent dates of photography.

From Diagram 1A, which shows the proportions of the whole survey area and the Regions, it can be seen that in the whole survey area the area of agricultural land decreased by 1%. the area of Other habitats decreased by 1% and the area of non-agricultural land rose by 2%.

There is some variation between the Regions however. In the Agricultural Regions of Dumfries and Galloway, Borders and Tayside the area of land under agricultural use remained the same or declined by 1%.

In the Industrial Regions of Central and Strathclyde there was a greater than average decrease in the area of agricultural land and an increase in the non-agricultural area. Only the area of Other habitats consistently declined: by 1 - 2% in all Regions.

The pattern is repeated in the Districts though there are some more extreme examples. In Kirkcaldy there was a 9% decline in the agricultural proportion of the lowland area and a 9% increase in the non-agricultural proportion and there were similar changes in East Strathclyde and Falkirk and Clackmannan. In most Districts however the difference between the early and recent proportions of the three land-use groups varied by only 1 - 2%.

3.5.11 The Main Net Changes

With some habitat types a greater sampling density would be necessary to clarify the results for the whole survey area. These are:- mixed woodland, dwarf shrub heath, permanent unimproved grassland, and open water. However all these results are valid for the 10% sample area and give an indication of the relative changes in the rest of the lowland areas. With other habitat types the source of the net change unreliability lay in the combination of the individual gains and losses. Examples of this situation are scrub and agricultural land.

It is necessary to draw conclusions as to which are the most important changes out of this myriad of results. Two definitions of a 'main' change are used here.

1) Where a large area of the habitat has changed.
2) Where a large proportion of the previous area has changed.

A third type of important change could be the situation where the remaining area of the habitat is small and so any change is crucial. This would apply to permanent grassland and dwarf shrub heath, but the results for these habitats were on the whole unreliable.

Using the two definitions of main change above the following lists of the most affected habitat types were drawn up. In these the changes were subdivided into those which were well substantiated and those which were not. In terms of area a main change is taken as being greater than 10,000ha, and in terms of proportion; greater than 15%.

1. '<u>Main' changes in terms of the absolute area of change</u>

Well substantiated net gains	Non- agricultural land	+244978ha
	Coniferous woodland	+23826ha
Well substantiated net losses	Improved rough grassland	-15971ha
	Agricultural land	-11810ha
	Deciduous woodland	-11208ha
Well substantiated individual gains	Non-agricultural land	+30068ha
	Coniferous woodland	+28922ha
	Agricultural land	+21479ha
Well substantiated individual losses	Agricultural land	-33288ha
	Improved rough grassland	-18446ha
	Deciduous woodland	-17872ha

It can be seen that all net changes of greater than 10,000ha in extent are more reliable.

2. '<u>Main' changes in terms of relative area of change</u>

Well substantiated net gains	Coniferous woodland	+ 77%
	Non- agricultural land	+ 21%
Unreliable net gains	Mixed woodland	+ 17%
Well substantiated net losses	Improved rough grassland	- 36%
	Deciduous woodland	- 17%
Unreliable net losses	Dwarf shrub heath	- 61%
	Permanent unimproved grassland	- 37%
Well substantiated individual gains	Coniferous woodland	+ 94%
	Felled areas	+ 81%
	Scrub	+ 38%
	Non-agricultural land	+ 27%

Unreliable individual gains	Mixed woodlands	+ 40%
Well substantiated individual losses	Felled areas	- 90%
	Improved rough grassland	- 42%
	Scrub	- 41%
	Deciduous woodland	- 26%
	Coniferous woodland	- 16%
Unreliable individual losses	Dwarf shrub heath	- 70%
	Permanent unimproved grassland	- 39%
	Wetland	- 26%
	Mixed woodlands	- 23%

It can be seen that a consideration of individual gains and losses yields more 'main' changes. These often cancel each other out when combined to make net change - for example with felled areas and scrub.

The net changes which appear 'main' in both analyses may be considered to be the major changes. These are:

Net gains to non-agricultural land and coniferous woodland.
Net losses to improved rough grassland and deciduous woodland.

In the previous sections the variation in the magnitude of the various changes in the Districts and Regions has been described. Some changes, not considered major for the whole survey area may still be critical at the local level. Diagrams 1 - 3 illustrate the variations in the proportions of the habitat groups at the two dates of photography for all Districts and Regions.

The habitats vary in their importance for wildlife. A fourth type of major change might be one where a habitat of greater ecological value has been altered.

The main changes in all the Districts and Regions have been identified using the same criteria as was used above for the whole survey area. These are presented in Appendix 3. In fact the four major changes identified above never occur together in any one District, and are only found together in one Region (Fife). In all fewer Districts results can be considered major; this is because they are less reliable. In some Regions the net gain in the area of non-agricultural land is not major. These are Borders, Dumfries and Galloway and Tayside. In Strathclyde the loss of wetland is also considered major and in Lothian, Central and Strathclyde the loss of deciduous woodland is not major. Central is the only Region where loss of improved grassland is not major.

3.6 INTERCHANGE

3.6.1 Reliability of Interchange Results

In Table 26 of the NCC computer print-out there is a breakdown of the changes in every District and Region. This is displayed in a two-way format:- Donor Type A to Recipient Type B. The dimensions of this table are 12 x 12. This breakdown will henceforth be referred to as 'Interchange'.

In theory there are 125 changes but in practice only 114 ever occur with a maximum of 90 in a Region and fewer in the Districts.

The reliability of individual changes has been assessed using the same criteria employed in Section 3.2 to assess the reliability of gains and losses (a more reliable estimate has a 95% confidence interval of less than twice the estimate). These have been collated to compare the reliability of interchange results in the Districts and Regions and to compare the reliability of the different habitats results.

Table 22A shows the number of more reliable change estimates as a proportion of the total number of estimates in every Region. Table 22B displays the same information for the Districts, within one of the more reliable, and one of the least reliable, Regions identified in Table 22A.

The maximum number of changes occurring in a Region is 90 - in both Dumfries and Galloway and Strathclyde. Not only do these larger Regions have more estimates, they also have a higher proportion of more reliable estimates. At best, two-thirds of the Regional results are more reliable, and at least, a third. In the whole area just under one half of the

TABLE 22A: Comparison of the Reliability of Regional Interchange

Region	Total number of 'less reliable' changes	Total number of changes	'more reliable' proportions %
Borders	58	87	33
Lothian	47	68	31
Fife	42	71	41
Central	52	81	36
Dumfries & Galloway	37	90	59
Strathclyde	35	90	62
Tayside	47	79	41
Total	318	566	44
Mean	45	81	

TABLE 22B: Comparison of the Reliability of Interchange Results of Districts in a more reliable Region and the least reliable Region

District	Total number of 'less reliable' changes	Total number of changes	'more reliable' proportions %
East Lothian	44	50	12
Midlothian	41	47	13
West Lothian	34	37	8
Total	119	134	11
Mean	40	45	
LOTHIAN	47	68	31
Annandale & Eskdale	53	70	24
Nithsdale	43	67	36
Stewartry	43	67	36
Wigtown	41	55	26
Total	180	259	31
Mean	45	65	
DUMFRIES & GALLOWAY	37	90	59

individual regional changes can be estimated more reliably.

Of the two Regions in Table 22B, the Districts in the least reliable Region have very few precise results (about 10%) whereas about one-third of the results in the Districts of the more reliable Region are precise. In the former, three times as many of the Region estimates are more reliable compared to the District estimates and in the latter twice as many are more reliable.

In the Districts fewer of the 132 possible changes occur - a mean of 45 in the Lothian Districts and 65 in the Dumfries and Galloway Districts compared to a mean of 81 in the Regions.

Thus it can be seen that there is an improvement in the reliability of results if the Regional results are considered rather than the District ones. However as has already been noted less than half of all the Regional interchange results are reliable. The most reliable information about interchange will be obtained by summing all the Regional results.

Table 23 illustrates the proportion of reliable gains and losses out of the total number of Regional estimates for each habitat type. The habitat type for which there are the highest number of reliable gains is, perhaps surprisingly, felled areas. In only five of the twelve habitat types are there more more reliable than less reliable gains. The other four are: deciduous woodland, coniferous woodland, scrub, and agricultural land. The most unreliable gains are those for the three Grassland and Heathland types and in fact, none of the permanent grassland results are more reliable. The habitat type for which there are the highest number of more reliable loss results is deciduous woodland. In Regions only four habitat types have more reliable than less reliable losses. The other three are: scrub, improved grassland and agriculture. The least reliable habitats are open water and again permanent grassland. Thus the data for the four major changes identified at the end of Section 3.5 are mostly reliable except for the non-agricultural changes. Taking gains and losses together there are only four habitat types where more than half of the interchange data is more reliable. These are deciduous woodland, felled areas, scrub and agriculture.

TABLE 23: Proportions of 'More Reliable' Regional Interchange Results for each Habitat Type

	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land
'Less reliable' number of gains	27	24	35	9	32	14	7	46	39	22	30	36
Total number of gains	58	64	56	26	69	17	7	56	51	30	68	68
'More reliable' proportion	5.4	6.2	3.7	6.5	5.4	1.8	0.0	1.8	2.4	2.7	5.6	4.7
'Less reliable' number of losses	17	34	30	29	26	27	19	22	30	31	16	30
Total number of losses	61	49	45	56	55	41	24	51	49	37	46	47
'More reliable' proportion	7.2	3.1	3.3	4.8	5.3	3.5	2.1	5.7	3.9	1.6	6.5	3.6
Mean 'More reliable' proportion	6.3	4.9	3.6	5.4	5.3	2.9	1.6	3.6	3.1	2.1	6.0	4.3

It is likely that there would be even lower proportions of more reliable results at the District level. The most reliable information about interchange is likely to be achieved by summing all the results. Table 24 presents this summary data. These results will apply only to the survey area as a whole; it will be less easy to appreciate the variability between the Districts. As a compromise the interchange results for the seven Regions have been presented in Appendix 4 with the less reliable changes clearly marked.

Even when using only the totals of the Regional Interchanges, the figures are not completely reliable. Moreover the degree of reliability varies from habitat to habitat. At one extreme are results where nearly all the constituent Regional data were unreliable and at the other extreme are the more reliable habitat changes listed above. It has already been pointed out that the results for three of the four major changes (coniferous woodland gains, and losses of deciduous woodland and improved grassland) are for the most part reliable. In order to indicate the reliability of changes between the two extremes the results in Table 24 have been marked as follows:

** Completely unreliable: 75 - 100% of Regional estimates less reliable
* Unreliable : 50 - 75% of Regional estimates less reliable
(No mark) Reliable : 50% of Regional estimates less reliable

Those completely unreliable results will give an indication of the situation in the 10% sample of the whole survey area. However the use of these indicators enables the reliability of the results to be judged for the whole area.

When Table 24 and the reliability indicators are taken together it can be seen that there is a relationship between the size of the change and its reliability. All changes of greater than 1000ha (except two:- dwarf shrub heath and permanent grass to coniferous wood) have been judged reliable. In addition a quarter of the changes between 100 - 1000ha are more reliable but only one below 100ha is more reliable. The major changes, in terms of size, will be the estimates in which most confidence can be placed.

TABLE 24: Summary of Areas of Interchange in the Whole Survey Area (hectares)

New Type / Old Type	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land	Total Losses
Deciduous Woodland		5723.9	2280.7	3976.1	1289.5	4.5	** 29.3	350.5	* 125.1	** 9.4	1781.9	1301.6	16872.0
Coniferous Woodland	* 141.2		** 847.3	2946.2	** 183.5	** 24.4	** 11.0	** 200.5	** 27.5		* 489.5	** 224.3	5095.4
Mixed Woodland	** 139.3	1214.1		769.1	* 133.3			** 24.1	** 7.7		** 391.9	** 71.4	2751.0
Felled Areas	861.6	5328.3	** 449.9		* 265.6	** 3.2		** 295.2	** 8.7	** 3.4	1109.1	222.1	8547.1
Scrub	2503.1	881.1	** 221.3	** 23.6		** 55.8	** 10.6	547.9	** 54.0	** 1.5	1291.0	412.6	600.3
Dwarf Shrub Heath	* 205.7	2360 **	** 82.2		** 121.3		** 32.9	** 455.9	** 12.4		** 852.5	** 91.7	4215
Permanent Unimproved Grassland	** 36.7	** 1247.6	** 2.0		** 126.0	** 3.4		** 172.6	** 23.4	** 2.2	** 160.9	** 6.7	1782
Improved Rough Grassland	961.0	7216	** 521.7		1326.6	** 352.2			** 556.5	** 24.5	6532.9	* 954.7	18446
Wetland	183.5	1494.7	** 173.3		* 227.1	* 76.1		* 335.2		** 47.0	* 5021.9	** 399.3	7958
Open Water	* 17.7	** 12.7			** 22.8		** 1.9	** 28.8	* 275.1		** 117.3	** 368.7	845
Agricultural Land	* 326.6	3161.8	** 80.5		849.2	* 50.6		** 17.6	2669.6	116.3		26015.2	33287.4
Non-Agricultural Land	* 288.0	* 282.0	** 95.3		1003.4	** 12.1		** 45.9	** 42.8	** 72.0	3729.2		5570.7
Total Gains	5664.4	28922.2	4754.2	7715.0	5548.3	582.3	85.7	2474.2	3802.8	276.3	21478.1	30068.3	105969.9

6002·

11372·1

(0·3 rounding error?)

** Completely unreliable
* Unreliable
No mark Reliable

3.6.2 The Main Interchange Results

In this section the origins and destinations of the main habitat net changes summarised in Sections 3.5.11 will be described. If an individual change, which is not a component of the main change, is similar in magnitude to one of the components, it will be included in this appraisal. The results for the whole survey area are presented in Table 24, expressed in terms of absolute area, and in Table 25, expressed as proportions of the total area of change.

1) Woodlands

a) Deciduous Woodland

Loss of deciduous woodland was one of the major changes in terms of both the area and the proportion of the old area lost. The largest recipient habitat types are: coniferous woodland, which gained over a third of the deciduous woodland lost, felled areas which gained one-quarter of the lost area and mixed woodland which gained one-seventh. Just over 10% of the area lost has gone to agricultural land. Every other habitat type has gained at the expense of deciduous woodland but these gains are all less than 10% and unreliable apart from the loss to non-agricultural land. Over 1000ha of deciduous woodland has been turned to non-agricultural use.

As the second largest recipient class was felled areas it is unclear what will be the eventual use of this land. Some light may be shed on this when the losses from felled areas are considered further on.

Though not a major change it was interesting to note a 9% gain in the area of deciduous woodland. Almost a half of this is at the expense of scrub i.e. a natural succession. One-sixth of the gain came from improved grassland and another sixth from felled areas. Again all the other habitat types have donated land to deciduous woodland, even coniferous woodland.

b) Coniferous Woodland

The gain in the area of coniferous woodland was one of the major gains in terms of area gained and the largest gain of any relative to the previous area of the habitat. The largest donor class is not, surprisingly, deciduous woodland but improved rough grassland. Over

TABLE 25: Interchange Areas (from Table 24) expressed as Proportions of the Total Changed Area (105970 hectares)

	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land
Deciduous Woodland		5.14	2.05	3.57	1.16	0.00	0.03	0.3	0.11	0.01	1.6	1.17
Coniferous Woodland	0.13		0.76	2.64	0.16	0.02	0.01	0.18	0.02	0.00	0.44	0.20
Mixed Woodland	0.12	1.09		0.69	0.12			0.02	0.01		0.35	0.06
Felled Areas	0.77	4.78	0.40		0.24	0.00		0.26	0.01	0.00	1.00	0.20
Scrub	2.25	0.79	0.20	0.02		0.05	0.01	0.49	0.05	0.00	1.16	0.37
Dwarf Shrub Heath	0.18	2.11	0.07		0.11		0.03	0.41	0.01		0.76	0.08
Permanent Unimproved Grassland	0.03	1.12	0.0		0.11	0.00		0.15	0.02	0.00	0.14	0.01
Improved Rough Grassland	0.86	6.47	0.47		1.19	0.32			0.49	0.02	5.86	0.86
Wetland	0.16	1.34	0.16		0.20	0.07		0.30		0.04	4.5	0.36
Open Water	0.02	0.01			0.02		0.00	0.02	0.25		0.10	0.33
Agricultural Land	0.29	2.84	0.07		0.76	0.04		0.02	2.40	0.10		23.4
Non-Agricultural Land	0.26	0.25	0.08		0.90	0.10		0.04	0.04	0.01	3.35	

one-quarter came from that source, a fifth from deciduous woodland and 18% from felled areas. Another unexpected result is that the fourth largest donor class (11%) was agricultural land. Again coniferous woodland has gained from all other habitat types but they each contribute less than 10% of the total gain. The gains from mixed woodland and wetland are both greater than 1000ha and reliable.

One of the main individual losses was the reduction in the proportion of coniferous woodland (17%). Over half of the area was felled. The rest of the results here are unreliable but in the 10% sample area, 17% of the area of coniferous woodland lost became mixed woodland, and just under 10% went to agricultural use. All other classes, except open water, gained small amounts from coniferous woodland. The possible future uses of felled areas will be discussed in 1 d).

c) Mixed Woodland

The net gain in the area of mixed woodland relative to the previous area (17%) was one of the main, but unsubstantiated net changes. The individual gains and losses were also deemed main, but likewise unreliable. Almost half of the gain comes from deciduous woodland. This is the only reliable constituent of the total gain. The rest of the donor information is descriptive of the sample area only: just under one-fifth of the mixed woodland gain came from felled areas and just over 10% from improved grassland.

Of the losses only two figures are reliable for the whole survey area: just under one half of the area lost has become coniferous woodland and over one-quarter has been felled. In the sample area only, a further 14% has been lost to agriculture.

Although it is possible for all habitat types except open water, to be changed to mixed woodland, mixed woodland never changes to dwarf shrub heath, permanent grassland or open water.

d) Felled Areas

Though the net change in this area was not among the main changes the individual gains and losses were, when compared to the early area of the type.

The losses from felled areas also have relevance when considering changes to the previous three habitat types. One-quarter of the areas lost from both deciduous woodland and mixed woodland had been felled and over a half of the coniferous woodland lost. However there are problems with this approach. The destinations of losses from felled areas between the 1940's and the 1970's may well be different from future destinations. It is possible for example, that, in the present economic climate, greater proportions could be planted with conifers than in the past. Secondly, the early felled area also included land gained from the other woodland classes apart from that under consideration: it is possible that the recipient classes from felled areas might be related to the earlier use; an ex-coniferous area may be more likely to be replanted with conifers. For both these reasons the use of the felled area losses as an indicator of the destination of lost woodland is only of partial assistance. Nonetheless it is considered to be a worthwhile analysis.

Almost two-thirds of the land lost from felled areas has been planted with conifers, 13% has gone to agriculture and exactly 10% was planted with deciduous species. If these proportions are maintained then altogether 2.5% of the land lost from deciduous woodland will revert to deciduous woodland but over one-third of the land lost from coniferous woodland will return to coniferous use. The other losses are all less than 10% and unreliable. However in the sample area, it can be said that 5% of the area lost from felled areas was planted with mixed species i.e. just over 1% of the area lost from mixed woodland is likely to return to mixed woodland.

The gains to felled areas, not unexpectedly, all come from the three woodland types with small but unreliable amounts from scrub in most Regions. Over half of the areas felled were deciduous woodland, 38% was coniferous wood and about 10% was mixed woodland.

2. Scrub

The net change to scrub was neither major nor reliable but the individual gains and losses were amongst the most reliable of the net changes in terms of their proportions of the previous area.

The main loss is to deciduous woodland (40%) but a fairly large proportion, a fifth, has been put to agricultural use; 15% has gone to coniferous woodland and just under 10% to improved rough grassland.

One quarter of the scrub gain is from improved grassland and slightly less comes from deciduous woodland, 18% of the gain is from non-agricultural land and surprisingly, 15% from agriculture. There have been losses and gains from and to all other habitat types but they are all less than 10% of the total loss or gain and unreliable.

3 Grasslands and Heathlands

a) Dwarf Shrub Heath

The proportion of the early area of dwarf shrub heath which was lost was one of the largest, but also one of the least reliable, net changes. All of the constituent losses are similarly unreliable. For the sample area the following conclusions may be drawn: that over half the area was planted with conifers, one-fifth was turned to agricultural land, and 10% became improved grassland. There was also a small gain in area (again unreliable). The main donor class was improved grassland which accounts for two-thirds of the gain, with just under 10% coming from scrub. Small amounts are again gained from or lost to most of the other habitat types.

b) Permanent Unimproved Grassland

The proportion of permanent grassland lost qualified it as one of the main net losses but as with dwarf shrub heath this loss was very unreliable. Again all the constituent losses are unreliable. In the 10% sample area over two-thirds of the area lost became coniferous woodland and 10% was improved. The third largest recipient class gaining just under 10% was agricultural land. There were also some very small gains, chiefly from woodland or scrub, which were again unreliable.

Though the major recipient class from both dwarf shrub heath and permanent grassland was conifer woodland, both these donations to this class are less than 10% of the coniferous woodland gained.

c) Improved Rough Grassland

This habitat suffered the major substantiated net loss in terms of both area and relative area. The main destination of this habitat loss was coniferous woodland (40%), and one-third of the area lost became agricultural land. The other losses are all less than 10% and all (except those to deciduous woodland and scrub) are unreliable.

There have been small gains in area but these gains are in total smaller than the two individual losses. Most of the results are inaccurate except for the gains from scrub and deciduous woodland. The former loss makes up just over one-fifth of the improved grassland gain and dwarf shrub heath is just under one-fifth. Deciduous woodland and wetland each contribute about 14% to this gain.

4 Freshwater Wetlands

a) Wetland

Though the net loss was neither main nor reliable, the individual loss was among the main losses (but was still unreliable). The major destination of this loss is for the first time agricultural land to which almost two-thirds goes, but this result is unreliable. An 18% loss to coniferous woodland is more reliable. The rest of the losses are unreliable and under 10%.

Of the gains, the main donor class was, interestingly, agricultural land which lost over two-thirds of the area gained. The gain estimate is more reliable than that of the area lost but is just over half its extent. This was the only reliable gain to wetland and the only gain of more than 10%.

b) Open water

The total gains and losses are both very small and the constituent changes very inaccurate.

5 Agricultural land

The net loss in the area of agricultural land was one of the main areal losses but this was not a very large proportion of the early area of agricultural land. The gain in area, though only two-thirds of the loss was also sizeable (over 20,000 ha). This gain in area is likely to be of much interest to the NCC.

Almost one-third of the gain comes from improved rough grassland and almost one-quarter from wetland, although this last result is only reliable in the 10% sample of the whole area. However, the third largest donor class with exactly one-sixth of agricultural land gained is non-agricultural land. None of the other habitats donate more than 10% of this gain but over 1000ha was gained from each of deciduous woodland, felled areas and scrub and all of these last three estimates are reliable. All of these changes except the gain from non-agricultural land should give cause for concern to the clients.

The losses from agricultural land, which are greater than the gains are also of interest. Almost 80% of the lost area, a massive 26,000ha, has gone to non-agricultural use, the largest individual change of all. Three other losses are large in terms of area and reliable: just under 10% to coniferous woodland, 8% from wetland and just over 2% to scrub.

6 Non-Agricultural Land

The net gain to non-agricultural land is one of the major net gains in terms of area relative to initial area, and the largest in terms of absolute area. The greatest proportion of this gain (86%) is from agricultural land, already identified as the major individual change of all. The other major losses to this class are all under 10% and inaccurate. The largest area lost is 1302ha from deciduous woodland or 4% of the total gain. This is the only more reliable result.

There is also a small percentage of loss but fairly large in terms of area - 5570ha. Two-thirds of this has been lost to agriculture and 18% has become scrub. These are the only two reliable estimates and the only two losses of more than 10%, though most of the habitat types, except permanent grassland, have gained from non-agricultural land.

3.6.3 Summary of Main Interchange

The best summary of the interchange results is Table 25 where the areas have been converted to percentages of the total changed area. From this it is possible to construct a league table of the twenty-one largest changes. These changes all account for 1% or more of the total changed area (or>1000ha). Those marked (*) are unreliable. They are presented in Table 26.

TABLE 26: Major Individual Changes

Change				Percentage of total change
1	Agricultural land	→	Non-Agricultural land	23.5
2	Improved grassland	→	Coniferous woodland	6.5
3	Improved grassland	→	Agricultural land	6.0
4	Deciduous woodland	→	Coniferous woodland	5.0
5	Felled areas	→	Coniferous woodland	5.0
6	Wetland	→	Agricultural land	4.5*
7	Deciduous woodland	→	Felled areas	3.5
8	Non-agricultural land	→	Agricultural land	3.5
9	Agricultural land	→	Coniferous woodland	3.0
10	Coniferous woodland	→	Felled areas	2.5
11	Scrub	→	Deciduous woodland	2.0
12	Deciduous woodland	→	Mixed woodland	2.0
13	Deciduous woodland	→	Agricultural land	1.5
14	Wetland	→	Conifer woodland	1.5
15	Improved grassland	→	Scrub	1.0
16	Deciduous woodland	→	Non-agricultural land	1.0
17	Deciduous woodland	→	Scrub	1.0
18	Scrub	→	Agricultural land	1.0
19	Permanent grassland	→	Coniferous woodland	1.0
20	Mixed woodland	→	Coniferous woodland	1.0
21	Felled areas	→	Agricultural land	1.0

* Less reliable result

Together the twenty-one changes out of 114 constitute almost 80% of all the change detected.

The largest individual change, of agricultural land to non-agricultural land, which constitutes almost one-quarter of the total changed area, is not one which could be considered to have consequences as far as nature conservation is concerned. The second largest change which is considerably smaller and only about one-quarter the area of the first one; from improved grassland to coniferous woodland, is more serious in terms of nature conservation. Three of the top five changes are gains to coniferous woodland. Together they account for 15% of all interchange. Most of the top ten changes suggest a reduction in value for wildlife, except the first and the ninth. The first has been mentioned and the ninth may represent a gain for wildlife. The first definite improvement for wildlife is the eleventh change (scrub → deciduous woodland). How serious these changes are in terms of wildlife conservation will be considered more fully in Section 3.

Perhaps the main conclusion which can be drawn from the interchange results is that there are a large number of changes involved. In all 114, out of 125 possible interchanges, have occurred. Not only are there gains and losses to every one of the twelve habitat types, but every one of the changes listed in Table 26 has also occurred in the reverse direction. In fact nearly every individual change has its opposite. The reversals of main changes are often small and unreliable but the fact that they are occurring is encouraging. Concentration on the main changes only can give a very one-sided picture. The true picture involves much 'shuffling' of the types.

CHAPTER 4 DISCUSSION AND SUMMARY OF CONCLUSIONS TO SECTION 1

The object of Section 1 was to describe the NCC 'Air-photo analysis of change' project, to present the findings and to extract from these the main habitat changes which had taken place over the last 30 years. The reasons for undertaking the work were described in Chapter 1, Chapter 2 outlines the methods and Chapter 3 presented the results.

This Chapter is divided into two main sections. In the first section the method used to assess habitat changes and its advantages and disadvantages are discussed. In the second section the main results are discussed further and compared with findings from other studies.

4.1 ASSESSMENT OF HABITAT CHANGE

Air photo assessment where possible offers by far the greatest amount of reliable information of habitat changes per unit time spent. Nevertheless there were problems and certain disadvantages in using the techniques which are now discussed. Following that, some other survey methods and possible refinements to the air survey technique are considered. Finally changes which cannot be assessed by air photo interpretation are discussed.

4.1.1 Photo-Interpretation Problems

The problems encountered during photo-interpretation are discussed in the report of the 'Air Photo Analysis of Change' project (Langdale-Brown et al, 1980, Chapter 4). On the whole the problems were satisfactorily resolved by refining the habitat classification and by ground checks. The main areas of difficulty were within woodlands and within grasslands.

It was often difficult to determine the point at which scrub succeeded to full deciduous woodland. This is a difficult decision to take even on the ground. Woodland was taken as any area with more than 50% tree cover (often clearer on the air photographs). The other problem was with young plantations; the trees were often too small to be positively identified as coniferous or deciduous. Initial field checks showed them all to be coniferous and on this basis all unidentifiable plantations were allocated to the coniferous woodland class. However, later field checks revealed some young deciduous plantations, suggesting that some young mixed and young deciduous woodlands may have been wrongly allocated. There was not enough time to check all young plantations on the ground.

At the scrub/grassland interphase, there wereagain problems. It was often difficult to draw a boundary round individual clumps of scrub, The solution was to treat each grassland/scrub area as a mosaic and estimate the proportion of each within it. Again this is an easier assessment to make on the air photographs than on the ground.

Problems in distinguishing the grassland types were also experienced on the ground. The solution was to define the three types very carefully: permanent unimproved grassland was seen as an elite category, which by its location (e.g. remote or steep areas) was unlikely to have been improved. Any doubtful areas were classified as improved rough grassland. This second category encompassed grassland communities where some 'improvement' such as drainage had taken place but not wholesale replacement of the sward. Any grassland area which had been seeded i.e. a ley, was classified as agricultural land. In fact, on the air photographs, leys were difficult to distinguish from arable land. It is possible that some areas classified as improved grassland were once sown, but as time passed they become more akin to improved rough grassland, in terms of nature conservation interest, than to leys.

The longer leys may develop some ecological interest as native species move in, but it must be remembered that they are periodically ploughed up and resown with agricultural grasses and legumes, and so are far less important than the other grassland categories.

Non-agricultural land includes many sub-categories some of which in time may develop wildlife interest. Road verges could be such a sub-category but they are too narrow to measure separately from the road. They could in future be measured as linear features. Wastelands are another example, discussed more fully in Section 3.

The main problem with hedges was in distinguishing them from walls which is easier when the photograph was taken with a low sun angle. Hedges on the boundaries of woods may have been missed because of overhanging branches. However in an earlier study of Midlothian, Crawford (1978), on ground checking, found only one instance of misclassification of a wall as a hedge, but 40% of hedges had been missed, most of these underlying trees. With larger scale photographs and greater skill in air photo interpretation it is hoped that that proportion has been much reduced in this survey. The main difficulty in picking out open water was that it was often obscured by overhanging trees e.g. on a river bank.

Because parts are obscured it might be better to consider streams as a linear feature in future surveys.

Within woodlands underplanting may go unobserved. However the ITE (Institute of Terrestrial Ecology) Deciduous Woodland Survey carried out in 1977 estimated that only 1% of the deciduous woodland area, marked on the last series of Ordnance Survey 1 inch: 1 mile maps, had to be deleted due to underplanting (ITE 1979). A more common practice seems to be the use of coniferous species as nurses for hardwoods such as beech. This was also noted in Crawford's (1978) study of Midlothian. The slower growing deciduous species are often invisible beneath the coniferous canopy. When the hardwoods no longer need protection the conifers have reached timber size and can be cropped, leaving deciduous woodland.

Another problem (which also occurs with maps) is that the surface area of any habitat may have been underestimated if it was consistently located on cliffs or gully sides. The most commonly found habitats in these circumstances were permanent grassland and woodland types. This can be rectified by more sophisticated air photo interpretation techniques.

Finally, certain habitats, particularly scrub and wetland (e.g. ditches) are too small to measure or even discern on the air photographs. Though these may not affect estimates of total area of change nonetheless they may be quite important local wildlife habitats. Larger scale Ordnance Survey maps often mark the main field drains - this is an area where maps can provide useful supplementary information.

4.1.2 Comparison with other methods

These include ground survey and comparing old maps. Complete ground survey for the sample area would have been extremely time-consuming and although it may have led to more positive identification in some instances, e.g. with young plantations, air survey has distinct advantages in other instances such as ease of defining boundaries between types, e.g. with spreading scrub, ease of assessing proportions in mosaics, and ease of estimating the proportions of deciduous and coniferous trees in the canopy of a suspected mixed woodland. The only other method which might yield the same sort of information in the same time would be to compare 1: 2,500 or 1: 10,000 Ordnance Survey Sheets of different dates. However they do not portray the same range of habitats as the aerial photographs, e.g. hedges and improved grassland are not marked, nor do they portray as much detail; habitats which occur in small areas such as scrub and wetland may not all be mapped - the smallest area of vegetation mapped is 0.4 ha. (OS 1983). Secondly Ordnance Survey maps are revised only periodically when there have been major changes in the area such as new roads. Thus comparative coverage might not be available for a random sample of areas. The best method seems to be the comparative air-survey with ground checks for problem areas.

4.1.3 Refinements of the techniques

If extra resources were available they would be best emplyed in analysing supplementary information such as the 4th of June Agricultural Returns and maps. If maps of the same date as the air photographs are available they would be useful in checking woodland types particularly young plantations. They could also be used to pick out rivers and ditches.

The comparison of 10% and 20% samples of Berwick District suggests that extra resources would not be best employed in increasing the sampling intensity. The gain in precision was between 15% and 40% for most habitat net changes. The main trends and relative changes have been established at the 10% sampling level.

Further refinements:

The non-agricultural land category includes much ground of wildlife interest e.g. road and railway verges, gardens and grounds. Urban areas include appreciable areas of garden and parkland which could be sub-sampled. In more rural areas, golf courses, often located on links or occupying old estate grounds, may well offer refuges particularly the areas of 'rough' and woodland. Some 'rough' areas were classified as improved grass, and once railways and mineral workings became disused they became more valuable. Scrub and dwarf shrub heath colonising them were classified as such, but grassland was still categorised as non-agricultural land. Other 'abandoned' areas 'left to nature' include old aerodromes and rough areas beside farms. A sub-category 'disturbed areas' could be created to include road and railway verges, disused railways and urban and rural wasteland, and a sub-category 'parkland' could include gardens and lawns, parks, golf courses and other recreational areas.

More detailed assessment could be made of woodlands. They could be subdivided easily with more practice according to age, density or species. Height could be assessed as an aid to defining age categories. Similar techniques could be applied to tree-lines, scrub and hedges. The width of the hedges could be measured and their gappiness assessed as an indication of degree of neglect.

With sensitive habitats an appraisal could be made of surrounding land uses, because, as will be seen below, some management techniques impinge on areas other than those for which they were intended.

It is not proposed that such refinements be added to the present technique as they would add little precision to the results for the extra time involved. Rather, specific studies could be carried out in each of the two main fields discussed here: non-agricultural land and woodlands, as separate quantitative assessments. However most assessment of the ecological value of habitats has to take place on the ground.

Another important area outwith the scope of this thesis is the visual impact of habitat changes. Important landscape features such as trees and hedges and varying land forms are easily assessed with air photographs.

4.1.4 Other Changes

There are certain changes to habitats, apart from their gross removal, which cannot be assessed with aerial photographs, but have important implications for wildlife. These include:

1) Drainage: the straightening, deepening and widening of natural waterways, clearing of ditches to improve drainage, and draining of marshes and bogs can affect surrounding habitats in addition to the wetland and open water habitats for which they were intended. The most important effect is the lowering of the water table, which has implications for nearby wetlands, wet meadows and other grasslands, and may be especially critical to trees. Stream and ditch-side vegetation may also be removed in the clearing operation. Finally the banking up of rivers in old flood plains prevents the old winter flood meadows from surviving, and they are thought to be of considerable wildlife interest (NCC 1976).

2) Chemicals: the use of pesticides to control pests may not only reduce population of specific 'weeds' or insects but also populations of many other species in the field or verge, though more selective sprays are now being developed. Moreover, not only infield plants and animals are affected, there is a danger of drift to nearby wildlife habitats e.g. hedges. These problems will be more serious where aerial spraying is practised.

Fertilisers enable crops species to grow or compete successfully with other plants. When applied to grassland, certain species will be favoured to the detriment of smaller slow growing species, and species diversity. Many of the inorganic fertilisers applied, especially nitrates, are very soluble and run-off, drainage (improved by (1) above), and seepage, can result in high concentrations reaching water courses and sources. Such eutrophication again leads to coarser species being favoured at the expense of more sensitive ones. With open water more vigorous waterweeds are favoured. Effects are magnified by the resulting deoxygenation. Perhaps the most insiduous effect is that nitrate under certain conditions can be reduced to nitrite which is toxic. Aquifers e.g. in the South Downs (Green 1981) have been found to have excessive nitrate levels. The main fear is that water percolation through aquifers is very slow and the contamination now appearing is the result of surface contamination over 25 years ago when levels of fertiliser application were lower than at present. Between 1960 and 1975, the use of nitrogenous fertilisers in England and Wales increased threefold (Green 1981).

3) Strawburning: is becoming general in more arable areas. Despite a strict National Farmers Union Code of Conduct, burns have been known to get out of hand and affect surrounding habitats. Even when contained, infield hedges and trees are likely to be affected, giving the farmer a further excuse to remove them.

All of these effects lead to simplification of remaining habitats. However, different habitat values can really only be assessed by ground methods. In Section 3 the ecological values of habitats are considered.

4.2 FURTHER DISCUSSION OF RESULTS

Reference should be made to the NCC report (Langdale-Brown et al 1980) for details of the statistical bases for the standards of reliability deemed acceptable for their purposes. Here the 95% confidence limits calculated in the NCC project have been taken as indicative of relative reliability. Interpretation has been concentrated on the 'more reliable' results, those for which the confidence interval is less than twice the estimate itself.

4.2.1 Discussion of Hedgerow and Tree-line Estimates

The length of hedgerows at the early date of photography was estimated at 28469 km falling to 21828 km, an estimated drop of over 23%. The range of Regional net losses was from 18% - 33% and District net losses ranged from 9% to 38%. Nominal gains occurred in over half the Districts, but were very small and unreliable.

The proportion of hedgerow loss in Midlothian District was estimated at 14%, slightly less than in an earlier study of a smaller area of that District by Crawford (1978), where it was estimated that 20% of all hedgerows had been lost between 1947 and 1974. The proportion of hedgerow lost in North East Fife was 38% (the highest of any District). However an earlier study by Weyl and Langdale-Brown (1978) in North East Fife, estimated that only 17% of hedges had been lost between the years 1954 and 1968, a shorter period than in this survey. However they thought that even that figure could be overestimated, because a lower rate of removal was found in the second half of the survey (when efficiency had improved).

The overall figure suggested by Pollard, Hooper and Moore (1974) for hedgerow removal in England and Wales between 1946 and 1974 was 23% which agrees very well with the estimate for this survey. Far higher proportions have been estimated for this period e.g. Baird and Tarrant (1973) studying hedgerow loss between 1946 and 1970 in different areas of Norfolk found losses of 29% to 72%, with a mean loss of 45%. Higher rates have been recorded in areas where arable agriculture is most predominant, the highest seems to be a loss of 88% in one Huntingdonshire parish (Pollard, Hooper and Moore 1974).

The mean hedgerow density for the whole area was 21m/ha at the early period with a range of 1.5 - 40m/ha. This fell to 16m/ha (District range: 1 -.33m/ha).

In North East Fife, the initial hedge density was estimated at 6.7m/ha falling to 5.3m/ha. Weyl and Langdale-Brown's (1978) figures for part of that District suggest higher densities 20m/ha in 1954 falling to

17m/ha in 1968 but this may have been unrepresentative of the District as a whole. It covered a block of 14,800 ha or a fifth of the whole District. The random nature of the sample in the NCC project is more likely to have ensured that less well hedged areas were included. In Midlothian the initial density was 11m/ha falling to 10m/ha. In an earlier study a higher density was again found for one part of the District; this time a block covering a tenth of the whole District. In 1947 there was an initial hedgerow density of 20m/ha which fell to 16m/ha (Crawford 1978). In fact the recent density was found to be an underestimate following a ground check. For England an average figure of 81m/ha falling to 62m/ha was suggested by Hooper (1978) based on Forestry Commission data. These densities are four times greater than those estimated in lowland Scotland. Pollard, Hooper and Moore (1974) suggest that fields laid out in the enclosure movement are larger than the first fields in England which were often carved out of woodland. The first hedges in Scotland were those of the enclosure movement which might explain why the overall density is lower. The largest densities quoted by Hooper (1978) were 99m/ha in Leicestershire and 199m/ha in Devon. The smallest densities estimated by Pollard, Hooper and Moore (1974) were 1.5m/ha in East Anglia and 2.6m/ha in Huntingdon.

The relationship between early hedge density and hedgerow removal was also explored. Baird and Tarrant (1973) compared hedgerow removal in two parts of Norfolk between 1947 and 1970. In the first area, enclosure had been fairly late and large fields had been established with a low hedgerow density. In 1974 there was 57m/ha of hedgerow. In the second area enclosure had occurred earlier and more sporadically and had created a 'web' of tiny fields. There the initial density was 129m/ha. In 1970 both areas had a density of 52m/ha; hedgerow removal had been larger where initial hedge density was higher.

However in lowland Scotland an opposite relationship was found; the Regions and Districts with the greatest proportion of hedgerow removal had lower than average initial densities. Districts where hedges were least secure were identified as North East Fife, Angus, Kirkcaldy, Falkirk and Clackmannan, Stirling and Lanark. Regions where these observations apply were Tayside and Fife. Regions with a high initial density of hedges were Dumfries and Galloway and Strathclyde; there hedgerow loss was average. The Districts where hedges appear most secure (Kyle and Carrick, Cumnock and Doon Valley and Cunninghame) had a high initial hedge density and low hedgerow loss. Reasons proposed for these were that in Fife and Tayside, the flatter nature of the topography gives greater scope for large fields, whereas in the western Region the topography may be more undulating. Another reason may be that stone walls are commoner field boundaries than hedges further north. Finally there may be a difference in land use practice. In the west there is more livestock rearing and hedges may still have some function, whereas in east coast Districts a greater proportion of land is put to arable use and so hedges become redundant.

Evidence from the English counties supports this last hypothesis. Pollard, Hooper and Moore (1974) give the example of Rutland county where both arable and grassland farming is practised. In the more eastern arable area of Rutland, the hedge density in 1947, was 12m/ha and by 1969, 23% of all hedges had been lost. In the western livestock area, the initial hedge density was 16m/ha and there only 8% of hedges had been lost. Westmacott and Worthington's (1974) results for six English counties suggest a range of losses from 7% to 39% of the early density. The highest loss occurred in an area of Huntingdon where extensive cereal growing is practised; this area had one of the lowest initial densities. In all the other counties in that study where mixed farming was practised, hedgerow loss was less than 10%.

Pollard, Hooper and Moore (1974) state that the highest rates of hedgerow removal occur in Huntingdonshire, Cambridgeshire and Lincolnshire which were amongst the latest counties to be enclosed, therefore initially had large fields. They suggest that Baird and Tarrant's (1973) results for Norfolk are atypical. Norfolk is now a predominantly arable county but previously there was more livestock rearing, which may explain the discrepancy. Thus one could conclude that present hedgerow density is related to farming practice. In Scotland hedges may be replaced by walls in some areas. Topography may play a part in limiting the size of fields; in the west there may be less scope for boundary removal than in the east.

Finally, the average annual loss over this study period was 282km/yr or 1% per year.

Tree-line Results.

The overall length of tree-lines was only one-third to a quarter that of hedges. The overall net loss in length was 14%; 10% less than hedge loss. Small gains as well as losses have been estimated in many Districts but they are mostly unreliable. The overall net loss in length was 1000km, one-sixth of the length of hedgerow lost. The early overall mean density was 5.7m/ha, one-quarter the hedge density and this fell to 4.8m/ha. Relationships between density of the tree-lines and proportions of loss are less clear cut than with hedges. The annual average loss was 54km/yr or 0.7%/yr. All Regions and most Districts with a high proportion of hedge loss have also a high proportion of tree-line loss.

Tree-lines without hedges seem to have been neglected in earlier studies. Perhaps tree-lines without hedges are more a feature of the Scottish landscape. Crawford's (1978) study of a part of Midlothian suggested a slight gain of 1% in tree-line length.

Most work has concentrated on trees in hedgerows which were not assessed separately from hedges in the NCC project. The main fear is that as a result of modern mechanical hedge cutting, potential hedgerow trees are eliminated. The evidence suggests that there are not enough saplings growing up to replace the maturing trees. Westmacott and Worthington's (1974) study of six English counties estimated removal rates of trees in hedges at 18% to 90% between 1947 and 1972.

4.2.2 Summary and Discussion of Habitat Extent Estimates

The estimates of early habitat extent of dwarf shrub heath and of permanent grassland were the least reliable of all estimates and those for agricultural land and non-agricultural land most reliable. The Districts with the most unreliable results were West Lothian and Dunfermline, both with a small number of sample frames. On the whole, out of 288 estimates, 230 were more reliable at the early date and 233 at the recent date.

These estimates of habitat extent were illustrated by a series of diagrams in Section 3.4.2. Diagram 1 was a series of pie charts illustrating the relative proportions of agricultural land, non-agricultural land and Other habitats, This last category included all areas with some nature conservation interest. At the early date, the mean proportion of agricultural land was 75%, non-agricultural land 8% and Other habitats 17%. There was a good deal of variation in these proportions and their ratios in particular Regions and Districts served to categorise them.

i) 'Agricultural' areas - those with a greater than average proportion of agricultural land and also a lower than average proportion of non-agricultural land.

ii) 'Industrial' areas - with a greater than average proportion of non-agricultural land and a lower than average proportion of agricultural land.

iii) 'Wildlife Conservation' areas - with a greater than average proportion of Other habitat types. There was a less clear relationship between the proportion of Other habitat types and either non-agricultural and agricultural land. All Wildlife Conservation Districts had a lower than average proportion of agricultural land. However, not all areas with a low proportion of agricultural land (e.g. Industrial Districts) had a high proportion of Other habitat types.

iv) 'Average' areas - with average proportions of the three habitat groups.

The Regions and Districts which fell into each of the groups were:

Industrial areas:	Strathclyde and Central Regions. West Lothian, Dunfermline, Falkirk and Clackmannan, Cunninghame, East Strathclyde and West Strathclyde Districts.

Agricultural areas: Dumfries and Galloway, and Tayside Regions. Berwick, Roxburgh, Midlothian, North East Fife, Annandale and Eskdale, Wigtown, Cumnock and Doon Valley, Perth and Kinross, and Angus Districts.

Wildlife Conservation areas: Ettrick and Lauderdale, Tweeddale, Kirkcaldy, Stirling and Stewartry Districts.

Average areas: Borders, Lothian and Fife Regions. East Lothian, Nithsdale, Lanark and Kyle and Carrick Districts.

Diagram 2, Other habitat types were divided into 'Woodlands', scrub, 'Grasslands' and 'Wetlands' in this presentation. In the survey area as a whole, Woodlands occupied the largest proportion; on average 8.5% or half the total area of Other habitats, followed by Grasslands; 4%, Wetlands; 3.2% and Scrub 1%. Geographically as might have been expected, the area of Wetlands was larger in western areas. The proportion of Grasslands was often larger in east coast areas. In many Districts and Regions, Woodlands often occupied a greater area than the remaining habitat groups combined.

In the last diagrams the proportions of individual habitats within these groups were considered. Within Woodlands, deciduous woodland occupied the largest proportion of land in most Districts, followed by coniferous woodland with mixed woodland occupying least. Within Grasslands, improved rough grassland was predominant, and dwarf shrub heath and permanent unimproved grassland each usually occupied less than 1% of the total survey area. The latter two types were absent from over half the Districts. Within Freshwater Wetlands, the area of open water was occasionally greater than that of wetlands.

A further point made in this section was that in all three diagrams the proportions of the habitat groups and types in the Districts did not always reflect the proportion in the Region as a whole.

Comparison with other results:

In Tables 27A and 27B the proportions of habitats found in two earlier studies are compared with the estimates in this project. The studies were:

1) Weyl and Langdale-Brown (1978): Aerial Survey of Changes (In North East Fife).
2) Crawford (1978): A Study of Changes in a Lowland Farming Area using Aerial Photographs (In part of Midlothian).

Table 27A North East Fife

This table compares both the early and the recent proportions of wildlife habitats in North East Fife generated in the aforementioned surveys. Weyl and Langdale-Brown (1978) assessed the area of wildlife habitats in an area of 148km^2 at two dates: 1954 and 1968. Roughly the same habitat types were covered as in the NCC project except that felled areas and improved grassland were not differentiated from woodland or grassland. An extra habitat ('dunes') was assessed. The estimate of the proportion of agricultural and non-agricultural land together was obtained by subtracting the total area of their 'Other' habitats from 100%.

The proportion of Other habitats in Weyl and Langdale-Brown's study was less than half that estimated in the NCC project. At the early date, the individual Other habitat types also occupied a lower proportion than in the NCC project except for unimproved grassland. However as their classification system did not pick out felled areas or improved grassland, it is likely that some areas classified as these types in the NCC project were classified as unimproved grassland in the earlier work.

At the recent date the proportions of deciduous woodland and dwarf shrub heath are closer but the NCC estimates are again mostly larger. Overall the results of the two surveys are nearly always of the same order of magnitude. As was concluded in the hedgerow discussion, the block of North East Fife covered in Weyl and Langdale-Brown's survey could be unrepresentative of the District as a whole.

TABLE 27A: A comparison of the proportions of habitats estimated in two studies of North East Fife
1 - Weyl and Langdale-Brown (1978) - block of 14800 ha
2 - NCC (1980) - based on random 10% sample

Habitat Type	1 1954 % of study area	2 'Early' % of lowland area	1 1968 % of study area	2 'Recent' % of lowland area	Net Change %	
					1	2
Deciduous Woodland	1.6	2.7	1.6	2.0	- 0.3	- 27.7
Mixed (or undifferentiated Woodland) *	0.2	0.3	0.2	0.3	+11.0	+ 11.5
Coniferous Woodland	1.2	2.8	1.8	6.5	+52.2	+130.4
Felled Areas	not covered	0.1	not covered	0.8	-	+530.6
Woodlands Total	3	5.9	3.6	8.8	+20	+ 49
Scrub	0.9	1.6	0.8	1.4	-14.2	-13.8
Dwarf Schrub Heath	0.2	0.9	0.03	0.04	-86.1	-95.7
(Permanent)** Unimproved Grassland	3.4	1.4	2.5	0.05	-28.6	-96.1
Improved Rough Grassland	not covered	6.4	not covered	3.6	-	-43.9
Wetland	0.06	0.3	0.04	0.4	-35.9	+14.0
Open Water	0.37	0.6	0.36	0.5	- 2.3	- 8.5
Dunes	1.25	not covered	1.25	not covered	0.0	-
Total 'Other' Habitats	8.1	17.2	7.4	15.5	- 9.2	- 9.9
Agricultural Land	91.9	77.3	92.6	77.6	+0.8	+ 0.4
Non-Agricultural Land		5.5		6.9		+24.6

* In Weyl and Langdale-Brown Survey this category was 'Mixed or undifferentiated woodland'. In NCC survey it was called 'Mixed Woodland'.

** In Weyl and Langdale-Brown Survey this category was 'Unimproved Grassland'. In NCC Survey it was called 'Permanent Unimproved Grassland'.

Table 27B Midlothian

This compares the results for a block of photography for Midlothian with the NCC results. In fact full air cover was not available for the earliest date and so only half the block was assessed for the 1947 - 1974 period. The main difference in the classification was that grasslands, heathlands, felled areas and wetland were not differentiated. Where grassland formed a mosaic with scrub, it was allotted to the rough grassland category.

The estimates for these rough grasslands are considerably higher than the total of the constituent NCC categories. All grassland which appeared rougher than arable land or leys was put into this category. Older seeded pastures were included together with rough grassland categories as non-agricultural land in the NCC project. This latter type was found on abandoned mineral workings, disused railway lines etc..

The other estimates are closer. The NCC project generated a higher proportion of deciduous woodland but less mixed woodland. The estimated area of agricultural and non-agricultural land was also higher in the NCC project i.e., the area of wildlife habitats was larger in the earlier study of Midlothian. Much of the area is still under estate management which could account for a greater retention of these habitats compared to Midlothian as a whole.

Both the Weyl and Langdale-Brown (1978) and Crawford (1978) studies made use of comparative air photo interpretation techniques. It is likely that any inaccuracies arising from the use of air photo interpretation for this purpose will occur in all three studies.

The ITE Deciduous Woodland Survey (1979) provides a source of data generated at ground level which can be compared with the NCC air survey results. In 1977 all deciduous woods marked on the 7th Ordnance Survey 7th Series 1 inch: 1 mile maps were visited. The minimum site size was five ha which is the smallest site which can be depicted on these one inch maps and enclose a woodland symbol. When the sites were visited a certain number of woods were found to have been turned to other land uses. As in the NCC project, Local Authority Districts formed the init of the survey area. However in the ITE survey the whole District was covered, not just the lowland area. Because the

TABLE 27B: A comparison, between two studies, of the proportions of habitats in Midlothian. 1 - Crawford (1978), 1a - block of 2989 ha, 1b - block of 5503 ha, 2 - NCC (1980) based on random 10% sample. Total area of district is 28697 ha.

Habitat Type	Proportions of Total Area						Net Change %		
	1a 1947	1b 1957	2 Early	1a 1974	1b 1968	2 Recent	1a	1b	2
Deciduous Woodland	6.2	3.7	8.5	4.3	3.4	7.6	-31	- 9.4	-10.8
Mixed Woodland	4.4	3.2	2.9	3.2	2.9	2.7	-28	-10.1	- 7.7
Coniferous Woodland	2.2	2.8	1.1	3.9	5.5	2.2	+80	+97.5	+104.2
Felled Areas	5.9	13.6	0.4	7.4	12.2	0.7	+25	- 4.5	+63.8
Permanent Grassland			0.02			0.02			0.00
Improved Grassland			2.0			1.4			-31.9
Wetland			0.5			0.6			+ 3.1
Scrub	0.9	1.3	0.6	1.6	1.4	0.6	+75	+ 6.9	+108
Open Water	0.5	0.6	0.5	0.5	0.7	0.5	+ 1.4	+ 1.6	- 0.1
Agricultural Land	79.8	74.7	77.5	79.0	73.9	75.1	1.0	1.1	+ 3.1
Non-Agricultural Land			5.9			8.7			+46.5
Total 'Other' Habitats	20.2	25.3	16.6	21.0	26.1	16.2	+ 4	+ 3.1	- 2
Total Woods	12.8	9.7	13.5	11.4	11.8	12.5	-11	+22	- 7

upland area of each District was included one might expect higher estimates of deciduous woodland in the ITE survey.

In fact Table 28 shows all the estimates in the ITE project are smaller than the NCC estimates. Only in Stirling, Perth and Kinross and perhaps Kirkcaldy do the results appear similar. In all other Districts the NCC results are two to three times greater. Over the area as a whole the NCC total was over twice the ITE total. As the ITE measurements were made after visiting every wood on the ground they are more likely to be accurate than results generated from air survey. However the ITE survey covered only woods greater than 5 ha whereas the NCC survey included smaller woods. The smallest wood measured in the NCC project was any area which a boundary could be drawn around. Because the scale of these photographs (1: 7000) is over ten times larger than that on the one inch maps (1: 63,760), far smaller woods can be assessed. In a random sample of 20 woods in Lothian Region (see Chapter 8 for sampling method) the smallest wood measured was 0.15 ha, and the mean area was 3.2 ha. Only two of these woods were larger than 5 ha. If the area of these two woods: 39.6 ha is subtracted from the total area: 63.7 ha, the area of small woods left is 24.1 ha or nearly 40% of the total area. Since the recent air photograph was taken (1969) the larger of the two woods greater than 5 ha in area (which covered 32 ha) has been felled and planted with conifers.

However the ITE results cover the whole District and the NCC only the lowland area though deciduous woodland is perhaps encountered less frequently in the uplands. A further source of the discrepancy may be misclassification of woods in the Air Survey project. In Section Two, old Ordnance Survey maps are used to provide evidence of past habitat changes in East Lothian. The most recent Ordnance Survey maps were compared with the air photographs to sort out possible differences in classification. It was found that many areas classified as deciduous woodland on the air photographs were in fact marked as mixed on the Ordnance Survey maps. The Ordnance Survey is more likely to be accurate because all detail is ground checked. (There is a small difference between the NCC and OS definitions of mixed woodland. By OS criteria (see Section 6.2.4) a slightly larger proportion of woods may be classified as mixed).

TABLE 28: Recent Areas of Deciduous Woodland in Scottish Local Authority Districts. A comparison of results in the
1 ITE Deciduous Woodland Survey of Scotland (whole district)
2 NCC 'Air Photo Analysis of Change' Project (lowland area of districts only)

Local Authority District	1 ITE	2 NCC
Berwick	719	1454
Roxburgh	466	1838
Ettrick & Lauder	378	2327
Tweeddale	327	799
East Lothian	998	3125
Midlothian	995	2176
West Lothian	222	956
North East Fife	283	1435
Kirkcaldy	469	718
Dunfermline	501	1685
Falkirk & Clackmannan	785	1732
Stirling	2644	2940
Annandale & Eskdale	341	1441
Nithsdale	896	2406
Stewartry	1371	2449
Wigtown	1011	2089
Lanark	625	1306
Kyle & Carrick	1174	2761
Cumnock & Doon Valley	164	1138
Cunninghame	473	954
East Strathclyde	1555	3481
West Strathclyde	475 (except Renfrew)	2419
Perth & Kinross	6433	8481
Angus	1287	3113
TOTAL	24592	53223

In the deciduous woodlands the ITE visited, a certain proportion of conifers were found. However woods were classified as deciduous unless over 50% of the canopy species were coniferous. It is unlikely that such a high proportion would be missed in the air photograph interpretation. In conclusion, the NCC estimates of the recent area of decidous woodlands are high when compared with the ITE results. This may be due to the inclusion of smaller areas in the NCC project survey and partly to classification differences.

In the whole survey area, the recent proportion of Woodlands was estimated at 9.5%. This is close to the 9% quoted by Simms (1981) for Britain as a whole.

4.2.3 Summary and Discussion of Net Change Results

Reliability of Net Change Results:

The net change estimates were on the whole less reliable than those for habitat extent, because smaller areas are involved. Moreover, change is rarely unidirectional. Just over half the Regional results, but only one-third of the results for Districts were in the 'more reliable' category (see Section 3.2). Only in the cases of deciduous and coniferous woodland, improved rough grassland, and non-agricultural land were there enough more reliable net change results to draw satisfactory conclusions. However the individual gains and losses which make up net change are more reliable. Eighty-four percent of the Regional individual gains and losses and 57% of the District losses can be considered. With mixed woodland, felled areas, scrub, wetland, open water and agricultural land the source of the unreliability in the net change lay in the combination of the individual gains and losses i.e. both are sizeable. With dwarf shrub heath and permanent grassland the individual gains and losses themselves are less reliable.

Woodlands

There has been an overall net loss of 17% in the area of deciduous woodland, with more than 10% lost in most of the Districts and Regions where the net change is more reliable. The greatest net loss was 35% in Kirkcaldy. However in most Districts and Regions there are gains as well as losses. Overall 26% of the deciduous woodland present at the early date has been felled with a gain of nine percent elsewhere. The new areas may not provide alternative habitat for species displaced in the fellings.

The area of coniferous woodland has risen by 77% in the whole survey area, with District gains as high as 340% (again in Kirkcaldy). New plantings amounted to 94%, losses to 17% - still fairly sizeable. Coniferous woodland has now replaced deciduous woodland as the main Other habitat. The results are significant because prior to this survey the majority of conifer plantings were thought to be occurring in the uplands.

The results for mixed woodlands are less reliable and hence less conclusive. Overall the area appears to have increased by 17%. But of the Districts and Regions where the results are acceptable, more have a net loss than a net gain. Where there was a gain it was usually far larger, which explains the overall net gain. However mixed woodland occupies less area than the first two habitat types and so this lack of clarity is less important.

The results suggest an overall reduction in the area of felled woodland of nine percent. Most of the Regional and District net changes are less reliable. And most of the individual gains and losses are more reliable. They suggest an overall gain of 81% and an overall loss of 89% i.e. there has been more reclamation than felling. As with all woodland results the District gains and losses are very variable, gains range from 25% to 274% in Districts and losses from 58% to 106%. In all Districts where both are more reliable, both are greater than 20%. The main importance of felled areas is as a transitional category reflecting the changes within the woodland categories and losses from woodland.

Overall the area of woodland increased. Losses in the area of deciduous woodland equalled the gain in mixed woodland and felled areas declined; the main reason for the gain therefore was the increase in the area of coniferous woodland.

Comparison with other areas

Weyl and Langdale-Brown's results for North East Fife (Table 27A) suggest only a very small decrease in deciduous woodlands compared with the NCC survey area mean and result for that District. The increase for mixed woodland, however, is similar but the overall extent of the type is small. Table 27A shows a very large increase in conifer planting, but it is not as large as that estimated in the NCC project. One reason for these discrepancies will be the different time spans involved, 14 years compared with 19 - 29 years in the NCC survey.

In the last section the areas of habitat types in the two surveys were found to differ but this is unlikely to affect net change results. The main conclusion that can be drawn is that deciduous woodlands are being lost to a lesser extent in this part of North East Fife, compared to the whole District.

If net changes estimated in the earlier study of Midlothian (Crawford 1978) are compared with the NCC results, the net changes between 1957 and 1968 can be seen to be fairly similar - losses in deciduous woodland of around 10% and a gain in coniferous woodland of nearly 100%. However, if Crawford's 1947 - 1974 results are considered, the deciduous and mixed wood net losses are much larger and the coniferous wood gains slightly less than the NCC results. Moreover the time spans 1946 and 1949 to 1969 and 1975 in the NCC survey and 1947 - 1974 (Crawford 1978) are fairly similar. The results suggest more deciduous and mixed woodlands are being lost in this part of Midlothian District than in the District as a whole.

On the whole the trends recorded in the two earlier surveys are the same as those in the NCC results, and the scale of conifer afforestation is similar.

The ITE deciduous woodland survey (1979) found a loss in the area of woods over five ha of 36% between the date of the last maps revision (late 1950's to early 1960's) to 1977. However the ITE surveyors thought there were errors in this estimate. They therefore carried out a more direct comparison between the area of deciduous woodland in Ettrick and Lauderdale in 1977 and the area in the 1947 - 1949 Forestry Commission census for Selkirkshire. The original raw data for the Forestry

Commission (FC) census were consulted to improve comparability. The study produced an estimated net loss in area of 58%, however, this was felt to be an overestimate as a result of methodological differences between the FC and the ITE surveys. The NCC 'Air Photo Analysis of Change' result for that District for that period showed a net loss of 17%. It is possible that the many small areas in the lowland area are less attractive prospects for reclamation or conifer planting than larger areas.

The only other estimates of net changes in the woodland area over the last 30 years are for places in England. All refer to deciduous woodland. In Cambridgeshire, 16% of broadleaved woodlands in a sample area were cleared between 1946 and 1973 and nearly 30% of a sample area in Lincolnshire in the same period (Peterken and Harding 1975). A study by the Womens Rural Institute in Devon in 1972 estimated a 20% loss of the county's broadleaved woods. Work by Rackham and Peterken suggests that between one-third and one-half of all ancient semi-natural woodland has been lost in Britain since 1947 (Goode 1981). All these estimates fall within the range of losses estimated for Districts in lowland Scotland.

One can conclude that a significant amount of deciduous woodland has been lost in the last 30 years, although the amount of the loss varies between different Districts and even between different parts of the same District, as the results for North East Fife and Midlothian suggest. Many of the results quoted for other parts of Britain are larger than the Scottish mean loss of 17%. It may be that only larger woods were considered in studies. Another possibility is that only the larger and hence more serious losses of deciduous woodland have been quoted in the literature.

Summary of Interchange Results for Woodlands

Over one-third of the area of deciduous woodland lost has been planted with conifers, one-quarter was felled and not yet replanted, and one-seventh was converted to mixed woodland. Just over 10% had gone to arable land (1000 ha). A small gain in the area of deciduous woodland was noted in the preceding section; half of this came from scrub i.e. a natural succession and so these woods may be quite valuable. One-sixth came from felled areas and another sixth from improved grassland.

The large gain in coniferous woodland was not all at the expense of deciduous woodland. In fact the largest donor class was improved grassland, then deciduous woodland, then felled areas. An unexpected result was that the fourth largest donor class was agricultural land.

Half of the gain in area of mixed woodland was previously land under deciduous woodland and half the area lost became coniferous woodland.

The losses from felled areas have further relevance when considering changes to the three woodland types. One-quarter of the losses from deciduous woodland and mixed woodland, and over half of the area of coniferous woodland were lost due to felling. The interchange results show that two-thirds of the area lost from felled areas was planted with conifers, 13% was changed to agricultural use and 10% was planted with deciduous species. If these proportions are maintained then only 2.5% of the area lost from deciduous woodland to felled areas will again become deciduous woodland.

These figures suggest that the area of deciduous woodland will continue to decline because there is very little new planting; the largest portion of the gain in area was from scrub, not new planting. Coniferous woodland however will continue to increase, and not only at the expense of deciduous woodland. The grassland types particularly improved grassland, are also at risk. The majority of areas which were felled at the early date have now been planted with conifers. Agriculture is not a significant force in the decline of deciduous woodland. In fact agricultural land is more likely to be planted with conifers than deciduous woodland be converted to agriculture.

This analysis agrees fairly well with results from other studies. Weyl and Langdale-Brown found gains to the area of deciduous woodland from birch regeneration, the small losses being due to felling and conversion. There the large increase in conifer planting was mostly due to the planting of shelterbelts on agricultural land.

Crawford (1978) found that just under half of the area of deciduous woodland lost had been planted with conifers and just under half had been converted to rough grassland i.e. probably felled. Conifer wood gained from most other types but over half the gain was from rough grassland (i.e. partly from felled areas). The second largest donor class (10%) to conifer woodland was mineral workings. This was part of the land reclamation following cessation of open cast mining in the area.

The deciduous woodland losses in England are now considered. The 30% to 50% loss in ancient and semi-natural woodlands assessed by Peterken and Rackham has been mostly ascribed to conifer planting. Likewise the land which supported 30% of the deciduous woodland in Lincolnshire has now been planted with conifers. The 16% loss in Cambridgeshire has been attributed to conversion to arable lands (Peterken and Harding 1975). This last result is different from the Scottish results.

In conclusion the changes to Woodlands area: an overall gain in the woodlands area; one-third of the deciduous woodland loss, and most of the loss in felled areas, can be attributed to conifer planting.

Agriculture had less of an effect on the woodland area that might have been supposed. In fact it is more likely to lose land to new planting than to gain it - 2663 ha of woodland were lost to agriculture and 3569 ha new woodland were gained from agriculture.

Discussion of Scrub Estimates

The estimates of net change to this type were on the whole less reliable. The reason for this was that there are equally large gains and losses in most Districts and their combination renders the net change over-variable. The individual gains and losses are more reliable; overall they suggest a 38% gain and a 41% loss i.e. a slight loss.

The Weyl and Langdale -Brown result for North East Fife in Table 27A, was remarkably similar to the NCC results. Furthermore in that study the two halves of the are were assessed separately and in one half there was a 35% increase in area and in the other half a 32% loss in area. This supports the NCC findings. There was more discrepancy between the sets of Midlothian results in Table 27B. Again different parts of the same District may have changes in different directions.

The most important conclusion is that there are gains and losses to the area of scrub in every district. The gains will have quite different effects on wildlife than the losses.

When the Interchange results are examined these changes are clarified. Forty percent of the scrub loss is to deciduous woodland, 20% has become agricultural land and smaller amounts have become coniferous woodland and improved grassland. Of the scrub gain however, the largest quantity comes from improved grassland, the next largest from deciduous woodland, one-sixth from non-agricultural land and 15% of this gain is scrub spreading on agricultural land. Losses from scrub to deciduous woodland are twice the extent of the gains from it. The losses to agricultural land are 50% greater than the gains from it. Losses to improved grassland are less than half the extent of gains from it. The picture is very dynamic. Scrub seems not to be an endangered habitat, but the gained areas may be less valuable initially than the areas lost.

Discussion of Grassland and Heathland Estimates

Overall a decline in the area of dwarf shrub heath is indicated. However nearly all Districts estimates of net loss, and even estimates of individual loss are less reliable. The Regional results are more reliable. In the whole survey area it has been estimated that 70% of the former area has been lost, 10% has been gained i.e. a net loss of 60%. Some of the more reliable Regional losses are even more serious e.g. 96% lost in Fife. On the whole a much greater intensity of sampling would be needed to estimate the extent of the loss with more precision. Even the estimate of the total extent of the habitat was very unreliable. This unreliability is probably connected with rarity; more sampling frames are necessary to encompass all the variation.

The 96% loss in North East Fife has been judged one of the few more reliable estimates. This magnitude of change is confirmed by Weyl and Langdale-Brown's (1978) figure of 86% for net loss of dwarf shrub heath.

There was slightly less drastic estimated fall in the area of permanent unimproved grassland but most of the Regional and District net change, gain and loss results are less reliable. The results for the 10% sample suggest some very high losses and a few small gains. Permanent grassland is already absent from one-third of the Districts which is in itself very serious. A greater sampling intensity would be necessary here to estimate the loss more precisely. Weyl and Langdale-Brown (1978) also found a high loss of unimproved grassland in North East Fife but it was not as high as the NCC estimate (one of the more reliable results for that type).

Improved grassland is far more extensive than the last two types. The results are more reliable and indicate a large net loss of 36%. The loss was estimated at 42%, and the gains at 6%. Though some of the District net changes and individual gains and losses are less reliable, all indicate a loss. The estimated overall area lost, 18466 ha, is the largest loss from any habitat type. At the early date this habitat was the commonest Other habitat type in seven Districts and the second most common Other habitat type overall. Now it is the commonest Other habitat type in only one District and the third commonest overall. This is one of the main changes.

In every District and Region there have been losses to the grassland and heathland types. The area of all three was estimated to have dropped by over one-third. Permanent unimproved grassland and dwarf shrub heath have probably fallen by a greater percent but the estimates were low and not reliable. There were very small gains but they are unlikely to replace the wildlife values of the lost areas. Permanent unimproved grassland has disappeared from many places.

In Crawford's (1978) Midlothian estimates, the area covered by rough grassland increased but this category also included felled areas and areas of non-agricultural land left to regenerate naturally, and so it is not comparable.

Most of the English data refer to chalk grassland, a habitat less common in Scotland. Figures of between 18% and 37% have been quoted for the loss of downland in the last 20 - 30 years in English counties (Goode 1981). These are of a similar scale to the grassland losses in lowland Scotland detected by the NCC. There are some figures for the loss of heathland e.g., 72% of coastal heathland between Lowestoft and Ipswich was lost between 1920 and 1968 (Council for the Protection of Rural England 1975). Grasslands and heathlands seem to be decreasing by large but variable percentages.

Grassland and Heathland Interchange

The individual change results for dwarf shrub heath were mostly unreliable. However the estimates suggest that over half the area lost has been planted with conifers, that one-fifth became agricultural land and 10% became improved grassland. There was also a small gain mostly at the expense of improved grassland. The constituent losses from permanent grassland were again very unreliable. The results suggest that over two-thirds of the area lost has become coniferous woodland, 10% became improved grassland and a further 10%, agricultural land. The small gains seem to have been at the expense of woodland or scrub.

The individual gains and losses to improved grassland are more reliable. Coniferous woodland was again the largest recipient class gaining 40% of the loss but one-third of the area has been turned to agricultural use. There are smaller gains and losses to and from woodland and scrub.

On the whole the major cause of losses in grassland and heathland has been conifer afforestation. Almost half the gain to that type is from improved grassland and although the major cause of loss from the other two types in this category, each donates less than 10% to the total conifer wood gain. The second largest recipient class from grassland and heathland types is agricultural land. Again improved grassland has donated most, and the loss from that type is again the major source of gain to the other. The next most important recipient class from permanent grassland and dwarf shrub heath was improved grassland but gains to improved grassland are small compared to the losses.

Weyl and Langdale-Brown's study (1978) on North East Fife in 1954 encompassed four areas of dwarf shrub heath. By 1968 one had been planted with conifers (birch regenerating), one had been converted to improved pasture, the third had been converted to improved pasture (and since 1968 to arable use) and the last area was unchanged. Most of the unimproved grassland areas had been upgraded to improved pasture or arable land, with some afforestation, and small areas going to scrub. For both habitats, conifer afforestation is less important than in the whole NCC area. In Midlothian, Crawford (1978) found conifer afforestation to be the main reason for loss of grasslands.

The main reason for old grassland removal cited by Shoard (1980) and Goode (1981) was agricultural improvement such as ploughing and reseeding, with scrub invasion and conifer afforestation occurring to a lesser extent. Conifer afforestation is less important than in the NCC survey area of lowland Scotland.

Freshwater Wetlands Estimate

Most of the wetland estimates of the net change were 'less reliable' but over half of the District estimates and most Regional estimates of individual gains and losses were 'more reliable'. They suggest an overall loss of 26% and a gain of 13% i.e. a net loss of 13%. Although the losses in most Districts do exceed the gains, most of these gains are more than 10% and so cannot be discounted. The 26% loss in the area of old wetland is one of the larger, though unreliable losses. Initially this was the third commonest Other habitat type equal in proportion to coniferous woodland but is now fourth most common. However it is very rare in some Districts (especially east coast areas).

Open water occupies a very small area and the changes to it are mostly less than 10% and unreliable. There were again both gains (mean 2%) and losses (mean 6%).

Taking both types together there has been a slight net loss in area. The most comparable results are those in Table 27A for North East Fife. Although the proportions of open water change were of similar magnitude in both the Weyl and Langdale-Brown and the NCC surveys, the first study suggests a large loss in wetland and the latter a gain in wetlands.

All of these losses were recorded in the first half of the survey area of North East Fife (Weyl and Langdale-Brown 1978). Other studies of changes to open water have concentrated on pond removal eg. for areas of Huntingdonshire and Leicestershire, about one-third of all ponds have been lost in the last 30 - 50 years (Relton 1972).

Wetlands Interchange

Although unreliable, the results suggest that almost two-thirds of all wetland lost has been turned to agricultural use. The second largest loss - one-sixth - was to coniferous woodland. Of the gains, two-thirds came from agricultural land - (Although this area is half the estimated area of wetland lost to agriculture, it is more reliable). This gain seemed due to areas which had been drained previously reverting to wetland. Confirmation of the possibilities of this occurring was to be found in a paper given by Jeffrey to a conference on Lothian habitats in 1982. Using Department of Agriculture and Fisheries drainage statistics for Lothian and the Borders for 1978, he stated that '51% of all schemes were on land where the old drainage system had recently 'packed in''. He then stated that agricultural authorities suggest that in Lothian 90% of all drainage is on land which has been drained previously. It seems likely then, that the wetland gains recorded in the NCC survey will be lost again in the near future.

Thus the picture is very much one of wetland loss and for the first time agriculture was the main agent of change. The greatest losses appear to occur in the west where that type is commoner than in the east. There losses to Wetland may exceed those to Grasslands.

Summary of Changes to Other Habitats

The total area of Other habitats decreased in every District and Region. The area of Woodlands actually increased by over 10% (mostly due to conifer planting) and the area of Wetlands declined by a similar amount. The area of Grasslands and Heathlands however decreased by over a third. The main reasons for the decline in the area of other Other habitats must be attributed to the loss in the area of deciduous woodland and the loss of improved grassland.

Discussion of Net Changes to Agricultural Land

Although the estimates of the total extent of this habitat type were amongst the most reliable, estimates of net change were amongst the least reliable, because of the combination of gains and losses of similar size. An overall gain of 2% was estimated and a loss of 3% i.e. a net loss of 1% or 11800 ha, the largest net loss in terms of area. In exactly half the Districts, gains exceed losses; where losses are larger they are much larger (though rarely exceeding 10% of the early area). The greatest decline in the agricultural area occurred in the Industrial Districts identified in Section 3.4.2. Overall the area under agricultural use has decreased. The individual gains totalled 21479 ha, a serious change if it were all at the expense of wildlife habitats. However the interchange results show that almost one-third of the gains are at the expense of improved grassland and almost a quarter comes from wetland. The third largest donor class, accounting for one-sixth of the gain was non-agricultural land. Although the gain wetland was deemed unreliable, it and the gain from improved rough grassland are likely to be of much interest to the NCC. Such changes are facilitated by Government grants to 'improve' such areas. Up to three-quarters of the cost can be claimed (Shoard 1980).

The losses, which are greater, are also of interest. Almost 80% of the area lost: 26,000 ha, has gone to non-agriculture, 10% to coniferous woodland and 8% to wetland.

Thus although a considerable amount of reclamation has been occurring, particularly by drainage of wetland and ploughing of old pasture, these changes are smaller than the loss of agricultural land to non-agriculture. The main causes for this appear to be the expansion of towns, road improvements (and new roads), and new farm buildings. Many farm steadings have increased in size as new sheds and silos are erected and again up to three-quarters of the cost can be met by capital grants.

Discussion of Changes to Non-Agricultural Land

This, the second largest habitat at both dates of photography, has increased by 22% over the survey period. The results are more reliable and indicate gains as high as 43% in Central Region and 66% in Falkirk and Clackmannan District. There have been losses in every District —

an overall loss of 5%. The gain in new areas of non-agricultural land is about 25%. The gain in area of 24,498 ha is the largest gain in area to any habitat type.

The interchange results show that the greatest gain (86%) is from agricultural land. This 26015 ha is the largest individual change. Though losses were only one-fifth of the area of gain, they are still sizeable: 5510 ha. Two-thirds of this area has been reclaimed to agriculture but 18% has been gained to scrub which may be significant for wildlife.

The areas which have gained most non-agricultural land are, not unexpectedly, the Industrial Districts and Regions identified in Section 3.4.2.

The Main Net Changes

The main net changes were identified as those in which the greatest proportion of the early area had changed and where there had been the greatest area of change. These were: net gains to coniferous woodland and non-agricultural land and net losses to improved grassland and deciduous woodland.

Although the gain to non-agricultural land is mostly at the expense of agricultural land and hence not significant to wildlife, the gain to coniferous woodland is significant because it is mostly at the expense of deciduous woodland and improved grassland, which may be more important wildlife habitats than coniferous woodland.

The rest of the habitat changes summarised in the earlier sections, are either smaller than these in terms of area and/or in terms of the proportion relative to the early area of that type, or less reliable. Some achieve 'major' status in certain Districts and Regions e.g. wetland loss is considered major in Strathclyde Region. In fact the 'major' changes identified above for the whole survey area rarely all occur together in any one District or Region. Gains to non-agricultural land, for example, are not major in the Borders,Dumfries and Galloway and Tayside Regions. This is not surprising; these last two Regions were identified as 'Agricultural' Regions in Chapter 3 (See Section 4.3.2.)

In the whole of the lowland study area, the area of agricultural land declined by 1% on average. On the other hand its extent remained the same or increased in the Agricultural Regions (Section 4.3.2). The area of non-agricultural land increased by 2% on average and by more in the Industrial Regions. The area of Other habitats declined by 1 - 2% in all Regions. Collectively, the loss of wildlife habitats must be considered major.

4.2.4 Summary and Discussion of Interchange Results

The interchange Tables showed a more detailed breakdown of all the habitat gains and losses. At the District levels these individual changes were found to be mostly unreliable and at the Regional level only about half the results were more reliable. In conclusion only the more sizeable interchanges were more reliable at these levels. The Regional results were therefore summed up and presented for the whole survey area. The possibility of comparing Regional and District interchange was sacrificed in order to obtain as reliable as possible a picture of interchange. These survey area interchange sums were graded for reliability according to their reliability at the Regional level.

Many of the individual interchanges have already been described in this summary alongside the net changes to which they are relevant. In all 8% of the study area has changes in the post-war period. There were 114 individual change types with gains and losses to every habitat type. In the case of scrub for instance, the total gains were almost equal to the total losses. Those of the individual interchanges which may be considered more serious for wildlife usually have a reverse interchange. Though these are usually smaller and initially of less value for wildlife the fact that they are occurring is encouraging. Change has been shown to be less one-sided than might have been thought.

The 21 largest interchanges account for over 80% of all interchange. The largest of these is the change from agricultural land to non-agricultural land, which accounts for nearly one-quarter of all change and losses from deciduous woodland, improved grassland and felled areas, to coniferous woodland, account for a further sixth of all change. The other of the 'top five' interchanges is that from improved grassland to agricultural land. The seriousness of these five changes for wildlife will be considered more fully in Section 3.

4.3 SUMMARY OF CONCLUSIONS TO SECTION 1

The most important conclusions are summarised below.

1. Almost one-quarter of all hedges were estimated to have been lost in lowland Scotland in the post-war period. Although this proportion is the same as that estimated for England over the same period, the lengths of hedge loss are less. This is because Scotland has always had less hedges than England.

2. A relationship was found between initial hedgerow density and proportion of hedgerow loss. Districts with a low initial density of hedges were those where the proportion of hedge loss was greatest. Reasons proposed for this included differences in agricultural practices, differences in topography and differences in the boundary materials available. In England a similar relationship between hedgerow density and loss was reported. The reason for this was thought to be different agricultural practices. Where arable farming is dominant as in eastern England, there were initially fewer hedges but field rationalisation continues. In more western areas where livestock rearing continues, fields are smaller and so hedgerow density is greater and there is less reason to remove hedges.

3. Many of the District estimates of habitat extent were unreliable especially in smaller Districts where there were fewer sample frames. On the whole, results for large Districts were more reliable, but even these included one or two unreliable estimates of habitat extent. The habitats where extent has been estimated with least precision are dwarf shrub heath and permanent unimproved grassland. This imprecision was thought to be related to the rarity of these types.

4. There was found to be more of a relationship between the proportion of agricultural land and non-agricultural land in a District rather than of either of these with any of the Other habitats (of wildlife interest). On this basis it was possible to categorise most of the Districts as either Agricultural or Industrial. 'Other' habitats were subdivided into Woodlands, Grasslands and Wetlands. West coast Districts supported more wetland and less grassland than east coast Districts.

5. The estimates of net change were far less reliable than the estimates of habitat extent. Only with deciduous woodland, coniferous woodland, improved rough grassland and non-agricultural land were there enough reliable results to draw conclusions. Much of the variability of the other habitats occurred because change is rarely unidirectional, there are gains and losses to each habitat, Scrub and agricultural land were particularly affected by this phenomena.

6. On the whole, the larger net changes were the most reliable. The major net changes identified were:

a) A 22% gain in the area of non-agricultural land. This occurs almost entirely at the expense of agricultural land.
b) A 77% gain in the area of coniferous woodland. This occurs mostly at the expense of the Grassland types, particularly improved rough grassland, and deciduous woodland.
c) A 17% loss in the area of deciduous woodland. A third of this area has been planted with coniferous woodland and one-quarter had been felled and awaits replanting.
d) A 36% loss in the area of improved rough grassland. Two-fifths of this area was planted with conifers and one-third has gone to arable use.

These four changes rarely all occur in one Region. In the more Agricultural Districts gains in the area of non-agricultural land were less serious. The loss in the area of deciduous woodland was less serious in some Regions than others. However the decline in the area of improved grassland was major in most Regions.

7) Many other changes have not been identified as major. This is because for the most part they are smaller in terms of area and/or their percentage of the early area or are unreliable. Some are major in some Regions only e.g. the loss of wetland in Strathclyde. Others will be important only at the District or sample frame level. All will be of consequence to wildlife but the effects will be less, overall, than the effects of the four more extensive changes above. In all 8% of the lowland area studied had changed.

8. The main individual change was found to be the loss of agricultural land to non-agricultural land which accounts for 23.5% of all change. This was nearly four times larger than the next largest interchanges:- improved grassland to coniferous woodland and to agricultural land, and deciduous woodland and felled areas to coniferous woodland.

9. Another conclusion to be drawn from the interchange table was that there have been a large number of changes: 114 out of 125 possible interchanges. A dynamic picture is painted - many gains and losses to each habitat type with even individual interchanges rarely unidirectional - the 'Shuffling' effect.

10. Initially agriculture occupied 75% of the study area, non-agricultural land 8% and Other habitats 17%. In the survey area as a whole, agricultural land decreased by 1%, non-agricultural land increased by 2% and Other habitats declined by 1%. The reason for the decline in the areas of agricultural land has already been cited as the change to non-agricultural uses. The decline in the area of Other habitats is a significant change.

The total area of Woodland increased despite losses to deciduous woodland. In fact there were also gains to mixed woodland equal to this loss. The main reason for the gain was the increase in conifer planting. The area of Freshwater Wetlands declined overall by a similar area to the Woodlands gain. However the area of Grassland and Heathland declined by over a third, much of this lost area being from improved rough grassland. Losses of deciduous woodland and improved grassland are major contributory factors to the decline in the area of Other habitats.

11. The final conclusion is that in lowland Scotland, the main forces behind changes were not agricultural intensification and reclamation as the NCC expected, but non-agricultural increases and conifer planting. The deciduous woodland decline is due to this last factor rather than to agricultural reclamation. However agriculture was the third major force behind change - the habitats affected in particular were improved grassland and wetland.

SECTION 2

The object of this section is to provide a historical context for the post-war habitat changes which were detected in the course of the NCC survey. This is used to assess further the significance of the findings of that survey.

Chapter 5 summarises the history of the British flora since the last ice age and considers the evolution of agriculture and forestry with particular reference to the lowlands of Scotland.

In Chapter 6 further information is presented on the nature and extent of wildlife habitats in lowland Scotland from the late Mediaeval period. Much of the evidence presented is for the District of East Lothian.

CHAPTER 5 VEGETATION AND LAND USE HISTORY

The information in this chapter has been derived from three main sources:

1) Histories of British flora
2) Histories of land use
3) Histories of landscape appearance

It is presented in six sections which deal with different periods: Before Man; Prehistory and Dark Ages; Middle Ages; The Improvers; 1800 - 1950; The Last 30 years.

Though the bulk of the evidence is concerned with the evolution of the major land uses, an attempt has been made to trace the history of the fourteen habitat types covered by the NCC project. These were: deciduous woodland; coniferous woodland; mixed woodland; felled areas; scrub; dwarf shrub heath; permanent unimproved grassland; improved rough grassland; wetland; open water; agricultural land, non-agricultural land, hedges and tree-lines.

5.1 BEFORE MAN

The evidence in this section comes mainly from pollen analysis (Godwin 1956 and Burnett 1965).

It is unlikely that any vascular plants survived beneath the ice sheets. The advancing glaciers must have literally erased all the vegetation they encountered. At least five times in the last million years the central belt of Scotland was completely covered in ice. In the interglacial periods it is probable that the country was completely vegetated. Godwin proposed the following cyclical succession for each interglacial:-

Sub-arctic species) tundra
Dwarfshrubs)
↓
Birch, pine, aspen forests

↓
Deciduous broad-leaved forest
(oak, alder, hazel and lime)
↓
Hornbeam, spruce, pine, birch forest
↓
Tundra, heath

At the 'climatic optimum' the vegetation would be very similar to what the climax vegetation would be today. In fact it is likely that the present era is an interglacial. It has been termed the Flandrian interglacial.

During glaciation itself there would be areas periodically exposed, rapidly frost-weathered and colonised by plants surviving in other temporary exposures, or in places the ice sheet did not cover. Locally these 'nunataks' included steep and high places, but nationally the area south of the Thames was never covered by the ice sheets.

As the ice last began to retreat, some 15,000 years ago, vast expanses of open land with fresh mineral soil became available for colonisation. Mabey (1980a)has described the processes of melting ice, solifluction and frost action as similar to the conditions on a modern building site, and the species found would be similar to those found on disturbed areas today. Godwin concluded that by the end of the late glacial period, no less than 50% of Britain's flora was already present. As a whole the vegetation resembled sub-alpine meadows: grasses, sedges, dwarf shrubs (including ericaceous species) and perhaps mosses and lichens with much scree and bare rock, but certainly treeless. The flora was predominantly arctic-alpine, even in the lowland areas, but such species are today confined to the highest mountains. Herbivores such as the Giant Deer, whose remains have been found at Corstorphine and Maybole in Ayrshire (Piggot 1957), elk, bison, horse and reindeer grazed the tundra.

The late glacial and early glacial would be periods of rapid plant spread, as fast, Godwin concluded, as that on waste land today. As well as those species which survived the glaciation in outposts, species were spreading in from the continent. Britain was still joined to main-land Europe with a land 'bridge' from near Scarborough to Demark and across the English Channel. Mabey (1980a) has pictured the countryside as a 'brilliant rockery' with many flowering plants exploiting the open condition.

With the start of the Post Glacial period some 10,000 years ago, woody species began to replace the earlier flora. Trees such as birch (Betula pubescens and Betula pendula) began to move into the tundra/heath, followed by Scots Pine (Pinus sylvestris). By the Pre-Boreal period which started 8000 years ago, a sparse birch/pine forest with rowan (Sorbus aucuparia) and juniper (Juniperus spp) was established with remnants of the late glacial flora existing below. As the forest cloaed the grass/heathland communities would be excluded. These plants which requireed open conditions would henceforth be confined to areas above the tree-line, coastal areas with continual erosion and accretion, permanently waterlogged areas, and the forest clearings created by lightning fires or windthrow. The arctic-alpine element of the flora retreated to the colder conditions in the north and up the mountains.

All these events were probably later in Scotland: Edlin (1969) suggests the ice sheets here began to melt 9000 years ago.

This period was followed by the true mixed deciduous forest which came to clothe most of the landscape. The species which now began to dominate were less hardy than the first colonisers. Over much of the Scottish lowlands oak (Quercus spp) was the dominant species growing with wych elm (Ulmus glabra), alder (Alnus glutinosa), lime (Tilia spp), hazel (Corylus avellana), aspen (Populus tremula) and birch (Betula spp). Each of these would achieve local dominance under certain ecological conditions. As the warmth increased the pine spread northwards, followed by hazel and was eventually confined to places where mixed deciduous forest could not grow for climatic or edaphic reasons. By then there would be vast continuous tracts of forest with only wetland, steep slopes, rocks and mountainland free of tree cover. In Scotland there was a greater proportion of these habitat types; Edlin (1969) postulates that perhaps only 50% of 'Scotland's broken and rugged land surface once bore natural forest'. He still concluded that 'until mankind appeared on the scene the trees held sway over mile after mile of hill and glen'.

The spread of the deciduous forest would be accompanied by the spread of other species absent from the earlier treeless period. These included shrubs such as holly Ilex aquifolium, yew Taxus baccata and hawthorn Crataegus spp, lianas such as ivy Hedera helix and woodland ground flora. The 'sea of deciduous forest' (Godwin 1956) itself changed conditions for migrating species. The spread of the late glacial flora was blocked and it became limited to the treeless places. By the end of the Boreal period the tree canopy was closed and the late glacial flora supressed.

It is perhaps ironic that the same climatic amelioration which enabled the land to become revegetated also prematurely curtailed colonisation from Europe. As the ice melted the sea level rose, drowning the lowland between Britain and Europe. In the same era the land, relieved of the great weight of ice, rose. This occurred primarily in Scotland (hence the raised beaches) and was accompanied by a downwarping effect in the south which deepened the channel. This happened about 5500 BC and it is cited as the main reason for the paucity of the British flora compared with that in other European countries. A total of 1500 species had arrived by then but France has 6000 native species (Mabey 1980a). It is thought that many species introduced artificially since then may well have colonised naturally had the land link with Europe not been severed so early. An example is spruce Picea abies which was present in the earlier interglacials (Godwin 1956).

As Britain became an island the climate became more oceanic. The Atlantic period which had begun in 6000 BC was a time of increasing wetness and warmth. These more favourable conditions enabled the deciduous forest belt to move northwards and higher up the hill. Certain species would be favoured by these conditions, for example alder.

However it also marked the start of more extensive peat and bog formation. The west winds and higher rainfall led to podsolisation, more acidic soils and the spread of sphagnum/calluna bogland. In fact many pedologists consider podsolisation to be the naturally dominant soil forming process in Scotland (Whittington 1980). Such conditions would limit the distribution of the more exacting species especially those requiring calcareous soils.

At times during the Atlantic era, the climate was warmer and drier and at others cooler and wetter. The forest itself was responsible for much climatic amelioration. As well as moderating climatic extremes, the effects of wind would be reduced and a fairly constant microclimate would be created. This in turn would enable more exacting species to survive, for example alder was a component of these old forests, which Dimbleby (1978) thought would be far moister than the less extensive woods today. Alder is found only in the wettest places today. Another effect was to enable forest growth to proceed into more extreme conditions than pioneer colonisation by these species could, for example, higher up the hill. The tree-line at the climatic optimum reached 1000 metres above sea level (Burnett 1964). In fact a possible origin of Scotland's ancient name of Caledonia is the Gaelic <u>Coille dun</u>: 'the wooded heights' (Edlin 1969). At the same time as this peat was being formed, as low as 380 metres O.D. in the Cheviots (Whittington 1980). The Cheviots are on the east side of the country where the oceanic influence is less. Where peat extended it was at the expense of the forest.

5.2 PREHISTORIC AND DARK AGE SETTLEMENT

On the eve of Mesolithic man's arrival in lowland Scotland in 6000 BC, deciduous woodland was still spreading northwards and achieving dominance over the earlier vegetation. However it is thought that the numbers of Mesolithic man and his method of survival ('hunter/gathering') had little more effect on the forest than other vertebrates such as deer and boar had. The first settlers colonised the coastland where the forest was thinner on the sandy soils of the raised beach. There they were able to supplement their living with fish and shellfish. By then they had knowledge of fire and crude axes, and made local clearances in the forest. Such inroads were short-lived however; the preponderance of forest round about ensured trees would soon regenerate. Theories about the purposes of these clearings include the encouragement of the growth of herbs, to collect, or to attract herbivores for slaughter (Whittington 1980). Fire may have been used to flush out the animals for hunting (Millman 1975).

Until now all the major habitat changes had been induced by purely non-anthropogenic factors. However with the development of the Neolithic culture man began to play an increasing part in the modification of the landscape. It is impossible to judge the extent of man's impacts in these early days because the climate was still changing. Around 3000 BC the climate entered the sub-Boreal phase. The junction of Atlantic period and the sub-Boreal phase has been proposed as the 'climatic optimum' (Godwin 1956). There was a return to drier conditions - a more continental climate. Podsolisation and peat formation slowed and wetland dried, enabling the trees to spread again. Ash (Fraxinus excelsior) seems to have been particularly favoured by the drier conditions. Neolithic man is thought to have arrived in Scotland around 2500 BC but most of the evidence for his effects still comes from pollen analysis; the artefacts left were mostly sepulchral. The evidence suggests that farming, where practised, was mostly pastoralism: the grazing of livestock in areas cleared of woodland. The later Neolithic people had knowledge of metallurgy and the tools for clearing woodland were more sophisticated. At Cairnpapple Hill near Linlithgow, an important burial site, metal axes have been found from this era (Piggott 1951).

It is likely that the hunter-gatherer type of existence continued alongside early agriculture. The first domesticated animals may have been the young of those killed in the chase (Symon 1959), for example, the boar ancestor of the pig, and wild cattle were known to roam the forests. However the first settlers probably brought domesticated animals with them and perhaps mated them to indigenous species. The decline in elm pollen at the time is thought to have been due to the practise of feeding the leaves to cattle (Whittington 1980). There is evidence of elm decline all over Scotland at that time, not only where there is archeological evidence. Theories for this include the climate change per se or Dutch Elm disease which is known to spread most in anticylonic conditions and these would have been prevalent in the Sub-Boreal summers (Green 1981).

These settlers penetrated the areas where the forest cover was lighter - hilltops, river valleys and coastlands but were probably still nomadic. Likewise the first cultivation was probably shifting: crops grown in the ashes left when an area of forest was burned, cropping continuing until the fertility was lost, and then movement to a new area. Iverson (1941) found evidence of all the stages of these temporary clearances from pollen analysis in Denmark. He termed them Landnam clearances (tree pollen → crop or herbpollen → tree pollen). Hunter-gathering, nomadic pastoralism and shifting cultivation were all practised at this time.

The presence of these clearances, albeit temporary, favoured those species of open habitats before the deciduous forest e.g. nettle Urtica dioica, Rumex spp, and fat hen Chenopodium album. Plantains Plantago spp are particularly favoured by these conditions; in fact the North American Indians named Plantago media 'White man's footprint' (Godwin 1956). Many of these 'ruderals' such as fat hen would be used directly as food.

The Bronze Age began around 2000 BC, but change probably continued to be slow and confined to those more accessible areas. It is unlikely that permanent inroads were made into the forested area until the early farmers became more settled, and there is little evidence of any such settlement before 1000 BC. All earlier archaeological sites are for burial or worship (Piggott 1951).

On the brink of this period of change, Scotland was still 50% forested with probably a higher proportion in the lowlands. The melt water valleys remained fairly wet, variously described as resembling Scandinavian water meadows (Burnett 1964) or as marsh with thickets of alder and willow (Millman 1975). It is hard to imagine such areas not supporting tree growth but it is likely to have been thinner than on well drained soils - today's 'carr'. Once the tree cover was removed, such wet meadows would be most easily maintained by grazing. Forest cover was also thinner on the coastal areas.

Thus the habitat types of deciduous woodland, felled areas, grassland, wetland and open water were already established. Pine is unlikely to have occurred by this stage in the lowlands and so neither coniferous nor mixed woodland were known. The proportion of felled areas was small compared to the deciduous woodland area, but as transient in nature as today.

Much of the initial settlement was coastal, on hill land near the main river systems or in lake dwellings (crannogs). The advantages of the first two sites would be the thinness of the forest cover, and better drainage. The crannogs and hill forts were possibly also so situated for defensive purposes. It is worth bearing in mind that the climate was warmer and less wet than it is today making habitation at these heights more bearable. There is evidence of cultivation on the east at 300m on land today used for rough grazing and forestry. However at around 500 BC the climate deteriorated to markedly sub-Atlantic conditions, but habitation at this height continued.

This climatic change, a return to more oceanic conditions: cooler, wetter and windier, coincided with the first settled cultures and it is difficult to distinguish purely anthropogenic effects. For example where tree cover was removed the minerals were leached from the soils, peat growth and podsolisation resumed leading to moorland dominated by ericaceous species. Lowland heaths were also found by this date at coastal areas, and lowland blanket bogs both supporting ericaceous shrubs. The presence of oak stumps and brown forest soils (Godwin 1956) beneath the surface of these bogs are evidence that deciduous woodland did occur, albeit in climatically more favourable times. However the microclimate effect of the whole forest would perhaps have prevented podsolisation at lower altitudes had trees not been removed. The heathlands were maintained thereafter by grazing and burning.

From 1000 BC onwards the processes of deforestation, cultivation and grazing, compounded by later climatic change, shaped most of the Scottish countryside. Initially it was thought that most Bronze

Age activity was pastoral but grains of early barleys and wheat have been found at sites in Dunfermline, Berwickshire, Ayrshire, Fife, Stirlingshire, Lanarkshire and Midlothian (Whittington 1980). However methods of cultivation are unclear; it is likely that the plough was not yet deployed and cruder tools similar to hoes were in use. However at most sites of this date the decrease in tree pollen was accompanied by an increase in the grasses and herbs of open habitat suggesting the continuance of pastoralism.

Godwin (1956) summarised the following changes caused by the introduction of settled agriculture: 1. The destruction of forest trees. 2. The habitats for the woodland flora diminished. 3. The introduction of cereals, initially wheat and barley, but later rye, oats, spelt and flax. 4. The introduction of alien weeds along with cereals which were also able to exploit open conditions. 5. The expansion in range of the late glacial flora into open habitats. It is difficult to determine which of these 'weeds' and 'ruderals' were already present and it is likely that most of them would have been present had land contact with Europe not been breached. The first pollen records of the poppy Papaver rhoes, charlock Sinapsis arvensis, bindweed Polygonum convolvulus and hop trefoil Trifloium campestre are either Neolithic or from the Bronze Age. 6. This was the first time scrub became a common habitat type. It had previously been confined to the most exposed places. Shrubs play a relatively minor role in the forest apart from a few shade tolerant species and tend to be found in clearings. The midland thorn Crataegus oxyacantha is thought to be a true woodland species being more shade tolerant than the more familiar Crataegus monogyna. Other woody species which increased in the pollen record with the onset of prehistoric agriculture include gorse Ulex europaeus, gean Prunus nigra and ash Fraxinus excelsior. Previously scrub had been present only as a stage in the succession to forest. The species which now survived tended to be fire resistant or unpalatable.

These six processes were uppermost in determining the later flora of the lowland area. Even where shifting cultivation was practised Whittington (1980) has suggested that the natural tendency towards podsolisation was compounded by farming, and leaching of minerals would reduce the likelihood of tree regeneration. In most places though grazing was the decisive factor in maintaining open habitats.

Climate change itself will have been responsible for the regrowth of bogs and marshes which had dried in the Sub-Boreal conditions.

The Iron Age people who arrived from 200BC onwards came to a climate less pleasant than that of the previous eras and would find many earlier clearings and settlements invaded by peat. The unpleasant stormy weather led to the need for more permanent shelters for both man and stock (Lamb 1972). These conditions and an increasing population would turn new settlers towards clearing new areas, more inland and further from the early riverside sites.

This era is better understood than earlier epochs because more of relict features and artefacts have been found and studied. The settlements were often built in defensive positions such as hill tops with surrounding palisade, walls and ditches. They were probably built by Celts moving northwards ahead of Roman activity (Piggott 1951). Later examples include groups of houses often still on high ground but without the defensive structure, though palisades may have been maintained to keep in stock (Whittington 1980). There is little evidence of an economy dominated by corn growing with small square fields which was prevalent in England at the time except at one place in the Borders - Torwoodlee (Symon 1959). However that grain was sown is supported by finds of primitive plough parts (mostly from south Scotland) querns and grain (Whittington 1980). The true plough is not thought to have reached Scotland until after the Roman period (Symon 1959). Pastoralism then, was still dominant in most of Scotland at this period with sheep, cattle, horse, pig and goats having arrived in the Neolithic and Bronze Ages. In southern Scotland it is likely that mixed arable and pastoral farming was practised (Whittington 1980) though the Romans described the Caledonians as herdsmen and hunters (Symon 1959). The Picts and Celts despite Roman description, had probably reached a fairly advanced stage of civilisation with knowledge of working metal, spinning and weaving.

It is known that further inroads were made into the great forest in this era, assisted by the iron tools, for charcoal for iron smelting, for oak bark for tannin, for construction materials, for fuel, and of course clearance for the grazing of stock which tended to precede cultivation. Regeneration in the cool temperate climate was very slow and so many of these changes were never reversed. With tree removal, the lower lying areas were more likely to be flooded which is why cultivation was confined to higher, better drained land in this period.

The Romans first crossed into Scotland in 80 AD and stationed troops in the south-eastern part of the country intermittently until 370 AD. However they never actually settled in the country and are unlikely to have influenced agriculture as much as they did in England. The reason for this was that their presence in the country was mostly defensive: to prevent the 'warlike' Picts from penetrating the English colonies. They were never able to contain the northern tribes completely and with continuing warfare it was perhaps not thought worthwhile to cultivate lands they might never harvest (Franklin 1951).

In the initial Roman conquest the southern part of the country was overrun and many of the native forts demolished. Burnet (1964) suggested that the dispossessed tribes moving northwards spread grazing and cultivation into formerly sparsely populated areas. Permanent forts and temporary camps were established in this period. However in 100 AD the garrison withdrew and work began on Hadrian's Wall to keep the northern tribes back.

There was a renewed advance in 140 AD to re-establish control over the lowland tribes who continued to menace the Roman defences. A new barrier was built between the Forth-Clyde isthmus - Antonine's Wall, with 20 forts. This defence made use of existing marsh and forest. It is less easy to trace the line of the wall compared to Hadrian's Wall because marsh and forest are long gone. In 190 AD the line was given up in favour of the more strongly fortified Hadrian's Wall.

Probably the most important effect of the two occupations was the establishment of new communication routes. Two main routes were cut to the Forth: on the east side of the country via the Cheviots, the Tweed valley and Lauderdale; (which corresponds roughly with today's A68) and on the western side through Annandale and Clydesdale, (roughly equivalent to the A74). The eastern route continued north to the Tay. North of this traces of Roman road can be found as far as Banffshire. Locally, the Roman road alignment was later followed by drove roads, footpaths, field and estate boundaries and occasionally by modern roads. Associated structures included permanent forts and marching camps.

Although South-East Scotland was beyond the frontier for most of the Roman occupation, friendly relations were cultivated with the remaining local tribes. This continued in the third and fourth centuries AD and the area acted as a buffer zone between the military and civil zone south of Hadrian's Wall and the Pictish tribes. Friendly relations and trading continued and Southern Scotland was probably subject to more Roman influence than other parts of Scotland. In 396 AD the Votadinii (Lothian, Strathclyde and the Merse) and Damnonii (Clydesdale) were entrusted with the defence of their own territories and Hadrian's Wall was abandoned.

During this period there was extension of the weed population in England. Many new species were introduced, accidentally or deliberately, and it is often difficult to distinguish which were used as food and which were true weeds. For example, ground elder Aegopodium podagraria, now a common garden weed was introduced by the Romans as a pot-herb. The following species have their earliest post glacial records at Roman-British sites

Pignut Conopodium majus, wild oat grass Avena fatua, cat's ear Hypochœris radicata, hedge parsley Torilis japonica*, black mustard Brassica nigra*, nipplewort Lapsana communis*, cow parsnip Heracleum sphondylium^x and welted thistle Carduus crispus^x. Those marked ^{x} were last recorded in the late glacial period and those marked * in an interglacial period (Godwin 1956). These are all now familiar weeds of field and verge. The continuing creation of open habitats and the opening up of roads by the Romans would aid their dispersal in Scotland.

The period after 400 AD when the Romans departed is commonly called 'The Dark Ages' because of the little historical information about the era. It is likely that with increasing settlement and farming, destruction of the natural vegetation continued but at a slow pace.

Many new cultures invaded the country through this period and it can be deduced that there would be constant struggle for the best lands. The first settlers were probably the Picts but waves of Scots, Britons and Angles followed and finally the Norsemen. Many of the old Iron Age sites were reoccupied. Evidence of where they settled is to be found in the place names of different regions.

The Picts (dominant in the north-east) and the Scots (dominant in the west), united under Kenneth Macalpin in 843 AD. However the Picts were severely defeated by the invading Vikings and so weakened that the Scots took over the whole throne. The Angles settled in the Lothians and in Northumberland in the 7th and 8th centuries. The earliest signs of their agriculture are to be seen in the hillside terraces on Arthur's Seat Edinburgh and at sites in Berwickshire and the Borders. These were probably formed with the spade and ran with the contours so as to prevent erosion (Symon 1959). Later the Angles were responsible for the introduction of the true plough and for the establishment of the open field system in the Lothians. The countryside and social organisation in this area would already be more similar to that in England than to the rest of Scotland.

Millman (1975) thinks that the first serious deforestation occurred with the arrival of the 'plundering, burning, raiding' Vikings in 800 - 1100 AD. While this may be true for the Highlands and the north coastal areas, other literature (e.g. Whittington 1980) suggests the lowlands were already much altered.

There is evidence of a degree of social organisation from the earliest historic times (Barrow 1973) which continued into the mediaeval period.

5.2.1 Summary of Prehistoric and Dark Age Eras

Though some writers believe that the most radical landscape changes did not take place until the Middle Ages, Whittington (1980) argues that by 1000 AD the landscape of the Boreal era had already undergone radical changes. This would be more true of southern and more accessible areas, whereas in the north there were probably still tracts of wild lands. In both areas the marshlands of the valley floors would remain the most resistant to change owing to the lack of drainage expertise (Franklin 1951).

Godwin (1956) considered that after the arrival of man, deforestation, grazing and cultivation had the greatest influence on the vegetation. However at least twice in the prehistoric period climate changes had a marked effect on Scotland's vegetation. Nonetheless, Edlin (1969) states quite unequivocally 'A change in land use from forest to grazing and arable lands, was responsible for the loss of most Scottish woodland. This took place so gradually that it was almost unperceived'. Pastoralism in particular led to the creation and maintenance of much grassland, heathland, and water meadow. The change from nomadic farming to more settled farming was also a crucial factor. There was little pure arable farming as in much of England; the Celts were dwellers of the hills and practised little arable cultivation. Even in southern Scotland at most mixed farming was practised. It was not until the arrival of the plains dwellers, the Angles, that arable farming became more extensive.

Before 1000 BC the habitat types of deciduous woodland and wetland were most prevalent in the lowland area though small pockets of grassland and felled areas-'landnams' were already present. By 1000 AD most of the habitat types considered in this project would already be present: deciduous woodland, felled areas, scrub, dwarf shrub heath, grassland, wetland, open water, agricultural land and non-agricultural land. The first crops grown were barley and wheat but with the onset of the cooler, wetter conditions of the Sub-Atlantic period oats became a more suitable crop. The 'non-agricultural' land was mostly roads and settlements, Barrow (1973) suggests that by the 12th century the settlement pattern was chiefly determined by the land that could be ploughed.

5.3 THE MIDDLE AGES

The onset of the Mediaeval period in England is usually taken as the Norman conquest (1066) but in Scotland a more convenient starting point is the reign of Malcolm II (1005 - 34) when the whole of Lothian (then extending from the Forth to the Tweed) was added to the Kingdom of the Picts and the Scots. Because Scotland was on the geographical and cultural periphery of Europe, new ideas arrived late and the Mediaeval period could be said to extend until the Union of Parliaments 1707 (Millman 1975).

There was however a peaceful Anglo-Norman invasion. The Kings of Malcolm Canmore's line, particularly David I (1124 - 53) encouraged Norman lords to settle in Scotland in order to control the turbulent portions of the population - a 'bloodless' Norman conquest (Symon 1959). Estates confiscated from tribes disloyal to this line of kings were granted to the Normans.

In times of peace the King and his lords were fond of hunting; a more formalised and pleasurable exercise than the hunting of their Mesolithic ancestors. Large tracts of land were laid aside for this purpose which in turn would conserve wild species. These hunting grounds were further protected by Forest laws to maintain the game species: deer, boar, hare, fox and game birds. These Forest laws aimed to limit the number of livestock which could be kept in the king's forests, to discourage poachers, and later to encourage tree planting. Areas protected included Ettrick Forest, Holyrood Park and areas in the 'Kingdom of Fife'.

'Forest' then meant a hunting area, which was not necessarily wooded and could include open areas and scrub. Wolves were hunted but less for sport than for the threat they posed to stock or children. The species was forced to extinction: it was absent from the lowlands by the early 16th century and from the country by 1747. Boar was also hunted to extinction, though at one stage they were so common as to be regarded as a nuisance. There are reports of them roaming Berwickshire in herds and scavenging in Haddington in 1543 (Fenton 1951). Bear and Lynx were also exterminated. However elsewhere the removal of woodland continued – the valleys of the rivers Gala and Leader in the Borders were disforested by the early 13th century. Despite the protection afforded to the hunting forests, even they began to be eroded towards the close of the 13th century (Dodgshon 1980). Forests were removed for security; for they harboured 'freebooters and thieves', and for timber as well as to clear land for farming. Fenton (1951) suggests that the destruction of Scotland's forests was complete by the 16th century, for there was legislation by then to prevent further disforestation. Burnett (1965) concludes that all the accessible woodland in the lowlands was gone by the 15th century.

The Normans also introduced the rabbit Lepus auriculus to Britain and though initially reared in warrens for food and fur, many later escaped. By the early 18th century they were extremely common and widespread through the country. (Godwin 1956) compared their influence to that of sheep in that they adapted well to the new open habitats and helped prevent the regeneration of woodland.

The Normans granted lands in Scotland introduced feudalism. The idea of one man and his descendants having exclusive rights to the land was thus new. Under the Celtic tribal system, which persisted alongside feudalism particularly north of the Tay, the chief was looked upon more as leader or father, trustee for the members of the tribe who all had equal rights to the land. The headship under the clan system was not necessarily hereditary, but passed to a relative descended from a common ancestor best suited as steward. Within the bounds of his estate the baron had complete control over all woods, arable land, pastures, moors, marshes, water meadows, roads, running water, fishing, ponds, game parks, brushwood, heather, salt pans, coal works, mills and the common people, (Franklin 1951) (This gives an indication of the habitats present at the time). The king became the ultimate owner.

Though the terms of the tenancy changed, the system of land cultivation which had developed through the dark ages continued. Barrow (1973) concluded that by 1100 AD the social-agrarian pattern of Scotland on both sides of the Forth was very long standing. The more sophisticated English techniques of the time were not yet in use.

The basic unit of development was the 'fermtoun' which housed a plough team; perhaps six to eight families. Its location was chosen for its proximity to water, arable land and construction materials (wood, straw, stone etc). The houses were loosely grouped and the hamlets scattered, altogether a more functional arrangement, than in the more 'social' English villages. Those in the South and east may have had a more structural layout (Dodgshon 1980).

The lands of the town would vary from 100 - 500 ha depending on the quality of the land. The best land, often that closest to the settlement, was called the 'infield'. This was cropped continuously, its size determined by the amount of manure available. For the most part this was the dung of the cattle and sheep housed indoors through the winter. The area beyond this was termed the 'outfield'. The majority of this land was pastureland but parts were taken into cultivation after having had stock on them for a season. (Stock were folded at night for fear of predators). The folds were then cropped until their fertility declined and returned to grass. Beyond the outfield and separated from it by the head-dyke lay rough grazing or wasteland: permanent grassland; heathland; scrubland and bog; held in common and possibly shared with other towns. The proportions of infield, outfield, and common grazing varied regionally. In the more fertile lowlands arable land could form a continuous block between towns.

The outfield could include damper land such as that by streamsides where there was periodic flooding, (this land was termed 'haughland' in the Scots language) and steeper or less conveniently situated areas within the head-dyke. There were also areas of rough grazing closer to the settlement: the 'loan' was a strip of grass running through the arable land and houses, and linking these areas to the common grazings: it served as road for man and stock, and as common green (Fenton 1980). Where good land was scarce the township buildings would be situated on more infertile land.

Although the Romans introduced drainage to England, little knowledge of the methods had reached Scotland. The land was formed during ploughing into humped ridges or 'rigs' (equivalent to the English 'strips') 20 - 40 feet wide with a furrow between. These were orientated perpendicular to the contours so that surplus water would flow off the rig into the 'furr' and would be carried downhill. However the furrows were often waterlogged or weed infested. The cropped land was usually situated on sloping land because the flattest land was usually too wet to cultivate.

The 'rigs and furr's' can still be seen today on land which has not been turned to modern agricultural use. They are found on the east coast close to the moorland boundary, on land which has since reverted to rough grazing, or on the parkland of country estates. On the west coast they are more frequently seen under grassland. It is often easier to pick them out with the aid of air photographs than on the ground. On the ground they are most visible in winter when the grass is shorter especially in the morning or evening, when the sun angle is low, or when there is frost or melting snow. They indicate that land once cultivated is not always retained for arable use. Those near the moorland boundary would be cultivated when usable land was in short supply; perhaps before the plains were drained.

The ridges were allocated amongst the inhabitants of the fermtoun by a system known as 'runrig'. They were divided so that all the co-tenants had an equal share of good and bad land scattered amongst the town. These were allocated by lot, and re-allocated periodically, e.g. at the start of a new lease or when more land was taken into permanent cultivation, to ensure equality. The rigs were ploughed communally, using oxen or cattle, and in turn so that no tenant had all his land first or last. Each member of the group then tended his own rigs, the main crops being oats and bere barley.

There are no references to any permanent divisions within the infield 'breaks' of different crops, or within the outfield. The folds in the outfield would be bounded by temporary turf banks. Altogether there is little evidence of any trees or scrub below the head-dyke. Much of the land above the head-dyke and at the sheilings would originally have been wood pasture. Grazing prevented the replacement of the wood when the original trees matured.

Apart from the inducements to Norman barons to settle, the other major civilising influence encouraged by David I was Christianity. Christianity first arrived in the 6th century. However followers of the earlier Celtic church led by St Columba, had both preached and farmed and it has been suggested by Symon (1959) that this division of interests led to the decline of the church. The Roman church had a more beneficial influence and succeeded for once in uniting the country. The most important influence, as regards land use, emanated from the monasteries. The monks confined themselves to spiritual matters and overall organisation whilst lay brethren were responsible for the farming and day to day management of the estates. David I and his successors encouraged the monks to settle granting them lands and funds, and they later received endowments from other sources. In all 36 monasteries were founded in this period, mostly of the Cistercian and Benedictine orders. Many of these were situated in the southern half of the country where the king had more influence. The first was founded in Scone in 1120, then Melrose 1136, Coupar 1164, Arbroath 1178 and Lindores 1191. Later abbeys were started in the Borders at Dryburgh, Kelso and Jedburgh, in Galloway at Glenluce, Dundrennan and Sweetheart Abbey and at Paisley, Cambusnethan, Culross, Dunfermline, Perth, Newbattle and Haddington.

The founders of the first abbeys were natives of other countries and had travelled enough to become familiar with more advanced farming techniques. Many of the Scottish founders had first settled sites in England where agriculture was considerably more advanced than in Scotland e.g. Cistercians from Citeaux in Burgundy founded Rievaux in Yorkshire in 1132 and from there founded Dundrennan and Melrose, the founders of Scone Abbey came from Pontefract, and Benedictines from Canterbury founded Dunfermline Abbey. As well as farming their lands efficiently they passed their expertise onto the local people.

The Cistercians, in particular, chose sites which were previously uncultivated: wasteland or 'loca deserta' such as marshes or scrub-lands which had potential to be reclaimed to fertile holdings. This reclamation was beyond the powers of Scottish farmers. Their lands were often added to by endowment or further reclamation making the establishment of separate offices; 'granges' or 'home farms' necessary, nearer the land. Kelso for example had 14 of these administration centres. Their estates included woods, fishings, quarries and coal pits, as well as arable and pasture lands.

They were great pioneers of land improvement, as well as knowledge they had wealth and labour to deploy schemes such as: liming; drainage; stream straightening etc. Though timber was cut for building and other purposes, the monks also took steps to protect the remaining woods and to replant trees for timber and shelter. Broom parks were established for fuel.

The majority of landlords, on the other hand, took little interest in the management of their estates, except to collect tithes. They seem to have been more interested in field sports and preparations for war.

The organisation of arable land on the monasterial estates also differed: there was no necessity for the run-rig system because the abbot owned all.

Instead of the infield - outfield systems, different crops and grass were grown in large fenced fields. Productivity on the monks land was greatly improved by their better methods. Rough pasture remained, unfenced, beyond these fields.

However by 1350 lay brethren were no longer in existence, and the Black Death has reduced the numbers of people willing to work on these lands, and so the monks became landlords. The land was leased to tenants, but the conditions stipulated in the terms of the lease ensured that sound management continued. Examples of such conditions were:

1) That the land would not be divided run-rig.
2) That particular crops and rotations should be used.
3) That certain weeds were to be eradicated.
4) That bogs should be dry for peat in such a way that their productivity was conserved.
5) That hounds were to be kept to hunt foxes and wolves.
6) That rook's nests were to be destroyed.
7) That grass pastures were to be laid down.
8) That broom parks were to be established for fuel, rabbit cover and winter fodder.
9) That sound water management practices should be followed: to drain land, to build enbankments alongside rivers and to irrigate pastures.
10) That woodland should be maintained.

If these conditions were not met, the abbot could nominate someone else to take the lease.

The monks had a wider influence through their membership of the Scots parliament. They initiated a series of Acts designed to enforce good farming practices. Such Acts included those of:

AD 1214: All landlords and tenants with cattle had to plough land (even the dates were stipulated, the area depending on the number of cattle) and those without cattle had to dig land.

This Act also enforced the lords to give their bondsmen land, and generally encouraged arable rather than pastoral farming.

1426: The above law was renewed and the amount of wheat to be grown stipulated.

1366: Horses or followers of the king's officers were forbidden to do damage to crops or hay.

1450: Hawking and hunting were not to take place in cornfields between Easter and harvest time or in wheat at any time of the year. Tenants who sowed corn marigold (Chrysanthemum segetum) seed with corn and failed to root it out were to be punished as traitors. The plant was locally called 'guld', and 'guld' riding was practised to find anyone disobeying the Act.

1449: Whoever had a written lease could not be interfered with so long as these Acts were fulfilled.

1457: All freeholders were to plant trees near their steadings, hedges round their fields and broom parks for shelter and winter fodder.

1472: Crop rotations stipulated. Main crops were wheat, peas, rye and beans.

1424: Rooks, crows and their nests were to be destroyed.

1457: The last law was extended to other destructive birds. This led to the killing of all kinds of birds and the uprooting of the bushes and hedges which held them. Eventually the erection of doo-cots had to be forbidden.

1503: In times of hardship, it was illegal to sell plough, oxen or horses if the debtor had other goods.

1581: The destruction of ploughs and the maiming of plough oxen was to be punishable by death.

These and other Acts illustrate that the monks considered sound husbandry to be more important than other land uses such as recreational hunting, and than wildlife. Most of their innovations, though increasing the productivity of the land would reduce wildlife habitats and hence their diversity e.g. sowing of grass for hay and pasture, the use of peat as fuel when it was forbidden to use wood for this purpose which would lead to a reduction in bogland and its replacement with pastureland, and drainage, which led to the first reduction in wetland habitats.

However the planting of woodland and scrub would be beneficial for wildlife, though, as has already been seen, predators and grain eating birds perched in them were destroyed. Signs that the area of woodland had already become seriously diminished are to be seen in the 1457 Act. The monks saw the value of tree planting for shelter, timber and other uses. Their methods of drainage included the planting of water tolerant species such as willows and broom.

However, the Acts seem not to have been well obeyed by others than the monks and their tenants. This is evident by the fact that certain of the laws had to be renewed. Nonetheless the example set by the monks seems to have been copied by some enlightened neighbours and the ideas began to spread.

The growing of hay had not been practised before but this, together with the growing of certain tree species, provided winter fodder for stock. Therefore they need not be slaughtered at the onset of winter. This, and innovations such as crop rotations, the sowing of grass and the replacement of oxen with the horse for draught were only of significance in the vicinity of the monasterial lands and were not adopted by farmers at large until the 'improvements' era.

Once land had been taken in from the wild for tended pasture, cultivation could follow. With the monks' encouragement corn was grown further and further up the hill.

Thus the civilising influences, encouraged by the line of kings after Malcolm Canmore, particularly David I: 'Scotland's greatest organiser' (Symon 1959), promoted two centuries of settled conditions often referred to as Scotland's 'Golden Age.' The 1214 law introduced by Alexander II encouraging the ploughing of land for crops illustrates the need to provide food for an increasing population. Arable land was beginning to replace grazed land described by Innes (1872) as a 'great, peaceful, silent revolution'. By the end of the period one-quarter of the land in agriculture was thought to be under arable use with probably a greater proportion of the abbey lands - one-third. (Franklin 1951).

Although there was greater stability relative to earlier times, the majority of the prosperity occurred on the abbey lands. Outside of these, the primordial infield - outfield system continued with many poor, wet, acid, weed infested soils. The poverty of Scotland was described by visitors from the 13th century onwards. Many people lived a wretched life on the edge of subsistence at the mercy of pestilence and famine (Dodgshon 1980). The monks were less exacting in their extraction of rents than most landlords who took up to one-third of the produce as rent. However the era is seen as 'golden' compared to the period after the War of Independence.

On monasterial lands, consequences were an intensification of arable use and improvement of pastureland. Perhaps it was the monks deployment of pasture which earned most of them fame. Much hill land, and forest pasture was used for sheep. The monks built up a great export trade in wool and cloth. The indigenous sheiling system was continued, the monks recognising the beneficial effects to the sheep of the change of climate and pasture. Grass nearer homes was conserved as hay for winter fodder. Other landowners adopted this system when its economic success became evident and the trend towards a greater proportion of arable land was reversed.

Elsewhere the use of land for grazing continued throughout the Mediaeval period. Cattle and sheep were particularly valuable and there was much movement of cattle between the highlands, where they were bred, and the lowlands where they were fattened: 'Highland bones to be covered with Scottish and English beef' (Fenton 1980). The establishment of droving routes improved communications; many were later converted into permanent roads. Others have long since fallen into disuse though the routes are traceable.

That the population was growing is evident by the need to enforce estate boundaries. At the start of the period there had been areas of 'waste': woodland, moorland, bogland and rough grazing which belonged to no-one; held as 'common'. By now the areas over which agriculture was practised were beginning to join up. Thus there was a need to determine boundaries in order to prevent disputes. These were enforced by the practice of 'riding the marches' from as early as 1220 (Franklin 1951).

However the Black Death in 1350, in which possibly one-third of the population died (Franklin 1951) and the Wars of Independence from 1296 checked population growth. After that the pioneering of new land between Edinburgh and the Border ceased for 300 years (Dodgshon 1980) as they were continually under siege. The east coast plain, the easiest route of penetration from the south, was particularly susceptible and also many monasterial lands in the Borders. Crops were fired or trampled by the barons and their followers going to war which made necessary the Acts of 1366 and 1450 to illegalise this. Symon (1959) states that in the 400 years after Bannockburn there was little or no 'improvement' in the way of life and the systems of managing stock and land. This was compounded by the demise of the monasterial system.

The monks in receipt of endowments, with agriculture so productive that there was a surplus to sell or export, and with the collection of rents once they became landlords, began to get rich. Some perhaps abandoned their previous pious and frugal living and lost respect. This and their wealth made them prey to the covetous: the king, the nobles and the pope all started to extract money from them. Once the prestige was gone, the monks holdings and other church lands were broken up. Franklin (1951) judges it took 150 years for agriculture to recover.

Lawlessness, unrest and turmoil, particularly in the Borders, persisted so long as there was war with England. And afterwards the Border lairds found they were better suited to cattle stealing from each other and from across the border, than raising their own. That grazing was still very economic is evident from the preponderance of cattle raiding at this time, In addition cattle were the chief export between 1603 and 1708. Scotland was then described as 'little else than a mere grazing field to England' (Dodgshon 1980). This eventually led to overstocking and the pushing of grazing lands higher up the hill which marked the demise of the summer-only sheilings in the lowlands.

The abbeys were sacked and destroyed: for example, in the Borders, Melrose, Dryburgh, and Kelso Abbeys and Coldingham Priory, together with five towns and 243 villages. However the Union of the Crowns in 1603, the Reformation and finally the Union of Parliaments in 1707 marked the onset of more peaceful conditions.

Though fertile areas such as Lothian were relatively prosperous, elsewhere there was much discontent, famine and disregard for the law. The root cause of this was thought to be the wretched state of agriculture (Symon 1959). Acts enforcing food rationing were necessary from 1555 and in 1584 an Act was passed forbidding the eating of meat on three days of the week. On many estates leases were short and tenure uncertain so that there was no incentive to try the improvements introduced by the monks and going on in England. Moreover communications were still poor. The infield-outfield system persisted; the continual cropping of the infield leading to soil impoverishment and a reduction in yields, compared to those in the 13th century. The humanising and beneficial effect of the Church declined. Famines, witch hunts and civil war were all ascribed to 'God's wrath' against sinning people.

Lamb (1982) suggests that: the switch from arable back to stock raising on higher areas after the 'golden age'; further poverty and famine and both clan warfare and the war with England may have been partly induced by climatic change. There is evidence that it deteriorated after 1350. The climate became colder and there were more north winds. Parry (1978) in his work in the Lammermuirs south-east of Edinburgh showed that the upper limit of cultivation fell from 425m above sea level around 1250 to 200m by 1600. The 70s and 80s of the 16th, 17th and 18th centuries seem to have been particularly extreme (Lamb 1977).

Over the Middle Ages colonisation was intensified in the lowland area. Much of the initial natural vegetation had already been removed by the start of the era. No new habitat types were created over the period but there was a certain degree of habitat change as lost habitats such as woodland were recreated, wetland lost to pasture and pasture land became cultivated. Such changes however occurred mainly on the monasterial lands.

In the lowlands as a whole there was an increasing trend towards arable agriculture with the proportion of 'infield' larger on the most fertile soils. Little natural forest remained, the traveller Samuel Johnson's quote of 1773 that the lowlands were treeless is often cited. Pockets of forest would remain in the valleys on areas too steep for the plough or livestock. The main obstacles to further agriculture were the waterlogged river valleys which only monks had begun to drain.

The population began to grow more rapidly as conditions became more settled. Dodgshon (1980) proposed the following estimates of the Scottish population, based on various sources.

Late 11th century: 250,000 people
Late 14th century: 400,000 - 470,000 people
Late 16th century: 550,000 - 800,000 people
17th century: 800,000 - 1,000,000 people

In the earlier centuries the problem had been more one of food supply as is evident by the 1214 and later Acts recommending that all should cultivate their land. Now, however the problem was one of land supply. Dodgshon (1980) suggests there are indications that in some suitable areas land had started to run out by the 17th century. Travellers began to write about the excess of cultivation even in the Highlands. Thomas Morer (1689) recorded 'arable ground is very considerable, tis almost incredible how much some of the mountains they plough'.

With the growth of population, arable agriculture spread onto areas previously used as outfield, or even beyond the head-dyke and higher up the hill. As mentioned earlier, abandoned rigs are to be found near the moorland boundary where their use for growing crops has only recently again become economic. Even the sheilings, much of which had already become permanent pasture rather than summer grazing, began to be cultivated.

One of the main settlement changes which occurred over this period, to deal with the growing population problem was fermtoun splitting. In most areas of Scotland there are still farms with the prefixes Easter, Wester, Nether, Upper etc. By 1608 there were already 978 references to such split touns in the Register of the Great Seal of Scotland. The reasons for this seem to have been to combat growing size and complexity as more land was taken into cultivation. They were divided into smaller, more manageable units. This regulation of toun size is argued by Dodgshon (1980) as a reason why Scottish touns did not take on a more village-like character.

However deserted settlements have also been observed from this period. Parry (1975) found 15 such settlements in the Lammermoors. Possible reasons for their abandonment included: climate deterioration in the late Middle Ages: effects of the war with England (buildings were still being made of perishable materials, so as to be easily dismantled when the tenure expired) or toun splitting - new sites being found in the centre of the new townships.

5.3.1 Summary of the Late Middle Ages

Dodgshon (1980) concludes that from 1100 onwards new settlement was mainly the infilling of areas already cleared and by fission, rather than frontier activity which probably occurred only in the old hunting forests.

There was probably still more pastureland than arable land. In many places mixed farming was practised whereas exclusively arable areas were confined to the better soils. On the whole habitats were open and, except in the monasterial lands, opportunities existed for animals and plants of open conditions to perpetuate themselves. Even in the cultivated areas, furrows would support many weeds. The outfield area may have resembled a meadow with scrub and coarse species kept more at bay than on the roughlands beyond the head-dyke. However ecological conditions, especially soil and climate, were perhaps less favourable above the head-dyke than below and so such habitats may have been less valuable for wildlife than they would have been if they had occurred lower down. The removal of trees in itself increases the impact of wind on the vegetation. Forest was rare and many woodland species such as red squirrel nearly extinct. However the lack of records from this period makes it impossible to judge the effects of these gradual habitat changes.

It is hard to imagine what the landscape looked like in the Mediaeval period because it was so radically altered over the Improvements period. The main evidence comes from maps, particularly those in the Blaeu Atlas (1654) and General Roy's Military Survey 1747-55, and Slezer's Theatrum Scoticae 1693, which will be discussed in the next chapter. Three prints from the last mentioned publication have been reproduced in this thesis. These were portrayals of the most important towns and buildings in the country at that time and the detail of the countryside may have been less closely observed. They reveal a picture of intensively cropped land, of a few areas of wasteland and of very few trees except near the buildings. A view of the Dean Bridge, near the West End of Edinburgh, has been shown in this chapter (Figure 16). This and the other prints will be discussed more fully in the next chapter.

5.4 THE IMPROVERS ERA

By the end of the Mediaeval period, the most distinctive feature of the Scottish landscape appears to have been its openness. Travellers and more recent descriptions include: undrained, unenclosed, over-acid, exhausted lands, vast stretches of tree-less landscape; infertile moors, wide areas of morass, miserable tracks, meagre and weedy crops of oats and bere on rocky hillsides (Symon 1959); 'open and largely incoherent, half moorland with a few trees' (Adams 1980); 'bare' (Fenton 1957) and another of Samuel Johnson's remarks made in 1775 was 'a tree might be a show in Scotland as a horse in Venice'.

Agriculture still consisted of the old infield-outfield system; intensive arable land, grassland, with rough grazings beyond of scrub, wetland, heathland and grasslands. Few trees remained except in the vicinity of the settlements.

It is hard to imagine such landscape. However from this period onwards the picture of the countryside becomes more familiar. The changes that were wrought shaped the landscape which survived until recently. Moreover there is more historical information for this era which enables the consequences of the activities to be more fully appreciated.

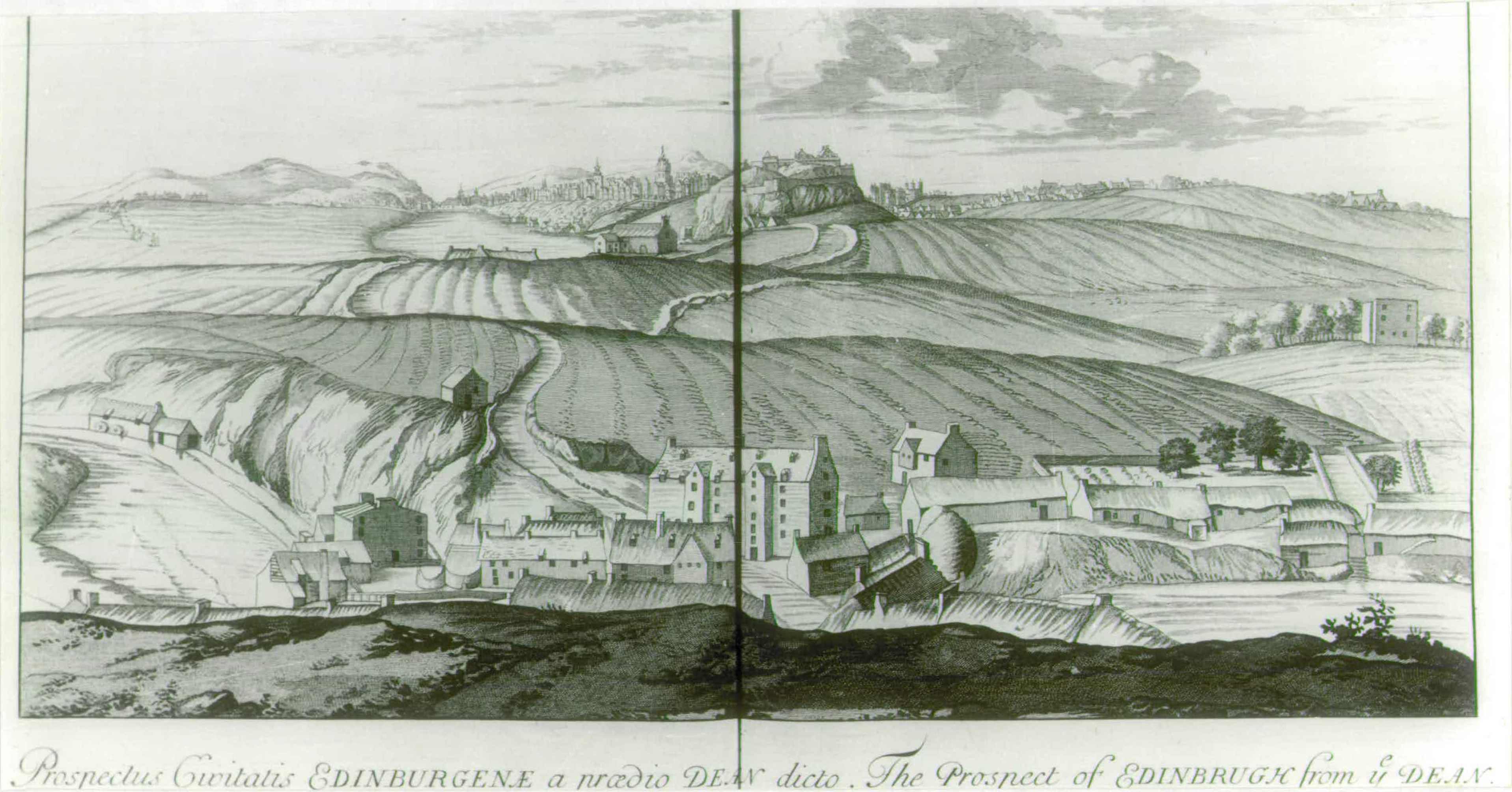

Figure 16: Edinburgh from the Dean Bridge 1670. Note the extensively cultivated area and the absence of trees. (From Slezer J (1693) Theatrum Scoticae).

In the 17th century radical landscape changes were occurring in England in its Agrarian Revolution. However such ideas did not begin to filter northwards until after the Union of Parliaments and the closure of unfriendly relations. The Scots representatives in the English parliaments were frequently large landowners, and in their travels and meetings with the English gentry they began to become aware of the agricultural innovations. Scotland lagged behind England for a number of reasons including poverty at all levels of society. The landlords who had subsisted on their tenants tithes for centuries appear to have taken little interest in their estates except as theatres of sport, and failed to notice the economic possibilities of their lands. The tenants could even less afford to make changes. It was thought that insecurity of tenure did not encourage improvement. However recent work by Whyte (1980) suggests that long written leases were first introduced in the early 17th century and that by the end of that century over one-third of all leases were far longer than 10 years. Another restraining factor was thought to be the prevalence of multiple tenancy; the communal runrig organisation of holdings. Whyte (1980) again provides evidence that by the 17th century most farms were held by a single tenant; only 10% of the leases examined involved joint tenancy. Other reasons for the tardiness of change include internal strife, religious discord, sloth, ignorance, caution, a fanatical adherence to outmoded customs and practices, and national pride (Symon 1959). Franklin (1951) summarises these effects as 'pride and poverty, feudalism and fraternity'.

However the incentives to change were already present. As well as the organisational innovations of large leases and single tenancies a series of Acts were passed in the late 17th century advocating improvement. Acts of 1661, 1685 and 1695 encouraged enclosure. That of 1685 made provision for the division of common wasteland by adjoining landowners, and the 1661 and the 1695 Acts enabled owners of land worked in run-rig to have them disentangled and reallocated, and empowered them to sweep away fermtouns. The 'Winter Herding' Act of 1686 encouraged those who held stock to keep them all year round rather than slaughter them for the winter. These Acts may have resulted from a series of bad harvests, snows and heavy frosts throughout the 17th century which led to much poverty and famine. The worst years were 1622-23, 1634-35, 1649-51 and 1655-56, culminating in seven bad years at the end of the century. It has been suggested by Franklin (1951) that one-quarter of the population were by then beggars. Lamb (1982) states that 'In parishes all over the country from one-third to two-thirds of the population died - a greater disaster in many places than the Black Death'. Lamb cites further evidence of the cold conditions: reports of the arrival of an Eskimo in his kayak several times between 1690 and 1728 (due to the southward spread of polar water) at the Orkneys and once at the river Don near Aberdeen, and travellers accounts of permanent snow on the Scottish mountains. The further climatic deterioration of the 16th and 17th centuries has earned the era the label 'The Little Ice Age' (Lamb 1982). As most of the population was engaged in agriculture there was a definite need to improve it. It has been suggested that the 1707 Act of Union was entered to improve the country's economic prosperity (Franklin 1951).

The first enclosures appear to have been parks around the lairds' houses. Timothy Pont's map of the Lothians shows that many of these already existed in the late 16th century, as islands in an otherwise open landscape. (see Figure 21A, Chapter 6). The incentive for these is thought to have stemmed from the Act of 1503 ordaining proprietors to plant at least one acre (0.4ha) of wood where there were no significant forests (Caird 1980). These parks seem to have been laid down primarily for deer and hunting.

Throughout the 17th century there are small scale localised examples of improvement, for example, the well-cultivated gardens and orchards of pioneer improvers in Fife earned that country the description 'a beggar's mantle fringed with gold' in 1600 (Franklin 1951). Liming was already practised in two Ayrshire parishes before the turn of the 17th century. Symon (1959) refers to a farmer at Beamston, East Lothian who began to bare-fallow part of his ground with much success. At the time turnips and root crops were garden vegetables. A few leases may have had clauses stipulating that sound management practices had to be used. Such innovations were the exception rather than the rule and on the whole, although agriculture was not as stagnant as formerly believed, the 17th century seems to merit Symon's (1959) description of the 'dark period before the dawn'.

After 1707 knowledge of the new methods began to percolate into Scotland. However it is thought that because of the political uncertainty change continued to come slowly. It was not until after the 1745 rebellion was squashed that the great landowners began in earnest to reform their holdings. This is evident from perusal of General Roy's maps; even in southern Scotland much of the lowland area was still unenclosed or even unreclaimed in the 1750's. This will be examined more fully in Chapter 6.

The great landowners had by now the power, knowledge, will and money to induce change. The improvements were made on their own estates and on the 13 large estates forfeited to the crown for treason in the 1745 rebellion. The commissioners appointed to oversee the management of these estates are seen as the pioneers who stimulated other landowners to follow their example (Adams 1980).

Whyte (1980) suggests that there were two main forces responsible for the transformation of Scotland from a 'feudal, subsistence-orientated rural society... to a highly capitalistic one', organisational changes and technical changes. These are useful headings under which to summarise the innovations.

Of the organisational changes, the switch to longer leases and single tenant occupancy has already been discussed. By the end of the 18th century leases of 15 - 21 years were common and in 1770 an Act was passed allowing 31 year leases to be made, particularly on unreclaimed land. With the single holding came the opportunity to abandon the run-rig system in lowland Scotland and the land was re-organised into large square fields with separate crops or live-stock, bounded by dykes or hedges. Ridges and furrows became narrower and straighter. In places shelterbelts were planted to improve conditions for stock. The infield-outfield system was finally abandoned with grassland farming a part of the new rotations. The organisational changes proceeded more smoothly than in England because the tenants had no rights over the wastelands and so no Acts were needed to enclose them. Of course there was resentment at the loss of common grazings but there was only a small scale 'Levellers' movement (tenants breaking down dykes). This was concentrated in Galloway where the degree of enclosure was highest because of the great profits to be made from rearing black cattle. Over the whole country, the old fermtouns were abandoned and new square stone farm steadings were set into the square field pattern, often at new locations from the old township. Where the previous tenancy had been communal, or where farm units were amalgamated, there were dispossessed tenants.

Those who remained in the country, as farm workers, were rehoused in the new planned villages. The field layout depended on topography, soil type and the type of farming to be practised. The earliest surveyors were often mathematicians which is one reason for their geometrical lines,but rectangular fields probably facilitated ploughing. Even then larger fields were preferred to smaller ones because hedges and trees bounding them reduced the area available for agriculture. Nearer to the steading the fields were smaller (Caird 1980). The boundaries would be dykes where stone was plentiful. Where stone was excessive 'consumptive' dykes were built as in the north-east. This period also marked the first appearance of the hedge, often with trees, over much of the Scottish landscape. Previous divisions had been temporary and often constructed of turf. In the south-west, a combination of the dry-stone wall and the hawthorn hedge developed called the 'Galloway Hedge' which is still thought to be the best stock barrier. Dykes and hedges were necessary, in areas such as Ayrshire and Galloway, where stock raising predominated, and also in regions with mixed farming. There the rotations practised resulted in all enclosures having stock on them at some period.

Technical changes include the introduction of new skills particularly those of reclamation, new methods of farming (especially rotation), new machinery, new crops and livestock. Perhaps the most significant effect on the lowland habitats followed the drainage of boggy valleys and flood plains and the removal of the peat layer from the mosses. Lord Kames, a landowner in the Forth carselands was responsible for the reclamation of one-third of the 1,800 acre Kincardine moss during his lifetime: up to eight feet of peat was cut, dried and burnt or floated down river. The underlying soil was then fertilised. Lochs were also drained, for example the Howe of Strathmore, canals and ditches were built and rivers banked up and straightened, amongst them the Clyde, the Forth, the Tay, the Dee and the Don. In Edinburgh Straighton's Loch was drained and planted with grass and clover (now the Meadows). Often at the foot of lochs, shell marl (limey clay), was found which could be used as fertiliser. In the early 19th century the sub-soil plough was invented; this could break down an indurated layer up to 16 inches below the surface. In 1843, tile drains came into use and replaced the broken stones used previously. Thus eventually the marshlands were re-claimed and they often proved to have fertile soils.

New farming methods included the introduction of crop rotations new to Scotland and the use of fertilisers. The latter enabled previously infertile lands to be cultivated; the former could ensure that this fertility was maintained. Liming or marling were particularly valuable on the predominantly acid soils and the materials required were often locally available. Other manures used were dung, peat and ashes and later salt, bones and soot. In 1842 guano was first imported from Peru and Chile and later that century nitrogenous and phosphatic manures were developed at Rothamstead. Their use spread. The sub-soil plough and tile drains already mentioned are examples of new technology that improved agriculture efficiency. Others were Small's two-horse swing plough; invented in 1764 and in general use by 1791, Meikle's threshing machine which separated the chaff from the grain; the harrower; the winnowing machine; the barley mill and in 1827 Bell's reaping machine.

Improved varieties of old crops were introduced in this period together with many new crops. The most significant of these were the potato (from 1730), turnips and sown grasses. The introduction of turnips around 1740 enabled stock to be kept alive during winter and the planting of rye grass and clovers, the first leys, greatly improved pasture production. Hay-making became more widespread. Leys were usually included in a rotation and lasted for three to four years. Permanent grassland was relegated to the steepest slopes or land most liable to be flooded. With the separation of stock into enclosed fields where spread of disease was less likely, it was now possible to fatten cattle in Scotland. Great advances in breeding of stock for both dairying and beef production were made in the late 18th and early 19th century. The introduction of artificial feed, e.g. linseed cotton seed cake, further increased production. The political and economic conditions which prevailed in the late 18th century made wheat growing economical.

As a result of the greater agricultural expertise, many lowland areas which had previously been unworkable came into use. The marshlands and haughs, in particular, proved to be very fertile. Thus the many areas of wasteland shown on Roy's map became cultivated and the higher touns abandoned as land became avaiable lower down (Parry 1980).

Another development which greatly facilitated agricultural improvement was road building. The Turnpike Road Act of 1751 made provision for the construction of firmer roads and their maintenance. The road network was increased in the latter half of the 18th century to take in most of the smaller villages and farms. This enabled manures such as lime and dung to be brought in, and farm produce to be taken to the market. The old muddy farm roads would take only horses and were likely to be blocked for half the year; now farm carts could be used. This increase in road building would also improve communications within rural areas and with other areas. Transportation and materials and produce became possible all year round: more distant markets could be supplied.

On the whole, this agricultural intensification must have led to a reduction in the proportion of wildlife habitats in the lowlands. Lowland marshes and heaths and other 'wastelands' came into agricultural production. The replacement of grasslands with sown leys also reduced habitat diversity. With more intensive, efficient farming there were fewer opportunities for species of open habitats in fields and they would be found only at the narrow headlands. However there were gains in new woodland and new hedges. Although scrub would have been lost from reclaimed common grazings, the planting of hedges round fields would have provided new habitats. Likewise shelterbelts; double or triple rows of trees, and single tree-lines could be colonised by those species which had survived in the woodland relics.

The improvements led to greater agricultural production; yields reached levels not seen in Scotland for 200 years (Franklin 1951). Most farmers produced a surplus which could be sold at market to those who no longer lived on the land. Not only was agriculture now able to feed the country's population adequately, but there was enough to export, wheat for example was sent to England. These markets in turn stimulated greater production.

The increased income generated by profits from farming enabled even the smaller landowning lairds to build new houses and lay out new estates. 'Policies' was the Scottish term for gardens and parks surrounding such houses. Slater (1980) thinks that their primary purpose was ornamental, although the parks could also be used for grazing and the woods for commercial timber production, and shelter of livestock. Edlin (1969) states that they were planted with four objectives in mind:

1) To grow timber, mostly for estate use.
2) To provide shelter for house, garden and farmland.
3) To provide cover for game.
4) To improve the estates from the scenic point of view and provide privacy for house and garden.

In the first parks laid down following the 1504 Act, mostly native species were planted: oak, ash, and elm on the better soils and alder, birch, rowan, Scots pine and willow on more marginal areas. The sycamore (Acer pseudoplantus) which was introduced to Scotland in 1550, and beech (Fagus sylvatica), also not native to Scotland, were widely planted. These parks were not exclusively forested and contained areas of fish ponds, rabbit warrens, dove cots, broom and grazing for deer (Edlin 1969). From the mid 18th century conifer species began to be planted, European Larch (Larix decidua)was the first conifer species to be planted commercially - at the Atholl estate in Perthshire. On many estates arbors of other exotics including Douglas Fir (Pseudotsuga spp), hybrid larch (Larix eurolepis), pines (Pinus spp), cedars (Cedrus spp) and rhododendrons were planted. Thus the habitats of mixed and coniferous woodland can be added to the list of habitats now present in lowland Scotland. Early planters included the Sixth Earl of Haddington who planted

325 hectares of woods on his Tynninghame estate in East Lothian between 1700 and 1735, the Second Duke of Athol 'Planter John' who planted 1625 hectares of Scots pine and larch between 1744 and 1747 and then 4,000 acres of larch between 1774 and 1830 and the Marquis of Tweeddale at Yester in East Lothian (Edlin 1969). Other deciduous introductions included lime (Tilia spp), horse chestnut (Aesculus hippocastanum), English Elm (Ulmus procera) and Norway maple (Acer platanoides) all of which are to be seen in today's shelter belts and estate woods. In this second wave of park establishment which followed the Restoration 1650 - 1760, the grounds were still laid out formally. They were still, as seen from Roy's maps, islands rather than extensive areas. After 1760 planting schemes began to take in the whole estate and more attention was paid to landscaping than previously. More informal designs became the norm. However Slater (1980) states 'it was not until the early 19th century that many of the 'fields ressembling parallelograms, divided like a chessboard by thin strips of plantation' (Scott 1827) were modified'. New plantings produced a more natural effect where woods conformed to the contours of the hillslopes. Gradually the plantings became a part of the whole landscape. They provided habitats that allowed the return of many species to the lowlands for example red squirrel and deer (Fenton 1951). Though some planting occurred on more fertile land such as near the mansion house, other planting took place on marginal areas unsuitable for agriculture. The richest landlords were able to modify considerable areas of land and then completely change them again as befitted their needs, according to their whims and the fashion of the time.

However the new prosperity benefitted all classes. Famine and poverty were lessened. Diets were changing from the old concoctions of oats, to a diet with more fresh vegetables and occasionally meat. Thus health and living standards generally improved. Diseases such as ague (malaria) finally disappeared following the draining of valley wetlands. The late 18th century in Scotland was also a time of great advances in other fields: industry, trade, art, science, architecture, engineering, medicine and philosophy. A cultural revolution seems to have followed the agricultural and industrial revolutions.

Other schemes started by the great lairds were small rural industries such as linen and cotton manufacture, quarrying, brewing, distilling, fisheries and lime burning but according to Shaw (1980) the textile industry was the most successful. The innovators planned new villages to house the workers (often the dispossessed) and even shifted the sites of old burghs to a greater distance from the estate when it was felt their privacy was invaded; for example, at Fochabers. Much previous settlement had been confined to fermtouns - small loose groups of houses. Most of these were swept away and replaced by planned steadings and villages, now such a feature of the landscape.

The landlords also further aided the dissemination of knowledge of new methods by setting up Improvers' Societies and publishing accounts of their work. The first of these societies was founded as early as 1723 but the 1785 founding of the 'Highland Society of Edinburgh' now the 'Royal Highland and Agricultural Society of Scotland' has had the most lasting consequences. In addition the founding of the Chair of Agriculture at Edinburgh University in 1788 led to further improvements in agricultural expertise.

However the main way in which the new methods were taken up by the small tenant farmers was through the terms of their leases. Long leases were granted on condition that improvements were made. The landlord was very often able to choose tenants on their past records.

5.4.1 Summary of the Improvements Era

This whole movement has been described as revolution rather than evolution (Caird 1964) but this has been debated by many writers including Caird since then. The present concensus is that change was very slow to begin with, having to contend with the various sources of inertia described in the first paragraph of this section; for example, plough teams believed that 'elf ill' could be avoided by ploughing crooked furrows which prevented the elves from shooting straight at the oxen (Symon 1959). However from about 1745 onwards, as internal political strife was finally resolved, it is felt that change accelerated greatly - 'a facet of the intellectual whirlwind that swept across the land' following cultural isolation (Adams 1980). Adams cites

1748 - 1770 as the most dynamic phase in the growth of the surveying profession (surveyors were employed to map the old and plan the new estates). Caird (1980) concluded that although the reshaping of the landscape accelerated in the second half of the eighteenth century 'the timing and form of the reshaping was neither simultaneous nor uniform'. The pace varied, depending on the motivation of the laird and his contact with the new ideas. It is likely to have been rapid on some estates and more gradual on others. Within the estate the areas closest to the mansions and the home farm would be the first affected, Likewise in the country as a whole re-organisation was likely to be earliest nearer the cultural centres, south-east Scotland being particularly open to the new ideas.

It is generally agreed that after this period of change, however long it took, the landscape had very little in common with pre-enclosure countryside. The old open landscape with numerous ferm-touns, of run-rig, infield-outfield and extensive and intermittent wasteland disappeared. It was replaced with a planned, ordered, landscape of fields bounded by hedges and dykes, interspersed with shelterbelts and coppices, with fewer farm steadings, with grand mansions and with much of the population in planned villages and employed in small industries. Ornamental parkland was densest around the mansion houses. The only link with the old landscape was the head-dyke between the upper limit of cultivation and the moorland edge but this is likely to have been lowered when the reclamation of lowland habitats made such high cultivation unnecessary (Parry 1980). This has been described by Millman (1975) as a new landscape of ' geometry, fashion, reason and efficiency'.

Throughout this period old habitats were reduced and new ones gained. By the end of the period the full complement of habitat types defined in the NCC project had been created. The new habitats were coniferous woodland, mixed woodland, hedges and tree-lines. However areas of grassland and wetland now became increasingly uncommon below the moorland boundary. Grasslands were simplified into leys and many of the areas of permanent grass which remained on the steeper slopes were planted with trees. Wetlands which may initially have occupied up to one-third of the lowland area were greatly reduced in this period. Scrub and heathland associated with grassland and wetland were similarily reduced. However the gains in woodland will have been significant. The overall effect on the period was an increase in the diversity of habitat types, but a reduction in the extent of many of the old wildlife habitats.

5.5 1800 - 1950 War, Prosperity and Depression

During the Napoleonic Wars 1793 - 1815 the price of grain, especially wheat, rose and this encouraged arable agriculture. The shortage was aggravated by a growing population and a series of bad harvests in that period. Immediately after the war there was a depression and wheat prices fell. High rents and overcropping of wheat during the war years, on less suitable land, led to poor crops and bankruptcy for many English farmers.

However the situation was less serious in Scotland. Oats were the main arable crop and few farms were predominantly arable. Most were mixed and the farmers survived by putting more resources into rearing cattle and sheep. Probably only in the Lothians where conditions were more suitable for wheat were the worst effects of the depression felt.

Corn Laws had been in operation from the late 17th century. They had the effect of stimulating home production of grain, especially wheat, by virtually prohibiting grain imports. Only when harvests were very poor or when prices rose to high levels were imports permitted. The protective effect of the Act ensured farmers did not reduce their wheat acreages and were able to feed the growing population. As a result of the post-war depression, wheat prices remained relatively low through the 1830's. However poor harvests at the end of the decade led to a price rise and there was much opposition to the Corn Laws, and advocation of Free Trade in order to supply the populace with cheap food. A disastrous harvest in 1845 led to the modification of duties in 1846; foreign grain was now allowed into the country, to supplement supplies (with a nominal duty).

In fact wheat prices remained high in the 1850's and 1860's; another 'Golden Age of Agriculture' (Franklin 1951) and this led to an increase in wheat growing. The resulting gain in income fostered further agriculture improvements.

In 1869 the nominal duty on wheat imports was removed, but it was not until after the American Civil War that cheap grain became available from overseas, especially from America and Canada. In 1875 imports first equalled home production. In the 1870's and the 1880's there was another world-wide depression which kept wheat prices low. After a disastrous harvest in 1879 in which yields of one-third to one-half less than average were recorded for most farmers, there was no compensatory rise in price induced by the shortage, (because of the availability of cheap grain imports) and many arable farmers went bankrupt.

There was no recovery of arable agriculture thereafter as on previous occasions because of the availability of competitive foreign grain. The remaining farmers therefore concentrated their efforts once again on livestock rearing. Scotland was again less affected than, for example, eastern England because in many areas especially the south-west the rearing of cattle for beef and dairying was already predominant whilst in the east because mostly mixed farming had been practised, the expertise required for stock raising was still present. Those farmers with no knowledge of livestock farming were most affected by the depression. Moreover the stock farmers were able to utilise the plentiful grain imports as feed. However much of the grassland was temporary leys and these have a similar value to arable lands as a wildlife habitat, although being slightly more permanent in nature. Other land was taken out of tillage and put down to permanent grass. The acreage of permanent grassland as well as leys rose during the period 1879 - 1914. In Scotland permanent grassland rose from 469,450 hectares to 603,000 hectares whilst there was a decline of 15% in the grain acreage, from 562,500 hectares to 480,000 hectares (Symon 1959). In the corresponding period in England there was a decline of 30% in the area under grain crops. Marginal areas were laid down to grass.

After the 1890's the worst effects of the depression were over and by 1912 agriculture had become mildly prosperous again. In fact because of improvements in cultivation, notably the use of higher yielding grain strains and fertilisers, the output per acre on the arable lands increased between the 1860's and the 1880's and so the non-cultivation of marginal lands hardly affected total production.

Nonetheless, with increasing meat consumption, Britain as a whole was supporting a lesser proportion of the population with home production, than it had in 1840. Symon (1959) states that in 1840 home produced food fed 24 million people but in 1914 fed only 16 million. The rest was imported. Thus with the arrival of another major war, the country was much less well prepared to feed an increased population.

The government was thought to be late in encouraging arable production for it was not until 1917 that guaranteed prices were offered for wheat and oats. Between the late 17th and mid 19th century Corn Laws had maintained arable production and during wars when imports slowed the increase in price had stimulated production. However up to 1917 because of the repeal of the Corn Laws and the reduced price of grain due to cheap foreign imports, there was no economic stimulus to encourage farmers to plough up the land which had reverted to pasture. The harvest of 1918 and 1919 justified the 1917 Corn Production Act for there was a 21% increase in the acreage of grain crops between 1916 and 1918 according to the June returns (Symon 1959). During the 1914 - 1918 War Scottish farmers had enjoyed a fleeting prosperity because they were less dependant on imports of feed for rearing stock than English farmers were.

In 1920 the Agriculture Act replaced the Corn Production Act in guaranteeing prices for arable crops. However with post-war depression the price of grain dropped, and the prospect of a huge bill to recompense farmers led to the repeal of this Act and the removal of guaranteed prices. This again led to the conversion of arable lands to grassland, for example in East Lothian 4,000 hectares were taken out of grain production, 1,200 hectares being sown with rotation grasses and 2,800 hectares put to permanent grass. In many areas land which had been permanent pasture was allowed to return to rough grazing in the inter war years.

Thus with the onset of World War II another great 'plough up' was required in order to meet home demand. However preparations for this had begun rather earlier than in the first World War. The 1937 Agriculture Act guaranteed prices for oats and barley and introduced the Land Fertility Scheme with grants for fertilising the land. The 1939 Agriculture Development Act offered grants for ploughing up 'worn out' permanent grassland (more than seven years old) and reseeding it. Over the whole inter-war period the cropped area had fallen from 850,000 hectares to 600,000 hectares with permanent grassland increasing by 127,500 hectares (Symon 1959). There had been losses to non-agricultural uses: housing, industrial development and sport. In Great Britain as a whole it has been estimated that 110,000 hectares had been lost between 1916 and 1939 to such uses.

By the fourth year of the war, the area of tillage had increased by 259,000 hectares with the production per hectare maintained and even increased. Livestock production probably fell. In 1942 grants of up to 50% were offered to break up and cultivate marginal land. With careful directions (for example, the application of manures, and which seed strains to use) such lands could be cropped. At the least they could be reseeded as grassland. Thus a maximum amount of land was under arable use during the last war which, together with rationing and allotments, ensured that there was enough food for all. Many worn out or over-acid soils were probably returned to fertility in these years.

It is also worth pointing out that the Improvements era did not cease with the start of the 19th century. The sort of improvements which had occurred most rapidly in the late 18th century such as enclosure, sowing of grasslands and land reclamation (especially drainage), continued in the early half of the 19th century, though more slowly and often in the remoter areas e.g. Sutherland. The importation of fertilisers such as lime and guano has already been mentioned. In 1835 nitrate of soda was introduced though appreciable amounts were not used until the late 1840's. In 1843 superphosphate was created. As regards wildlife habitats, they enabled marginal areas, which were un-reclaimed due to their lack of fertility, to be brought into use and would also have effects on the grassland categories. There were also advances in machinery. In 1828 Bell invented the reaper. However with cheap labour still available the scythe continued to be used and it was not until the 1850's that reapers began to be manufactured. Ironically the invention had more impact in the U.S.A. It was emulated by the McCormacks and enabled grain to be produced more cheaply there (Franklin 1951). There were changes in the livestock kept on farms. With the lighter swing-plough horses had by now replaced oxen; they utilised less resources and enabled greater numbers of other stock to be kept. Stocking densities were generally greater because of the 'improved' pastures and winter feed. Meat first began to be widely available.

Parry (1973) has looked in some detail at the changes in the level of cultivation in the Lammermuir Hills, south-east of Edinburgh, between 1600 and 1900. For the period under consideration here (1750 - 1850) he shows that there was both reclamation and abandonment of lands at the moorland boundary: 5230 hectares of land were taken in from the moor for arable use and 4500 ha of formally improved land abandoned in the Lammermuirs. He concludes that at the turn of the 19th century, notably between 1803 and 1816 when grain prices were high, the limit of cultivation stood at its highest level since the 14th century. Thereafter any advances were balanced by abandonment as more lowland areas were reclaimed. By 1860 he suggests that the head-dyke was a more continuous line than in the past with few blocks of moor left in the lowland areas. Further to this he estimates that nationally the area of cropland grass had increased by 20% over the period between Roy's map and the first June returns (1866) (Parry 1980).

Good farming practice was ensured less by government intervention than by the terms of landlords leases which required for example; attention to rotation; prevention from selling dung and straw from farms and cutting of weeds by a certain date to prevent weed dispersal. By 1850 the landscape pattern, which persisted until 1950, was largely complete over the whole lowland area. Though there were later improvements their impact was less than those in the period from 1750 - 1850. Changes were often more internal to the framework laid down in between 1750 and 1850 e.g. varying the proportions of arable land and grassland according to the prevailing economic conditions.

This last section has focussed on agricultural land management because, since the Improvements era, it had become the major land use. The habitats most affected by the changes were agricultural land, permanent grassland, rough grazing and other waste areas. In agricultural terms permanent grassland is really a long ley; at some stage it has been reseeded. In time the NCC habitat type it will most resemble is improved grassland. The NCC term rough grassland most resembles is permanent unimproved grassland but in agricultural terms this type can also include areas of dwarf shrub heath, scrub and wetland. When food is scarce or returns for crop growing high, then these habitat types would be at a minimum. During depression, more areas would return to grassland and rough grazing which in time, would become more valuable wildlife habitats. The old saying 'up corn down horn' (Body 1982) is very descriptive of these times.

There were parallel and not unrelated advances in industry and forestry in the 19th century. Much tree planting continued on the estates and, as with agriculture, forestry reached the more remote areas in this period. In Scotland planting of conifers or a mixture of conifers and deciduous species was widely practised. However there was much felling of these newly reafforested lands in the first World War and concern over timber supplies led to the foundation of the Forestry Commission in 1919. Their main objective was timber production whereas the planting lairds had had additional objectives of provision of cover for game, and provision of shelter, but mostly provision of amenity. In Forestry Commission planting economics have largely governed the tree species used. Much of the land they acquired was of too poor a quality or too high up for agricultural use, therefore much of this afforestation did not affect the lowland areas. However coastal areas began to be planted with coniferous species in this period. The first plantings were just reaching timber size when the second World War began and an even more concentrated effort was necessary after this war to replace past losses.

Prior to the Agrarian Revolution, settlement had been confined to the old 'touns' mostly fermtouns but also 'kirktouns' and burghs. Some of the touns remained as centres but often the improving landlords built new villages to absorb the surplus population. Small local industries were established to provide employment. The enclosure movement had reduced the proportion of people working on the land, partly because of the high cost of establishing hedges and other fences, and also because the reorganisation of farms involved the displacement of the lesser tenants and subtenants. The planned villages were found mostly in the north-east with some down the west coast principally in the south-west. Only in the south-east was the village concept not impoted. There the Anglian influence had resulted in the presence of large villages already, for example, Stenton and Dirleton, though Ormiston was planned by one of the great improvers - Cockburn. The planned villages are easily identified by their regular geometrical lay out which contrasts with the irregular form of the burgh and towns. Often the kirktouns provided a focus for new settlement when a new village was not imposed.

The new villages provided centres for trade, crafts and local services. Often small industries were established therein to provide employment for the dispossessed. Millman (1975) suggests that the landowners saw their foundation as not only economically beneficial but also morally beneficial, in view of the social disruption caused by the agricultural changes, 'to keep a working population virtuous and respectful'. However the industries were most likely to improve the wealth of the landowner and maintain their control over an area.

Improvements in communications in this era, established by the wealthy, notably roads, bridges, railways and canals, made possible both the transport of raw materials for industry and for agriculture, distribution and marketing of produce and goods. Many settlements grew at road, rail and canal junctions notably Grangemouth and Inverness. As well as improving the flow of ideas, improved transport enabled people to move about for leisure reasons and coastal towns, such as Largs and Ayr, began to develop as resorts. Though the early impetus for road building had come from the improvers, the responsibility was handed over to the local authorities in the 19th century. Progress was slower away from the main roads. It was felt that road, railway and canal building would stimulate local development and hence keep the population employed. However Millman (1975) refutes that and concludes that it had the opposite effect in facilitating movement away from rural areas. There were few bridges until the early 19th century. Perhaps the most impressive monuments to this era are the rail bridges over the Tay and Forth - the latter opened in 1890.

Some of the new villages never fulfilled their owners' expectations in achieving economic prosperity. Others flourished and the population began to drift away from the rural nuclei to new industrial centres

With the coming of the steam-age, the smaller water powered mills were less competitive and industry thrived in areas where fuel was accessible, notably in coal mining areas and where transport was more efficient. The legacy of the era is the industrial belt of the Scottish lowlands, which stretches from Angus to Ayrshire. The greatest concentration is in the Central area between Glasgow and Edinburgh. Historians record that the Industrial Revolution followed 'hard on the heels' of the Agrarian Revolution partly because cheap labour was plentiful. Though within agriculture there had been a shift from 'quasi-subsidence towards a more commercial farming economy' (Parry 1980), the trend away from the rural agriculture-based economy to the more industrial one has had far reaching consequences. In some counties such as West Lothian, the oil-shale industry was far more important than agriculture and the settlement pattern was more related to the concentrations of this mineral. Initially the textile industry was the most important industry in lowland Scotland but thereafter the exploitation of minerals and coal and their use in heavy industry replaced it. By 1820 the population of Glasgow with its greater trading possibilities, particularly with America, exceeded that of Edinburgh.

On the whole the improvements in agriculture and industry made possible a higher standard of living. Improved material wealth and advances in the field of medicine, particularly the prevention of disease, led to a rapidly growing population. Possibilities for further employment and higher demands for food stimulated both agriculture and industry. Industry in particular flourished. The rest of the world was comparatively undeveloped at that time and was a ready market for the cheaply produced goods. Thereafter succeeding generations grew up and lived solely in the urban centres. This trend has continued; since the early 18th century the population has changed from being almost wholly rural to almost wholly urban.

As industries and urbanisation increased, the control of the landed gentry lessened although they maintained their power in the rural areas. In the growing towns and cities power shifted to those who controlled the main industries. They formed a new wealthy class initially separate from the landed elite. However the 'nouveau riche' often bought and managed lands back in the countryside, the wealth providing opportunities for further improvements and laying out of estates.

The final legacy of this era is the dereliction left behind by past and failed industries. Even in the country there are the remains of small rural industries which did not survive the steam age -mills and quarries used for building new villages and mansions. In the areas closer to the mineral wealth the landscape is often dominated by spoil heaps for example, the 'bings' of West Lothian. In those days little attempt was made to restore the landscape. Such areas were colonised by the plants of open habitats (excluded by more efficient agriculture, and then scrub species), and have become small reservoirs of wildlife.

5.6 THE LAST 30 YEARS

The trends which commenced with the Agrarian and Industrial Revolutions have continued: agricultural intensification and reclamation; afforestation; urbanisation and industry.

Three factors have been paramount in influencing the activities of the major land-users in lowland Scotland since the war. These are political and economic factors and technological advances. They are interrelated.

Millman (1975) argued that planners have taken on the role of controlling the appearance of the landscape in the last 30 years.

'Since World War II the Scottish landscape has become increasingly subject to the direct and indirect effects of comprehensive planning legislation at both the national and local levels.' This he thought left industrialists, foresters and farmers more concerned with the day to day management of the land.

However both farming and forestry were exempted from planning control in the 1947 Town and Country Planning Act. This left them free to change the use of a piece of land without having to go through the usual planning procedures. The 'non-agricultural' land uses are, of course, subject to planning control, nevertheless, according to the NCC study, these uses have increased by a significant amount in the post-war period.

The government has further encouraged both farming and forestry since the war. The financial inducements to farmers have been exhaustively covered by Shoard (1981) and Body (1982). Perhaps the most important of these are:

a) Price support. This has been continued under the EEC Common Agricultural Policy - farmers are guaranteed prices for their products. This is thought to encourage farmers to 'expand indefinitely' (Shoard 1981).
b) Capital grants. These subsidise the reclamation of marginal lands.

However in Section 1 it was concluded that agricultural change had had less effect on lowland Scotland than increasing afforestation and industry.

Most of the woodland in the lowland area is on private estates or farmland rather than state managed. Despite the recently introduced grants offered to plant hardwoods, the planting of conifers is favoured. This is because they grow at twice the rate of broadleaf woodland. Aldhous (1972) presented figures which showed that the discounted revenues can make conifers as much as ten times more valuable than hardwoods.

The technological advances described in the literature are mostly relevant to agriculture. Examples are new, larger machinery which requires larger fields in which to manoeuvre, leading to field rationalisation, new machinery to tackle steeper slopes, which leads to further reclamation of marginal lands, new strains of crops, and greater use of fertilisers and chemicals which allow intensification of agriculture in existing areas. There have been parallel advances to improve the efficiency of forestry operations.

However in lowland Scotland it appeared from the NCC project that the rate of growth in non-agricultural land uses has been greatest in the post-war period, often at the expense of agriculture. Farming itself has become more of an industry. Factory farming is not uncommon. Many new farm buildings have been erected over the period which may account for some of the increase in the non-agricultural area. However the main reason is increasing urbanisation and attendant industrialisation. One reason behind this is further rural depopulation. Light industry is being found outwith the main conurbations in the vicinity of new straighter roads. Motorways have finally sliced through the gulf between town and country, further facilitating the spread of urban influences into the country.

One favourable trend, which seems to emanate from the cities, is environmental conservation. Although this had its roots in the Victorian era, the last generation has become increasingly aware of ecological issues. Nature conservation is, at least, now recognised as a land use. It is to be hoped that this particular trend will continue and will help to abate the possible deprivations of 21st century man.

Figure 17: Modern agriculture and the legacy of industry. The large open field enables today's giant combine harvester to spend a minimum time turning. Spoil heap of a disused mine - note regeneration of scrub and grassland on western flank. (Midlothian, September).

Figure 18: Modern non-agricultural land and the old farming pattern. A new dual carriageway dominates the view as it sweeps across the Tay near Perth. Much woodland and settlement is scattered through farmland. At centre right a deciduous wood screens mineral workings. At far left conifer block planting can be seen. (from Kinnoull Hill, near Perth, May).

CHAPTER 6 CONTEMPORARY EVIDENCE OF PAST CHANGES

6.1 INTRODUCTION

The information presented in Chapter 5 was derived almost completely from recent literature and relies on the authors' interpretation of material from both primary and secondary sources. There are dangers of distortion especially where secondary sources are used. Moreover all these accounts were written for different purposes than are implicit in this thesis. There is as yet no published history of all habitat changes since the retreat of the glaciers in lowland Scotland - the information presented in Chapter 5 was often arrived at by deduction. The coverage in the literature about wildlife habitats was frequently anecdotal.

All the evidence in this chapter is derived from records produced at the time of the periods under consideration. The main materials used were old maps, illustrations, and reports in the 'Statistical Accounts'. There are very few surviving, available reports from earlier than the 17th century. Thus the period considered in this chapter is from late mediaeval onwards.

From the literature appraisal in Chapter 5, it appears that the period when changes were most likely to have been of a similar magnitude to those of recent years was the Improvements era when changes were reported to have been proceeding at a revolutionary rate; particularly the late 18th century. Therefore additional material to the quantified evidence has been presented for this period. It is hard to appreciate how radical these changes were without being able to envisage the mediaeval landscape. Therefore materials produced before or during the late 18th century were also examined. Where possible the supplementary information referred to in the last two paragraphs will be presented in chronological order.

6.2 METHODS

6.2.1 The Study Area

This thesis is concerned with lowland agricultural Scotland, but it would not have been possible to make a detailed appraisal of the whole area, or even of the 10% sample of it in the time available. Lothian Region was chosen as the area for study primarily because the ecological evaluation was proceeding in the same area. For this reason and because of its accessability from Edinburgh, a greater degree of familiarity, and hence understanding, of the area was likely. In the event it was possible to cover only East Lothian in the quantitative assessment of change. However it could be argued that because East Lothian is closest to England - the main location from which ideas of new methods were derived, and close to Edinburgh, that changes were likely to be most pronounced. The supplementary evidence, from maps and illustrations, of the late mediaeval landscape was derived from material about other places in lowland Scotland. This will be detailed in the appropriate sub-sections. In addition a small amount of information has been presented about changes in Cramond parish during the 18th and 19th centuries. This material was gleaned from local sources and illustrates in greater depth the sorts of changes which occurred on individual estates.

6.2.2 Sources of Information

A The main sources of information were early maps:

1) Timothy Pont's survey of Lothian and Linlithgow surveyed in the 1590's and published in the Atlas Novus of Wm.& J. Bleau 1630

Timothy Pont travelled much of Scotland by foot between 1579 and 1601, an era of poor communications and danger from lawless factions of the populace, and surveyed the geography and topography of the country. However the maps he produced were not published until 1630. The literary patron, John Scott (a landowner), was responsible for getting the maps published in conjunction with the Dutch Atlas makers William and John Bleau. This Atlas of Scotland was one of a series of World Atlases being produced at the time. The 1630 Atlas contained, in total, 46 topographic maps of parts of Scotland and of Ireland. Thirty-six of these maps were definitely the work of Timothy Pont, four were surveyed by the geographers and cartographers Robert and James Gordon and the remainder have no authorship. That of Linlithgow and Lothian has no authorship but is thought to be the work of Pont. It was executed in the 1590's. (Cash 1901).

2) General William Roy's Military Survey of Scotland 1747 - 1755 Sheets 8 and 9 - East Lothian

This survey was instigated as part of the process of pacifying the Highlands after the Jacobite uprising in 1745. Part of the problem was felt to be the inaccessible nature of the area; a map would provide the basis for establishing roads and military posts, and generally opening up the Highlands. The survey of the Highlands was completed and a fair copy of the work produced by 1752. It was then decided to extend the survey southwards for 'administrative rather than military reasons' (Skelton 1967). The survey of southern Scotland was completed by 1755 but a fair copy was never produced because of the interruption of the Seven Years War. Thirty years later Roy described the map as being:

> Still in manuscript and in an unfinished state...with many of its imperfections unremedied...rather a magnificent military sketch than a very accurate map of the country.

Nonetheless with a scale of 1000 yards to the inch and with a detailed portrayal of topography, the map was regarded as unequalled in the country and possibly in the world at that time (O'Donaghue 1977). Skelton (1967) comments that in the mid-18th century the Highlands of Scotland were better mapped than the English Home counties.

The map is regarded by modern geographers (Millman 1975 and Coleman 1979) as notable because of its detailed portrayal of land use - the first such map. Categories include: mountain land; moorland; woodland; unenclosed and enclosed cultivated land; parkland; settlement; roads; open water; marshland and hedgerows. However these types are less clear in the map of south Scotland (compared with that of the Highlands) because colour was deployed less than in the fair copy. Perhaps the most important factor is that it portrays the country just before the main Improvement era. Though there were already signs of enclosure much of the mediaeval layout remains.

3) First Ordnance Survey Maps of Scottish Counties, published 1853, surveyed at Six inches to the mile - East Lothian Sheets.

Following on from the survey of Scotland, Roy felt there should be a comparable plan of England in case of foreign invasion. His first proposal was made in 1763. However, it was not until 1783 that Roy was permitted to undertake the triangulation of south east England. Roy had to reinvent more precise surveying instruments for this purpose. His reports set out the procedure used. The Board of Ordnance was established in 1791 to undertake 'A General Survey of the Kingdom' but unfortunately Roy did not live to direct this. It was not until 1853 that the first Ordnance Survey maps were produced for Scotland. These are the first, accurate, large scale maps. They portray the post-enclosure landscape. The detail is the same as on modern Six-Inch: 1 mile maps. Although the maps are planimetrically accurate they do not portray the same range of vegetation features as Roy's maps nor the ones used in the Air Survey of Changes project (discussed further in Section 6.2.4).

4) Ordnance Survey Sheets surveyed 1893-1894, published 1902-1903. The first 25" : 1 mile maps of Scotland - East Lothian.

These maps are of an even larger scale than the last but portray the same range of landscape features.

5) First Land Utilisation Survey of Britain, edited by L. Dudley Stamp Surveyed 1931-1939.

Land Use categories were mapped on the most recent Ordnance Survey Six Inches:1 mile series by graduates, students and school children. The information was published at One Inch:1 mile. However, because the one inch sheets do not portray the same degree of detail as the air photographs and larger scale Ordnance Survey maps, copies of the original Six Inch:1 mile survey sheets were used.

6) Recent maps

a) The Second Land Utilisation Survey, surveyed 1966 - 1971 co-ordinated by Alice Coleman

The survey was carried out largely by school children, again at 6 inches: 1 mile. The initial intention was to publish them at a scale of 2½ Inches: 1 mile, but only one sheet, Dunfermline, was ever published. Therefore again the original survey sheets of 6 inches: 1 mile were used.

b) Ordnance Survey 1:2500 Sheets - Most recent series

These two sets of maps were used mostly for comparing the classification used by Ordnance Survey and Land Utilisation surveys with that used in the NCC 'Air Photo Analysis of Change' Project, and for checking the air photo interpretation of the 'recent' air photographs.

(Examples of Maps 1 - 5 above are to be found in Figures 21A - 21E

B Illustrations of the Mediaeval Landscape are contained in John Slezer's Theatrum Scoticum published 1693

Slezer (a Dutchman) travelled round Scotland 20 years before the above date of publication in order the sketch the major buildings in the country at the time. These were: 'the most considerable Towns and Colleges', ruins of Abbeys, Monasteries and Convents, and 'their majesties Castles and Palaces'. This is thought to be the earliest attempt to publish a collective series of such views (Cameron 1899). Though the main objective was to portray buildings, many of the 'prospects' also include detail of the landscapes round about. Three of these illustrations have been included in the thesis (Figures 16, 19, 20).

C Written accounts of the landscape around the time of the Improving movement were to be found in the Statistical Accounts:

1) The Statistical Account of Scotland ed. John Sinclair. Vol. II. The Lothians. This contained accounts of the various parishes. They were first published in separate volumes between 1789 and 1793 and later collated into one volume.

2) The New Statistical Account of Scotland published 1845

a) Linlithgowshire and Haddingtonshire.

b) Edinburghshire.

John Sinclair, one of the foremost Improving landlords, organised the first Statistical Account. Every minister was to prepare a description of his parish. Areas to be covered included: extent; topography; hydrology; geology; history; population; industry; agriculture etc. Initially the idea was to write a new version every 50 years but work on the third Statistical Account did not commence until the 1950's and has only recently been completed.

D Information on Cramond parish was derived from a number of sources; local knowledge: primarily that of historian Barclay Fraser and records in the Cramond Archive; mostly estate plans and written accounts. Information about Dalmeny Estate was mostly derived from estate plans held by Lord and Lady Rosebery and from conversations with them. The main source of information was John Wood's Account of Cramond Parish, published in the 1790's. The account of Cramond parish in the Statistical Account was in fact written by John Wood rather than the minister because he had already collated much information on the area. This information was obtained while working in the area in 1982.

6.2.3 Description of the Late Mediaeval Landscape

Timothy Pont's map of Lothian for 1590 and William Roy's sheets for East Lothian in the 1750's were perused to obtain a general picture of the landscape.

John Slezer's illustrations in the Theatrum Scoticae were studied to give a ground view of the landscape in the 1670's. There were approximately 60 illustrations (the number depending on which edition was consulted) and half of these showed only the building or town of interest and half showed the countryside surrounding the building or town of interest. The main objective was to portray the buildings and so less attention may have been paid to the landscape round about. However, on perusal of the 'prospects' they do appear remarkably detailed in both artefact and landscape. These 29 illustrations were examined and general conclusions drawn. Three of these illustrations have been included in the thesis:

1) Prospect of Edinburgh from Dean (Figure 16)
2) Prospect of Linlithgow (Figure 20)
3) Prospect of Dryburgh (Figure 19)

A more detailed description accompanies each.

6.2.4 Identification and Measurement of Habitat Extent and Habitat Change in East Lothian 1760-1932

The methods employed here were similar to those in the NCC 'Air Photo Analysis of Change' project. The same 10% sample of East Lothian was used but the results have been presented for the sample itself and have not been multiplied to give an estimate for the whole District. The method was as follows:

1) Six photocopies were made of each of the 21 frames which formed the 10% sample of East Lothian. The old maps (Roy's Military Survey, 1853 Ordnance Survey, 1900 Ordnance Survey and the First Land Utilisation Survey) were examined in turn and habitat changes between succeeding maps marked onto the photocopies. The procedure chosen was to compare each map with the recent air photograph and note differences on the photocopy for that map. Then succeeding sets of map data were compared and changes between them marked with a different coloured pen. It was easier to do it this way because of the size of the maps involved, and because it was often possible to derive information about several frames from one map.

2) The changes were measured with a dot grid (10 dots per square centimetre) and recorded on interchange summary sheets. These measurements were then scaled up to hectares. All the changes were measured on the recent air photograph to give a common base. This also eliminates errors possible because of distortion in the photocopying process. It was possible to use the air photograph in this way because the framework of wood and field boundaries within which the changes occur has remained remarkably constant since 1853. However, this was not possible with Roy's map because a) it was not as accurate as

Ordnance data and b) everything had changed so drastically between 1750 and 1850 that there was no common framework. The fact that the boundaries laid down in the Improving movement have remained largely the same but had altered so much since Roy's maps is in itself an indication of the degree of change.

3) Tree-lines present on the early Ordnance Survey maps were picked out and their length measured in centimetres with a 'Map Measurer' then scaled up to kilometres.

4) Field areas are marked on the 1:2500 maps. Thus it is possible to compare the average field sizes of 1900 and recent Ordnance Survey maps to determine the degree of field enlargement in East Lothian. Field areas were noted for 11 of the sample frames on the appropriate photocopies for the two dates. These were then totalled for each frame, then the whole sample area and the average field size calculated.

5) The areas of interchange between the habitats were then treated in two ways:

a) Summated to give total gains and total losses to each habitat type. These were then subtracted from or added to the habitat extents already worked out for the later date, to give the earlier habitat extents. The habitat extents for the air survey data were obtained from the original recording sheets used in the 'Air Photo Analysis of Change' project. 'Early' interchange data was summated, total habitat gains or losses then subtracted from or added to give 1932 habitat extent and so on. These calculations were done for the individual frames which were then added to show habitat extents at each date in the whole of the survey area. This information can be further used to show net changes to each habitat between the survey dates.

b) Interchange data for the 21 samples were summated to give total interchange for the sample survey area between pairs of dates: 1853-1900; 1900-1932; 1932-c1949; c1949-c1970.

However this procedure was not as straight forward as would have been liked because of the difference in the land classification systems used. These differences can be divided into two main types:

a) Differences in the amount of detail portrayed on the map.
b) Differences in the vegetation types.

These differences are a result of the different objectives of each map maker. Because they are the main reason for errors in this section the different classification systems used by the three main types of map makers used in the survey will be discussed.

1) Ordnance Survey Maps
2) Land Use Surveys
3) Roy's Military Survey

This will be followed by the methods adopted in attempts to overcome the problems they present.

Differences in the objectives behind the classification systems:

A) The objective behind the Air Photo Analysis of Change project was to measure change in the extent of wildlife habitat. Therefore areas were classified according to their nature conservation interest.
B) The objective of the Ordnance Survey is to accurately map ground surface features. The maps are designed to be used by a wide range of people. Ordnance Survey now recognise that if they are to be put to more specific uses, the user would prefer to use maps as base data and superimpose his own categories on it. The Forestry Commission for example would eliminate all the Ordnance Survey woodland symbols and divide such areas up according to their own woodland classes. Ordnance Survey also recognise that because each area is surveyed on the ground it would not have involved much more effort to include land use categories. In fact the first surveyors kept a field book in which the size and use of each parcel of land was recorded, but this practice was later discontinued for reasons of economy. However there was less interest in land use maps at that time, and now, as already mentioned, the trend is towards simplification of the information portrayed.

C) The objectives of the Land Utilisation surveyors was to portray the use to which each parcel of land was put. They used Ordnance Survey sheets as base data. They were produced by geographers primarily for geographers. Stamp (1948) felt that the first survey showed 'the balanced need for conserving the farmland resource and improving the urban environment'. Wildlife habitats are rather incidental to this. Indeed it is only recently that wildlife conservation has been recognised as land use. However these land-use maps do in fact give more detail of the habitat types used in this project than the Ordnance Survey maps.

D) The objectives behind Roy's survey of south Scotland were to make the first comprehensive sketch of the area and put in some surface features of use for military purposes. These include terrain, relief, the main rivers, the main roads (for purposes of troop movement and tactics), settlement and areas of agriculture for purpose of assessing where troops could be stationed and subsistence available. In fact the detail shown is much more than that necessary for a military sketch and most of the important land use categories can be distinguished. However the accuracy with which the surface features were portrayed varied, as there was no accurately surveyed base map on which to plot the information, as available to later land use surveyors.

The main classification difference between these three sets of maps and the NCC habitat types are as follows:

1) Ordnance Survey Classification

This information was derived by comparing the 'recent' photograph with the most recent map, from perusal of earlier Ordnance Survey maps, from discussion with staff at Ordnance Survey, Edinburgh, and from their notes to surveyors.

a) Differences in the amount of detail portrayed. On the air photographs every surface feature can be discerned down to a minimum size determined by the scale of the photograph. For the Air Photo Analysis survey this was defined as the minimum area a boundary can be drawn round or in the case of mosaics of vegetation, the minimum area which can be measured with a dot grid. Thus theoretically the smallest area which can be picked up is 0.05 ha; the area represented by one dot on an air photograph of scale 1: 7000 (a rough average). On the Six Inch: One mile maps the smallest area shown must occupy at least 0.4 hectares (and have a minimum width of 10 metres). On the 1: 2500 maps 0.1 is the minimum area (and a minimum width of 5 metres). In fact such criteria were less well defined when the earliest Ordnance Survey maps were made and the minimum area tended to be one in which the classification symbol could be fitted. This would vary between recorders. The trend towards greater clarity and simplification on the more recent maps has at least reduced that source of variability. On the whole, more detail can be picked up from an appraisal of the air photograph than a map of similar date. The solution to this problem was as follows: where a small area was present on the air photograph but not on the preceding map such areas were taken as having been present on the map for there was no evidence that change had occurred. Of course it is likely that small areas present at the time of the map making were not picked out and, for reasons above, if they have been lost this would go unrecorded. This is unlikely to affect the proportions of the main habitat types but means estimates of the area of habitats which come in smaller parcels may be inaccurate. These include scrub and wetland in which much nature conservation interest is vested.

The width restriction means hedges are not shown. Tree-lines are supposed to be shown except where the symbol would obscure more important detail, but in practice their appearance is variable. They appear to be absent from the more recent maps and present in varying degrees on the 1853 and 1900 maps. Though of a larger scale the 1900 maps, on the whole, portray less tree-lines than the 1853 maps. Although it is possible that there has been tree-line loss in this period the fact that each map often shows tree-lines not present on the other gives rise to suspicion. Therefore the measured changes in the length of tree-line must be treated with caution.

b) <u>Differences in the vegetation types</u>

The main problems here were with the woodland types and, as ever, with grassland. It was observed that many of the woodlands classified as deciduous woodland on the recent air photographs were marked as mixed on the earlier Ordnance Survey maps. This is an unlikely change to have occurred, though it is possible if the faster maturing conifers were taken out first. However it is thought unlikely that this would have occurred quite so consistently across all the sample frames.

Reference to the recent Ordnance Survey maps showed such areas were marked as mixed. The reasons for this difference therefore must be either because of an error in photo interpretation or differences in classification. On appraisal it was thought all policy woodlands could have been 'blanket marked' mixed, but the staff at Ordnance Survey stressed that every area on the map was surveyed on the ground. Although there is increasing use of air survey for map updating at Ordnance Survey, ground checks are taken of every parcel of land and in any case all the early maps were made from the ground survey alone. It is more likely that interpretation would be accurate at ground level, if the woods are penetrated, than air interpretation.

The Ordnance Survey staff also described how the symbols accurately reflect the proportions of coniferous and deciduous species, particularly in earlier maps where density classes were used. The recent simplification of symbols and uniform density portrayal, means proportions are less accurately portrayed now. One further source of the difference may be that the Ordnance Survey definition of mixed woodland was any deciduous or coniferous woodland with more than one-sixth of the other type whereas the NCC project's definition was any deciduous or coniferous woodland with more than one-quarter of the other type.

The solution to this problem was to treat areas marked as deciduous on the air photograph but mixed on both the old and recent Ordnance Survey maps as deciduous as no change had occurred. However for areas marked as mixed on the oldest maps, which definitely had undergone change; i.e. are portrayed as another type on a later map, usually felled, grass, scrub or another woodland category, then such areas are taken as mixed on the old maps. This could lead to a greater proportion of areas identified as mixed woodland compared to deciduous woodland on the early maps than on recent air photographs. By checking between maps it is possible to clear up most of the discrepancies and ensure only real changes are recorded.

The main problem with grassland was that because these are not land-use maps, no attempts were made to further categorise enclosed lands. Thus it is likely many areas of improved grassland were missed and changes from improved grass to arable go unrecorded. (The difference in definition of rough grassland, permanent pasture, improved grassland etc. of the different map makers will be discussed and clarified below.)

The Ordnance Survey 'rough grassland' applies to all areas of uncultivated grassland normally found higher up the hill. This is roughly equivalent to the NCC category 'permanent unimproved grassland' but is likely to include areas of improved grassland, felled areas and non-agricultural land.

A comparison between the most recent OS maps and recent air photographs shows that most areas classified as felled on the air photograph are still classified as woodland on the maps. This means earlier measurements of felled areas may be underestimates. Occasionally such areas are classified as rough grassland. However if the area was wooded on both earlier and later maps, such areas can be reclassified as felled for this analysis. However such discrepancies are probably not serious because of the transitional nature of felled woodland.

Many areas of what was termed 'non-agricultural' land in the NCC survey, for example, road verges, disused railways and old mineral workings are classified by the Ordnance Survey as rough grassland. However it is usually possible to distinguish these by location and reference to the maps and air photographs, and to reclassify them as non- agricultural. Perhaps Ordnance Survey inadvertantly recognised the potential wildlife value of such areas.

2) Land Utilisation Survey Classifications

The First Land Utilisation map was much easier to use than the Ordnance Survey maps because the categories used were similar to the NCC habitats. However the points above hold for woodland and degree of detail on them. The main difference is in grassland classification. Much fell into the meadowland, permanent grass and parkland category. This seems closest in nature to 'improved' and was re-classified as such; but it is likely that some of it has been seeded at some time. Most of the land in this category is enclosed which suggests it may have been sown, at the time of the enclosure. In agricultural terms permanent grassland or pasture is initially sown grassland which is not ploughed up and resown or turned to crops every few years. However as time goes on these permanent pastures will more and more resemble 'natural' grassland as native species move in to replace the sown species. Much of this land was classified as arable on the 'recent' air photographs so there is no way of checking how close to the NCC 'improved' category it really was. In the Second Land Utilisation Survey, Coleman recognised the difficulties in distinguishing long leys from, on one hand short rotation grassland leys, and on the other hand from more permanent grassland. Thus all forms of enclosed grassland were treated as one category. The only other category in which grassland was included was heathland, moorland and roughland, which would be similar to the NCC categories 'permanent unimproved grassland' and 'heathland' below the limit of cultivation. This is in effect more similar to the Ordnance Survey classification and so could not be used to check grassland classification on the First Land Utilisation Survey.

Coleman recognises that more errors were made in identifying leys than any other category, so it is possible some of them may have been categorised as meadowland. However they are likely to have been long leys and more akin in nature to improved grassland. It is equally likely that some of the meadowland would be classified as permanent unimproved grassland in NCC terms. These may balance out. In all it appears that the grassland in this category though not all strictly improved in the NCC sense (in not having been seeded) will have close affinity to it in species composition (due to time since seeding). In any case there is no way of finding out now which parts were wrongly classified. Thus the designation as improved grassland stands. There are problems however when comparing such areas with the earlier Ordnance Survey maps because enclosed lands have not been differentiated. For these purposes it has been assumed that such areas were unchanged between 1853 and 1932, if enclosed at both dates, as there is no evidence of a change.

3) <u>General Roy's Military Survey</u>

The classification system used in fact appears similar to that in the First Land Utilisation survey. Apart from the lack of small scale detail as in Ordnance Survey and Land Utilisation maps there were additional problems experienced in using Roy's maps: firstly the maps were not as accurate as General Roy would have wished because of the use of 'Instruments of common or even inferior kind' and want of financial provision (Skelton 1967). Skelton further describes how rivers and roads and any detail near to them were fairly accurately surveyed, but how all the rest of the detail was sketched by eye or copied from existing maps.

The second problem in using the maps was that much of the land was unenclosed; there were few field boundaries to tie in with the post-enclosure landscape. Settlements, even churches appear to have disappeared or changed position - which is quite likely from historical accounts. The main features which can be used are large towns and rivers. There are few of the former and the rivers sometimes appear to have changed direction.

Because of doubts about the accuracy of the maps and because the landscape changed so much in the intervening period, it is very difficult to match the maps with the later 1853 Ordnance Survey maps - an attempt was made but one could not put complete confidence in the matching-up process. Thus it was not really possible to use Roy's maps for measuring changes in the same way that the later maps were used. A different approach had to be adopted.

A wealth of detail is portrayed on the maps, in particular, lands still unenclosed and worked on the old 'infield-outfield system' lands enclosed and cultivated or enclosed as pastureland, land still uncultivated 'roughland' and mountainland, larger marshes, natural woodland and plantation woodland, parkland and formal gardens, burghs and fermtouns, rivers, steep slopes, and field divisions. Field boundaries were portrayed; where it has been possible to match them up, they are either hedgerows - usually with trees - or shelterbelts.

Although the detail may not match up exactly, the proportions of these habitats will be roughly accurate. The method used was to transfer all the detail from Roy's map on the photocopy of the air photograph and tie in as far as possible with the detail on the air photograph. Five main categories were recognised.

1) Woodland: both natural and plantation - equivalent of NCC categories - deciduous, coniferous and mixed woodland and felled areas.

2) Roughland: this was usually marked with a symbol, or was unmarked land on steep slopes - roughly equivalent to a mixture of NCC categories - scrub, dwarf shrub heath, permanent unimproved grassland and wetland. Large areas of wetland were often separately marked but have been included in this category here because smaller wetland areas appeared to be included (as deduced from later maps).

3) Grassland: this was enclosed pastureland and small unmarked areas between unenclosed cultivated areas - roughly equivalent to NCC improved grassland.

4) Cropland: both unenclosed and enclosed - equivalent to agricultural land.

5) Roads and Settlement: roads, tracks, fermtouns, kirktouns, mills and burghs - equivalent to non-agricultural land.

These were then measured with a dot grid on the photocopy and scaled up to hectares. They give a very rough estimate of the proportions of these main habitat groups. These can be compared with the later data by grouping it into the above categories. The lengths of field boundaries were measured with the Map Measurer.

The main changes were noted and summarised but not measured because of difficulties in obtaining a close match with the 1853 Ordnance Survey map.

Examples of the five maps and recent air photographs have been reproduced here (Figures 21A - 21F) for the area near Gladsmuir. A fuller explanation of both Pont's map (Figure 21A) and Roy's map (Figure 21B) is to be found in Section 6.3.1.

The main difference between Roy's 1760 map and the 1853 OS map (Figure 21C) is that the whole area is now enclosed. The difficulties in matching up the two maps are in evidence. Gladsmuir and the main road can be linked up but some of the enclosures south east of the town and west of Claybarns appear to have been planted with trees. Hopefield appears to occupy the location of Claybarns - an avenue of trees leading up to it is clearly visible. All the roughland round about Claybarns has now been enclosed. The only roughland remaining in the whole area is just south of Gladsmuir. Old Gladsmuir on Roy's map seems to correspond to the Bench Mark at the curve of the road running south from Liberty Hall on the OS map.

Yet the OS map also shows the location of the Old Kirk as further west. It is possible the kirk was at a separate location to the rest of the town.

It is far easier to match up the succeeding OS maps. Between 1853 and 1893 (Figure 21D) the last area of roughland south of Gladsmuir has been almost entirely reclaimed. Other examples of changes are:-
An area of marsh and wetland has been left where the brick field was and the Brick and Tile works themselves have been removed.
A new farm has taken over the name of Brick Field. A tree-line running from Hopefield east has been removed. The area south-west of Liberty Hall South wood appears to have reverted to grassland.

By 1932 (Figure 21E) the site of Old Gladsmuir kirk and graveyard has been planted with trees. An enclosed paddock has been created east of Hopefield. Part of the open water left behind the brick field has been made into a Curling Pond.

On the recent air photographs (Figure 21F) it can be seen that the older half of Cuddie Wood has been classified as deciduous woodland, yet it is marked on the OS maps as mixed.

Changes between the late 40's and 1975 are also marked on the air photograph, e.g. the growth of Gladsmuir and Nairns Mains farm. A small area of rough grassland appears to have survived since 1760 - south east of Gladsmuir. This area may have been quarried but is probably worthy of further study.

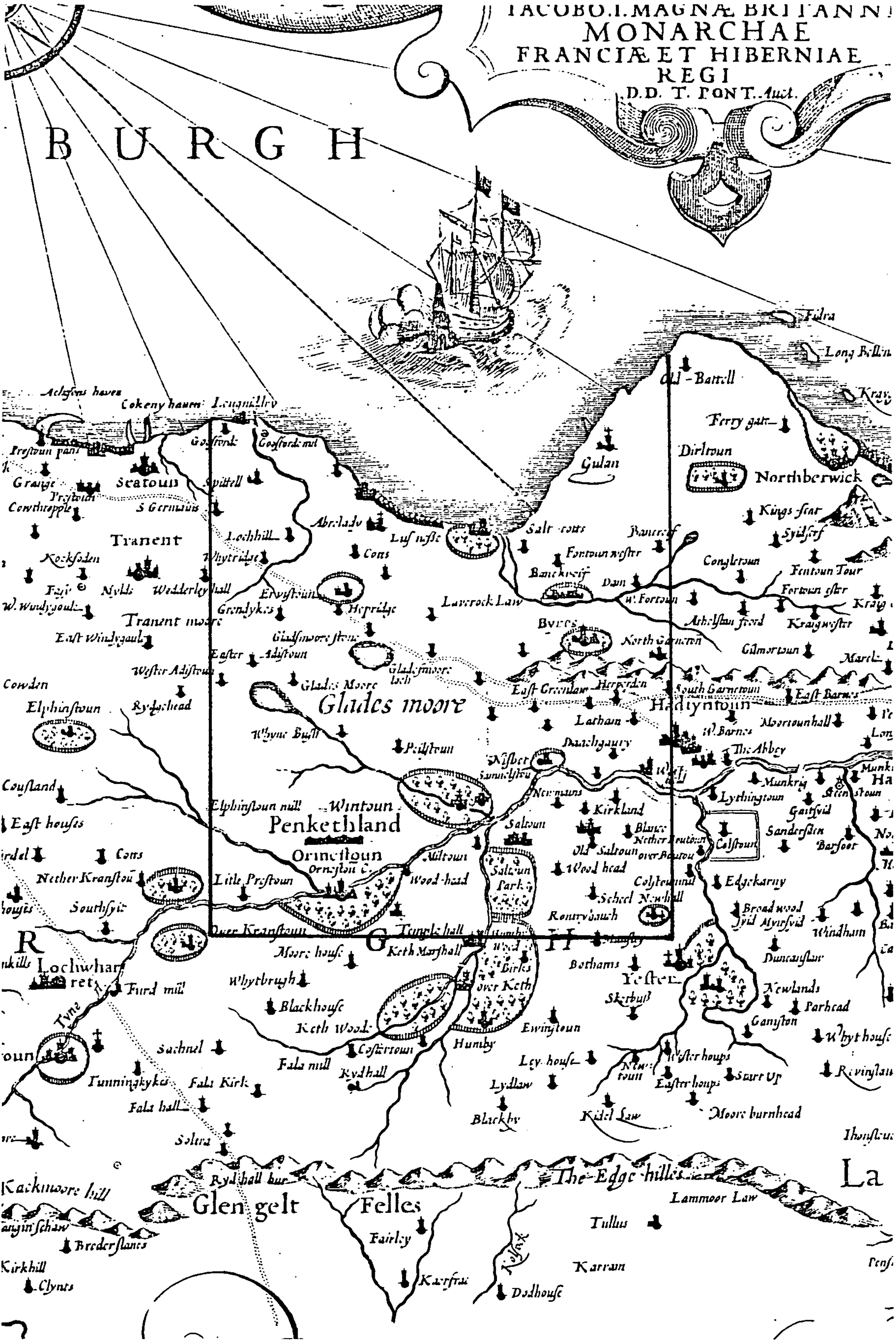

Figure 21A: Excerpt from Pont's map of Lothian. Surveyed 1590.

——— Approximate boundary of excerpt from Roy's map (Figure 21B).
See pages 243 to 244 for fuller description.

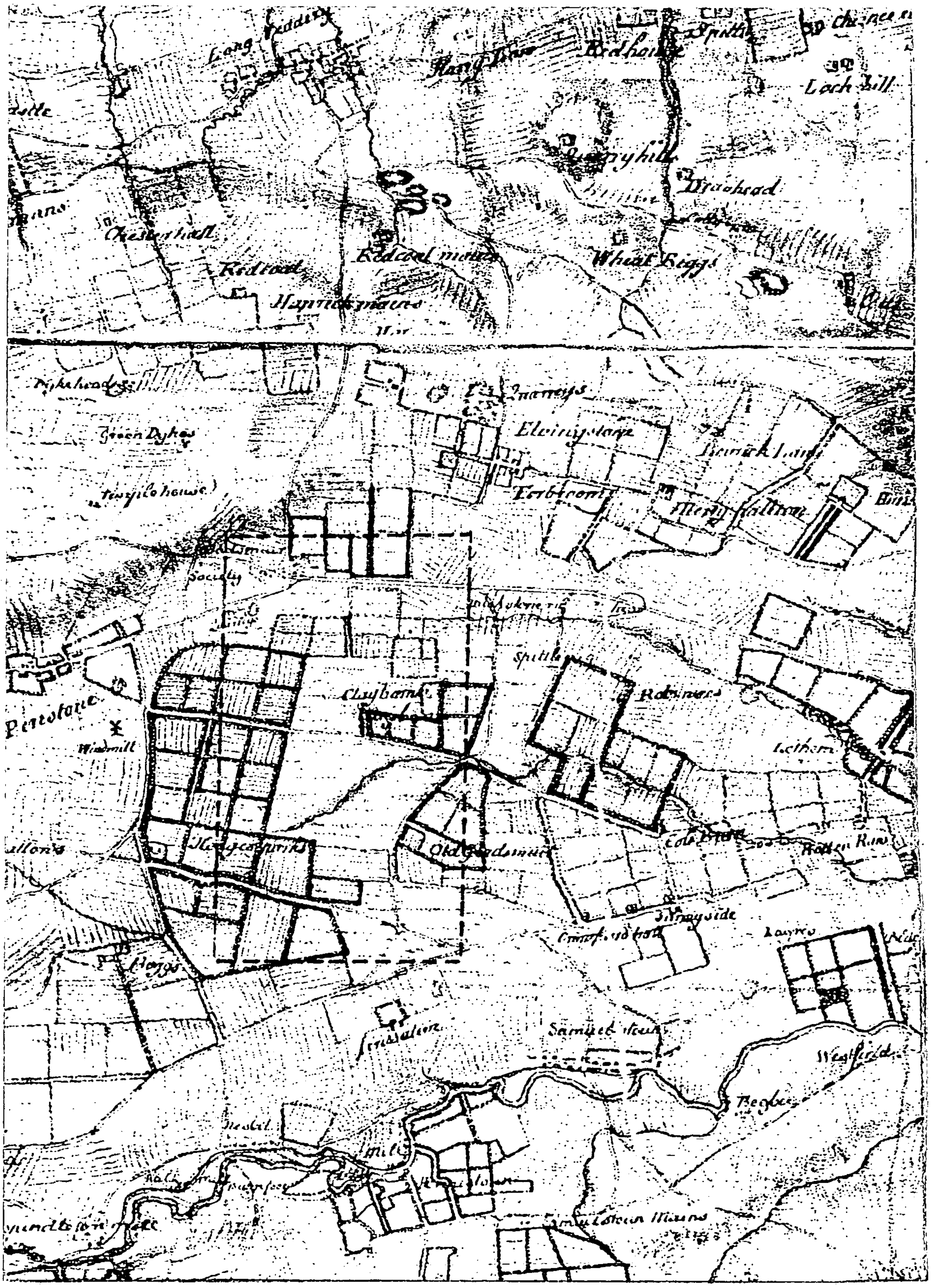

Figure 21B Excerpt from Roy's military survey executed 1752-1755.
Area common to Figures 21B - 21F. See pages 234 to 235 and 246 to 248 for fuller descriptions.

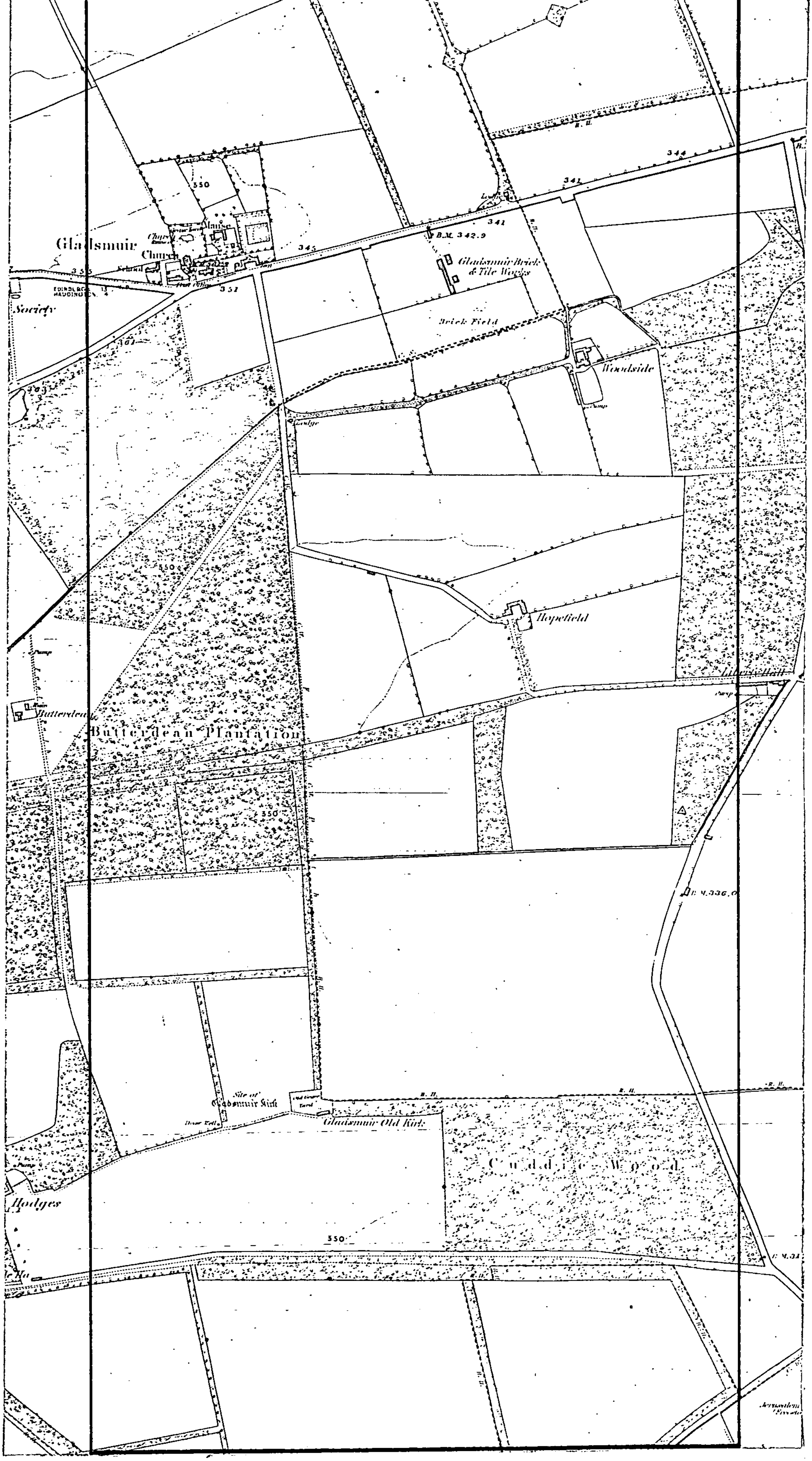

Figure 21C. Ordnance Survey 1853 (six inches: 1 mile)
area common to Figures 21B - 21F. See page 234 for fuller description.

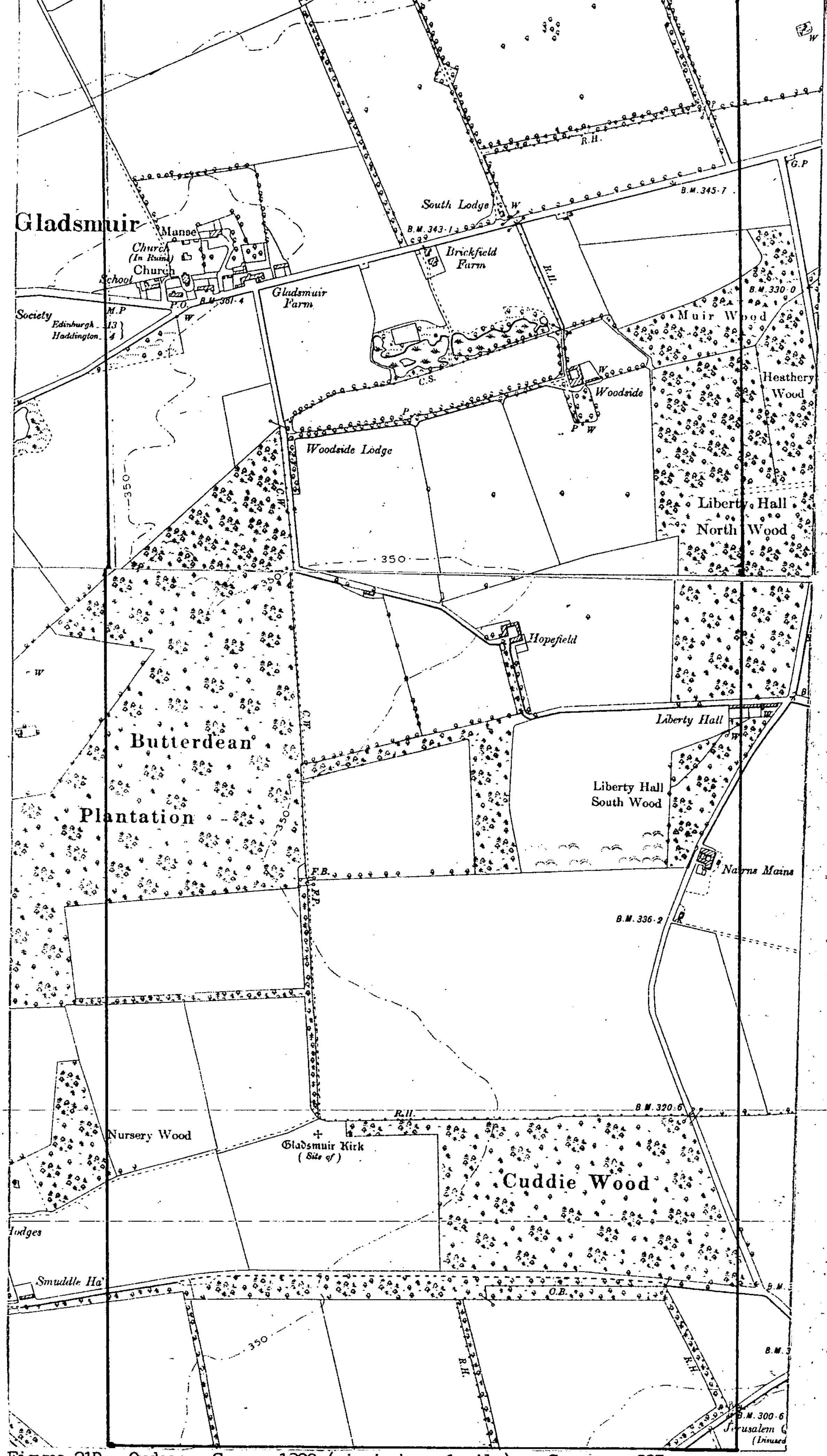

Figure 21D Ordnance Survey 1893 (six inches: 1 mile). See page 235 for description.

Figure 21E Second Land Utilisation Survey 1932 (directed by l. Dudley Stamp). A = Arable, M = Meadow, F = Forest, d = deciduous, c = coniferous, m = mixed. See page 235 for further description.

Figure 21F (i) Upper half of Gladsmuir area. 'Recent' air photograph (flown by Ordnance Survey, scale approximately 1: 7000). Red marks are recent interpretation Blue marks are 'early' habitat types from R.A.F. cover (where changed).
1 = deciduous woodland, 2 = coniferous woodland, 3 = mixed woodland, 5 = scrub.
7 = permanent unimproved grassland, 8 = improved rough grassland, 10 = open water,
11 = agricultural land, 12 = mom-agricultural land, 13 = hedges, 14 = tree-lines.
See page 235.

Figure 21F (ii) Lower half of Gladsmuir area. 'Recent' air photograph.
Key as 21F (i). See page 235 for description.

6.2.5 Further Description of the Improvements Era

The information for this section was derived from the Old and New Statistical Accounts for East Lothian. Only these parishes into which the 21 sample frames fell were used. There were 15 of these in all: Bolton, Dunbar, Garvald, Gladsmuir, Haddington, Humbie, Innerwick, Oldhamstocks, Ormiston, North Berwick, Pencaitland, Spott, Tranent, Whittingham and Yester. The information extracted mostly referred to agriculture, natural history and industry. This information was supplemented with extracts from the New Statistical Account of Midlothian parishes.

The description of changes in Cramond parish in this area was gleaned from sources described in 6.2.2 (D).

6.3 RESULTS

6.3.1 The Late Mediaeval Landscape

Features portrayed on Timothy Pont's map of Lothian are: rivers, the main hills, lochs, roads, burghs, fermtouns, and enclosed parkland round certain seats. The latter occupy a very small proportion of the county of East Lothian and are few and far between. There are 24 in the whole county, and seven appear sizeable. Five of these seven are marked on the excerpt (Figure 21A) included in the thesis, near Pencaitland and Ormiston. The other eighteen are about the size of Ervytoun park. All have the tree symbol within but literary sources suggest that parts of parkland were laid down as grassland, broom, fish ponds, hedges and rabbit warrens (e.g. Edlin 1969). There are references in Anderson (1967) to some of these woods. Woodlands near the kirk of Keith were granted to Kelso Abbey in 1160. In 1550 the wood of Ormystoun was called upon to supply timber for cart-shafts. In 1494 oak for guns and artillery stocks was obtained from Saltoun. Some of these woods may therefore have been older than those laid down in response to the Forest Laws of 1457 and 1503. However it appears that other large extensive areas of wood have been lost e.g., the whole of the Peffer Burn between Saltcoats and Fenton was wooded in the 13th century. Only at Yester are there trees marked which are not part of the park.

Only one road is marked:- that from Edinburgh to Dunbar, with an offshoot to Haddington, presumably there must have been rougher tracks to link the touns.

The overall impression is of very open landscape with many small scattered settlements; fermtouns and kirktouns. Larger settlements can be seen at Haddington, North Berwick and Dunbar, Pencaitland, Aberlady and Tranent.

The area reproduced here, round Gladsmuir, shows a greater proportion of parkland and unsettled lands than is typical for East Lothian as a whole. The area round Gladsmuir has few settlements. A clue to the reason for this may lie in the two large lochs suggesting much marshland in the vicinity and the 'moore' part of the old name.

The main impression to be gained from Slezer's prints is one of large open fields in which the majority of the land is cultivated. These are as yet unenclosed and there is little to break the view except the land forms themselves e.g. hills and rivers. Although there are some areas of grassland, wetland or rough lands, the majority of the land has been ploughed. The reason for the predominance of cultivated areas in the prints may be that they lie close to the towns, and there the need for cultivation is greatest.

There were a few areas of enclosed land round the houses and in towns. These appear more like gardens than farmed areas.

A number of these points are illustrated in the prints (Figures 16, 19, 20). Figure 16 shows a view from the Dean Bridge near Edinburgh. Though not strictly part of lowland agricultural Scotland today, it was then. The land is extensively cultivated; the 'rig and furr' clearly visible. Only the area in the foreground, the river banks, the loch to the left of the old town and an area centre-right are unploughed. There are few trees except close to the buildings - settlement itself is the main break in the view. There are a few walled paddocks at the Dean village (near right).

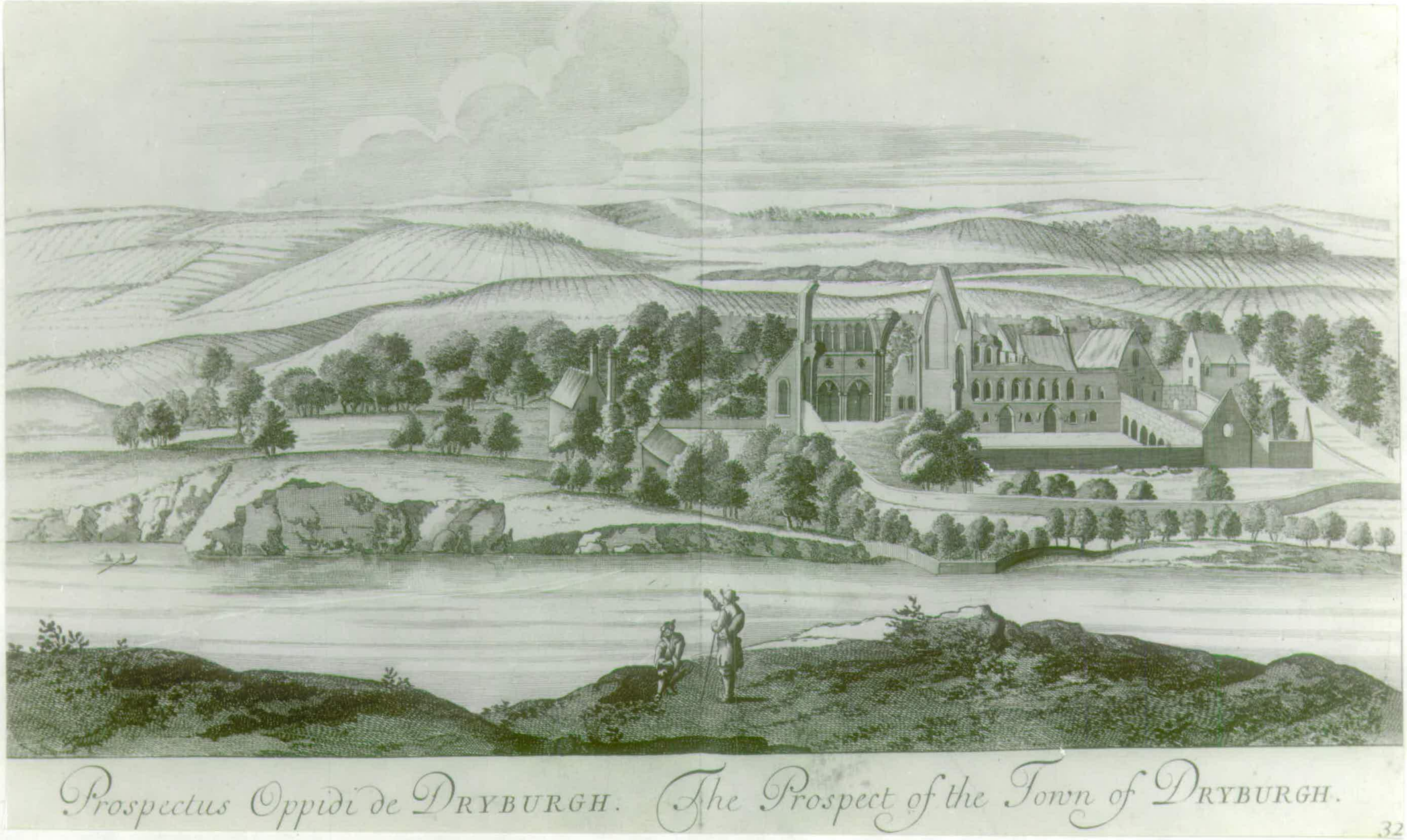

Figure 19: Dryburgh across the River Tweed 1670. Extensive cultivation over the hills. Apart from the parkland round the old abbey, trees are scarce. (From Slezer J (1693) Theatrum Scoticae).

Figure 19 portrays Dryburgh Abbey in the Borders and its surrounds. It shows a similarly open landscape, though with a few more trees. The area round the abbey is well planted with trees and there are also areas of grassland in the vicinity. This may resemble the parkland round the main seats. There are a few clumps of trees in the distance which may owe their presence to earlier monasterial activity. The hills are largely bare and cultivated though there are a few more areas of grassland than in the first print e.g., the area touched by the spire of the abbey. The foreground may represent 'roughland' with areas of scrub. Overall the impression again is of open, extensively cultivated landscape.

The third print of Linlithgow in West Lothian (Figure 20) presents a similarly open picture. However less land is under plough and more under grassland. Again there are few trees escept east of the palace. There are also enclosed areas of grassland east of the palace.and the aforementioned trees form part of the hedgerows. This part of the print appears far more diverse and broken up than the areas north and west of the town. The houses at the town have walled enclosures round them, with hayricks within. This demonstrates that farming was still the major livelihood for the inhabitants. These features all suggest that pastoral farming rather than arable is predominant in the area, though a few 'rigs' can be seen.

In summary all these prints present a fairly open landscape with few trees except close to buildings. Most of the land is under the plough, the ridges and furrows clearly visible. It is as yet unenclosed though there are a few walled enclosures close to the settlements. By Linlithgow the first hedges and enclosures can be seen but here pastoralism is more in evidence.

Roy's Map of 1760 gives a more detailed picture of the landscape compared with Pont's map, and also illustrates what the countryside was like away from the main buildings. The excerpt shown here (Figure 21B) covers the same areas as the excerpt from Pont's map (Figure 21A) - round Gladsmuir. To aid orientation, the following place name changes in the centre of the area are given:-

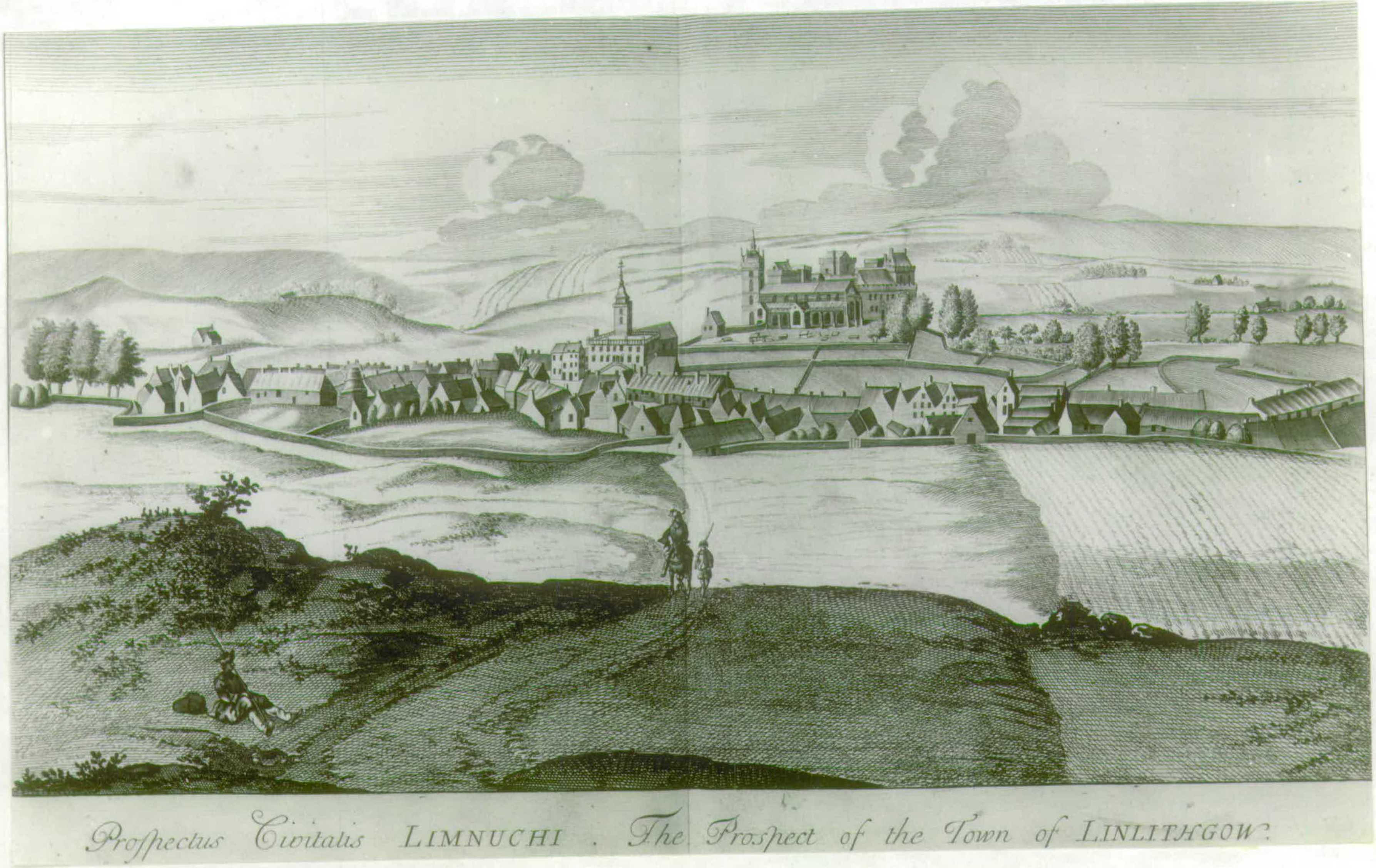

Figure 20: Linlithgow 1670. Pastoral farming is in evidence with the first hedged enclosures east of the Palace. (From Slezer J (1693) Theatrum Scoticae).

Ervytoun is now Elvingstone
Gladsmoore Stone is probably in the area of Huckstone Rig
Glades Moore itself is now Old Gladsmuir
The fermtoun of Green Dykes is still present in the top left of the map and the larger village of Samuelstoun in the lower right of the map

The lochs appeared to have been drained; the river below Claybarns and above Old Gladsmuir may run through the site of the earlier loch.

Three main types of land use can be seen. Unreclaimed areas and unenclosed cultivation ridges and enclosures. The top part of the map illustrates what much of the countryside must have been like before the enclosures: scattered fermtouns e.g. at Templehouse, Greendykes, Dykehead and Chesterhall, with fairly extensive cultivation (cross hatched areas) between.

Around Greendykes and Templehouse fairly extensive rough areas can be seen. Much of the area south of New Gladsmuir has by now been enclosed but there are still fairly large areas of unreclaimed land e.g. west and south of Claybarns and south of Old Gladsmuir. Within the enclosures themselves both arable land (hatched areas) and grassland (dotted areas) can be seen. The main boundaries are probably shelterbelts with thinner lines perhaps denoting hedges e.g. north of Claybarns.

The picture is very much one of transition. Much of the old farming pattern is still evident interspersed with 'islands' of enclosure and unreclaimed rough lands. Once more extensive woodland is notable by its absence. Apart from the new shelterbelts the only sizeable wood is at the top of Elvingstone estate and the location and shape of this suggests it was probably planted.

With reference to other parts of East Lothian, this area is atypical in having more of the land already enclosed. The excerpt was chosen to illustrate some of the problems in matching up Roy's map with the Ordnance Survey map of 100 years later (see 6.2.4) rather than to depict a typical late mediaeval area.

6.3.2 Changes 1760 - 1970

Table 29: 1853 - 1970 - All Habitat Types

Table 29A shows the area of each of the 12 habitat types at the various Ordnance Survey and Air Photograph dates, and the net percentage change between the consecutive dates. The final column shows the overall net change from 1853 to around 1970. For the air photographic data, 1949 has been taken as the mean date of the 'early' photograph and 1970 as the mean of the 'recent'. Data from Roy's map has not been included in this analysis because the maps do not portray the same range of habitats. Table 29B shows the area of each habitat as a proportion of the total sample area at each date.

Woodlands

The area of deciduous woodland has remained fairly constant over the period, the largest change being the 18% loss in the post-war period. Though there is an overall decline, there was an increase in area for the first 100 years of the period.

The change in the area of coniferous woodland is remarkable; it is almost four times greater than in 1853. Over half of this increase occurred in the post-war period but the area has always been increasing. However at the most recent date it still occupied less area than that of deciduous woodland.

The area of mixed woodland has shown a marked decline from 1853, although it increased slightly in the post-war period. Part of the reason for the earlier decline may lie in the classification differences. (see Section 6.2.4). The greatest drop occurred between 1932 and 1949. This could be attributed either to the wartime felling or to the changeover from the NCC classification to the Ordnance Survey classification.

Overall the joint area of mixed and deciduous woodland has declined by almost one-third: from 541 ha to 370 ha between 1853 and 1970. However in the post-war period the total area of the two has declined by only 10%. The largest drop in the area was between 1932 and 1949 - 20% which suggests that some of the large decline of mixed woodland alone in that period was because of war-time felling rather than because of misclassification as deciduous woodland.

TABLE 29A: Extent of Habitats (hectares) in the 10% Sample of East Lothian at 1853, 1893, 1932, c1949 and c1970, with Net Change in Area between these Dates Expressed as a Percentage of the Earlier Area

Habitat Type	1853 ha	1853 to 1893 Change as % of 1853	1893 ha	1893 to 1932 Change as % of 1893	1932 ha	1932 to 1949 Change as % of 1932	c1949 ha	1949 to 1970 Change as % of 1949	c1970 ha	1970 Change as % of 1853
Deciduous Woodland	275	+ 10	302	+ 1	304	+2.5	312	- 18	256	- 7
Coniferous Woodland	42	+ 20	50	+ 7	54	+78	95	+105	196	+367
Mixed Woodland	266	- 3	258	-16	216	-53	102	+ 12	114	- 57
Felled Areas	5.5	+173	15	-14	13	-16	11	+250	38	+590
Scrub	46	-8.5	42	0	42	+66	70	- 18	57	- 24
Dwarf Shrub Heath	52	- 16	44	+18	51	-45	28	- 99	0.4	- 99
Permanent Unimproved Grassland	132	- 20	105	+ 3	108	-28	78	- 8	72	- 45
Improved Rough Grassland	838	- 10	755	+ 3	780	-76	186	- 42	109	- 87
Wetland	15	0	15	+ 9	17	- 2	16	+ 18	19	+ 27
Open Water	6	+ 24	7.5	-25	6	+ 1	6	- 3	5.5	- 8
Agricultural Land	2733	+ 3	2817	-0.3	2808	+22	3424	+ 1	3454	+ 26
Non-Agricultural Land	139	- 1	138	+ 8	149	+46	218	+ 4	226	+ 62

TOTAL 4548 ha

TABLE 29B: Habitat Extents expressed as Percentages of the Total Sample Area of East Lothian at 1853, 1893, 1932, c1949 and c1970

Habitat Type	1853	1893	1932	c1949	c1970
Deciduous Woodland	6	7	7	7	6
Coniferous Woodland	1	1	1	2	4
Mixed Woodland	6	6	5	2	2
Felled Areas	0.1	0.3	0.3	0.2	0.8
Scrub	1	1	1	1.5	1.2
Dwarf Shrub Heath	1	1	1	0.6	0
Permanent Unimproved Grassland	3	2	2	1.7	1.5
Improved Rough Grassland	18	17	17	4	2
Wetland	0.3	0.3	0.4	0.3	0.4
Open Water	0.1	0.2	0.1	0.1	0.1
Agricultural Land	60	62	62	75	76
Non-Agricultural Land	3	3	3	5	5

The area of felled woodland, as might be expected, fluctuated over the period with a slightly larger proportion at the end of the period. Its area is considerably less than the main woodland types.

Roughlands

The area of scrub though somewhat larger than that of felled woodland remains fairly constant over the period with only slight fluctuations. The biggest increase appears to have occurred between 1932 and 1949. However part of the reason for this may lie in the greater degree of detail on the air photographs compared with the maps: gains, but not losses are likely to be picked up in the intervening period.

The area of dwarf shrub heath though always low has been steadily declining over the years and is now almost non-existent. There were very few sample frames with heathland on them initially. The decline has taken place as a result of reclamation of a few areas close to the limit of cultivation.

The area of permanent unimproved grassland has also declined steadily over the period; overall almost half the initial area has been lost.

Improved Rough Grassland

There has been a marked decline in the area of Improved rough grassland over the years. It has gone from being the second commonest category to the fifth commonest, an overall drop in area of almost 90%. The greatest reduction occurred between 1932 and 1949. As described in the methods section, some of this old grassland is permanent pasture in agricultural terms; that is, it has initially been sown. It is also possible that some long leys may have been included in this category. However, whatever their origins, the area had probably been out of cultivation long enough for them all to have attained some nature conservation interest. There must be a definite loss in wildlife value as they are turned to intensive arable use. This loss of old grassland ties in very well with the historical material cited in the last chapter; during the depression years when cereal prices were low, much arable land was allowed to revert to grassland but this land was taken into cultivation again when war arrived. During the air photo interpretation of 'early' (late 1940's) and 'recent'

(1970's) frames there were a number of areas found on the 'recent' photographs which photogrammetrically would have been classified as improved grassland. However when the 'early' photograph was referred to they were clearly cultivated. Such areas had to be classified as arable therefore on the recent photographs.

There was no way of eliminating such errors in the early maps. Thus the overall decline may well be an overestimate. It does appear that some areas were allowed to revert to grassland after the 'Dig for Victory' campaign of the last war and these areas will become more valuable for wildlife in time.

Wetland and Open Water

Areas of wetland and open water have fluctuated slightly over the period - no definite trends can be discerned. In wetland especially it is possible that small areas present at the time of the early maps and since drained would not be picked up. Overall there is a small gain in the area of wetland. This could be for the above reason or because reversion to wetland owing to inadequate drainage, exceeds new draining.

Agricultural Land

The area under intensive arable use had increased steadily over the period; from occupying just under two-thirds of the total area to over three-quarters. The agricultural area has increased overall in area by 26% with the only period of stagnation between 1893 and 1932. The largest jump in area occurred between 1932 and 1949 when old grassland appears to have been put to more intensive agricultural use. These findings again tie in very well with the historical evidence in the literature.

Non-Agricultural Land

This area has also increased over the period by nearly two-thirds. The post-war increase is not as great as it was in other local authority districts such as those in the Industrial Belt.

Summary

The largest net gains in terms of both area and percentage are those to agricultural land: 721 ha, coniferous woodland: 154 ha and non-agricultural land: 87 ha. The largest net losses in terms of area and percentage are those to improved grassland: 729 ha (roughly equivalent to the agricultural gain) and to mixed woodland: 152 ha. The percentage losses from roughlands are also seriously large. The decline to these habitats was never constant. In the other habitat types, the area fluctuations were slight.

As well as illustrating overall habitat changes and the direction of changes through time, these data can also be used to determine whether the rate and scale of post-war changes are really greater than in earlier periods, and so to provide a context for assessing the significance of recent changes.

Although there is continual flux, changes in the period 1932 - 1949, which encompass the Second World War, are of similar magnitude to post-war changes. If the data for habitats with overall changes of greater than 10% are more closely examined, in over half the habitats (mixed woodland, scrub, permanent unimproved grassland, improved rough grassland, agricultural land, and non-agricultural land), there are earlier changes which are greater in terms of both area and percentage net change. As suspected most of these occurred between 1932 and 1949. Because this is a shorter period the rate of change must also have been greater. In deciduous woodland, coniferous woodland, felled areas and dwarf shrub heath the post-war changes are greater in terms of area and percentage. However if one accepts that some areas of deciduous woodland have been misclassified and are really mixed woodland and consider the two types together then the greatest decline in these policy woodlands again occurs between 1932 and 1949.

The statement in the NCC publication 'Nature Conservation and Agriculture' (1977) cited in the introduction that 'the rate and extent of change in the last 35 years has been greater than at any similar length of time in history' is consonant with the findings for East Lothian (since 1853) if we bear in mind the different periods of observation: 1932 - 1949 and post 1950 in the present study and 1941 to 1976 for 'Nature Conservation and Agriculture'. If the findings of both studies are considered together, the greatest rate and scale of change occurred in the war and immediate post-war years.

Table 30: 1760 - 1970 Changes to Habitat Groups

Table 30A shows the area of main habitat groups at various dates since 1760. It must be stressed again that 1760 estimates are very rough. There is a certain loss of detail through amalgamating the habitat types but it is the only way that the early data could be used. It also eliminated possibilities of misclassification within woodlands. Table 30B shows the proportion of these groups at each date.

Woodlands

The total area of woods has been fluctuating since 1760. Overall there has been an increase in area of 150% but much of this increase occurred in the first period 1760 - 1853. The 1760 figure may be an underestimate because the smaller scale of the map permitted only large areas of woodland to be shown. These findings tie in very well with the literature which suggests there was a great deal of planting in this period,for example, of shelterbelts and policy woodlands. The area continued to rise until 1893 after which there was a decline. This again provides evidence for the effects of the two wars on timber supplies. More recently the area has begun to rise again. However much of this is due to planting of non-deciduous woodland.

Roughlands

At the time of Roy's map, there were still extensive areas which had not come under the plough. In East Lothian such areas occupied a third of the countryside; a proportion very similar to that of cropland. The greatest decline in terms of area took place over the Improvements era, but this trend has continued apart from a slight gain between 1893 and 1932. Now only 10% of the initial area remains.

Improved Grassland

The area of improved grassland has declined over the period by a similar percentage to that of roughlands. The greatest proportion of loss occurred between 1932 and 1949. Although in most periods there has been a loss, there was a slight increase between 1893 and 1932.

TABLE 30A: Extent of Habitat Groups (hectares) in the 10% Sample of East Lothian in 1760, 1853, 1893, 1932, c1949 and c1970 with Net Changes between Dates Expressed as a Percentage of Earlier Area

Habitat Group	1760 ha	1760 to 1853 Change as % of 1760	1853 ha	1853 to 1893 Change as % of 1853	1893 ha	1893 to 1932 Change as % as 1893	1932 ha	1932 to 1949 Change as % of 1932	c1949 ha	1949 to 1970 Change as % of 1949	c1970 ha	1970 Change as % of 1760
Woodlands	239	+146	588	+ 6	625	- 6	587	-11	520	+16	603	+152
Roughlands	1498	- 84	245	-16	206	+ 6	218	-12	192	-22	149	- 90
Improved Grass	994	- 16	838	-10	755	+ 3	780	-76	186	-42	109	- 89
Cropland	1695	+ 61	2733	+ 3	2817	0	2808	+22	3424	+ 1	3454	+104
Roads and Settlement	109	+ 27	139	- 1	138	+ 8	149	+46	218	+ 4	226	+108
Open Water Sea	7·2 9·5		6·0		7·5		5·6		5·7		5.5	- 24

TOTAL 4548 hectares

TABLE 30B: Extent of Habitat Groups Expressed as Percentages of the Total 10% Sample of Lowland East Lothian 1760 - 1970 (except Open Water)

Habitat Group	1760	1853	1893	1932	c1949	c1970
Woodlands	5	13	14	13	11	13
Roughland	33	4	5	5	4	4
Improved Grass	22	18	17	17	4	2
Cropland	37	60	62	62	75	76
Roads & Settlement	2	3	3	3	5	5

Cropland

The area of land under agricultural use has more than doubled since 1760. It has gone from occupying just over one-third to three-quarters of the lowland countryside. The largest increase in area occurred between 1760 and 1853 which suggests that it was largely at the expense of roughland with another large jump in area between 1932 and 1949, which must have been more at the expense of improved grassland.

Roads and Settlement

This area has increased steadily over the period with the largest increase occurring between 1932 and 1949.

Summary

The main trends have been illustrated in Diagram 4.

In all these habitat types the change over the whole period is around 100% or more in the case of woodlands.

The 1760 - 1853 changes in roughlands, improved grassland and croplands tend to back up the findings in Table 29; the overall trend is one of decline. However the overall magnitude of change in this 90 year period is far larger than that for the next 80 year period particularly for the increase in agricultural land and the decrease in roughlands. With woodlands the picture is slightly different in that there is a large increase over this first period which unlike the other changes must be advantageous to wildlife. Although there have been subsequent periods of decline in the woodland area, there have also been increases and levels have never again sunk to the pre-improvement ones.

As regards rate and scale of decline, the period 1760 - 1853 does appear to be on a par with recent changes.However this earlier period is about 90 years long and the recent period 35-50 years long depending on the date of the recent photographs. A rough comparison of the rates and scales of the change may be achieved by halving the changes for the former period. Table 31 presents this information. This shows the net changes and percent net changes to each habitat group for the period 1760 - 1853, these quantities halved and the net changes and

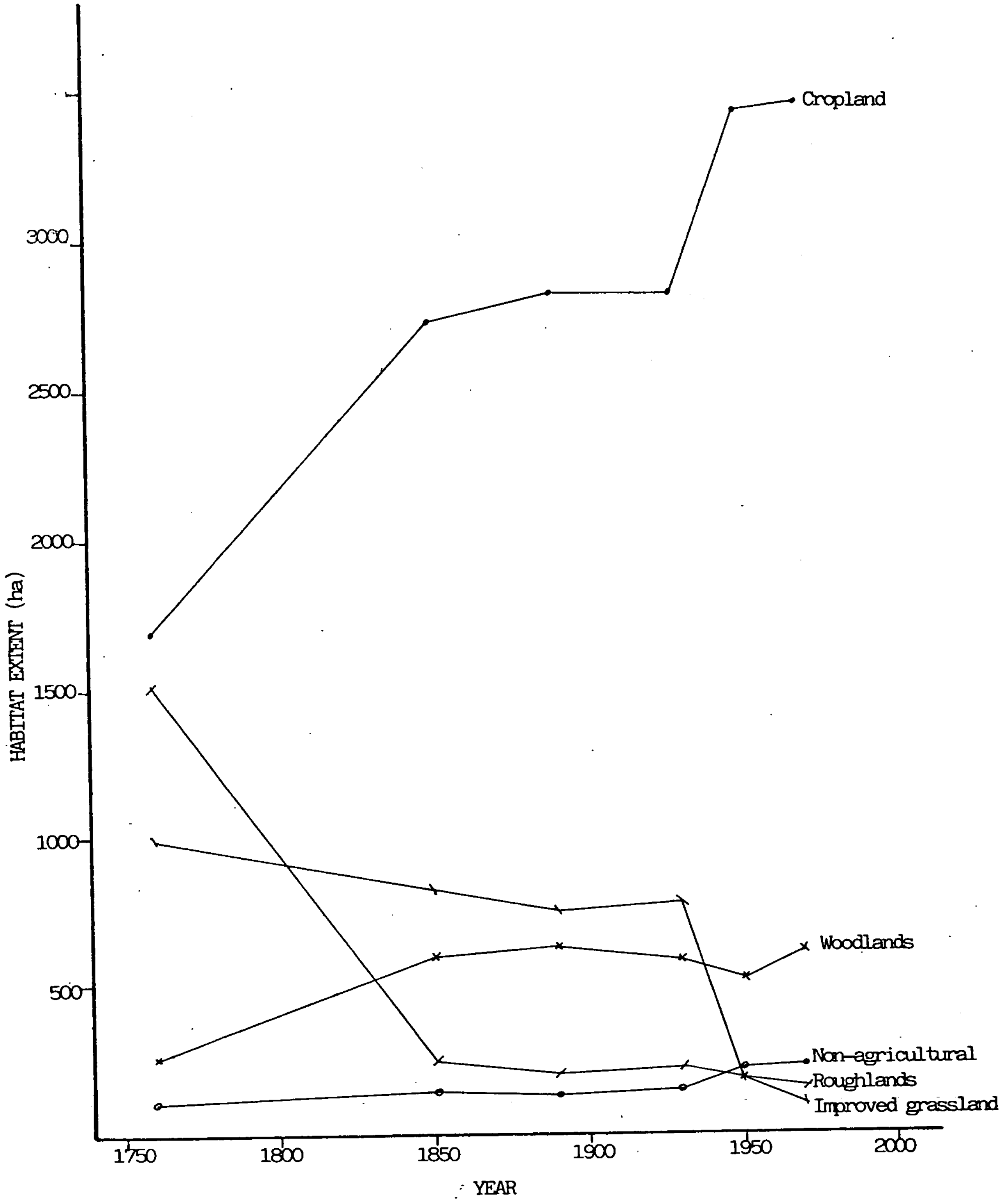

Diagram 4: Changes in the areas of the main habitat groups 1760 - 1970.

percent net change for the period 1932 - 1970. The rate and scale of changes can be seen to be greatest for woodland and roughland in the Improvement era, though the former is beneficial. Changes to cropland are similar over both periods and to improved grassland and roads and settlement greater in the more recent period. It has been shown that the bulk of these recent changes occurred in the war and immediate post war years. Overall the rate and scale of changes in the Improvements era appear to be on a par with those in the recent 35 - 50 year period.

TABLE 31 Rate and Scale of Changes in the Two most Changeable periods

HABITAT	Net Changes 1760 - 1853				Net Changes 1932-70	
	Area (ha)	%change	$\frac{\text{Area (ha)}}{2}$	$\frac{\text{change\%}}{2}$	Area (ha)	change%
Woodland	+349	+146%	+175	+73%	+16	+3%
Roughland	-1253	-84%	-626	-42%	-69	-32%
Improved Grass	-156	-16%	-78	-8%	-671	-86%
Cropland	+1038	+61%	+519	+30%	+646	+23%
Roads, Settlement	+30	+27%	+15	+14%	+77	+52%

It is the trend of certain of these changes that gives most cause for alarm. Although the bulk of roughland: scrub, heath and unimproved grassland was already lost by 1853, it has continued to decline. The area of agricultural land has continued to increase. The area of improved grass has also steadily declined. The gain in woodland is the only benefit but this disguises recent increase in coniferous species at the expense of deciduous woodland.

Table 32 Interchange

These tables show the origins and destinations of habitats undergoing change.

Table 32A for the period 1760 - 1853 is much simpler than the other four tables. Only the five habitat groups can be studied and because of the more approximate nature of Roy's map compared to later maps, no attempt was made to quantify the changes. Instead the main changes

TABLE 32A: Interchange 1760 - 1853 : Origins and Destinations of Main Changes

The first number in each box is the number of the 21 samples in which the change occurs and the second number is the mean ranking - lower figures mean the change is larger. Main changes have been underlined.

DESTINATION 1853 ORIGIN 1760	Woodland	Roughland	Grassland	Cropland	Roads and Settlement
Woodland		1, 3		5, 3.4	
Roughland	11, 2.6		9, 2.9	12, 1.5	1, 4
Grassland	4, 3.2			15, 1.7	2, 7
Cropland	7, 4.6		10, 2.5		16, 5.1
Roads and Settlement				17, 4.8	

on each sample frame were noted and ranked i.e. the commonest change:- 1, the next commonest:- 2, and so on. Of the two figures in the box, the first figure shows the number of the 21 frames on which the change occurs and the second is the mean of the rankings. The higher the number of samples the change occurred in and the lower the ranking mean, the more important the change. The major individual changes have been underlined.

The most important changes are that of improved grassland to cropland and roughlands to cropland . The next most important group of changes are roughland to woodland, cropland to improved grassland and roughland to improved grassland. There are a few instances of both improved grassland and cropland being planted with trees, and of woodland being converted to cropland. Finally in nearly every sample area there are instances of settlement removal and replacement elsewhere, and the creation of new roads.

Thus even then change was not wholly unidirectional. It was not just a case of roughland and grassland being put to more productive use; some previously cropped areas were laid down as pasture or allowed to revert to grass in the parkland surrounding the new mansions. The whole landscape does appear to have been remodelled.

Table 32B portrays areas of interchange for the period 1853 - 1893. From Table 27A it was seen that the main net changes in this period were a net gain in the area of deciduous woodland, a net loss in the area of permanent and improved grassland and a gain in the area of agricultural land. Apart from the loss in permanent grassland, these are all smaller changes than occurred at other periods.

Half of the gain in the area of deciduous woodland has been at the expense of permanent grassland, with gains also from improved grassland, scrub and agricultural land. There were a few losses to this area.

The loss in the area of permanent grassland has mostly been to deciduous woodland though some has been to improved grassland. None has gone to

TABLE 32B: Interchange 1853 - 1893 : Origins and Destinations of Individual Changes (hectares)

DESTINATION 1893 ORIGIN 1853	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land	ORIGIN TOTALS
Deciduous Woodland		1.4	0.2		0.3			1.0	0.3		1.0		4.3
Coniferous Woodland	0.4												0.4
Mixed Woodland	2.3	0.8		9.7	0.7		0.3	15.7			4.5	0.9	35.0
Felled Areas			0.2										0.2
Scrub	5.2						1.2	0.1			0.4		7.0
Dwarf Shrub Heath		0.9						7.6					8.6
Permanent Unimproved Grassland	17.7	1.7	1.0		1.5			7.3					29.2
Improved Rough Grassland	4.5	0.9	8.7			0.3	0.8				103.3	1.8	120.3
Wetland											0.3		0.3
Open Water	0.2		0.1					0.1					0.4
Agricultural Land	3.7	3.0	6.4							1.2		16.8	31.2
Non-Agricultural Land	0.6	0.1	13.5					0.1		0.6	5.3		20.3
DESTINATION TOTALS	34.6	8.9	30.1	9.7	2.5	0.3	2.3	32.0	0.3	1.9	114.9	19.4	257.0

cropland; an interesting finding.

However the loss in area of improved grassland is accounted for by a gain to agricultural land, though deciduous and mixed woodland are also recipient. There has also been a gain in improved grassland although this is only a quarter that of the loss. The main donor classes were mixed woodland, heathland, and permanent grassland.

The gain in the area of agricultural land was largely at the expense of improved grassland although there were also small gains from mixed woodland and non-agricultural land.

Although the net change to both mixed woodland and non-agricultural land is low there have been significant gains and losses to each, notably, the planting of old mineral workings and the conversion of mixed woodland to improved grassland.

Overall there has been a fair amount of change. The largest individual change is the conversion of improved grassland to agricultural land.

Table 32C. This shows the individual changes in area between 1893 and 1932. From Table 27A the main net gains and losses were a loss in the area of mixed woodland, and a small gain in the area of improved grassland. From these figures it appears to be the most static period and in fact has the smallest total changed area of all.

The majority of the area lost from mixed woodland has become improved grassland with felled areas, heathland and permanent grassland receiving smaller amounts. There was a small gain in area mostly from other woodland types.

The gain in the area of improved grassland is largely due to the loss of mixed woodland. This was partly due to felling of open woodland in parkland round mansions. This is the largest individual change between 1932 and 1947.

TABLE 32C: Interchange 1893 - 1932 : Origins of Individual Changes (hectares)

DESTINATION 1932 ORIGIN 1893	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land	TOTAL
Deciduous Woodland				0.6	1.7		0.3	0.7			0.5	1.2	5.0
Coniferous Woodland			2.2	0.4							0.3		2.9
Mixed Woodland		0.5		7.1	0.7	7.8	6.2	27.0			1.7	0.1	51.0
Felled Areas	1.1	2.7	5.8		0.5								10.1
Scrub	1.4	0.4	0.9				1.0	1.5			0.2		5.4
Dwarf Shrub Heath													
Permanent Unimproved Grassland	0.5				1.0			3.2			0.3		5.0
Improved Rough Grassland	2.0	0.2	1.5		0.2						3.7	0.2	7.8
Wetland	0.1	1.4					0.1			0.1			1.6
Open Water									0.9		0.0	0.8	1.8
Agricultural Land	2.1	1.2	0.9		1.1		0.5	0.2				13.4	19.4
Non-Agricultural Land	0.4	0.1								0.1	4.0		4.6
TOTAL	7.5	6.4	11.4	8.1	5.4	7.8	8.0	32.6	0.9	0.2	10.6	15.7	114.5

The other changes are similar to those occurring between 1853 and 1893 although on a smaller scale. The only other sizeable change is that from agricultural to non-agricultural land.

Table 32D: Interchange from 1932 - 1949. This period has had the largest amount of change of any which has been quantified.

The main changes identified in Table 27A were net gains to coniferous woodland, scrub, agricultural and non-agricultural land and net losses from mixed woodland, dwarf shrub heath, and the two grassland types.

The gain in the area of coniferous woodland is largely at the expense of mixed woodland with some from felled areas. This marks the beginning of a strong upward trend in the area planted with conifers in the lowlands.

The scrub gain occurred largely at the expense of mixed woodland suggesting areas were felled and left to their own devices for a while. Improved grassland was a smaller donor.

The gain in the area of agricultural land was for the most part due to a loss from improved grassland but there were also notable losses from heathland, permanent grassland and mixed woodland, all of which may be considered serious in a wildlife context. The gain in the area of non-agricultural land is partly at the expense of improved grassland and partly from agricultural land.

The habitat types which have increased at the expense of mixed woodland are coniferous woodland, scrub and improved grassland, with a lesser amount being converted to agriculture.

Nearly all the area of permanent grassland which has been lost is now under agricultural use and likewise with improved grassland though the quantity involved in the latter case is much larger. Some improved grassland has gone to non-agriculture.

TABLE 32D: Interchange 1932 - 1949 : Origins and Destinations of Main Changes

DESTINATION 1949 ORIGIN 1932	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land	TOTAL LOSSES
Deciduous Woodland				0.5	0.5		3.7	2.8			3.6	2.9	15.0
Coniferous Woodland				0.5	0.9						2.7		4.1
Mixed Woodland	7.2	28.8		6.3	32.8	2.7	3.8	33.1	1.0		11.8	1.0	128.4
Felled Areas	5.1	4.3											9.4
Scrub	2.2											0.1	2.2
Dwarf Shrub Heath	1.8	3.4									20.8		26.0
Permanent Unimproved Grassland	1.3	1.8			0.9			13.5		0.2	18.1		35.8
Improved Rough Grassland	1.2	3.2	0.4		4.1						592.7	37.9	639.4
Wetland	0.5								0.7	0.54			1.67
Open Water	0.3										0.4		0.8
Agricultural Land	0.5	3.0			2.7						37.0	2.8	46.0
Non-Agricultural Land	2.7				1.3			0.1			1.3		5.4
TOTAL GAINS	22.6	45.5	0.4	7.2	43.2	2.7	7.5	49.5	1.0	0.8	652.1	81.6	914.2

The largest individual change in this period is that from improved grassland to agricultural land.

Table 32E: Individual areas of change 1947 - 1970. Overall there is less than half the total area of change that there was in the preceding period. The main changes were net losses in deciduous woodland, dwarf shrub heath and improved grassland and the main gains were to coniferous woodland, felled areas and agricultural land.

Most of the deciduous woodland lost has gone to one of the other woodland types with mixed woodland the main recipient. Agricultural land and scrub gained small amounts.

The area of dwarf shrub heathland lost has been mostly planted with conifers and much improved grassland has also been planted. Deciduous woodland and agricultural land have also gained at the expense of improved grassland.

Much of the gain in the area of coniferous woodland has been at the expense of heathland and improved grassland. The third largest donor was deciduous woodland and small amounts were previously mixed wood and agricultural land.

The gain in the area of felled areas has come mostly from deciduous woodland with mixed woodland the second largest donor.

Finally agricultural land has gained at the expense of improved grassland, deciduous and coniferous woodland and non-agricultural land.

The situation in East Lothian is different from that in the survey area as a whole where the main change was from agricultural land to non-agricultural land.

Summary of Interchange

A fairly dynamic picture has been presented. There are changes though often small, going on all the time. The main findings are summarised in Table 33. The total possible number of changes is 125.

TABLE 32E: Interchange 1947 - 1970 : Origins and Destinations of Main Changes

DESTINATION c1970 ORIGIN c1947	Decid. Wood.	Conif. Wood.	Mixed Wood.	Felled Areas	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric. Land	Non-Agric. Land	TOTAL LOSSES
Deciduous Woodland		26.9	32.1	22.5	6.6		1.4				11.6	0.4	101.5
Coniferous Woodland			1.2	4.0	0.9				1.0		10.4		17.6
Mixed Woodland	5.6	11.8		8.5	2.8						2.2		30.9
Felled Areas	1.2	0.9			1.5					0.1	2.6	1.1	7.5
Scrub	22.2	4.8	4.1				0.6	1.8			2.7	0.6	36.8
Dwarf Shrub Heath	0.6	27.2											27.8
Permanent Unimproved Grassland		0.8			4.1						0.4		5.3
Improved Rough Grassland	14.4	37.7	4.3		6.85				1.0		14.3	6.4	84.9
Wetland													0.0
Open Water									0.25				0.25
Agricultural Land		8.2			1.9				0.7			16.4	27.2
Non-Agricultural Land		2.8						0.5			7.4		10.6
TOTAL GAINS	44.0	121.0	41.7	35.0	24.6		2.0	2.2	3.0	0.1	51.7	24.9	350.3

TABLE 33: Summary of Interchange

Period	Total Area of Change hectares	Total Area of Change as % of Total Survey Area	Number of Changes	Main Change
1760 - 1853	Unquantifiable	> 50%	13/20	Improved Grassland → Cropland
1853 - 1893	257 ha	6%	49	" " "
1893 - 1932	115 ha	2.5%	53	Mixed Wood → Improved Grassland
1932 - 1949	914 ha	20%	53	Improved Grassland → Agriculture
1949 - 1970	350 ha	8%	50	Improved Grassland → Coniferous Woodland

The main period of quantified change was between 1932 and 1949 when one-fifth of the whole survey area was involved in change. Over half the change was that from improved grassland to agricultural land though there were some doubts about the validity of the classification of these grasslands in the First Land Utilisation Survey. The second most changeable period was one covered by the Air Photo Analysis of Change Project. Large changes appear to have occurred in the period 1760 to 1853 but there was no way of quantifying those due to difficulties in matching up the two maps.

The number of changes remains remarkably constant throughout but the extent to which each occurs varies.

Finally the main changes always involve improved grassland, usually a loss, and usually to agriculture. Improved grassland may represent an intermediate category, perhaps the agricultural equivalent of the felled areas for woodland. On the whole its area is getting less; under the NCC classification once an area has been seeded it cannot revert.

Field Rationalisation

A few small summaries about fields and their boundaries are presented here.

Before the Improvements era, it has been recorded that most fields were large, open, and unenclosed. In Slezer's illustrations of 1670, it could be seen that only small areas close to towns and steadings were enclosed; mostly as paddocks and not as part of arable rotation. By the time of Roy's Maps, the first signs of larger scale enclosure could be seen although the majority of the land appeared unenclosed. Table 34 gives a summary of the state of enclosure in the 21 samples at that date.

TABLE 34 Degree of Enclosure in the 21 sample areas of East Lothian at the time of Wm Roy's Survey c1760

Proportion of frame enclosed	Number of frames
Almost whole frame	6
Half the frame	2
Small proportion	9
No enclosure	4

Thus it can be seen that field enclosure had already occurred on nearly all the photographs. The land was completely reorganised however on less than one-third of the sample frames.

By 1853 and the first Ordnance Survey maps, enclosure of all agricultural land was complete, but there still remained a few unreclaimed areas.

Table 35 shows the length of field boundaries at various dates. The boundaries on the Roy map, which can be identified in 1853, appear to be a mixture of shelterbelts and single tree-lines (many of which will have hedges below). The Air Photo Analysis of Change project distinguished tree-lines from hedges. A tree-line with a hedge below was classified as a hedge. Thus care must be taken in interpreting these results.

TABLE 35 <u>Lengths of certain boundary features at 1760, 1853, 1893, c1970 in kilometres (Boundary features are defined in text above)</u>

Date	Feature	Length (km)	
1760	Boundaries	121	
1853	Tree-lines	57	
1893	Tree-lines	32	
1947	Hedges	104)	127
	Tree-lines	23)	
1970	Hedges	84)	105
	Tree-lines	21)	

The figures suggest a decline in the length of tree-lines prior to 1947 but it is difficult to comment on the validity of the data. Tree-lines can be seen on the Sections of Ordnance Survey map (Figures 21C and 21D). These also illustrate what appear to be gains in length between 1853 and 1893, for example along the boundary running east of the top of Cuddie Wood, and along the west end of the intersection between Nairns Mains and the foot of Butterdean Plantation. An apparent loss in the period can be seen on the road running north east of Nairns Mains.

It is interesting that the total boundary length recorded in 1760 when, as can be seen in Table 31, less than half the area was enclosed is very similar to the recent totals of hedge and tree-line lengths. Although this length also included shelterbelts it is possible that there have been boundary losses prior to 1947.

Table 36 shows average field sizes estimated on the earliest (1893) and most recent (c1967) Ordnance Survey maps. One of the reasons for hedgerow removal has been the need to make fields larger in order to reap benefit from the new, larger farm machinery. Table 36 indicates a modest increase of 12½% in the 80 year period. The total area of the fields has decreased slightly in line with the countryside trend (losses to farm buildings and other non- agricultural purposes). The pressures for a policy of field amalgamation do not seem to have been strong in the study area.

TABLE 36 Differences in field size between 1893 and 1967 (hectares)

Date	Total field Area (ha)	Number of Fields	Average Field Area (ha)
1893	1551	199	7.8
1967	1538	176	8.7

In Westmacott and Worthington's (1974) 'New Agricultural Landscapes' average field sizes are given for sample areas in seven English counties: Cambridge; Huntingdonshire; Dorset; Somerset; Herefordshire; Yorkshire and Warwickshire. In 1972 these ranged from 5 ha in Somerset to 18 ha in Huntingdonshire, and the mean of the seven county samples was 9.3 ha. However field sizes in 1945 ranged from 3.6 in Somerset to only 7.7 ha in Huntingdonshire with a mean of 5.7 ha. Huntingdonshire is one of the English counties where probably the most extensive cereal growing is carried out, certainly more so than East Lothian and so one would expect there to be larger fields ultimately. These figures suggest that initially field sizes were smaller than in Scotland and so there was a greater need for boundary removal. Even in 1893, the East Lothian field size was larger than the 1945 average of the seven counties above and about the same as the Huntingdonshire figure - the largest encountered at the time. It appears that these fields were laid out larger initially than the English fields, and so are more suitable for modern agriculture. This conclusion is supported by Millman (1975) who states:

> The initially large fields have been considerably less subject to enlargement to take new farm machinery introduced in the last fifteen years, compared with smaller fields laid out in the areas of England affected by parliamentary enclosure. The Scottish landscape has remained more stable.

6.3.3 Further Evidence of Changes in the Improvements Era

The coverage of topics in the Statistical Accounts listed in the sources section 6.2.2 (C) was variable between the 15 parishes of East Lothian. It seems to have been left to the parish ministers themselves to decide what to include. Some ministers covered all the headings, others concentrated on specific aspects they were interested in and other accounts were very brief and gave little information. Coverage of the natural history sections was patchy; thorough in some parishes and absent from others. However all accounts describe agriculture, woodland, industry and settlement in some detail. The remaining topics were less comprehensively analysed but provide illustrations of the prevailing opinion.

1780 First Statistical Account: East Lothian

Settlement and Industry

There are presumed Roman camps in Whittingham, Humbie and Garvald parishes. In Innerwick a Danish Castle is described and in Garvald parish, in the Lammermuirs Whitecastle was supposedly built to guard the pass from the Merse and England. Haddington was thought to be of Saxon origin 'a town of great antiquity'. In 1178 David I granted the charter for its abbey to be built. This had extensive grounds. There was also a monastery near North Berwick and a nunnery in Garvald parish. Dunbar was a royal burgh created in the reign of David II. Thus there are signs of early settlement, conflict with the south and monasterial influence.

By 1780 parishes seem to be fairly intensively cultivated and the main industry agriculture. In Bolton, Humbie and Dunbar there is mention of certain feudal customs, such as thirlage to the lord's mill, although the minister for Dunbar states ' these Gothic customs are falling into disuse among the sensible part of the gentlemen in Scotland'. A similar impression is gained from the Reverend Sangster of Humbie parish.

There are specific references to a decrease in population, in the agricultural part of seven parishes since the onset of the improving era. This is attributed to the amalgamation of farms and reduced requirements for farmworkers with the introduction of the two horse plough. The consequences were a reduction in the number of cottages on farms and an increase of people in the towns and villages. In some parishes there are references to new accommodation having been built and alternative industries founded or encouraged. For example, at West Barns near Dunbar, cotton and flax mills were erected; there are references to quarries in a number of parishes and coal mining was practised in at least six parishes. Other employment was to be found in trade, crafts and fishing. In most parishes the inhabitants were still mostly engaged in agriculture but in a few parishes the town was beginning to offer more opportunities. In many parishes there are references to the poor state of the roads (other than post roads), and the need for their improvement.

The village of Ormiston was one of the few planned villages in south east Scotland: it was established by the noted improver, John Cockburn. He began his agricultural improvements to the land of Ormiston in 1732.

Agriculture

In nearly all the parishes, enclosure is noted as being almost complete, although some of the open fields remain. Where enclosure is not mentioned specifically, fairly elaborate rotations are described which suggests that some of the improving ideas were being taken up. The parts of parishes where little enclosure had occurred included hill land and unreclaimed areas, for example, in Gladsmuir parish. The boundaries themselves are described as hedges and ditch or dykes where stone is more plentiful. In North Berwick, the hedge and dyke together were being used. The Reverend Colville felt that the hedges of Ormiston (whitethorn mixed with sweet briar, honeysuckle and hedgerow trees) could give rise to a stranger mistaking the area for part of England.

The county as a whole is seen as being well farmed 'the utility of enclosures, universally aknowledged' (Reverend Hill, North Berwick). The minister for Oldhamstock (John Cochran) felt that enclosures were wanted on higher ground where the country appears bleak, and there was a need for shelter to increase the vegetation. There was one note of discord however. The Reverend Harvie of Innerwick parish writes on 'inclosures'; 'some farmers think them disadvantageous as they occupy too much of the high rented corn land and harbour birds'. Other technical advances, apart from the new ploughs, were threshing machines, mentioned in Oldhamstock and Garvald parishes.

Rough acreages of arable land, sown grasses, pastureland, land in 'a state of nature' (for example, links and laws) and woodland are given for some of the parishes. Upwards of 60% of every parish was tilled with perhaps 10% - 30% rotation grasses and 10% pasture. Thus in most parishes the total agricultural area was more than 80%. Woodland, common and rough grasslands usually occupy only 5 - 10% of the land. However in Innerwick parish about 40% of the area was still occupied by common.

Reclamation of the poorer lands is also described; the use of limestone, 'sea-ware' and dung, to improve soil fertility. However there were problems in Gladsmuir parish because the moor had for centuries been robbed of its turf by the local people. Where fertilisers were not available, the sowing of land with grass seeds and turning it to pasture was recommended by the minister of Garvald. In all there seems to have been a greater proportion of grassland than previously and this was cited as another reason for depopulation as fewer farm workers were needed for pastoral farming.

Woodland

In most parishes woodland occupied only a few hundred acres out of 3000 to 5000 acres. Much had recently been planted. The Reverend Hill of North Berwick writes that there was planting of strips and clumps of trees 'not only round the seats of the gentlemen in the parish but in different quarters of it, which both afford much shelter, and greatly adorn the face of the country.'

In most parishes the policies of the large mansion houses are described in glowing terms, for example Yester and Hopes estates in Garvald parish and Winton House and Fountainhall in Pencaitland parish. Some appear to have been laid down in earlier centuries, for example, at Lethington in Bolton parish there was a park of 3 - 400 acres with 12 foot high walls. This was said to have been laid down in the reign of Charles II, after a disparaging remark by the Duke of York that he had not seen a deer park in the whole of Scotland. Other signs of earlier planting include descriptions of large trees: for example, in the grounds of Ormiston Hall, a large tree which was eleven feet in circumference, and had a canopy covering one-twentieth of an English acre, was estimated to be at least 200, perhaps as much as 300 years old.

There are also descriptions of plantation on unreclaimed land and common. At Gladsmuir early attempts to cultivate the land failed despite liming but it was afterwards successfully planted with oak, Scotch fir (Scots pine) and birch. In Innerwick one heritor planted 120 acres of common heathland and small plantations were made on Traprain Law and West Barns Links. Humbie Wood was felt to harbour a cattle distemper called wood-ill or Muir-ill. This had been used as an excuse to root out natural woods in the area.

Few natural woods remained. They are mentioned in only four parishes, Humbie, Pencaitland, Spott and Whittingham. On the whole the new planting was regarded as good because of the lack of woodland in the county. In Oldhamstock the minister described how the natural wood which once abounded was almost entirely destroyed and the minister for Dunbar stated 'there is but little wood which makes the country look naked.'

1850 The New Statistical Account: East Lothian

These accounts were on the whole more detailed but the same areas were covered as in the last account.

Settlement and Industry

A few more relevant historical details can be gleaned from the accounts. The minister of Dunbar describes the Dunbar area as a 'theatre of war'. In 1548 the town was burnt by the English.

However times were more peaceable by 1850 - there is evidence of further industry being provided in the towns and villages - breweries and distilleries in Haddington - more coal working in Gladsmuir (though it had been wrought in Penston from the fourteenth century) - lime quarrying and burning for fertiliser. Another new industry near Gladsmuir was brickworks, which also made tiles for drains. There are suggestions however that not all of these new industries were flourishing. In Ormiston and Dunbar the linen industry had failed and in 1815 the Belhaven cotton factory closed. The main source of employment was still agriculture with mineral workings second. An improvement in roads was widely reported.

Agriculture

Whilst the First Statistical Account describes mostly the new rotations, crops and enclosures, these accounts dwelt more on reclamation. For improving soil fertility, rape and bone dust were the new manures, though lime was still used and there are more mentions of lime works in the Districts than in the earlier account.

In the first account reclamation by drainage was barely mentioned but many ministers describe it in these second accounts. The minister for Haddington states that drainage was now better understood than previously. Many ministers describe how 'wasteland' (flood meadows, moss and heath) in their parishes had been brought under the plough due to drainage and fertilisation, for example, Morphin Muir in Bolton parish. At Tranent 'the impossible morass' which separated two armies in 1745 now bore crops. At Gladsmuir there had been the additional problem of removing large stones. The Reverend Ramsay of Gladsmuir describes how there was 'now not a marsh in the parish'. In Pont's map of the 1590's two large lochs are clearly visible there (Figure 21A). He goes on 'The whole parish many parts of which a century ago were bleak and barren, covered with broom, furze and brambles, has gradually been brought into a state of high cultivation capable of producing all kinds of crops.'

Muir, links, old meadows, and common roughlands were all gradually being reduced. One benefit from the drainage had been to reduce the incidence of ague (malaria). The Reverend Cook at Haddington describes how the aged people in the parish remember how every spring numbers used to be laid aside with ague. This rarely happened by 1840. The minister of Gladsmuir felt the climate had been improved by cultivation. However some improvements were considered to be detrimental to health; for example, tree planting was thought to restrict air flow. Tree planting was also felt by some to be disadvantageous to agriculture. The minister for Ormiston, though recognising that hedgerow trees gave a rich and beautiful appearance to the parish stated 'these circumstances, however, prevent the free circulation of air which is so favourable to the crops'. Prejudice against trees and plantations was described by the Reverend Jaffray of Dunbar. He reported that there was 'little plantation but such as adorns the houses of the proprietors' for land was too valuable to be used that way and 'the farmer has little fancy for the produce. He prefers a well-dressed hedge to enumerable rows of brushwood which in England occupy at least one-tenth of the soil'. On the whole the ministers were well pleased with the new agricultural practices. The minister of Dunbar felt it an honour that East Lothian should lead the way in the grand era of agricultural improvement. One or two noted that because of the depression many farmers were beginning to 'throw' more of their fields into pasture.

Woodland

Planting continued round the seats and attention was again drawn to the lack of natural woodland. The ministers of Haddington describe copses on Coalston estates as a remnant of the copse which covered most of south Scotland (of oak, hazel, birch etc.). The Reverend Thomson of Yester draws attention to place names in his parish that show there were formerly large forests there: Woodhead; Broadwoodside; Eckyside (oak-woodside); and Pyot Shaw (shaw is Anglo Saxon for wood). The minister at Innerwick cited Woodley, Braidwood, Woodhall, Aikengall, Elmscleugh and Birkiemuir as examples in his parish.

In earlier centuries woodland must have been extensive for the buildings were mostly of timber. However this made them susceptible to fire. In 1244 the town of Haddington was 'consumed by fire' as were Stirling, Roxburgh, Lanark, Perth and Forfar in the same era. Remnants of earlier plantings were again described, for example, at Broxmouth 'a magnificent beech' 18 foot 6 inches round at three foot above the ground'. The circumference of the yew at Ormiston was now 12 foot 8 inches. The Reverend Forman at Innerwick felt that there was still a need of wood to be put among the fertile but bare fields. He was very impressed with one of his proprietors planting 160 acres of Innerwick common in 1783 to form Thurston High Wood (shown on air photograph 65/2 - 459).

There were more accounts of natural history in the Second Statistical Account though 'the dominion of the plough' was noted by the ministers at North Berwick and Dunbar. Some botanical lists are given.

In the county as a whole - 72% was estimated to be arable, 6% plantation and 2% non-arable. The remainder was upland in the Lammermuirs.

1840 Midlothian

The accounts read (Penicuik, Crichton, Newbattle, Borthwick and Inveresk) present a similar picture to those of East Lothian but perhaps more was made of drainage and planting. The minister at Penicuik felt that drainage was leading to an amelioration of the climate in reducing the coldness and wetness of some areas. However he also stated 'drainage of moss would, however, appear to be at first accompanied by prejudicial effects to the health, as its decomposition is stated by Sir H. Davy to prove very unhealthy'. Moreover he felt the flow of streams to be less even when there had been drainage of their upper districts, with a likelihood of reduced flow in some seasons and greater floods in others. But perhaps the most telling remarks as regards nature conservation are those made by the minister at Borthwick, who was a great naturalist. He describes seeing glow worms on warm summer evenings in the valley between Borthwick and Crichton. He remarks that they are uncommon in Scotland. However they had become less abundant of late due to extensive drainage in the valley. In the description of estate plantings coniferous species are frequently mentioned. The minister of Penicuik felt 'Scotch firs, spruces and larches are planted promiscuously with other hardwoods'. In Crichton parish the minister felt fir gave an agreeable sheltered appearance. There were more contestants for the largest tree in Scotland. A beech tree in the grounds of Newbattle Abbey was reputedly 22 feet in circumference at three feet above the ground.

Cramond Parish in the Improvements Era

Early estate plans of Dalmeny Estate show a very different lay out from that after 1820.

The sort of confusion that can arise in trying to compare Roy's map with later Ordnance Survey maps is illustrated by what happened on the estate. Of the old fermtouns, East Craigie was removed and rebuilt half a mile further from the sea. The only evidence of its former location is to be seen in the continuation of a present estate road by an avenue of trees which ends in the middle of a field. On Pont's map there is a settlement called Cockle Barns marked near the parish boundary, the Cockle Burn - no traces are to be found of it today. The only evidence of settlement at Gallowlaw (on Roy's map) is that the field it was in is called by that name on the present estate plans. A small village on the Mons Hill was also cleared but remains of the inn and other buildings can be seen in the 'snowdrop' wood close to the Leuchold. At the time a new village was laid out at Dalmeny and one can only suppose that the former inhabitants of these settlements were rehoused there. These findings are also supported by accounts submitted to John Wood, who was writing an account of Cramond parish, by a Dr Spotswood.

On Cramond Estate, the lairds of Cramond House had half the old village destroyed after 1820 when their new estate was laid out. A plan of the old village remains. On the river Almond, the old grain mills were converted to water powered iron mills. These failed to compete in the steam age but there is much evidence on the ground of their former existence.

The old road from Edinburgh to Cramond ran through Barnton Estate. The proprietor had a new road built further south and this is the present location of today's Queensferry Road.

6.4 FURTHER SOURCES OF EVIDENCE

The main conclusions in this chapter concern changes in East Lothian District. However they may be atypical because of the closeness of East Lothian to sources of new ideas (Edinburgh and England) and because of its suitability for extensive cultivation. Change may have occurred at a faster pace here than in more remote Districts. In addition only a 10% sample of the District was studied and this sample may not be typical of the whole District, although at the time of the Statistical Accounts there was a good deal of similarity between the parish accounts.

There are many other sources of evidence which could be used to provide more information about change in one particularly District. In addition such work should also be extended to other Local Authority Districts to see if habitat changes there occurred at a similar rate and on a similar scale. The present findings should be seen only as a small preliminary survey.

Perhaps the most obvious sources not used in the quantitative assessment of change in the survey area of East Lothian were estate plans. These were made for all estates re-organised at that time. The ones examined for Cramond parish mostly showed the new layout or concentrated on specific parts of the estate such as the iron mills. One of the plans for re-organisation of Dalmeny Estate did show the old layout below. However this plan was not in fact used. Lands not in the immediate environs of the seat are less likely to be mapped. Thus the coverage by estate plans is less comprehensive but probably more accurate than that of Roy's maps. Because the coverage by estate plans is not comprehensive it would not be possible to study a random sample of sites in a District. However a certain amount of information could be obtained for single estates.

At the time the first Ordnance Survey maps were made, field surveyors kept field notebooks with a record of the size and use to which each parcel of land was put. However this method of recording was subsequently dropped for reasons of economy (Balchin and Coleman 1979).

From 1866 onwards there is a certain amount of information about land use to be derived from Agricultural Statistics based on the 4th of June Agricultural returns but these naturally give less emphasis to wildlife habitats than to agricultural crop types, fallow grass, and rough grazing. Computer maps of these statistics can be consulted in Edinburgh University, Geography Department. Much of this information is summarised in the regional accounts brought out by Dudley Stamp after the First Land Utilisation Survey e.g. Scola (1944).

Evidence before late mediaeval times is more piecemeal. Large scale maps are non-existent and one would have to glean information from historical documents.

One possible source of information is old place names. The first settled areas would often be named after natural features and other natural phenomena. This may give a clue to former habitats in areas now cultivated. Names incorporating wood elements where natural woodland is now non existent have been cited in the extracts from Statistical Accounts. Muir elements are also common. Other natural phenomena may be incorporated into place names, for example Gladsmuir; glade is an old Scots name for the kites which are said to have frequented the moor before it was reclaimed. Likewise Cranston in Midlothian was described by the minister of that parish as meaning 'Cranes farm', an interpretation supported by Nicolaison (1976), the main authority on Scottish place names, though it is possible the reference is to herons.

Unfortunately many of the names have been subtly corrupted over the years and anglicised. The names marked on the Ordnance Survey maps were the surveyors transcriptions of local speech. In many places the names have their roots in languages now obsolete in this country, including two main forms of the celtic tongue (p-celtic the forerunner of Welsh spoken by the Picts and the Britons) and (q-celtic the forerunner of Gaelic), Old Norse and old Scots (an Anglian language) - languages unknown to most people. Nicolaison stresses the need to find the earliest form of a name to exclude possibilities of later corruption. Such sources are probably best known to historians. A dictionary of Scottish place-names is in preparation. Meanwhile Nicolaison's 'Scottish Place Names' (1976) explores the problems. Examples from this book include Hawick, a 12th century old English name meaning hedged farm; Glasgow, a green hollow; Linlithgow, lake in a moist hollow and Berwick, barley farm, which is thought to refer to a grange on an outlying part of an estate.

Finally evidence may be found on the ground often aided by air photographs. The most obvious example is the old 'rig and furr' but less obvious are dark patches in fields which may represent former areas of wetland. At ground level there are enumerable archaeological remains which throw light on the effects of the early settlers. Although most of today's landscape is largely a product of 18th and 19th century improvement, evidence of more extensive natural habitats before this time is definitely available.

CHAPTER 7 CONCLUSIONS TO SECTION 2

7.1 SUMMARY OF CONCLUSIONS OF CHAPTER 5 (VEGETATION AND LAND USE HISTORY)

1. The vegetation of lowland Scotland has been in a continual state of change since the last Ice Age.

2. There are two main kinds of changes: natural changes induced by, for example, edaphic or climatic factors; and changes induced by man.

3. Two factors are of particular importance when considering these changes; their scale and their rate.

4. After the last ice-sheet retreated some 10,000 years ago the landscape gradually changed from being bare and loosely colonised by species similar to today's pioneer species, through a succession of open habitats, shrubland, and finally woodland.

5. Deciduous woodland had replaced the earlier pine forest by about 5000 BC. The other main habitat type in lowland Scotland would be wetland, in the low-lying areas, perhaps supporting open woodland.

6. In the prehistoric period and the Dark Ages, the Scottish lowlands were slowly altered from being at least 50% forested to more open. Though man was the main agent of change, the climate continued to fluctuate throughout the prehistoric period. It is impossible to say to what extent the creation of new habitats was due to climatic change or anthropogenic factors. It seems certain that had man not intervened, the country would still be largely forested.

7. Three of man's activities were cited as paramount in shaping the new landscape: clearance of forest, pastoralism, and arable agriculture, often in that order chronologically. The change from shifting cultivation to more settled agriculture was also significant.

8. At the start of the mediaeval period, much land was under the plough, with extensive areas of grazings and unreclaimed land. Most of the primary woodland had been cleared.

9. Change continued to be slow and piecemeal throughout the Middle Ages.

Only on the monastic lands were new techniques employed. The reasons for the prevalence of more primitive methods elsewhere were continuing war and climatic deterioration. In response to an increasing population, lands were cultivated higher and higher up the hill (where soils were lighter and better drained) owing to the lack of reclamation expertise.

10. Most of the habitats considered in this project were present by the late Middle Ages: Deciduous woodland (in areas unsuitable for agricultural use); felled areas; rough unreclaimed areas above the head-dyke and as islands in the arable areas (scrub,dwarf shrub heath, unimproved grassland and wetland); outfield grassland and flood meadows); agricultural land (infield); and non-agricultural land (roads and settlement).

11. Famine, poverty and disorder - the result of climatic extremes, poor farming methods, the demise of the Roman Catholic chirch, war and an increasing population, precipitated the Union of Parliaments in 1707.

12. Easier relations with England were finalised after the 1745 rebellion. The more settled conditions helped to foster a great improvement in farming techniques.

13. In previous centuries change had been described as slow and evolutionary. Change in the Improvements era has been described as accelerated and revolutionary. However the alterations would occur more slowly away from the 'hearth' areas.

14. There were two kinds of change in this era: technological advances and organisational changes.

15. Organisational changes included: longer leases; the re-organisation of the old open 'infield - outfield' farming system into enclosed fields; and planned settlement - new mansion houses with policies, and the planned villages which replaced the old scattered fermtouns.

16. Technological advances included the introduction of lighter ploughs which could be horsedrawn; and reclamation: drainage and the employment of fertilisers enabled previous 'marginal lands' to be cultivated.

17. There were both gains and losses to wildlife habitats as a result of the Improvements. The overall diversity of habitat types was increased with the addition of mixed and coniferous plantings (in shelterbelts and policies), and hedges and tree-lines - dividing the fields. The losses were the many areas of lowland roughland: heathland; old grassland; and wetland reclaimed to agriculture.

18. These trends were furthered by improved communications but this also facilitated the movement of people away from the countryside to the towns and even abroad.

19. Changes continued throughout the 19th century and early 20th century but seemed to be at a slower rate and more piecemeal than in the period 1750 - 1850. The largest changes were internal: 'up corn, down horn' in response to changing socio-economic conditions. Thus the framework of landscape features laid down in the Improvements era - the 'traditional landscape' survived virtually unaltered until the 1950's.

20. The repeal of the Corn Laws and availability of cheap foreign grain imports have been cited as the factors leading to the decline of arable agricultural in the late 19th century and early 20th centuries.

21. Extra government stimulus was necessary in the two World Wars to encourage farmers to plough up the areas allowed to revert to grassland in the agricultural 'depression' and turn these lands again to raising crops.

22. The Industrial revolution followed the Agrarian revolution. Employment was available, for those who had been dispossessed of their lands in the Improvements era, in the planned villages. New urban centres began to grow particularly where there was mineral wealth.

23. In the late mediaeval period the population had been almost entirely rural. Today the population is almost entirely urban.

24. The most important factors in shaping the landscape since the shift from a subsistence economy to a capitalistic one have been: agricultural intensification; reclamation of semi-natural 'marginal' areas; afforestation; and urbanisation and attendant industrialisation.

25. The last 30 years are thought to have been another period of accelerated change. However some of the power to influence landscape appearance is thought to have shifted from landowners and industrialists to planners.

Farmers and foresters are exempted from planning control as part of a package of government incentives to maintain viability of these land uses. However the results of the NCC Air Photo Analysis of Change Project indicate that it is non-agricultural land uses which have increased most markedly in the post-war period.

26. 'Environmental awareness' has increased in the post-war era, emanating from urban cultural centres. Nature conservation is now recognised as a land use. However whether this movement will have sufficient force to alleviate the effects of agriculture, forestry and urbanisation on wildlife habitats is uncertain.

7.2 SUMMARY OF CONCLUSIONS TO CHAPTER 6 (CONTEMPORARY EVIDENCE OF PAST CHANGE)

1. A study of maps and illustrations executed in the late Middle Ages bore out accounts of landscape appearance in the literature: an open treeless countryside with scattered settlements and few elements of structural diversity save the land forms themselves.

2. Roy's map of 1760 showed the first evidence of enclosure but one-third of the lowland area was still uncultivated. Of the cultivated areas well over half the area still consisted of large open fields.

3. Between 1760 and 1853, the area of roughland (scrub, wetland, permanent grassland and heathland) declined dramatically. This again bears out the literature, though the extent of the loss - 84% was unexpected. The other major increase was in the area of cropland - from just over one-third of the total study area to nearly two-thirds. Improved grassland declined but by less than in the later period 1932 to 1947, and woodland doubled in area (from 5%).

4. Between 1853 and 1970 the total area of woodland increased but much of this increase is due to the recent planting of exotics - the area of coniferous woodland increased by four times over

the period. The area of mixed and deciduous woodlands declined by one-third. The greatest decline of deciduous woodland has occurred since the last war but the largest drop in mixed woodland occurred between 1932 and 1949, presumably due to war time felling.

5. The greatest decline in the period 1853 - 1970 (in terms of percentage of former area) occurred to roughlands: scrub, dwarf shrub heath and permanent grassland which together declined by just under one half, and to improved grassland which decreased by 87%. Heathland and grassland declined most markedly in the period 1932 - 1949 and the decline has since continued so that dwarf shrub heath is now virtually extinct. The greatest decline of any period was the 76% decrease in the area of improved grassland between 1932 and 1947. This bears out the accounts in the literature of pastureland being turned to crop production in the Second World War.

6. Agricultural land increased from 60% to 75% over the period 1853 - 1970, much of this occurring in the period 1932 - 1949.

7. Non-agricultural land increased by nearly two-thirds between 1932 and 1949 but the recent increases are less than in many other Local Authority Districts.

8. The post-war changes measured in the 'Air photo analysis of change project' were not the greatest and most rapid since records began. The period from 1932 to 1949 experienced changes of an equal if not greater scale and rate. However it would be fair to say that changes over the last 50 years were greater and faster than in any other period since 1853. This recognises that these trends began in the last war.

9. Overall the findings suggest that the rate and scale of change over 1760 - 1853 was greater than the last 50 years for two types: woodland gain and roughland loss; about the same as that for cropland gain and less than that for two types: improved grassland loss and non-agricultural gain. The bulk of the cropland gain and improved grassland loss had occurred by 1947. In summary changes in the Improvement era were greater than the post-war changes and at least equal to changes in the last 50 years.

10. The interchange results for the periods 1760 -1853, 1853 - 1893, 1893 - 1932, 1932 - 1949 show a similar 'shuffling' effect to the NCC c1949 -

c1970 results i.e. change is rarely undirectional.

11. Though gains and losses are often compensatory, there are definitely periods when the total interchange is of a greater scale than at others. Of the periods for which a quantitative assessment was possible (those after 1853) the greatest interchange was found to occur in the period 1932 to 1949 when 20% of the total area was involved in change. As this is the shortest period there must also have been the greatest rate of change. However half of this change is due to the conversion of improved grassland to arable land. The post-war period was the second most changeable with about 7% of the total area altered whereas changes were smaller in the period between 1853 and 1932.

12. The net changes in results for the period 1760 - 1853 have shown it to be one of the most changeable periods but it was impossible to measure the individual changes. The ministers reports in the Old Statistical Account bear out that this was a period of great activity. The new farm methods were extolled, the planting of trees welcomed in the light of earlier forest removal and the start of a drift to the towns noted. These accounts illustrate the extent to which the landowner could fashion the land to his own ends.

13. The largest individual interchange in all periods involved improved grassland suggesting it may be an intermediate category.

14. On the maps produced from 1853 onwards it was easy to trace the course of change because it occurred within existing boundaries. However it was less easy to match up Roy's 1760 map with the OS 1853 map. Though this was partly due to inaccuracies in the earlier maps, the main reason was that there were no common boundaries - changes had been so sweeping in the intervening period. This bears out one of the conclusions of Chapter 5 - changes since the Improvements era have largely occurred within the framework then laid down, whereas changes between 1760 and 1853 were more radical.

15. A small comparison was made between the size of fields in East Lothian at the turn of the century and in the late 1960's. This showed that field size had increased on average by one-eight over

the 70 year period, which is less than the degree of enlargment in some English counties over the last 30 years. The evidence suggests that Scottish fields were initially laid out larger than their English counterparts and so there has been less need for field rationalisation. The average field size in one of the most extensively arable areas of Scotland was larger in the 1960's than that for the seven English counties in 1949 (including Huntingdonshire).

16. The findings of Chapter 6 support the accounts from the literature in Chapter 5.

7.3 CONCLUSIONS TO SECTION 2

The landscape of Scotland has been through many changes since the last Ice Age. By the start of the mediaeval period most of the 'climax' forest had been removed leaving a largely open, landscape. In 1760, when some replanting had already occurred, only 5% of the lowlands of East Lothian were forested whereas initially forest is thought to have covered over 50% of the lowland area. This represents a decline of over 90% in woodland area.

It is thought that the rate of these changes - slow - and the scale - piecemeal - gave wildlife time to adapt. The species colonising the new open habitats would be the ones prevalent immediately after the retreat of the ice sheet; they had been 'waiting in the wings' since deciduous woodland became dominant. These early changes have been described as 'evolutionary'.

Most wildlife would be concentrated in the areas which could not be turned to arable use. The largest such areas would be the roughlands: scrub; grassland; wetland; and heathland, which were maintained by graziers. An equilibrium must have prevailed for hundreds of years with considerable benefit to wildlife. The ecological value of these roughland habitats will be considered more fully in Section 3. Meanwhile it is important to remember that without grazing such areas would have reverted to woodland i.e. roughlands are 'semi-natural'. The only 'natural' habitats would be found in the areas which were of limited use for agriculture or grazing, e.g. woodland remained in some steep sided valleys. A small amount of replanting took place in the late Middle Ages in the 'parks' round the main seats.

Though the change has been continual throughout, there are times when the pace quickened; described as 'revolutionary'. The most notable of these periods were the Improvements era and the last 50 years. In the former period, change appears to have been radical. The open, treeless landscape was replaced by a more diverse, structural landscape often mistakenly referred to as the 'traditional' countryside.

The main changes of the Improvements era were the reclamation of large areas of previously 'leap frogged' roughlands and the consolidation of arable lands. There were habitat gains in the hedgerows which bounded the enclosures, and the establishment of policies in the vicinity of the new mansions. The net effect then was a marked loss in the area of the old 'semi-natural' habitats but an increase in the diversity of habitat types.

Since the Agrarian and Industrial revolutions, the most important trends have been the intensification of arable agriculture, the reclamation of roughlands, afforestation and urbanisation and attendant industrialisation. After the Improvements era, such changes continued but at a slower rate. The recent changes seem to be a logical progression of these trends, the wheels of the new revolution set in motion by the Second World War.

The picture is not completely one-sided: in all periods studied since 1760, there have been gains in area as well as losses to wildlife habitats. Whether these gained areas will be as valuable to wildlife as losses of more 'mature' areas will be considered in Section 3.

The main conclusion to this section is that the post-war habitat changes detected in the NCC project are not of a greater rate and scale than in earlier eras. The findings for East Lothian and the NCC publication 'Nature Conservation and Agriculture' taken together suggest that the rate of scale of changes between 1941 and 1949 were the most rapid since 1853. Thus the recent period may be divided into two:

1) A period of intense activity in the Second World War and just after, following a period of depression since the First World War.
2) The period since 1950 when large scale changes continued but at a slower rate.

If this whole 35 - 50 year period is compared with the Improvements era; the changes of the Improvements era seem to have been on an equally large if not larger scale. The loss of roughlands in the Agrarian Revolution appears very serious. There were gains in the area of woodland, but whether the woodland species surviving in the small relics of primary woodland were able to colonise them is another question. Such questions will be considered more fully in Section 3. Moreover the effect on the landscape of the recent changes has been less radical; the enclosure landscape is still recognisable whereas the old mediaeval landscape was obliterated in the Improvements era.

Figure 22: Midlothian plain 1980. The Rev John Henderson of Tranent writing from the same position in 1845, in the New Statistical Account, stated 'The view ....from this spot with the rich and varied fields of Midlothian, is perhaps one of the finest that can be found in the vicinity'. Today the fields are less varied but are interspersed with plantations and settlements. (From Falside Castle near Tranent, East Lothian).

SECTION 3

The object of this section is to make an appraisal of the ecological implications of the habitat changes detected in the NCC 'Air Photo Analysis of Change Project'. Chapter 8 considers the 'ecological values' of the main habitat types in the NCC survey. In Chapter 9 the ecological values of the habitats involved in the main changes, summarised in Section 1 are compared, and conclusions drawn as to the effects of these changes for wildlife.

Background

There is no shortage of opinion in the literature about the implications of the sorts of wildlife habitat changes detected in the NCC project. However there is little real evidence of the effects of such changes - very few scientific appraisals have been made of this subject. The reason is not hard to see - the early habitat is gone and so it is impossible to evaluate how important it was for wildlife. Even if relics of the original area remain, their smaller size compared with the original may render them intrinsically less valuable, e.g. their site area may be too small to contain a viable population of certain birds and mammals. Moreover such relics will be more susceptible to the effects of management practices in surrounding areas (e.g. drainage and spray drift) because of their high boundary to area ratio and so changed that it is impossible to say whether their value today is the same as it was 30 years ago. In any case such relic sites are not common.

Most of the literature on habitat change refers to England but as it has already been shown, Scotland is different both historically and in the nature of the changes which have been occurring recently. Most of the literature refers to losses due to agriculture while in Scotland's lowlands it seems to be a less important force than those of urbanisation and conifer afforestation. Changes which may represent a gain in value (e.g. scrub to deciduous woodland) were also detected in Scotland.

The approach chosen, therefore, was to study the 'ecological value' of the habitat types as they are today and then to judge the ecological effects of the changes using these values. Again changing management practices may invalidate some of these comparisons e.g. application of nitrogenous fertilisers increased threefold in England and Wales between 1960 and 1975 (Green 1981). However the main purpose of this section is to assess the consequences of change in the extent of the particular habitats.

CHAPTER 8 ECOLOGICAL EVALUATION OF HABITAT TYPES

This chapter has been divided into three sections:

1) The approach to the problem of ascertaining 'ecological values'.
2) The methods employed.
3) The results.

8.1 THE APPROACH

The terms 'ecological value', 'nature conservation value' and 'wildlife value' have been used rather loosely up till now. Stricter definitions will now be used.

'Ecological value' is taken as the assessment of ecosystem attributes _per se_. 'Wildlife value' should be value for wildlife generally. These are taken here as distinct from 'nature conservation value' which could be defined as the assessment of the functions of the natural environment for human society; necessarily rather a subjective process. If 'nature conservation value' were considered there would be additional problems in reconciling different human interests. For example, Brotherton (1978) discussed the attitude of different scientists towards grassland: the botanist prefers a well grazed sward which supports a wider range of wild flowers and fewer of the more competitive species; the entomologist prefers the coarser grasses and herbs to remain, because a greater range of structural diversity encourages a greater range of invertebrates; the ornithologist would prefer that areas of scrub were present so that more birds would survive. To avoid such problems 'ecological value' as defined above was studied.

The scale of integrated ecological values established is related to succession. The highest ecological value is here awarded to the 'mature' ecosystem or climax i.e. the system with the greatest degree of complexity and homeostasis. The lowest ecological value would be attached to the young or simple ecosystem where emphasis is on growth and change.

Odum (1969) has summarised the differences between the two extreme types of ecosystem as follows:

Young Ecosystem	Mature Ecosystem
Production	Protection
Growth	Stability
Quantity	Quality

It must be recognised from the outset that it is very unlikely that climax ecosystems will occur in lowland Scotland. Where man's influence is profound as in the lowland agricultural area it is more likely that the younger types of ecosystem will be found. Indeed man often maintains early successional types of ecosystem in order to maximise production of timber or agricultural crops (Odum 1969).

There are many ecosystem attributes, both biological and physical, which could be assessed in order to indicate the degree of ecosystem maturity e.g. soil fertility, diversity, productivity, biomass and survival strategies. An in-depth appraisal of one ecosystem could become a complete project in itself; it was necessary to adopt a more selective approach, considering first which ecosystem attributes would be relevant in lowland Scotland and then choosing those which could be assessed with the time and resources available.

Many attempts have been made to establish criteria for the assessment of ecological value. (e.g. Helliwell 1978, Peterken 1967, Gehbach 1975, and Goldsmith 1975). They are mostly anthropocentric in conception. Helliwell's 'Indicator Species' analysis (Helliwell 1978) seems valuable and efficient but was devised to integrate the value of farmland as a whole. The criteria defined by Ratcliffe (1977) to assess sites for inclusion in 'A Nature Conservation Review' seemed to be the best starting point, being concerned with specific habitats. Moreover the approach is not wholly subjective, for certain ecosystem attributes are included which could be scientifically assessed.

Ratcliffe's ten attributes were: size; diversity; naturalness; rarity; fragility; typicalness; recorded history; position in the ecological/ geological spectrum; potential value and intrinsic appeal. However these criteria were designed to select the best sites to conserve. A different set of attributes was chosen for the assessment of the more 'typical' habitats encountered in lowland agricultural Scotland.

These were: i)environmental limitations; ii) size; iii) diversity; iv) naturalness; v) habitat specificity; vi) viability; vii) potential value. Each of these will be discussed in turn, though all are related.

The discussion is based on Ratcliffe (1977) and Odum (1969).

i) Environmental Limitations

The natural vegetation of a site is partly determined by non-biological factors. These include; soil characters e.g. pH; availability of nutrients and of water; slope; aspect; and climatological factors e.g. rainfall; windiness and temperature. Within a vegetation type other wildlife will be influenced by the dominant species. For example, within a forest, tree litter can affect the soil pH and hence nutrients available; the denseness of the canopy will determine the light regime, and there is an overall microclimate effect by which climatic extremes are reduced and moisture regime improved. However in the lowland agricultural area, the actual vegetation type is largely determined by man and these other environmental factors are more likely to influence the species which can adapt to the conditions created.

ii) Size

It is generally argued that larger sites are more likely to encompass a wider range of species and genetic variations (e.g. Diamond 1976, Margules, Higgs and Rafe 1982). Smaller areas are thought to be less capable of sustaining viable populations and more subject to the influence of surrounding land use. However, for economic reasons large areas of semi-natural habitat have been attractive reclamation subjects. Indeed in the lowland agricultural area relics of semi-natural vegetation are usually confined to rather small areas.

The size of life-forms present is often relevant. Larger plants i.e. trees and larger animals have longer, more complex life cycles. These are described as being 'K selected', where 'K' is the carrying capacity of the ecosystem in contrast with 'r selected' species which have a greater intrinsic rate of production. The former have fewer offspring which take longer to mature, whilst the latter produce many offspring which mature faster. The 'r selected' species are seen as opportunists more able to exploit the conditions in simple ecosystems. It is recognised that not all 'K selected' species are large and 'r selected' species small; it is possible for these strategies to be adopted within different strains of the same species e.g. insects (Wellington 1957 and Baltensweiler 1964). However the presence of large life forms, with a lower growth rate is indicative of a greater degree of ecosystem maturity. This holds so long as they have arisen naturally and may not apply when trees have been planted.

iii) Diversity

Two sorts of diversity are considered: species richness and structural diversity. Diversity has often been taken out of context as an indicator of ecosystem stability and hence value. However, as yet, no 'cause and effect' relationship has been determined. Whilst species richness certainly increases in the early stages of the succession, it is not always maximum at the climax e.g. Johnston and Odum (1959) found in a study of bird populations along a successional gradient that the number of species increased during the early stages of old field succession, then declined during the early forest stages and then increased again in the mature forest. Margalef (1963) postulates that species diversity will peak during the early or middle stages of succession and then decline in the climax. Another indicator is structural diversity; both spatial heterogenity and stratification. These reflect both environmental variation and the stage of the succession, Species diversity will increase only as long as there are vacant niches i.e. so long as increasing biomass and stratification exceed counter effects such as competitive exclusion. Diversity of course, is related to both i) environmental limitations and ii) size.

iv) Naturalness

Again two facets of this attribute are considered: presence of native species and degree of perturbation by man. Sites composed of native species which have arisen spontaneously and are not subject to man's influence are rare in the countryside as a whole and not just in the lowland agricultural area. Sites are at best 'semi-natural'.

These include:

a) Assemblages of (indigenous) species which arose naturally but are subject to some sort of management e.g. coppiced woodland and unimproved grassland.
b) Assemblages of (indigenous) species which arose naturally on sites put for a time to alternative use and then abandoned e.g. scrub woodland growing on wasteland.
c) Assemblages of (indigenous) species of which the dominants were planted but which may in time resemble a naturally developed site.

If the word indigenous is included in these definitions then such sites are still unlikely to be encountered in lowland Scotland. There seems to have been an almost puritanical emphasis on native species amongst 'nature conservationists'. Presence of native species is more relevant when selecting sites to collectively conserve a representative range of the British flora and fauna. It is understandable where a native species is likely to be out-competed by an introduced species over certain parts of its range e.g. the grey squirrel (Sciurus carolensis) over the red squirrel (Sciurus vulgaris). The grey squirrel was introduced a century ago into the central belt of Scotland and is now spreading to the Borders and Deeside. Circumstantial evidence suggests that the range of the red squirrel has been contracting since the 1940's (McCarthy 1979). He further suggests that the grey squirrel may be beginning to move into the coniferous areas to which, until now, the red squirrels have seemed better adapted. Pepper Wood in West Lothian supports a collection of rare species but these are annually threatened by the alien winter butterbur Petasites alba (Carlyle 1982). (However most of the rare species were also introduced to this wood.) Other examples are less conclusive.

There are examples of alien species being actively encouraged e.g. beech is not native to Scotland but it is commonly planted in Scottish policy woodlands. In fact 700 or more of 2300 British plant species and 19 out of 40 terrestrial mammals have been introduced by man (Green 1981).

Another objection to alien species is that fewer flora and fauna are able to adapt to them. Research indicates that on the whole native trees have more insect species associated with them than aliens e.g. oak has 284, willow (Salix spp) has 266 and birch 229 while sycamore has only 15, sweet chestnut (Castanea sativa) has five and horse chestnut (Aesculus hippocastanum) has four (BCTV 1980 after Southwood (1961) and Dennis (1972)). However further examination of these findings reveals some interesting facts e.g. larch has 20 insect species associated with it which is more than holly Ilex aquifolium which has 15. Holly may be less palatable to insects than softer leaved species. Thus the presence of a native species does not necessarily indicate a greater value for other flora and fauna than that of an introduced species. In time, some of the alien species may become just as valuable. Rose and Harding (1978) show the number of epiphytic lichens recorded from trees and shrubs in Britain. Again oak is the richest with 324 taxa associated with it, followed by ash, beech, and elm Ulmus spp with sycamore, surprisingly, the fifth most important tree in the list with 183 taxa.

In Section 2 it was noted that the arrival of British flora after the Ice Age was prematurely curtailed when the land-link with Europe was cut. Hence there were a large number of vacant niches. Many of the species which have arrived since than may well have arrived if the land-bridge had not been severed. It seems therefore that the most important factors are not nativeness per se but the time the species has been present and its suitability for use by other flora and fauna (e.g. whether plant parts are palatable).

Thus under naturalness, more weight is here placed on vegetation which has arisen spontaneously and free from man's influence, rather than the presence of native species. It is recognised that certain of the latter can serve as indicators of the stage in the succession e.g. the presence of oak rather than birch indicates greater ecosystem maturity (so long as they have not been planted). Finally, plantations will aquire wildlife value but are unlikely to attain the complexity associated with a natural wood. Mabey (1980) considers that the Forestry Commission in their objectives, regard woods as 'a kind of building inside which creatures live, rather than a community with a life of its own, greater than the sum of the living parts'.

v) Habitat Specificity

This criterion is used here in place of Ratcliffe's criterion of rarity because it was felt that rare species were very unlikely to be encountered in the lowland area. Species more commonly found in one habitat type e.g. woodland or wetland, will be valued more highly than generalists.

This follows on from the concept of niche specialisation. In the early stages of succession, 'r selected' species with broad niches predominate. Later on in the succession, as more species arrive and competition for resources increases, specialists which can exploit a narrow range of conditions are more likely to survive. Then niches are narrower, competition is avoided and growth rates are slower (K selected species).

The presence of 'typical' woodland species therefore indicate a maturer ecosystem rather than one with many opportunitists. One reason why rarities are unlikely in the lowland habitats is that they often have the narrowest niches of all i.e. the most specialised requirements for growth and reproduction. This would make them vulnerable to any change or disturbance both of which are common in the lowlands. For instance, Moss (1900) concluded that the influence of drainage had been paramount in causing the decline of species in the Halifax area - 'the longest list of extinctions in the District is that of the hygrophilous and hydrophilous species'. Many commentators at that period saw the activities of the plant collector as a threat to rare species, an influence which had extended with the advent of the railways (Sheail 1982).

Of course if a rare species is present this is a bonus; it indicates stable conditions. Here the presence of habitat type species is used to indicate degree of stability.

The commoness or rareness of a species nationally can be determined from an Atlas of British Flora (e.g. Fitter 1978).

vi) Viability

The viability of a habitat depends largely on man's activities. It is the likelihood of the habitats itself surviving in the light of management practices on or around the area. These management practises range from the likelihood of conversion to another type, through rotational practices such as felling, to the effects of adjoining land changes e.g. drainage of a nearby wetland.

vii) Potential Value

This recognises that most of the habitats in the lowland area are seral stages and refers to the degree to which natural succession is likely to proceed. The proximity of appropriate seed sources and animal populations is critical. Related habitat types may serve each other to this end, e.g. hedgerows and woodlands. It also relates to past land use, present land use (i.e. degree of management), environmental limitations and time.

In conclusion, in the lowlands man's influences and time are the most important determinants of the degree to which natural succession has occurred.

Plagio-climax

It is recognised that with certain low-input types of management, semi-natural habitats can evolve e.g. grasslands. A fairly regular low key perturbation over a long time span can lead to a 'plagio-climax'. Such 'pulse stability' occurs naturally e.g. 'fire climaxes'. These areas can build up a degree of complexity, and if the management does not affect all areas simultaneously then re-colonisation is possible. Under different climatic or edaphic conditions such types may well be the true climax e.g. Section 2 records how a fairly open vegetation was prevalent in this country before conditions were warm enough for trees. Moreover, grasslands and heathlands are still found above the tree-line and in exposed areas. However, in the lowland area, if management were removed, all habitat types would develop into scrub and then woodland.

8.2 METHODS

It must be stated at the outset that because of time limitations and the vagaries of the Scottish weather, it was not possible to complete the ecological survey.

It is hoped that the survey will be continued and completed at a later date. In this Section, owing to the incompleteness of the survey findings, they are referred to under the above headings rather than in tabular summary. The whole survey method has been reproduced here, because it was felt it might be a useful approach for future studies.

Three main sources of information have been referred to in this account:

1) The randomly selected set of aerial photographs from Lothian
2) Site visits in Lothian
3) The literature

Table 37 shows the main source of information used to rate the seven attributes discussed in Section 8.1 and assess overall ecological value. Supplementary sources have been named in brackets.

Methods used to assess each of the constituent items will be described under the source headings. Lothian Region was chosen as the survey area because of its accessability from Edinburgh. Time limitations allowed only the habitat types involved in the five main habitat changes in Table 26 to be considered initially. These were:

Non-agricultural Land
Agricultural Land
Coniferous Woodland
Improved grassland
Deciduous Woodland
(Felled areas)

TABLE 37: Sources of Information used in Ecological Survey

Ecosystem Attribute	Items	Sources of Information
Environmental Limitations	Location, slope	Air photographs
	Light, water, fertility and pH	Site visits Floras
Size	Areal extent	Air photographs
	Presence of larger life forms	Site visits
Diversity	Structural diversity (number of strata and spatial heterogeneity))))	Site visits
	Species richness)))	Site visits
Naturalness	Native species	Site visits
	Site naturalness (degree of man's influence)	Site visits (Literature)
Habitat specificity	'Habitat type' species))	Site visits Floras and Distribution Atlases
	Commoness/rareness)	
Viability	Surrounding land use	Air photographs
	Management	Site visits (Literature)
Potential Value	Surrounding land use	Air photographs
	Past land use	(Site visits and Literature)

Felled areas were deleted from this list because they are known to be an ephemeral category; unlikely to build any degree of ecosystem complexity before they are replaced with another land use. Scrub and hedgerows were added to the list. Scrub was thought to be of interest because it arises spontaneously. Moreover in Table 26 scrub was involved in the first change which appeared to represent a gain in value (scrub to deciduous woodland) and this was judged to be worthy of further study. The decline in the length of hedgerows of 23% was considered to merit the status of a major change. Furthermore the national decline in hedgerows has attracted much publicity but few studies have been made of their ecological value in Scotland.

8.2.1 Use of Air Photographs

Further information about habitat characteristics can be gained from the air photographs themselves. It was decided to select randomly and study, 20 sites for each habitat type. The 51 Lothian photographs were renumbered and a 10" x 10" square grid constructed to fit over a frame. Then using pairs of random numbers (the first to select the photograph and the second to select the position on the photograph) the sites were selected. With less common types it was necessary to use several pairs of random numbers until a 'hit' was made on the required site type. With the rarest habitat types, the individual sites were renumbered and one set of random numbers used to select the sites to study.

Where possible the habitat types were divided into sub-types using the air photographs e.g. age of woodland or types of non-agricultural land. This was done in order to gain an indication of the proportions of these sub-types within a habitat type for it was thought they were likely to have different ecological values. The photographs were perused and the following items noted for each of the 20 habitat types: aerial extent; sub-type; location; surrounding land uses; and past land use (if it had changed from the late'40's). The area was measured using the dot grid method employed in the NCC study.

8.2.2 Fieldwork

The main part of the fieldwork consisted of a floristic survey at each site, but the following general observations were also recorded:

- i) apparent management impact
- ii) structure complexity
  - a) number of vegetation strata
  - b) degree of spatial hetrogeneity (presence of clearings, paths etc)

The main objective of the fieldwork was to assess the richness of the flora. This was to be used as an index of species richness of all wildlife. It was considered that a simple species list would be misleading without information on the frequency with which species were encountered (e.g. in a wood there could be 100 species but only ten commonly found). Initially it was hoped to visit enough of the 20 sites of each habitat type to obtain statistically significant measures of the differences between types. Therefore the methods adopted in the assessment of the species frequency were designed to enable scientific comparisons to be made. In the event, limits were imposed by time and weather and only between two and four sites of each habitat type were visited, It is recognised that for the purpose of this report a less scientific appraisal of frequency would have sufficed.

The method employed to assess species frequency had to be rapid and simple and applicable to a range of diverse habitat types. It was decided to sample the vegetation with quadrats in order to assess the frequency of the main species at the site. These quadrats should be located at random to remove possibilities of bias. The species assessment proceeded in the following stages:

1) Thorough perambulation of the site identifying all the ground flora.
2) Random sampling of the site. Using the air photographs an outline of the site was sketched and a suitable starting point determined. Two axes were superimposed from the starting point at right angles to each other. These axes were then

paced out in the field to determine their length, using a compass to ensure 90° separation between them. Pairs of random co-ordinates were used to select the sampling sites and they were located by pacing, again with a compass.

3) A 1m x 1m quadrat was used to sample the vegetation at each randomly selected location. All the vascular plants, and for certain sites mosses and liverworts, within each quadrat were determined.
4) At least ten quadrats were taken for each site. Sampling continued until two-thirds of the species found in the initial perambulation had been encountered.
5) In the case of woods or scrub, an assessment was made of the tree species present and their frequency by identifying the ten trees closest to each quadrat.

Certain modifications were made to the method depending on the dimensions of the site. If the length of one axis exceeded more than 100 paces then each block of 100 paces was sampled separately with the same number of quadrats taken in each. If the final block length was less than a 100 paces then a proportion of quadrats was taken from it relative to that from the 100 pace blocks. Some of the sites were more linear in nature than others e.g. hedges and verges and often in those cases only unidirectional pacing was necessary. Again the same number of sample quadrats were taken from each length of 100 paces.

Using the method it was possible to sample one or two sites per day.

There were some problems encountered during the fieldwork. On occasion one arrived at the site to find it had been converted to another land use or had been wrongly classified. Such instances will be referred to under the relevant habitat types. The main problem was that of seasonal variation in the numbers of species encountered at different stages over the summer. Fieldwork proceded from May to September - at the earlier time some species were not yet evident and at the later date, some species had already disappeared. With a larger number of sites these effects would tend to balance out so long as all sites for one habitat type were not visited in the same month, but spread through the summer. However because of the small number of sites, bias was possible. In further work a separate study could be made to determine the effects of seasonal variation on species diversity and frequency.

8.2.3 Literature

a) Analysis of field work

The species encountered were listed and the 'commonest' flowering plants used as indicators of site conditions. The 'commonest' species were defined as those found in more than 10% of the quadrats taken.

For the analysis of site conditions, 'The Atlas of the Wild Flowers of Britain and Northern Europe' was used (Fitter 1978). This shows the tolerance ranges of the following environmental factors for each flowering plant: water regime; pH; fertility; shade. This Atlas also shows the national distribution range of each plant from which an assessment of its national frequency can be determined.

The Excursion Flora of the British Isles (Clapham, Tutin and Warburg (CTW) 1968) yielded information on habitat specificity - the range of habitats in which the species is encountered, and whether the species is introduced or native.

Hubbard (1968) and CTW (1968) yielded information on the environmental tolerance of grasses. However it was less comprehensive than that for wild flowers. The grasses were used to supplement indications of environmental conditions shown by flowering plants.

b) Apart from the more specific appraisals noted in (a), the literature was used to supplement the information obtained in the field assessment. Most of the information obtained was general information on ecological value of a habitat type and most relevant in the rating of potential value.

8.3 RESULTS

Table 38 is a summary of the information obtained from the aerial photographs for each habitat type: number of sites (excluding misclassifications and changed areas); mean area of site (hectares); sub-types (where relevant); 'early' land use (if different); other site characters (e.g. location); frequency with which similar habitat types adjoin it; commonest adjoining types. To assess the commonest adjoining types the four main habitats round each site were noted. The four commonest of these for all the sites have been presented in decreasing order of fequency of encounter. The seven habitat types will now be examined in turn, their ecosystem attributes discussed, and their ecological values assessed.

8.3.1 Non-agricultural land

General

Non-Agricultural land encompasses a wide range of sub-types: urban and industrial areas; roads and railways and their verges (including disused railways); mineral workings; urban and rural wasteland; parkland and recreational areas. The random selection of 19 sites comprised: 16 roads; two areas of wasteland and one house and grounds. Figures 13, 14, 18, and 22 illustrate roads and their verges and the last two of these also illustrate other non-agricultural uses.

Environmental Limitations

Of the four sites visted, three were roads and one an area of wasteland. The roads were completely sterile but the verges were vegetated. The wasteland was a disused air field. The central area had been reclaimed to agriculture but a large area round the exterior had been left. Part of this, possibly the old runway, was still surfaced and some old shelters remained but otherwise the area had become completely vegetated. This disused air field is depicted on Figure 12. The species present for all four sites indicate that there are no soil limitations. However as regards light, all are plants of more open conditions or slightly shaded conditions as would be found at a woodland edge. A wider range of conditions is indicated for the aerodrome site. In all there are likely to be few environmental limitations apart from the presence of concrete and tarmac. However, at the airfield even those areas are being colonised. Figure 12 shows vegetation growing

TABLE 38: Further information derived from Air Photographs of randomly selected sites in Lothian Region

Habitat Type	Number of sites	Mean Area (hectares)	Sub-type	Other Site Characters	late 1940s land use	Sites with similar type adjoining	Commonest adjoining habitat types
Non-agricultural Land	19	-	16 roads 2 waste 1 house & grounds	-	All the same	16 Non-agricultural 16 Agricultural	Agricultural Non-agricultural Deciduous wood Felled areas
Agricultural Land	20	8.2	All fields	-	All the same	All Agricultural 10 Non-agricultural	Agricultural Non-agricultural Deciduous wood Coniferous wood
Improved Grassland	17	1.6	8 fields 8 valleys 1 waste	-	1 was waste 16 the same	8 I.R.G. 3 P.U.G. 2 D.S.H. 1 Wetland	Agricultural Non-agricultural Improved grass Scrub
Scrub	15	0.4	8 grass 3 wood 4 waste	-	1 was Deciduous 1 was I.R.G. 1 was Mixed 12 the same	2 Scrub 2 Deciduous	I.R.G. Agricultural Non-agricultural Open Water
Deciduous Woodland	18	1.7	1 young 1 inter. 11 mature 5 m.o.	4 valleys 2 fields 6 estate 6 belts	2 were same	3 Decid. or Mixed 5 Coniferous 2 Scrub 8 Any of above	Agricultural Non-agricultural Coniferous wood Open Water
Felled Areas	19	0.9	-	10 ex-belts 10 ex-estate	14 were Decid. 3 were Conif. 2 were Mixed	11 Decid. or Mixed 5 Coniferous	Agricultural Deciduous Non-agricultural Coniferous
Coniferous Woodland	18	1.8	12 young 3 inter. 1 mature 2 m.o.	9 belts 6 estate 2 l.p. 1 field		5 Coniferous 10 Decid. or Mixed 3 Scrub 12 Any of above	Agricultural Non-agricultural Deciduous I.R.G.

Abbreviations

Habitat types: I.R.G. = Improved Rough Grassland, P.U.G. = Permanent Unimproved Grassland, D.S.H. = Dwarf Shrub Heath, Mixed = Mixed Woodland

Sub-types: waste = wasteland, valleys = river valley sites, inter = of inter-immediate age, m.o. = mature and open, wood = woodland scrub, grass = grassland scrub

Other Site characters: valley = river valley site, fields = infield site, estate = part of extensive estate planning, l.p. = large plantation block up the sides of a shelter and stonecrop (Sedum sp) invading the old runway.

Size

No mean size has been calculated for the 19 randomly selected sites. This was becaue the 16 roads were continuous in nature rather than discrete.

The three other sites had a mean area of 4 ha. The section of the airfield studied was 9.5 ha in size.

Diversity of sites visited

a) Structural diversity: The sites were mostly open with a few shrub species.

b) Species richness: Between 30 and 50 plant species (herbs, grasses, shrubs, young trees, ferns and horsetails) were found at each of the sites. The species list is known to be incomplete at the airfield, shrubs in particular were not listed. In addition ten mosses were recorded at one of the road verges.

Naturalness

a) Native species: All the herbs and nearly all the grasses found in the quadrats were native except for the presence of Italian rye-grass Lolium multiflorum at one road verge site and barley Hordeum vulgare at one of the other road verge sites.

Seedlings of sycamore were found at one verge, but the remainder of the young trees and shrubs were native. Outside the quadrats a few more introduced species were encountered. For example, at one road verge site shrubs and seedlings of beech, Symphoricarpos rivularis, privet (Ligustrum vulgare) and Ribes spp were present. At another verge Lolium hybridum and pineapple-weed (Marticaria matricaroides) were found and at the airfield Lunaria annua was present. The majority of the species at all four sites were however native.

b) Site naturalness: Though the airfield was artificially created it seems to have been left undisturbed since the war. The area has been used for recreational purposes, but this seems to have left most of the vegetation unaffected.

Road verges are cut once or twice a summer otherwise they too are relatively undisturbed. It is usually only the area closest to the road which is cut (to prevent obstruction of the driver's view) and an area of taller vegetation remains behind this. At two of the verges eight woody or shrub species were present including willows, wych elm and hawthorn (Crataegus monogyna) suggesting that succession is occurring.

Habitat specificity

Most of the species commonly found at these sites (i.e. present in more than 10% quadrats) occur in a range of habitat types usually verges, grassland, hedgerows and wasteland. Examples are yarrow (Achillea millefolium), present at three of the four sites which CTW (1968) note as being common on pastures, heathland and verges. Other species have an even wider distribution e.g. ragwort (Senecio jacobaea) present at all four sites is noted as being common on dunes, wasteland, verges and overgrazed pastures. Other species common on three of the four sites were hogweed (Heracleum sphondylium), white clover (Trifolium repens), and ribwort(Plantago lanceolata) all of which are generalists. The commonest grasses found were Arrhenatherum elatius, Poa pratensis and Holcus lanatus, all of which are ubiquitous. Some more habitat specific plants were found outside the quadrats e.g. at one verge, harebell (Campanula rotundifolia), a plant of poor, dry grassland. In summary most of the plants are commonly found on a range of disturbed habitat types and though a few more 'grassland' type species are present e.g. yarrow, none could be described as having exacting requirements. All require open conditions.

Viability

The commonest surrounding land uses were agricultural land, non-agricultural land, felled areas and deciduous woodland. The continuous nature of roads may enable linear spread of species. The effect of surrounding land is demonstrated by one of the road verge sites which was adjacent to the rough area of a golf course. There were yarrow, Lady's bedstraw (Galium verum), heath bedstraw (Galium saxatile) and harebell present all of which are common on the grassland. At another verge near a crossroads and adjacent to agricultural land more 'weedy' species were found: nettle (Urtica dioica), goose-grass (Galium aparine), and dandelion (Taraxacum vulgare).

None of the 19 sites had changed in the post-war period, indicating a certain degree of stability.

Potential value

The sites at present have between 30 and 50 species, little management and fairly stable conditions. The species are a mixture of coarse, weedy species with some more typical grassland species, but more exacting species are absent. That scrub species are beginning to colonise shows that complexity is increasing. There seems to be no reason why such sites should not develop more ecological value in time.

The other kinds of non-agricultural land are partly sterile e.g. houses, factories and roads. However many such sites do have areas of rough land round about which may be of some interest. Gardens in particular offer much physical diversity; lawn (open spaces), flower beds and vegetable growing, shrubs and trees (scrub). Owen (1983) has found 1731 species of flora and fauna in a 700 m^2 garden in Leicester over the past 11 years. The list includes 345 species of flowering plants, 21 species of fungi, two amphibians, 50 birds, five mammals, 55 spiders and 1226 species of insect including 330 Lepidoptera and 666 Hymenoptera.

Perhaps it is the areas of wasteland: old railway lines; spoil heaps; and disrupted rural and urban areas such as the airfield mentioned earlier, and the rough areas beside farms where old machines are left, that offer most potential. More interest is being shown in non-agricultural land now, particularly in urbanised areas (e.g. Teagle 1978 and Gilbert 1983).

8.3.2 Agricultural Land

General

Agricultural land is composed of cropland and grass leys but these two sub-types cannot be distinguished from each other on the aerial photographs. From general observations of Lothian Region barley growing was by far the commonest use to which fields were put. Of the four sites visited, three supported arable crops (barley and potatoes) and one was a hay field. In the hay field perennial rye-grass (Lolium perenne), Italian rye-grass and the hybrid between the two, (Lolium hybridum), and Phleum pratense were common with clovers (Trifolium spp).

Although there can be no climatic or edaphic limitations because the fields all support healthy barley crops, the crops exclude almost all other vegetation. It is likely that the fertility of the fields has been increased by the application of fertilisers and that other plants are kept down with herbicides. Nevertheless a few species could be seen in the cropped area notably pineapple-weed, field poppy (Papaver rhoeas) and common fumitory (Fumaria officinalis). Later in the season Arrhenatherum elatius was evident in ripening barley fields. The cropped part of the fields could not be sampled.

The verges of the fields however, supported more vegetation. The species present at all sites confirm the fertility of the soil with some species of very fertile conditions e.g. nettle. The most influential factor appears here to be light - most are species of open conditions.

Size

The mean size of the 20 randomly selected sites was 8.2 ha, however seven of the fields were on the edge of the photograph and hence not entire. The mean of the 13 whole fields was 9 ha. This is very similar to the mean East Lothian field size estimated in Chapter 6 (8.7 ha). These are the largest individual sites under study, however the great majority of them support crops and are devoid of floristic interest. In two of the fields, the area of the verge was assessed as sampling proceeded. This was done by measuring the width of the verge with a tape-measure at 50 pace intervals, or less, if the width widened e.g at corners. In the first field where the area was 7.05 ha, the verge area was 1169m^2 or 0.12 ha and in the second field where the total area was 12.7 ha, the verge area was 0.19 ha. Although these represent only 1.6% and 1.5% of the whole field area respectively, they nevertheless represent a considerable area comparable in size to some of the smaller woods and areas of scrub.

Diversity

Structural diversity:

The verges were all fairly uniform in height. The only physical diversity was caused by the hedge (where present). Incidentally the floristic diversity was usually less at verges with a hedge than at more open verges. The shade thrown by the hedge must eliminate the plants requiring the most open conditions, However the hedges will provide habitats for birds and insects.

Species richness:

The four verges supported between 41 and 77 species of grasses, rushes, horsetails and herbs. The site with 77 species was the largest in terms of extent and the verge bordered onto a small stream at one edge and a grassy hummock in the middle which increased both structural diversity and species richness.

Naturalness

Nearly all the species encountered in the sample quadrats were native except for barley at two sites, Italian rye-grass and rye-grass hybrid at one site and Bunias orientalis at another site. The following alien species were also found outside quadrats: pineapple-weed and Avena fatua.

These areas must be more subject to man's influence than most other habitat types, yet a collection of grasses and herbs survives at the edge. There was no evidence of recent herbicide application on the verges of the four fields studied. In a field adjacent to one site, spraying had taken place and the vegetation at the verge was mostly dead with only coarser grasses such as cock'sfoot (Dactylis glomerata) growing nearer to the fence.

Habitat specificity

The plants are commonly found in a wide range of open habitats - wasteland, fields, grassland and verges. There are some species described as being found on cultivated ground only e.g. charlock (Sinapis avensis) and common fumitory. The distribution maps of such species show they are common only in areas where arable farming predominates and are less common to rare in the west to north of Scotland, e.g. Sonchus arvensis, Euphorbia helioscopia and field poppy.

In summary the species are found in a wide range of open habitats. Although those habitats are usually wasteland and fields, a few species found in grassland were present e.g. daisy Bellis perennis and Cynosorus cristatus . On the whole, the plants are typical of such disturbed areas, with fairly wide ranges of environmental tolerance, apart from the need for very open conditions. All the species are described as common but some have a more limited national distribution related to the distribution of arable agriculture.

Viability

The commonest adjoining land use was agricultural land, followed by non-agricultural land. Therefore the species found in these habitats have much opportunity to spread. The management of the field itself eliminates most species but the verges appear healthy despite the occasional effects of spraying. The predominance of agriculture will ensure the survival of the verges and prevent natural succession. None of the sites had changes since the 'early' date of photography.

Potential value

It seems likely that such habitats will continue to survive as they are. The plants present are the so called 'weed' species - opportunists which can exploit the disturbed conditions. It is interesting that many of the species are not common in western and northern areas of the country. However, this land use is likely to prevail for some time and so the species are in no way threatened. The longer a ley is left before being ploughed and put to arable use or resown the more the floristic richness will increase. However the verge of the hay field, though having fewer 'field' species still had more of the wasteland

and verge species, than grassland species.

8.3.3 Improved Grassland

General

This habitat encompasses a wide range of 'intermediate' grasslands, meadows, rough uncultivated areas on less steep slopes, parkland on estates, the 'rough' on golf courses, and probably some old once-sown pastures and misclassified permanent unimproved grassland. None could be considered wholly 'natural', the processes of natural succession being averted by grazing. However, if left such areas become semi-natural and if management is constant, fairly stable. Figures 8, 9, and 10 illustrate some of the types. The area on Figure 8 stands out from the ley because it has been fenced in preparation for tree planting. The underlying ground at that part of the field appears very irregular. Figure 10 illustrates parkland.

Two sites were visited, one of which is depicted in Figure 9, lying beyond the wasteland close to the farm and separated from it by a fence. It stretches to the fence below the scrubby slope. This area could be described as a meadow with some areas taken over by scrub, and others by wetland. The second site was situated on a knoll in the midst of fairly undulating grazing.

Size

The mean area of the 17 randomly selected sites was 1.6 ha. The sites visited measured 0.2 and 0.7 ha, the larger site being the one in Figure 9.

Environmental Limitations

The smaller site may be less fertile than the other-species such as Bird's foot trefoil (<u>Lotus corniculatus</u>), and harebell being found in quadrats, although there were one or two patches of nettle, indicative of more fertile soils. The commonest herb was germander speedwell (<u>Veronica chamaedrys</u>) and the commonest grass, <u>Agrostis tenius</u>, indicative of moderate to poor soil. Much of the site was on sloping ground round the sides of a knoll. Though no stock were present on the field there was evidence of intense grazing with clumps of ragwort and thistles (<u>Cirsium spp</u>) left, the former of which could be evidence of overgrazing. Rabbit droppings were obserevd in some of the quadrats as well as evidence of cattle. Intense grazing may have prevented scrub invasion, for it was present all round the area. The second site had fewer environmental limitations with species indicative of more fertile, moist to wet soils. The area is on flat land by a stream. It was also grazed by cattle.

Diversity

Structural diversity:

The smaller site was well grazed with a few coarser species such as ragwort and nettles (Urtica dioica) in clumps. Round the periphery of the area there was scrub. The second site was more diverse physically with a small stream, areas of grassland, areas of wet grassland, areas of full wetland and scrub. Both sites were more structurally diverse than the agricultural and non-agricultural sites.

Species richness:

The first site supported 31 grasses and herbs and three shrubs. At the second site the areas which were either exclusively scrub or wetland were not sampled, there being discontinuity between larger blocks of these types and grassland. In other places there was a small-scale mixture of wetland and grassland and such areas were sampled. In all 64 species of herbs and grasses were encountered, two Juncus spp and common horsetail (Equisetum arvensis).

Naturalness

Not one alien species was found at either of the two sites. Both areas are subject to grazing but the presence of scrub species nearby shows that natural succession can continue in places. One other site visited could not be sampled because it had become completely overgrown with scrub. Although perennial rye-grass is present at the smaller site, it is less common than Agrostis tenius, Holcus lanatus and Festuca rubra. Therefore, if the area had been sown it was some time ago. At the second site perennial rye-grass was encountered more frequently but a far greater range of grasses were present (18 species in all). Festulolium loliaceum was found which, according to Hubbard (1968) is found on old grassland and water meadows on rich soils. It is possible that perennial rye-grass itself was more common here than at the first site because the soil is richer. In summary, though both areas may once have been sown, perennial rye-grass was not the commonest grass at either site and at least nine other grasses were present. Of the 17 sites, half were enclosed i.e. probably sown initially, and half were in river valley sites, like the second of the sites considered here, and probably more 'natural' than enclosed sites.

Habitat specificity

At the smaller site some of the commoner wasteland species were in evidence, e.g. ragwort, Cerastium fontanum and dandelion, but a few other more typical grassland species were present especially germander speedwell, Lady's bedstraw and bird's foot trefoil. Closer to the scrub foxglove (Digitalis purpurea) was found. There were only half the number of grass species present than there were at the second site, some of which e.g. Holcus lanatus and Festica rubra are also found on disturbed areas. Other more typical grassland species such as Cynosurus cristatus and Agrostis tenius were also present. The suggestion is that a combination of poorer soil and overgrazing have allowed coarser species to thrive rather than more typical grassland species. However the commonest herb and grass germander speedwell and Agrostis tenius are both grassland species.

At the second richer site some more 'weedy' species were also in evidence e.g. thistles and ribwort but there were many other more typical grassland species present e.g. lesser knapweed (Centaurea nigra), Lathyrus pratensis, tormentil (Potentilla erecta), daisy and Festuca pratensis. By the wetter areas, meadow sweet (Filipendula ulmaria), Lotus uligonosis and even Rorippa nasturtium-aquatica were found, also the grasses Phalaris arundinacea and Glyceria maxima. By the scrub, species such as Alchemilla vulgaris (very common), Stellaria graminea and Primula vulgaris were found. Though the areas of wetland were small i.e. could not be picked out with air photographs, there was a definite discontinuity between the larger patches and the grassland with species such as Epilobium palustre , Veronica becca-bunga and Caltha palustris and three species of Juncus in the wetland .

Viability

Of the 17 sites, the commonest adjoining land uses were agricultural land, non-agricultural land, improved grassland and scrub. Of the two sites visited, the smaller site had scrub all round with ley grassland beyond and the larger site, as can be seen from Figure 9, had scrub, rough grassland and a ley rearby. The smaller site was in danger of being either swamped by scrub or overgrazed. The larger site seemed more stable, a balance having been reached between scrub, wetland and grassland. The farmer, in fact, stated that he had kept the study area rough because he had read in the farmers press that the cattle liked some variety to their rye-grass diet. An adjoining field had been seeded but he intended to keep the studied area as it was.

Of the 17 sites only one had undergone change since the late 1940's indicating a degree of stability.

Potential value

The larger site seemed very valuable at present with diversity of both habitat type and structure. It is maintained by grazing and a stable balance between wetland, grassland and scrub was in existence. The first site seemed less valuable due to more environmental limitations. It may lose floristic diversity if scrub encroaches but may become more valuable for other species such as birds.

8.3.4 Scrub

General

Like grassland, scrub is only a seral stage in the natural successsion. However, it is one stage further on in the transition between grassland and woodland. Of 15 randomly selected sites, three main types of scrub could be distinguished on the air photographs. Almost half were found in areas of grassland, three were in woodland areas which had been felled and left and four were on wasteland or disused railway lines. The wasteland type may have affinities with the grassland type.

Two sites were visited. One was of the 'grassland' type and the second area was cleared woodland which, it was thought, might represent a stage further on in the succession.

Environmental Limitations

The 'grassland' type site was situated on sloping ground. In the area nearby which supported grassland, scrub was often present on the slopes where grazing was less intense. In 'wasteland' type areas, scrub appears to be more randomly situated than that. The 'woodland' scrub site could be described as an 'island' in a large barley field. Since the 'early' date of the photographs, several hedges had been removed to make three smaller fields into one large field. The only other environmental heterogeneity was a road running along the base of the area which linked it to two smaller areas of deciduous woodland and the farm-office. Although the woodland had been felled between the late 40's and the survey date, the fact that it had not been completely removed, like the hedges, could be due to environmental limitations.

The species present at the 'grassland' site indicate a fertile to poor site. The plants present were mostly those of light shade but a few open species were found such as tormentil. The scrub woodland site appeared very fertile with perhaps a slightly basic soil. Species found include dog's mercury (Mercurialis perennis) and nettle. Both the last mentioned species can be seen in Figure 23, which shows a quadrat towards the edge of the site.

Size

The mean area of 15 sites was 0.4 ha which was the smallest mean site size of the habitats under study. Of the two sites visited here, the 'grassland' site was 0.31 ha in size, and the 'woodland' site 0.67 ha. The size of the vegetation was considerably larger than that in the first three habitat types with both shrubs and some 10 - 15 year old trees present.

Diversity

The sites were spatially diverse: at the 'grassland' side there were open areas amongst the shrubs; and the 'woodland' site was open round the edge. The sites had at least two strata-ground flora and shrub layer, while at the 'woodland' site there were two shrub layers, one composed of species such as hawthorn and elder (Sambucus nigra), and young trees, and the other of taller trees including both birch species and ash.

Despite the small size of the areas, all were remarkably rich floristically. At the 'grassland' scrub site, 48 species of grasses, herbs, ferns and other monocotyledonous plants were found, six shrubs (and at least 13 mosses), and at the 'woodland' scrub site, 45 species of grasses, herbs etc. and 16 shrub and tree species. Salisbury (1917) was one of the first ecologists to draw attention to the ecological interest of scrub, pointing out that such areas usually contained a much higher number of species than either the habitat from which they had developed or were tending towards probably because they contained species characteristic of both habitats.

Naturalness

The species were nearly all native apart from sycamore and privet at the 'woodland' site.

By the location of the scrub 'woodland' site it is likely that it was initially planted as part of estate woodland. However, since felling it has been left to regenerate and the presence of the birch and ash suggest that natural succession is occurring. The only evidence that the site was initially planted was the occasional presence of Quercus robur which is the oak species more commonly planted. The 'grassland' scrub also appeared to have grown naturally (on a less intensively grazed area). It was dominated by gorse (Ulex europeaus) with some blackthorn (Prunus spinosa).

Habitat specificity

Though some of the plants present at each site are described as species of open habitats e.g. ribwort and Cerastium fontanum, there are far more shade tolerant species present at these sites. e.g. Torilis japonica Stachys sylvatica, Alliaria petiolata and Solanum dulcamara. Most of the species present are not woodland specific, being again found in a range of habitats but the range now includes woodland. Athyrium felix-femina and Dryopteris dilitata were also present.

The scrub and tree species themselves were then the most woodland specific plants apart from foxglove (Digitalis purpurea), Bromus ramosus and at the 'woodland' scrub site Dog's mercury. This last mentioned species has been used as an indicator of continuously wooded conditions, because it is slow to colonise new woodland e.g. by Pollard (1973), Peterken(1974) found that Papworth Wood in Cambridgeshire which is known from old records to have originated by 1279 had still not been colonised by the plant though it was present at similar sites less than 1.6 km away. However it was found to colonise an abandoned wheat field at Rothamsted within 30 years (Brenchley and Adam 1915). It may be more likely to spread into an area where woodland is adjacent. On the whole the scrub 'woodland' site appears to support a more specialised flora.

Viability

Of 15 sites, the commonest adjacent land use was improved grassland followed by agricultural land and non-agricultural land. In improved grassland areas, the areas round about may be intensively grazed and only unpalatable species such as gorse survive. However on slopes, the scrub may spread and new species may colonise e.g. species such as rowan were present at the 'grassland' scrub site. At sites where there is no active management such as the 'woodland' scrub area a greater mixture of scrub species was found and trees such as birch, ash and wych elm. In time, if left unmanaged, such areas will become woodland whereas the 'grassland' scrub type remains as scrub.

Of the 15 sites, three had changed in the last 30 years, - two from felled woodland and one from improved grassland. Of the sites visited, the 'woodland' site seems the most likely to be converted in view of the hedge removal earlier.

The effects of adjoining land uses were only obvious at the edge of the sites, e.g. grassland species such as harebell were found at the 'grassland' scrub site and the 'weeds' of arable land were present round the 'woodland' scrub site e.g. Lamium album. However the interior of this site was more shaded with fewer generalists.

Figure 23: Fieldwork. This 1m x 1m quadrat was taken near the edge of an area of scrub woodland. Dog's mercury (Mercurialis perennis) at the near edge of the quadrat and nettle (Urtica dioica) are both indicators of fertile conditions. Dog's mercury has been taken as an indicator of continuously wooded sites. (near Haddington, East Lothian).

Figure 24: Modern Forestry. The 'South Bank Wood' of the River North Esk supported mature deciduous woodland on the air photograph but since 1969 the area has been felled and planted with conifers. Shrubs and young deciduous trees are regenerating close to the woodland centre right. (Penicuik Estate, Midlothian).

Potential value

Although the grassland 'scrub' is likely to remain as such, the other site may develop to full woodland. The effects of surrounding land use were obvious only at the edge of such sites, inside more shade tolerant plants were found. The scrub sites were only occasionally adjacent to other woodland types or hedges and so the spread in of woodland species may be slow. Such small areas appear to offer great potential for plants and other smaller forms of life but whether they are large enough for birds and mammals is unknown.

8.3.5 Hedges

General

Much interest has been shown in hedges particularly since it became clear that many were being removed. However they have a slightly different history in Scotland than in England. The oldest hedges in England are thought to have been the edges of the original forest, which was left as woodland was cleared for agriculture. As a result they provided refuges for many woodland species as agricultural land uses began to predominate. However in Scotland, the earliest hedges were planted, and few appear to have been in existence before the 18th century, except on monastic lands. They were introduced into an open landscape.

Apart from their value as refuges for woodland species, they are also thought to provide 'corridors' for the movement of woodland species between small woods. Pollard, Hooper and Moore (1974) reported work comparing birds populations of woods in area which had never had hedges, such as the Fens and the Southern Uplands of Scotland and found that such isolated woods contain similar numbers of species of small birds such as the wren and the long-tailed tit, as small woods linked by hedges. It was suggested that hedges may have been more important for small birds before the sparrowhawk population declined (due to organochlorine pesticides and gamekeeping) but now they can fly across open areas more safely. It was thought by Pollard, Hooper and Moore (1974) that hedges as corridors might still be important to small mammals, reptiles and invertebrates. However too little is on record to apply a rating, this subject is too complex for consideration here and so hedges have been judged on their value as refuges for woodland species.

Of a sample of 15 hedges, one was no longer present when a field visit was paid to the area, the hedge having disappeared under the spoil heaps of open cast mining (see Figure 11). Of the remaining 14 hedges, seven were in fields, five were by roads, one was by a shelterbelt and one was in a built up area. Of the two hedges visited in the field, one was by a road and the other was a double infield hedge. The area between the double row of hedges was mostly overgrown but was a right of way, according to a nearby smallholder.

The lengths of the individual hedges were not assessed as they often formed continuous stretches with hedges in adjacent fields. They were treated as continuous linear features like the earlier verges. Only a 30m length close to the sampling point was studied in detail.

Environmental Limitations

The species present suggest there are no soil limitations.

Diversity

Structural diversity:

As linear features there is little spatial heterogeneity with a continuous verge and hedge. However the double hedge had a rough overgrown area between, which added another element to the physical diversity. There were two strata at the double hedge (ground flora and hedge) and three at the roadside hedge where trees were also present. At both sites, the hedge was continuous. However at many other sites observed from both the air photographs and the ground, hedges were gappy due to neglect and repaired with post and wire fencing (see Figure 25).

Species richness:

The hedges were perhaps also atypical as regards the number of shrub and tree species in them. The double hedge had eight species and the roadside hedge fourteen.(those assessments include the woody species bramble (Rubus fruticosus), wild raspberry (Rubus idaeus), Ribes uva-crispa and dog rose (Rosa canina)). Most hedges observed in the field had only one species, hawthorn. Figure 13 shows hawthorn hedges with elm colonising at the foreground hedge.

Tozer and Taylor's (1978) sample of hedges in East Lothian showed that most infield hedges were single species (*Crataegus monogyna*) but that most roadside hedges were composed of mixed species (e.g. beech, hawthorn and holly).

Of herbs and grasses, 21 species were recorded at the double hedge and 32 at the hedge with trees. These figures seem slightly lower than at some of the earlier habitats studied. This may be because the length of hedge studied was too small to be comparable or because fewer plants can survive in the more shaded conditions. At the double hedge, only three of the species were shade tolerant: nettle, wood avens (*Geum urbanum*) and ground elder (*Aegpodium podagraria*).

Naturalness

The double hedge included hornbeam (*Carpinus betulus*) which is not native to Scotland, and the introduced ground elder. At the hedge with trees the introduced beech, sycamore and lime were present. However the majority of the species at both sites were native.

However many of the other shrubs and herb species in the hedge with the trees, are also likely to have been planted as they included aspen (*Populus tremula*) , gean (*Prunus avium*) and holly. They were probably planted for ornamental reasons as the hedge runs from a lodge house on an estate road. At the double hedge, the rest of the species present may have arisen naturally e.g. wild raspberry and ash. On the whole neither site could be described as particularly natural having been initially planted in a linear form. However at both sites there were areas which had not been managed and had become overgrown, e.g. between the double hedges.

Habitat specificity

At the first double hedged site most of the species were those commonly found in agricultural areas e.g. hogweed, *Bromas sterilis* and *Galeopsis tetrahit* which would have been present at the verge anyway. The only more 'woodland' species was wood avens.

However at the second hedge with tree sites there were some more 'woodland' species or 'wood' edge species i.e. more shade tolerant species: herb robert (Geranium robertianum), Alliaria petiolatia, red campion (Silene dioica) and bluebell (Hyacinthoides non-scripta) Like Dog's mercury, bluebell has been used as an indicator of a continuous wooded site (Pollard 1973). One interesting find at this second site was the hybrid between white campion (Silene alba) and red campion. Silene alba is more a plant of open conditions such as those in cultivated areas. Although there are a few common verge species present e.g. dock (Rumex obtusifolius)and hogweed, overall more wood edge or woodland species were present.

At the first site all the species were common but at the second site some species have more localised distributions e.g. Solanum dulcamara is more eastern in distribution and bluebell is shown as less frequent in parts of Scotland.

Viability

The former double-hedged site, if it is a right of way, is likely to survive. However though the hedge itself may be of value to birds, the verge below is very typical of other arable verges i.e. this site does not provide a refuge for woodland species. The second hedge with trees also seems likely to be left. A fairly large ditch ran along the north site, and there were nearby areas of open water and wetland at the site of former brickworks. Thus the area might not have potential for reclamation to agriculture.

Many other hedges seemed less viable however, infield hedges in particular are often removed. The commonest management practice is the mechanical cutting of the top and sides which does not encourage basal growth and so the bottom of the hedge thins out and eventually gaps develop The only way to prevent gaps developing is to 'lay' the hedge every seven to twenty years, This involves splitting leading shoots and weaving them horizontally between adjacent plants. The practice seems to have fallen into disuse in Scotland and has been observed on only one estate in Midlothian in the whole of Scotland. Figure 26 shows a hedge in the south-west of Scotland where a rough form of 'laying' seems to have been practised recently.

Figure 25: Hedge 1980. A typical hedge which has been maintained by trimming, with many gaps. A fence now runs along its entire length. (Midlothian).

Figure 26: Hedge Management. A rough form of 'laying' has been carried out to maintain hedge continuity. (near Auchencairn, Galloway, March).

In Tozer and Taylor's (1978) study of East Lothian, no 'laying' was encountered, and they found that for many years the hedges had been maintained by clipping. They were made stock proof with wire fences. Most hedges were clipped fairly regularly, especially those beside roads whereas in fields hedges were more neglected. They concluded that the better managed roadside hedges were more likely to be kept.

Potential value

The flora of the double hedge was influenced by the surrounding agricultural land use and this is unlikely to change in the near future. However this does not discount the possibility that the site may be valuable for invertebrates or birds. The second site, though also having some of the ubiquitous verge species present also holds woodland species, which may be valuable if other areas of woodland round about were lost. Equally however, if the wood were lost, the hedge verge would be more subject to the influence of agricultural land use. It was adjoining an area of woodland so some species could still spread in. Because of the predominantly agricultural land round about, neither site seems likely to foster more woodland species.

Nearly all hedges have arable land on at least one side and this seems to be a major influence on the flora of the verge in the absence of woodland.

8.3.6 Deciduous Woodland

Deciduous woodland is valued because it was the climax vegetation over much of the country before clearance for agriculture. The remaining areas of woodland are thus thought to be valuable in providing habitat for the woodland species which were once common over more extensive areas. However it has been shown that most woodland in the lowland area was planted in the Improvements era and so will only be valuable if species from relics of primary woodland were able to colonise them.

Of 20 randomly selected sites, two had to be discounted. One was a misclassification and the other had been felled and planted with conifers. The last site is illustrated on Figure 24. Three of these sites were visited, and also Dalkeith Oakwood SSS1 which, it was thought, might represent more natural woodland.

Environmental Limitations

Four of the remaining 18 sites were situated on sloping land of river valley sites but the rest were on flatter land. Of the three sites visited on the ground two were on fairly flat land but the third was situated on a hummock in the middle of an agricultural field. Many stones had been dumped in the area but whether this would account for the origin of the site or whether it was initially irregular is unknown. Dalkeith Oakwood consists of a fairly flat plateau with steep terraces leading down to, on one side, the North Esk, and on the other, the South Esk, with the convergence of these at the north of the site.

The species found at the three randomly selected sites indicate that there were no edaphic limitations.

Size

Of the initial 20 random sites, the largest site was 32 ha in size but this had to be excluded because it had been planted with conifers, (Figure 24, far bank). The mean area of the remaining sites was 1.7 ha. The three randomly selected sites visited were of 0.16 ha, 0.81 ha, and 2.62 ha in size. The smallest of the three was the boulder dump site. Dalkeith Oakwood SSS1 is 33 ha in area. The size of vegetation is at its largest on woodland sites.

Diversity

Structural Diversity:

The three randomly selected sites visited had two to three strata, the shrub layer being more patchy at one of the sites. Two of the three sites were fairly uniform but the largest of the three was more heterogenous spatially with open areas, paths, areas dominated by rhododendron and areas where the tree canopy was more complete.

Species Richness :

Discounting mosses, the number of plant species at the three sites ranged from 33 to 58 at the more spatially diverse site. The presence of lianas - ivy (Hedera helix) and honeysuckle (Lonicera periclymenum) at two of the three sites is evidence of further complexity. A consideration of the richness of the canopy species may be misleading because they have probably been planted. At the hummock site only one canopy species were present - beech, whereas at the other two sites 11 and 12 canopy species were present. At Dalkeith Oakwood over 90 species of herbs, grasses, shrubs and trees were encountered but this is a much larger site.

Of more interest is the diversity of younger trees and shrubs which have colonised the plantations. The number of such species ranged from five at the hummock site to thirteen at the largest site.

Naturalness

At all three sites, the commonest canopy species is beech which is introduced. Other aliens present were sycamore, lime, Tsuga heterophylla, larch (Larix spp) and whitebeam (Sorbus aria). Other species present which were probably planted, were Scots Pine(Pinus sylvestris) (which is not native to this part of Scotland), pedunculate oak, and yew (Taxus baccata). Though the canopy was mostly composed of planted or introduced species, other tree species were present which were more likely to have arisen naturally: wych elm, ash, holly, willows, rowan and two birches.

The ground flora was nearly all composed of native species, except for barley at the hummock site and rhododendron and spearmint Mentha spicata at the largest site.

In the absence of intensive management these sites have developed a complex structure i.e. present a 'natural' appearence.

Habitat Specificity

The commonest ground flora at the largest and smallest sites were the ubiquitous herbs: goose-grass; hogweed; and nettle and cock's-foot grass. However, at the medium sized site, wood-sorrel (*Oxalis acetosella*), a woodland species is the commonest herb. At the hummock site, none of the ground flora could be described as woodland species and only one species is shade tolerant: *Glechoma hederacea*. The arable land round about seems to have had more influence on the flora than the trees. At the largest site there were a few woodland species e.g. wood avens, *Valeriana officinalis* and *Brachypodium sylvaticum* . The most habitat specific was *Circaea lutetiana*. It has a more limited distribution in Scotland as a whole than the other woodland species mentioned. Although the medium sized site had only 36 species (compared to 58 at the larger site) there were a few other woodland species apart from wood-sorrel e.g. common violet *Viola riviniana*, herb bennet and *Dryopteris dilatata*.

In summary, the plants present were the common verge plants or 'wood' edge plants and they are most frequent in the clearings. A few shade tolerant, woodland species were present at the larger two sites. Perhaps the most habitat specific species are the shrubs and trees which have colonised. The first site was perhaps too small and subject to influence from agricultural land nearby.

At Dalkeith Oakwood, the plateau area supports a number of very old widely spaced oaks. These are most valued for the populations of insects they support (NCC 1971). The open area below is well grazed and more akin to grassland. The main areas where woodland species were to be found were the steep river terraces. There grazing must have been less intense as natural regeneration of sessile oak and the other trees was occurring. Woodland flora there included: Dog's mercury, wood-sorrel, *Teucrium scorodonia*, *Stellaria holostea* and *Lysimachia nemorum*. However many grassland species were also present in this area and the ubiquitous ragwort.

Viability

Of the 18 randomly selected sites, the commonest adjacent land use was agricultural land, followed by non-agricultural land. Eight sites adjoined another woodland type or scrub.

Fifteen sites were unchanged since the 'early' photography. Of the others, two were previously scrub and one was improved grassland.

Out of 18 sites, 16 were mature which means they are likely to be felled. Many will be planted with conifers in line with the countryside trend detected in the NCC survey. There were few signs of ongoing management of the woodlands visited except for the grazing at Dalkeith Oakwood. This latter site is more viable because it is an SSSI but it seems unfortunate that grazing is continued in an area which has potential to develop fuller woodland characteristics.

Potential value

Although the majority of the species found were generalists, all the sites visited provided refuge for some woodland species. No rare woodland species were found. One of the most specific ground species found was Circaea lutetiana at the largest of the three randomly selected sites.

At all sites, native trees and shrubs and lianas have arisen and if the woods were left, there seems to be no reason why complexity should not increase. However, many seem to be in danger of being felled and planted with conifers.

8.3.7 Coniferous Woodland

Coniferous woodland is of interest because there have been extensive areas planted in the last 30 years. This planting is often in areas which formerly supported deciduous woodland (albeit planted).

Size

Of the 18 randomly selected sites, the mean size was 1.8 ha which is about the same as the deciduous woodland units. The two sites visited were 0.51 and 1.54 ha.

Environmental Limitations

Both sites were fairly flat but well drained. The species present indicate that there are no edaphic limitations. The main environmental limitation is likely to be the effect of the conifer trees which cast shade all year round and shed acid litter. At the larger of the two sites, 15 - 20 year old Sitka and Norway Spruce formed a dense canopy and there was virtually nothing growing on the forest floor. A few mosses were found growing on dead wood e.g. *Thuidium tamariscimum* and *Eurynchium praelongum*. All the ground flora at that site occurred in the rides and ditches at the edge of the plantation. At the second site; a slightly older larch wood, the canopy was lighter and there was a complete covering of ground vegetation.

Diversity

Structural Diversity:

At the first site, the spruce canopy was uniformly dense i.e. only one strata was present. At the larch site, which was more open and less uniform, there was a ground layer and occasional shrubs.

Species Richness:

Virtually no species were to be found at the spruce site within the wood. At the edge, 25 species of grasses and herbs were recorded including some species of damp habitats e.g. *Geum rivale* in the ditches. At the larch site 21 species of grasses, herbs and ferns were recorded plus seven woody species (e.g. brambles and young trees).

Naturalness

The dominant species were all alien. The closeness and uniformity of the trees in the plantations were also unnatural, particularly in the spruce plantation. However all the species found round the edge of that plantation were native. At the larch wood a more open situation prevailed. All the ground flora were native, and some woody species such as pendunculate oak and elder had also established themselves. The introduced beech and sycamore were also present at the larch site however.

On the whole there was less complexity in these coniferous woods compared with the deciduous woodlands though both types are artificial initially.

Habitat Specificity

All the ground flora found at the larch site were generalists and present in a range of habitats. Many were species of verges and wasteland e.g. Arrenatherum elatius , nettle, goose-grass and Rose-bay willow herb. Two more shade tolerant species - red campion and Stachys sylvatica were present but were not common enough to be present in the quadrats. Although these species are commonly found in woods, they are not confined to them.

At the spruce site, many of the edge species were more typical woodland species; wood-sorrel, common violet and even dog's mercury. Other species present were also to be found in other habitats e.g. Fragaria vesca, Ajuga reptans and yarrow. There were fewer species of open disturbed conditions compared to the larch site.

These differences may be the result of differences in past land use, or adjoining land uses today. The rides of the spruce site suggest a previously continuously wooded site whereas the larch site has collected species from surrounding farmland.

Viability

As a habitat type, coniferous woodland is not under threat. Indeed its area is on the increase often at the expense of deciduous and mixed woodland. More attention to timber production than amenity in present estate practice has eliminated other elements of woodland.

Potential Value

At the thicket stage there is a danger that all the ground flora will be lost except at rides and clearings. If the wood is allowed to reach maturity, more open conditions will prevail and woodland species may re-colonise. This will depend on surrounding land use and the viability of the seed of woodland species. Over half of the random selection of 18 sites were adjacent at one edge to deciduous or mixed woodland but the commonest adjoining type was agricultural land. Thus if the mature open stage is reached, agricultural species are equally likely to spread in. However many coniferous woodlands have a fairly short rotation length compared to deciduous woodland. Clear felling and replanting may be more likely to occur than progressive thinning so the mature open situation may not occur.

8.3.8 Summary of the Ecological Value of Habitat Types

The assessment of 'ecological value' will enable the habitat changes to be 'weighted' for impact on wildlife which could then guide and support conservation priorities. It is unfortunate that insufficient sites could be studied, though it is by no means certain that the number of sites in the original plan would have provided an adequate amount of quantitative data for this purpose. The intended analysis has been replaced here by a subjective ranking of ecosystem attributes on a scale of 0 - 3 where '0' is absence and '3' is full development of the attribute, often not achieved in the area under consideration (e.g. size, naturalness).

The results from the field survey and further air-photo interpretation are summarised in Tables 39 and 40, together with the subjective rating allocated to each habitat type attribute. Notes on the special points that arise in the rating of each habitat, follow.

(i) Size
  a) Area. Most of the habitats were very small. Linear features were awarded a slightly higher rating than they would receive on their nominal area because of their continuous nature.
  b) Vegetation height is taken as an indicator of the size of vegetation.

(ii) Diversity. Species number increases with the logarithm of area in homogenous vegetation and more rapidly where there is environmental or structural heterogeneity. An arbitary scale is used here to indicate species richness, which will inevitably show some low bias for small sites:

0 - 50 species = 1
50 -100 species = 2
$>$ 100 species = 3

(iii) Naturalness

a) Site naturalness - it was felt that no sites in the lowland agricultural area were completely natural and the maximum value awarded was $2\frac{1}{2}$.

b) Native species - where no aliens were present the maximum score of 3 was awarded. Where the dominants were all exotic but a native ground flora was present, a score of 1 was awarded.

(iv) Habitat specificity The great majority of species recorded could be described as generalists and the highest value awarded to any species list was 2.

(v) Viability The highest value was awarded when it seemed likely that the habitat type would survive despite man's effects. This was related to management practices in or around the area and the likelihood of conversion to another type (deduced from past history)

(vi) Potential value - one mark was added to the ecological value score, if the site was judged to be capable of developing greater complexity.

With the best sites a maximum score of 28 would be attainable. However it has already been noted that within the lowland area the following four attributes are unlikely to be fully developed: size, species diversity, site naturalness and habitat specificity. Therefore a maximum of 24 would be expected. In fact the highest rating allocated was $20\frac{1}{2}$ to scrub.

Notes follow on the ecological evaluation of each habitat type summarising the most important attributes within each.

TABLE 39: Assessments of Ecological Value for sites investigated in Lothian

Ecosystem Attribute / Habitat	Size		Diversity			Naturalness					
	Area	Vegtn. Height	No. Strata	Spatial	Species Richness	Native Species?	Site Naturalness	Habitat Specificity	Viability	Potential Value	Total Ecol. Value
Improved Rough Grassland	small (1)	low (1)	1 (1)	medium (2)	31-67 (1½)	all native (3)	grazing only (2½)	some (1½)	viable (3)	stable -	(16½)
Scrub	small (1)	medium (2)	2-3 (2½)	medium (2)	54-61 (2)	all native (3)	high (2½)	some (1½)	viable (3)	high (+1)	(20½)
Hedges	linear (1½)	medium (2)	2-3 (2½)	low (1½)	29-46 (1)	a few aliens (2½)	art-nat (2)	present (1)	may be removed (2)	stable -	(16)
Deciduous Woodland	small (1)	high (3)	3 (3)	high (3)	34-70 (1½)	some dominants exotic (1½)	art-nat (2)	some (2)	may be felled (2)	high (+1)	(20)
Coniferous Woodland	small (1)	high (2½)	2-3 (2½)	low (1)	25-28 (1)	dominants all exotic (1)	artificial (1)	present (1)	viable (3)	low -	(14)
All Types	small	various	various	various	various	few accidental some deliberate	various	not pronounced	all fairly resilient	some stable some developing	(17½)

Abbreviations: Vegtn. = Vegetation : No. = Number : Species Richness = Total Number of Species recorded at site
art-nat = artificial origins but natural succession is occurring

Habitat assessments

Improved grassland

More natural conditions prevail here. In the assessment of spatial heterogeneity, a mixture of coarse ungrazed areas (which may be valuable for invertebrates), shorter grass, and the fact that many areas adjoin scrub has been recognised. A few grassland specific plants were present. This is one of the more stable habitat types - maintained by grazing.

Scrub

This type has been assessed as most valuable. The 'woodland' type scrub is probably more valuable than the 'grassland' type. The attributes it has scored most highly on are naturalness and diversity. However it is recognised that deciduous woodland which has developed from this would be more valuable.

Deciduous woodland

Although canopy species were planted, native trees and shrubs have colonised. This type has the highest degree of habitat specificity because the trees and shrubs are 'woodland' species. However because of its unnatural origins, it is not rated quite so highly as scrub in this assessment. Deciduous woodland is the most structurally diverse site and the potential to develop further complexity has been recognised. It seems unlikely that this type will gain all the attributes of primary woodland. Many of the species were generalists due to the prevalence of agricultural rather than woodland seed sources round about.

Hedges

The hedges are of most floristic value when adjacent to woodland and less well maintained. The hedge itself adds an element of structural diversity which may be valuable for other life forms.

Coniferous woodland

This type is of much less value than deciduous woodland, though deciduous woodlands were also initially planted. This may be partly due to the age of the woods studied which were often dense at the uniform,closed canopy stage rather than at the mature open stage that the deciduous woodlands hád attained. It is also due to the management regime and shorter rotations. Where a site has been continuously wooded, woodland species are to be found at the edge, but their habitat extent has been greatly reduced. Where there is less recent history of woodland, the more ubiquitous species prevail.

Non-agricultural land (Table 40)

Two assessments have been made. The first refers to the majority of non-agricultural land - roads, buildings etc., which was found to be sterile of wildlife interest. The second refers to the areas which were covered by vegetation, investigated in the field. These are all artificial in origin but are now virtually unmanaged apart from the cutting of road verges. Such areas are felt to have the potential to develop into more valuable habitats. The final ecological value rating was obtained by estimating the proportions of each type at the three road verge sites. These were 5%, 20% and 49% vegetated; 95%, 80% and 51% concreted i.e. an average 25% of non-agricultural land is taken to have wildlife interest. Further investigation would be necessary to confirm this figure.

Agricultural land (Table 40)

Again two assessments were made. The first refers to the cropped area which is virtually devoid of ecological interest and the second assessment refers to the field verges which were found to support vegetation. These occupied around 1.5% of the total field area, so the overall rating is not altered. This is amongst the simplest of habitats. However the species richness is comparable to that in other habitats and the highest number of species,of any site, was recorded on one verge.

Felled areas

A rough assessment can be made of the ecological value of this type, based on the destinations of areas which were felled at the early date of photography (62% became coniferous woodland, 13% to agriculture, 10% to deciduous woodland, etc). The proportions of each type were multiplied by the ecological value for that type and added. This gave a value of 14.5 for felled areas.

TABLE 40: Ecological Value ratings for Agricultural and Non-Agricultural Land

Habitat / Ecosystem Attribute	Size		Diversity			Naturalness		Habitat Specificity	Viability	Potential Value	Total Ecol. Value	
	Area	Vegtn. Height	No. Strata	Spatial	Species Richness	Native Species?	Site Naturalness					
Non-Agricultural	small-large (2)	- (0)	- (0)	- (0)	- (0)	- (0)	- (0)	- (0)	viable (3)	low -	(5)	7.5
Wasteland & Road Verges	mostly linear (1½)	low-medium (1½)	1-2 (1½)	low (1)	30-50 (1)	a few aliens (2½)	art-nat (1½)	low (½)	viable (3)	high (+1)	(15)	
Agricultural	large (3)	low (1)	1 (1)	absent (0)	a few (½)	nearly all alien (½)	artificial (0)	- (0)	viable (3)	low -	(9)	9
Field Verges	linear (1½)	low (1)	1 (1)	absent (0)	41-77 (1½)	a few aliens (2½)	artificial (1)	low (½)	viable (3)	low -	(12)	

For abbreviations see Table 39.

The mean ecological value for the eight habitat types was 14.75. The habitats can be ranked in relation to the overall mean as:

Scrub	+5¾
Deciduous woodland	+5¼
Improved grassland	+1¾
Hedges	+1¼
Felled areas	- ¼
Coniferous woodland	- ¾
Agricultural land	-5¾
Non-agricultural land	-7¼

8.4 SUMMARY AND CONCLUSIONS

1. 'Nature conservation value' was found to be an anthropocentric concept; hence there are difficulties in assessing it scientifically. Moreover individuals may rate habitat types differently depending on their outlook and interests. Instead 'ecological value' was considered i.e. only biological attributes were evaluated.

2. The scale of ecological values chosen was related to natural succession. The most valuable attributes are probably complexity and homoestasis. However it was recognised that stability was possible under certain management regimes; grassland in particular could be considered to be a 'plagio-climax'.

3. The following conclusions can be drawn for the attributes studied (based on a floristic survey of examples of each of the habitat types involved in the main changes in Section 1).

(i) Size. Most sites apart from agricultural land were small therefore there are doubts about their viability. They are certainly under the influence of surrounding land uses.

(ii) Diversity. Spatial heterogeniety, the number of strata of vegetation and species richness is also thought to be influenced by the size of the site.

(iii) Naturalness. It was recognised at the outset that 'climax' vegetation or even 'natural' vegetation was unlikely to occur in the lowland area. However with certain habitat types management had ceased (e.g. wasteland), or was low-key (in mature deciduous woodland) and there natural succession was occurring. Some alien species were found, but it was felt they could be tolerated as long as they occupied vacant niches. In most of the woodlands the dominant trees had been planted and those in the deciduous woodlands were often not native to Scotland, for instance, beech. Over time such woods had taken on a 'natural' appearance.

(iv) Habitat specificity. With rare species unlikely in the disturbed, lowland area the presence of flora specific to a habitat type was used as an indication of increasing niche specialisation. In scrub, hedges, deciduous and coniferous woodland, 'woodland' or 'wood edge' species were sought. In improved grassland, agricultural land and non-agricultural land 'grassland' species were valued. In fact at most of the sites the species present were found in a wide range of habitat types. Specialists were found only at improved grassland, scrub and woodland sites. At deciduous woodland sites most of the specific plants were naturally regenerating shrubs and trees, but the ground flora was mostly composed of generalists. The agricultural sites supported a few species whose national distribution is limited to areas where arable agriculture is practised. These do best with very open conditions and bare soil and do not compete well once more vegetation has established itself; they are pioneer species e.g. common poppy. The species present seemed to be influenced most by past, present and surrounding land uses. With more open habitats, the species found on adjoining habitats had established themselves - often the agricultural/non-agricultural generalists. At one hedge site adjoined to woodland, woodland specialists were present.

(v) Viability. All the habitats seemed fairly resilient having developed a range of species tolerant of the management regime. The main threat would seem to be the wholesale removal of the site. The likelihood of this can be deduced from the results of the NCC Air Photo Analysis of Change Project.

(vi) Potential value. None of the sites visited seemed particularly valuable. The importance of time was recognised where natural regeneration was occurring. Scrub, deciduous woodland and some non-agricultural land (e.g. wasteland and disused rail lines) were estimated to have most potential.

(vii) Environmental limitations. The most important physical factors seemed to be light and slope. Though soils on a slope may be more leached, the net effect of the slope was often beneficial e.g. scrub spreads more freely on slopes because grazing is less intense there. Many woodland relics are in steep-sided valleys e.g. Woodhall Deans SSSI, East Lothian. The vegetation itself may provide physical constraints e.g. trees shade out light - this was very noticeable with coniferous woodland. The most important limiting factor in the lowland area is undoubtedly man.

4. Because of limitations imposed by time and weather, the field work was not completed. A subjective ranking of habitat types was therefore carried out in order to compare their ecological values. It was recognised that more data would need to be gathered before coming to more definite conclusions.

(i) Few of the habitat types were especially valuable: the attributes of size, species diversity, site naturalness and habitat specificity were never fully developed.

(ii) The ecological values of scrub, deciduous woodland, improved grasslands and hedgerows were assessed as greater than average. Scrub was estimated to be most valuable as a result of its natural origins. Deciduous woodland was rather disappointing as a habitat. This quote by Mabey (1980) refers to modern plantations but it is also applicable to the woodlands established in the Improvements era:

> The unspoken assumption...is that where there are trees there's a wood, and therefore - perhaps in some kind of biological tautology - woodland plants and creatures: nut bushes,...sheets of bluebells, glades,...and a few venerable trees distinctive enough to be places in their own right, with their own mosses and hollows and woodpeckers...They are the products not simply of tree cover, but of long periods of woodland stability.

It appears that the distance between the woodland relics and these woodlands established 150 - 200 years ago has precluded recolonisation by woodland ground flora. The most valuable sites will be those where woodland cover has been continuous.

Hedges were also somewhat disappointing due to bad management and the impact of surrounding agricultural land.

(iii) Coniferous woodland, agricultural land and non-agricultural land were assessed as least valuable, although each has some noteworthy characteristics: the verges of fields were richer floristically than had been expected; the verges of coniferous woodland could provide habitat for woodland flora if the site had been continuously wooded; and non-agricultural areas such as wasteland had potential to develop greater complexity.

(iv) In summary there are four kinds of sites:

1) Those greatly simplified by man - agricultural and most non-agricultural land.
2) Those maintained in an intermediate state by management - improved grassland, hedgerows and road verges.
3) Those with larger management cycles - woodlands.
4) Those left free of man's influence - scrub and wasteland.

5. Though the field assessment was not completed, a working method was established which could be used in future studies. More sites of each type would need to be surveyed and ideally the survey would be extended to all habitat types. Additional work to determine the effects of seasonal variations on species richness would be valuable. Because some areas of non-agricultural land are potentially more valuable than others the proportions of the sub-types should be more accurately determined.

CHAPTER 9 THE ECOLOGICAL IMPLICATIONS OF THE MAIN HABITAT CHANGES

Using the ecological values derived in Chapter 8 (Tables 39 and 40), the main changes between habitat types (Table 26) can be re-examined giving a clear indication of their relative importance to wildlife.

9.1 THE FIVE MAIN CHANGES

	Change in value
Agricultural land to non-agricultural land	$(-5\frac{3}{4} \text{ to } -7\frac{1}{4}) = -1\frac{1}{2}$
Improved grass to coniferous woodland	$(+1\frac{3}{4} \text{ to } -\frac{3}{4}) = -2\frac{1}{2}$
Improved grass to agricultural land	$(+1\frac{3}{4} \text{ to } -5\frac{3}{4}) = -7\frac{1}{2}$
Deciduous woodland to coniferous woodland	$(+5\frac{1}{4} \text{ to } -\frac{3}{4}) = -6$
Felled areas to coniferous woodland	$(-\frac{1}{4} \text{ to } -\frac{3}{4}) = -\frac{1}{2}$

9.1.1 Agricultural to Non-agricultural land

Although the main part of the area of both types are virtually devoid of wildlife interest, the areas which are less intensively utilised were found to have some value. The wasteland site examined was amongst the largest sites and was thought to have particular potential to develop greater environmental complexity.

The main causes of the change were the construction of new farm buildings, the expansion of towns, new roads and road re-alignment. The most important attribute of the agricultural verge was its species richness. Although most of the species are generalists and are also found on wasteland, some are found only on bare areas e.g. common poppy. These species are by no means rare, though their distribution is often limited to arable areas. Such species would be lost. However if in the new non-agricultural uses there are less intensively utilised areas, there may well be gains in value. The gardens of houses, for example, can become quite complex with a range of elements from open areas to trees. On the whole, a loss in value is indicated but there may be gains in value in some areas. This is not a change which is likely to have serious consequences for wildlife for agricultural land was found to be well below average in ecological value.

9.1.2 Improved grassland to Coniferous woodland

Both these areas have value as wildlife habitats but their most important attributes differ. The main attribute of improved grassland is its stability. The grazing regime enables a range of small-scale habitats - scrub, coarse grass and shorter sward to co-exist. Half the sites were in river valleys and so small areas of wetland can be added to this list. Evidence of the continuing stability is the presence (albeit limited) of some grassland specific species. The most important attribute of coniferous woodland is the increase in the vertical structure of the ecosystem. The total size of the vegetation has increased and more strata would develop under older and less dense canopy. However spatially, the vegetation is more uniform. In some instances the closeness of the canopy can exclude all ground flora except for mosses and lichens. Remains of previous vegetation survive only at the edges. As a whole, species diversity was low at the sites visited. Both the dominant species and the management regime are unnatural. If grassland species can survive in the rides, or if the seed remains viable in the soil then they may get a chance to manifest themselves when the area is clear felled. ITE research suggests that seeds of herbaceous flowers and shrubs can remain viable for up to fourteen years under the accumulating layers of pine litter, but after that, chances of germination fall (Mabey 1980 p.97). However felled areas are often dominated by coarser species such as Rose-bay willow-herb, and more sensitive grassland species may not compete successfully.

Hill and Jones (1978) studied the vegetation changes resulting from the afforestation of neglected, rough grazings in South Wales. The most important factor in determining changes in flora was considered to be light. In 1976, under Sitka spruce, they found shade was often so great that ground flora was virtually absent. However under larch (Larix leptolepis)there was more than 50% cover of vascular plants. Only Dryopteris dilatata, heath bedstraw and Vaccinium myrtillus were present under the spruce whereas, under larch and pine a flora similar to that under a local sessile oakwood had developed.

The vegetation had been assessed in 1944 and was mostly dominated by Calluna vulgaris, Pteridium aquilinum and Vaccinium myrtillus which were later eliminated under spruce. They concluded that variation in the ground vegetation was mostly by crop species. Thus if the canopy is not too dense and deciduous woodland is nearby, then the change from improved grassland to coniferous woodland may represent a gain.

However, under larch on Dalkeith Estate, in this survey, a flora composed of generalists and species of disturbed areas, with a few shrubs was found. Clearly the nature of neighbouring habitat types is important.

Overall the change from improved grassland to coniferous woodland represents a loss in ecological value. Spatial heterogeneity, semi-natural vegetation and grassland species were lost and replaced by a larger, though more uniform biomass where only the rides and margins may be hospitable to flora species.

9.1.3 Improved grassland to Agriculture

This change is far more straightforward than the last. The old grassland is ploughed and resown or put to arable use. All the grassland species and the species within sub-habitats are lost as is spatial heterogeneity. Some species may survive on the verge, but they are more likely to be the generalists among grassland plants. The findings suggest that this is the largest drop in ecological value of all.

9.1.4 Deciduous woodland to Coniferous woodland

Another large drop in ecological value is suggested as a result of this change. However the comparison may be unreasonable in that the deciduous woodlands studied were all fairly mature, whereas the coniferous woods were still very young, dense, and evenly spaced. However rotation times are shorter for conifers and the mature open stage may not be reached. Data collated by Cousens (1982) provide the basis for a direct comparison between the floristic diversity of a mature coniferous wood and a mature deciduous wood. The woods were both in Argyll, and grown in similar soils; Arinechton oakwood, probably initially planted in the late 18th century with much pedinculate oak; and Mackenzie's grove, planted around 1912, compased of European larch, Sitka spruce and Douglas fir Pseudotsuga menziesii). The data were gathered by undergraduates between 1976 and 1982.

The average species richness in the oakwood was 62 and that in Mackenzie's grove, 44. There were fewer constant species (species present in over 60% of the quadrats) at Mackenzie's grove - 9, compared with 20 at Arinechton (the main difference being in the numbers of herbs and mosses). Moreover the constants were more abundant at the conifer wood than at Arinechton, probably due to lack of competition. The reasons for these differences may be partly edaphic - the oak wood site has rocky outcrops and wet areas i.e. small scale habitat types, whereas the conifer site is more uniform. Other reasons cited include the accumulation of coniferous litter and different light regimes - Mackenzie's grove being darker and more uniform and Arinechton oakwood having many gaps in the canopy. Another important difference is that there is no vernal aspect in the conifer plantations and species such as bluebell, which flower before the deciduous trees are fully open, are not present. Mackenzie's grove is recognised as one of the better examples of a coniferous woodland by the Forestry Commission and has been maintained to demonstrate to the public what a mature conifer wood looks like. It has probably a better developed flora than the average conifer plantation.

Thus under similar conditions, the species richness at a conifer wood site may be only two-thirds of that at a deciduous woodland site. There are other differencies resulting from the change from deciduous to coniferous woodland. There are reductions in diversity - the deciduous woodlands being less uniform spatially than the conifer woodland . Another main difference is in site naturalness - the management regime at the conifer wood e.g., thinning and felling, is likely to be more disruptive than at the deciduous woodlands which now appear to be unmanaged. Both these last factors are related to time.

The margins of a coniferous woodland area may remain fairly rich floristically (compared to some deciduous woodland sites), but the 'extent' is limited and they are liable to perturbation (during extraction of thinnings etc).

Although all the evidence gathered indicates that the ecological value of a coniferous woodland is less than that of a deciduous woodland, further research would be worthwhile.

9.1.5 Felled areas to Coniferous woodland

Felled areas were not subjected to a full appraisal of ecological value because they were felt to be a transient category. Though for a while there is a profusion of growth due to extra light available, if the areas are replanted, the species which achieved abundance will soon be shaded out. The origins of these felled areas are more relevant here. Table 24 showed that just over half the gain was from deciduous woodland and so the conclusions of sub-section 9.1.4 will apply to that proportion, nearly 40% was previously coniferous woodland i.e. no change, and just under 10% was previously mixed woodland. The mixed woodlands in the Lothian area were again mostly mature policy woodlands laid down in the last century, and are probably more akin to the deciduous woodlands in the area than coniferous woodland. Therefore 60% of the change may be considered to lead to a reduction in ecological value.

9.2 THE NEXT SIX MAIN CHANGES

Comment may also be made on the implications of the next six main changes detailed in Table 26.

	Change in value
Wetland to Agriculture	not assessed
Deciduous woodland to Felled areas	$(+1\frac{3}{4}$ to $-\frac{1}{4}) = -2$
Non-agricultural land to Agricultural land	$(-7\frac{1}{4}$ to $-5\frac{3}{4}) = +1\frac{1}{2}$
Agriculture to Coniferous woodland	$(-5\frac{3}{4}$ to $-\frac{3}{4}) = +5$
Coniferous woodland to Felled areas	$(-\frac{3}{4}$ to $-\frac{1}{4}) = +\frac{1}{2}$
Scrub to Deciduous woodland	$(+5\frac{3}{4}$ to $+5\frac{1}{4}) = -\frac{1}{2}$

Together with the first five changes, these account for two-thirds of all the changed area.

9.2.1 Wetland to Agriculture

The ecological value of wetland was not assessed because of time limitations.

Even in the small areas of wetland which could not be discerned in the air photograph, in the better of the two improved grassland sites (Figure 9) there was a sharp discontinuity in the type of species present. The wetland areas are probably relics of the larger areas of wetland which once predominated in the valleys and have a fairly specialised flora. Large gains and losses are involved and the overall change estimate is unreliable. However, there can be little doubt that there has been an overall loss in both quantity and quality of wetland (gains are often due to the collapse of subsoil drainage systems: they may eventually be repaired; their collapse does not allow reversion to the original conditions).

9.2.2 Deciduous woodland to Felled areas

In this change the destinations of the changed area have been considered. Table 24 showed that 62% of such areas were planted with conifers i.e. the conclusions of 9.1.4 again hold, and that 12% are turned to arable use i.e. one of the most serious losses possible according to the ecological evaluation of Chapter 8 and exactly 10% will be replanted with deciduous trees i.e., no change. However as pointed out in Chapter 3.6.2, it is possible that the destination of felled areas in the last 30 years may not reflect future trends. It is likely that an even greater proportion will be replanted with conifers.

9.2.3 Non-agricultural land to Agricultural land

Neither of these habitat types is particularly valuable, so the change is less serious than many of the others. A small gain is indicated.

9.2.4 Agricultural land to Coniferous woodland

This represents a gain in value as the structural diversity is increased. However, whether woodland plants will re-colonise an area which has been under agricultural use will depend on the proximity of other woodland areas. Table 37 showed that over half of the conifer wood sites adjoined other areas of woodland.

9.2.5 Coniferous woodland to Felled areas

The change from coniferous woodland to felled areas has, for the most part, few implications for wildlife, as nearly two-thirds of it is likely to be replanted with conifers, though there will be a small loss to agriculture.

9.2.6 Scrub to Deciduous woodland

Finally the change from scrub to deciduous woodland is not likely to result in a small loss in value as Table 39 suggests. All the deciduous woodlands studied were planted, and so were found to be less complex than naturally regenerating woodland.

9.3 HEDGEROW LOSS

The loss of an infield hedge would suggest a fall in ecological value from $+1\frac{1}{4}$ to $(-5\frac{3}{4})$ i.e. (-7) which is very serious. The main elements lost are structural complexity and some woodland species.

9.4 ECOLOGICAL IMPLICATIONS OF THE CHANGES

In the preceding analysis the greatest falls in ecological value occur with the following changes: Improved grassland to agricultural land (-45%) and deciduous woodland to coniferous woodland (-30%). The largest gain in value occurs when agricultural land is planted with conifers (+55%). The ecological impact of these changes must also take account of their relative extent.

In Table 41 the relative area (Table 26) of each of the changes considered above has been 'weighted' by multiplying it by the change in ecological value. The ecological impact is the difference between the relative area of change and the 'weighted' change.

The impacts of most of these changes are detrimental ecologically. The largest have been underlined. The assessment of the first change may be inaccurate because the true proportion of more valuable non-agricultural land is unknown. The change from improved grassland to agricultural land therefore appears the most serious. As a result of these ten changes a drop in value for wildlife of 13% is indicated, in the lowland area.

TABLE 41: Ecological impacts of the main changes

Habitat Change	Proportion of total interchange %	'Weighted' change	Ecological impact
Agriculture → non-agriculture	23.4	19.5	-3.9
Improved grassland → coniferous woodland	6.5	5.5	-1.0
Improved grassland → agriculture	5.9	3.2	-2.7
Deciduous woodland → coniferous woodland	5.1	3.6	-1.5
Felled areas → coniferous woodland	4.8	4.6	-0.2
Deciduous woodland → felled areas	3.6	2.6	-1.0
Non-agriculture → agriculture	3.4	4.0	+0.6
Agriculture → coniferous woodland	2.8	4.4	+1.6
Coniferous woodland → scrub	2.6	2.7	+0.1
Scrub → deciduous woodland	2.2	2.2	-
TOTAL	60.3	52.3	-8.0

$$\text{'Weighted' change} = \text{proportion of total interchange} \; X \; \frac{\text{ecological value of early habitat}}{\text{ecological value of recent habitat}}$$

underlined impacts = most important changes for wildlife

A provisional analysis was extended to all interchanges involving the habitats evaluated in Chapter 8. The resultant impacts are presented in Appendix 5. An indication of whether the impact of the other changes is likely to be beneficial or detrimental has been given based on the table of nature conservation values in 'Nature Conservation and Agriculture' (NCC 1977). The changes assessed constitute 75% of all interchange. Again a detrimental net impact is indicated though it is slightly less (9%) than that for the ten changes in Table 41. However the impact is likely to be more serious because in four of the five habitats not assessed, dwarf shrub heath, permanent unimproved grassland, wetland and open water, a net loss in both area (Table 18) and ecological value is indicated A more detailed study of the first three of these habitats is clearly desirable to determine whether the indications from this study are valid.

Some further impacts in Appendix 5 rank alongside those in Table 41. They are loss of deciduous woodland to agriculture and gains from agricultural land and non-agricultural land to scrub.

Overall, although some of the changes may be seen as beneficial, the changes of the last 30 years have been detrimental for wildlife.

SECTION 4 CONCLUSIONS

The object of this section is to provide comment on the significance of post-war wildlife habitat changes in the light of the results of the last three sections.

In Chapter 10 the conclusions to each section are first summarised and areas where further research would be worthwhile are indicated.

CHAPTER 10 CONCLUSIONS

> Where has all the old nature gone? What became of the wild, writhing inapproachable mass of the life of the world and what happened to our old, panicky excitement about it? Just in fifty years, since I was a small boy in a suburban town, the world has become a structure of steel and plastic, intelligible and diminished...Now...at night I can hear the soft sound of cement, moving like incoming tide down the Sunrise Highway from New York.
>
> If you fly around the earth and keep looking down you will see that we have inserted ourselves everywhere. All fields are tilled. All mountains have been climbed...The fish are all trapped and domesticated, farmed in zoned undersea pastures. As for the animals...soon the only survivors will be the cattle and the sheep for the feeding of us, and the dogs and the cats in our houses...And the rats and the roaches, and a few reptiles.
>
> The winged insects are vanishing, the calcium in the shells of eggs, and the birds.
>
> We have dominated and overruled nature, and from now on the earth is ours, a kitchen garden until we learn to make our own chlorophyll and float it out in the sun inside plastic membranes...
>
> We will have everything under control, managed. Then what do we do?
>
> (Lewis Thomas, 1981)

10.1 SECTION 1

10.1.1 Introduction

Opinions about the effects of the recent land-use changes on wildlife in Scotland had been based on circumstantial and fragmentary evidence. Firstly information about the extent of such changes was lacking. Secondly there was little appreciation of the historical factors which had moulded the array of wildlife habitats and hence little evidence of the rate and scale of past changes. Thirdly the relative value of different habitats as wildlife refuges was a matter of speculation. Finally some of the public concern over the recent changes may be the result of sentimental attachment to the old landscape.

10.1.2 The NCC project

There was even less information about habitat changes in Scotland than

England. Recognising this, the NCC sponsored a survey in 1978 to measure post-war wildlife habitat changes in the lowland agricultural area of Scotland using a comparative air survey technique.

The results revealed a more complex picture than had been expected. They confirmed that there had been widescale changes in the areas of habitats but the changes were rarely unidirectional. Some losses and gains were only significant at the local level or the Regional level. However many of the changes identified in the sample area could not be extrapolated with confidence to the total area being sampled. From the myriad of District and Regional results, the following changes were the largest and the estimates most reliable.

(i) Hedgerows - one quarter lost overall - a higher proportion in arable areas.

(ii) Improved rough grassland - a 36% decline in area.

(iii) Deciduous woodland - a 17% decline in area.

(iv) Non-agricultural land - a 22% increase in area.

(v) Conifer woodland - a 77% increase in area.

Eight percent of the total lowland area had changed, almost one-quarter of this due to the conversion of agricultural to non-agricultural land. The main causes of the changes were not agricultural reclamation and intensification of agricultural techniques as had been expected but urbanisation/industrialisation and afforestation with agricultural reclamation third.

10.2 SECTION 2

A literature search revealed that the Scottish countryside had been in a state of flux since the last Ice Age. The natural or post-glacial 'climax'-forest had been almost entirely cleared by the Middle Ages. In the resultant open, almost tree-less landscape, the main refuge for wildlife was probably unreclaimed rough grazing land (Roy's 1760 maps of East Lothian indicated that one-third was roughland and only 5% woodland). The change seems to have occurred gradually and in a piecemeal fashion over many centuries and such wildlife as could adapt to the new conditions had time to do so. There have been two periods since of what must have been, by comparison, exceedingly rapid change - The Improvements era (1750 - 1850) and the last 50 years. The recent phase of changes had begun in the war years and the rate of change measured in East Lothian between 1932 and 1949 was greater than the rate of change in the period since then.

The scale of changes in the Improvements era was equally as large as that in the recent period. The large areas of previously unreclaimable land were put to agricultural use but there were gains in the area of woodlands and hedgerow. Though the roughlands (wetland, scrub, permanent grassland and heathland) would never have evolved the ecological complexity of primary woodland, their stability over many centuries would make them valuable wildlife habitats. The 84% decline in the area of roughland in East Lothian must have had a serious impact on the wildlife which had adapted to this area over these centuries.

The debate as to whether the recent changes are the greatest in history is incidental. The trends over the last 200 years should give the greatest cause for concern. Agricultural reclamation and intensification, urbanisation and industrialisation and afforestation were all initiated in the Improvements era and look set to continue. In this period in East Lothian, the area of agricultural land rose from 37% to 76% of the lowland area.

10.3 SECTION 3

10.3.1 Ecological evaluation

The intrinsic ecological values of the habitats involved in the main changes in Section 1 were assessed. The criteria chosen led to the conclusion that none were of a very high value (in subjective rating the highest value awarded was 20½ out of a possible 28). There were two main reasons for this both of which are a result of man's activities:

(i) Most of the sites visited were 'young' in ecological terms or maintained at an intermediate stage of the natural succession. For example, most of the deciduous woodland sites were planted probably 150 to 200 years ago (mostly with beech) and had not yet built up the complexity associated with natural woodland.

(ii) The predominance of agricultural land round about and the distance from the similar semi-natural habitats, which could often act as seed sources, often resulted in a flora composed of generalists rather than one specific to that habitat type.

These reasons are, of course, inter-related.

The more valuable sites were those where natural succession was occurring or where a recent history of less intense management had allowed a degree of complexity and stability to develop. These were: scrub, deciduous woodland, hedges, improved grassland and some non-agricultural land. All had specialists amongst their flora and many have potential to develop greater wildlife interest.

Sites which had been under continual, low-key management over a longer period were the most valuable, for example, the scrub woodland site in East Lothian and the improved grassland site in Figure 9. At newer sites it is uncertain how long it will take for the characteristics associated with primary or semi-natural vegetation to develop particularly in view of (ii) above.

10.3.2 Ecological implications of the changes

The changes which have had the most detrimental ecological impact (change in area and change in ecological value) were:

(i) agricultural land to non-agricultural land
(ii) improved grassland to agricultural land
(iii) deciduous woodland to coniferous woodland.

A few of the changes had had a beneficial impact. The most marked of these were:

(i) agricultural land to coniferous woodland
(ii) non-agricultural land to scrub.

These gains are encouraging but in the six largest changes (by area) all involve the replacement of a habitat of greater value with one of lesser value. Overall a fall of 9% in ecological value was estimated but this fall would almost certainly have been greater had it been possible to include wetland, permanent grassland and dwarf shrub heath. No assessment of the ecological value of these habitats has been made in the present study but the NCC (1977) rate them highly.

10.4 EFFECT OF THE CHANGES ON LANDSCAPE

The effect of the changes on landscape appearance has not been evaluated. Landscape appreciation is highly personal and hence difficult to evaluate. Some (perhaps farmers) prefer a well structured, tidy landscape with no untamed corners. Some prefer the wide open spaces of the uplands. Indeed in the lowland area, the sites which seemed most valuable ecologically had an air of wildness and untidiness about them e.g. scrub sites, wasteland and the improved grassland site in Figure 9. However, that said, the prevailing opinion about the lowland area (if only because of what we are used to) is that it should be varied: a mixture of the open (e.g. agricultural land) and closed (e.g. woodland) with structural diversity enhanced by hedges and tree-lines. These last elements have declined in the last 30 years and the trend is towards fewer, more discreet blocks of land-use types (see Figure 22).

10.5 FURTHER RESEARCH

10.5.1 Air Photo-interpretation

The sampling procedures adopted by the NCC study were adequate to estimate changes in the commonest habitat types. Some of the habitats with potentially high wildlife value occur infrequently. In consequence the changes recorded on the sample photographs could not be assumed, with any confidence, to be representative. It is clear that a more intensive study of permanent grassland and dwarf shrub heath is needed. With wetland the net change estimate was unreliable because there had been large gains as well as large losses. A more intensive study of this habitat type is also required.

One habitat type in particular proved to be very heterogenous in its wildlife values (non-agricultural land) and should be sub-divided in any further studies of this kind,

10.5.2 Historical research

The search of the records for East Lothian proved a very valuable exercise. But the important historical factors that have operated in East Lothian may not be representative of lowland Scotland as a whole: changes may have been more drastic owing to the favourable growing conditions and the proximity to cultural centres. It would be worthwhile studying an area where livestock rearing is more predominant e.g. Kyle and Carrick and an area more remote from a city e.g. Wigtown.

Historical research may be of particular value to wildlife conservation when it identifies areas that have escaped intensive management over long periods e.g. the area south-west of Gladsmuir in Figure 21F (i).

10.5.3 Ecological research

The assessment of ecological value presented here is based on less than the minimum number of sites deemed desirable at the planning stage. If it becomes possible to rectify this deficiency, the work should also be extended to the areas noted in 10.5.1 above. Some may be vestiges of the roughland which covered extensive areas before the Improvements era. An indication of their value could be seen in the improved grassland site in Figure 9. For instance, small areas of wetland there carried a remarkably rich specialised flora.

The fieldwork was spread over summer months and this lack of synchrony may have allowed seasonal variation to influence the estimates of species diversity. It would be useful to know how important seasonal changes might be.

An ecological survey which includes fieldwork on fauna as well as flora is clearly desirable in assessing 'ecological value'. Dalkeith Oakwood has been designated an SSSI for the insect fauna associated with old oaks, despite the fact that it is open and grazed and has a ground flora quite unrepresentative of oakwoods.

In the situation revealed in lowland Scotland, relics of semi-natural vegetation are of more than usual importance as sources of biota that can spread to the generally impoverished habitats dispersed through the predominantly agricultural land.

Ideally a net-work of semi-natural habitats should be maintained which could serve each other in this way, (the parkland and policies of country estates seem particularly valuable in this respect). Although natural succession may be occurring on wasteland areas, more specialised plants may be slow to arrive because of their isolation from other semi-natural areas. It would be worthwhile researching the possibilities of re-creating natural habitats on unused areas, for example, Pepper Wood SSSI in Edinburgh District is valued for its collection of rare plants and naturalised aliens established 150 years ago by a keen local botanist (NCC 1975). Meanwhile, time (after freedom from intense management) is undoubtedly the most important factor in enabling all the attributes associated with natural ecosystems to develop.

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ABBREVIATIONS USED IN APPENDICES

Appendix 1

$$\text{CL\%} = \frac{\text{Upper 95\% Confidence Limit - mean}}{\text{mean}}\ \%$$

Appendix 3

Main changes (area) are those $>$ 10,000 ha in extent

Main changes (proportion) are those $>$ 15% of early area

Net loss area - main net losses in area
Net loss proportion - main net losses (proportions)
Net gain area - main net gain in area
Net gain prop. - main net gains (proportions)
Loss area - main individual losses in area
Loss proportion - main individual losses (proportions)
Gain area - main individual gain in area
Gain proportion - main individual gains (proportions)
1 - Deciduous woodland
2 - Coniferous woodland
3 - Mixed woodland
4 - Felled areas
5 - Scrub
6 - Dwarf shrub heath
7 - Permanent unimproved grassland
8 - Improved rough grassland
9 - Wetland
10 - Open water
11 - Agricultural land
12 - Non-agricultural land

Appendix 4

Decid. - Deciduous woodland
Conif. - Coniferous woodland
Mixed - Mixed woodland
Felled - Felled areas
D.S. Heath - Dwarf shrub heath
P. Grass/V. Grass - Permanent unimproved grassland
P.I.Grass/I.Grass - Improved rough grassland
O. water - Open water
Agric. - Agricultural land
Non-agric. - Non-agricultural land

All Appendices

* Less reliable estimate

Upper line: Early area of Habitat Types in each District and Region (in hectares) Lower line: CL% for each estimate.

Habitat → District or REGION ↓	Deciduous wood	Coniferous wood	Mixed wood	Felled areas	Scrub	Dwarf shrub heath	Permanent unimproved grassland	Improved rough grass	Wetland	Open water	Agricultural land	Non-Agricultural land
Berwick	1917·1 44·4	885·2 57·4	1011·6 54·1	480·1 52·2	739·0 58·0	324·0 112·6*	913·1 66·0	2634·9 37·6	225·5 90·3	178·7 80·0	54870·1 4·5	2750·6 22·41
Roxburgh	2287·8 40·1	2539·6 83·8	1078·6 44·8	691·4 66·3	256·4 37·8	441·5 121·3*	600·0 71·7	2335·9 53·4	665·4 40·0	512·6 67·3	51314·2 5·6	1622·5 27·5
Ettrick & Lauderdale	2799·1 60·0	1044·6 38·9	1302·4 48·1	699·6 49·0	517·9 48·7	292·7 161·7*	379·8 44·5	4053·6 73·8	447·6 110·9*	588·0 60·0	40440·0 13·4	6752·5 82·3
Tweeddale	860·5 90·0	1583·4 45·8	554·0 62·9	311·1 93·0	73·2 79·6	62·2 192·6*	97·7 200·6	777·9 66·7	180·7 88·7	243·5 97·5	15217 21·3	1782·6 109·8*
BORDERS	7864·5 28·0	6057·8 39·0	3946·6 26·0	2182·2 32·0	1586·5 32·0	1090·4 72·0	1990·6 39·0	9802·3 35·0	1519·2 41·0	1522·8 37·0	161841·1 4·0	129482·2 46·0
East Lothian	3873·8 31·1	1055·4 58·8	1167·4 81·0	147·2 84·1	800·5 31·8	271·5 190·8*	888·8 90·0	2093·8 62·6	171·6 104·4*	71·0 80·3	41933·8 6·3	2692·2 36·5
Midlothian	2440·5 91·1	309·4 52·3	840·9 59·0	122·1 92·7	166·3 65·8	3·4 200·0*	5·2 150·0*	572·3 79·1	151·8 105·9*	143·1 132·6*	22239·3 13·3	1702·8 53·4
West Lothian	1070·0 59·7	360·0 68·6	95·6 83·6	1·1 609·1**	211·7 138·6*	171·0 143·0*	6·4 167·2*	1170·0 164·6*	357·1 104·1*	199·5 116·6*	19242·8 24·4	4677·7 64·0
LOTHIAN	7384·3 35·0	1400·8 46·0	2103·9 51·0	270·4 62·0	1178·5 34·0	445·9 128·0	900·4 89·0	3836·1 62·0	680·5 65·0	413·6 74·0	83415·9 7·0	9072·7 36
North East Fife	1985·5 33·4	2084·3 51·6	188·4 84·1	92·6 88·4	1192·9 45·2	691·4 91·2	1019·8 208·4*	4748·3 47·4	240·1 65·0	416·2 91·6	56990·9 5·0	4063·8 36·0
Kirkcaldy	1099·5 50·4	205·0 58·0	122·8 70·8	82·6 123·8*	162·5 51·0	0·0 0·0	116·6 119·2*	1670·3 138·0*	1381·7 77·2	256·6 69·2	17967·7 14·7	1940·7 28·4
Dunfermline	2386·8 27·6	231·5 182·9*	241 300·8*	173·9 59·2	202·3 94·2	98·5 197·9*	13·7 116·0*	1094·3 100·9*	398·2 81·6	126·4 235·2**	19872·1 10·1	3619·8 53·5
FIFE	5471·8 20·0	2520·8 46·0	335·3 58·0	349·1 48·0	1557·7 37·0	790·2 84·0	1150·1 185·0	7512·9 45·0	2020·0 56·0	799·2 64·0	94830·7 5·0	9624·3 26·0
Falkirk & Clackmannan	2324·4 47·0	383·7 96·0	301·3 71·0	65·6 71·0	477·0 81·0	2·6 148·0*	0·0 0·0	333·4 64·0	80·4 114·0*	723·0 147·0*	25517·7 10·0	6003·9 29·0
Stirling	3232·7 26·9	979·2 54·5	1074·8 70·6	1055·5 87·5	532·4 44·6	166·3 196·9*	2·7 166·7*	1069·9 43·2	1619·8 36·4	1643·2 147·2*	33804·3 11·0	3872·2 65·8
CENTRAL	5557·1 25·0	1362·9 48·0	1376·1 57·0	1121·1 82·0	1009·4 45·0	218·9 97·0	2·7 163·0	1403·3 36·0	1700· 35·0	2366·2 112·0	59322·0 8·0	9876·1 31·0
Annandale & Eskdale	2033·1 50·8	2256·7 42·6	476·1 66·8	1245·8 62·8	399·6 51·2	188·9 125·9*	46·0 117·6*	2566·4 44·1	1653·9 45·2	684·4 48·6	49149·9 5·7	2829·2 18·6
Nithsdale	2856·1 32·8	2497·0 78·8	891·6 128·0*	390·7 71·6	518·6 41·3	127·7 97·0	0·0 0·0	1518·4 38·2	3283·3 50·0	634·8 81·2	50170·5 73·0	4856·9 52·7
Stewartry	3138·8 36·3	2136·5 75·1	624·0 89·1	406·7 89·9	1100·0 27·8	118·7 147·8*	238·8 156·2*	3823·1 74·2	5047·7 33·3	1166·1 60·1	50732·8 8·2	2184·3 24·0
Wigtown	2501·9 43·8	215·6 72·6	136·0 118·1*	141·1 89·6	928·5 32·0	3·0 190·0*	280·7 112·9*	2100·9 33·0	2082·2 28·2	489·4 64·1	60528·8 3·8	3707·9 27·2
DUMFRIES & GALLOWAY	10529·9 20·0	7105·8 38·0	2157·7 62·0	2184·3 42·0	2946·7 18·0	437·8 73·0	565·5 87·0	10008·8 32·0	12066·6 21·0	2974·7 33·0	210582·0 3·0	13578·3 21·0
Lanark	1326·6 35·5	979·4 40·2	110·6 77·1	428·2 47·0	466·8 45·1	501·6 56·7	0·0 0·0	1718·0 51·9	1405·3 30·8	544·8 35·3	37066·9 5·9	4649·8 33·5
Kyle & Carrick	3260·9 30·3	1201·5 79·2	26·4 94·3	326·4 60·1	731·8 30·6	48·0 168·8*	0·0 0·0	1172·1 59·1	2601·5 74·1	347·2 54·2	43361·4 8·2	4404·9 77·6
Cumnock & Doon Valley	1109·1 43·3	466·7 85·4	334·6 151·7*	283·8 67·3	156·5 56·0	20·1 194·5*	6·8 205·9*	688·0 88·9	986·5 69·3	510·2 105·8*	24230·7 7·6	1671·8 48·7
Cunninghame	1034·2 36·4	16·0 77·5	11·3 128·3*	13·8 165·9*	292·1 74·2	63·2 146·7*	0·0 0·0	244·0 121·1*	393·6 87·6	340·9 123·0*	20972·0 7·9	4277·8 30·4
East Strathclyde	3555·4 26·0	119·4 57·0	40·8 89·0	309·7 89·0	841·1 34·0	354·4 67·0	0·0 0·0	1049·4 56·0	1127·6 48·0	491·5 42·0	37266·1 8·0	13795·6 20·0
West Strathclyde	2822·8 22·0	567·1 33·0	114·1 69·0	325·8 51·0	858·6 39·0	147·4 158·0*	3·4 132·0*	2146·8 51·0	2655·0 31·0	1123·0 70·0	62491·0 7·0	13684·0 31·0
STRATHCLYDE	13109·0 13·0	3950·1 30·0	637·8 82·0	1687·7 28·0	3346·9 18·0	1091·5 41·0	10·2 144·0	7018·3 26·0	10469·5 25·0	3357·6 33·0	225388·1 3·0	42483·9 15·0
Perth & Kinross	10135·8 21·2	6731·5 40·7	805·8 70·7	1119·3 64·6	1986·1 48·8	765·0 51·7	0·0 0·0	2537·2 44·3	847·6 65·7	1755·6 40·7	110849·3 4·5	8092·7 28·6
Angus	4377·7 26·7	1678·6 48·3	459·4 123·4	655·9 109·8*	948·4 39·5	1130·3 85·6	0·0 0·0	1978·2 58·7	873·6 120·4*	409·7 84·8	80841·0 4·5	6767·1 41·8
TAYSIDE	14513·5 17·0	8410·1 34·0	1265·2 68·0	1775·2 57·0	2934·5 35·0	1895·3 55·0	0·0 0·0	4515·4 36·6	1321·2 60·0	2165·3 37·0	191690·3 3·0	14859·8 25·0
WHOLE SURVEY AREA	64430·1	30808·3	11822·6	9569·8	14560·2	5970·0	4619·5	44097·1	29777·2	13599·4	1027070·3	112443·3

Upper line: Recent area of Habitat Types in each District and Region (in hectares) Lower line: CL% for each estimate.

Habitat → District or REGION ↓	Deciduous wood	Coniferous wood	Mixed wood	Felled areas	Scrub	Dwarf shrub heath	Permanent unimproved grassland	Improved rough grass	Wetland	Open water	Agricultural land	Non-Agricultural land
Berwick	1454.4 49.1	2125.8 46.0	650.4 36.2	180.1 35.5	730.9 58.1	18.2 161.0 *	641.5 68.8	2078.2 34.3	245.4 85.2	174.6 82.0	55732.8 4.3	2897.2 23.8
Roxburgh	1837.8 43.1	3770.6 59.5	724.8 42.7	651.2 41.9	305.3 43.4	123.1 142.6 *	395.2 81.3	1805.8 47.3	720.3 42.9	510.3 67.7	51846.1 5.1	1665.5 28.0
Ettrick & Lauderdale	2326.6 62.4	2103.1 37.6	1453.5 54.7	334.7 64.2	671. 66.9	58.0 184.3 *	276.3 84.7	3675.6 87.0	441.9 106.5 *	582.5 59.6	39538.1 15.8	7861.4 80.9
Tweeddale	798.7 93.7	1521.8 53.1	486.9 71.1	465.4 85.8	137.0 55.8	56.8 73.4	130.6 202.8 *	570.5 110.2	184.4 100.8 *	242.0 99.2	15187.2 22.8	1962.6 109.6 *
BORDERS	6417.7 30.0	9521.3 28.0	3315.6 29.0	1631.4 33.0	1844.3 34.0	256.1 83.0	1443.6 45.0	8130.1 42.0	1592.5 40.0	1509.4 37.0	162304.2 5.0	14386.7 47.0
East Lothian	3124.8 32.2	2152.4 61.0	1388.9 73.4	478.8 61.3	637.9 47.2	3.3 218.2 *	851.4 90.1	1169.7 77.1	203.3 94.6	69.2 83.5	42284.4 6.2	2802.7 35.6
Midlothian	2176.3 100.6 *	631.8 61.7	775.9 57.0	200.0 68.9	184.2 73.4	0.7 200.0 *	5.2 150.0 *	389.5 50.7	156.6 97.8	142.9 132.9 *	21540.1 4.0	2493.8 60.3
West Lothian	955.9 56.4	109.6 152.5	104.9 91.1	68.7 103.6 *	288.3 79.4	168.4 145.0	1.2 208.3 *	814.7 154.8 *	288.2 76.6 *	158.3 145.6 *	18536.1 25.8	5742.7 63.0
LOTHIAN	6257.0 39.0	2893.8 48.0	2269.7 49.0	747.5 44.0	1110.4 36.0	172.4 142.0 *	857.8 90.0	2373.9 66.0	648.1 51.0	370.4 82.0	82362.6 8.0	11039.2 37.0
North East Fife	1434.7 36.4	4802.2 65.4	210.1 72.9	583.6 62.6	1028.9 38.3	29.9 135.8 *	40.2 219.6 *	2664.3 51.9	273.8 64.3	380.8 97.8	57201.0 4.5	5064.7 49.2
Kirkcaldy	718.1 55.1	906.7 66.3	337.5 120.3 *	227.0 58.4	161.4 56.1	0.0 0.0	37.3 79.9	1164.9 174.5 *	1174.0 70.0	244.5 77.5	15676.8 14.0	4357.7 79.8
Dunfermline	1685.0 47.4	790.3 139.2 *	323.7 79.9	187.9 109.3 *	297.5 25.4	0.0 0.0	13.7 116.0 *	204.2 107.7 *	336.6 96.7	109.9 216.1 *	20139.2 10.0	4153.5 33.0
FIFE	3837.8 26.0	6499.2 52.0	871.3 58.0	998.5 44.0	1487.8 28.0	29.9 136.0	91.2 104.0	4033.4 61.0	1784.4 50.0	735.2 65.0	93017.0 4.0	13575.9 33.0
Falkirk & Clackmannan	1732.4 43.6	233.9 96.0	276.3 73.0	261.8 76.0	740.4 69.0	0.0 0.0	0.0 0.0	182.7 94.0	90.6 76.0	709.4 152.0 *	21968.9 14.0	9966.5 25.0
Stirling	2940.0 26.8	2313 52.8	1035.5 81.7	713.8 51.6	402.8 43.1	111.8 95.8	2.7 166.7 *	977.5 60.5	1566.2 42.6	1643.2 147.2 *	33221.7 11.2	4124.7 59.8
CENTRAL	4672.4 23.0	2646.9 48.0	1311.8 66.0	975.6 43.0	1143.2 47.0	111.8 96.0	2.7 163.0 *	1160.2 53.0	1658.8 40.0	2352.6 112.0 *	55190.6 9.0	14091.2 25.0
Annandale & Eskdale	1441.2 41.3	4795.4 28.1	801.3 88.2	426.7 48.7	328.8 36.8	24.1 138.2 *	35.4 127.6 *	1265.6 63.5	1460.7 52.5	674.2 49.8	49156.1 5.5	3120.6 20.4
Nithsdale	2406.2 24.3	4386.7 59.5	1328.4 123.9 *	524.7 69.7	435.0 41.0	2.3 195.6 *	0.0 0.0	698.3 35.6	2422.8 41.2	623.8 81.6	50371.4 6.9	4547.4 52.1
Stewartry	2448.8 45.4	3437.5 60.1	1249.3 107.6 *	200.5 96.0	1028.3 33.6	16.0 160.6 *	231.5 162.5 *	2615.4 78.7	4769.8 34.2	1150.8 57.8	51216.3 7.8	2382.6 24.7
Wigtown	2085.8 50.0	473.8 65.8	69.2 113.3 *	378.4 65.7	1016.7 28.5	2.1 195.2	251.5 125.2 *	1586.5 41.3	1876.9 26.5	499.5 63.1	61283.4 3.4	3589.3 22.1
DUMFRIES & GALLOWAY	8385.0 21.0	13091.4 28.0	3448.2 65.0	1530.3 34.0	2808.8 18.0	44.5 96.0	518.2 88.0	6165.8 38.0	10530.2 20.0	2948.3 32.0	212027.2 3.0	13639.8 19.0
Lanark	1306.1 33.4	1384.0 51.1	107.2 69.9	321.1 50.4	404.0 44.8	325.9 86.3	0.0 0.0	1049.6 54.6	1579.8 22.3	554.5 34.8	36820.3 6.2	5346.1 32.6
Kyle & Carrick	2761.4 22.0	2344.8 73.9	18.4 88.6	185.7 60.5	701.4 33.3	21.6 182.9 *	0.0 0.0	345.2 24.9	1488.4 82.6	343.8 54.9	44213.6 7.7	5014.4 68.6
Cumnock & Doon Valley	1138.5 43.3	513.7 88.1	299.7 173.6 *	128.4 73.4	126.2 54.8	19.3 194.3 *	6.8 205.9	358.7 83.3	787.3 73.0	265.7 43.2	24627.7 7.3	2193.0 58.4
Cunninghame	453.6 39.8	91.2 129.8 *	11.3 128.3 *	16.5 101.8	298.1 40.0	8.9 165.2 *	0.0 0.0	273.4 132.2 *	1140.6 82.2	321.3 123.2 *	20616.9 9.1	4927.1 33.6
East Strathclyde	3481.0 28.0	1302.3 53.0	32.4 89.0	226.0 62.0	912.6 31.0	367.7 77.0	0.0 0.0	609.2 62.0	1171.0 48.0	368.9 40.0	32457.9 12.0	18922.1 22.0
West Strathclyde	2418.7 20.0	950.9 30.0	112.0 74.0	371.3 54.0	761.5 47.0	162.2 13.1 *	3.4 132.0 *	1725.5 53.0	2210.3 34.0	1096.6 70.0	54430.1 8.0	17696.5 30.0
STRATHCLYDE	12059.3 12.0	6586.9 31.0	581.0 92.0	1249.0 26.0	3203.8 17.0	905.6 50.0	10.2 144.0	4361.6 29.0	8377.4 23.0	2950.8 31.0	218166.5 4.0	54099.2 15.0
Perth & Kinross	8480.7 22.8	9839.3 34.8	1176.4 55.5	1061.6 50.7	1434.7 28.2	299.2 112.2 *	0.0 0.0	1149.2 55.2	543.2 70.3	1755.7 40.5	111454.7 4.3	8381.9 23.7
Angus	3112.6 27.8	3555.8 36.9	850.5 74.8	548.2 75.8	1072.0 39.5	518.5 178.3 *	0.0 0.0	702.2 74.9	485.8 120.0 *	408.8 84.9	80738.5 4.7	7727.0 40.4
TAYSIDE	11593.3 17.0	13395.1 27.0	2026.9 48.0	1609.8 42.0	2506.7 23.0	817.7 120.0	0.0 0.0	1901.4 46.0	1029.0 68.0	2164.5 36.0	192192.6 3.0	16108.9 23.0
WHOLE SURVEY AREA	53222.3	54634.6	13824.5	8742.1	14105.0	2338.0	2923.7	28126.4	25618.4	13031.2	1015260.7	136940.9

Early (upper line) and Recent (lower line) areas of Habitat Types expressed as a proportion of Region or District lowland area.

Habitat → District or REGION ↓	Deciduous wood	Coniferous wood	Mixed wood	Felled areas	Scrub	Dwarf shrub heath	Permanent unimproved grassland	Improved rough grass	Wetland	Open water	Agricultural land	Non Agricultural land
Berwick	2.86 2.17	1.32 3.18	1.51 0.97	0.72 0.27	1.10 1.09	0.48 0.03	1.36 0.96	3.94 3.11	0.34 0.37	0.27 0.26	81.98 83.27	4.11 4.33
Roxburgh	3.55 2.86	3.95 5.86	1.68 1.13	1.07 1.01	0.40 0.47	0.64 0.19	0.93 0.61	3.63 2.81	1.03 1.12	0.80 0.79	79.73 80.56	2.58 2.59
Ettrick & Lauderdale	4.72 3.92	1.77 3.55	2.20 2.45	1.18 0.56	0.87 1.13	0.49 0.10	0.64 0.47	6.83 6.20	0.75 0.74	0.99 0.98	68.17 66.65	11.38 13.25
Tweeddale	3.96 3.67	7.28 7.00	2.55 2.24	1.43 2.14	0.34 0.63	0.29 0.26	0.45 0.60	3.58 2.62	0.83 0.85	0.12 1.11	69.98 69.85	8.20 9.03
BORDERS	3.70 3.02	2.85 4.48	1.86 1.56	1.03 0.77	0.75 0.87	0.51 0.12	0.94 0.68	4.62 3.83	0.72 0.75	0.72 0.71	76.21 76.43	6.10 6.77
East Lothian	7.02 5.66	1.91 3.90	2.12 2.52	0.27 0.87	1.45 1.16	049 0.01	1.61 1.54	3.80 2.12	0.31 0.37	0.13 0.13	76.00 76.65	4.88 5.08
Midlothian	8.50 7.58	1.08 2.20	2.93 2.70	0.43 0.70	0.58 0.64	0.01 0.00	0.02 0.02	1.99 1.36	0.53 0.55	0.50 0.50	77.50 75.06	5.93 8.69
West Lothian	3.93 3.51	0.13 0.40	0.35 0.38	0.00 0.25	0.78 1.06	0.63 0.62	0.02 0.00	4.30 2.99	1.31 1.06	0.73 0.58	70.64 68.06	17.17 21.08
LOTHIAN	6.65 5.63	1.26 2.60	1.89 2.04	0.24 0.67	1.06 1.00	0.40 0.16	0.81 0.77	3.45 2.14	0.61 0.58	0.37 0.33	75.08 74.13	8.17 9.94
North East Fife	2.69 1.95	2.83 6.51	0.26 0.28	0.13 0.79	1.62 1.40	0.94 0.04	1.38 0.05	6.44 3.61	0.33 0.37	0.56 0.52	77.31 77.06	5.51 6.87
Kirkcaldy	4.40 2.87	0.82 3.63	0.49 1.35	0.33 0.91	0.65 0.65	0.00 0.00	0.47 0.15	6.68 4.66	5.53 4.70	1.03 0.98	71.85 62.69	7.76 17.43
Dunfermline	8.45 5.97	0.82 2.80	0.02 1.15	0.62 0.67	0.72 1.05	0.35 0.60	0.05 0.05	3.87 0.72	1.41 1.19	0.45 0.39	70.36 71.31	12.82 14.71
FIFE	4.31 3.02	1. 5.12	0.26 0.69	0.27 0.79	1.23 1.17	0.62 0.02	0.90 0.07	5.92 3.18	1.59 1.40	0.63 0.58	74.69 73.26	7.58 10.69
Falkirk & Clackmannan	6.41 4.78	1.06 0.92	0.83 0.76	0.18 0.72	1.32 2.04	0.15 0.60	0.00 0.00	0.92 0.50	0.22 0.25	1.99 1.96	70.37 60.58	16.56 27.48
Stirling	6.59 5.99	2.00 4.72	2.19 2.11	2.15 1.46	1.09 0.82	0.34 0.23	0.01 0.01	2.18 1.99	3.30 3.19	3.35 3.35	68.91 67.73	7.89 8.41
CENTRAL	6.51 5.48	1.60 3.10	1.61 1.54	1.31 1.14	1.18 1.34	0.26 0.13	0.00 0.00	1.64 1.36	1.99 1.94	2.77 2.76	69.53 64.69	11.53 16.52
Annandale & Eskdale	3.20 2.27	3.55 7.55	2.75 1.26	1.96 0.67	0.63 0.52	0.30 0.04	0.07 0.06	4.04 1.99	2.60 2.30	1.08 1.06	77.36 77.37	4.45
Nithsdale	4.22 3.55	3.69 6.47	1.32 1.96	0.58 0.77	0.77 0.64	0.19 0.60	0.00 0.00	2.24 1.03	4.85 3.58	0.94 0.92	74.04 74.35	7.17 6.71
Stewartry	4.44 3.46	3.02 4.86	0.92 1.77	0.57 0.28	1.55 1.45	0.17 0.02	0.34 0.33	5.40 3.70	7.13 6.74	1.65 1.63	71.71 72.39	3.09 3.37
Wigtown	3.42 2.86	0.29 0.65	0.19 0.09	0.19 0.52	1.27 1.39	0.00 0.00	0.38 0.34	2.87 2.17	2.85 2.57	0.67 0.68	82.78 83.82	5.07 4.91
DUMFRIES & GALLOWAY	3.83 3.05	2.58 4.76	0.78 1.25	0.79 0.56	1.07 1.02	0.16 0.02	0.21 0.19	3.64 2.24	4.39 3.83	1.08 1.07	76.54 77.06	4.94 4.96
Lanark	2.70 2.65	1.99 2.81	0.22 0.22	0.87 0.65	0.95 0.82	1.02 0.66	0.00 0.00	3.49 2.13	2.86 3.21	1.11 1.13	75.34 74.84	9.45 10.87
Kyle & Carrick	5.68 4.81	2.09 4.08	0.05 0.03	0.57 0.32	1.27 1.22	0.01 0.04	0.00 0.00	2.04 0.60	4.53 2.59	0.60 0.60	75.49 76.97	7.67 8.73
Cumnock & Doon Valley	3.64 3.74	1.53 1.69	1.10 0.98	0.93 0.42	0.51 0.41	0.07 0.06	0.02 0.02	2.26 1.18	3.24 2.58	1.67 0.87	79.54 80.84	5.49 7.20
Cunninghame	3.61 3.33	0.06 0.32	0.04 0.04	0.05 0.06	1.02 1.04	0.22 0.03	0.00 0.00	0.85 0.95	4.86 3.98	1.19 1.12	73.18 71.94	14.93 17.19
East Strathclyde	5.94 5.82	1.20 2.18	0.07 0.05	0.52 0.38	1.41 1.52	0.59 0.61	0.00 0.00	1.75 1.02	2.39 1.96	0.82 0.62	62.26 54.23	23.05 31.62
West Strathclyde	3.25 2.78	0.65 1.09	0.13 0.13	0.37 0.43	0.99 0.88	0.17 0.19	0.00 0.00	2.47 1.98	3.05 2.54	1.29 1.26	71.88 68.36	15.74 20.36
STRATHCLYDE	4.19 3.86	1.26 2.11	0.20 0.19	0.54 0.40	1.07 1.03	0.35 0.29	0.00 0.00	2.25 1.40	3.35 2.68	1.07 0.94	72.11 69.80	13.59 17.31
Perth & Kinross	6.96 5.82	4.62 6.76	0.55 0.81	0.77 0.73	1.36 0.99	0.53 0.21	0.00 0.00	1.74 0.82	0.58 0.37	1.28 1.21	76.12 76.53	5.56 5.76
Angus	4.39 3.12	1.68 3.57	0.46 0.85	0.66 0.55	0.95 1.07	1.13 0.52	0.00 0.00	1.98 0.70	0.47 0.49	0.41 0.41	81.07 80.97	6.79 7.75
TAYSIDE	5.92 4.73	3.43 5.46	0.52 0.83	0.72 0.66	1.20 1.02	0.77 0.33	0.00 0.00	1.84 0.77	0.54 0.42	0.88 0.88	78.13 78.34	6.06 6.57
WHOLE SURVEY AREA	4.70 3.89	2.25 3.99	0.86 1.01	0.70 0.64	1.06 1.03	0.44 0.17	0.34 0.21	3.22 2.05	2.17 1.87	0.99 0.95	75.04 74.17	8.21 10.00

APPENDIX 2A Upper line: Net change in area to each Habitat Type (hectares)

Habitat → District or REGION ↓	Deciduous wood	Coniferous wood	Mixed wood	Felled areas	Scrub	Dwarf shrub heath
Berwick	-462.6 -241	1240.6 140.2	-361.2 *-35.7	-300.0 -62.5	-8.1 *-1.1	-305.8 *-94.4
Roxburgh	-450.0 -19.7	1230.9 48.5	-353.7 -32.8	-40.2 *-5.8	48.9 *19.1	-288.4 *-70.1
Ettrick & Lauderdale	-472.5 -16.9	1053.4 100.4	151.1 *11.6	-364.9 -52.2	153.2 *29.6	-234.7 *-80.2
Tweeddale	-61.8 -7.2	-61.5 *-3.9	-67.1 *-12.1	154.3 *49.6	63.8 87.2	-5.4 *-8.7
BORDERS	-1446.9 -18.4	3463.4 57.2	-630.9 -16.0	-550.8 *-25.2	257.8 *16.2	-834.3 -76.5
East Lothian	-749.0 *-19.3	1097.0 *103.9	221.6 *19.0	331.7 225.4	-162.6 *-20.3	-268.2 *-98.8
Midlothian	-264.1 -10.8	322.3 *104.2	-65.0 *-7.7	77.9 *63.8	17.9 *10.8	-2.7 *-79.0
West Lothian	-114.1 *-10.7	73.6 *204.3	9.2 *9.6	67.6 *6059.2	76.6 *36.2	-2.5 *-1.5
LOTHIAN	-1127.2 -15.3	1492.9 106.6	165.8 7.9	477.2 176.5	-68.1 *5.8	-273.4 *-61.3
North East Fife	-550.8 -27.7	2719.9 130.4	21.7 *11.5	491.0 530.6	-164.0 *13.8	-661.5 -95.7
Kirkcaldy	-381.4 -34.7	701.7 342.3	214.7 *174.8	144.4 *174.9	-1.0 *-0.6	0.0 0.0
Dunfermline	-701.7 -29.4	559.3 *241.7	299.6 1240.8	14.0 *8.0	95.2 *47.0	-98.8 *-100.0
FIFE	-1633.9 -29.9	3978.9 157.8	536.0 159.9	649.4 186.0	-69.8 *-4.5	-760.3 -96.2
Falkirk & Clackmannan	-592.0 -25.5	-49.8 *-13.0	-25.0 *-8.3	196.2 299.1	263.4 55.2	-52.6 *-100.0
Stirling	-292.7 *-9.1	1333.9 136.2	-39.3 *-3.6	-341.7 *-32.4	-129.6 -24.4	-54.4 *-32.7
CENTRAL	-884.7 -15.9	1284.1 94.2	-64.3 *-4.7	-145.5 -13.0	133.8 *13.3	-107.0 *-48.8
Annandale & Eskdale	-591.9 *-29.1	2538.7 112.5	325.2 *68.3	-819.0 -65.7	-70.7 -17.7	-164.9 *-87.3
Nithsdale	-449.8 *-15.8	1887.7 75.6	436.7 *50.0	134.0 *34.3	-83.5 -16.1	-125.0 -98.2
Stewartry	-690.0 -22.0	1301.7 *60.9	595.3 *91.0	-206.1 *-50.7	-71.7 -6.5	-102.7 *-86.5
Wigtown	-413.1 -16.5	258.2 119.8	-66.8 *-49.2	237.3 *168.2	88.2 9.5	-0.8 *-28.2
DUMFRIES & GALLOWAY	-2144.8 -20.4	5985.7 84.2	1290.4 *59.8	-653.8 -29.9	-137.7 *-4.7	-393.4 -89.9
Lanark	-20.5 *-1.5	404.6 *41.3	-3.4 *-3.0	-107.1 *-25.0	-62.8 -13.4	-175.7 -35.0
Kyle & Carrick	-499.4 *-15.3	1143.3 95.2	-8.0 *-30.2	-140.7 -43.1	-30.3 -4.1	16.8 *350.1
Cumnock & Doon Valley	+29.4 *2.6	47.0 *10.1	-34.9 *-10.4	-155.4 -54.8	-30.3 -19.4	-0.8 *-4.1
Cunninghame	-80.6 -7.8	75.2 *468.9	0.0 0.0	2.7 *19.4	6.0 2.1	-54.4 *-86.0
East Strathclyde	-74.4 *-2.1	582.9 81.0	-8.4 *-20.6	-83.7 *-27.0	71.5 8.5	13.3 *3.7
West Strathclyde	-404.1 -14.3	383.8 67.69	-2.1 *-1.8	45.5 *14.0	-97.1 -11.3	4.8 *10.0
STRATHCLYDE	-1069.6 -8.0	2638.8 66.8	-56.8 -8.9	-438.7 -26.0	-143.0 *-43	-186.0 -17.0
Perth & Kinross	-1655.1 -16.3	3107.8 46.2	370.7 *46.0	-57.7 *-5.2	-551.4 -27.8	-465.8 -60.9
Angus	-1265.0 -28.9	1877.2 111.8	391.2 85.2	-107.7 *-16.4	123.6 13.0	-611.8 -54.1
TAYSIDE	-2920.1 -20.1	4985.0 59.3	761.9 60.2	-165.4 *-9.3	-427.8 *-14.6	-1077.6 -56.9
WHOLE SURVEY AREA	-11207.8 -17.4	+23826.3 +77.3	+2001.9 +16.9	-827.7 -8.7	-455.2 -3.1	-3632.0 -60.8

Lower line: Net change expressed as a percentage of Early area. APPENDIX 2A

Habitat → District or REGION ↓	Permanent Unimproved grassland	Improved rough grass	Wetland	Open water	Agricultural land	Non-Agricultural land
Berwick	-271.7 -29.8	-556.7 -21.1	20.4 *9.0	-4.9 *-2.3	862.7 1.6	146.6 5.3
Roxburgh	-204.9 -34.1	-530.0 -22.7	54.9 *8.2	-2.4 *-0.5	531.9 *1.0	3.0 *0.2
Ettrick & Lauderdale	-103.5 *-27.2	-378.0 *-9.3	-5.7 *-1.3	-5.6 *-1.0	-901.8 *-2.2	1108.9 *16.4
Tweeddale	32.9 *33.6	-207.4 *-26.6	3.7 *2.0	-1.5 *-0.6	-29.9 *-0.2	179.9 *10.1
BORDERS	-547.2 -27.5	-1672.1 -17.1	73.3 *4.8	-13.6 *-0.9	462.9 *0.3	1438.4 11.11
East Lothian	-37.4 -4.2	-924.1 -44.1	31.7 *18.5	-1.8 *-2.5	350.6 *0.8	110.5 4.1
Midlothian	0.0 0.0	-182.8 *-31.9	4.8 *3.1	-0.2 *-0.1	-699.2 *-3.1	791.0 465
West Lothian	-5.2 *-80.7	-355.3 *-30.4	-68.9 *-19.3	-41.2 *-20.6	-704.7 -3.7	1065.0 22.8
LOTHIAN	-42.6 -4.7	-1462.2 -38.1	-32.4 *-4.8	-43.2 *-10.4	-1053.3 -1.3	1966.5 21.7
North East Fife	-979.6 *-96.1	-2084.0 -43.9	33.7 *14.0	-35.4 -8.5	210.1 *0.4	1000.8 *24.6
Kirkcaldy	-79.3 *-68.0	-505.4 *-30.3	-207.6 *-15.0	-12.2 *-4.7	-2290.9 *-12.8	2417.0 *124.5
Dunfermline	0.0 0.0	-890.2 *-81.3	-61.6 *-15.5	-16.5 *-13.1	267.1 *1.3	533.7 *14.7
FIFE	-1058.9 -92.1	-3479.6 -46.3	-235.5 *-11.7	-64.1 -8.0	-1813.7 *-1.9	3951.5 41.1
Falkirk & Clackmannan	0.0 0.0	-150.7 -45.2	10.1 *12.6	-13.5 *-1.9	-3548.8 -13.9	3962.7 66.0
Stirling	0.0 0.0	-92.4 *-8.6	-53.6 *-3.3	0.0 0.0	-582.6 -1.7	252.5 *6.5
CENTRAL	0.0 0.0	-243.1 -17.3	-43.5 *-2.6	-13.5 *0.6	-4131.4 -7.0	4215.2 42.7
Annandale & Eskdale	-10.7 *-23.2	-1300.8 -50.7	-193.2 *-11.7	-10.3 *-1.5	6.2 *0.01	291.4 10.3
Nithsdale	0.0 0.0	-820.1 -54.0	-860.4 *-26.2	-11.1 *-1.8	201.0 *0.4	-309.5 *-6.4
Stewartry	-7.2 *-3.0	-1207.7 *-31.6	277.4 *-5.5	-15.3 *-1.3	483.5 *0.9	198.3 9.1
Wigtown	-29.4 *-10.5	-514.4 -25.5	-205.4 *-9.9	10.1 *2.1	754.6 *1.2	-118.6 *-3.2
DUMFRIES & GALLOWAY	-47.3 *-8.4	-3843.0 -38.4	-1536.4 -12.7	-26.6 *0.9	1445.3 0.7	61.6 *0.4
Lanark	0.0 0.0	-669.0 -38.9	174.4 *12.4	9.7 *1.8	-246.6 *-0.7	696.3 15.0
Kyle & Carrick	0.0 0.0	-826.9 -70.6	-1113.1 -42.8	-3.4 *-1.0	852.2 *2.0	609.5 13.8
Cumnock & Doon Valley	0.0 0.0	-329.3 *-47.9	-199.2 -20.2	-244.5 *-479	396.9 *1.6	521.2 *31.2
Cunninghame	0.0 0.0	29.4 *12.0	-253.0 *-18.2	19.6 *-5.8	-355.0 *-1.7	649.3 15.2
East Strathclyde	0.0 0.0	-440.3 -42.0	-256.6 *-18.8	-122.5 *-24.9	-4808.2 -12.9	5126.5 37.2
West Strathclyde	0.0 0.0	-421.3 -19.6	-444.7 -16.8	-26.4 -2.3	-3060.9 -4.9	4012.5 29.3
STRATHCLYDE	0.0 0.0	-2657.4 -37.8	-2092.2 -20.0	-406.7 *-12.1	-7221.6 -3.2	11615.3 27.3
Perth & Kinross	0.0 0.0	-1338.0 -52.7	-304.5 *-35.9	0.1 *0.0	604.9 *0.6	289.1 *3.6
Angus	0.0 0.0	-1276.0 *-64.5	12.2 *2.6	-0.9 *-0.2	-102.5 *-0.1	959.8 14.2
TAYSIDE	0.0 0.0	-2614.0 -57.9	-292.3 *-22.1	-0.8 *-0.0	502.4 *0.3	1248.9 8.4
WHOLE SURVEY AREA	-1695.8 -36.7	-15970.7 -36.2	-4158.8 -14.0	-568.0 -4.2	-11809.6 -1.2	+24697.6 +21.8

Gains (upper line) and losses (lower line) in area of each Habitat Type expressed as a percentage of Early area.

Habitat ⇨ District or REGION	Deciduous wood	Coniferous wood	Mixed wood	Felled areas	Scrub	Dwarf shrub heath	Permanent unimproved grassland	Improved rough grass	Wetland	Open water	Agricultural land	Non Agricultural land
Berwick	0.9 25.0	143.6 3.5	4.6* 40.2	24.5 87.0	13.9 15.0	0.0 *94.4	0.0 29.8	0.4 31.6	9.7* *0.7	1.0* 3.3	1.9 0.4	6.7 1.3
Roxburgh	1.6 21.3	53.5 *5.0	5.8* 38.6	76.1 81.9	40.9 21.8	1.3* *71.4	0.1* 34.2	0.4* 23.0	13.1* *4.9	0.9* *1.3	1.4 0.3	2.1 1.9
Ettrick & Lauderdale	3.8* 20.6	14.4 *14.0	21.9 10.3	45.0 97.2	57.8 28.2	0.0 *80.2	3.3* *30.5	4.9 *14.2	2.8* *4.1	0.4* *1.3	1.2* *3.4	19.1* 2.1
Tweeddale	5.6* 12.8	24.4 28.3	10.1 33.2	155.8 106.2	114.9 27.7	44.1* *52.9	33.6* 0.0	7.0 *33.6	11.0 *9.0	0.0 *0.6	1.4 1.6	11.6 *1.5
BORDERS	2.6 21.0	69.6 12.4	11.4 27.4	66.1 91.4	37.2 21.0	3.0* 79.5	2.3* 29.8	5.5 22.6	9.3 4.5	0.6 1.4	1.5 1.2	13.3 2.2
East Lothian	13.8 33.1	124.1 20.2	50.1* 31.1	284.0 58.6	36.6 56.9	0.0 *98.8	2.8* 7.0	1.2* 45.4	18.5* 0.0	1.4* *4.0	1.7 0.8	9.3 *5.2
Midlothian	4.3 15.1	116.5 *12.3	14.4 22.1	160.8 *97.1	55.6 44.8	0.0 *79.0	0.0 0.0	6.6 *38.5	10.0* *6.9	1.2* *1.3	1.0 4.2	51.1 *4.6
West Lothian	5.4* 16.1	236.9* *32.6	13.4 *3.7	6059.2* 0.0	60.4 *24.2	0.0 *1.5	0.0 *80.7	2.0* *32.4	8.5* *27.8	0.0 20.6	1.2 4.8	26.1 3.3
LOTHIAN	9.4 24.7	125.3 18.8	34.1* 26.2	252.2 73.8	43.6 49.4	0.0 *61.3	2.7* 7.45	2.3 40.4	11.4 *16.1	0.6* 11.1	1.4 2.6	25.8 4.1
North East Fife	8.2 35.9	146.2 *15.8	18.5* *7.0	6125* 81.9	21.4 35.2	0.0 95.7	0.0 *96.1	4.0 47.8	22.3 8.3	1.2* 9.7	2.3 *1.9	26.5* 1.9
Kirkcaldy	5.8 40.5	380.8 *38.5	174.8* 0.0	274.9 *100.0	51.6 52.2	0.0 0.0	0.0 *68.0	2.8* 33.1	7.3* 22.4	1.8* *6.5	2.4 *15.2	129.9* 5.4
Dunfermline	3.6* 33.0	273.8* *32.1	1293.1 *52.3	92.4* 84.4	108.7 61.7	0.0 *100.0	0.0 0.0	3.6* *85.0	13.6 29.1	3.5 *16.6	5.5 4.2	27.5 12.8
FIFE	5.7 35.6	177.0 *19.1	167.5 *77	273.4 87.4	35.9 40.4	0.0 96.2	0.0 92.1	3.6 50.0	10.4 22.0	1.7 9.8	3.0 4.9	47.7 6.7
Falkirk & Clackmannan	4.6 30.0	28.6* *41.5	14.9* 23.2	399.2* 100.1	87.9 32.7	0.0 *100.0	0.0 0.0	4.8 50.0	44.9* 32.3	2.2* 4.1	0.9 14.8	68.6 2.6
Stirling	12.0 21.0	177.1 40.8	13.0 16.6	60.7 93.0	30.0 54.4	21.6 *54.4	0.0 0.0	17.5 26.1	24.5 27.8	0.2 0.2	2.2 3.9	14.6 *8.1
CENTRAL	8.9 24.8	135.2 41.0	13.4 18.1	80.5 93.4	57.4 44.1	16.4 65.3	0.0 0.0	14.5 31.8	25.4 28.0	0.8* 1.4	1.6 8.6	47.5 4.8
Annandale & Eskdale	9.3 38.4	122.2 9.7	93.3* 25.0	29.4 95.2	41.9 59.6	0.0 *87.3	0.0 *23.2	1.7* 52.4	20.2 31.9	2.6* 4.1	1.7 1.6	13.8 3.4
Nithsdale	18.0 33.7	91.0 15.4	55.0 *6.1	128.1 93.8	40.2 56.3	0.0 98.2	0.0 0.0	2.9 56.9	11.8 38.0	5.4* 7.1	2.4 2.0	8.3 14.7
Stewartry	7.8 29.8	98.3 *37.5	121.6* 30.5	48.4 99.1	28.0 34.5	0.0 *86.5	6.4* *9.4	8.3 39.9	12.6 18.1	2.4 3.7	2.3 1.4	10.1 1.0
Wigtown	6.2 22.7	133.7 13.9	9.3* *58.4	254.2* 86.0	36.4 26.9	0.0 *28.2	0.0 *10.5	8.8 33.3	13.1 23.0	3.7 1.6	2.4 1.1	12.1 *15.3
DUMFRIES & GALLOWAY	10.5 30.8	104.4 20.2	80.8 21.0	65.1 95.1	34.7 39.3	0.0 89.9	2.7* 11.1	5.9 44.3	13.5 26.2	3.3 4.2	2.2 1.5	10.8 10.3
Lanark	20.1 21.7	66.7 25.4	52.4 55.5	66.4 91.4	36.9 50.3	16.6 51.6	0.0 0.0	3.9 42.0	38.0 25.6	8.4 6.6	3.3 4.0	21.6 6.7
Kyle & Carrick	10.6 25.9	105.2 10.1	11.4* 41.6	44.5 87.6	43.1 47.2	450.1* *100.0	0.0 0.0	0.5* 71.0	4.9 47.7	1.9 *2.9	3.8 1.8	15.6 1.8
Cumnock & Doon Valley	10.2 7.5	26.0 15.9	8.2* *18.7	27.3 82.1	23.0 42.4	23.9* *28.0	0.0 0.0	3.8 *51.6	16.8* 37.0	0.0 *48.0	3.5 *1.9	34.4* *3.2
Cunninghame	0.9 8.7	484.6 *15.7	0.0 0.0	116.6* *97.2	39.8 37.8	6.1* *92.0	0.0 0.0	37.5* 25.4	6.3* *24.5	2.9* *8.7	1.7* 3.4	18.0 2.9
East Strathclyde	14.5 16.6	88.7 7.7	34.5* 55.2	52.4 79.4	57.4 48.9	32.0 28.3	0.0 0.0	6.3 48.2	9.0 27.0	1.3* 26.2	1.9 14.8	41.7 4.5
West Strathclyde	7.1 21.4	89.4 21.7	24.4* *26.2	78.4 64.5	28.9 40.2	60.6* *60.6	0.0 0.0	2.9* 22.6	5.9 22.7	0.6* 3.0	1.8 6.7	30.8 1.5
STRATHCLYDE	11.1 19.1	82.6 15.8	20.5 29.4	55.7 81.7	41.0 45.2	29.0 46.0	0.0 0.0	4.4 42.2	11.5 31.5	2.2 14.3	2.6 5.9	30.6 3.3
Perth & Kinross	11.1 27.4	55.0 8.8	60.7 *14.7	75.4 80.5	27.0 54.7	11.1* 72.0	0.0 0.0	12.6 65.3	8.4 44.3	3.1 3.1	2.0 1.5	13.0 *9.4
Angus	6.3 35.2	135.0 23.2	103.8 *18.7	80.9 *97.4	39.8 26.8	9.9* 64.0	0.0 0.0	8.0* 72.5	8.3* *5.7	1.2 1.4	1.6 1.8	17.9 *3.7
TAYSIDE	9.7 29.8	70.9 11.6	76.4 16.2	77.4 86.7	31.1 45.7	10.4* 67.3	0.0 0.0	10.6 68.5	8.3 30.5	2.7 2.8	1.8 1.6	15.2 *6.8
WHOLE SURVEY AREA	8.8 26.2	94.0 16.5	40.0 23.3	80.7 89.3	38.1 41.2	9.7 70.6	1.8 38.6	5.6 41.8	13.0 26.0	2.0 6.0	2.0 3.2	26.7 5.0

APPENDIX 3 The main Changes in each District and Region - see Abbreviations.

REGION, District ↓ TYPE OF MAIN CHANGE →	net loss area	net loss proportion	net gain area	net gain prop	loss area	loss proportion	gain area	gain proportion	MAJOR CHANGES
BERWICK	1,3* 8	1,3*,4 6*,7,8	2,11	2	1,3 4,8	1,3,4 6*,7,8	2,11	2,4	−1, −8 +2
ROXBURGH	1,3 8	1,3,6* 7,8	2,11*	2,5*	1,3,4 6*,8	1,3,4,5 6*,7,8	2,4 11	2,4,5	−1, − −8 +2
ETTRICK AND LAUDERDALE	1,11*	1,4,6* 7	2,12*	2,12*	1,4, 8*,11	1,4,5 6*,7*	2,11 12*	2,3,4 5,12*	−1 +2
TWEEDALE	8	8	12*	4,5 7*,12*	2,4 8*,11	2,3,4 5,6*8*	2,4 11,12	2,4,5,6* 7*	−8
BORDERS	1,8	1,3,4* 6*,7,8	2,12	2,5*	1,4 8,11	1,3,4,5 6,7,8	2,4 11,12	2,4,5	−1, −8 +2
EAST LOTHIAN	1,8	1,*5*,6* 8	2*	2*,3* 4,9	1,5 8	1,2,3,4 5,6*,8	1,2,3* 4,11,12	2,3*,4,5 9	−8
MIDLOTHIAN	1,11*	6*,8*	2*,12	2*,4* 12	1,8* 11	1,3,4*5 6*,7*	2,11 12	2,4,5,12	+12
WEST LOTHIAN	8*,11	5,*7*,8* 9*,10*	12	2,4,12	8*,11	1,2*,5* 7*,8*,9*,10*	11,12	2*,4*,5,12	+12
LOTHIAN	8,11	1,6*,8	2,12	2,4,12	1,8,11	1,2,3,4 5,6,8,9*	1,2 11,12	2,3*,4 5,12	−8 +2, +12
NORTH EAST FIFE	7*,8	1,6,7* 8	2,12*	2,4, 12*	1,7* 8,11*	1,2*,4,5 6,7,8	2,11 12	2,3*,4* 5,9,12*	−8 +2
KIRKCALDY	8*,11*	1,7*,8* 9	2,12	2,3,4 12	8,11*	1,2*,4,5 7*,8,9,11*	2,12	2,3*,4,5	+2, +12
DUNFERMLINE	1,8*	1,6*,8*	2*,12*	2*,6* 8*,9*	1,8* 11,12	1,2*,3*,4 5*,6*,8*,10	2*,11 12	2,3,4*,5 9,12	−1
FIFE	1,8 11	1,6,7* 8	2,12	2,3 4,12	1,8 12	1,2*,4,5 6,7*,8,9	2,11 12	2,3,4,5 12	−1, −8 +2, +12
FALKIRK AND CLACKMANNAN	1,11	1,6*,8	12	4,5 12	1,6,* 8,11*	1,2*,4,5 6,7*,8	12	2,4*,5,9* 12	−1, −8 +12
STIRLING	11	4*,5,6*	2	2	1,4 11	1,2,3,4 5,6*,8,9	2,4 11,12	2,4,5,6 8,9	+2
CENTRAL	11	1,6* 8	2,12	2,12	1,4 11	1,2,3,4 5,6,8,9	2,4 11,12	2,4,5,6 8,9	+2
ANNANDALE AND ESKDALE	1,4,8	1,4,5*,6* 8	2	2,3*	1,4 8,11	1,3,4,5 6*,7*,8,9	2,11	2,3*,4,5 9	−1, −8
NITHSDALE	8,9*	1*,5*,6,8 9*	2	2,3,4*	1,8,9 11,12	1,2,4,5 6,8,9	2,11	1,2,3,4 5	−8 +2
STEWARTRY	1,8*	1,4*,6* 8*	2*,3*	2*,3*	1,2*,8 9,11	1,2*,3,4 5,6*,8,9	2,3* 9*,11	2,3,4,5	−1
WIGTOWN	1,8	8 1,3*,6*	11	2,4	1,7,8, 11,12*	1,3*,4,5 6*,8,9,12*	4*,11 12	2,4*,5	−1
DUMFRIES AND GALLOWAY	1,8 9	1,4,6* 8	2,11	2,3	1,8 9,11	1,2,3,4 5,6,8,9	2,11	2,3,4,5	−1, −8 +2
LANARK	8	4,6,8	12	2*,12	8,11	1,2,3,4 5,6,8,9	2,9 11,12	1,2,3,4 6,8,9,12	−8 +12
KYLE AND CARRICK	1*,8 10*	1*,3*,4 8,9,10*	2,11* 12	2,6*	1,8 9,11	1,3,4,5 6*,8*,9,10	2,11 12	2,4,5,6* 12	−8, −9 +2
CUMNOCK AND DOON VALLEY	8*,10*	4,5*,8*,9 10	7*,12*	12*	4,8,9 10,11	2,3*,4,5 6*,8*,9,10*	11,12*	2,4,5,6* 9*,12*	−
CUNNINGHAME	9*,11*	6*,9*	12	2*,4* 12	9*,11	2*,4,5,6* 8*,9*	11*,12	2,4*,5,8 12	+12
EAST STRATHCLYDE	11	3*,4*,8* 9*,10*	12	2,12	11	1,3,4,5 6,8,9,10	12	2,3*,4,5 6,12	+12
WEST STRATHCLYDE	11	8,9	12	2,12	11	1,2,3*,4 5,6,8*,9	11,12	2,3*,4,5 6*,12	+12
STRATHCLYDE	8,9 11	4,6,8 9	2,12	2,12	8,9 11	1,2,3,4 5,6,8,9	2,11 12	2,3,4,5 6,12	−8, −9 +2, +12
PERTH AND KINROSS	1,8	1,5*,6* 8,9*	2	2,3	1,5,8 11	1,4,5,6 8,9*	1,2 11	2,3,4,5	−1, −8 +2
ANGUS	1,8*	1,4,6 8*	2,12	2,3	1,8 4,11	1,2,3*,4* 5,6,8	2,11 12	2,3,4,5 12	−1 +2
TAYSIDE	1,8	1,6,8 9*	2,12	2,3	1,8, 11	1,3,4,5 6,8,9	2,3 4	2,3,4 5,12	−1, −8

APPENDIX 4A: INTERCHANGE IN BORDERS REGION.

*LESS RELIABLE ESTIMATE

ST [illegible] OF CHANGE(HA) FOR DISTRICT

LASSIFIED BY OLD HABITAT . NEW HABITAT

	DECID	CONIF	MIXED	FELLED	SCRUB	DS.HEATH	P.GRASS	PI.GRASS	WETLAND	O.WAT[illegible]
ECI[illegible]	0.0	608.6	261.6	498.3	[illegible]	0.0	0.0	[illegible]	4.8*	0.0
[illegible]	0.0	0.0	14.8*	629.9	14.9	0.0	11.0*	37.5*	0.0	0.0
[illegible]	29.4	429.9	0.0	313.7	31.4*	0.0	0.0	11.6*	4.1*	0.0
.ELL[illegible]	92.2	1420.5	89.4*	0.0	42.0	0.0	0.0	[illegible]*	5.0	0.0
C[illegible]	58.6	180.7	4.9*	1.4*	0.0	0.0	0.0	[illegible]	4.3*	0.0
S.[illegible]TH	16.2*	515.5*	2.8*	0.0	7.7*	0.0	32.9*	178.1*	0.0	0.0
.[illegible]	0.0	216.3*	0.0	0.0	50.5*	3.4*	0.0	135.5*	21.9*	2.2*
.[illegible]	0.6*	553.0	11.6*	0.0	[illegible]	[illegible]*	0.0	0.0	[illegible]*	1.0*
ETLAND	0.0	0.0	0.0	0.0	[illegible]*	0.0	0.0	[illegible]*	0.0	[illegible]*
.WATER	0.0	0.0	0.0	0.0	2.2*	0.0	1.9*	1.0*	[illegible]*	0.1
GRIC	1.7*	257.0	51.4	0.0	149.4*	0.0	0.0	1.6*	[illegible]*	4.7*
ON AGRIC	7.9*	55.4*	[illegible]	0.0	121.4	0.0	0.0	2.2*	0.0	0.0
[illegible]	206.6	4217.1	449.9	1443.2	590.7	[illegible]	45.8*	[illegible]	141.9	[illegible]

	AGRIC	NON AGRIC	LOSSES
ECI[illegible]	92.5	59.2*	1653.5
C.IF	14.1*	31.4*	753.5
[illegible]	254.3*	6.6*	[illegible]
[illegible]	249.9	22.5	1994.1
C[illegible]	38.9	14.1	332.9
S.HEATH	112.1*	1.9*	867.1
.GRASS	155.8*	6.7*	593.0
.GRASS	1363.1	146.6*	2210.0
ETLAND	52.0*	7.7*	82.6
.WATER	6.8*	3.2*	21.9
GRIC	0.0	1417.9	1955.9
ON AGRIC	79.3	0.0	279.5
[illegible]	2418.8	1716.1	11811.1

ES[illegible] OF CHANGE(HA) FOR DISTRICT

LASSIFIED BY OLD HABITAT . NEW HABITAT

APPENDIX 4B: INTERCHANGE IN LOTHIAN REGION

* LESS RELIABLE ESTIMATE

	DECID	CONIF	MIXED	FELLED	SCRUB	DS.HEATH	P.GRASS	PI.GRASS	WETLAND	O.WAT
[illegible]	0.0	581.6	510.2*	462.7	153.4	0.0	16.9*	11.5*	0.0	0.0
[illegible]	0.0	0.0	16.8*	61.2	14.7*	0.0	0.0	0.0	9.9*	0.0
[illegible]	64.6*	214.1	0.0	157.0*	46.5	0.0	0.0	8.5*	0.0	0.0
LLED	30.1	31.0	49.7*	0.0	20.0*	0.0	0.0	13.3*	0.0	1.0*
[illegible]	368.5	56.4*	64.0*	0.0	0.0	0.0	7.7*	26.0*	0.0	1.[illegible]
.HEATH	9.3*	261.6*	0.0	0.0	2.5*	0.0	0.0	0.0	0.0	0.0
GRASS	0.0	9.1*	0.0	0.0	52.9	0.0	0.0	0.0	0.0	0.0
GRASS	193.3	600.8*	6[illegible]*	0.0	114.2	0.0	0.0	0.0	11.5*	[illegible]
TLAND	2.4*	0.0	5.0*	0.0	0.0	0.0	0.0	15.3*	0.0	1.7*
WATER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9*	4.0*	0.0
GRIC	27.4*	167.5*	6.2	0.0	60.5	0.0	0.0	0.0	52.1*	0.0
N AGRIC	0.0	33.2*	3.7*	0.0	43.7*	0.0	0.0	9.1*	0.0	0.0
[illegible]	695.5	1755.7	718.0*	692.0	513.6	0.0	24.5*	86.7	77.3	2.7*

	AGRIC	NON AGRIC	LOSSES
ECID	219.4	66.3	1822.9
.IF	159.9*	0.0	262.8
XED	55.4*	6.0*	552.2
LLED	46.7*	13.0*	264.9
RUB	45.0*	14.1	581.6
.HEATH	0.0	0.0	273.4
GRASS	5.1*	0.0	67.1
GRASS	255.7	312.1*	1548.7
TLAND	60.5*	24.9*	109.[illegible]
WATER	13.5*	25.4*	45.9
RIC	0.0	1878.6	2199.6
AGRIC	264.2	0.0	372.9
T	1145.4	2340.5	[illegible]041.7

[illegible] OF CHANGE(HA) FOR DISTRICT

APPENDIX 4C : INTERCHANGE IN FIFE REGION

CLASSIFIED BY OLD HABITAT . NEW HABITAT

* LESS RELIABLE ESTIMATE.

	DECID	CONIF	MIXED	FELLED	SCRUB	DS.HEATH	U.GRASS	I.GRASS	WETLAND	O.WATER
ECID	0.0	575.8	262.9	374.4	166.7	0.0	0.0	[illegible]	1.6	0.0
CONIF	0.0	0.0	0.0	357.3*	33.3*	0.0	0.0	[illegible]	0.0	0.0
IXED	0.0	0.0	0.0	18.0*	3.5*	0.0	0.0	0.0	0.0	0.0
FELLED	50.0	11.6*	36.5*	0.0	6.0*	0.0	0.0	2.2*	0.0	0.0
CRUB	152.0	69.8	40.0	4.9*	0.0	0.0	0.0	157.2	0.0	0.0
S.HEATH	0.0	678.5	0.0	0.0	1.0*	0.0	0.0	0.0	0.0	0.0
.GRASS	76.3*	982.0*	0.0	0.0	12.8*	0.0	0.0	52.3*	1.5*	0.0
.GRASS	63.7	15[illegible].5	[illegible]*	0.0	161.3	0.0	0.0	0.0	67.1*	5.5*
ETLAND	0.0	89.1*	12.9*	0.0	3.5*	0.0	0.0	[illegible]*	0.0	2.6*
.WATER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7*	[illegible]	0.0
GRIC	9.0*	481.0	3.4*	0.0	39.2	0.0	0.0	0.0	[illegible]	5.7
ON AGRIC	11.8*	6.4*	17.9*	0.0	132.4	0.0	0.0	0.0	2.2*	2.2*
AINS	312.9	4460.5	561.7	754.6	559.7	0.0	0.0	274.4	209.1	1[illegible].9

	AGRIC	NON AGRIC	LOSSES
ECID	197.6	146.2	1946.8
ONIF	31.2*	59.8*	481.6
IXED	3.1*	1.1*	25.7
FELLED	109.6	89.3	305.1
CRUB	198.0	7.7	629.5
DS.HEATH	47.2*	33.7*	760.[illegible]
U.GRASS	0.0	0.0	1058.9
I.GRASS	1550.3	149.2	3759.[illegible]
ETLAND	249.0*	49.5*	444.7
.WATER	0.0	22.7*	77.[illegible]
GRIC	0.0	4034.7	4669.[illegible]
ON AGRIC	469.5	0.0	642.5
GAINS	2855.6	4594.0	147[illegible]6.[illegible]

APPENDIX 4D: INTERCHANGE IN CENTRAL REGI

* LESS RELIABLE ESTIMATE.

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S        OF CHANGE(HA) FOR DISTRICT

LASSIFIED BY    OLD HABITAT  .  NEW HABITAT

            DECID      CONIF      MIXED      FELLED      SCRUB    DS.HEATH    U.GRASS    I.GRASS    WETLAND    O.WATER

ECID         0.0       279.7       42.3      363.4       1[illegible]4.1      0.0        0.0       39.4        1.5*       0.4*
ONIF         3.6*        0.0       21.7*     435.7        22.9*      0.0        0.0        1.3*       3.4*       0.0
IXED         9.8*       24.9*       0.0       99.3        10.5*      0.0        0.0        0.0        0.0        0.0
ELLED      150.4       732.6*      66.5        0.0        2[illegible].0       0.0        0.0       13.3*       4.9*       0.0
CRUB       207.9        42.5        5.2*       3.7*        0.0       0.0        0.0       20.4        0.[illegible]*       0.0
S.HEATH      0.0         6.3*       0.0        0.0        11.2*      0.0        0.0       7[illegible].9*       4.7*       0.0
.GRASS       0.0         0.0        0.0        0.0         0.0       0.0        0.0        0.0        0.0        0.0
.GRASS     116.1        16.6       14.9*       0.0        95.1*      2.3*       0.0        0.0       78.5*       0.0
ETLAND       9.3*      116.0       32.9*       0.0        1[illegible].2      12.[illegible]*       0.0       45.9*       0.0        0.5
.WATER       0.0         [illegible].8*       0.0        0.0         2.6*      0.0        0.0        0.5        1.7*        .5
GRIC        12.6*      557.2        0.0        0.0        [illegible]5.7      20.0*       0.0        0.0      327.9*      1[illegible].2*
ON AGRIC     3.[illegible]*        1.3*       0.5        0.0       127.6       0.0        0.0        2.7*       6.7*       1.[illegible]*
---------------------------------------------------------------------------------------------------------------
AINS       493.3      1[illegible]43.2      184.4      962.0       579.2      55.9        0.0      20[illegible].0      432.4       19.9*

            AGRIC    NON AGRIC    LOSSES

ECID       119.0      340.2    |  1378.0
ONIF         2.5*      67.4*   |   559.1
IXED        11.1*      33.3    |   248.7
ELLED       57.0       34.5    |  1047.5
CRUB        75.6       89.3    |   445.5
S.HEATH     30.5*       5.3*   |   143.0
.GRASS       0.0        0.0    |     0.0
.GRASS      74.1*      50.5*   |   446.1
ETLAND     236.2       10.7*   |   475.9
.WATER       6.6*      18.0*   |    33.5
RIC          0.0     4063.9    |  5087.4
ON AGRIC   225.6*       0.0    |   471.9
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INS        956.1     4667.1    | 10336.7
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TABLE 26

EST AREA OF CHANGE(HA) FOR DISTRICT

CLASSIFIED BY OLD HABITAT . NEW HABITAT

CL.BY 43 44

APPENDIX 4 E : INTERCHANGE IN DUMRIES AND GALLOWAY REGION.

* LESS RELIABLE ESTIMATE.

SS	DECID	CONIF	MIXED	FELLED	SCRUB	DS.HEATH	U.GRASS	I.GRASS	WETLAND	O.WATER	AGRIC	NON-AGRIC	LOSSES
I.GRASS	WETLAND	O.WATER											
DECID	0.0	1200.6	692.8	669.8	200.5	0.0	12.4	69.8*	83.8	1.0	207.8	108.5	3247.0
CONIF	19.0*	0.0	632.3*	678.1	11.2	0.0	0.0	72.8*	0.7*	0.0*	15.2*	3.9*	1433.3
MIXED	28.6*	295.7	0.0	69.8	34.1*	0.0	0.0	0.0	3.6*	0.0	18.9*	1.4*	452.1
FELLED	213.3	1516.6	58.6	0.0	23.4*	0.0	0.0	36.8	2.6*	0.0	214.3	10.8*	2076.4
SCRUB	343.5	240.5	68.1	4.9*	0.0	0.0	2.9*	182.2	41.6*	1.5*	249.6	24.0	1159.0
DS.HEATH	28.6*	341.5	2.6*	0.0	0.0	0.0	0.0	17.1*	0.0	0.0	3.5*	0.0	393.4
V.GRASS	10.4*	40.2*	2.0*	0.0	10.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.7
I.GRASS	284.2	2115.5	104.4	0.0	309.0	0.0	0.0	0.0	296.8,	18.2	1246.6	59.1	4433.7
WETLAND	79.9	1078.1	121.3*	0.0	50.7	0.0	0.0	177.2	0.0,	26.3	1615.6	17.8	3166.5
O.WATER	10.0	0.0	0.0	0.0	6.7	0.0	0.0	3.8*	47.3	0.0	28.0	28.8	124.6
AGRIC	17.9	550.8	3.5	0.0	191.3	0.0	0.0	6.4*	1145.4,	28.2	0.0	1206.2,	3149.7
NON AGRIC	66.6	39.4	57.3*	0.0	184.6	0.0	0.0	24.4*	8.2*	23.0*	9952	0.0	1398.7
GAINS	1102.2	7418.8	1742.9	1422.6	1021.4	0.0	15.3*	590.6	1630.0,	98.0,	4594.9	1460.3,	21097.3

[illegible] F [illegible]GE(HA) FOR DISTRICT

LASSIFI[illegible] OLD HABITAT . NEW HABITAT

APPENDIX 4F: INTERCHANGE IN STRATHCLYD REGION.

* LESS RELIABLE ESTIMATE

	DECID	CONIF	MIXED	FELLED	SCRUB	DS.HEATH	U.GRASS	I.GRASS	WETLAND	O.WAT.
ECID	0.0	972.0	68.0	497.7	[illegible]	0.6	0.0	[illegible].7*	7.5	0.4*
ONIF	27.3	0.0	19.2*	[illegible]	26.[illegible]	0.0	0.0	14.4*	13.4*	0.0
IXED	7.1*	66.2	0.0	[illegible]	4.5	0.0	0.0	1.6*	0.0	0.0
ELLED	199.9	651.3	23.6*	0.0	72.4	3.2*	0.0	5.2*	1.2*	0.2*
CRUB	[illegible]93.2	114.0	6.3*	3.7*	0.0	8.0*	0.0	[illegible].1	4.0*	0.0
S.HEATH	49.9	49.2*	0.0	0.0	[illegible]	0.0	0.0	14[illegible].6	3.2*	0.0
.GRASS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible].0	0.0	0.0
.GRASS	139.7	648.0	[illegible].2*	[illegible]	[illegible]	207.1	0.0	0.0	[illegible].9	0.0
ETLAND	79.[illegible]	193.7	1.2	4.6	15[illegible].5	63.3	0.0	29.[illegible]	0.0	15.[illegible]*
.WATER	0.2*	8.9*	0.0	0.0	[illegible]*	0.0	0.0	0.0	173.7*	0.0
GRIC	[illegible].0	423.3	1.2*	0.0	194.[illegible]	21.8	0.0	9.4*	905.[illegible]	35.6
ON AGRIC	133.3	135.6	2.2*	0.0	[illegible]	12.1*	0.0	0.0	[illegible]5.7*	74.2*
AINS	1449.4	3262.1	130.6	[illegible]	1370.6	316.2	0.0	305.1	1202.0	74.8

	AGRIC	NON AGRIC	LOSSES
ECID	268.7	412.3	2499.0
ONIF	[illegible]0.2	44.5	625.5
IXED	49.1*	18.8*	187.3
ELLED	377.0	45.0	1379.4
CRUB	359.7	251.8	1513.8
S.HEATH	161.[illegible]	46.4	502.3
.GRASS	0.0	0.0	0.0
.GRASS	1415.1	1[illegible]9.7	2962.4
ETLAND	2403.9	226.6	3294.3
.WATER	48.0*	243.4*	4[illegible]1.6
GRIC	0.0	11491.7	13179.5
ON AGRIC	724.7	0.0	1394.9
AINS	5957.9	13010.0	26020.0

[illegible] 28A

APPENDIX 4G : INTERCHANGE IN TAYSIDE REGION

* LESS RELIABLE ESTIMATE.

S OF CHANGE(HA) FOR DISTRICT

CLASSIFIED BY OLD HABITAT . NEW HABITAT

	DECID	CONIF	MIXED	FELLED	SCRUB	DS.HEATH	U.GRASS	I.GRASS	WETLAND	WATER
ECID	0.0	1707.6	442.1	[illegible]	[illegible]	[illegible].5*	[illegible]	1[illegible].1	25.5*	7.[illegible]*
ONIF	91.3	0.0	142.[illegible]*	594.1	59.7	24.4*	0.0	74.0*	0.0	[illegible]
IXED	0.0	123.3	0.0	71.4*	[illegible]*	0.0	0.0	2.4*	0.0	0.0
ELLED	145.7*	964.5	125.6*	0.0	73.[illegible]*	0.0	0.0	147.6*	0.0	1.[illegible]*
CRUB	679.4*	177.2	3[illegible].[illegible]*	0.0	[illegible]	47.8*	0.0	64.0*	[illegible]*	0.0
S.HEATH	101.7*	507.4	76.[illegible]*	0.0	5[illegible]*	0.0	0.0	[illegible].2	4.5	0.0
.GRASS	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	[illegible]	0.0	0.0
.GRASS	163.4	1711.6	137.0	0.0	260.4	113.4*	0.0	0.0	24.[illegible]*	0.0
ETLAND	12.1*	17.8*	0.0	0.0	[illegible]*	0.0	[illegible]	7.[illegible]*	0.0	[illegible]
.WATER	6.8*	0.0	0.0	0.0	4.[illegible]*	0.0	0.0	.[illegible]*	3.[illegible]*	[illegible].0
GRIC	159.4	744.7	14.3	0.0	121.6	8.0*	0.0	[illegible]	48.5	27.5
ON AGRIC	44.6	10.7	0.0	0.0	74.3	0.0	0.0	7.5*	0.0	21.3*
AINS	1404.4	5964.7	966.1	1574.[illegible]	914.6	197.0*	0.0	477.0	110.1	58.7

	AGRIC	NON AGRIC	LOSSES
ECID	676.9	160.9	4324.5
ONIF	176.8	17.3*	979.8
IXED	0.0	4.2*	204.3
ELLED	74.6	7.0*	1539.7
CRUB	304.5	51.6*	1340.5
S.HEATH	491.9	4.4*	1274.7
.GRASS	0.0	0.0	0.0
.GRASS	598.0	51.3*	3091.1
ETLAND	162.7	2.1*	402.4
.WATER	14.2*	27.2*	59.3
GRIC	0.0	1922.2	3047.[illegible]
ON AGRIC	30.7*	0.0	1009.3*
ATAL	4349.9	2258.2	17273.1

APPENDIX 5: Ecological Impacts of the changes (see Chapter 9.4 and Table 41 for method of calculation)

	Decid.	Conif.	Mixed	Felled	Scrub	D.S.H.	P.U.G.	I.R.G.	Wetland	Open Water	Agric.	N.Agric	Total
Decid.		-1.54	n/c ?	-0.98	n/c ?		n/c ?	-0.05	n/c ?	n/c ?	-0.88	-0.73	-3.45
Conif.	+0.05		+ ?	+0.09	-0.06	+ ?	+ ?	+0.03	+ ?		-0.16	-0.12	-0.17
Mixed	n/c ?	- ?		- ?	n/c ?			- ?	n/c ?		- ?	- ?	- ?
Felled	+0.29	-0.18	+ ?		+0.10			+0.04	+ ?		-0.38	-0.10	-0.33
Scrub	n/c ?	-0.25	- ?	-0.01		n/c ?	n/c ?	-0.10	n/c ?		-0.65	-0.24	-1.25
D.S.H.	n/c ?	- ?	n/c ?		n/c ?		n/c ?	- ?	n/c ?		- ?	- ?	- ?
P.U.G.	n/c ?	- ?	n/c ?		n/c ?			- ?	n/c ?		- ?	- ?	- ?
I.R.G.	+0.18	-0.98	+ ?		+0.29	- ?			- ?	+ ?	-2.66	-0.47	-3.64
Wetland	n/c ?	- ?	n/c ?		n/c ?	n/c ?		- ?		- ?	- ?	- ?	- ?
O. Water	- ?	- ?			- ?			- ?	+ ?		- ?	- ?	- ?
Agric.	+0.35	+1.56	+ ?		+0.94	+ ?		+0.02	+ ?	+ ?		-3.9	-1.03
N. Agric.	+0.43	+0.22	+ ?		+1.56	+ ?		+0.05	+ ?	+ ?	+0.65		+2.91
TOTAL	+1.3	-1.17	+ ?	-0.89	+2.54	+ ?	n/c ?	-0.01	+ ?	+ ?	-4.08	-5.56	-6.98

Key : n/c = no change, ? = not assessed, — = main impact