ABSTRACT OF THESIS

Name of Candidate RICHARD CECIL ALLAN FOWLER

Address JOINERS COTTAGE, DALL, RANNOCH STATION, PERTHSHIRE, SCOTLAND.

Degree MASTER OF SCIENCE *Date* OCTOBER 1967

Title of Thesis THE PRESENT CONDITION OF SHELTERBELTS ON FARMS IN THE VICINITY OF THE PENTLAND HILLS, MIDLOTHIAN, SCOTLAND.

An account of the history of shelterbelt planting in parts of Lowland Scotland provides the key to interpretation of data on the present condition of shelterbelts collected during a field survey of shelterbelt sites. In the Study Area there are eighty-six farm units, which are mostly exposed to the sweep of prevailing winds as well as to chilling winds that may bring snowstorms in spring time.

Silvicultural information about shelterbelts and the reasons why they were established are considered over a period of 250 years, starting with references to hedges and hedgerows used for enclosure in the early eighteenth century. Evidence from manuscript material in estate records is extensively drawn upon and is related to the pattern of shelterbelt systems as revealed by contemporary manuscript plans and published maps. The progress of shelterbelt planting is followed through the period of the Agricultural Revolution in Scotland, and is concluded by reference to tree planting on farms by the Forestry Commission. Shelterbelt location is shown to be influenced by topography, wind direction and date of planting; belt width and species used also beind a function of the date of establishment.

The condition of a shelterbelt site is an expression of the completeness of the stand of trees and hence also of its effectiveness as a windbreak. Nearly 500 belts including 95 derelict sites are classified in five condition classes. Survival of belts is examined particularly on the basis of the role a belt plays, or has played on the farm. Reasons are also given why there are no belts on eleven of the eighty-six farms. Siting, species choice, and methods of establishment and maintenance are treated in general terms, but specific examples are also given. Likewise the reasons for, and results of neglect of shelterbelts are examined within the Study Area as a whole as well as on particular farm units.

Changing patterns of ownership of farm woodlands, and of agricultural practices, are shown to be the principle reasons behind a decline in condition of belts in old-established shelterbelt systems; belts being in particurlarly poor condition on small owner-occupied farms where cropping is important. The Report also indicates that new belts are being established and old sites rehabilitated and maintained in good

Use other side if necessary.

condition on estates run in traditional manner, on farms on which stock rearing is the chief enterprise, and where the proprietors are not concerned only with immediate returns from the land, but are prepared also to invest money in shelterbelts as fixed equipment that can contribute to farm economy in various ways.

THE PRESENT CONDITION OF SHELTERBELTS ON FARMS IN THE VICINITY OF THE PENTLAND HILLS, MIDLOTHIAN, SCOTLAND

Richard C.A. Fowler, B.Sc.(Lond.)

Degree of Master of Science

Department of Forestry and Natural Resources,
University of Edinburgh.

October 1967.

PREFACE

For three years, 1964 - 1967, the Agricultural Research Council have financed Shelterbelt Research in the Department of Forestry and Natural Resources, University of Edinburgh. One project, conducted by Dr. J.K. Marshall, was designed to evaluate crop responses to shelter. A second project was to make a survey of the Present Condition of Shelterbelts: Mr. P.O. Hopkins worked for one year, and the writer for a further two years, on the latter.

ACKNOWLEDGEMENTS

During the period of research and in the preparation of this thesis the writer received valuable assistance from many competent persons.

Special thanks are extended to Professor J.N. Black who directed the course of study. Also to many members of the staff of the Forestry and Natural Resources Department, whose knowledgeable comments on shelterbelts, shelter effects, woodland management, and photo-interpretation have been freely drawn upon, and from whom many helpful suggestions originated. Paul Hopkins deserves credit for formulating methods and for indispensible co-operation in the early part of the second year of this project, when the writer started work.

At the same time, Mr. James Hope of the Planning Research Unit, Department of Architecture, Edinburgh University, put many maps and information about the Livingston Hinterland at the writer's disposal, and has

always been ready with helpful advice on the Project. Likewise, in other Departments of the University, teaching staff and research workers have kindly given of their time, notably: Professor J.T. Coppock and Dr. J.B. Sissons (Geography) and Mr. David Murison (School of Scottish Studies).

The writer extends grateful thanks to all the proprietors who readily allowed access to their properties, and to all the farmers and some of their employees for willing co-operation in the field survey.

Acknowledgement also goes to the following for considerable assistance in supplying verbal information and MS material about the five estates on which much of the historical chapter is based, to: the factors of Penicuik and Malleny estates; the chief tenant and the secretary of Dalmahoy estate; the solicitors of the former Baads estate; the Secretary and the Library Advisor, Company of Merchants of the City of Edinburgh (Cockburn Estate); and the proprietor of part of the former Whim estate.

Thanks are also due to the following for providing research facilities and helpful advice: The Keeper of Manuscripts and staff of the MS Search Room, National Library of Scotland; Miss A. Young, Superintendant, and staff of the Map Room, N.L.S.; Dr. Ian Adams, Map Archivist, and the staff of the Historical Search Room, Scottish Record Office, (Register House). And thanks also go to certain officers and staff in the following organisations: Forestry Commission (Glentress and Mid Calder); Department of Agriculture for Scotland (Edinburgh); Hill Farm-

ing Research Organization (Edinburgh); Meteorological Office (Bracknell and Edinburgh); South of Scotland ~~(Edinburgh)~~ Electricity Board, Stirling Area (Blackburn); Ordnance Survey (London and Southampton); British Museum, Map Room (London); Midlothian County Council Planning Department (Edinburgh); and the Town Planning Department, City and Royal Burgh of Edinburgh.

Permission to reproduce data on the birds that use Whiteside Plantation (Appendix IV) and the Plan of Westfield (Figure 15) is gratefully acknowledged.

Sincere thanks are extended to those who helped in various stages of production of the thesis, to: Mrs. R.J.P. Lorman, who typed drafts of the manuscript and checked all the Tables; Mr. A.L. MacGilp and Mrs. Joan Fowler, who prepared certain of the Figures for reproduction; and Mrs. Janet Valentine who typed the final copy.

The writer is endebted to the Agricultural Research Council for bearing the expenses of this research project.

TABLE OF CONTENTS

Page

Page

CHAPTER VI - DESCRIPTIONS OF CONSTRUCTIVE SHELTERBELT MANAGEMENT TECHNIQUES AND OF POSITIVE USES OF SHELTERBELTS ON CERTAIN FARM UNITS IN THE STUDY AREA AT THE PRESENT TIME

Page

Page

INDEX TO TABLES

LIST OF FIGURES

ABSTRACT

An account of the history of shelterbelt planting in parts of Lowland Scotland provides the key to interpretation of data on the present condition of shelterbelts collected during a field survey of shelterbelt sites. In the Study Area there are eighty-six farm units, which are mostly exposed to the sweep of prevailing winds as well as to chilling winds that may bring snowstorms in spring time.

Silvicultural information about shelterbelts and the reason why they were established are considered over a period of 250 years, starting with references to hedges and hedgerows used for enclosure in the early eighteenth century. Evidence from manuscript material in estate records is extensively drawn upon and is related to the pattern of shelterbelt systems as revealed by contemporary manuscript plans and published maps. The progress of shelterbelt planting is followed through the period of the Agricultural Revolution in Scotland, and is concluded by reference to tree planting on farms by the Forestry Commission. Shelterbelt location is shown to be influenced by topography, wind direction and date of planting; belt width and species also being a function of the date of establishment.

The condition of a shelterbelt site is an expression of the completeness of the stand of trees and hence also of its effectiveness as a windbreak. Nearly 500 belts including 95 derelict sites are classified in five condition classes. Survival of belts is examined particularly on the basis of the role a belt plays, or has played on the farm. Reasons are also given why there are no belts on eleven of the eighty-six farms. Siting, species choice, and methods of establishment and maintenance are treated in general terms, but specific examples are also given. Likewise the reasons for, and results of, neglect of belts are examined within the Study Area as a whole as well as on particular farm units.

Changing patterns of ownership of farm woodlands and of agricultural practices are shown to be the principle reasons behind a decline in condition of belts in old-established shelterbelt systems; belts being in particularly poor condition on small owner-occupied farms where cropping is important. The Report also indicates that new belts are being established and old sites rehabilitated and maintained in good condition on estates run in traditional manner on farms on which stock rearing is the chief enterprise and where the proprietors are not

concerned only with immediate returns from the land, but are prepared also to invest money in shelterbelts as fixed equipment that can contribute to farm economy in various ways.

CHAPTER I INTRODUCTION

Previous Research

In Scotland, research work on shelterbelts, as opposed to shelter *per se*, has been conducted along four main lines:

1) Silviculturalists have tackled the problem of growing and managing strips of trees to shelter farmlands from damaging winds. (Anderson, 1957).

2) Meteorological studies have provided data on penetrability and windspeed reduction for belts of varying age, structure and species composition. (Caborn, 1957).

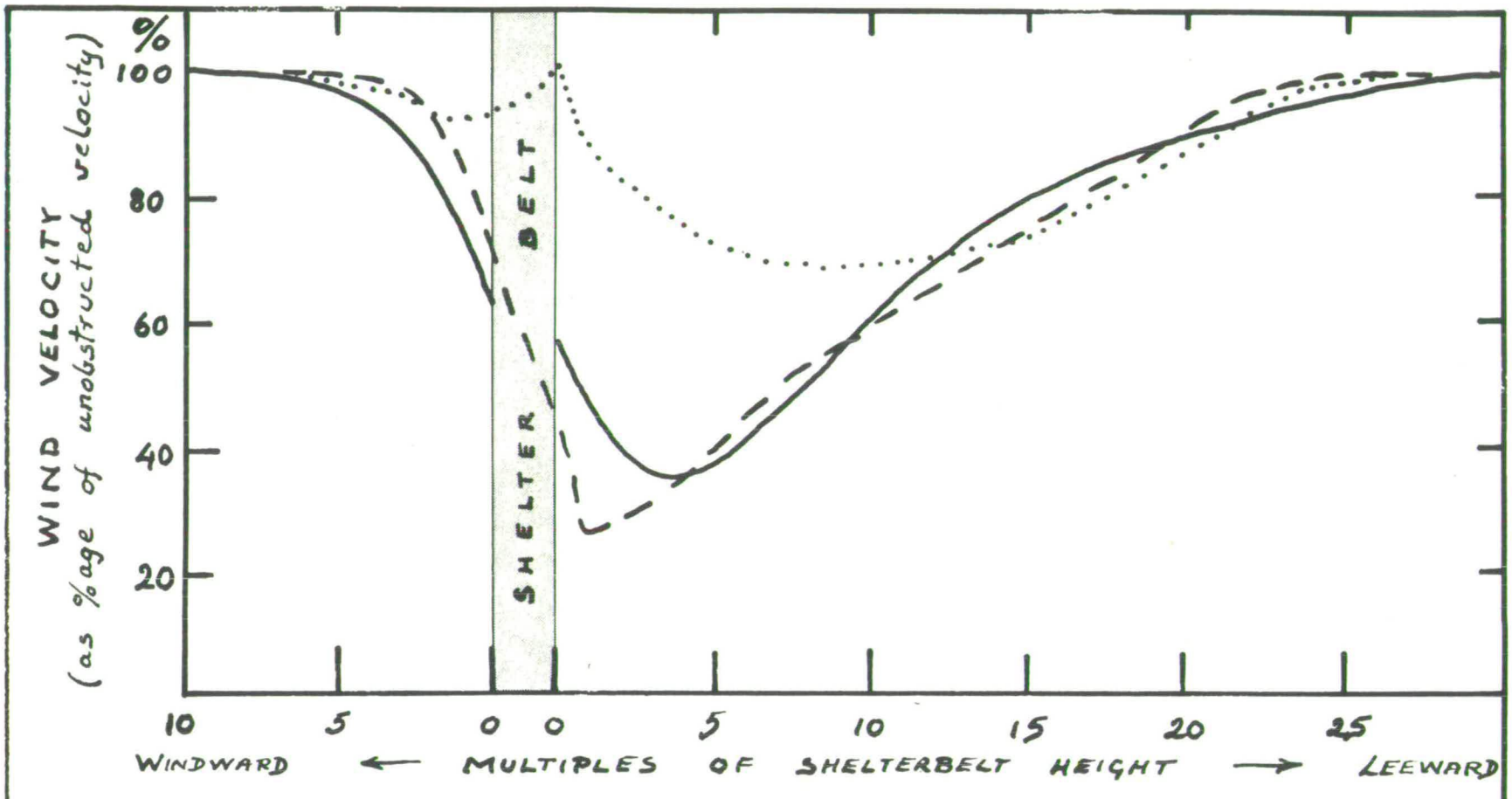
3) A pilot scheme of shelterbelt classification has been devised by foresters. (Murray & Mutch, 1961).

4) Shelterbelt condition has been studied in parts of South East Scotland. (Hopkins, 1965).

Most of the work refers to the Lowlands of Scotland where the numerous tree strips may be indicators of a need for shelter on the farms. But as Murray and Mutch pointed out, many of the belts are old and have not always been carefully tended. Such belts may not be very effective windbreaks even if they are still required for shelter.

Ideal Shelterbelt Structure

The structure of an 'ideal' shelterbelt for general purposes is a latticework of branches, uniformly penetrable to the wind: the



..... LANGWHANG BELT : Old conifer stand – canopy moderately penetrable by wind but trunk space very penetrable

—— MEAN CURVE for moderately penetrable belts (after Nägeli)

– – EAST SALTOUN BELT : Unthinned mixed stand – almost impenetrable.

FIGURE 1. WIND CONDITIONS IN THE VICINITY OF SHELTERBELTS OF DIFFERING STRUCTURE (from CABORN, 1957, p. 117)

penetrability approximating to 50% (Nageli, 1953). Caborn has shown in his study of eight shelterbelts in Mid- and East-Lothian how very variable belt structure can be, and how structure affects the pattern and degree of shelter afforded by any belt (Caborn, 1957, and Figure 1.1). In practice, belts rarely have an even, lattice-like structural composition from the ground to crown level; those that approach this structure are usually young belts with branches right down to the ground. Unless they are only a few rows wide, however, these belts are invariably too dense, and the area sheltered is less than maximal because there is no cushion of slow-moving air filtering through the trees to keep the fast-moving current off the ground after it has passed over the belt. Hence the unobstructed windspeed recurs at ground level somewhat nearer the leeward edge of the belt than it does behind more penetrable structures. For the special purpose of close-up shelter for stock, however, a dense belt may be the best sort; it is not good for cereal crops because the pressure of wind eddying over the barrier may flatten the crop.

With increasing age, belts usually become less efficient windbreaks because the trunk space tends to be too easily penetrated, and the canopy offers too much resistance to the wind. Because of this varied penetrability the wind rushes between the bare trunks with increased velocity. As the graph shows (Figure 1, Langwhang belt), there may be a reasonable degree of shelter far out in the field. Draughty windbreaks can be harmful to the health of stock (Yeates, 1942), but usually have

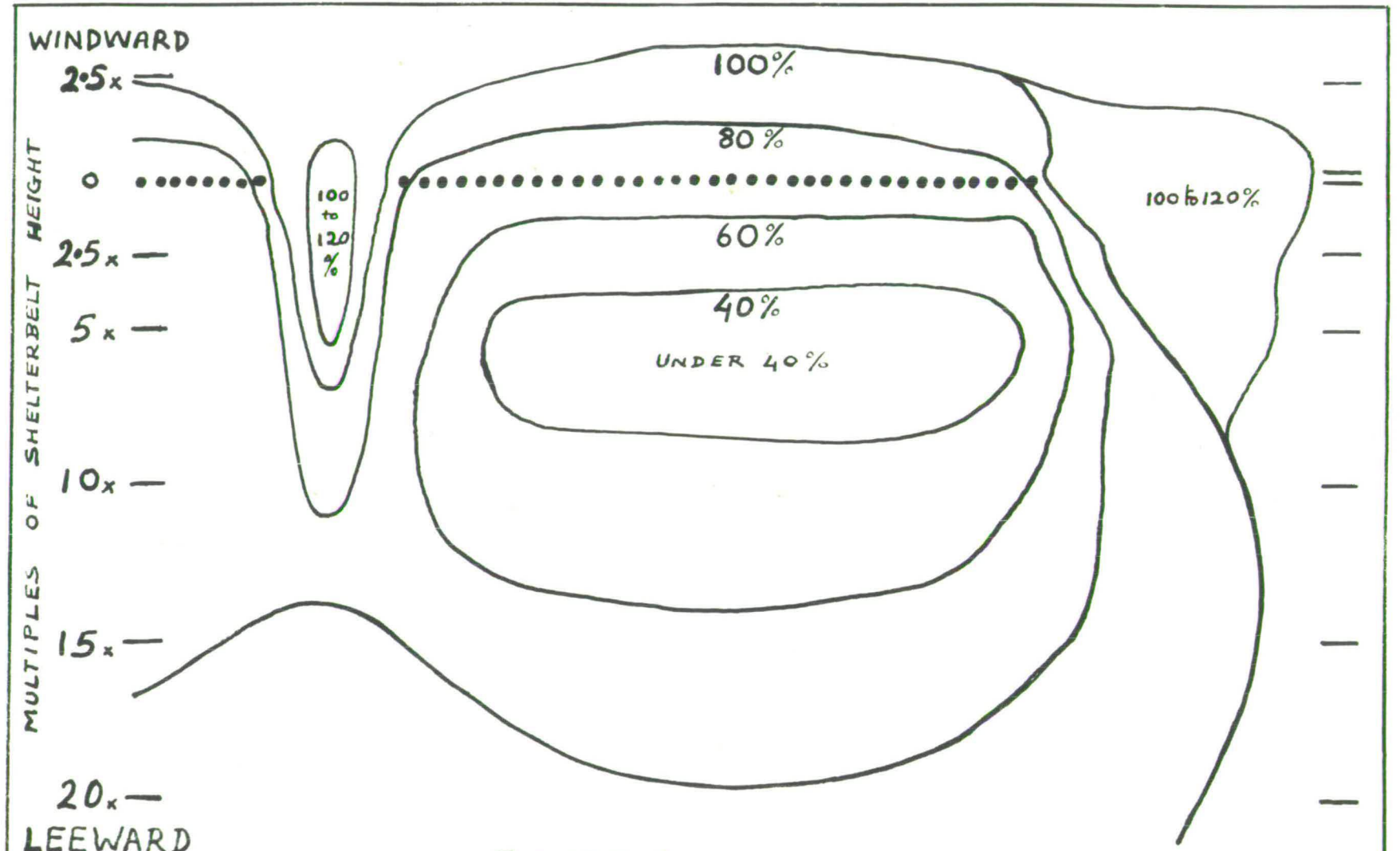


FIGURE 2

PLAN OF WIND VELOCITY IN THE VICINITY OF A MODERATELY PENETRABLE BELT WITH A GAP IN IT. (From: READ, 1964 & CABORN, 1957 after NAGELI)

less obvious effects on standing crops. Likewise the effect of the harsh microclimate within the belt is not obvious, but almost certainly bears on the health of the trees.

Once trees start to fail, gaps of various size are formed and there ceases to be uniform penetrability along the belt. Gaps right through the stand are particularly serious since not all the wind that impinges on the adjacent standing trees has to pass over them: some is deflected to right or left, and increases the velocity of that passing through the gap. Thus the windspeed increases in the vicinity of the gap, and the belt acts as though it were two short belts. Therefore the total area of sheltered ground is considerably reduced (Figure 2).

The Present Study - Condition of Shelterbelts

This thesis is based on a field survey of shelterbelts on farms above the 500' contour in the vicinity of the Pentland Hills, Midlothian. The object was to discover the present condition of all shelterbelts in the study area, 'condition' being a concept dependent on the distribution of trees on a shelterbelt site (Hopkins, 1966). Caborn has shown that it is possible to manage such a site so that the trees (and other vegetation) on it will continually provide effective shelter (Caborn, 1965). It has further been argued that this technique of maintaining belts at optimum penetrability is really an agricultural one, although in Scotland, unlike in the U.S.A., the task has usually been delegated to foresters (Anderson, 1957; Read 1958).

The reason for this attitude to Scottish farm woodlands has its origin in early eighteenth century land reclamation and improvement schemes. From that time, right up to the start of the present century, farmlands have been owned by very few landlords (Highland and Agricultural Society Report, 1878). Hedges, hedgerows, and shelterbelts, used to divide and shelter the ground, were almost invariably established by estate forestry staff or by specialist contractors. Tenant farmers have traditionally been concerned only with crop and animal husbandry, though they were usually bound to upkeep hedges by the terms of their leases. Nevertheless, responsibility for all woodland management was held by the proprietor's employees, with their interest centered in the policy plantings round the mansion. It is only since the early years of this century that a greater number of farmers have become owner-occupiers. Former tenants who bought their farms when estates were broken up had, therefore, no experience in silviculture (Home, 1921), or else they had limited capital which they preferred to invest in short term land improvement or in farm buildings (Borissow, 1963). In recent years, however, there has been an increase in the number of owners with capital to invest and with the knowledge and foresight to use trees in effecting that investment in long term land improvement schemes.

The present condition of shelterbelts is the resultant of the great age of many of the sites and even of the trees on them; the location of the belts, their width and species composition, the changing use of land on each side of a belt with fluctuations in the economics of

agriculture, and numerous ecological factors. Proprietorial management policy from the early Seventeenth Century to the present day, in connection with design, establishment, and maintenance of shelterbelts is, however, the most important factor that determines what condition belts are in at present.

The results of the field survey on the present condition of shelterbelts on farms in the vicinity of the Pentland Hills, together with the descriptive accounts of the historical progress and the present state of shelterbelt planting in the study area, demonstrate how and for what purposes successive proprietors have made and maintained particular shelterbelt systems, and provide specific examples of and reasons for site degradation.

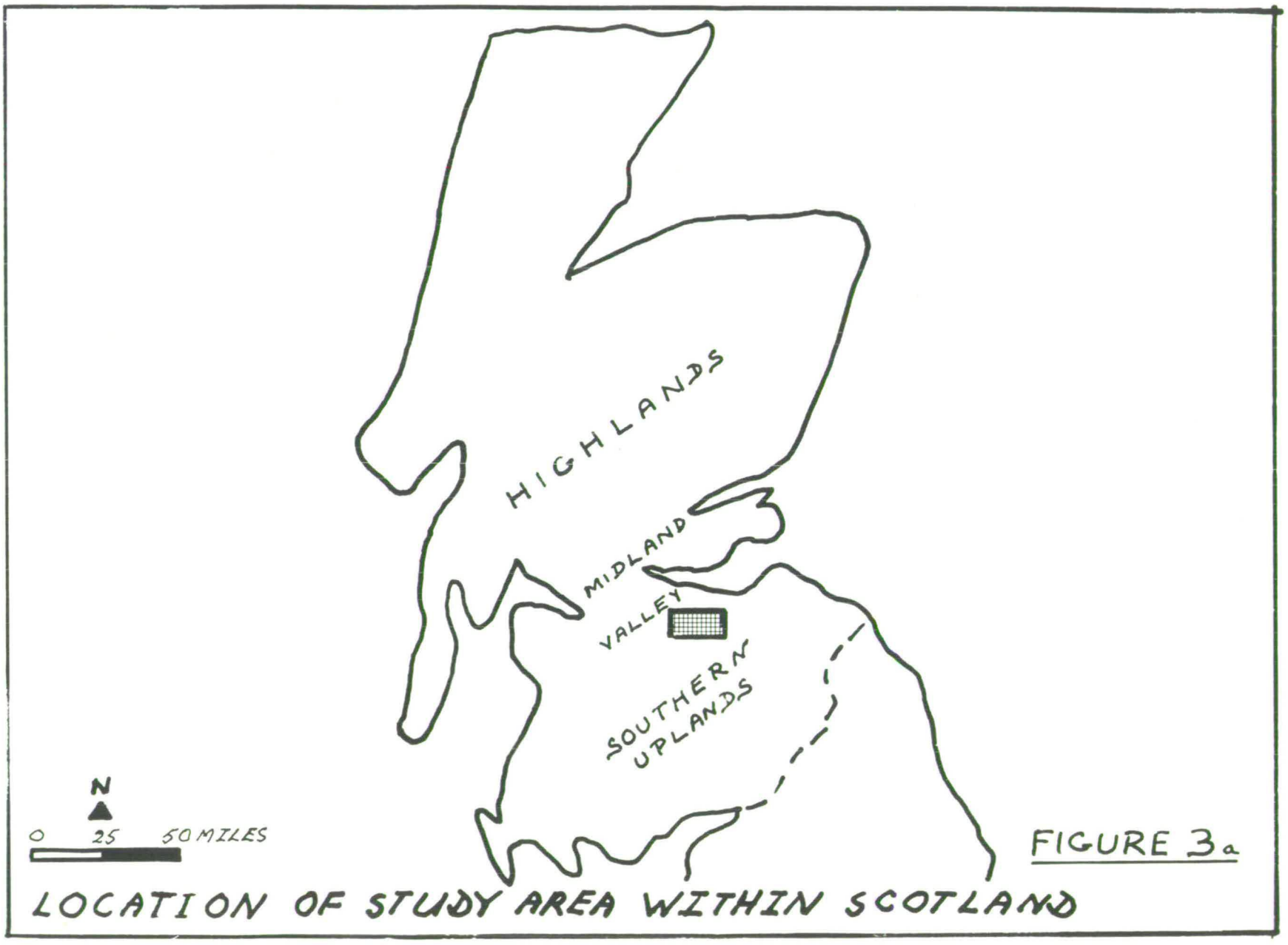


FIGURE 3a

LOCATION OF STUDY AREA WITHIN SCOTLAND

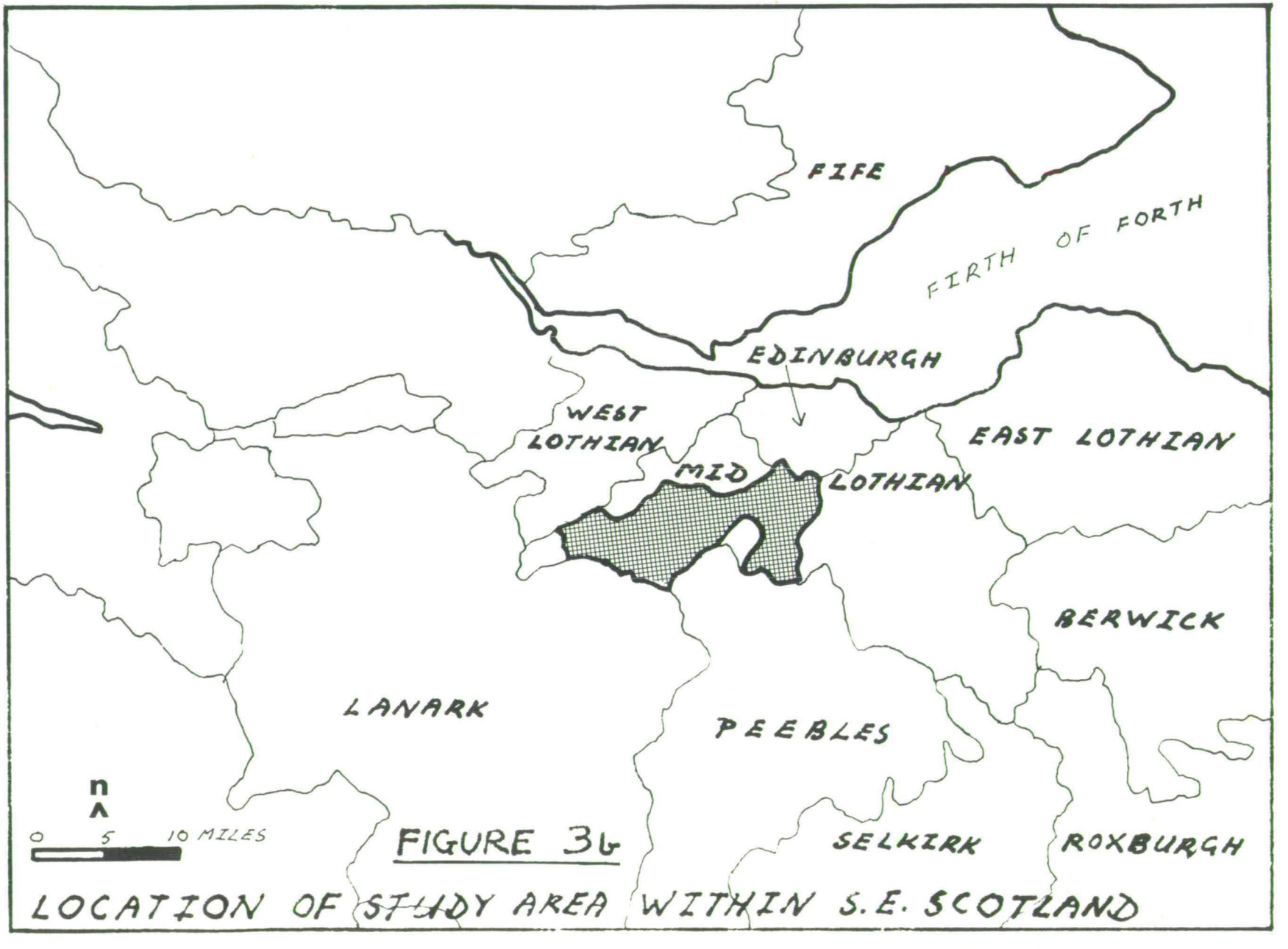


FIGURE 36

LOCATION OF STUDY AREA WITHIN S.E. SCOTLAND

CHAPTER II THE SHELTERBELT STUDY AREA

Choice of Study Area

The choice of an area in which to study shelterbelts was made after considering the following requirements:

1) A tract of land exposed to the sweep of the prevailing winds.

2) A region where farming is the major occupation and where mining or quarrying have not altered this form of land use to any appreciable extent.

3) The presence of an adequate number of belts as indicated by the most recent 1" O.S. maps (1965).

4) A desire to compliment data obtained by Hopkins (1965) on a survey of the conditions of shelterbelts in part of south east Midlothian, East Lothian and Berwickshire.

The region in the vicinity of the Pentland Hills (Figure 3) was chosen because it satisfied these requirements. Part of the Tweed Valley east of Kelso was the only other area considered suitable for intensive study, but transport costs ruled it out.

Location and Boundaries of the Study Area

The study area is in two lobes, one on each side of the Pentland Hills in Midlothian (Figure 4). The extent of the survey was influenced by natural and artificial features, and the limits of the area were defined during the course of the field work. The boundaries and limiting features are:

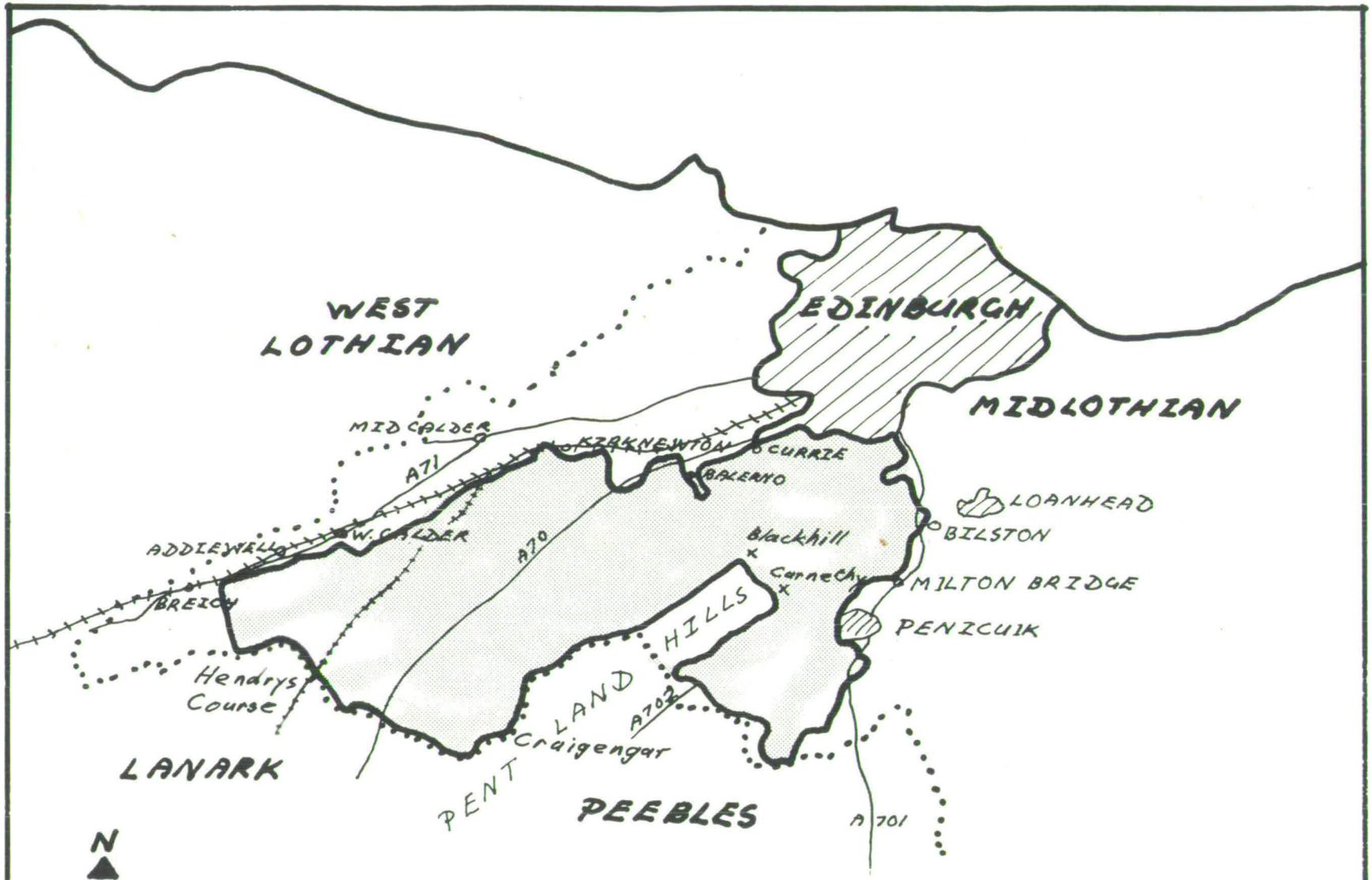


FIGURE 4 BOUNDARIES OF STUDY AREA : NATURAL AND ARTIFICIAL FEATURES

A. The Western Lobe

1) Starting at Kirknewton, twelve miles WSW of the G.P.O. in Edinburgh, the northern boundary follows approximately the 500' contour and the railway line to West Calder, and then the A704 road to Lanark as far as Woodmuir forest. The following non-agricultural features also influenced decisions on which farms to include:

a) Shale mines at Oakbank near Mid Calder.

b) The Livingston Designated area, within which urbanization has already started.

c) Coal mining and associated industries at Polbeth, West Calder and Addiewell.

2) The eastern edge of the Forestry Commission plantation at Woodmuir constitutes the short western boundary.

3) On the south, the Midlothian County boundary with Lanarkshire along the watershed between Forth and Clyde river systems coincides with moorland farm boundaries eastwards to the foot of Craigengar, 1,700'.

4) The remaining part of the Western Lobe boundary follows farm boundaries along the chain of prominent peaks on the NW side of the Pentland Hills. Initially it coincides with the watershed between the Forth and the Tweed, which is also the county boundary between Midlothian and Peebleshire. Further north, farm and study area boundaries follow the watershed between the Water of Leith and the North Esk Water, as far as the foot of Black Hill, 1,636', the point where the two lobes meet.

5) The choice of the north boundary from Kirknewton eastwards was influenced by the following non-agricultural and natural features:

a) An airfield.

b) The Water of Leith, except where a farm unit crossed the river.

c) The urbanization around Balerno and along the Lanark road (A70) through Currie.

B. The Eastern Lobe

Because it is topographically more varied than the above, the Eastern Lobe has a less regular boundary. The intention was to stay west of the Edinburgh-to-Peebles road, A702 to Hillend, A703/A701 to Penicuik via Milton Bridge, and A701 to Leadburn. Other determining features were:

1) Boundaries between agricultural and non-agricultural land, e.g.

a) The limits of the southern suburbs of Edinburgh.

b) Hillend Public Park.

c) Sand and gravel mining around Old Pentland.

d) Coal mining and urbanization at Bilston and Roslin.

e) Glencorse Barracks and Milton Bridge township.

f) Penicuik Burgh boundary.

2) Suitable farm boundaries across Auchencorth Moss near the watershed between the Forth and the Tweed. (There is again some coincidence of farm and county boundaries at the southern end of this lobe.)

3) The former boundary of Penicuik Estate (Plan: Ainslie, 1797) from the Esk gorge to Nine Mile Burn, and then northwards again, along the lower slopes of Braid Law and South Black Hill.

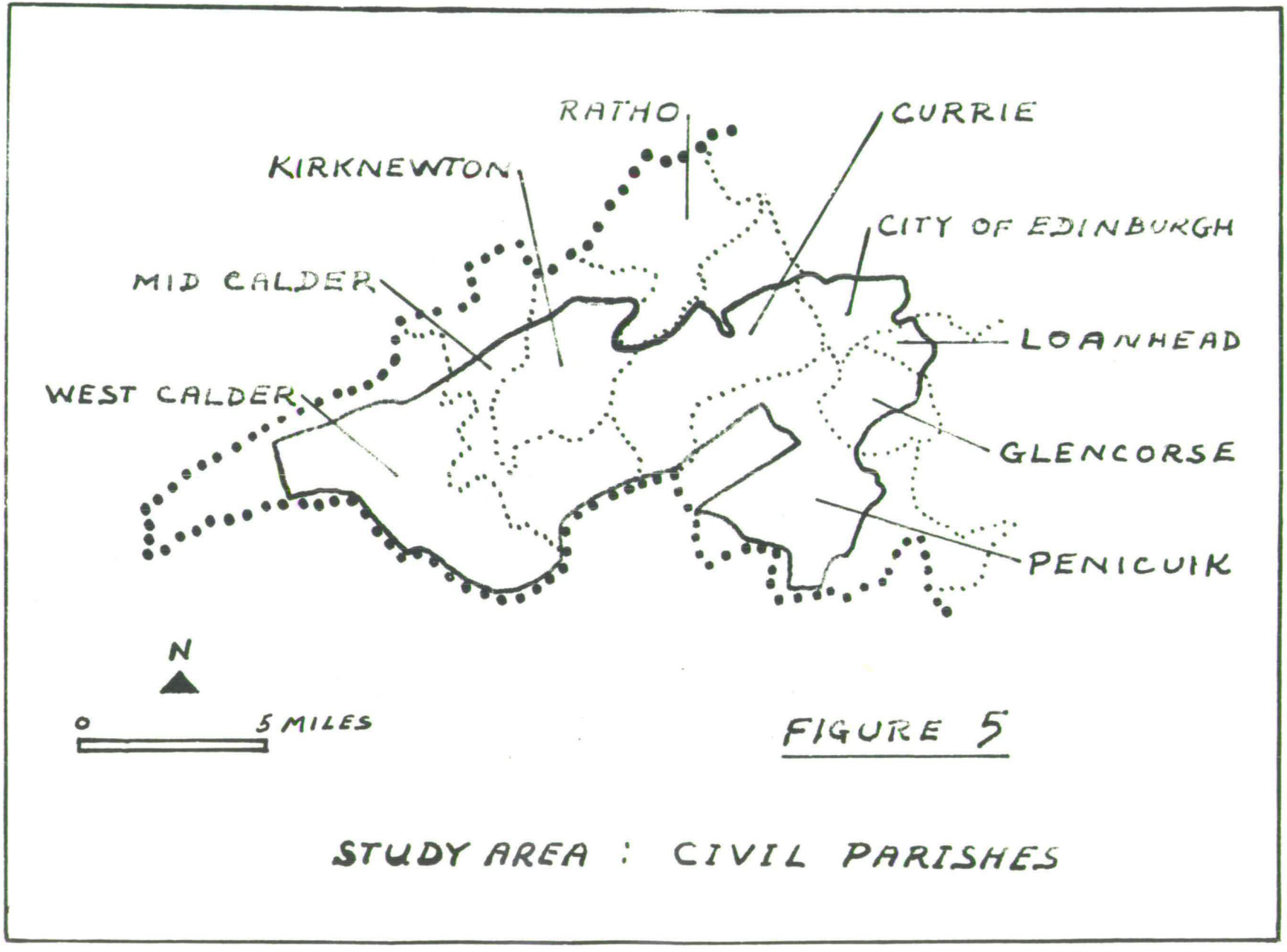


FIGURE 5

STUDY AREA : CIVIL PARISHES

4) Finally, the area boundary follows march dykes through the Pentlands, in a north-westerly direction, between Scald Law, 1,899', and Carnethy, 1,890', to the foot of Black Hill.

With the exception of the county boundaries mentioned above, administrative boundaries have not been followed. Certain civil parish boundaries actually traverse a few of the present-day farm units (Coppock, 1965). Parts of the following parishes are included within the study area, from west to east: West Calder, Mid Calder, Kirknewton, Currie, Penicuik, (City of Edinburgh), Lasswade, Glencorse, and Penicuik again (Figure 5).

Zones

For the purpose of comparison, the study area is divided into eight zones. Except for zones IV and V, zonal boundaries follow farm boundaries along pronounced topographical features (Figure 6). Zones IV and V contain hill and upland farms across the catchment areas of the waters that divide zones I and III.

Farm Units

A farm unit is that land division used during the field survey. It is either a single farm or a number of farms run by the same person, be he owner-occupier, manager, or tenant.[1]

---

1. Certain 'units' do not conform to this definition. These exceptions are explained in footnotes to the tables of data in Appendix I.

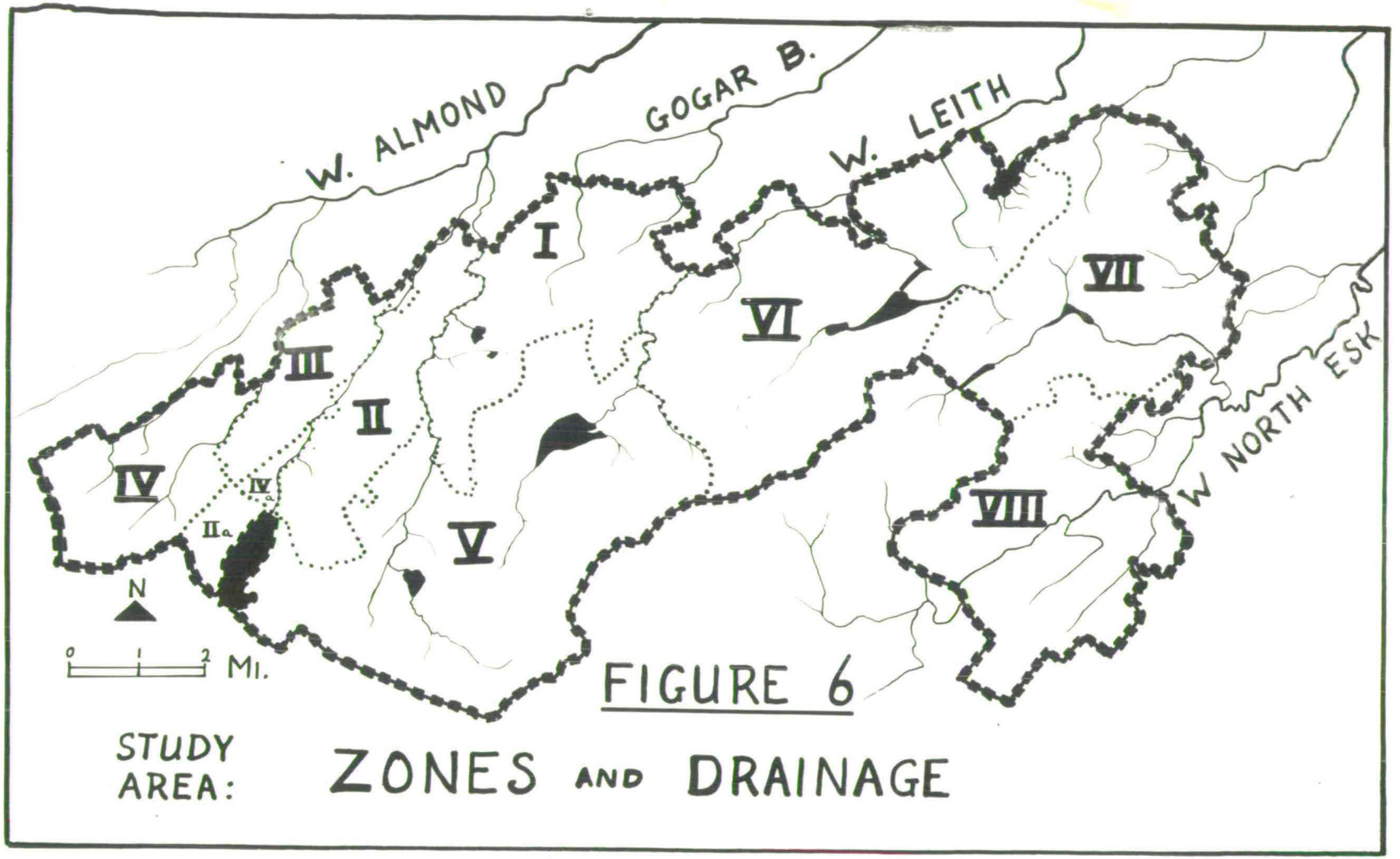


FIGURE 6

STUDY AREA: ZONES AND DRAINAGE

Geology

Relief, drainage patterns, and soil types have their origins far back in geologically distant times. Knowledge of the following facts proved most useful during the survey.

The study area lies on the floor of a rift valley that was formed toward the end of the Silurian era. Rocks of this age are the oldest found within the area, though debris from Ordovician rocks on the valley walls occurs as conglomerates of Lower Old Red Sandstone (Devonian) age. Some faults and folds within these strata are associated with formation of the rift valley and are thus oriented approximately WSW-ENE; others are associated with the anticlinal fold of the Pentland Hills and have a SW-NE orientation. Lavas of Lower Old Red Sandstone age were extruded through such faults and intruded as dikes and sills within the contemporary and older sedimentary rocks. Younger sedimentary rocks of the Devonian and Carboniferous eras are also complicated by tilting, faulting and the products of vulcanicity.

By the Quaternary era, erosion had produced a landscape broadly similar to that of today; the oldest rocks are exposed along the Pentland Hills and progressively younger ones to east and west, with streams exploiting fault lines and weaker rocks. The Pleistocene ice sheets further eroded the high ground and spread some of the debris over the lower ground as boulder till. Ice sheets came from both sides of the rift valley. Sometimes from one side, sometimes from the other, they moved across the study area; that from the south in a north easterly

direction, that from the highlands nearer due east. Thus the boulder till in the western lobe of the study area originates from the Carboniferous limestones and sandstones, while that to the east of the Pentlands is derived from Devonian and Silurian rocks.

During the ensuing, warmer fluvio-glacial period, steep-sided drainage channels were cut by melt waters which sometimes followed preglacial stream courses and other times cut new courses, all in a general north easterly direction. In places, the moranic material was redistributed via these channels (Geikie, 1901; Kirby, 1966).

On the lower ground, mineral soils have developed by weathering processes from the boulder till or redistributed material; the parent rock determines the lime-efficiency. This is generally poor in the western lobe of the study area and medium class in the eastern lobe (Anderson, 1925). On the high ground parent rocks have been exposed by erosion of the layer of boulder till, but soils are mostly thin and leached. Peat soils occur in places where blanket and/or raised bogs developed and spread under suitable climatic conditions. Such peat bogs or mosses are now confined to the upland parts of the study area; those that occurred on lower ground have been reclaimed (Aiton, 1811; Steele, 1826).[1]

---

1. The farm name, Mossend, (NT 006609) may be a guide to the former northern extent of the peat in zone IV. It is now about one mile from the nearest peat hags.

Climate

In geologically distant times the climate fluctuated from desert conditions in the Devonian era, and tropical forest conditions during parts of the Carboniferous era, to ice and permafrost in the Quaternary era. But even during the ice ages, there were interglacial periods when conditions were tropical once more. These past climates are reflected in sedimentary rock types and hence in the modern soils, as indicated above.

Small-scale fluctuations in climate have influenced vegetational growth in recent times. Lamb (1964) has shown that in Scotland a post-glacial optimum for tree growth occurred between 2700 B.C. and 2200 B.C., and that there was another warm epoch from A.D. 1070 to A.D. 1300. This was followed by a cold period between 1300 and 1700, during which deficient summer warmth, windiness, and wetness were probably the most important factors behind a decline in the extent of forests in Scotland, as well as being responsible for frequent crop failures and resulting famines.

The warm decades at the beginning of the eighteenth century are parallelled by those at the beginning of this century (Manley, 1952). But there are already signs of increasing oceanic influence on the British climate (Lamb, 1966). When continental influence weakens, a smaller percentage of winds come from the east, and there is less snow in the late winter. More frequent depressions mean more cloudy weather and hence less incoming solar radiation and less evapo-transpiration even if rainfall does not increase.

The climatological data[1] presented below was mostly collected during the latest optimum period.

i) Temperature. When an oceanic weather system prevails, a summer may not only be cooler and hence the growing season shorter than when a continental weather pattern prevails, but it also affects the intensity of plant growth. Should cereal crops fail to be an economic proposition, stock rearing may then be favoured even on lower ground (Ellison, 1953; Whyte, 1963). Anything that can be done in the way of retaining or increasing flexibility in the use of such marginal land, obviously increases output from the farm. Landale (1963) has shown that shelterbelts can fulfil this function economically by reducing loss of heat from farm land and buildings. The plant growing season is measured as the number of days when the mean temperature is above 5.5° Centigrade.[2] At Turnhouse Airport it is 243 days (Figure 7). Table 1 shows how altitude affects the length of the season at various other recording stations near and within the study area.

---

1. Numerical data from Lothians Regional Survey and Plan, 1966, II, and Plant, 1966.

2. 5.5°C is a threshold of plant growth, and is taken here to apply to both North Temperate agricultural crops and forest trees. (Pearsall, 1950; Anderson and Fairbairn, 1955).

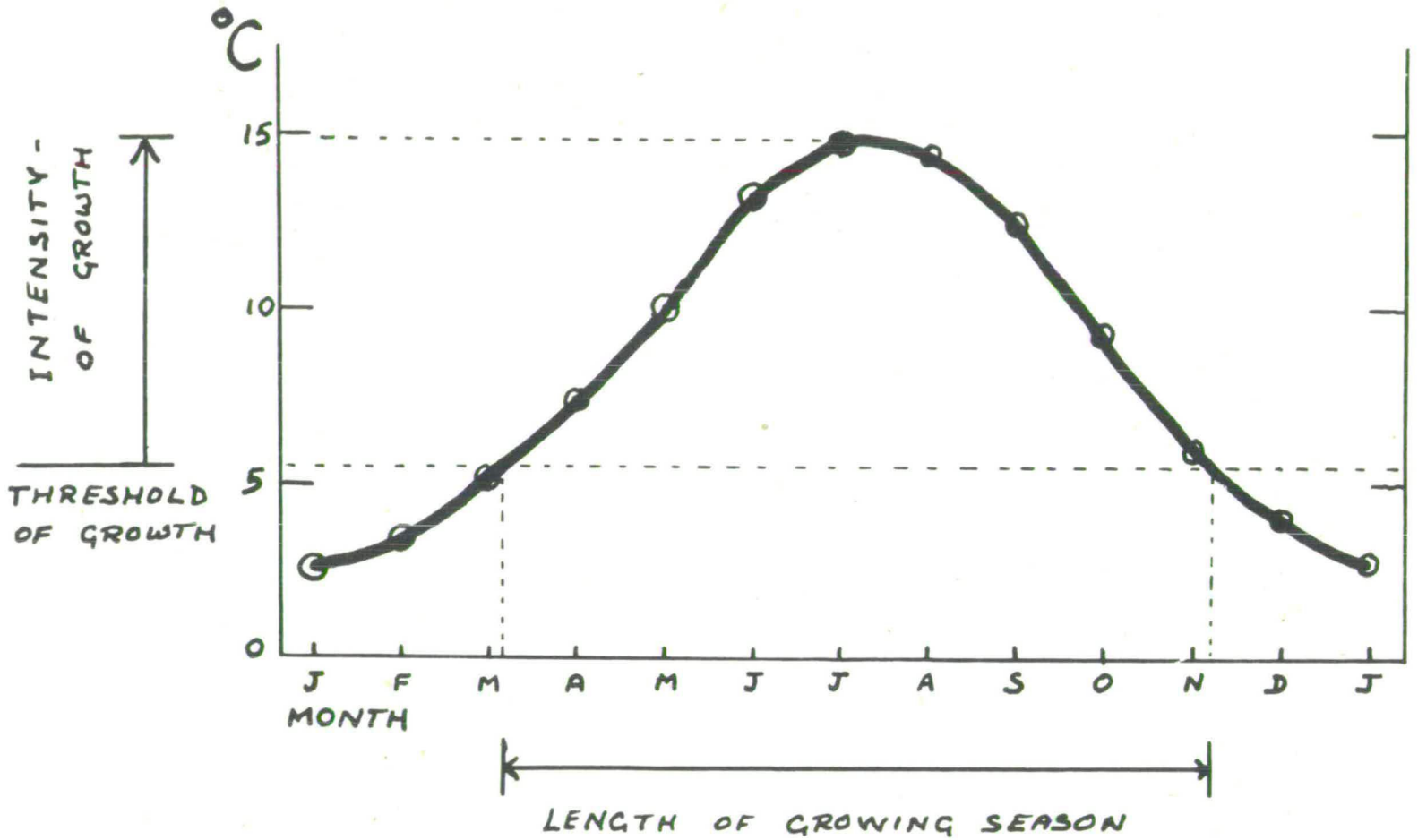


FIGURE 7

THE PLANT GROWING SEASON AT TURNHOUSE AIRPORT

(1931–1960) ALT 114' O.D LAT. 55°74'N

Table 1. The location, altitude, and length of growing season at four recording stations

Recording Station and Location	Altitude (feet above O.D.)	Length of G.S. (No. of plant growing days)
Royal Botanic Garden, Edinburgh.	76	243
Blackford Hill, Edinburgh.	441	230
Boghall, Milton Bridge, Midlothian.	639	205
West Linton, Peeblesshire.	820	188

ii) Rainfall. In recent years, a negligible amount of the annual precipitation has fallen as snow. Rainfall statistics are therefore adequate to illustrate the amount of ground moisture that is available. Table 2 indicates that in general, rainfall increases with altitude. Anderson and Fairbairn (1953) have shown that several other factors must be taken into account when estimating the effect of total rainfall on growth of trees, namely, aspect, soil type, and exposure. These factors also affect crop growth.

Although annual and monthly means of rainfall are almost identical for the two recording stations, Balerno and Penicuik, both woodland and field crops do far better near the latter than near the former. Around Balerno, the land has a northerly aspect, the soil is fairly retentive, and the ground very exposed, except where there are good

shelterbelts, whereas there are more readily drained soils and more sheltered ground on the south easterly slopes of the Pentland Hills.

Table 2. The location, altitude, and mean annual rainfall at five recording stations

Recording Station and Location	Altitude (feet above O.D.)	Mean Total Annual Rainfall (inches)
Turnhouse Airport, Edinburgh.	114	26.97
Blackford Hill, Edinburgh.	441	27.53
Penicuik, Midlothian.	620	37.32
Balerno, Midlothian.	700	37.09
Crosswood, Midlothian.	950	40.62

iii) Wind. No station within the study area records quantitative data for wind speed and direction. Wind roses for Edinburgh and Turnhouse Airport give a good indication of the conditions of exposure that probably prevail over the study area as a whole, though local topographical features may affect wind direction and intensity in places. Thus, with regard to the prevailing winds, the district around Balerno lies in a funnel between the Pentland Hills and Dalmahoy Crags. Conversely, there are some places in the lee of the Pentland Hills that are sheltered from prevailing winds, but perhaps more exposed to north

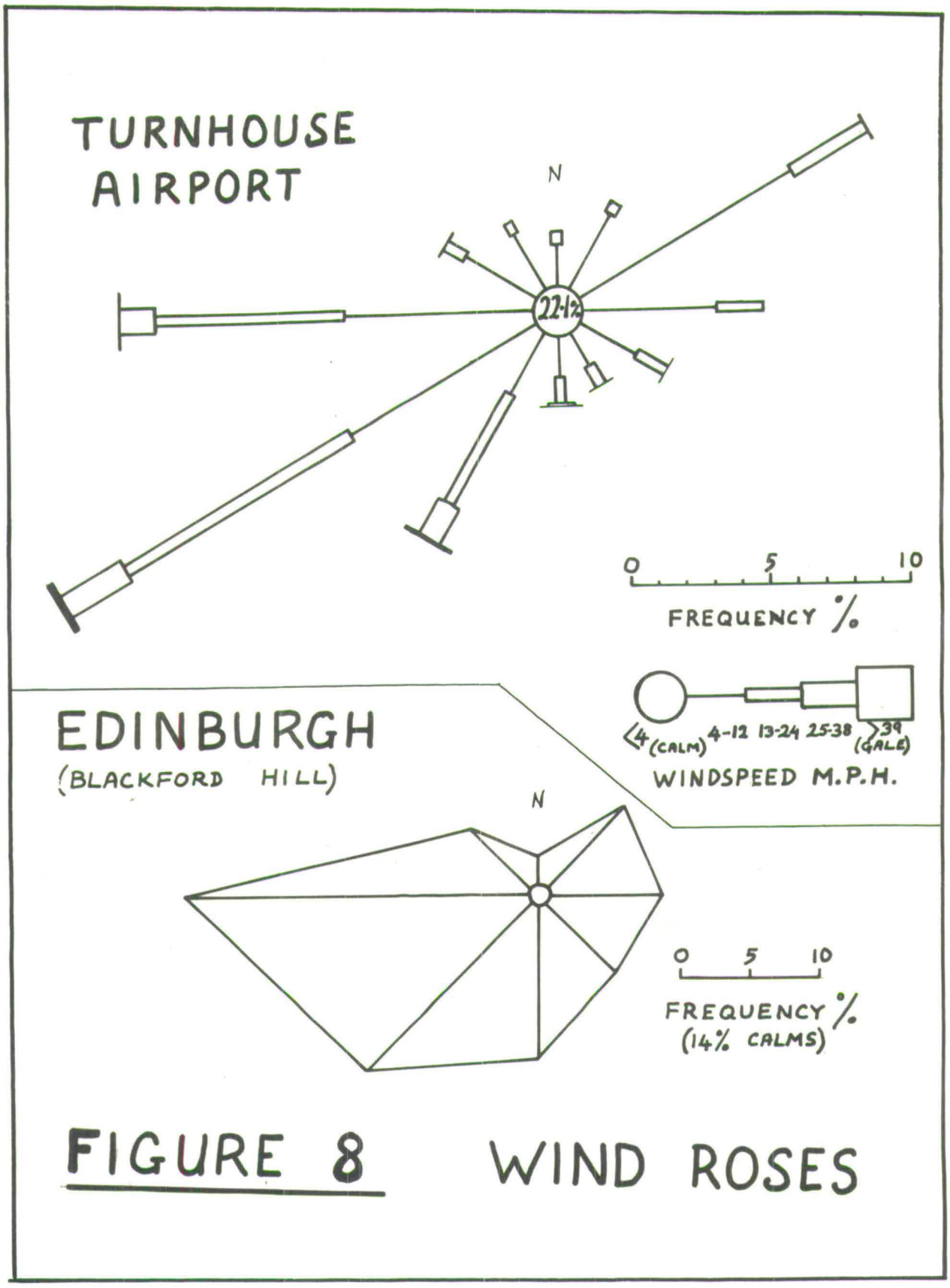


FIGURE 8 WIND ROSES

easterly winds. The influence of topography is also seen in the Edinburgh wind rose since the prevailing south westerlies have been deflected round the end of the Pentlands and channelled between them and the series of parallel east-west ridges on which the city is built. From the more precise Turnhouse data, which is plotted by 30° arcs instead of the conventional 45° ones, it is clear that winds most frequently come from directions parallel to major topographic features, i.e., parallel to the primary features (the rift valley walls, WSW-ENE, and the Pentland Hills, SW-NE), and also parallel to the secondary features such as ice-scoured crags and the courses of many misfit streams in glacial drainage channels.

Shelterbelts are obviously most likely to provide shelter to the adjacent land when they lie normal to the wind direction. But to be effective, the trees in the belt must be healthy and uniformly distributed over the site. Belts with orientations oblique or parallel to prevailing winds may provide shelter from winds that come from unusual directions, but such belts can be shown to have a subsidiary or even a major productive function. In addition, viable belts inevitably provide suitable habitats for numerous animal and plant species and make a major contribution to landscape variety. Protection of agricultural land from the adverse effects of wind, particularly in respect of grazing animals that suffer increasing physiological stress as wind speed increases is the prime reason why belts have been established and maintained in the study area (Munro, 1962; Doney, 1963).

CHAPTER III METHODS

Meeting the Farmers

Farmers' names and, for tenanted farms, the proprietors' names, were obtained from the Midlothian County and Edinburgh City Valuation Rolls (1965, 1966). Each farm was visited and an interview sought with the farmer. The minimum requirement was to obtain permission to examine the shelterbelts, though in the case of a tenant this permission was obtained from the proprietor before hand and access to the belts was asked of the farmer. In no instance was permission refused. Interest in the study was frequently expressed and the following information readily supplied.

1) The location of the farm march fences.

2) Farm acreage.

3) Rough grazing acreage (if applicable).

4) The uses of shelterbelts (and other woodlands) on the farm and any ways in which woodlands affect the farming regime.

For some properties information was also given on how belts are being planted and maintained for particular uses.

In the field, 2½" O.S. maps were used. All permanent fence lines are marked on them and the present-day boundaries of each farm unit were drawn in. The most important consideration was to find out the exact position of the march line when a wood was found to lie on the farm boundary. Information about other marches was obtained from neighbours if there seemed to be any doubt about their location.

Total farm acreage and area of rough grazings were checked by or obtained from 25" maps or by the Method of Squares (Monkhouse and Wilkinson, 1952. 100 sq. mm. was taken to represent 6.4 acres at 2½" scale). The extent of rough grazing was taken as that shown on the 1955-1958 revisions of the 2½" O.S. map.

Examination of the Shelterbelt Sites

On each unit, all the shelterbelts (as defined by Murray and Mutch, 1961, p.3) were examined and for each one notes were made on the following:

1) Top height (approximate) obtained by visual estimation or with a Haga altimeter from selected 'representative' trees, or by pacing blown trees.

2) Width, by pacing.

3) Type, condition, and location of fences.

4) Stock usage (if fences incomplete).

5) Evidence of damage by other agencies, e.g. building, electricity poles and pylons, water-erosion, and bogs.

6) Type of stand. Three types were recognised: predominately broad-leafed species, pure conifer, and intimate mixture.

7) Site condition (see below).

8) Any other points of interest, e.g. situation and aspect of site, ring counts, behaviour of drifting snow, and location of stock in relation to the belt. Whenever possible, farm employees and other persons met

with in the course of field work on the farms were asked for their opinion of the value or disadvantage of shelterbelts in that particular situation.

Shelterbelt Site Condition

The condition of the shelterbelt site, rather than the condition of the trees themselves (Murray and Mutch, 1961), was used as the basis of a five-class scheme of classification. Derelict sites fit naturally into the series, which was devised by Hopkins (1965). Completeness of the stand expressed as a percent distribution of stems is the objective principle behind the scheme, but in the field the condition-class into which any shelterbelt site was placed had to be determined subjectively.

Condition Class A: Distribution of stems regular and 96-100% complete. Usually young plantations, but some well-maintained, older stands.

Condition Class B: Stem distribution less regular and 80-95% of 'optimum' expected for size of trees. Small gaps because of failure or windthrow. Stands of young to medium-aged trees, less carefully tended.

Condition Class C: Irregular distribution, larger gaps, but 60-79% complete overall, and the canopy still more-or-less complete. Trees usually approaching maturity, and fairly carefully tended.

Condition Class D: Distribution very irregular; only 20-59% complete and with gaps of various sizes in the canopy, and trees mature or overmature. Rarely tended.

Condition Class E: Scattered trees or deforested. Ineffective as a windbreak.

Woodland Management Types

As an aid to description, the units were subsequently grouped into four Woodland Management Types on the basis of belt condition.

Type a: Proprietors thoroughly involved in woodland management at present, or in recent past. Therefore either i) a majority of sites in A - C condition, or ii) a number of sites in A - C condition plus large productive woods.

Type b: Either i) present belt management active; some A - C condition sites, but still a majority of D and E condition sites, or ii) recent planting activity followed by inadequate maintenance: young or rehabilitated stands in B, C and even D condition, and degeneration unchecked.

Type c: Little evidence of recent planting activity and the present owner not particularly concerned about shelterbelt management.

Type d: Units without shelterbelts.

Recording the Results

Field work was undertaken during the two winters, 1965/66 and 1966/67, during the months of November - April which are traditionally associated with silvicultural activity on Scottish estates.

The data were collected on specially designed cards so that information about the belts on each farm unit was readily available for

reference. In addition to the transcribed field notes, individual belt areas were entered on the cards. Acreage (to the nearest 0.1 acre) was obtained from the 25" O.S. maps, 1907-08 edition. For twenty-five belts planted since the maps were published, areas calculated from site dimensions, (i.e. from aerial photographs or 6" O.S. maps), or data supplied by the farmer were used.

The basic information about each farm unit is given in Appendix I under the following headings:

1) Unit number, which normally indicates the order in which any farm was visited, although a number was occasionally reserved pending a later visit.

2) Land Tenure: Owner-occupier, manager, or tenant. (Footnotes are used to explain certain peculiarities in tenure).

3) Woodland management type (a to d).

4) Shelterbelt Condition: the totals of area and number for belts in site condition classes A to E.

5) Other woodland area.

6) Improved land area (fields used for arable and pasture).

7) Rough grazing area.

8) Total farm area.

CHAPTER IV
A HISTORY OF TREE PLANTING FOR SHELTER AND OTHER PURPOSES ON FARMS IN LOWLAND SCOTLAND, WITH PARTICULAR REFERENCE TO THE STUDY AREA, 1728 - 1967.

Introduction

When Samuel Johnson wrote about his tour of Scotland in 1773, he made remarks that angered Scottish gentlemen at that time. Even his travelling companion, Boswell, writing eleven years later, took pains to correct the erroneous impression that Johnson had said there were no trees on the east coast of Scotland. Put in context, the statements reveal the state of silviculture at the time. Johnson wrote:

> "From the bank of the Tweed to St. Andrews I had never seen a single tree which I did not believe to have grown up far within the present century... The variety of sun and shade is here utterly unknown. There is no tree for either shelter or timber.
> "That before the Union [of Parliaments] the Scots had little trade and little money is no valid apology; for plantation is the least expensive of all methods of improvement. To drop a seed into the ground can cost nothing, and the trouble is not great of protecting the young plant till it is out of danger, though it must be allowed to have some difficulty in places like these, where they have neither wood for palisades nor thorns for hedges." (Chapman, 1948, pp. 9 - 10, present writer's emphasis).

Obviously Johnson was so concerned with the fact that there were so few old trees to be seen along the route, that he was not careful to comment upon the trees that had been planted during the eighteenth century. The occasional old policy plantings that he later alludes to, e.g. at Cawdor (Nairn) and Inverary (Argyll), can be shown to date from the period following the Union of Crowns (1603). (Anderson, 1967, I, pp.359-360).

Neglect of silviculture before the eighteenth century can be attributed to many factors, among them the extreme poverty of the lairds,

and the interest of the land-owning classes in struggles for power at a time when the monarch and his close advisors preferred salaried posts upon their adherents. By 1700 Scotland's social and economic position was desperate. Seven crops in ten had failed. Famine was widespread and there were large numbers of poor peasant farmers who could find no alternative employment to earn even a subsistance wage. Furthermore an unsound financial venture, the Darien Scheme, had left virtually no ready money in the whole of Scotland.

But early in the eighteenth century, after the Union of Parliaments (1707), the domestic situation became more stable. Scottish lairds returned from fighting wars or from political exile on the Continent, and the younger members of the landed families, lawyers, doctors, and ministers of the church, who had concluded their training abroad, also returned to Scotland at this time. Many of them then turned their attentions to farming and tree planting, both on parts of the large family estates and also on smaller properties that they were able to purchase. They did this partially of economic necessity and partially as a recreational pursuit. (Allardyce, 1888; Smout, 1964). To improve output from the land they used methods currently employed in countries they had been to. In Holland they had seen fields cultivated like kitchen gardens (Louden, 1838). Hedgerows for enclosures were an idea imported from England, and English workmen were even brought north to build them (Anderson, 1957). A fashionable craze for landscaping after the French style of the time led to the incorporation in farm layout of avenues, clumps of trees, and

strips of planting (Graham, 1875). Some of these strips of planting constituted the first agricultural shelterbelts in Scotland.

Coincidental with this great surge of interest in agriculture and silviculture in Scotland, the climate of the British Isles changed from an oceanic to a continental type (Lamb, 1965). The warmer summers and longer growing seasons presumably favoured tree growth. The plantations also thrived initially because of the great care with which the trees were planted and tended (Colville, 1904). But later in the eighteenth century, it became apparent that some of the introduced ideas were not suited to the Scottish climate and that wider belts planted with hardier tree species were required wherever exposure was severe (Sinclair et al. See below).

Certain influential members of the Society of Improvers in the Knowledge of Agriculture in Scotland, formed in 1723, were particularly active in forwarding tree planting in Scotland, notably: Lord Ilay, Treasurer General for Scotland in Robert Walpole's government, Justice General of Scotland throughout his life, and Third Duke of Argyll, 1745 - 1761 (MacEwen, 1776 MS); Sir John Clerk of Penicuik, Baron of the King's Court of the Exchequer in Edinburgh, one of the gentlemen who treated for the Unions, and a celebrated antiquary (Grey, 1892); the Sixth Earl of Haddington, Hereditary Keeper of the Park of Holyrood House (Anderson, 1957); and the Second Earl of Stair, Ambassador at Paris 1715 - 1720 (Graham, 1875). Another learned Society, but one with wider terms of reference was founded in 1739. It was the Society for Improving Arts and Sciences. Sir John Clerk was the Vice President, and the first President

was James, Fourteenth Earl of Morton.

Learned and titled gentlemen and many other well-educated people met regularly in Edinburgh under the aegis of one society and then the other to hear papers read and to discuss the theory and practice of agriculture (Handley, 1953). The improvement schemes they initiated consumed much time and money.[1] But the poor found employment and the productivity of the land was increased tremendously by revolutionary changes in crop and stock husbandry. Hedgerows and shelterbelts were among the most important long term investments that these proprietors made in the land.

The extent of enclosure and shelterbelt planting in the middle of the eighteenth century can be estimated from General Roy's Military Survey of Scotland (1747 - 1755). The map is at a scale of 1000 yards to one inch and, in the original, all woodland is shown by green symbols in plan view (Skelton, 1967). The importance of this map in tracing the development of silviculture is tremendous. For Midlothian, the next

---

1. Compare and contrast Kenya: 1907-1962 conversion of land to profitable farms by European imigrants who gave employment to many local inhabitants. Immediately prior to independence, under a 1,000,000 acre resettlement scheme, subsistance farming was re-introduced. Most divided farm units supported neither the same number of people, nor these at the same living standard as previously. However, on the positive side, the Prime Minister, Mr. Jomo Kenyatta, has led a campaign for tree planting.

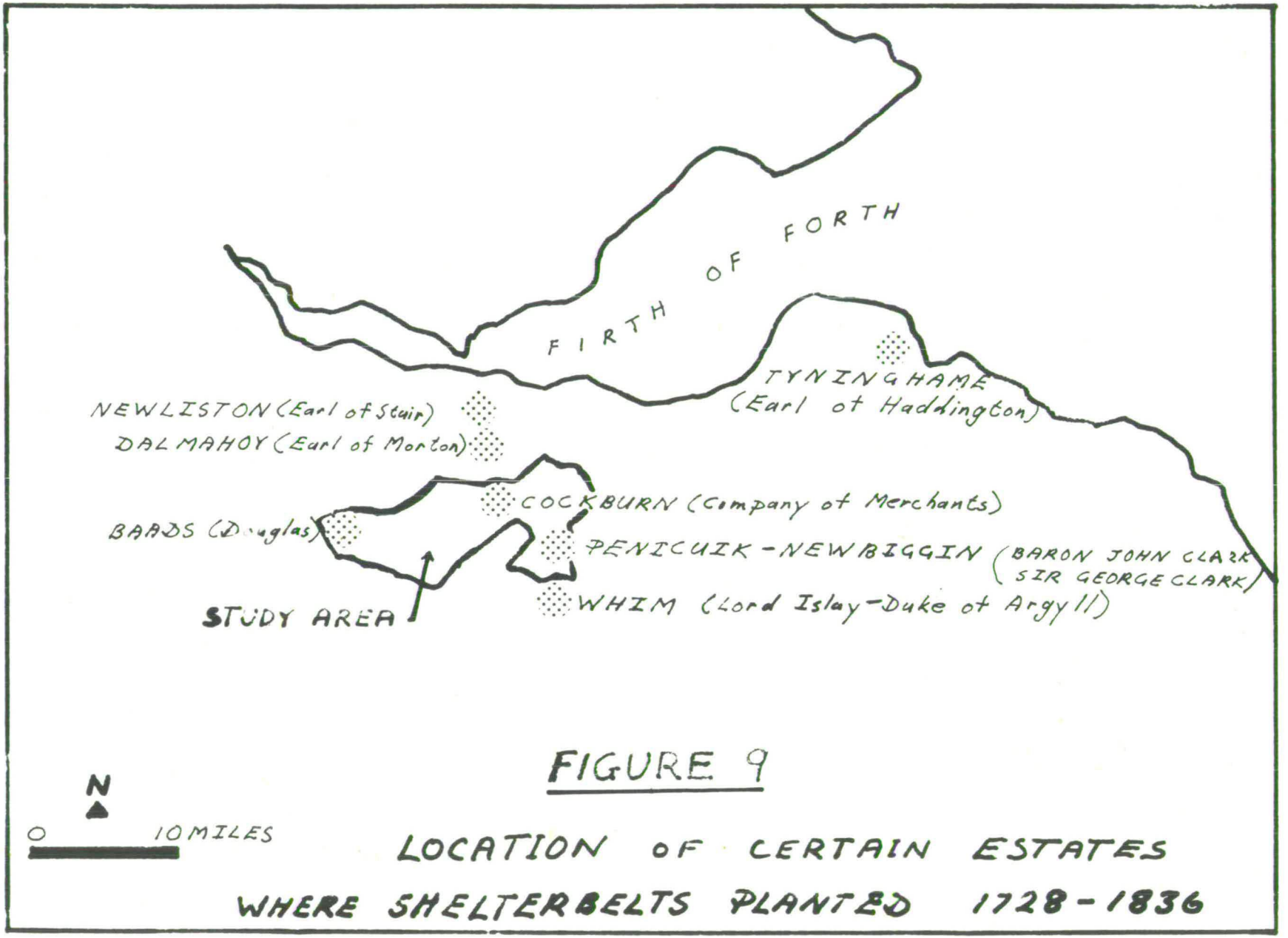


FIGURE 9

LOCATION OF CERTAIN ESTATES WHERE SHELTERBELTS PLANTED 1728-1836

map with woodlands accurately shown is that of Knox, 1812 (scale: 1½" to 1 mile). Scottish Estate plans are extremely rare for the intervening period (Adams, 1966), but where they exist, as for Dalmahoy and Penicuik Estates in the study area, they too are valuable tools in tracing the changes in the landscape of lowland Scotland brought about mainly by the creation of numerous shelterbelts (Third, 1957). MSS, printed works, and aerial photographs have also been used in the compilation of this chapter.

It is important to start this investigation into the origin of shelterbelts in the Scottish lowlands by reporting methods and designs used in establishing hedgerows on certain estates, the location of which are shown in Figure 9. Although hedgerows appeared to the earliest Improvers to be the ideal form of fence for enclosures where some shelter was required, it was not until the last quarter of the eighteenth century that agriculturalists realised that it was necessary to plant strips of trees if provision of shelter were to be perpetual. Shelter for crops is sometimes mentioned as a reason for shelterbelt planting, but in almost every instance where records are available for the time belts were actually established, it is surprising to find that shelter for stock rearing was the prime consideration. This includes growing grass and clover in sheltered fields for winter feed, as previously few cattle had survived through the winter season.

The Early Improvers

i) Sir John Clerk, laird of Penicuik from 1722 to 1751, began to plant trees on the braes of the North Esk water about 1701, when he was only 17 years old. Later he wrote several practical papers about the methods he used,[1] e.g. "Method of Improving the Baronie of Penicuik Which Will Likeways Suit Most Places in Scotland".[2]

> "... They may, as other lands, be improven double or triple to what they are by inclosing them with hedges and ditches: the first will fence and keep them warm, and the last will drain their superfluity of moisture, but I would advise no inclosure to exceed ten aicres. Stone dykes are the best fences but they do not meliorat/e/ the ground... They confine cattle to dung where they eat and not in loans, roads and by-places as they commonly doe when they run at large.."

Sir John used several designs of hedges, but regarding the hedgerow illustrated (Figure 10) he commented that it was very effective against hunters as no horses could leap it.[3] For seven years after he made 15 enclosures on about 100 acres (Scots) of ground, he employed a herd with a dog to preserve the young hedgerows until the seedling thorns and trees were out of danger from cattle.

---

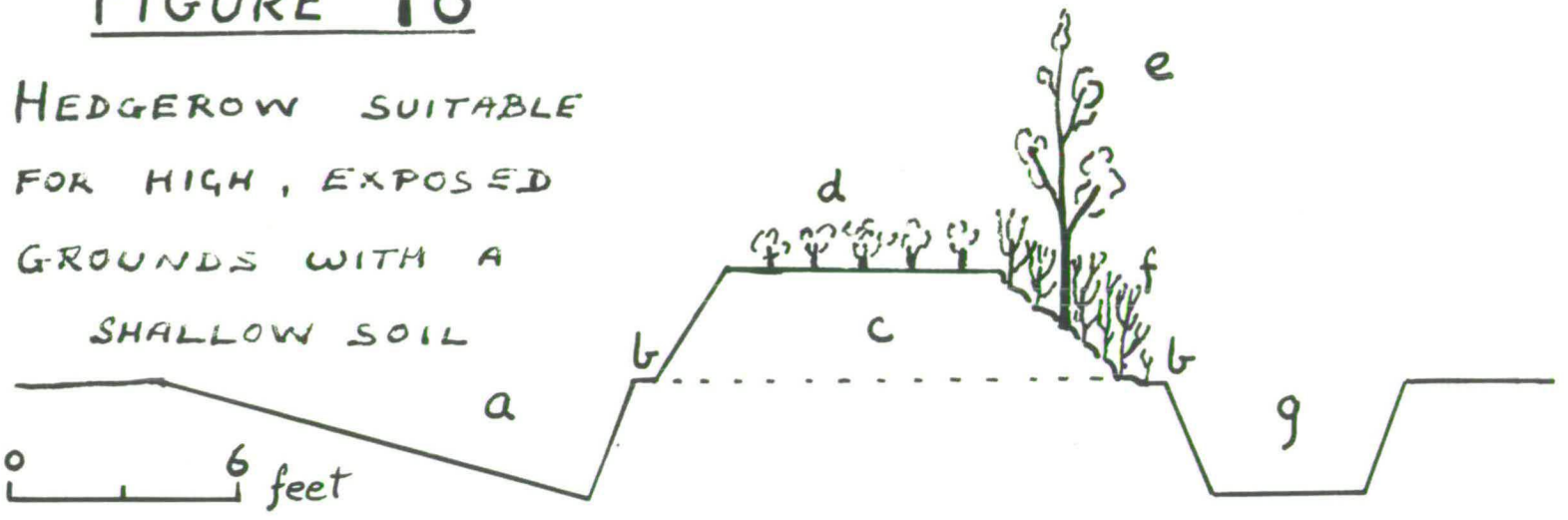
1. The majority are among the Clerk of Penicuik Muniments in the Scottish Record Office (henceforward S.R.O.). Each MS has a catalogue reference. number GD 18/___. Others are held on the estate (Third, 1955, 1958).

2. GD 18/1480, 24 Dec. 1728. Punctuation modernised.

3. GD 18/1693. "A Few Memorandums about Inclosing of Grounds, Made by Forty Years Experience at Pennicuik, 18 April 1739". Revised 27 Dec. 1742.

FIGURE 10

HEDGEROW SUITABLE FOR HIGH, EXPOSED GROUNDS WITH A SHALLOW SOIL



a) Wide ditch – provides plenty of good soil for bank c.

b..b) Scarsements – prevent bank slipping into ditches.

c) Broad bank – Supports vegetation well & will not dry out.

d) Whins (gorse) grown from seed. e) Oak trees, 12'-15' apart.

f) Thorn seedlings between turfs – kept weeded, especially from gorse seedlings in later years.

g) Drain for intercepting water from springs and boggy places.

(Diag. & Text after Clerk, 1739, GD 18/1693)

ii) The Sixth Earl of Haddington's wife encouraged him to improve his estate at Tyninghame in East Lothian (Anderson, 1957). He made his hedges about half as wide as Sir John Clerk's and there were considerably narrower ditches on each side. Writing about his developments, the Earl explains that he also used a hedge with a single ditch to fence shelterbelts (op. cit. p.62), and he also wrote:

> "... As I knew the coldness of the climate and the bad effects the high winds had, I made strips of planting betwixt every enclosure, some forty, fifty, or sixty feet broad... These look very well and I hope will be a great shelter and come to warm the ground." (op. cit. p.92).

At Leslie in Fife, before he moved to Tyninghame, the Earl had made enclosures where his horses could graze because hay was so expensive to buy (p. 91). He remarked that the new hedgerows and strips of planting at Tyninghame could be expected to yield timber and other produce, like blackthorn faggots five or six feet long that could be sold to the overseers of the highways for binding road surfaces.[1] Within the enclosed fields he sowed grass or clover for hay and for new seed. After mowing, cattle grazed the fields until the wet weather, in the autumn, when they were taken out before they could poach the ground. Barley is mentioned as a cover crop undersown with clover, and corn followed grass on rich or well-manured soils. (pp. 71-72).

---

1. Part of this chapter on fences pp. 61-70 is quoted from a communication from a "skilful gentleman...living near Windsor Forest." A Dorsetshire man had been brought north to show the local workers how to construct hedges and hedgerows.

iii) Sir John Clerk worked on fairly easily drained ground near the 800' contour, and the Earl of Haddington's enclosures were near sea level on a light soil. But Lord Ilay, who was one of the foremost exponents of the fashionable art of cultivating foreign trees and shrubs (Loudon, 1838), and who took an active part in the promotion of agriculture, trade and manufactures in Scotland (Lindsay, 1733), set about improving about 100 acres of blanket bog on the watershed between the Forth and the Tweed. He called his little estate "The Whim" but showed that it was possible to improve even deep peat given enough capital and plenty of cheap labour.[1] Aerial photographs and 25" O.S. map show that the moss ground south of the house (NT 217534)[2] was once divided into twenty-one four acre fields. There are banks, sixteen yards wide, between the deep ditches at the field margins. These banks, which may once have been planted as shelterbelts,[3] are still slightly raised

---

1. Letters among the Salton Papers on loan to the National Library of Scotland, e.g. Lord Ilay to Andrew Fletcher, 18 Sept. 1734, mentions "Soldiers" who were digging the "Great Drain" through the moss.

2. Map reference. See copy of Ordnance Map inside back cover.

3. Findlater (1802) states that on the moss itself, trees had mostly failed by the end of the century except where mineral soil had been thrown up out of the ditches onto the banks. Roy's map does not show any trees planted between fields, though the grid pattern of double drains is indicated and the avenues and amenity planting associated with the house are drawn in.

above the level of the rest of the moss. When trees[1] were planted near the house, great care was taken to ensure that the roots did not become chilled or waterlogged; wherever the peat was not sufficiently decomposed, a spadeful of gravel was put in to the hole that had been prepared for the seedling.[2] Descriptions of the theory and methods used in planting on peat compare very favourably with Zehet-mayr (1954).

In 1730, wheat, barley, oats and clover were grown, each under several trial conditions, in an enclosure near the house. The crops grew very well and a neighbour was so impressed, that he immediately tried to interest his tenants in aerating and manuring their ground in a similar manner.[3] Although numerous letters contain references to trees, there is no intimation that any plantation was designed to shelter crops.

A Second Generation Improver

James, Fourteenth Earl of Morton, was the son of a Member of the Society of Improvers in the Knowledge of Agriculture in Scotland and first President of the Society of Improving Arts and Sciences. In 1748 he bought the estate of Dalmahoy from the descendants of another

---

1. Tree seedlings came from local estates and also from Holland and England. Some of the tree seeds were from North America.

2. Fletcher to Lord Ilay. 29 March 1731.

3. Fletcher to Lord Ilay. 1730.

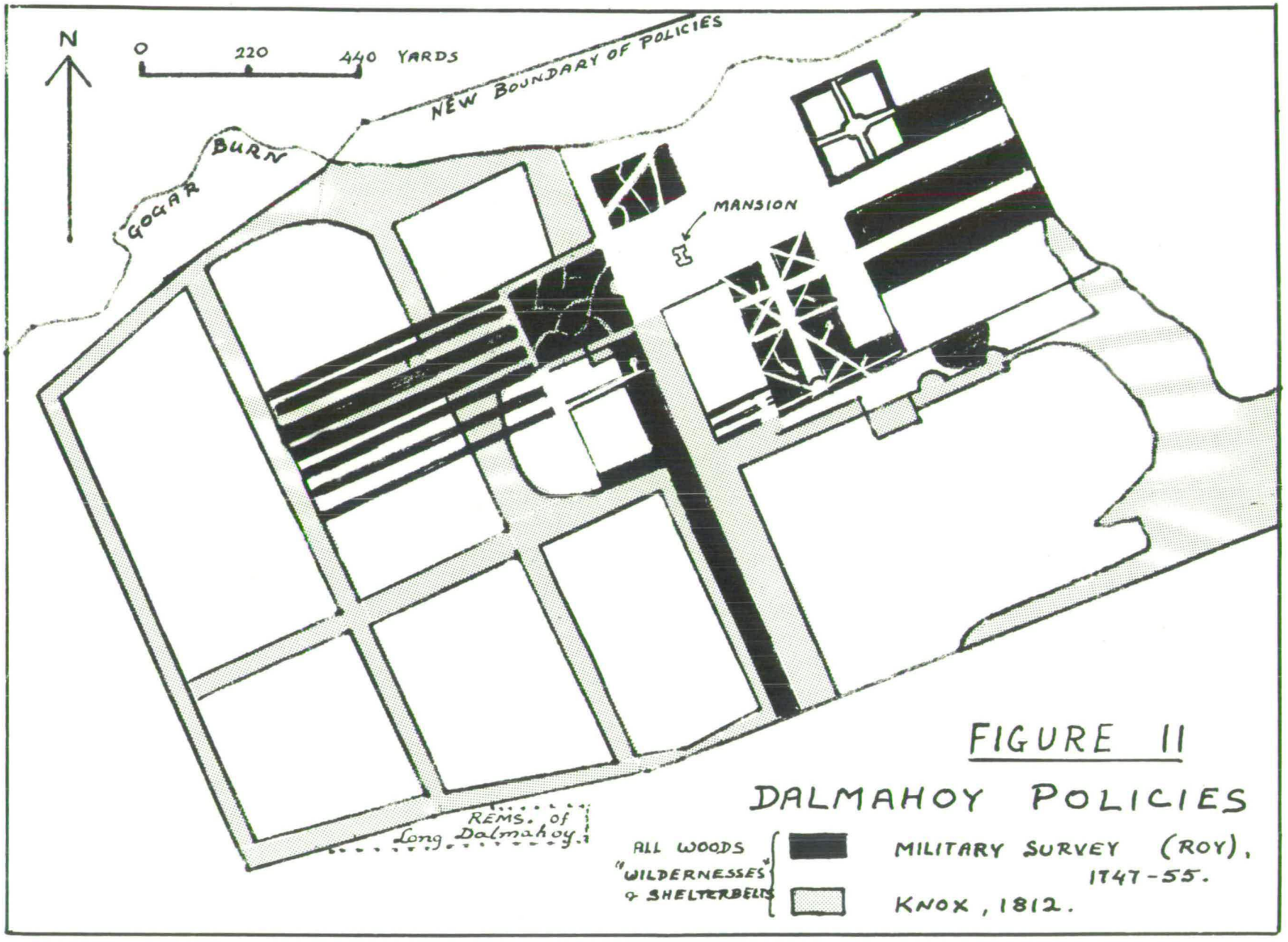


FIGURE 11

DALMAHOY POLICIES

Member, the Hon. George Dalrymple, who had concentrated on developing the policies (Roy's map, Figure 11).

For the period 15 August 1748 to 12 August 1749 there is a daily record of the work done by each of the new laird's workmen[1] and there is an interesting Estate Plan of the ground outside the original policies made before these were extended to their present limits.[2] Third has dealt with the social implications of the Earl's improvements schemes, which led to the emparkment of run-rig farmland and the depopulation of the village of Long Dalmahoy. Third's criticisms are not entirely justified: changes in land use meant that there was plenty of other work to be had, and many of those who were moved from the village probably found a better living in the Earl's employment.

There was a block of trees west of the mansion with parallel "views" through it, known as the Firr Park. The gardeners dug pits in the spaces in this plantation and were "filling up the views in the Firr Park with young firrs" early in 1749. At the end of February that year they were "planting small firrs and oaks in the strips round the Clover Park, on the west side of the Firr Park." They were later kept busy

---

1. S.R.O. Morton papers (henceforward GD 150) GD 150, Box 120, Reports on Farms and Offers for Farms. "Book of Workmen's Days at Dalmahoy".
2. Thomas Winter, 1749, "A Plan of the Lands of Dalmahoy without the Inclosures", S.R.O. RH Plan 1021: Part of which is reproduced by Third, 1957, p.52.

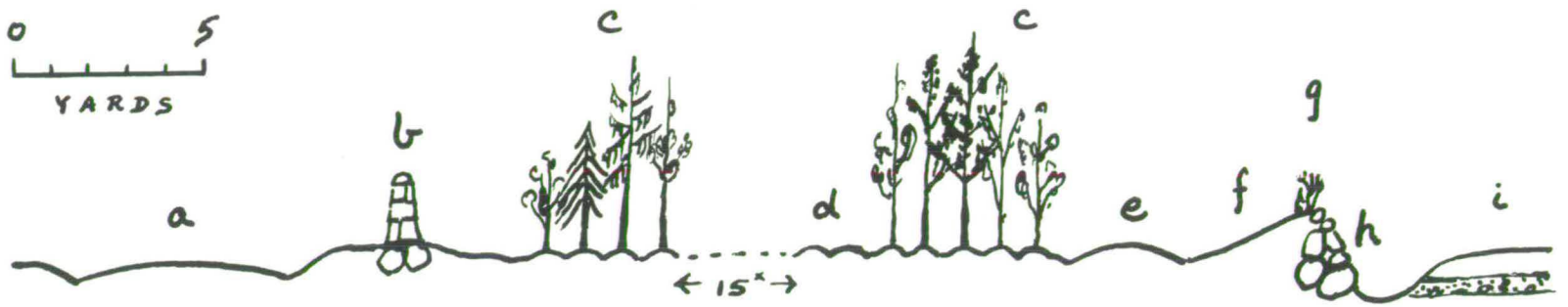


FIGURE 12 DIAGRAM: CROSS-SECTION OF A SHELTERBELT ON THE WINDWARD BOUNDARY OF DALMAHOY POLICIES (NT 135680), Ca 1815, OR FIVE YEARS AFTER PLANTING. (Based on MS material & field observations)

---

a) Public track (later a road) b) Boundary wall, cut stone & mortar, 6' high

c...c) Shelterbelt trees. Main sph: Sycamore, Beech & Silver fir; Nurses: larch, etc.

d) Ground prepared by double digging. Ridges 3' wide kept clear of weeds

e) Estate road of access to fields (parks) f) Grass bank of sunk fence

g) Hedge fence or paling (optional; only made if field used for sheep)

h) Stones & boulders (glacial erratics) used to face bank of sunk fence

i) Level field. Margin sloping into ditch – the outfall for underdraining

tending the young trees, chestnuts in the strips of planting west from the house (week beginning 12 June), and seedling oaks in the strips of planting west from the Firr Park (weeks beginning 26 June and 3 July). The conifers were evidently intended as nurses for the oaks (see below p. 40a for later examples of this practice on Dalmahoy Estate) and do not seem to have received such careful tending, as they are not mentioned in either of the weeding entries. The new policy parks were surrounded by strips of planting, protected by sunk fences, on the tops of which there were carefully tended hedges[1] (Figure 12).

Enclosure proceeded rapidly and the nine grass parks west of the mansion were let annually for growing hay and feeding cattle. Access to the fields was by roads alongside the trees, but the tenants had no right to the grass which grew among the trees or on the tops of the fences.[2]

The Earl died in 1768 and his son outlived him by only six years. In the Sixteenth Earl's time (1761-1827, succ. 1774) the ground was considered sufficiently improved and crops were grown once more, 1772 onwards. (Third, 1957).

---

1. Book of Workmen's Days, weeks beginning 22 May, 10 April, and 17 April.
2. GD 150, Box 125. Miscellaneous Estate Papers. "Conditions of Roup of the Parks of Dalmahoy..., 1772. Third (1957, p.54) says that the lands were let for £500 sterling annually to an Edinburgh butcher, 1766 - 1783.

Shelterbelts and the Agricultural Revolution in Scotland

Whereas the early improvers had to follow examples of estate planning on the continent and in England, and had even to import seedlings from these countries on occasion, by the end of the eighteenth century there was a considerable fund of local knowledge about hedgerows and shelterbelts and the necessary seedlings could be bought locally. Information about the state of agriculture at the end of the eighteenth century is available in the "General Views of the Agriculture of the Counties" and the "Statistical Accounts" of the parishes of Scotland. Both of these series of reports were written at the instigation of Sir John Sinclair; the former by farmers and experts in agriculture, the latter by the incumbents.

Perhaps some of the material should be treated with caution as, especially in the parish accounts, it would frequently have been all too obvious whose improvements - or lack of them - were being commented upon. Nevertheless, the records reveal both the state of some old plantings and reasons for some changes in design of shelter plantings at that time.

Kirknewton Parish[1] (p.34)

> "Agriculture has lately made a rapid progress in this part of the country, and the appearance of the ground ... is now greatly altered both in soil and climate, by means of the improvements and thriving wood-plantations that shelter and adorn the higher parts ... There are complete enclosures for pasture and ... belts of plantation, variegated with every kind of wood suited to the soil. (p. 414).

County of Midlothian[2]

i) Hedges for crop protection.

"Enclosures are productive of other and much higher benefits than merely defending the land from cattle, etc. The warmest air lies nearest the surface of the earth ... and fences of all kinds prevent such a valuable covering from being blown off by the winds ... While a hedge fence protects the land from boisterous weather to a great distance beyond the place where it stands; it also in calm weather allows the air to circulate ... a circumstance highly favourable to the healthy growth of the immediately contiguous crop." (p. 35, footnote).

ii) Hedgerows.

A hedgerow planted on top of a bank with a ditch on each side "never fails to become abortive in the end, the wood and the thorns mutually injuring one another". (p.36). However, it was found that in some places a bank with one ditch or no ditches could support a hedgerow.

---

1. (p.33) Old Statistical Account, 1793, Vol. 9, pp. 407-419. Woodlands were chiefly confined to Meadowbank Estate at this time. In 1758, Dr. Cullen, proprietor of the neighbouring property, Ormiston Hill, "... for the first time laid open the true principles concerning the nature of soils and the operation of manures". p.416.

2. Robertson, G., 1793. He was a farmer at Granton on the coast near Edinburgh. The first quote (reproduced in full by Hopkins, 1965) indicates that Robertson fully understood the way a penetrable barrier produces its shelter effect. But it should be noted that the hedges (used on low-lying grounds) were designed for crop shelter and to exclude cattle. Trees in hedgerows did not grow satisfactorily, hence the insistance on shelterbelts for timber production.

iii) Shelterbelts for timber production

"... it may, in general, be remarked that over the country as a whole, forest trees planted in hedgerows come to no good. The rows planted together are too few by which they perish, merely for want of shelter; for the same kinds of trees on similar soil, when planted thicker, survive well enough. A thin belt of four or five rows will not stand the climate here; there should be twenty rows at the least." (p.74).

iv) Notes on Tree Species

Oak	"Flourishing in many places"	"Ready sale for timber"
Elm and Ash	"Never fail to thrive"	
Beech and Plane (Sycamore)	"The most luxuriant in growth but not much valued for timber"	
Scots Pine	"The Scotch Fir is much cultivated, but to very little purpose; for it neither grows large nor is the wood much esteemed"[1].	
Larch	"The Larix ... seems to succeed but of the fir kind"	
Silver Fir	"The next best"	
Norway Spruce	"Spruce fir ... does not thrive at all, becomes soon stunted and is even worth less than the common fir (Scots pine) itself".[2]	

---

1. The Earl of Haddington had different views on Scots Pine, but was careful in selecting the seed. (Anderson, 1957).

2. Steele (1826) thought well of this species for shelterbelts on wide, raised banks between fields on moss ground.

Southern Districts of the County of Perth[1]

The author's description of suitable places to put fences is useful because wet troughs and gravelly ridges are common sites for belts. Presumably his insistence on evergreen species is connected with winter shelter for stock. The different widths of shelter and amenity plantings is significant.

> "Where inclosures have been made judiciously, their extent is proportioned to the size of the farm, and to the relative situation of the ground ... When the land is in knolls, with strips of spouty ground betwixt them or when the soil is of superior quality in one part of the field to the rest of it, or cut by small brooks, so as to make little valleys, or by any other natural boundary, the inclosing is regulated by these local circumstances." p.60.
>
> "Many of the stone walls and hedges have rows of trees, where shelter is the object, and the ground of little value, these belts are in many cases forty feet broad, and filled mostly with common firs; where ornament alone is studied they are planted with different kinds of timber and are seldom so broad."
>
> "All bleak countries ought to abound in these belts, because they change the temperature of the air, and form a milder climate. As far as hedges afford shelter superior to a stone wall, so far are belts of trees which keep the leaf in winter, superior to everything else." p.62.

Scotland as a Whole[2]

> "It may be asserted that, combining the production of timber with the acquisition of shelter, so important an object in this climate, the most proper direction of a belt of planting is from the south east to north west ... The too frequent error committed in the construction of these belts, is that of making them of little breadth. Where they are not of sufficient depth, the trees cannot shelter one another; the

---

1. Robertson, J., 1794. "General View of Agriculture in the Southern Districts of the County of Perth", London.

2. Sinclair, Sir John, 1814, 5 vols.

> exposed front necessarily fails, and the interior has never received protection. No belt of planting, in one exposed situation should be of less breadth than fifty or sixty yards." (Vol. II, pp. 277, 278).

The author then goes on to write at length on the subject of expenses and returns from improvements, and he considers such important points as draining, fencing against stock, thinning (weeding) and in other ways tending young plantations.

Estates in the Study Area

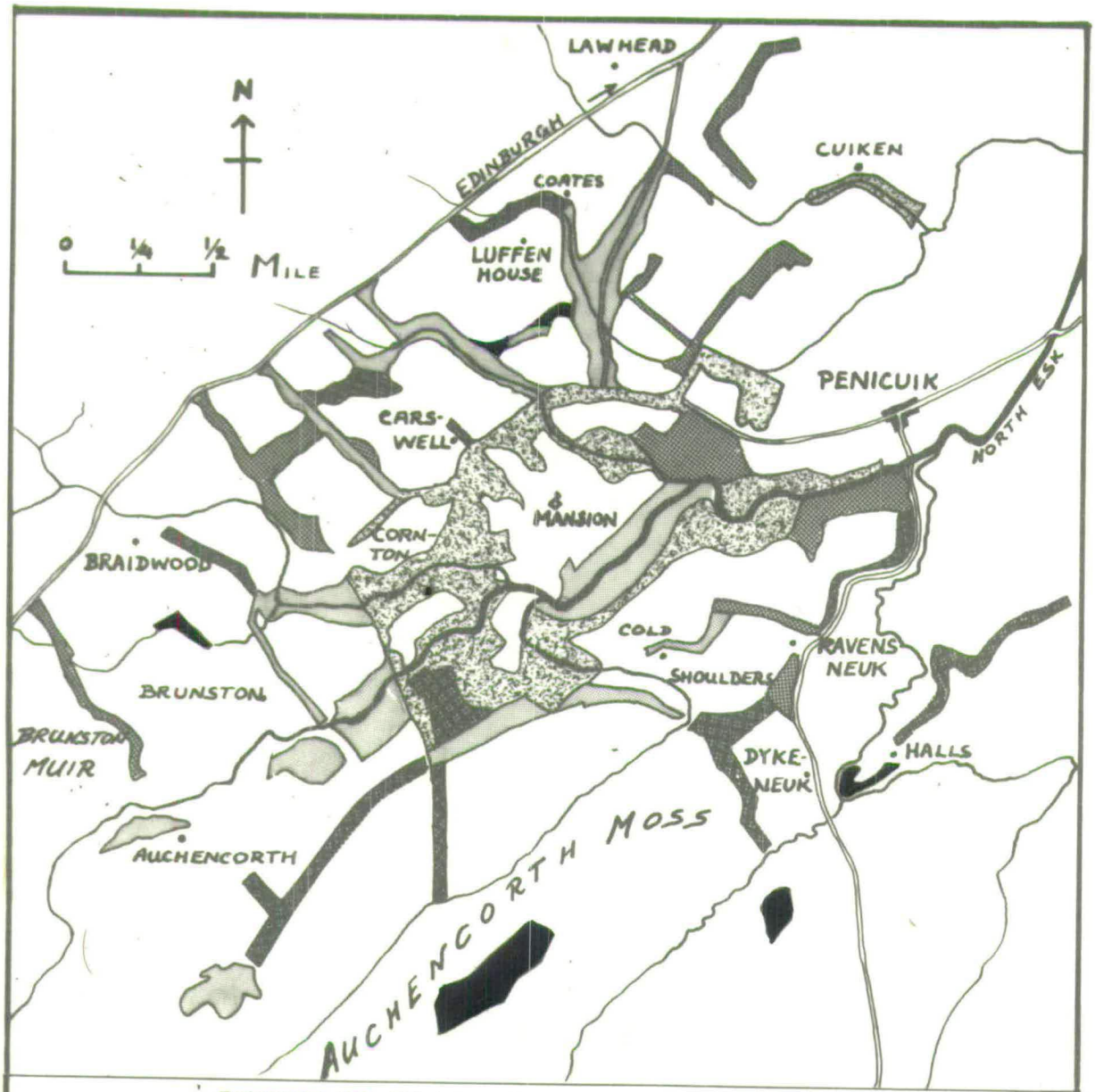
i) Penicuik. Sir John Clerk had written in one of his pamphlets[1] that he advised any of his descendants who had sufficient ready cash to invest it in improvements to the existing lands rather than to increase the size of the estate. Another reason for his planting trees is also given, namely, the "where timber abounds, houses can be made and kept up at a small expense, whereas a multitude of houses is never to be thought of where timber is expensive in itself or difficult in its carriage."

Sir George Clerk, grandson of the above, was laird of Penicuik from 1798-1867, and was also a dedicated and efficient improver. In 1796/97 Alexander Low examined the land and wrote a report[2] in which he

---

1. Grey, Ed. 1892, p.253, 254. "Scheme for Improvements of the Barony of Penicuik" 1741.

2. GD 18/1487 "Report regarding the Estate of Pennycuik, 1797". Alexander Low was a well known person for his work as a land surveyor and valuator during the Agricultural Revolution in Scotland (Handley 1963). In 1807 and 1817 he valued Cockburn Estate (see below).



EXTENT OF BELTS & WOODS ON MAPS	DATE
AINSLIE (MS)	1797
KNOX	1812
SHARP, GREENWOOD & FOWLER	1828
ORDNANCE SURVEY	1853-58
" " , 2nd. EDITION	1898

FIGURE 13 THE PROGRESS OF TREE PLANTING ON PENICUIK ESTATE (PART) 1797 - 1898.

refers to shelter from woodland strips, but he was evidently no silviculturalist.

> "Hardenburn Park near Carswell farm is well sheltered, and deserves improvement by draining and liming. There are several banks viewed from these fields which would much improve the scenery of the place by being planted. However the encouragement to plant does not seem to be very great, as there is something in the soil or climate not friendly to the growth of trees, which appears from the sickly state of some and the soggy state of others. However planting on this estate is so great an improvement, that it cannot fail to excite a desire to extend it ... in general it will thrive best in all places sheltered from the west wilds." (MS p.12).

At the same time (1797) John Ainslie prepared a book of 27 plans of the estate.[1] Using the detailed farm maps for planning purposes[2] Sir George Clerk progressively planted up sites that were least valuable for agricultural purposes and then set wide belts at the limits of the "hard ground" on the borders of blanket bogs (Figure 13). These belts are equivalent to the "head dyke" on a hill sheep farm, only in this flatter country the improved ground in the lee of the shelterbelt is at much the same altitude as the rough grazing land beyond the belt. Details of the sort of methods used are available from the Baads Estate (see below).

Silvicultural and other information about Penicuik Estate comes from a glowing report in the N.S.A. (I, p.32).

---

1. RH Plan 6064. 27 photostats of the originals. Ainslie's work is highly thought of by geographers (Adams, 1966).

2. Evidence; MS additions of plantation boundaries on some of Ainslie's farm plans. Also Third, 1953 and 1957.

> "Scotch firs, spruces, larches are planted promiscuously with oak and other hard-woods. Great attention is paid to thinning and constant extensions are going on. The whole planting is done on the Scotch or pitting system. Though shelter and picturesque effect form probably the chief inducements to extend these plantations, yet the wood also yields a profitable return - single trees having brought as high a price as £30.[1]
>
> "In 35 years ... rents have trebled without being at all oppressive."

ii) Dalmahoy. An estate factor managed farm and woodland affairs in this part of the large domains of the Earls of Morton. Letters between the factor and the Earl, and estate wood books and other MS material provide insight into management policies and techniques.

The proprietor reserved the power "of making roads, plantations or pieces of water in any form or extent on sufficiently fencing the same and deducting the rent of the grounds so occupied by arbitration."[2] On one occasion an extension was made to a small wood in the Deer Park to use up surplus seedlings that were ready for transplanting.[3] The policies received far more attention than the whole of the rest of the estate. Certain strips in the policy parks were planted after the ground had been prepared by double digging. The planting pattern was as follows:

---

1. The trees that sold so well were probably some of the 300,000 that Sir John Clerk had planted 1701 - 1755.

2. GD 150 Box 125, "Articles of Agreement between the Earl of Morton and _____". 1792.

3. GD 150 Box 125, Letter from Stobie to the Earl of Morton, 3 March 1792.

> "The strips ... to be planted with Plane [sycamore] especially on the west side, Beech and Silver fir. The planes, beeches and silver fir are to stand and therefore to be planted far assunder and not interfering with each other, the intermediate spaces to be filled with larch and other plants."[1]

This provides an excellent example of the practice of using "nurse" species (mentioned also above, p. 32). The quick-growing larch would be valuable for obtaining good clean boles in the trees that were to remain and when cut out, would provide reasonable timber for estate use, e.g. for palings. Scots pine may have been one of the "other plants". Some of these were never felled and remain mixed with the hardwoods to this day.[2] The ridges, three feet apart, on which the trees were planted can still be discerned. Nearer the house "carrots etc." were sown and cultivated in a young plantation so competition from weeds would not have been a problem during establishment.[3] References to the policy

---

1. Ibid. 19 January 1809.

2. Many trees were cut down for a transmission line to be put across one belt in 1964. A ring count on Scots pine stump indicated that it was 163 years old when felled. Thus the date of planting of this belt was ca 1801, eight years earlier than the belt referred to in the letter.

3. GD 150 Box 125. Letter from Cunningham to the Earl, 5 February 1788. This compares with the practice on good ground in Kenya: weeds would be a serious problem if farm labourers were not encouraged to plant their potatoes, beans, and onions between the rows of trees. Thus they cultivate the ground like a kitchen garden for a few seasons after the seedlings are planted out. (Pers. exp. and comm. from J.R. Carles, Timau, Kenya.)

parks of adjoining properties in the Earl's possession, provide useful information about plantation fences and stocking of the fields:

> "The fence that was to be made of wood on the east side of the intended plantation of Addiston is mainly compleated... Some of the temporary fencing on the north parks of Addiston and also the pale at Kierhill and Warriston plantations will require repairs ... before the sheep go into the fields."[1]

Young plantations were well protected against cattle and sheep, as was a wood that had been coppiced.[2] The nursery was also fenced against hares[3] and concern was expressed when a strange buck had been seen near the nursery and had pealed the bark off "several of the young elm trees".[4] But older plantations were not always kept fenced. Two sketch maps that accompanied letters to the Earl are of considerable interest in this connection. Two dry stone dykes (or the facing walls of sunk fences) were demolished by Kirklands strip ("1" on Figure 14) and the stones used to fill up a drain that was continually wet. Presumably soil was drawn over the stones to form one of the "rumbling drains" that exist and still function on the property.[5] On the other map[6] some woods are labelled "planted lately" and are evidently fenced. But two shelterbelts have

---

1. GD 150, Box 125. Letter from Stobie to the Earl, 21 February 1807.
2. GD 150, Box 125. Letter from Cunningham to the Earl, 30 April 1788.
3. GD 150, Box 125. Letter from Stobie to the Earl, 19 February 1809. "Hairs".
4. GD 150, Box 125. Letter from Tait to the Earl, 17 August 1813.
5. GD 150, Box 125. Letter from Tait to the Earl, 24 April 1813.
6. GD 150, Box 125. Sketch map of NE policies, N.D. but on paper identical to that on which letters were written on 23, 26 June and 14 July 1813.

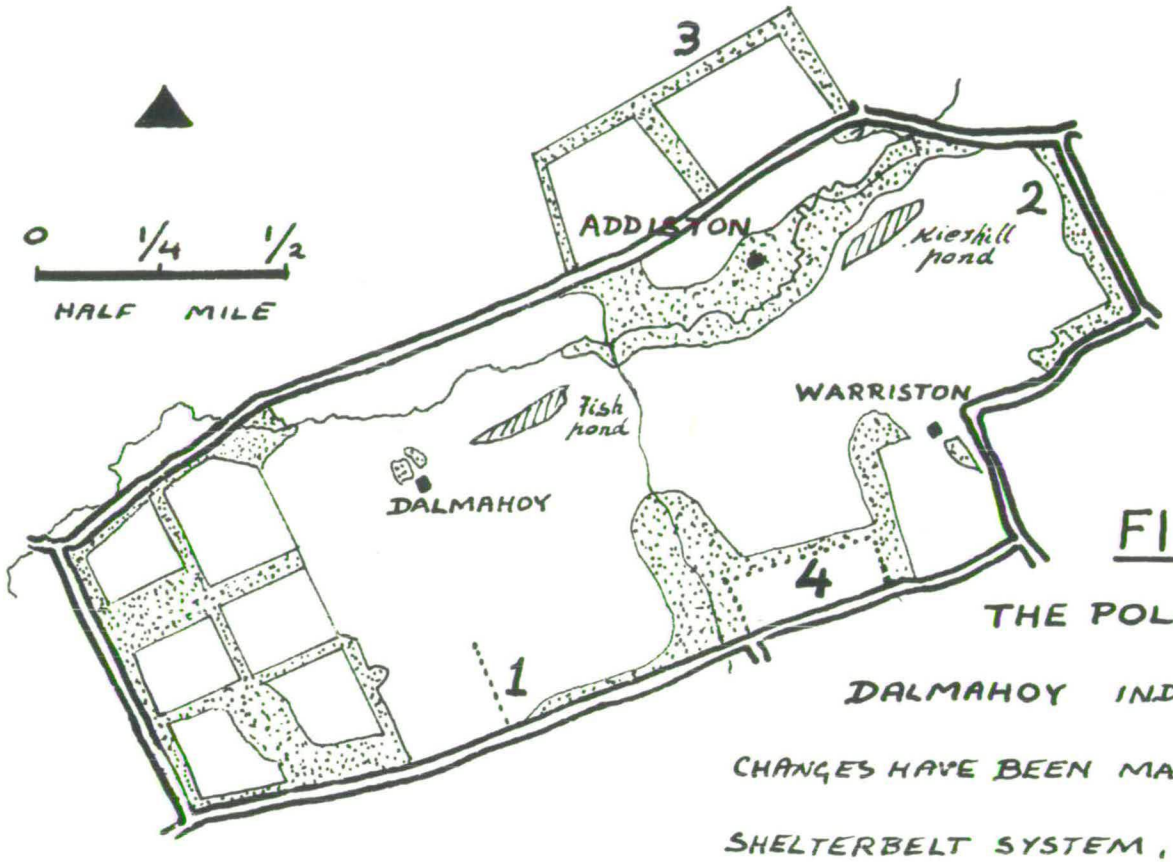


FIGURE 14

THE POLICIES OF DALMAHOY INDICATING WHERE CHANGES HAVE BEEN MADE TO THE SHELTERBELT SYSTEM, 1813 - PRESENT.

1. Open drain filled with stones alongside Kirklands strip, 1813.
2. Plantation in Warriston policy parks "laid open", 1813
3. (?) March of Addiston parks with Mr. Crawford's lands straightened. 1813
4. Part of Muir o' Dean plantation reclaimed for agriculture, 1964-65.

"old plantation laid open" and "strip laid open" alongside them, ("2" on Figure 14) and would thus have been deliberately exposed to stock. The former was against the boundary wall and was probably replanted later; the latter was presumably no longer required following landscaping operations and the construction of Kierhill pond.

Since inefficient fences and faulty drains at field margins were found to affect both the belts (by stock access) and the farmer's attitude to trees (especially from root competition), it is pertinent to record two further examples of the practice of altering the nature of fences.[1] In one case, a tenant had filled up the ditches round some fields with the result that the low bank had to be made fenceable by putting two strands of wire on the top. In another, it was recommended that the outfall drain round a field should be filled in with a 12" tile drain.

On the north march of Addiston policies with the land of a certain Mr. Crawford, some ground was planted in the form of a belt after the line of the march had been straightened. Mr. Bauchop, land surveyor and cartographer, was called in to survey the ground ("3" on Figure 14).[2]

---

1. GD 150, (Additional) Volumes of Farm Valuations 1863 - 1880. Vol. IX p. 10, and Vol. XIII, p. 55, respectively.

2. GD 150, Box 125. Letters from Tait to the Earl, 10 and 30 April 1812. Map reference of belt probably NT 153700. Another example of this practice is a 10-12 acre belt planted along the new march NT 485661, between Salton and Gilchriston Estates in 1791 (N.L.S. (Salton Papers) "Old plan of Gilchriston 1803." Larch nurses were removed in 1805 (MS note on plan).

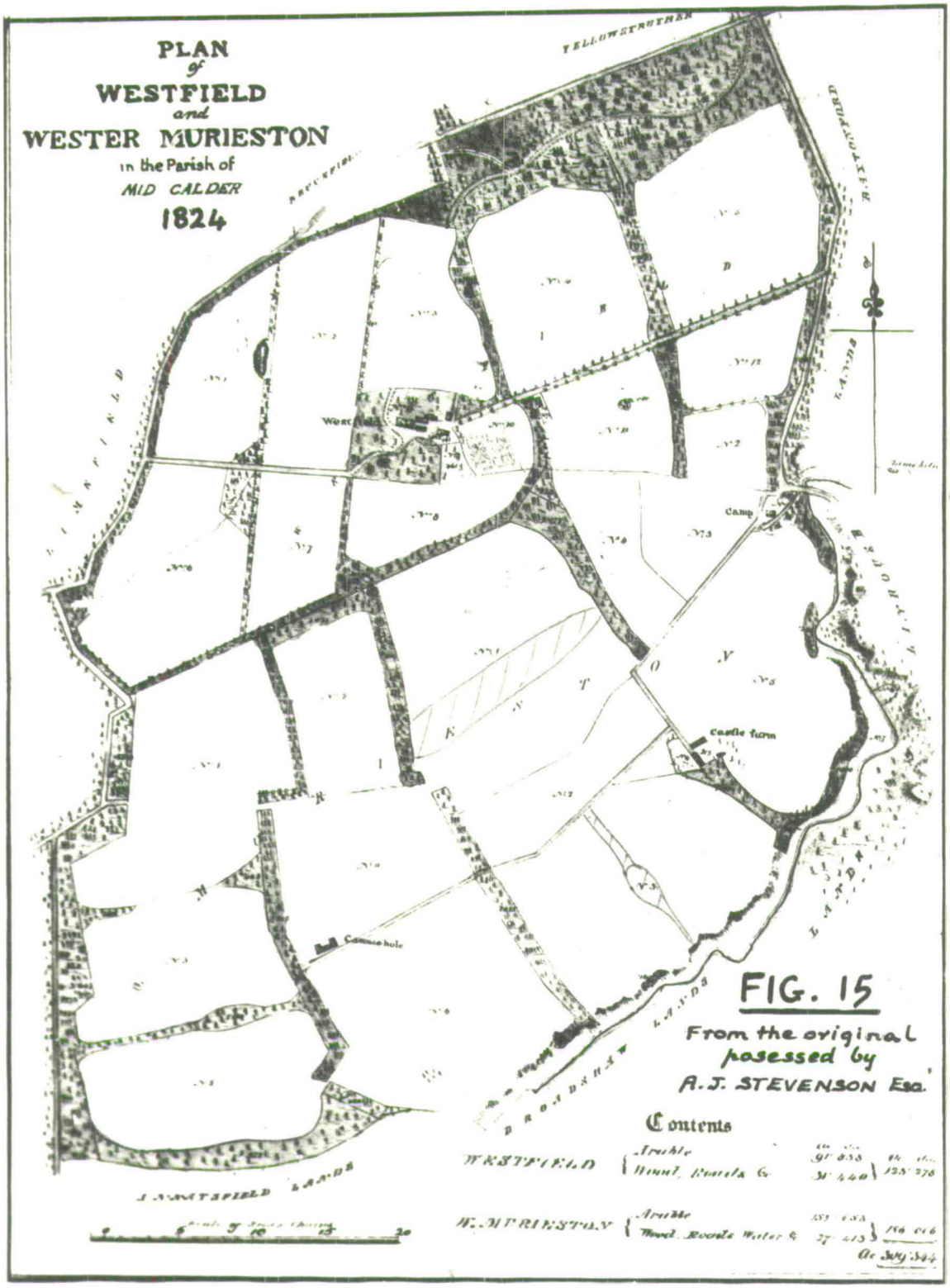
In 1825, Robert Monteath[1] wrote a report on the woods on Dalmahoy. He considered that all the woodlands including the belts round the policy parks should be managed for ornamental purposes and for timber. A remarkable total of £7,488 - 6 - 6 (sterling) was his estimate of the value of the trees that should be thinned out. This sum referred to 2,434 entries in the book[2] and he averred that the few trees to be removed compared most unfavourably with the vast proportion that would remain, "as to their entrinsic value, health, and prosperity, and ornament to the estate." (p.2.) His Woodland Management Plan was directed towards

> "keeping always a proper crop of long-lived ornamental and profitable trees on the ground so far as to suit situation and soil, as well as bringing in the most money possible from ... thinning, which should be persisted in without a season being lost." (p.4.)

---

1. Robert Monteath, author of "Foresters' Guide", 1820, Wood Surveyor and Valuator from Stirling. His MS, now catalogued as GD 150 "Volume" (In Index of Morton Papers after Box 124), is titled "Survey, Valuation, and Report of the Woods, Plantations and Timber Trees on the Estate of Dalmahoy".

2. Some entries referred to a group of trees, not always of one species.


PLAN
of
WESTFIELD
and
WESTER MURIESTON
in the Parish of
MID CALDER
1824
YELLOWSTRUTHER
BROADSHAT LANDS
Camp
Castle farm
Cairnhole
FIG. 15
From the original
posessed by
A. J. STEVENSON Esq.
Contents
WESTFIELD
W. MURIESTON

iii) Westfield. A plan[1] of this small estate in 1824 (Figure 15) is accompanied by an advertisement of intended sale of the property in two lots, Westfield and Wester Murieston.

> "Lot 1, The Lands of Westfield ... 123 acres /Scots/ divided into fields surrounded with hedge row trees and belts of planting ... 31 acres of valuable wood in a thriving state, a great part of which is of such an age as to be fit for immediate use, and may be cut without injuring the appearance of the property."

Both lots may have been purchased by the same person because there are MS additions on the estate plan of proposed belts on West Murieston. However, it is likely that the new proprietor did recoup some capital by selective felling. Some new planting was done on the sites proposed and to straighten out the Z-shaped strip[2] south of Canniehole steading.

In 1865, the Caledonian Railway Company were required to pay a very high price for the land they took from this estate. A cutting was made through the North Wood, and whereas for agricultural land in the

---

1. Photocopy: N.L.S. Map Room.

2. The course of the original drains round the Z was determined by topography. They were very deep and must have continued to function after the alteration to the belt. It seems that they were required to drain rather flat ground near the steading (Field survey). This ground was badly waterlogged because a water main laid in 1966 had interfered with drainage, see Chapter VII.

district they had paid from 2/6 to 45/6 per Imperial acre, for the woodland they were required to pay £90 (sterling) per acre. Hence the owner received £382/10/- for the 4.175 acres of ground that he sold.[1]

iv) Cockburn Estate.[2] Alexander Low valued this estate at between £650 and £795 in 1807. Ten years later he made a second valuation and reckoned that there had been a 30% reduction in the value of the land; by 1818, the proprietors could only expect between £455 and £556 - 10 - 0. rent per annum (11 November 1817, See note 1, P. 46).

A forestry expert, Mr. George Brown,[3] was called in. He advised an extensive system of new shelterbelts and clumps of trees, and made very useful comments about the locality and the condition of some old shelterbelts. His report contained the following:

---

1. S.R.O. GD 150 (Additional) Volumes of Farm Valuations and Reports 1863 - 1880, Vol. 4, pp. 162 - 175. The Earl of Morton's Factor arbitrated on behalf of the land owners.

2. The MS source of material is: the Minute Books of the Company of Merchants of the City of Edinburgh. Dates in the text refer to meetings of the Governors of George Watson's Hospital, who were the proprietors.

3. George Brown, of Fountainbridge near Edinburgh. No further evidence of his work has been seen than the most significant document minuted on 16 April, 1818, and subsequent entries in the Company's Minute Book.

> "There can be no doubt that the lands from the nature of their soil, being mostly a cold, retentive clayey or tilly loam, and the high and exposed climate they lie in - are more succeptible of improvement by inclosing and planting than by any operation of farming - however judicious - that can be applied.
>
> "Regarding the quantity of land to be taken off the tenants for planting ... 45 /Scots/ acres to be taken rent free and 42 to be paid for ... The old wood about Cockburn is in a bad and decayed state from the ground being so wet and spongy, and most of the fences on that farm are irretrievably gone, apparently from the same cause." (16 April, 1818).

The old belts round the policy parks of Cockburn mansion (already used as a farmhouse in 1818) are 13 yards wide. Brown advised new belts of various widths, (Table 3), the widest to be on the west as these would bear the brunt of the winds and tend to shelter the others.[1]

---

1. Brown also advised that clumps be planted in the larger fields. He expected all the trees to grow 50 or 60 ft. high. In fact they have grown only 30-40 ft. (replantings) and the wind has been shown to reach its unimpeded velocity within certain fields (Caborn 1957)(pp.102-105). Had the trees reached the expected height and had there been some clumps, the grid system designed by Brown would probably have provided windspeed reduction over the whole estate from whatever direction the wind blew.

Table 3 Belt Width in Relation to Situation
Cockburn Estate, 1820-21

Situation and Nature of belt	Width of Belt (Yards)	
	Recommended	Planted
West boundary	36	50
South boundary	36	34-40
Subdivision plantations		
Two, E - W	24	27-40
4 - 5, N - S	24	25-35

The scheme was adopted and speedily executed with Brown acting as overseer. It is instructive to note the methods used, species choice, contract details, and subsequent maintenance of the protective fences and of the shelterbelt trees themselves. During construction, 60 to 80 workmen were employed by a contractor. Several tenders had been received in response to newspaper advertisements, and:

> "It was agreed to prefer the following from Mr. Alexander Henderson, Seedsman in Edinburgh...
>
> 1. To furnish thorns and beech for hedges in the proportion of three thorns to one beech, for 14/- per 1,000.
> 2. To furnish plants and uphold for three years:
>
> | | |
> |---|---|
> | 3,500 | 1 year transplanted Scots firs |
> | 2,500 | 1 year transplanted Larch |
> | 6,000 | to each Scots acre for £3/10/0d. |
>
> 3. The plants to be carried from the nursery to the ground to be planted at the expense of the proprietor.
>
> "It being understood that the whole work, including the plantations, to be completed before 1st April next." (2 December 1820.)

The hedge plants were planted on ground prepared with lime (30 October 1820 and 3 October 1822) and were protected by temporary palings

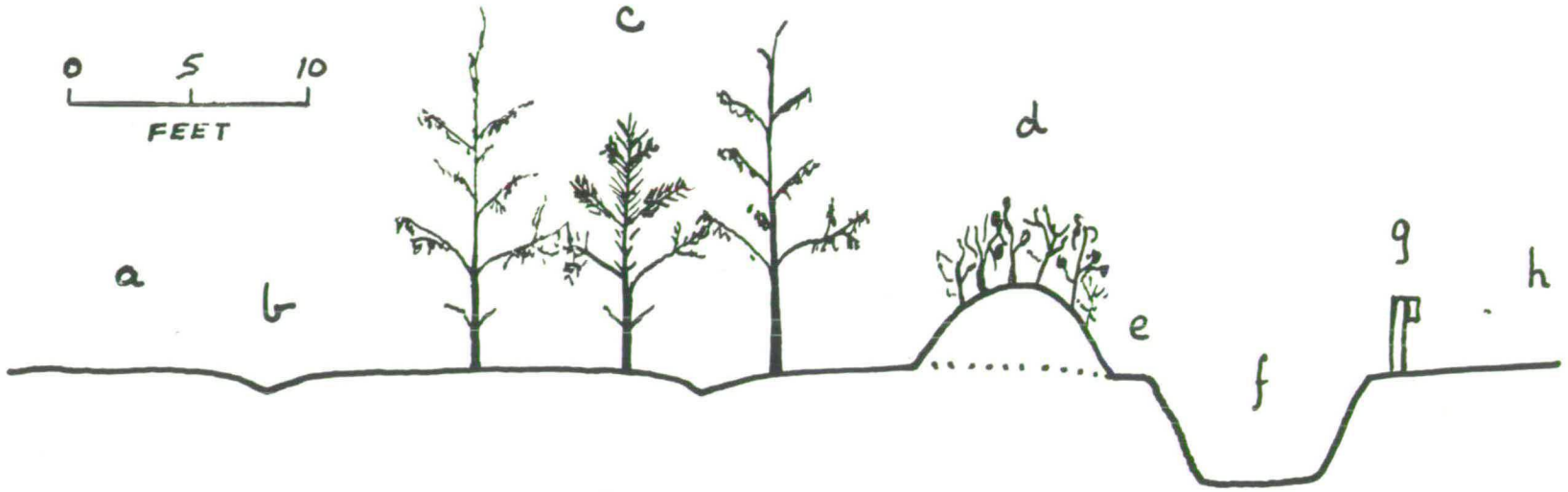


FIGURE 16.

DESIGN OF A FENCE TO PROTECT PLANTATIONS ON COCKBURN ESTATE (in 1825, 5yrs. after planting).

(Drawn from Brown's original description, 30 Oct 1820, & modifications, 10 Feb 24, & field survey)

a) Former agricultural land raised into ridges about 6 yds. broad

b) Drain (baulk) between ridges c) Shelterbelt trees, S. pine & E. larch

d) Hedge of thorns & beech e) Scarsement 9ins. wide f) Ditch 3½ ft. deep

g) Paling with single rail to exclude tenant's cattle till hedge effective (previously on e.) h) Field, initially with surface drains as a...b.

(Figure 16) which were intended to last four or five years until the thorns were stockproof. Later the palings had to be moved to the outer bank of the ditch because heavy snow had broken them down when they stood on the scarsement, and also because cattle had been able to get at the hedge plants, and the structure had hindered weeding operations. (10 February 1824).

Great damage was done by inexperienced workmen at the time of planting. They had first made a hole with a dibble, "... and afterwards put in the plant, by doubling the foot, and then thrusting it down with this sharp instrument." (17 January 1822). Furthermore many of the plants were very small, and the ground "coarse and grassy". Consequently there was a high failure rate in the first year. The contractor supplied replacements (3 October 1822, 12 August 1823). Part of the plan was for:

> "... a sufficient quantity of acorns to be dibbled in at proper places. And at the end of three or four years, the spaces where the fir and larch plants may have failed to be planted with hardwood plants". (30 October 1820).

This was to apply mainly to the strips on the lower part of the estate and Brown thought that in time, they would be "productive both of additional embellishment and profit" (10 February 1824). Planting on Cockburn farm followed ten years after that on the higher ground (31 August). In the meantime, the tenant was cropping the ground and permanent fences were considered unnecessary, while the newly sheltered fields on three other farms were chiefly used for grazing and little ground was cultivated, 4 April 1825. In this connection the proportion of ground planted on

each farm is interesting (Table 4). In the present century, Landale has put forward a strong case for a 1 : 10 ratio of planting to make farming profitable in the hills of south east Scotland (Landale 1961).

Table 4 Comparison of Area of Ground in Fields and Woods on Cockburn Estate.[1]

Area of Shelterbelts (acres)	Todholes	Shothead	Cockburn	Goodtrees
i) Existing belts	0	3	8	10
ii) Belts planted 1820-21	66	35	5	8
iii) Total No. of belts	66	51		18
Field Area (acres)	330	450		200
Ratio of areas (Shelterbelts : Fields)	1 : 5	1 : 9		1 : 11

At this time (1824) the enclosures on the Cockburn Estate were evidently surrounded by unenclosed moorland, as a neighbour had black-faced sheep on his "muir" next to the east boundary of the estate. Brown recommended that a two-rowed paling be placed on top of the hedge to protect the plantations (11 February 1823). There was also the problem of damage to hedges and young trees caused by "persons coming on the ground to shoot and to hunt". (10 August 1824).

---

1. Farms from west to east: Todholes (now Cockburnhill, Unit 5); Shothead (Cockdurno); Cockburn; and Goodtrees (Boundaries from MS Plan 1854. Now amalgamated with other farms: Unit 58). Cockburn and Cockdurno are managed together today (Unit 52), hence the layout of the table.

A neighbouring proprietor on the west shared the expense of the march dyke along the Cock Burn, but declined to plant a belt on his side of the boundary. He did agree, however, to plant a ten acre block (NT 141628) though this promised to be of greater value for shelter to the Cockburn estate than to his own property. (3 April 1821). Brown acted as the Estate Factor during the whole of the time that the plantations were being constructed on Cockburn. His enthusiasm and the constant hard work of the resident forester in maintaining the fences and tending the trees ensured that the shelterbelts grew and flourished.

v) Baads.[1] Two members of a London firm prepared a valuation of this estate in 1835.[2] They recommended enclosure, underdraining and shelterbelts in addition to improving the tenants' dwelling houses and steadings, and having an estate plan made.[3] The estate forester was strongly criticized because he was a drunkard and had neglected the existing shelterbelts.

---

1. The Douglas family of Baads owned the adjoining estate of Haywood in Lanarkshire and another estate in Dumfrieshire as well as the island of Antigua and other property in the West Indies. (Papers in Solicitor's office: J.C. & A. Steuart, W.S., Edinburgh).

2. Original not seen: Typescript notes in Department of Forestry and Natural Resources. Page references refer to the latter.

3. Plan in the office of J.C. & A. Steuart, W.S., Edinburgh. It was prepared from O.S. 6" sheets, published between 1853 and 1864, but is not dated.

The new shelterbelts were established on farm boundaries in places that were particularly exposed to the westerly wind. The enclosing ditches in some cases conducted water away from the margins of blanket bogs and thus prevented it soaking into the fields (e.g. the belt at NT 010597, now derelict). The specifications for the belts were as follows:

> "...broad belts... We do not think less than fifty yards would answer on this estate... The following trees and proportions are the best adapted for an exposed country, being the most likely to give good shelter and improve the appearance of the property, as well as ultimately to yield the best profit, viz. per Imperial acre: 1,500 larches; 1,000 Scotch pine; 100 elms; and 250 in proportion of poplars, birch and alder for the wet land; and also a few /Norway/ spruce.
>
> "These are at 3½ feet apart...as in exposed situations it is easier to thin than replant.
>
> "We have procured an estimate ... in Edinburgh and find the cost of furnishing trees of proper heights and sorts ... and planting the same will be £3 per Imperial acre." (Letter, pp. 2,3).

Right up to 1835 the tenants on the semi-moorland farms had practiced a type of shifting cultivation on extensive areas of unenclosed land. The six to seven-yard wide, parallel ridges, with open drains between, show clearly on aerial photographs. Unlike the ridges that were specially prepared for trees on Dalmahoy, the line of these former cultivation ridges, on which shelterbelt trees have been planted, can also be discerned in the fields next to the belts.[1] When a belt was established directly on former agricultural ground, it probably did well

---

1. See footnote 1 page 52.

because tree roots could easily exploit the well-drained, aerated soil, though the latter may have been somewhat impoverished as regards available minerals.

Contemporary and Later Shelterbelt Planting in Parts of Continental Europe

> "It is clear that shelter planting in Scotland started a long time before Albrecht began his campaign for the restoration of tree shelter on the devastated Westerwald plateau in Germany in 1832; before Graff sought to combat drought and wind through partial afforestation of the extensive steppe regions of Russia and the Ukraine in 1843; before Dalgas founded the Danish Health Society in 1866 to develop and colonise the sandy heathlands of Jutland to balance the loss of Schleswig-Holstein. It began at least a century before organised planting for shelter was introduced to the North American prairies. These early and very practical efforts in Scotland, though frequently forgotten gave rise to many of the present agricultural shelterbelts." (Caborn, MS, 1958).

Developments in Shelter Planting and Afforestation Since 1853

Once agriculture had been turned into a profitable occupation, the lairds appear to have turned their attention to developing industry in Scotland from the middle of the nineteenth century. At any rate, the amount of capital invested in new farm woodlands was no longer on the scale of the previous 150 years. However, from map evidence of woodland composition (e.g. a change of symbols from 'broadleafed' to "coniferous'

---

1. (from p.51) The crest of the ridge was usually between 6" and 1' above the drain. Just outside the study area ridges over 2' high occur on a derelict site parallel to the country house amenity strip at NT051649.

on O.S. maps) and from ring counts made on recently cut stumps on old-established belt sites there can be no doubt that maintenance of existing shelterbelts was included in the programme of management on many estates. In the period 1853 - 1898, a number of blocks of woodland were established on the slopes of the Pentland Hills and on other rough grazing ground used for sheep. But it was not until the Forestry Commission bought ground in the study area in the early 1950's, and later extended their activities to constructing a belt and several blocks on farms that any extensive new planting was done this century. Planting grants that were available under the Hill Farming Act (1946) and the Livestock Rearing Act (1951) and the formation of the Scottish Woodland Owners' Association (1949) have undoubtedly contributed to the recent awakening of interest in shelter planting among proprietors. Provision in both Acts enabled shelterbelts to be planted as fixed equipment on upland and hill farms (M.A.F.F. leaflet 15, 1961). Now that no new improvement schemes are eligible for grants under either of the Acts, shelterbelts over 2 acres in extent may still be established using Forestry Commission Small Wood grants. The rate of subsidy at present (1967) is £25 - 5 - 0d per acre, £17 - 10 - 0d of which is payable at the time of planting and the remainder three years later, provided the belt has been adequately maintained.

Since public funds are now being used to employ people in forestry and to extend woodland cover in the study area, it is interesting to find that 200 years ago Sir John Clerk wrote:

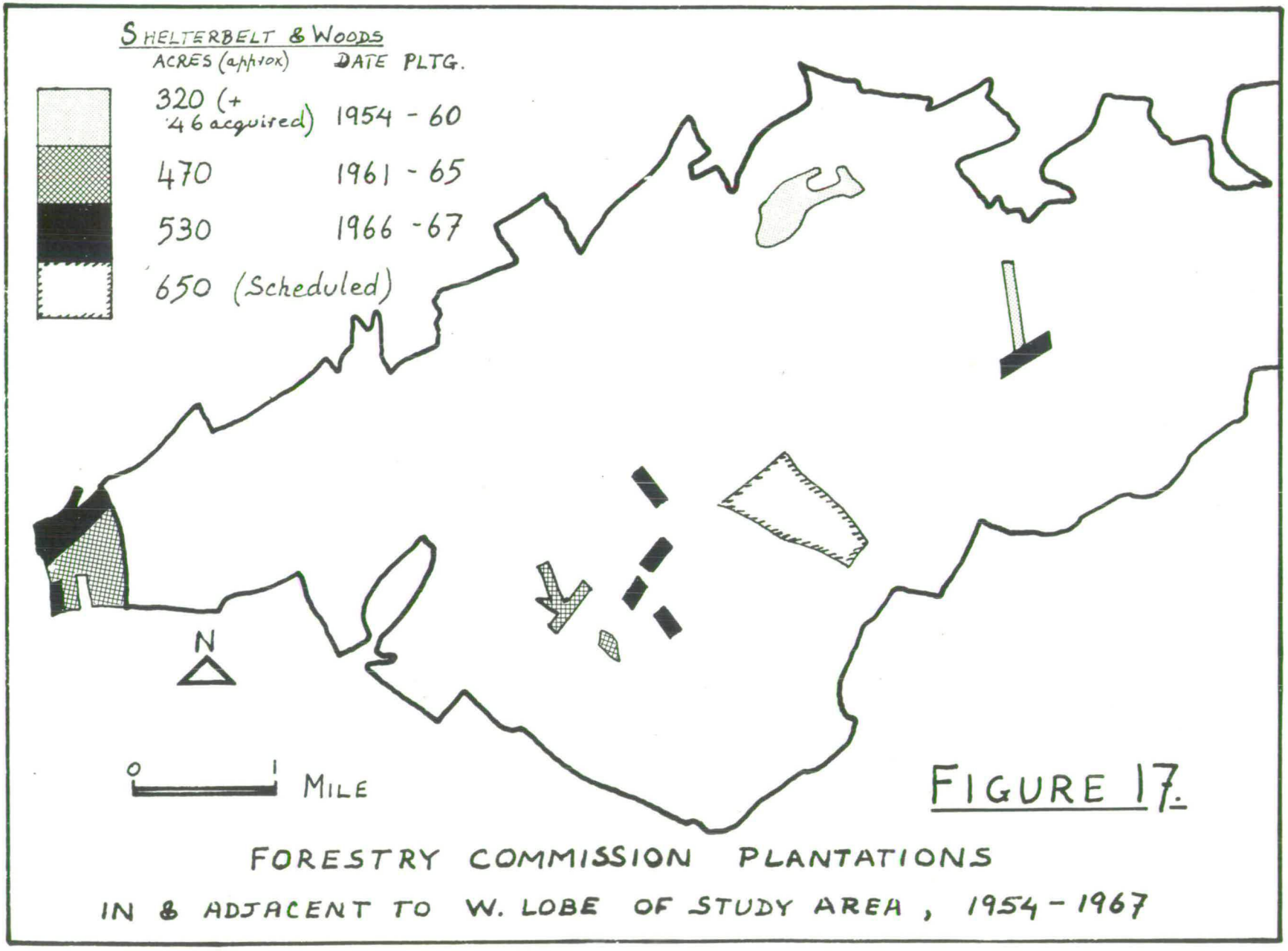


FIGURE 17.

FORESTRY COMMISSION PLANTATIONS

IN & ADJACENT TO W. LOBE OF STUDY AREA, 1954 - 1967

> "I have always thought that my salary as a Baron of the Exchequer was publick money and a gratification I owed to my Country, and therefor/e/ I laid out the whole of it and some more of my private patrimony for the improvement of my country ... and the upkeep ... of several of my poor countrymen." (Grey, 1892, p.232).

There are, indeed, some other similarities between the progress of Forestry Commission planting at the present time west of the Pentland Hills, and that which has occurred over the centuries on Penicuik Estate, east of the Hills. Both schemes started at a particular point and then expanded to cover available ground in the vicinity. At Penicuik the nucleus of woodland activity has always been the policy woods. The Forestry Commission started at Selm Muir but have recently moved their local headquarters to the village of Mid Calder and the old policy grounds of Calder Hall. At Penicuik most of the planting outwith the policies was designed to assist agriculture and the ground planted was either steep braes not suited to crop of animal husbandry or flat ground given up by the tenant with suitable rent remission. West of the Hills, ground has had to be purchased or feued from the farmers. Wherever possible large areas have been acquired for planting (Figure 17), but many of the earlier acquisitions were quite small areas and the shelter value of these small woods and one shelterbelt is high, whereas the large timber producing blocks exist to the exclusion of agriculture.

Apart from the activities of the Forestry Commission who are necessarily concerned with timber production, the main reason for planting on farms in the study area is for stock, both directly as shelter from wind and storms and indirectly by enabling improvement of the grasslands in the lee of belts.

The proprietors involved are not farmers of the traditional tenant farming type, but are people with higher education and sometimes with professional qualifications in agriculture and other fields. Their properties are well run on profits ploughed back into the business plus capital in the form of grants and from other sources (e.g. other jobs, investments, family savings). Their development schemes invariably include belts of trees. Although attention is paid to amenity in certain places and to timber production in others, the principle reason behind shelterbelt rehabilitation and establishment at present is the provision of shelter to farmlands.

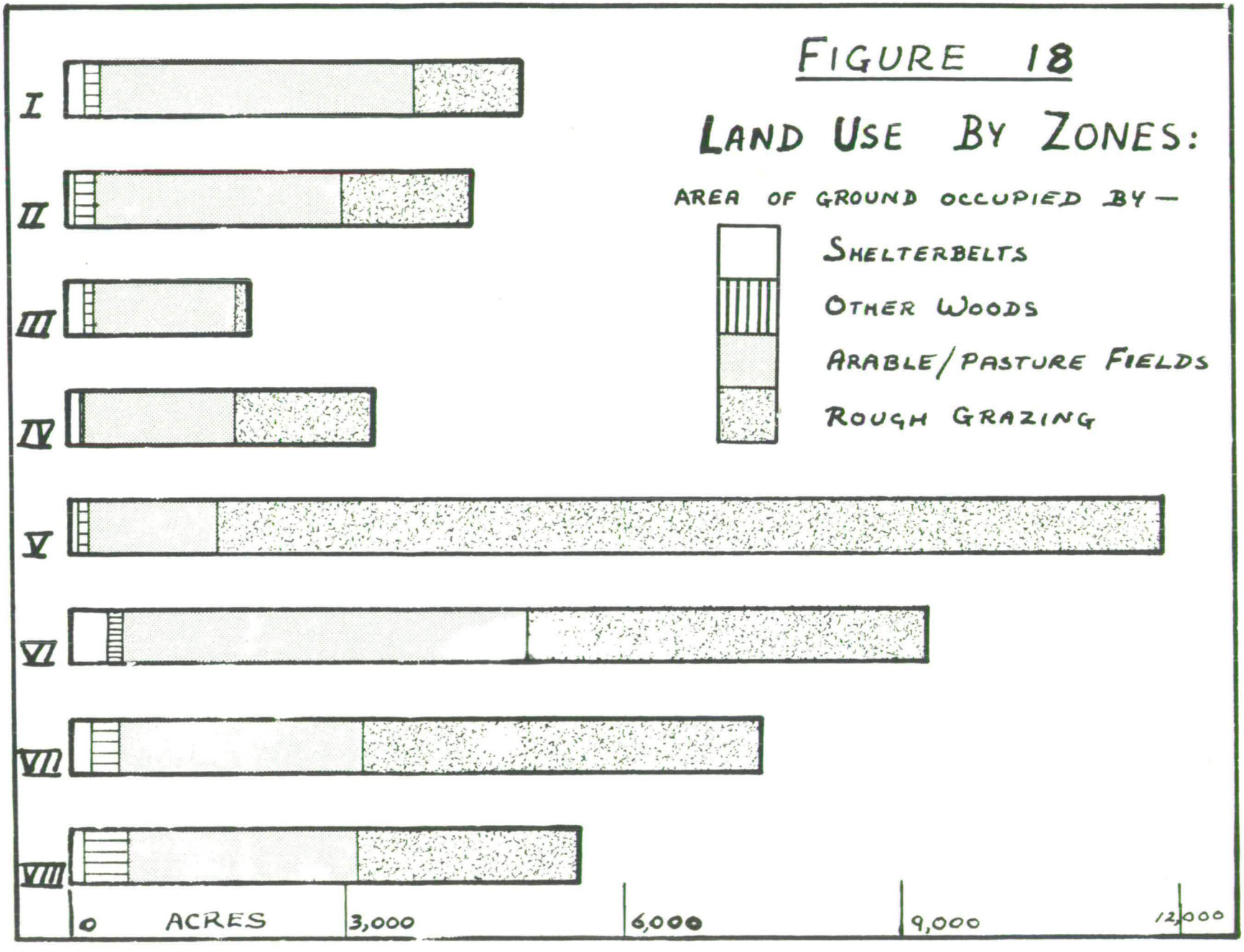


FIGURE 18
LAND USE BY ZONES:
AREA OF GROUND OCCUPIED BY —
SHELTERBELTS
OTHER WOODS
ARABLE/PASTURE FIELDS
ROUGH GRAZING
I
II
III
IV
V
VI
VII
VIII
0
ACRES
3,000
6,000
9,000
12,000

CHAPTER V RESULTS OF THE SURVEY: PRESENT CONDITION OF SHELTERBELTS IN THE STUDY AREA

Data were collected, as indicated above, for each of the 86 farm units within the study area boundary. Appendix I contains the basic data for every farm unit in each of the eight zones. The proportion of wooded ground, shelterbelts and other woods to ground used for conventional agricultural purposes, arable/pasture fields, and rough grazing in each zone is shown in Figure 18.

Regarding shelterbelts, historical information and the field survey revealed that a belt's location in relation to the adjacent land is basically responsible for the present condition of that shelterbelt site. Since the existing pattern of belts was established by degrees during the last 250 years, the approximate extent of various proprietors' spheres of influence at the time of tree-planting activity (Figure 19) is important. In some places integration of silviculture with agriculture is complete, while in others only small fractions of certain properties have been planted with trees. This strongly affects the proportion of ground occupied by belts in any zone, and it is obvious that on estates like Dalmahoy and Bavelaw little planting has been done up till now on ground outwith the policy parks.

Present Farm Unit Size, Shape, and Situation in Relation to Belt Number, Location and Survival.

At various times, estates have been split up and farms amalgamated to give the present pattern of unit boundaries (Figure 20). Most belts

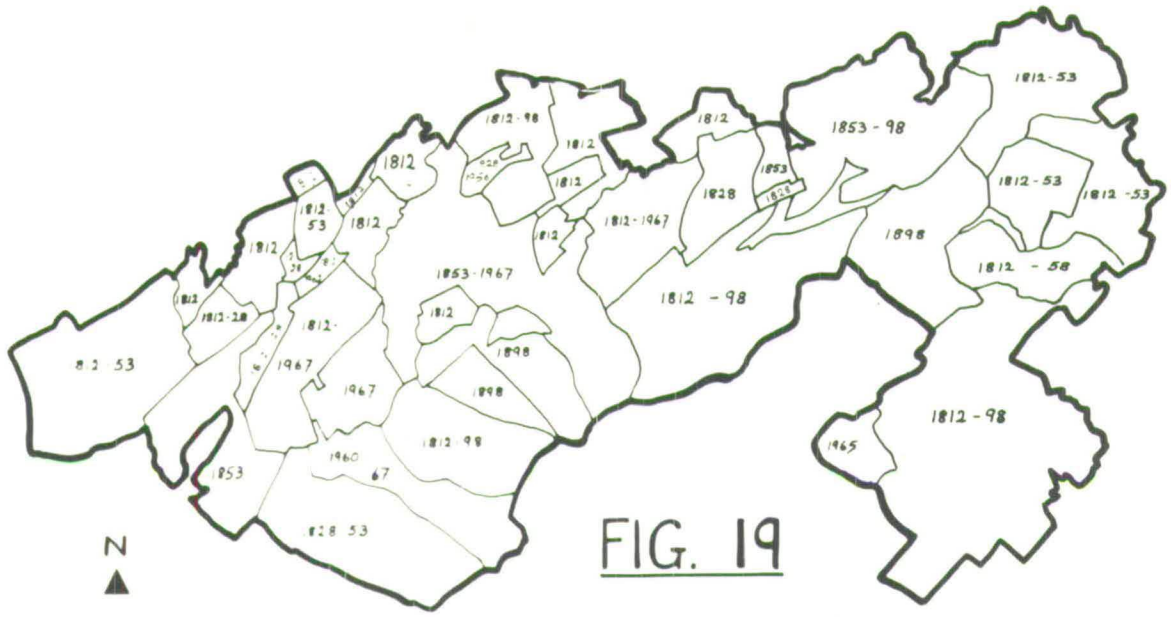


FIG. 19

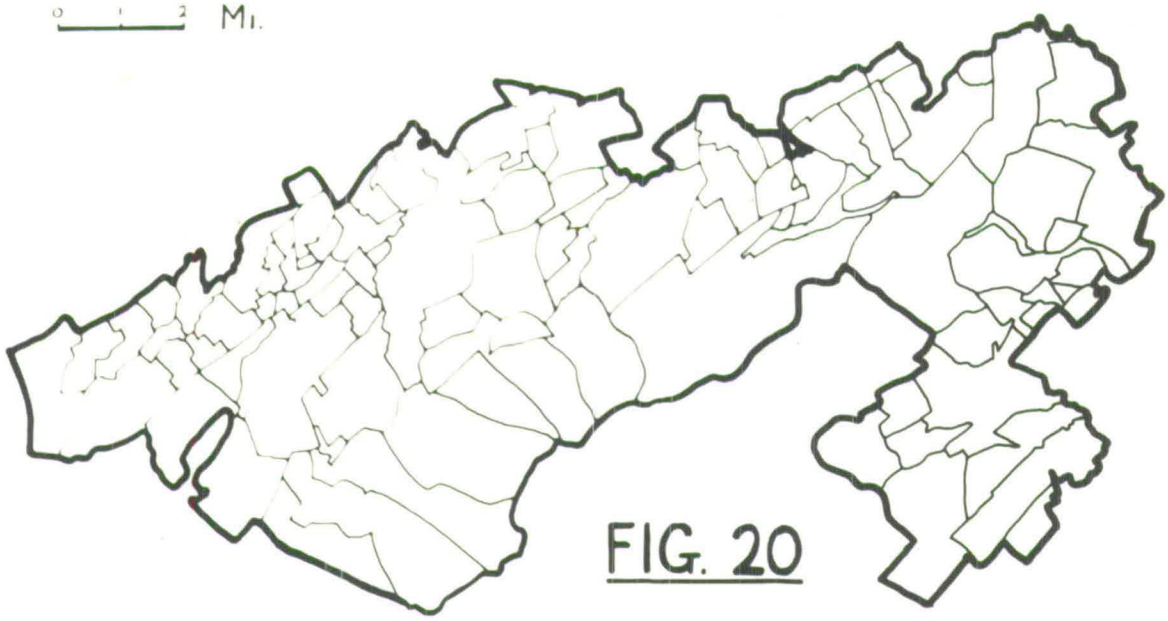


FIG. 20

FIGURE 19. STUDY AREA: SPHERES OF INFLUENCE (APPROX) OF VARIOUS PROPRIETORS AT THE TIME OF TREE PLANTING ACTIVITY (DATES OF APPEARANCE OF NEW SITES)

FIGURE 20. STUDY AREA: PRESENT PATTERN OF FARM UNIT BOUNDARIES

shown were in existence before properties changed hands. This has led to abnormalities like Unit 58 where the steading is over a mile away, by road, from the policy grounds of a former mansion (NT 146662), now in ruins, and three miles from some well-sheltered fields on the other side of the water of Leith (NT 146667).

When compared with a map showing altitude and the extent of rough grazings (Figure 21), it can be seen that, in general, the small farms are on low ground where there are brown-earth soils, whereas the large, linearly shaped farms are mainly associated with the podsols and peats on hills and blanket bogs (Zones IV and VIII). The majority of the 498 belts are associated with fields on better ground, or are near the steadings and/or country residences on poorer ground. The few remaining belt sites are larger than average and are situated in those parts of Zones IV, VI and VII where shelter planting extended onto moss ground and exposed hill slopes in the early years of the nineteenth century (Baads, Cockburn and Penicuik estates, respectively).

Table 5 Number and Area of Shelterbelts, by Zones

	I	II	III	IV	V	VI	VII	VIII	S.A.
No. belts	68	38	84	42	29	112	80	45	498
Area	156	73	163	104	67	341	142	127	1173
Av. size (ac.)	2.3	1.9	1.9	2.5	2.3	3.0	1.8	2.8	2.4

It is important to note that in Zone III where many of the Units are considerably smaller than the zonal average (Table 5), 32% of the 84 belt sites in the zone are now derelict and a further 64% are in

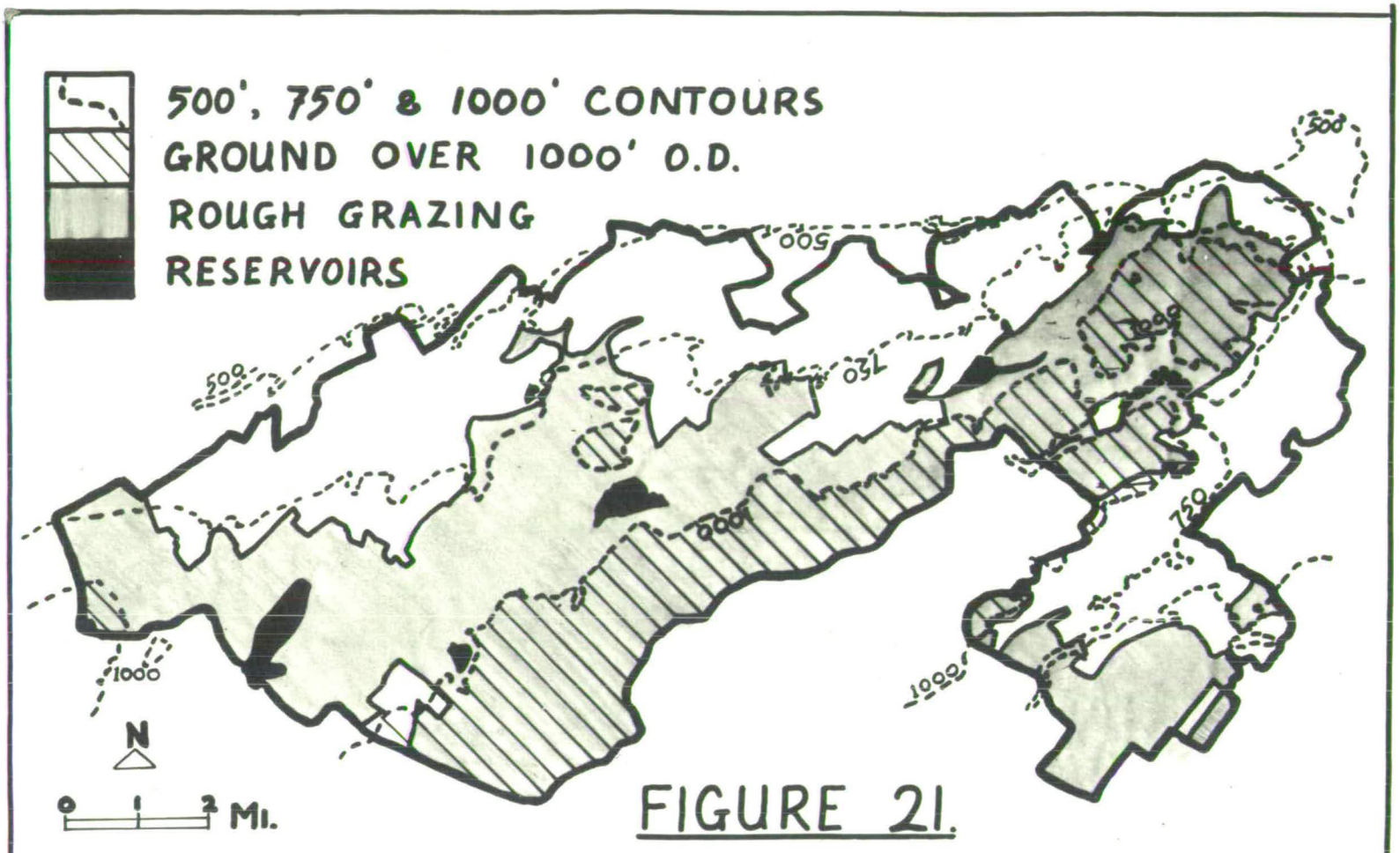


FIGURE 21.

STUDY AREA: ALTITUDE & EXTENT OF ROUGH GRAZING

D Condition. Unit size is also below the respective zonal averages in five of the six zones where there are units without belts, and these beltless units are particularly small (Table 6). On small farms a form of land hunger may prevent the allocation of any land to shelterbelts or serve to hasten deterioration in condition of the existing (rather small) shelterbelts, e.g. by excessive stock use. Conversely, in zone VI, where zonal averages for both unit area and belt site area are considerably larger than the respective zonal average, 57% of 112 sites are in Condition A - C.

Table 6 No. and Area of All Units and of Units without belts, by Zones

									S.A.
Total No. Units	7	11	12	8	11	16	11	10	86
Total Area (ac.)	4850	4402	1921	3298	11787	9933	7964	6084	50239
Av. Size (ac.)	693	400	160	412	1072	621	724	608	584
No. Units w/o belts	0	1	1	0	3	2	3	1	11
Area (ac.)	0	80	60	0	3450	570	559	260	4979
Av. Size (ac.)	-	80	60	-	1150	285	186	260	453

In Zone V, the 3 units without belts are on average larger than the average unit in that zone. Two units (Nos. 49 and 50) are on the Dalmahoy Estate, the planting on which is more or less confined to the eighteenth century system of policy woods. Furthermore, members of the family Grey have been tenants of Unit 50 for over 250 years and disinterest in shelterbelts may be hereditary.

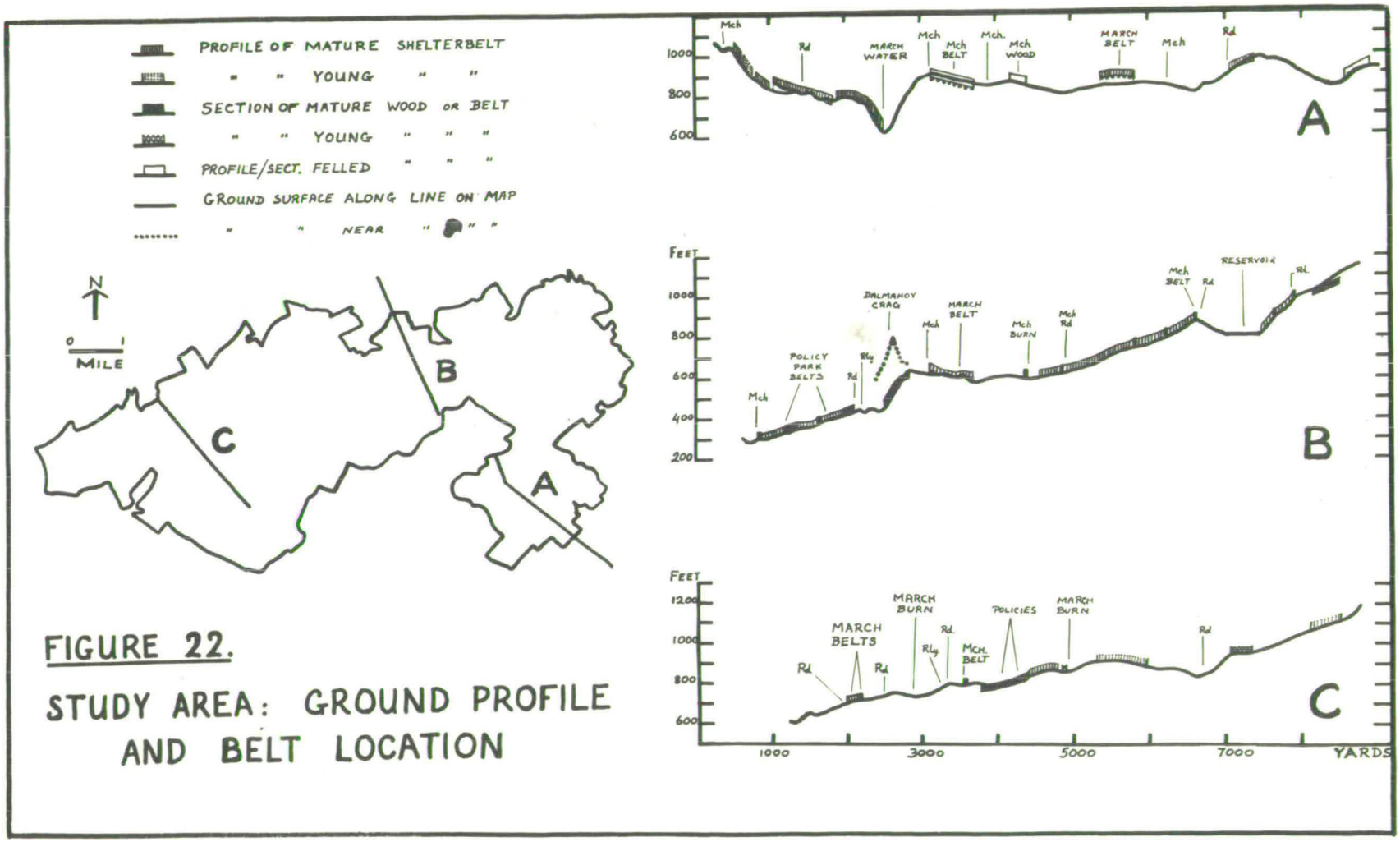


FIGURE 22.

STUDY AREA: GROUND PROFILE AND BELT LOCATION

Influence of Topography in Siting and Survival of Belts

Three sections across the study area (Figure 22) indicate how representative belts are sited. Belts that are sited at right angles to the topography happen to be normal to the prevailing wind. This applies to both the majority of belts, where 'normal' means they have their long axis oriented approximately NW-SE and also to belts in Zone VI where the wind tends to be deflected by the topography and the axis of these belts approaches a north-south orientation (Table 7).

Table 7 Orientation of Belts by Zones[1] (percent of number of belts by Zones)

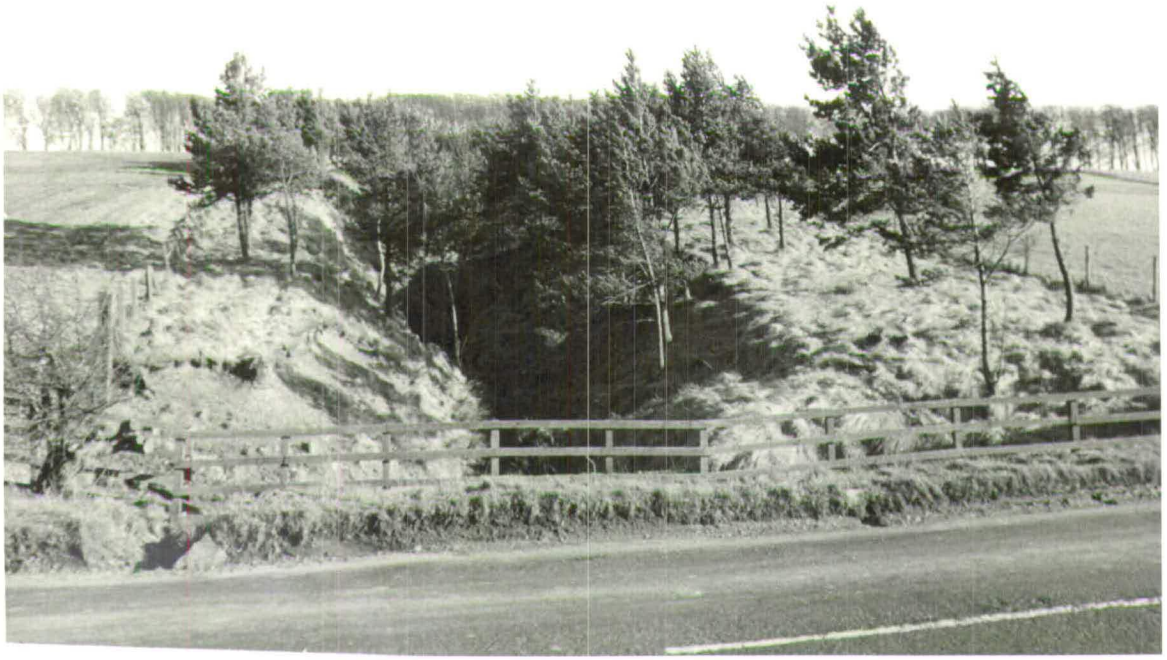
Orientation	I	II	III	IV	V	VI	VII	VIII	S.A.
Normal	64	68	62	69	65	54	52	73	61
Oblique	4	11	5	14	0	5	13	9	8
Parallel	32	21	33	17	35	41	35	18	31

Obliquely oriented belts and those parallel to the wind follow major topographic features. Some of these features, notably watercourses and the crests of ridges were used as boundary markers before enclosure. During enclosure or at the time of tree planting, if this lagged behind enclosure, these natural marches were frequently chosen as sites for strips of trees. Roads are other features that have belts alongside. Data about belts associated with watercourses, farm boundaries, and roads are given by orientation and by zones in Appendix II, and are analysed below:

---

1. Data on orientation and location of belts extracted from record cards.

FIG. 23. BELTS ASSOCIATED WITH WATERCOURSES



a) Former Whim Estate (NT 225542)

b) Penicuik Estate (NT 234579)

a) Sites along watercourses: There are 70 belts (14%) in the study area associated with natural or artificial watercourses (Table 8). The former are frequently used as field and farm boundaries (see below); the latter represent attempts to rationalise field shape, as far as topography will allow, when water is drained from mosses or springs, or when small streams are diverted. There are some excellent examples of artificial watercourses on the former Cockburn Estate (Zone VI), especially at NT 1436643 (Figure 23).

Table 8 Proportion of Belts Associated with Watercourses (Percent of No. and area of all belts in each Zone)

	I	II	III	IV	V	VI	VII	VIII	S.A.
Number	10	16	11	12	28	15	20	4	14
Area	11	21	9	13	25	22	26	13	17

About a quarter of the shelterbelt acreage in Zones II, V, VI and VII is found by water, and the average size of belts in this situation is 2.8 acres. Consequently these belts which may shelter several fields represent a larger proportion of all sites when calculated by area than by number, especially in Zones V and VI. The respective proportions of belts associated with watercourses in the two categories are found to be 64 : 36. (Table 9).

Table 9 Orientation of Belts and Location of Watercourses (Percent of Number of Belts by Watercourses)

Belt Orientation	Location of Watercourse	Percentage	
Normal or Oblique	Windward side	24	64
	In belt	29	
	Leeward side	11	
Parallel	One side	27	36
	In belt	9	

b) Sites on farm unit boundaries: There are 154 belts (31% of all belts) on present-day unit boundaries, and are located as shown in Table 10.

Table 10 Orientation of Belts and Location of Marches (Percent of Total Number of Belts on Marches.)

Belt Orientation	Location of March	Percentage	
Normal or Oblique	Windward side	34	67
	Leeward side	19	
	One side	14	
Parallel	One side	33 -	33

Again the proportion is approximately 2 : 1, and not only are a third of the belts of little use for shelter, being-end-to-wind, a fifth (19%) of the boundary belts are apparently providing shelter to neighbours' fields for much of the year. However, 112 (80%) of the boundary sites are in Condition Classes D and E, and 63 of these sites are end-to-wind, or on the leeward side of properties, whereas only ten of the 42 boundary belts in condition A to C are similarly situated. Therefore the neighbours

are not receiving as much shelter as the figures suggest. In all zones except V and VIII, between one third and one half of the shelterbelt acreage is found on boundaries of farms (Table 11). The average size of boundary belt sites is 2.9 acres, because they are much larger than average in zones II, V, VI and VII.

Table 11. Proportion of Shelterbelts on Present Day Farm Unit Boundaries (Percent of Number and Area of all Belts in each Zone)

	I	II	III	IV	V	VI	VII	VIII	S.A.
Number	35	26	43	36	10	29	28	25	31
Area	34	41	46	45	20	41	40	26	38

c) Sites associated with roads: Major roads from Edinburgh run the lengths of each lobe of the study area, and topography of the zones means that the branch roads also tend to run in a south-westerly direction. Some minor roads are parallel to the above, others are at right angles, connecting them together. There are several examples of roads that have been forced to follow circuitous routes immediately outwith old-established policy plantings, e.g. Westfield (NT 0463) and Ormiston (NT 0966), but for the most part, the modern pattern of roads in the area developed as foot-paths and tracks contemporarily with enclosures, though shelter planting was not necessarily involved, e.g. at NT 189661.[1] However, on maps by Knox (1812) and Sharp, Greenwood and Fowler (1828), well defined roads and areas of shelterbelt planting frequently do coincide.

---

1. See footnote 1, p. 63.

Because roads and tracks are intended as lines of communication between farm and market and between steading and farm lands, they often run over some of the best soils on each farm. Favourable site conditions and the high amenity value of many of the 93 roadside belts (especially the old hardwood ones) have contributed to their survival even when the majority of the belts on a unit are derelict, e.g. Unit 54, D Condition belt at NT 164642.

In each of the zones the frequency of belts (Table 12) tends to reflect the number of roads that there are, but grid planting is more likely to follow or to determine the road pattern (Zones I, III and VII particularly). Conversely, where there are mainly isolated belts, few are sited along roads as more useful sites for belts have usually been found elsewhere.

Table 12 Proportions of belts associated with roads (Percent of number and area of all belts in each zone)

	I	II	III	IV	V	VI	VII	VIII	S.A.
Number	28	13	24	28	7	15	23	11	19
Area	23	4	30	11	2	17	14	10	16

Of the lower lying zones, Zone II is atypical; hedgerows are still maintained on many farms, and the major area of planting on Harburn

---

1. (from p.62) The road here is on an ancient route to the south over Currie brig on the water of Leith and through Maidens Cleugh. It was used by Royalist troops as a short cut before the battle of Rullion Green, 1666, and was fenced between 1812 and 1828 probably for use by cattle drovers.

estate (Unit 12) has made little use of public or internal roads during shelterbelt construction.

Nowadays it is recommended (e.g. Caborn, 1965) that shelterbelts should be planted on the windward side of the road so that some of the disadvantages like shading, drip, and root competition are minimised, as the road occupies that position where field crops do least well. However, grass grows better in the immediate lee of a belt, particularly in regard to the "early bite" for stock in spring. The figures in Table 13 seem to confirm historical evidence that stock only were considered and not crops when the shelterbelts were first established; the animals could get right up to 41% of the roadside belts and avenues. In most cases the contemporary proprietor owned the land on both sides of the road, so he could have made a belt on either side or allowed a new road to pass either side of an existing belt.

Table 13 Orientation of Belts and Location of the Roads (Percent of number of belts by roads)

Belt Orientation	Location of roads	Percentage	
Normal or Oblique	Windward side	36	56
	In belt (avenue)	5	
	Leeward side	15	
Parallel	One side	41	44
	In belt (avenue)	3	

End-to-wind components of grid-planted systems account for the high proportion (44%) of parallel belts associated with roads.

Influence of Wind on Siting and Survival of Belts

Where the ground is almost flat, as on the raised bogs in Zone V, choice of site is primarily influenced by prevailing wind direction. Thus two new belts on Camilty Moss (NT 0559) are oriented NW-SE, athwart the prevailing wind.

Even gale force winds have little effect on the survival of healthy belts. However, wind shaping by prevailing winds in the growing season and the generally stunted appearance of trees in the windward margin of belts with axes normal to these winds indicate that growth rate and top height are severely affected by wind. There were flag-crowned Scots pine, 21 feet high in the first row of a 3-chain-wide, D Condition belt at the lower (NE) side of Auchencorth Moss (NT 227578).[1] A ring count on a newly felled tree gave its age as 128 years, i.e., it was one of the original trees planted when Sir George Clerk was laird of Penicuik. The stump was 15 inches in diameter. The tree had reached about 9 inches diameter in only 38 years; there were 90 rings in the outermost 3 inches. Other locality factors besides wind may have checked growth rate on this site, wetness in particular.

Another form of wind damage, attributable in part to an edaphic peculiarity, was seen in the roots of a 60 ft., 70-year-old Norway spruce blown down in an oblique C condition belt (NT 182655). Many roots had

---

1. The tree was in the lee of a drystone dyke which had been damaged by the tree's swaying. An unusual feature of this dyke was that it was on a slight bank with the remains of ditches on each side, possibly it replaced a failed hedge fence when the shelterbelt was planted.

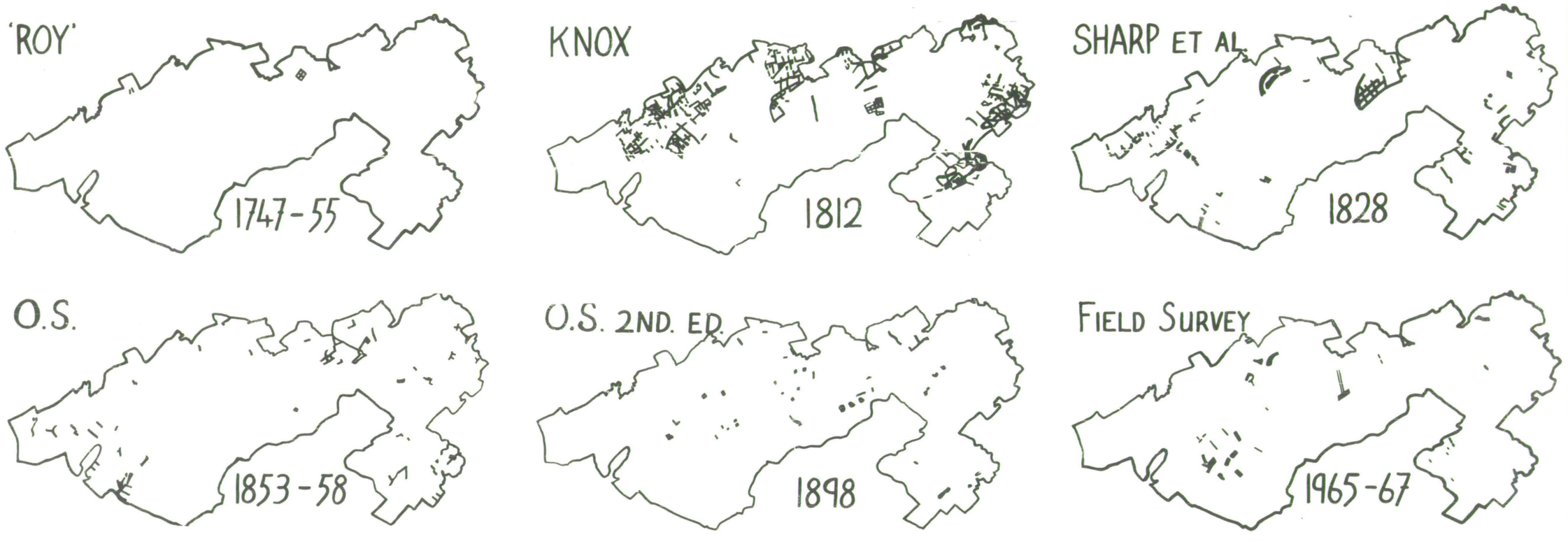


FIGURE 24. STUDY AREA: LOCATION OF SHELTERBELTS AND OF OTHER WOODS ADDED TO SYSTEMS 1747 – 1967

been sharpened like pencils by friction with stones in the subsoil prior to windthrow.

Influence of Date of First Planting on the pattern of Shelterbelt Systems, the Species Planted, and Subsequent Survival of Belts.

Shelterbelt site area varies according to the period when trees were first planted on the site (Table 14) and according to the design of the belt systems, which is also largely a function of time as revealed by the series of published maps (Figure 24). Sites are small where grid-planted systems of narrow belts ($\frac{1}{2}$ - $1\frac{1}{2}$ chains wide) were established prior to 1812, (e.g. Zones III, IV and VII), whereas the expansive grid-planting of broad belts (2 - 3 chains wide) on the higher ground of Cockburn estate accounts for the 1812 - 1828 average of 3.9 acres per belt in Zone VI. Similarly, site area is considerably above the period average where systems of normally oriented shelterbelts, 2 - 3 chains wide, were established between 1828 and 1854, e.g. those on the then exposed uplands in Zones III, IV and VIII, having 3.8, 3.4 and 3.2 acres per site respectively. The bold 'Z' of strips on Penicuik estate put in at this time extends to forty acres but the sites are 6 chains wide and so fall outside the remit of this survey.

In the last 113 years (1854 - 1967) only 23 belts (11% of all belts) have been established and the units concerned lie mainly in the upland and moorland parts of Zones V, VI and VIII. In the period 1854 - 1898, belts were established round the edges of enclosures that had been made much earlier[1] on the Malleny Estate (Zone VI).

---

1. See footnote 1, p.63.

A Forestry Commission five-chain-wide belt accounts for the 8.2 acre average for the period 1898 - 1967 in Zone VI. Similarly, recent extensive belt planting schemes using long, two and three chain wide belts on previously unenclosed lands in Zone V, account for the average of 3.9 acres per belt. In other zones where there has been recent planting, the old-established field patterns are limiting on belt length and new belts are average sized.

Table 14 Average Size of Belts (Acres) by Date of Planting and by Zones

Period	I	II	III	IV	V	VI	VII	VIII	S.A.
Before 1812	2.3	2.0	1.8	1.4	1.4	1.7	1.7	3.2	1.9
1812 - 1828	2.3	1.5	2.3	2.5	2.3	3.9	3.0	2.9	2.9
1828 - 1854	1.4	2.6	1.8	3.7	3.0	3.1	2.2	3.2	2.9
1854 - 1898	2.9	2.1	-	1.7	0.9	4.3	-	3.9	2.9
1898 - 1967	2.0	1.5	-	-	3.9	8.2	1.2	1.3	3.2
Present Average Size	2.3	1.9	1.9	2.5	2.3	3.0	1.8	2.8	2.4

When shelterbelts were first planted in the study area and during the next hundred years, suitable soils and sites and the availability of cheap labour resulted in the successful establishment of hardwood belts. Nurse species were used in many instances and in some cases, particularly in Zone VII where there are 51% mixed belts (Table 15), it may be assumed that suitable stand density could only be retained by leaving in many of the conifers. Where the hardwoods grew best,

however, nurses have mostly been selectively felled (or have died off) leaving the longer-lived and more ornamental trees. Hardwoods were occasionally introduced into conifer stands once local shelter was available (e.g. on Cockburn Estate, see above p. 48). This practice probably accounts for the high proportion of belts with mixed species composition in Zones VI - VIII.

Table 15 The Proportion of Sites Carrying Broadleafed, Mixed or Conifer Stands in A to D Condition by Zones (Percentage of A - D Condition Sites in Each Zone)

	I	II	III	IV	V	VI	VII	VIII	S.A.
Basis: No. of A-D Condition Sites	54	32	57	34	25	92	74	35	403
Broadleafed	58	41	65	44	0	16	26	14	33
Mixed	20	22	23	21	32	44	51	43	34
Conifer	22	37	12	35	68	40	23	43	32

Before the end of the eighteenth century, conifer belts were advocated for high and exposed sites on poor wet soils, and conifers have invariably been favoured for replanting and for filling gaps in belts, even on low ground. In Zones VI and VIII where shelter planting was most active towards the middle of the last century and has again been revived in recent years, 40% and 43% respectively of the wooded sites bear pure conifer stands, and of the few belts in Zone V, 68% have a similar composition. (Fig. 24b).

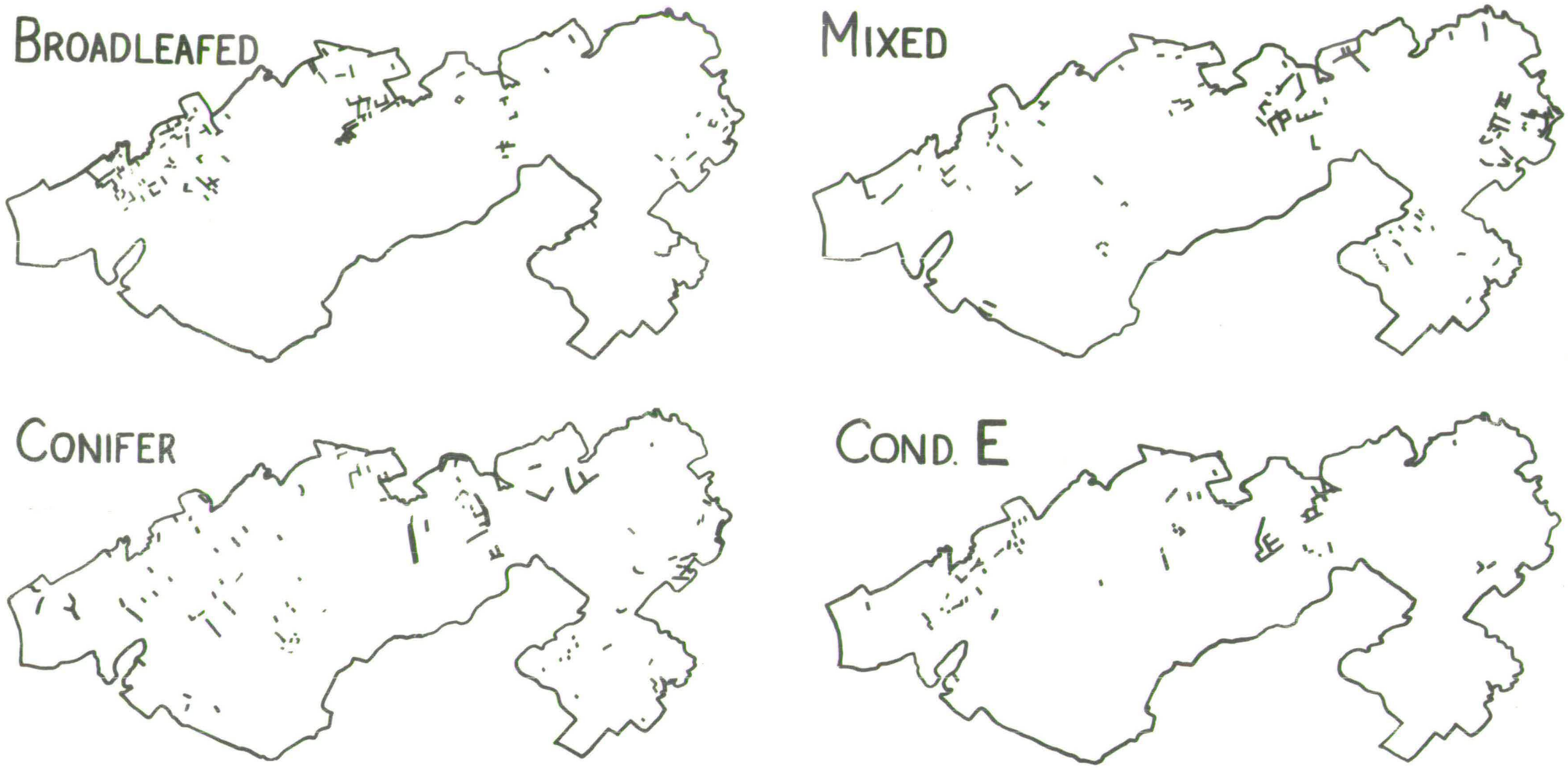


FIGURE 24b. STUDY AREA: LOCATION OF BELTS OF DIFFERENT SPECIES COMPOSITION & OF DERELICT (E COND) BELT SITES

The figures in Table 15 substantiate the cautiousness of Murray and Mutch (1961) in drawing conclusions about width and species composition from a pilot survey of 130 belts. A check through their original record cards revealed that 50 of the belts they classified lie in Zones V - VIII, while the rest lie outwith the study area. It can be shown (see below, Chapters VI and VII) that given even the present day optimum level of belt maintenance, conifers are the only practical species to plant in shelterbelts. However, if the prime function of those belts is to provide shelter, then it is certainly unnecessary to advocate a greater width than 3 chains.

Table 16 Number, Average Size, by Orientation, and Species Composition of All Belts in the Study Area.

Orientation	Broadleafed		Mixed		Conifer		Derelict	
	No.	Av.Size (ac.)	No.	Av.Size (ac.)	No.	Av.Size (ac.)	No.	Av.Size (ac.)
Normal	81	1.9	80	2.0	85	2.9	59	1.9
Oblique	10	1.8	11	2.0	14	4.5	5	6.9
Parallel	44	2.1	48	2.4	29	2.7	31	2.6
Study area	135	1.9	139	2.1	128	3.0	95	2.4

the prevalence of conifer planting on fairly wide (2 - 3 ch.) sites, throughout the nineteenth century, meant that several even-aged stands happened to be of suitable size when timber was requisitioned during the two World Wars. Standing obliquly oriented conifer belts (av. size, 4.5 ac.) are on sites that are nearly twice the study area average (2.4 ac.). Clear felled sites of this type average 6.9 acres, and some good timber was extracted from them, e.g on Unit 52 (Pers comm., Mr. Archie Marshall, Sen.).

On Unit 60, a normally oriented belt at NT165628 was felled in the 1940's and has not been replanted. Part of a stand at right angles to it and once in its lee is now in D condition, following windthrow. A certain amount of this may also be attributed to local waterlogging, but as a continuation of the belt westwards has always been exposed to wind and is still in C condition, opening up of the belt system is thought to be the main reason for deterioration in the condition of the adjacent site.

The influence of Woodland Management Type and Tenure of Farm Units On Use and Survival of Belts.

Choropleth maps (Figure 25) provide qualitative data about land tenure and the Proprietor's Woodland Management Type. Quantitative information on land tenure and size of units is presented by zones in Appendix III. West of the Pentland Hills the majority of the farms are

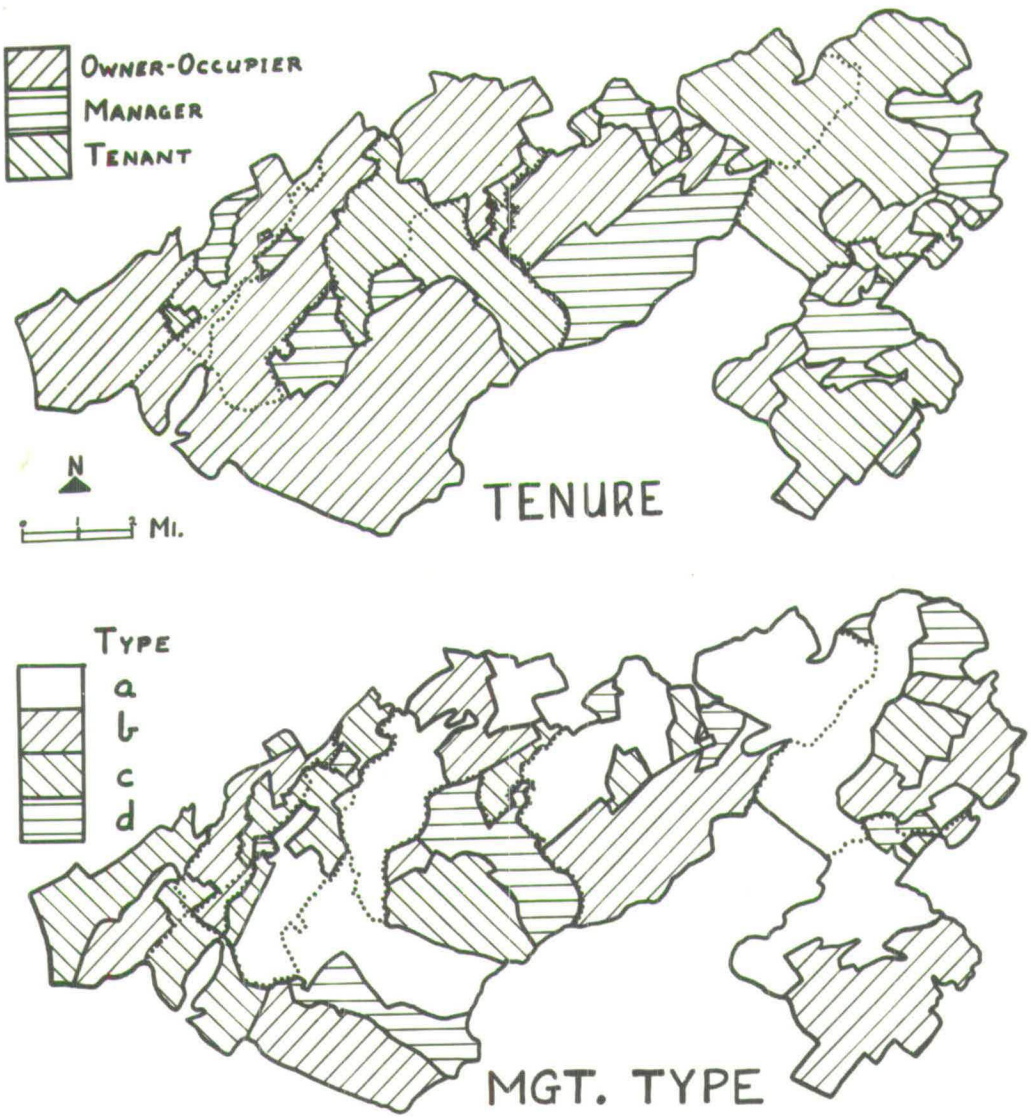


FIGURE 25. STUDY AREA: LAND TENURE & WOODLAND MANAGEMENT TYPE

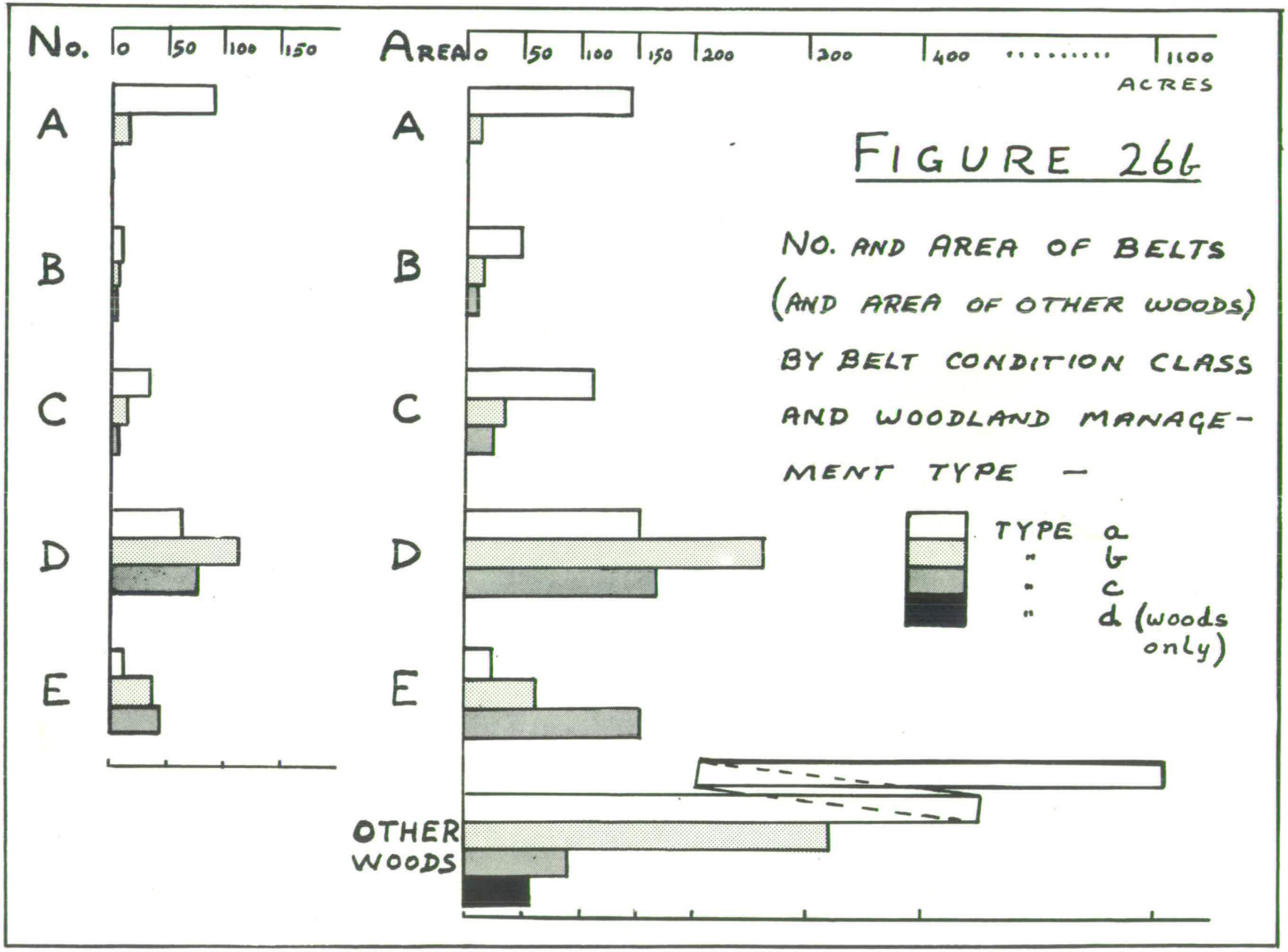
owner-occupied. North of the hills (Zone VI) owners and managers together are found as frequently as tenants, though the latter run smaller units. In the eastern lobe of the study area a higher proportion of units are tenanted compared with owner-occupied and managed units.

Table 17 Number and Average Size of Units by Tenure and by Woodland Management Type.

Woodland Management Type	Owner-occupied		Managed		Tenanted		Study Area	
	No. Units	Av. Size	No. Units	Av. Size	No. Units	Av. Size	No. Units	Av. Size
Type a	9	752	4	617	10	814	23	755
Type b	12	623	5	1102	5	766	22	764
Type c	24	381	-	-	6	272	30	360
Type d	5	406	-	-	7	542	11	480
Study Area	50	488	9	886	27	624	86	584

Distribution of woodland management type is more complex, but it can be shown to be related to farm size and to the use of the sheltered land (see Chapter VI). Proprietors of Types a and b own, on the average, considerably larger farms than those in Type c (Table 17). There are 24 owner-occupiers of Type c, whereas only six tenanted farms come in this category. In contrast, managed and tenanted units are more likely to be in Types a or b, and this most often occurs when the units concerned are parts of estates with extensive woods on them.

In the study area one important reason why belts are being constructed (e.g. Units 9 and 13) and maintained (e.g. Unit 53) at the present time, is to provide shelter for sheep and cattle at various seasons of the year. Another obvious use to which belt sites are now being put is that


No.
0
50
100
150
A
B
C
D
E
AREA
0
50
100
150
200
300
400
1100
ACRES
A
B
C
D
E
OTHER WOODS
FIGURE 266
NO. AND AREA OF BELTS (AND AREA OF OTHER WOODS) BY BELT CONDITION CLASS AND WOODLAND MANAGEMENT TYPE –
TYPE a
" b
" c
" d (woods only)

of timber production (Table 18) and it is significant that on two of the estates in the "timber" category there is a site where a second belt was established parallel to a standing strip.[1] There are also relatively extensive other woods on each of these properties, whereas on "shelter" units there is rarely a large area of other woods.

Table 18 Comparison of Size, Condition and Management of Shelterbelts on Selected Units

Unit Number	Belts Managed mainly for:	Condition Class (average size of sites in acres) A	B	C	D	E	Total belt acres	Other woods acres
9	Shelter	2.6	-	-	1.0	0.8	18	0
13	Shelter	7.0	-	-	-	-	14	2
53	Shelter	1.5	2.6	1.8	0.8	-	52	9
58	Timber	-	1.5	2.5	1.3	3.0	33	38
81-86	Timber	10.2	-	4.2	3.0	-	87	63
1	Timber	-	-	2.9	3.4	2.9	51	128

Apparent abnormalities in the table can be accounted for: on Unit 13 there is a 7/8 mile of new, 2-chain-wide shelterbelts in A condition on previously open rough grazing, and on Unit 58 the belts in B condition are all associated with old-established fields. The important points about belts that are managed mainly for timber production in the study area are:

---

1. Parallel belts: Malleny Estate (NT 176667) and Unit 58 (NT 158650). Compare also the Forestry Commission belt (NT 128634), where new ground was planted on both sides of an old site.

i) They are on sites that are larger than average.

ii) If managed for softwood production, they tend to be in C condition because the silvicultural technique of thinning for good incremental growth reduces stand completeness to Condition C level in 20 - 30 years, and, on suitable sites, can maintain it in that condition until the trees are felled.

iii) Hardwood production belts, by the same token, tend to be in D condition now. Stem frequency was probably thinned to D condition level in about 80 years, but the trees in most hardwood belts are now considerably older than this.

The Influence of Land Use on Survival of Belts, Including Reference to Stock Entry of Belts.

When notice is taken of land use on each side of shelterbelts, it is possible to estimate the relative importance of belts in various situations on farms in the study area (Table 19). Only 24 belts (5% of sample) are exclusively associated with rough grazings or farm buildings, or were said to be intended for non-agricultural purposes like snow barriers ("RG" in table). While 379 sites (76%) are in A - D Condition and have fields on one or both sides; the fields being rotationally ploughed for cash-or-feed-crops, or sown with improved pasture grasses ("A/P" in table). Ninety-five belts (19%), in various situations, are derelict, E Condition. Derelict sites can have no influence on the microclimate of the neighbouring farm land but they can affect the way the land is used in another way; by providing small areas of rough grazing between fields used for arable

or pasture. Consequently the distribution and situation of E condition sites can usefully be compared with sites carrying trees.

In the study area, dereliction has occurred in identical proportion with overall belt frequency, and thus with the number of wooded sites also; the 2 : 1 ratio again, i.e. failure rate is independent of orientation.

Table 19 Proportions of Derelict and Wooded Sites by Orientation and by Land Use. (Percent of total no. of belts in each category)

Orientation	Land Use	Derelict %		Wooded %	
Normal or Oblique	A/P both sides	44	67	50	67
	A/P leeward (RG wind)	11		9	
	A/P windward (RG lee)	6		3	
	RG on both sides	6		5	
End-to-wind	A/P on both sides	22	33	25	33
	A/P on one side (RG on other)	7		7	
	RG on both sides	4		1	

Where there is rough grazing on both sides of the sites, E condition sites are found on average nearly twice as frequently (10%) as extant shelterbelts (6%). A further 24% of E condition sites are found to lie on the fringes of cultivated ground. This is slightly higher than the figures (19%) for all A to D condition sites that occur in such situations, namely, on the edges of moorlands, mosses or against non-agricultural ground, where belts are particularly susceptible to failure as a result of adverse locality factors should regular maintenance be witheld for some reason. Thus a lower proportion of E condition sites lie between fields used for arable or improved pasture (66% derelict compared with

75% wooded).

Regarding the incidence and effect of stock entry, just over half the belts examined (55%) were not open to stock whereas 45% of the belts were obviously used by farm animals or else had defective fences on the field side; the field being currently under crops but presumably seeded to grass in rotation and then stocked at certain seasons.

Comparison by zones (Table 20) reveals that maintenance of field/shelterbelt fences is best in Zones VI and VII where most of the units are of Woodland Management Types a or b, and least good on the small farms in Zone III and, in Zone IV, on the farms bought by the Baads Estate sitting tenants in 1947, when the belts were already somewhat neglected (Chapter VII).

Table 20 Comparison of Stock-Entered Belts with Stock-Proof Belts by Zones. (Percent of number of belts in each zone)

	I	II	III	IV	V	VI	VII	VIII	S.A.
Stock-entered	53	34	68	69	59	29	19	58	45
Stock-proof	47	66	32	31	41	71	81	42	55

Cattle and sheep were the animals most frequently seen in shelterbelts and horses were using belts on Unit 54. Pigs and goats were seen in certain roadside belts in Lanarkshire but in no belt within the study area. Chickens were exposing root buttresses by scratching in several belts on Unit 76 (e.g. NT 229588). The principal features of stock entry are: damage to soil structure, particularly on wet sites; physical damage to root buttresses and trunks by barking; and damage arising from

attack by pathogens consequent upon either or both of the above features. Fortunately, cattle are quartered in steadings from October to April on most of the units where belts are unfenced, but Unit 2 provides several examples of belts where dereliction is now proceeding rapidly because cattle have unlimited access at all seasons.

The Present Condition of Shelterbelts, Details by Five Condition Classes

Stand completeness in itself does not necessarily indicate directly the shelter potential of any belt, unless the site is in Condition E, when it is nil, or nearly so; what it does show is whether or not that belt is being managed carefully. A summary of the results of the survey of present conditions of shelterbelts (Table 21) and the distribution of sites in each condition class (Figure 26) indicate the enormity of the problem of D and E condition belts in the study area. Nevertheless, the figures also show that about 27% of all sites carry stands of trees with a stem distribution 60% complete or more, (i.e. those in Condition Classes A to C). From the maps it is clear where some of these slightly larger sites (33% of shelterbelt area) are situated.

Table 21 Number and Area of Sites by Condition Classes

Site Condition	A	B	C	D	E	S.A.
Number of sites concerned	51	25	57	270	95	498
Number of sites as % of total	10	5	12	54	19	100
Totals of site areas (acres)	149	65	160	568	227	1169
Site area as % of total	13	6	14	48	19	100
Average size of belt (acres)	2.9	2.6	2.8	2.1	2.4	2.4

Analysis of data about the condition of shelterbelt sites on 75 farm units (for 11 have no belts) is made by classes below:

Class A

The fifty-one sites in best condition were found on seventeen units (Table 22). On some farms there was a combination of regeneration and new planting; eight proprietors had planted only on old sites, four on both old and new, three only new sites, two on new sites and sites incorporating old belts, and one had increased the width of a site.

Table 22 Thee Planting Activity Leading to A Condition Sites

Description	Number of Belts	Number of Farm Units Concerned
Regeneration on old site	30	13
Entirely new belt	17	8
Belts incorporating old site	4	3

There are obvious concentrations of A condition belts in certain

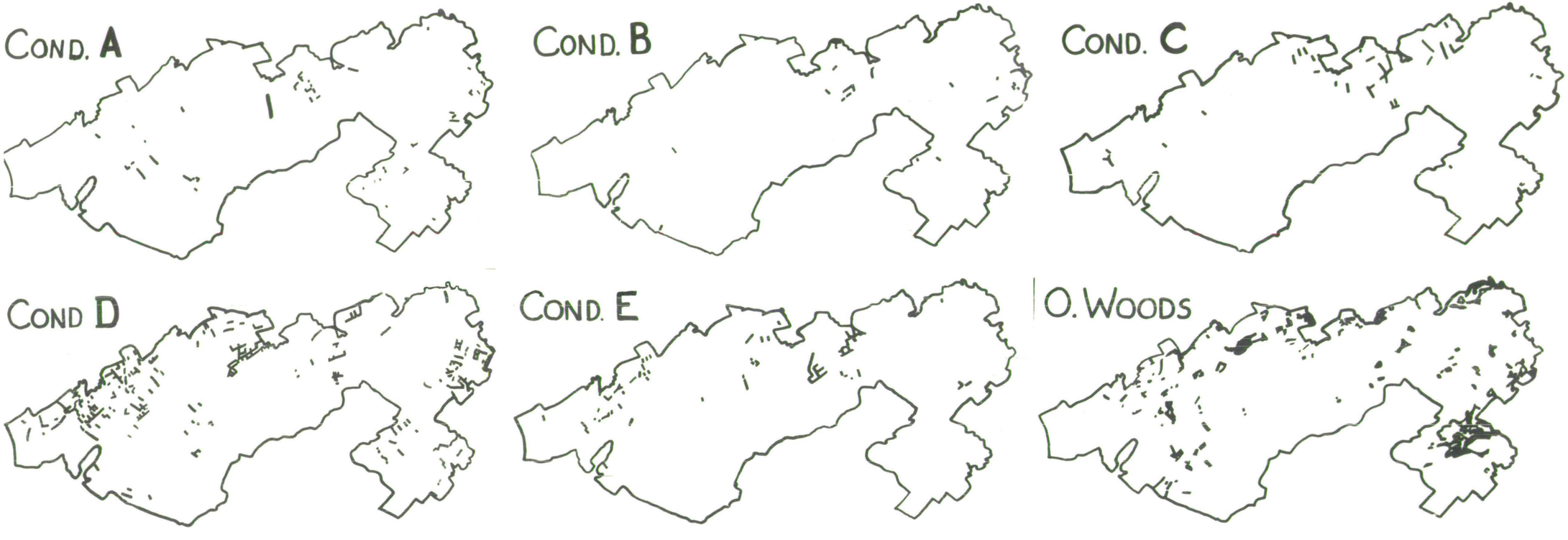


FIGURE 27 STUDY AREA: LOCATION OF SHELTERBELTS IN FIVE SITE CONDITION CLASSES, A-E, & LOCATION OF OTHER WOODS

parts of Zones V, VI and VIII. The recent introduction of shelter planting for sheep and hill cattle has led to the three long, normally oriented sites in Zone V. Two large sites in Zone VI are primarily for timber, but between them (on Unit 52), regeneration of grid-planted belts has been effected within older structures (usually similar to the irregular stands on D condition sites) by planting up the gaps with groups of suitable transplants. This has also been done on Unit 62 (Zone VII) and the resulting uneven-aged stands are designed to provide shelter in perpetuity.

Class B

There are only twenty-five sites in this condition on nine farm units. Most of the sites carry stands that are between 10 and 45 years old; on one, the trees are probably 60 years old; and two others bear recent plantings that have already started degenerating through lack of attention. On Unit 52 and 62, belts with regeneration groups that have partially failed since they were planted (1952 onwards) have also been classified as B.

On five farms (with 15 of the B condition belts), there are also sites in A condition. On one small property the only belt is in condition B. Similarly, the remaining nine B condition belts are the best stocked sites at the present time on six other farms.

Four of the belts in this class are on new sites; two others are on sites widened when replanted, and the rest (19 belts) occupy old sites that have been entirely replanted, or rehabilitated by under-

planting or by group regeneration (Table 23).

Table 23 Tree Planting Activity Leading to B Condition Sites

Description	Number of Belts	Number of Farm Units Concerned
Regeneration on old site	19	8
Entirely new belt	4	4
Belts incorporating old site	2	1

Class C

The age range of trees in this class is similar to that in condition B but with a higher proportion of belts planted around or before the turn of the century. Because of the greater age, no attempt will be made here, or in the section on D condition belts below, to itemize sites according to type (original planting, new planting on old site, etc.,). Instead other characteristics of farm belt management that seem to bear on condition are introduced.

Although there are only a few more sites in C condition than in A condition, it is interesting to note that the former are far more widely distributed, and rarely found in association with A or B condition belts but are most often located in the vicinity of other woods with which they are managed for timber production. Only on three farms (Units 53, 62 and 72) are there belts in condition A, B and C. On each of these units active belt management started in the early 1950's and the distribution of belts in condition classes is obviously a function of the length of time

regeneration has been practiced (Chapter VI). Of the 25 farm units with sites in C condition, 15 have no better belts, and 13 have only one belt (not necessarily their best) in condition C.

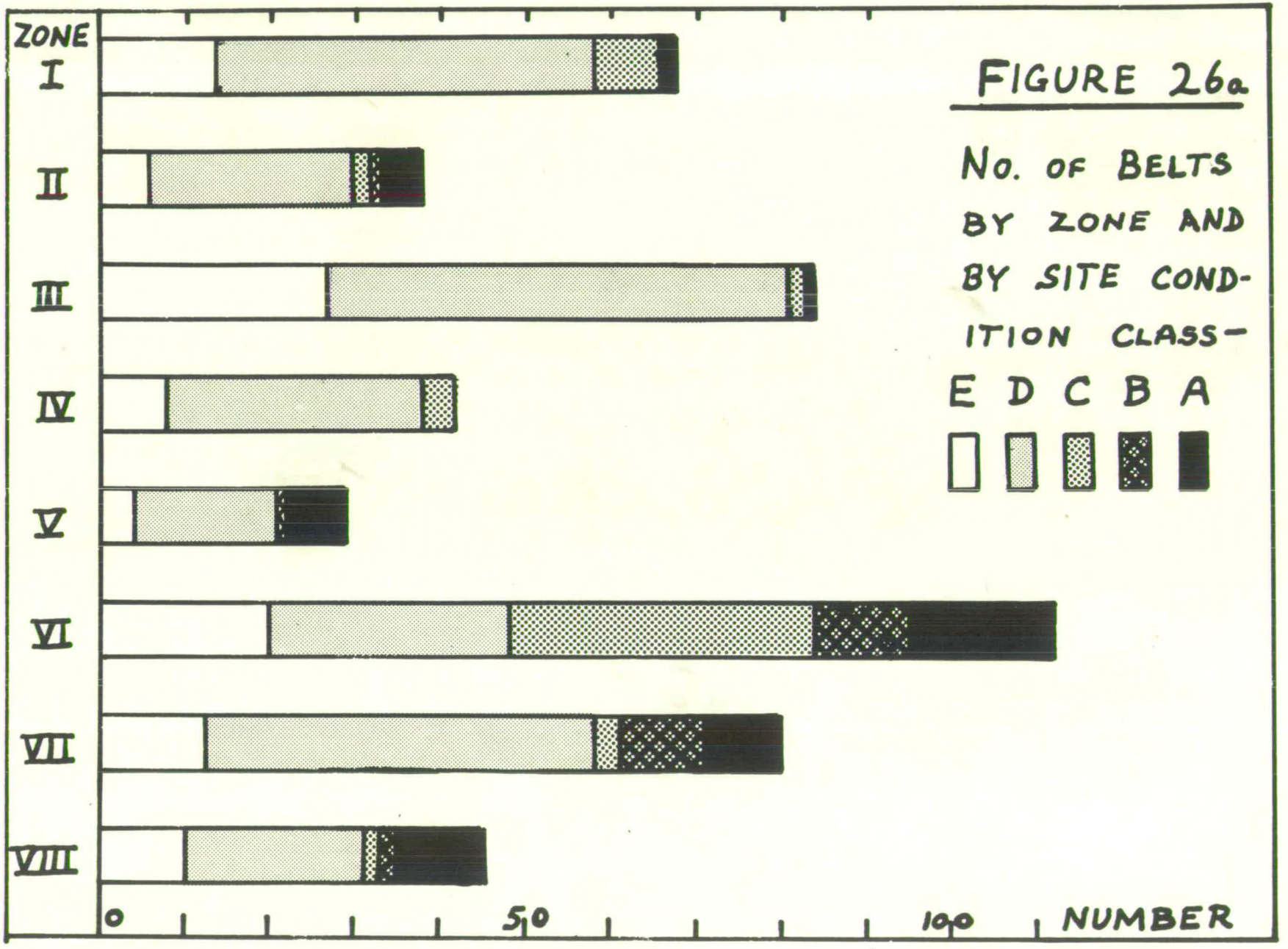
Table 24 Frequency of Occurence of C Condition Sites on Twenty-five Units

Number of C Condition Belts per Unit	Number of Units Concerned	Total Number of Belts
1	13	13
2	6	12
3	2	6
4	2	8
9	2	18
	Total 25	Total 57

Class D

This class necessarily contains all remaining belts that are not actually derelict. There was little difficulty in assigning belts to this category, for on very few sites did stem distribution come near the upper class boundary of 60% completeness, and dereliction rarely approached the lower limit of 20% completeness; gappiness is a characteristic that is easy to recognise in the field.

If stand completeness followed a normal distribution over the range 20 - 100%, there would be approximately as many belts in condition A - C as in D - E. This does not pertain in the study area, largely because shelterbelt planting activity has not been a continuing process,


ZONE
I
II
III
IV
V
VI
VII
VIII
0
50
100
NUMBER
FIGURE 26a
NO. OF BELTS BY ZONE AND BY SITE CONDITION CLASS-
E D C B A

and the histograms (Figure 23) show how widely the number of belts in the five condition classes varies from zone to zone. Some of the D condition sites carry only old trees (60 - 150 or more years) which should have been regenerated artificially (as indicated above for A condition sites) if the proprietors were interested in perpetual shelter, and had the necessary capital to invest. Other D condition sites are partially stocked with uneven-aged trees either because of natural regeneration, especially of birch, beech, Scots pine, sycamore and willow, or as a result of underplanting with some of these and other species at times when the belts were better maintained. That many of the components of grid systems of planting are in D condition is a function of their early establishment, and the reason so many of these belts have survived, though perhaps long neglected, is because eighteenth century proprietors invested in hardwoods when they planted these more favourably situated sites.

Class E

Sites that are derelict are often closely associated with D condition sites and many are also found as components of grid-systems, or are portions of belts within these systems that are unfavourably situated or have received harsh treatment (Chapter VII). They are characterized by sparse tree cover or complete bareness of site. Thirty-five farms have E condition sites on them, but only two (Units 16, 1 site; and Unit 69, 2 sites) have no other belts.

The tables of statistical information together with the data given on maps and histograms reflect not only the management policies of the present and former proprietors of lands in the study area, but also the end results of variations in the siting of particular belts and in the design and lay-out of shelterbelt systems during the past two hundred and fifty years.

CHAPTER VI
DESCRIPTIONS OF CONSTRUCTIVE SHELTERBELT MANAGEMENT TECHNIQUES AND OF POSITIVE USES OF SHELTERBELTS ON CERTAIN FARM UNITS IN THE STUDY AREA AT THE PRESENT TIME

Today, both the ideas about the role of shelterbelts and also the purposes for which they are actually established and used, are virtually the same as they have been during the past 250 years. In the planning stage there are sometimes thoughts of protecting crops from damaging winds, especially at harvest time, but no proprietor in the study area has yet planted a belt specifically for this purpose. The principle object behind all recently established belts is to shelter grasslands grazed by stock. Only one new belt, planted by the Forestry Commission, was specifically designed to produce timber. On a number of units with extensive other woods several old established sites are managed for timber production, but even if production is not a major object, saleable thinnings and timber for farm use are an inevitable by-product of regular belt maintenance. Shelterbelts provide cover for pheasants on two family estates where the woods are run on traditional lines. Present-day gentleman farmers who establish new sites or rehabilitate old ones near their residences often take into account the amenity value of tree strips and so plant ornamental species, as do proprietors of country houses with little farmed land.

The very fact that a belt is required, however, often means that locality conditions are harsh (Anderson, 1957). In general, therefore, only quick-growing and hardy coniferous trees are planted, though a few belts of mixed hardwood and softwood species were established on three

units about ten years ago. Some of these belts were subsequently tended with seasonal help from student labour (Unit 62), but none has been adequately maintained and failure of hardwoods has been serious.

New belts are rarely found as isolated entities. Some form extensions to existing shelterbelt systems, and have been established at the further limits of outlying fields prior to the improvement of permanent pasture.

Other new belts are on exposed rough grazing land, where fences were formerly few and far between. In one case new belts effectively divide previously open moss ground, that is to be made into paddocks for intensive stock rearing based on grass. In another case, a hill unit, the allignment of the new belts is such as will provide storm refuges for sheep without interfering with the natural rake of the flock. This is a recent innovation in an effort to intensify hill sheep management on the lines that have been so successfully used for beef cattle during the past two hundred and fifty years.

Particular points about the way certain of the belts are being made, maintained and positively used at present on representative units are given below.

Shelterbelt Management for Multiple Use on Traditional Lines

On two family estates, the policy woods and the home farms are still run on traditional lines, although the area of agricultural land "in hand" is now larger than it was in former times. This is in line with a tendancy towards amalgamation of small farms that has occurred

throughout the study area. Unit 12, for instance, consisted of a small home farm and two tenant farms until recently. The forestry staff of Unit 71 still have farm woodlands to tend on five other units within the study area and on other tenanted farms nearby. The details are as follows:

a) Unit 12 (II, 0, a).[1] Game, timber, shelter, amenity: this is the order of importance that the proprietor's son (and the estate manager) put on the woodlands. With a view to forwarding these aims, he has planted new sites and rehabilitated others at the limits of the improved ground round the policies. He also mentioned income tax relief obtained because capital was being invested in the woods. The only E condition site (2.6 acres, NT 035602) is scheduled for replanting. Like two of the new, A condition sites, this one is oriented parallel to the prevailing wind and lies on the estate boundary.

b) Unit 71 (VIII, M, a). The Penicuik Estate. This unit has the most extensive woodlands of any unit in the study area. Timber is produced for sale and for estate use, and the Factor is concerned to fell only at such a rate that regeneration can keep pace, despite the large number of mature hardwoods which are making uneconomic use of ground at present. All proceeds from timber sales are ploughed back into the woodlands now, though this was not the case after fellings in the First World War, after which planting did not begin again until 1936.

---

1. (II, 0, a) refers to the units classifications into zone, land tenure, and Woodland Management Type, respectively (Appendix I).

Regeneration is mainly with conifers on clear-felled sites that are mostly too wide to be included in the shelterbelt survey. Nevertheless, several narrow woods located on field margins are providing useful close-up shelter for stock, e.g. at NT202592 & NT213600. Two A condition belts, which join at right angles at NT209594, have been underplanted rather than clear-felled for two reasons; first, to fulfill a desire for continuance of shelter and amenity, and second, to provide a link with good ground cover for pheasants which are reared for their high sporting value.

Shelterbelt Management where Timber Production is Important

Timber produced in estate woodlands has been put to many purposes in the past. Sir John Clerk wanted it to make tenants' houses more easily and cheaply, and in the nineteenth century good prices were obtained for farm forest produce. Thinnings and small saw timber made paling rails and use was made of lop and top as an artificial shelter screen behind which to plant shelterbelt trees (Webster, 1890). Scots pine treated with modern preservatives has replaced larch for fencing stobs on some farms.

In the study area, many of the shelterbelts that are now being managed mainly for timber production were once managed on traditional lines, but for one reason or another proprietors are less interested in the amenity and sporting aspects of farm woodland management. Production belts are invariably found where there are fairly extensive other woods on the unit or group of units (estate). Some of these belts are wide and parallel to wind direction; hence of little shelter value. Even normally oriented belts have less than optimum shelter value because of thinning practice, as detailed in Chapter IV, above.

a) Unit 1 (I, O, a). This is the home farm and policy grounds of a small family estate. At present there are four sites in C condition, carrying 11.5 acres of Scots pine and Norway spruce, and intended primarily for timber. These belts are all athwart the prevailing wind, and sheltered fields were being used as follows: turnips for winter feeding, 1965-66 (NT 105663); lambing in spring 1966 (NT 109662); and protection of farm

buildings (NT 114658) and (NT 118659). Some regeneration has been carried out in a D condition belt at NT 120661, and two woods have recently been planted up. Any belt that is cleared for timber will be replanted. The proprietor is a member of S.W.O.A., who have advised on matters of rotation and felling.

b) Unit 20 (II, 0, a). The single D condition belt (NT 059629) was used as a windbreak behind which a 16-acre conifer wood was established about 15 years ago. Now that this production wood is well grown, the belt will be clear-felled and then replanted, because the older shelterbelt trees are now suppressing the first two rows of trees in the wood. There are eleven more acres of production and amenity woodland associated with the old mansion house on this 44-acre property, which once was the centre of a thriving estate (see below, Chapter VII).

c) Unit 58 (VI, M, a). The working manager has only recently been employed. He has experience in forestry and is continuing the policy of managing shelterbelts for production. Timber has recently been extracted from a C condition oblique belt (NT 158650), and from two small woods, the latter by S.W.O.A. contractors. The manager talked of the shading problem posed by overhanging branches of old hedgerow beeches and of his intention to plant up a wet patch in one field.

Rhododendron and other shrubs occur in many of the belts and form a satisfactory understory to the canopy of the mature trees. Although they now serve to tender these belts more uniformly penetrable to wind, they were originally planted (e.g. at NT 152662) to provide cover for

game birds once reared on parts of the estate. In the last hard winter (1962/63) some sheep forced their way into a belt to get at the evergreen vegetation, and one hogg had died from a surfeit of rhododendron leaves. (This was determined by autopsy).

d) Units 81 - 86 (each VI, T, a). The Malleny Estate. All the shelterbelts and woods are managed by the estate Factor in conjunction with woods on other properties in the Lothians. There is a resident forester. Eleven of the 22 belts are in C condition and the conifers on them are either approaching maturity or are now ready for felling. The A condition site (NT 177654) bore hardwoods that were felled and replaced by conifers in spring 1967.

Referring to a long belt on his west march (NT 189661) the tenant of Unit 84 said that he would ask for a remission in rent if that belt were ever clear-felled. Shelter from the ¾-mile-long, twelve-acre strip of C condition woodland is obviously important to him. It would be disasterous, as far as he is concerned, if the proprietor were to remove the trees. The bird population of this particular shelterbelt has been studied since 1962, by an amateur ornithologist. He considers that the belt is a most important ecological niche, as thirty bird species are genuinely associated with it. (Rawcliffe, C., personal communication. See Appendix IV).

e) Unit 64 (VII, T, a). The tenant appreciates the shelter afforded by numerous belts, and his tractor hand commented that in spite of having a modern machine with a cab fitted, it was far more pleasant to

plough the sheltered fields above 600' altitude than the exposed fields on a virtually treeless farm, a hundred feet lower down the hill.[1] A great deal of hard and soft wood timber has been extracted from the belts during the last thirty years.[2] Certain sites have been clear-felled and replanted for timber, notably a long oblique strip along a steep river bank, a parallel belt, and a normally oriented irregular area. Only the last of which has much shelter value. (They are respectively: NT 237633 B; NT 235624 and NT 234627, both A.)

The planting programme was suspended on Unit 64 as well as the home farm, Unit 63, following the head forester's retirement. Rosebay-willow-herb, Chaemaenerion angustifolium, has grown strongly since sites were partially or completely deforested. Although it seriously hinders regeneration, it is not a menace to the field crops. Only one replanted strip (NT 237627) is not doing well, and is now in D condition, as weeding (e.g. by trampling willow-herb around the young trees) and beating up are no longer practiced and part of the strip is waterlogged. The older trees on the other replanted sites are growing satisfactorily.

---

1. The farm (NT 262624) is owned by the tenant of Unit 64. (It is out-with the study area.)

2. The late Mr. Harry Cruden made extensive use of timber from this estate in constructing sections for prefabricated buildings during the Second World War.

Shelterbelt Management for Shelter in Conjunction with Stock Rearing

Modern transport has enabled hill and upland farmers to specialise in stock rearing. Good hay at £7 a ton is brought from low ground (Unit 9) and it is becoming standard practice to feed concentrates to sheep in winter. In conjunction with this intensification in stock rearing, several proprietors of large hill and upland units have started to plant shelterbelts. Capital for this afforestation mostly comes from outside sources including other jobs, tax relief, and Forestry Commission Small Wood Grants, but the size of the units and hence the stock carrying capacity is an important consideration. The beasts catered for and the units concerned are:

i) Cattle

Unit 48 (I, T, a). This unit is run in conjunction with the former policy parks of Dalmahoy estate, and other grounds outwith the study area, by the chief tenant and heir apparent of the proprietor. The tenant, who obviously has a great incentive to improve the farm, aims to increase beef production. Large shelterbelts-cum-production blocks are planned on a SW-NE ridge (NT 0762—NT 0862). Each site will be 15 - 18 chains long by 3½ - 4 chains wide, i.e. it will bear 5 - 7 acres of trees, mainly conifers. Enclosure of rough grazings will accompany the planting programme, which will result in zigzag patterns of belts, normal or parallel to the prevailing winds.

ii) Sheep

a) Unit 9 (V, O, a). On certain of the seven old sites near the steading underplanting and replanting (one, NT 085589, with increase

in width started in 1967). There are five sites in A condition, but these are just the start of a system of belts that will extend to 100 acres in ten years' time. The major intention is to provide close-up shelter for sheep against snowstorms, hence the scheme of planting, drawn up with the help of S.W.O.A., takes into account the alignment of the hefts they graze at present. Much of the woodland will be on the lower ground on this farm, at about 1000 ft. O.D. It will have the secondary function of production, but species choice (Sitka spruce and lodgepole pine) was really determined more by edaphic and climatic factors than by any expectation of marketable timber yield. Nevertheless the proprietor had asked for some belts (e.g. the one already planted, NT 079590, six acres on flat, deep, waterlogged peat) to be made three chains wide "while we are about it", instead of the two chains wide as originally planned.

Near the house, where there is already some shelter and the mineral soil is not overlain by peat, amenity has been taken into consideration and many ornamental species, both conifer and broad-leafed trees, are being included. A belt alongside the farm road (NT 082589) is designed as a snowbreak because the proprietor commutes to Edinburgh daily and requires that road to be passable at all seasons.

b) Unit 60 (VI, M, b). The Black-faced sheep on the hirsel on which the belts lie habitually draw down into sheltered fields (e.g. at NT 161629) if storms threaten. At night too, the sheep are found in these fields unless the weather is fine and warm, when they stay on the

hill grazings. Only the ground at one field entrance was fouled and puddled. Elsewhere there was no evidence to suggest that the sheltered ground was receiving excessive use. Therefore there seems to be no justification for the criticism that belts are a hazzard to sheep health by encouraging a build-up of parasites on the soil; careful shepherding has prevented this happening on Unit 60.

iii) Cattle and sheep.

a) Unit 13 (V, M, a). In 1966, two normally oriented, two-chain-wide Sitka spruce belts were established across an extensive peat bog (NT 053593) and (NT 059601). The working manager who is of tenant farming stock and unused to farm forestry, was rather incredulous of the proprietor's plans to use the 7/8 mile of windbreaks as the first stage of improvement of the peat land. He was knocking fencing posts into the shaking surface at the time, but said that eventually it was hoped to divide the ground into paddocks for intensive management of improved quality stock; both cattle and sheep.

b) Unit 51 (VI, O, a). On this unit there are two C condition strips put in by a previous owner, and a one-mile-long Forestry Commission belt in A condition. The C condition sites carry stands of Scots pine planted about 100 years ago. One (NT 128642) is actually the six or eight windward rows on an eight-acre block, the rest of which was felled for timber during the last war, but the leeward part is not to be replanted.

The five-chain wide, 40-acre A condition belt (NT 128633) is on land feued to the Forestry Commission and is being managed for timber. It is also very important for shelter; although only 10 - 15 feet high at the present, it will increase in usefulness with age.[1] In addition to the shelter that the proprietor really wanted when he negotiated for this belt, he receives an annual feu for the ground. His only expense has been part of the cost of fencing, which he would have required anyway for controlling sheep and cattle, which he is starting to manage more intensively.

c) Unit 70 (VIII, 0, a). The 15-year-old L-shaped belt (NT 212608) covers five acres. It is now in A condition and is planted with conifers intended primarily for timber. When the site was clear-felled during the First World War, a tenant is reported to have said that his fields were "quite ruined" by the removal of shelter. This belt was replanted before some of those on the home farm (Unit 71, considered above) because of a greater shelter need and a desire to please the tenant. Although the altitude is 900 ft. at this point, Black-faced X Border-Leicester ewes were lambed in the field SW of the belt in spring 1967. They had been served by a Suffolk tup and good grazing in the lee

---

1. The trees, planted in 1956, are mostly six feet apart. The sides of the belt are of Sitka spruce planted pure (nine rows windward, 13 rows leeward). In the middle, blocks of Sitka spruce alternate in a chequer pattern with blocks of Japanese Larch (36 rows)(9 trees in each block). There was formerly a $2\frac{1}{2}$ chain wide belt down the centre of this site but only the drain and some hedgerow trees remain.

of this belt ensured that their high-grade lambs got off to a good start. The farmer has recently planted a shelterbelt to protect an exposed steading (930', NT 183582) from westerly winds that sweep down a valley between 1600' high hills. He would also like a two-acre block to provide a sheltered spot on hill grazings (e.g. at NT 210610).

From conversation with the farmer during a conducted tour of the modern farm buildings, it was apparent that shelter is very important to his method of increasing output from the farm; but not necessarily shelter provided by belts of trees. Throughout the winter, for instance, he rears beef calves in a large covered building that is divided into hard standing, self-feed silage clamp, calving pen, and rearing pens with slatted floors. Like shelterbelts, this building is a long term investment, but unlike them it was immediately useful for shelter. Nevertheless it is interesting to note that shelterbelts have been planted both as an aid to more effective and efficient use of ground on this relatively small unit, and also to improve amenity.

Shelterbelt Management to Allow Intensive and Flexible Use of Sheltered Fields

On each of four units where there are old-established shelterbelt systems, recent intensification in their respective proprietor's agricultural pursuits has been accompanied by a belt rehabilitation programme. The Forestry Department,[1] University of Edinburgh, has played a not incon-

---

1. Now Forestry and Natural Resources Department.

siderable part in designing belts and/or drawing up Management Plans on three of these units (Nos. 53, 62 and 72). On Unit 35, the renewal of tree planting activity is very recent.

It is significant that on Unit 53 and 72, where the proprietors are absolutely convinced of the value of shelter to the success of their farming enterprises, the units have each been classified in Woodland Management Type a, whereas Unit 62, in Type b, is managed by more traditionally-minded agriculturalists; a confirmation of the writer's impression, gained during excursions with Scottish Peat and Land Development Association and with Royal Scottish Forestry Society Members, that some farmers have yet to be convinced of any positive role trees may have in modern crop and mixed-farming in Lowland Scotland.[1] If there had been no stimulus from foresters and no capital from external sources to offset the cost of belt maintenance it is certain that the belts on Unit 62 would now be in worse condition than they actually are. In the meantime inefficient belt management has been exceedingly wasteful of time and materials.

a) Unit 35 (III, 0, b). A belt on the leeward boundary (NT 025617) was the first shelterbelt site on the property to receive attention. Larch and Scots pine were being planted on a derelict site

---

1. In this connection the results of Marshall's work in East Lothian on crop yields in response to shelter from temporary screens, are expectantly awaited. (Dr. J.K. Marshall worked in the Forestry and Natural Resources Department, University of Edinburgh, under the aegis of A.R.C. during two seasons, 1965 and 1966.)

in the spring of 1966 as "neither sort is much good as a Christmas tree!" and the unit is near the West Calder township. The belt is a boundary maker on this small estate and amenity is considered important. On the day the farm was visited, however, snow was falling and drifting before a stiff NE wind. Under such conditions this belt will be of considerable use for shelter. At present a sheep flock has access to the former policy parks in winter but sheltered fields further from the steading will allow of a more flexible scheme of farm management in future years, for example by using the policy parks to grow grass (for silage), while the sheep graze early grass in sheltered fields further from the steading. The owner of Unit 35, therefore intends to rehabilitate many of the other sites presently in D and E condition on this unit and on his tenant's farm (Unit 40).

b) Unit 53 (VI, 0, a). The shelterbelts are managed so that they will provide shelter in perpetuity to strip-grazed grasslands between 600 and 900 ft. O.D., and any returns as forest produce are incidental. The Management Plan for the 52 acres of shelterbelts and nine acres of other woods was prepared, at the invitation of the (senior) proprietor, by members of the staff of the Forestry Department, University of Edinburgh, in 1956. Now that a second ten-year cycle of management has begun, the effectiveness of regeneration methods can be evaluated. These methods have been applied particularly to those belts on the western sides of the two farms (NT 1464) and around the highest-lying fields to the south (NT 1563). All belts are ring fenced against the

cattle and every precaution is being taken to ensure that the trees grow and flourish. Certain changes in management policy are worthy of notice because those that appeared ideal to foresters have not always turned out to be practical propositions on these farms. The difficulties and the ways they have been surmounted are listed below:

1. Roving hill sheep destroyed most of the young trees in a belt on the south west corner of the property during the severe winter of 1962/63 (NT 152636). The design of the original attempts at rehabilitation was "like a Persian Carpet" (a reference to coloured shapes on an experimental forester's planting map). Gaps have now been replanted in larger groups and using fewer species, notably Sitka spruce, in a second attempt to reform the windward margin. Within the belt, natural regeneration of hardwoods (rowan and birch) has occurred in two clumps, presumably where conditions are less severe due to the presence nearby of larger trees and ungrazed ground vegetation.

2. Roe deer were shot after they had done considerable damage by rubbing the bark off saplings in the mating season (e.g. at NT 152639). Hares are also controlled by shooting.

3. Only small spaces were cleared for regeneration in the past. Root competition and shading are chiefly thought to be responsible for failure of the regeneration groups. Larger areas are now used; for example in the belt being prepared for replanting in spring 1967 (NT 157638), only the wind-firm and deformed marginal trees and stouter deep-rooted internal trees, like Scots pine, were left standing. Root competition

and overshading will thus be minimal, though local shelter is still good.

4. In the old-style, small groups, some original replanting and most of the attempts at beating up were on 18-inch-square turfs. Now that the cleared areas are larger, mechanical turf ploughing is practical. Thus the initial planting is speeded up, better surface drainage is provided, and subsequent maintenance is facilitated.

5. Regeneration rate was formerly regulated by the number of plants that the forester could tend, so only about two acres were planted each year. In 1966, Arboguard spraying apparatus was introduced. As the forester can now clear about two acres of weeds by chemical means in one day, the clearing rate is no longer a limiting factor in the rehabilitation programme.

6. Hardwood planting, especially the "fancy diamonds" of some early species trials, has been abandoned in favour of conifers. The latter are preferred because they grow more quickly, are easier to see among competing vegetation, and are more likely to grow than some hardwoods. One of the proprietors (the son) considers that hardwoods may be introduced in suitable situations once gaps have been closed somewhat by a thicket of conifers.

Other points worthy of notice on Unit 53 are:

1. The only alterations to the original pattern of belts that was established over 150 years ago (Chapter III) are two narrow belts near the upper farm's steading (NT 152646); one of these belts being designed to shelter a row of workers' cottages from the west wind.

2. There are open ditches around many of the shelterbelts. These are kept open and it is intended to deepen some of them to help cut off spring water that wells up within certain fields.

3. On lower ground (e.g. at NT 146645), in beech hedges that were formerly close trimmed, standards have been allowed to grow up at intervals. The resulting irregularity of profile and added height of the barrier will give increased shelter to fields as the standards become small hedgerow trees.

c) Unit 62 (VII, M, b). In the Revised Management Plan, 1963, for the woodlands on this estate,[1] the following objects of management are listed:

"1) The provision in the fullest possible manner of shelter to the lands and buildings on the estate from harmful climatic influences.

2) The production of the maximum amount of forest produce in perpetuity (primarily for consumption on the estate).

3) To preserve and enhance the amenity of the estate for both ornamental and recreational purposes.

4) To provide opportunity for research and education."

The woods are run under the Approved Woodland Scheme of the Forestry Commission, but partly due to the shape and distribution of the woods, partly to the past history of neglect before the centre was established in the

---

1. Edinburgh Centre of Rural Economy. Part is outwith the study area, but Unit 62 is equivalent to the Policy Woods and home farm of a traditional estate. A tenanted farm, Unit 61 is also included in the study area, (Chapter VII). The Management Plans, 1952 and 1963 were prepared by members of staff in the Forestry Department, University of Edinburgh.

early 1950's, and partly to the nature of the present objects of management, the woods do not show a trading profit.

The shelterbelts are still principally in D condition. All are ring fenced[1] however, and regeneration is at the rate of approximately two acres per annum. But rabbits, hares and roe deer have not been ruthlessly controlled and have caused considerable damage to shelterbelts rehabilitated under the first ten-year plan. Hardwoods have suffered most and regeneration groups of the old type (small "Anderson Groups" on D condition sites carrying mature trees) have largely failed because of persistent animal damage and the great difficulty of weeding without damaging some of the irregularly placed and closely planted seedlings.[2] On new and clear-felled sites, and where groups of conifers were used

---

1. Fences paid for by the users of the fields.

2. At one time students from the Forestry Department did part of the field work in their curriculum on this Unit. Although the students were only present for 2-3 weeks in spring and another 2 weeks in summer, work done in planting and weeding during these visits meant an increased number of man-hours spent on estate silviculture without proportional increase in capital expenditure. This is analagous to olden day estate practice, where hardwoods were successfully grown using plentiful (cheap) labour. But the student labour, being seasonal and only temporary meant that these trees did not receive really adequate tending during the course of the year's round work, which was geared to a very much smaller forestry staff.

as nurses between hardwood groups, belts are now in B condition (e.g. 15 year old belts: NT 257645, 2.0 acres; and NT 254637, 1.8 acres). But the nurses have had to be left standing in order to retain the desired stand density on these small sites. Species selection is made according to the particular site and is aimed at approximately 50% oak, 25% elm, ash and sycamore, 10% beech, and other species including conifers 15% in the upper canopy. Regeneration is now being carried out in groups not less than 0.1 acre in extent and in any group only 2 species are planted, one of which may be a nurse species.

d) Unit 72 (VIII, 0, a). The four shelterbelts (5.8 acres) in A condition and another two-acre belt in B condition contribute to this farm's air of well-being (Figure 28). The owner himself attends to the shelterbelts but has sought advice from silviculturalists on planting and maintenance techniques. Thus: regeneration of part of one strip (NT 190586) was effected on a Forestry Commission Officer's advice; and a friend, who works in forestry in the Borders, advises on thinning and marks trees for felling from time to time. A 40 year old, Sitka spruce, belt in A condition (NT 195593) is at present (1967) supplying thinnings to a fencing contractor at Nine Mile Burn. It is also most valuable for shelter, and as the earliest grazing is found near it, ewes with twin lambs are put into the field NE of the belt in spring. The "early bite" is particularly valued after a hard winter.

A ten year old experimental belt (NT 195595) of the Forestry Department, University of Edinburgh, has not done so well as expected. The first serious setback was damage done by hares when there was two

CAP LAW

WEST KIP
1806'

SOUTH BLACK
HILL

BRAIDLAW

FIG. 28. SHEEP & SHELTERBELTS ON UNIT 72

feet of snow cover in the winter of 1962/63; tall geans (Prunus avium) were barked up and had later to be cut right back. A strong growth of cocksfoot, (Dactylis glomerata), itself a possible cause of hurt to the trees, caused the death of oak and ash because field mice ring-barked the saplings beneath the matted grass cover. The plantation originally contained a highly diversified mixture of hardwoods and conifers. Blanks have mostly been filled with conifers for similar reasons to those noted above for Unit 53.

Shelterbelt Management where Amenity is an Important Consideration.

Units 24 and 67 provide examples of belts managed for amenity. Each is associated with a large country house and the absence of steadings indicate that the land has never been an important source of income to the proprietors.

a) Unit 24 (II, M, a). Most of the farm land is let by fields annually for cultivation or grazing. The woods are principally managed for timber, but there is one shelterbelt that was recently planted under contract by S.W.O.A. This A condition belt is on an old site in the lee of a stone wall (NT 048621). It is composed of three rows of Scots pine alternating with three of beech. It was designed with ornamental purposes in mind, but is favourably sited to give shelter.

b) Unit 67 (VII, O, a). There are two belts on the property boundaries. The strip along the northern side is in A condition (NT 235622) and that on the south west in D condition. The former has high amenity value and provides shelter in the spring months; the latter

is superfluous at present because both landscape variety and shelter are provided by tall hedgerow trees on the neighbouring property (Unit 66).

Shelterbelt Management for Special Purposes on Various Types of Farm

The use to which the sheltered land is put is unusual on Units 56 and 79, and belts were established for unusual purposes on Units 65 and 74. However, all the belts are managed on conventional lines.

a) Unit 56 (VI, M, b). The single B condition belt (NT 168648) on the 13 acre holding is specifically designed to shelter fields, dog kennels, and other animal houses from NE winds in spring. In the belt, twenty five year old Scots pine and Norway spruce, though severely suppressed, together with a beech hedge provide a very satisfactory understory to old hardwoods. Trees on neighbouring properties (Units 54 and 55) provide the necessary shelter from prevailing winds.

b) Unit 74 (VII, T, b). New planting is concerned with shelter, but timber and amenity are important.[1] One replanted site helps to keep the east wind off a playing field, (NT 221679), and another elongated wood lies to the west of a rifle range (NT 224677). An unusual function of the woods to the north of the old policy grounds has been that of preventing further encroachment of the built-up area at this point (NT 2268 and NT 2368).

---

1. Ca. 1920, when the Edinburgh Forestry School (later Forestry Department, University of Edinburgh) first opened, students did practical work on this estate.

Recently the northern slopes of the Pentland Hills have been described as an "area of high amenity" (The City and Royal Burgh of Edinburgh Development Plan, 1965, Review Map No. 3). This map indicates also that most of the unit will continue to be part of the City's "Green-belt", even after the proposed Outer Ring Road is constructed. Caborn (1958) noted that the long belt at NT 230680 was of great value for shelter to the neighbouring farm (Unit 78). But this is understandable given that the two units were once part of the same estate and the belt was at the leeward boundary of the policies. This belt is also used as a pedestrian walkway to the hills. At present such use is permissive only. Should some of the recommendations of the Lothians Regional Survey and Plan (1966) be carried out, more access routes with tree planting alongside might be planted to the mutual benefit of the residents of the Lothian conurbation and the farmers around the Pentland Hills. But it would probably be important to have a wide walkway between two parallel belts, to isolate pedestrians from the farmland and to prevent damage to the woodland.[1]

---

1. Depredation by the populace is no modern phenomenon. The Earl of Stair's Factor wrote to him on 19 April 1731, from Culhorn (Wigtownshire) about damage to regenerated oaks and of a desire to fence off a public right of way in these words: "..The bank of Drumrick loch is cleared and there is a great deal of fine oaks on it.. If the country people would but let them grow, it would soon be a fine bank.." "The avenues will be done tomorrow night. I would gladly have that made a road that the people may not tres-pass on the grounds." Graham 1875, II p.182-183.

c) Unit 65 (VII, T, a). This is a farm among the Pentland Hills. It has 47 acres of woods of various ages on it, including one new planting. The 4.4 acre belt in C condition is on land owned by the Water Department, Edinburgh Corporation. When this belt was felled ("most inexpertly, by contract labour on piece rates", about 1952), the farmer felt its loss, but now that larch trees are up once more, he is again making use of the field south of the belt for lambing. This belt (NT 214641) was actually designed to prevent picnicers from sitting too close to a stream that flows into the reservoir, but it effectively shelters that part of the field from east winds sweeping through Glencorse Glen.

d) Unit 74 (VIII, T, b). The A condition site was designed as a snowbreak to prevent the farm road becoming blocked by drifts at a point where it crosses a dry valley parallel to the North Esk Water (NT 196571). Penicuick Estate forestry staff did the planting, but the tenant had to fence the 1.5 acre strip at his own expense. Netting was used to exclude hares.

Plans and Methods for Alterations to the Design of Existing Shelterbelt Systems

Although it is rarely possible to alter old-established systems because of the nature of former fences (banks and ditches) and the presence of tiled under draining in most fields, specific examples of plans for alteration (Unit 51) and methods already being tried (Unit 77) provide a basis for discussion of certain factors involved. Thus:

a) Unit 55 (VI, T, c). The tenant of this farm thought that if the proprietor (who runs Unit 54, c) ever thought of planting trees, two of the E condition sites should not be rehabilitated in their present positions (NT 159645 and NT 163646), as the sites are too close together, and too much shelter would hinder cropping. His farm is in the lee of the well-maintained systems of belts on Units 53 and 58 and he follows a four year rotation: a cereal crop followed by roots and then two years of grass. Indicating the 45-foot-high C condition conifer belt on the leeward boundary of Unit 53, he said that another belt like that could be put across the middle of the field between the present sites, i.e. about 500 yards away from the conifer belt, whereas the two existing sites are about 350 and 750 yards distant, respectively, on a downhill slope. If the existing belt on Unit 53, and the suggested one on Unit 58 were about 50% penetrable and 45 feet high, then theoretically a westerly wind would not reach its unobstructed speed anywhere on the fields on the lee of the belts, though an easterly one would do so because of topography.

Another site (NT 162650) in E condition is well covered by gorse bushes. This locally sheltered area is used by the tenant's cattle as a "maternity unit". He rents 135 acres of fields but pays nothing for the use of 25 acres of shelterbelts and 11 acres of other woods that are inadequately fenced. It is furthermore interesting to note that the proprietor considered the 7.0 acre site at NT 162644 to be an example of ground that had never been reclaimed for agriculture. Maps indicate that it formed an important part of a shelterbelt system established between 1853 and 1898. The fact that it is wider than any other on the property and parallel to topography and the prevailing wind, and that there is a mag-

nificent row of beech trees between it and another mansion house (NT 165644) formerly called Muir Bank - Knox, suggests that it was once planted with conifers for timber. This is confirmed by O.S. maps. It was clear-felled, probably during the First World War, but it was never re-stocked and is now known as "Rowan Strip" from scattered natural regeneration of this species among the heather (Calluna) and other moorland species that have colonised the site.

b) Unit 77 (VIII, 0, b). The young proprietor's father-in-law is connected with an active private forestry company and he has obviously influenced developments on this unit. The A condition belt (NT 224563) shelters the steading from "winds that haven't touched the ground since they left Ireland", and the vegetable and flower gardens have been satisfactorily protected by plastic mesh netting. A narrow site (2.1 acres at NT 223560) has been reclaimed to make a larger field for feed-cropping, principally as grass silage. Yields are noticeably poorer on the newly broken ground which lacks underdraining. Tile drains precluded replanting with width increase on this site, though this policy may be applied elsewhere in an attempt to combine shelter with timber production. The flat ground has encouraged the proprietor to use the Australian type of strained, high tensile steel, wire fence with droppers. He considers its relative cheapness both in materials and in labour costs would merit its wider use on this type of ground, though the conventional stob and galvanized wire fence is preferable on uneven ground.

Plans for Creation and Rehabilitation of Shelterbelt Systems as an Aid to Agricultural Practices.

Only on one of the five units for which there are plans for planting trees for shelter was there mention made of its requirement for crops. But the farmer who wanted belts for this purpose is that one of the five who is least likely to do any planting.

a) Unit 5 (I, 0, a). A high annual turnover of capital on this large unit has enabled the farmer to plough back profits on development schemes. At present he is growing cereals as a cash crop as well as for feeding cattle, but said he would rather concentrate on cattle if he could be sure of the market. Should stock become his main activity, he would improve grasslands and consider rehabilitating certain belts, notably the 4.2 acre one at NT 094657.

The proprietor once tried to interest the Forestry Commission in afforesting a strip of land along a windward march. The belt would have run from their Selm Muir forest up the side of Corston Hill (NT 090634). Unfortunately he was not willing to 'lose to forestry' more than a 75-yard-wide strip of ground (about 14 acres of his rough grazing land). His neighbour (Unit 48) quite understandably did not wish to give up ground for planting on his leeward boundary. Negotiations therefore broke down and this part of Unit 5 remains unsheltered despite an expressed need for shelter.

b) Unit 37 (II, 0, b). There is only one belt in C condition, on this property at present. A younger son of the family that owns Unit 12 (mentioned above) had just taken over this farm in spring 1966, and he

is eager to increase the amount of shelter. He wished that the end-to-wind belt along the crest of the ridge (ST 998603, 2.9 acres of mixed wood in D condition) were his to rehabilitate. The belt belongs to his neighbour (Unit 42, O, c) but as it is fenced only on the neighbour's side, the sheep belonging to Unit 37 have access to the site at present.

c) Unit 49 (V, T, d). The farmhouse on a shoulder of Auchinoon Hill, at 1000 ft. O.D., is fully exposed to S.W. and N.E. winds. The shepherd said that any shelter to the house and elsewhere on this sheep farm would be much appreciated. The farm is part of Dalmahoy Estate and is at least seven miles by road from the old mansion house and the present Estate Office. But it is possible that now planting has begun outwith the policies (on the neighbouring unit, No. 48) as outlined above, it may be extended to this unit also.

d) Unit 57 (VI, O, d). This was once part of Malleny Estate but was sold to the present owner (and former tenant) about 20 years ago. He indicated two field boundaries along which he has often wished that shelterbelts had been planted in the past. He has sometimes considered planting the belts himself but has not done so because he has no one to succeed him on the farm. He suffered serious cereal crop losses in the autumn gales of 1966 and considered that shelter would have helped reduce loss by shaking and flattening. The Malleny Estate Factor, commenting on this statement, said that they had lost crops in fields surrounded by trees in estate policies near South Queensferry, Westlothian. And the tenant of Unit 73 suffered total loss of a barley crop in a field (NT 210587) among the Penicuik policy woods. In the latter case, definitely, and

probably in the former also, the woodland serves as an impenetrable barrier to the wind and such damage is to be expected from wind eddying forcefully in the lee of the trees. Furthermore, pheasants were able to exploit the wind laid crop on Unit 73; they either reached up to peck at the grain, or "trampled it quite flat" before eating it. To use a field in such a situation for cereal cropping is obviously a very risky undertaking.

e) Unit 59 (VI, T, d). On this small farm to the windward of Unit 58, of which estate it forms a part, the tenant pointed out a site (NT 138653) on a river terrace beside the Water of Leith and said that ten years ago he had asked for a shelterbelt to be planted along the margin of his 16 acres of rough grazing. The area (two acres) was to be given up free of rent remission. Nothing has come to date of his request to shelter the haugh land for grazing cattle.

CHAPTER VII
DESCRIPTION OF THE EFFECTS OF VARIOUS FACTORS ON SHELTERBELT CONDITION

A well established shelterbelt in good condition is a complex viable structure. The very fact that any ~~one~~ exists in Scotland is dependent upon the resourcefulness of man in overcoming considerable difficulties in his desire to grow a climax type of vegetation on a small site that previously supported farm crops, natural grasses, or one of several types of moorland plant community. In the study area, it requires five to seven years of careful maintenance to establish a shelterbelt. Thereafter, continuous silvicultural treatment ensures that the trees remain healthy and that the belts continue to fulfil their functions, as detailed in Chapter VI.

Site degradation is usually a gradual process too. After active belt maintenance ceases, it may take several years before small changes in the habitat affect the health of mature, deep-rooted trees and thus render them liable to attack by pathogens. Windthrow of shallow rooted trees like spruce is more dramatic, but is likewise attributable to a lack of adequate maintenance. Where broken fences allow stock to enter a belt, their grazing, trampling and manuring alter ground vegetation and soil structure. Edaphic factors are most easily upset in belts established on non-arable land, particularly if drainage is poor. Adverse climatic factors like gales and snow are most likely to damage unthinned or unhealthy belts. In addition to deterioration in the condition of some sites resulting from neglect, there are a number of other sites in poor condition because they are located near urban and industrial centres.

In the study area, belts have been damaged by the construction of railways, roads, an airfield, a reservoir, and watermains; during the erection of electric transmission and distribution lines and telephone lines; and in the course of mining for oil-shale and coal. War time felling and fire have rendered other sites derelict.

Specific examples are given below of the ways in which these factors have affected or are now affecting the condition of certain representative shelterbelt sites in the study area. Points raised by the owners of these affected sites, together with information from other stated sources, provide the bases for discussions.

The Effect of Economic Factors on Shelterbelt Condition

The size of a unit and the type of farming practiced bear on belt condition, thus:

i) Small farms where cropping is important:

In the past, the tenant farmer was sometimes allowed proportionate remission of rent for ground taken for planting. At other times he had to pay 5% or even 7½% interest on the capital outlaid in improvement. Nowadays shelterbelt sites may neither yield returns to the owner nor help adjacent agriculture, particularly cropping. For example:

a) Unit 21 (II, O, c). This farm has, at present, 103 acres of fields and 5.1 acres of D condition shelterbelts (NT 056623). At some time in the past this windward boundary shelterbelt, which had covered 2.9 acres, was increased in width by addition of a parallel belt, presumably for the production of timber (See below, Linhouse Estate).

The 2.2 acres that constitute this addition are now scheduled for reclamation for crops and pasture. Because this is a very small farm, with relatively good soil, an increase of approximately 2% in the amount of useable land is very important to the present farmer. And, since the 24-ft. high oak coppice and birch scrub on the original site has an almost perfect latticework of branches, the amount of available shelter will not be materially reduced.

b) Unit 61 (VII, T, b). The tenant gave leave to examine a rather derelict system of belts with the proviso, "so long as you're not going to plant any trees." He is mainly interested in growing cereals on 140 acres of land between 600 and 800 feet O.D. His fields are partially enclosed by 10.5 acres of ring fenced, estate shelterbelts and there are a further 3.7 acres of belts along his northern march with Units 62 and 68. The ratio of planted ground to farm area is 1 : 10 approximately, which is higher than average (1 : 16). Furthermore, from the slight wind shaping of trees, it appears that the farm is not very exposed. All the belts are in D condition and are stocked with mature or over-mature hardwoods, with a mixture of old conifers in places. The average height of trees is 50 feet. Shading and root competition seriously lower crop yields near field margins, but no comments were available regarding possible increases in yield in parts of the field away from the trees.

The tenant's attitude, based on experience with these D condition sites, is probably one reason why belt rehabilitation has not yet extended to this part of the estate. It is possible, however, that the farmer

might revise his views if the large, overhanging trees were removed and the sites regenerated in accordance with the objects of the Management Plan (see above, p. 98, Unit 62). The tenant admitted that, prior to the installation of a second fence alongside one belt (NT 234634) he used to be glad of 2.2 extra acres of grazing for which he paid no rent. So it is certain that he would not have fenced off this ground had he been an owner-occupier.

ii) On farms where stock are important:

On these farms derelict sites and sites carrying a few overmature trees contribute to farm economy in various ways. But they almost invariably do so at the expense of (further) deterioration in site condition.

a) Unit 1 (I, O, a). When Kaimes Wood (NT 126662) was replanted about 5 years ago, a tenant lost his spring-time holding ground. Previously not only were his cattle able to obtain roughage to supplement their diet of new grass, but also by putting them there for part of the day he prevented them from poaching adjacent fields while the ground was still wet.

b) Unit 48 (I, T, a).[1] A thirty-five yard wide D condition belt at Dalmahoy (NT 135680) was being used to paddock black hill cattle in wintertime. In February, 1967, while the cows were being fed from a

---

1. The classification applies only to the upland farm. Had Dalmahoy been included, the tenant would have been in Woodland Management Type c, not Type a. (See Chapter VI, p. 89)

Land Rover, and their calves tended to in this relatively convenient spot, the field to leeward was being ploughed for the next feed crop. The ground within the belt was poached to a depth of about 6 inches by the constant trampling of the cattle and the passage of the transport vehicle. Sycamore had been barked for food and many trees bore evidence of recent hoof damage to surface roots.[1]

Another tenant considered that grazing had effected a considerable improvement within an adjacent part of these old policy plantings. Since about 1925, he has rented a single 20 acre field (NT 138678) and his dairy cattle have access to all the ground under the belts of trees. The cows are only in the field from May to September, as the weather allows. Although access is limited, the animals have suppressed all the understory shrubs (mainly rhododendron and blackberry) which are found in ring-fenced belts nearby. Grass now grows beneath the trees. Besides the valuable extra grazing, two further benefits to the cows from these old trees are: shade on hot days; and protection from summer rainstorms. In comparison with this, some increase in wind velocity beneath the canopy is of negligible importance. However, it must be stressed that these

---

1. There has already been considerable expenditure on farm buildings and feed silos. As an alternative to buildings, use of woods for wintering is common practice in parts of Scotland, but to use them as a means of increasing carrying capacity usually results in overstocking of the forested ground, as has occurred here. (Borissow, 1963).

are large, well-drained shelterbelt sites and access is limited to a few hours a day, so the trees (mainly hardwoods) have not been materially damaged (c.f. the "stomp and shade" lots, of Read, 1957).

c) Unit 2 (I, O, c). The heavy Friesian cows kept on this dairy farm have unlimited access to all belts. They are outwintered[1] in fields furthest from the house where exposure is severe. They were seen crowded against the dry stone march dyke on many occasions, and only a few trees on two sites have survived this treatment (5.7 acres E condition, NT 103626). In another belt, root erosion is severe because the site (D condition, NT 102632) is on a steep slope.[2] A sycamore tree was stripped of all its bark to a height of 6 feet during a particularly cold

---

1. This unit lies alongside the Edinburgh-Lanark road. The owner appears to be known throughout the west lobe of the study area for his "rough" farming methods.

2. About half of 3.3 acres of oblique shelterbelts are referred to in "Report in the Process of Division of the Commonty of Calder Cleir, 1807" in these terms: 'The encroachment made by Mr.Swanston...he has emparked it with his lands.., built a wall and straighted the march of the common' And, in the "Scheme of Division", with reference to its location on a plan prepared by Mr.Bauchop the Surveyor, the point was settled as follows: '..parcel No.13. Estimated at £30.6.3. Stg., being 25 years purchace.' (S.R.O., E.P. Court of Session 1840, March, No. 1992; and R.H. Plan 533 "Plan of Calder Cleir Commonty".

spell in February 1966 (NT 109638) and the root buttresses of other trees near the road were damaged by the cows' hoofs as they congregated by the gate.

A further example of the slight importance attached to trees on this unit is that formerly a march belt (NT 106638) was shared but 2.1 acres of D condition woodland were exchanged for a fence on the field side.

Effects of Changes of Ownership on Shelterbelt Condition

Historical data prove that the majority of belts were established around policy grounds and on tenanted farms belonging to heritable estates. The remainder were put in on the farms associated with the country residences of successful business men. This pattern of development has been shown (Chapter VI) to be true at the present time also.

Where owner-occupiers now run farms that were formerly tenanted, in Zones II and IV, D and E condition sites are particularly abundant. Little is known for certain about changes of ownership in Zone II, (but see below, section on Railways). In Zone IV, Baads Estate was broken up in 1947. Sitting tenants bought the farm units and have since done little to the belts. Only on Unit 37 (0, b) is there any liklihood of renewed shelterbelt maintenance. This unit has recently changed hands again and it is obvious that lack of knowledge about woodland maintenance is a reason why the tenants-become-owners of the other six farms have, in general, failed to maintain their belts (Home, 1921).

When due consideration is given to the adverse locality factors that certain of the Baads belts were designed to overcome (Chapter V, p. 50) it is surprising to find that shelterbelt trees have survived there

as long as they have done. There are two E condition sites on the farm, but they were already more or less derelict when the tenant bought this unit. Change of ownership is only a minor detail in the chain of events that have affected these two belts (Table 25).

Table 25 Events Leading to the Destruction of Two Belts on Unit 40

Date	Event	Evidence and Remarks
Between 1835 and 1853	Sites established a) 50x wide 5.1 acres (NT 008601) b) 60x wide 6.0 acres (NT 010589) Planted mainly with larch and Scots pine.	Baads MSS (1835). Belts first shown on O.S. map 1853. Drains alongside belt to divert water from blanket bog on hill ground.
1857	A few hardwoods introduced in places on Site a.	Ring count on oak stump, 107 years (cut 1964).
1894	Major part of Site a "blown down" and replanted with Scots pine.	MS addition to Baads Estate Plan: ring count on Scots pine stump, 70 years (cut 1964).
ca. 1935	Site a; Extensive damage by fire which spread to the pole stand from the heather moor south of it.	Farmer's experience. Prior to this, stand had been "quite dark inside and the ground a carpet of pine needles" (possibly inadequately thinned).
Early 1940's	Wartime felling on Site b. Rendered derelict.	Farmer's experience. Horses used in extraction. Trees possibly those of original planting.
Late 1940's	Windblow on part of Site a.	Farmer's experience. He attributed this to the lack of maintenance of drains by estate forestry staff.
1964	Felling at SE corner of site a for a transmission tower.	Field survey - ring counts on Scots pine and Oak stumps.
1966	Both sites in E condition	Field survey.

The owner of Unit 41 (b) and his family, which is rather a large labour force for this 350 acre unit, have cleared all moribund trees from the 6-acre D condition mixed belt (NT 004608) near the steading, and spoke highly of the value to lambing of shelter from a one-chain-wide conifer belt (NT 028607, 1.6 acres).

A former owner of Unit 35 (III, 0, b) is partially responsible for the appalling condition of many of the sites. Granted that certain sites are derelict because of age and faulty species choice, for example, a few oaks about 20 feet high are all that remain on a peaty site (NT 029-612, E condition, 2.8 acres. One stump, cut in 1964 for an electricity transmission tower was 8 inches in diameter and a ring count showed it was 144 years old, i.e. planted in 1820). Elsewhere hardwoods had grown better, but were felled to raise ready cash. The proprietor used to call at the sawmill in Kirknewton occasionally in the 1930's and 1940's requesting an advance of £40 or £50 and invite the sawmiller to "come and cut what you want" (Mr. Archie Marshall, Senior, Sawmiller and Fencing Contractor, Kirknewton, Personal Communication).

The present proprietor has cut out some beeches that had spread outwards, since relieved of competition. One had subsequently blown down. It had heart-rot in the lower part of the bole and a ring count of 120 about five feet above ground level indicated that this tree was about as old as the oak (belt at NT 024618). Such trees would have been better felled a long time ago and it will be many years before the present proprietor's belt rehabilitation programme can redress the cumulative effect of his predecessor's neglect.

The Effect of Changing Agricultural Practices on Shelterbelt Condition

Much of the ground that was first enclosed and sheltered so that farmland could be rested from excessive cropping and used to rear beef cattle instead, has subsequently been used for crop production again. This reversion to crop husbandry has had various repercussions on belt condition: originally belts were always protected from stock by a strong hedge with a substantial ditch in front of it. Even for crops the hedge was still maintained under the tenant's terms of lease. However, it is evident that many outfall ditches have been tiled and others filled with stones and soil. In this way the headlands were made easier to plough[1] and field area was effectively increased. But whereas ditches were frequently scoured, thus preventing roots from encroaching on the fields, tiles carrying water, and the fresh soil along the outside of the shelterbelt would encourage root development in this direction.

Tile drains blocked by roots were mentioned by the proprietor of Unit 54 (VI, c), and his tenant on Unit 55 (VI, c). In the former instance the obstruction was caused by poplar roots from a suburban back garden (NT 160660) and in the latter by roots of a five-foot hawthorn hedge not associated with a belt, but dividing arable fields (NT 159645). The principle almost certainly applies elsewhere in connection with

---

1. By horse or ox-drawn ploughs, originally. Though manual labour, mostly by women and children, was used well into the Scottish 'Shelterbelt Era' for cultivation of field crops.

shelterbelt trees and more especially with beech and hawthorn hedge plants that have not been kept trimmed since the introduction of wire fences. Some such hedges have gradually grown into large trees, for example: on Unit 60 (V, M, b), there was a D condition belt only 7 yards wide (NT 166633). In it there was a 60 ft. beech with branches that extended eleven yards out into the field from the leeward fence line, and yet among the grass, Rumex sp. plants indicated that crops had recently been grown on that field. On Unit 33 (III, O, c) all the overgrown hedgerow beeches have recently been felled along the leeward margin of a D condition belt (NT 038631) because their leaning trunks and overhanging branches hindered cropping.

On Unit 58, (VI, M, a) an unlopped branch damaged a combine harvester on one occasion. In this case and in most other cases where shelterbelts in poor condition were said to hinder agriculture, the objections themselves were valid enough, but the basic cause was invariably incompetance or inefficiency in one or more spheres of farm management. Nevertheless, however harshly his belts were being treated from the silviculturalist's point of view, no Type c farmer said that he wished all the trees were removed from a shelterbelt site. Obviously some shelter is better than none at all.

The Effect of Development in Communications on Shelterbelt Condition

Roads, railways and an airfield have each affected certain shelterbelt sites in the study area, thus:

i) Roads: To date roads have had little direct influence on

shelterbelts; the effects they have are nearly all indirect:

a) Unit 71 (VIII, 0, a). The single example of direct destruction of part of a site resulted when the high road from Penicuik to Biggar was rerouted some time between 1828 and 1853. The new road cut through a belt that had formerly terminated on the old turnpike road at NT 198599. 1.3 acres were thus isolated from the rest of this windward boundary site. Both parts are in D condition but that west of the new road, to which direct access could not be had via the walkways within the woods,[1] has not received the same amount of tending, judging by sparser distribution of stems and absence of conifers.

b) There are two examples of disused throughfares becoming shelterbelt sites in Zone I. On Unit I (0, a), there is a D condition site alongside the windward boundary wall[2] (NT 105662). It is only ten yards wide (1.8 acres) and carries assorted broadleafed trees and shrubs.

---

1. In a grid-system of plantations, the ring-fences are, strictly, round each field, not each shelterbelt; internal fences are uncommon, so the belts provide useful pedestrian throughfares, e.g. for the estate forestry staff on routine maintenance work. c.f. Dalmahoy policies (Ch.IV) where a network of roads and avenues was incorporated when the belt system was established.

2. Boundary with Unit 5. The road would only have been a track when the wall was built and the planted site would effectively prevent trespass on the NE side. Now that the road is not used the owner of Unit 5 considers he should have half its area from the belt site to NT 101669.

There is a 4.2 acre C condition site 30 yards wide alongside it, planted with Scots pine, which has effectively isolated the former site from the field. No information was available on the date the road ceased to be used regularly, but it is probably within this century. The old, compacted road surface is probably one reason why the self-sown trees have not grown well.

The second example of a road-become-shelterbelt site is rather more interesting. There used to be an access route to Calder Cleir Commonty[1] from East Calder village, but by 1898 the belt site at NT 084-652 had been established. It lies between the dry stone dykes that had been built to confine drovers' cattle when they used this route to the south via Cauld Stane Slap over the Pentland Hills (Haldane, 1952). The Scots pines that occupy ~~that occupy~~ the 2.8 acre D condition site of variable width, have only grown to a height of 25 feet. Windshaping indicates that exposure is one reason the trees have not done well, but another reason is that the drove route passed over a ridge crest at this point so there is probably little soil, and that of poor quality, for the trees to root in.

ii) Railways: In 1845, the Caledonian Railway Company's Edinburgh to Carstairs line is shown superimposed on the existing farm shelterbelt systems (Fowler's map, based on Sharp et. al., 1828). In the lower-lying

---

1. Details of the division of the commonty are given in MSS: S.R.O., E.P. Court of Session 1840, March, No. 1992.

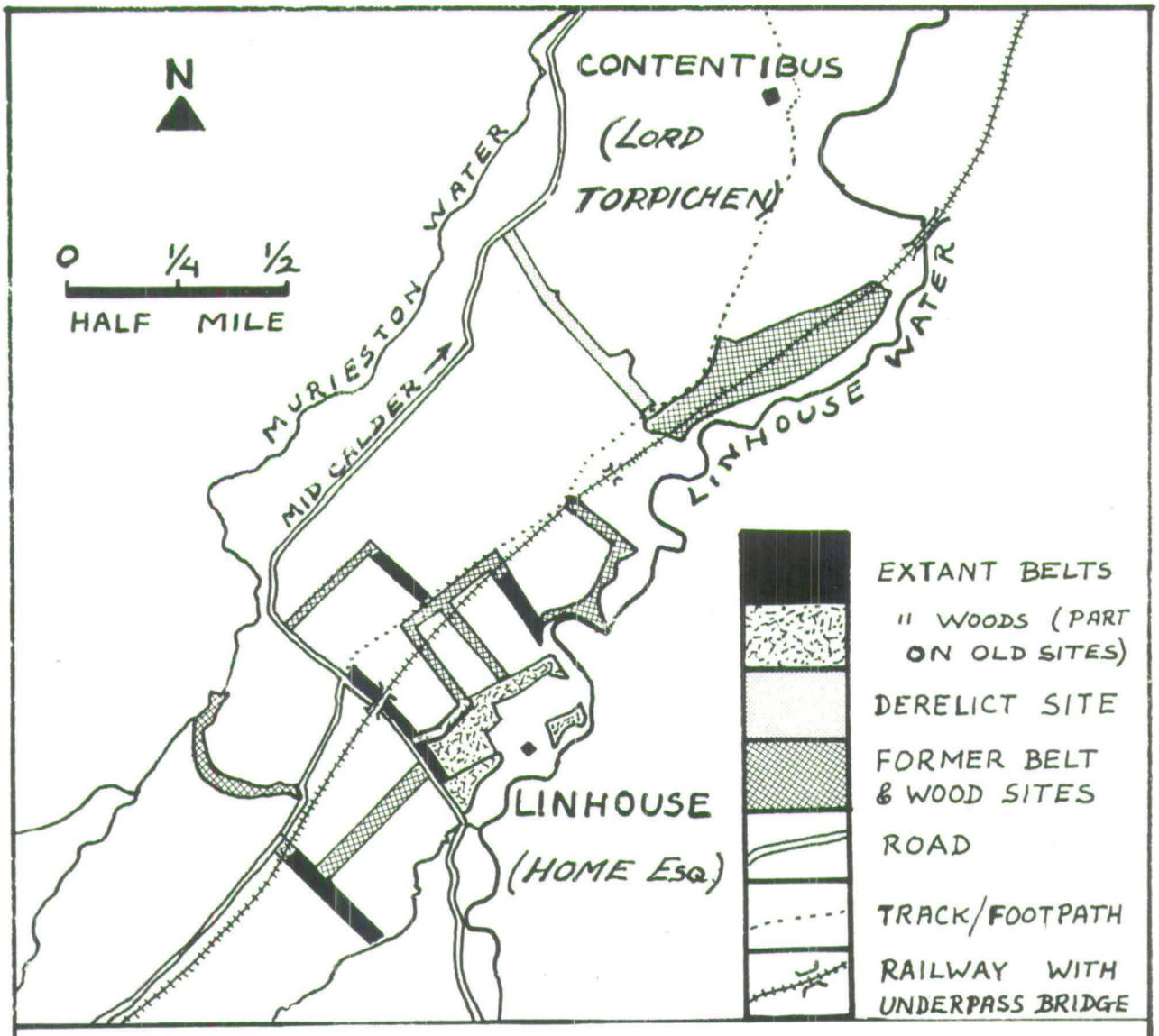


FIGURE 29.

THE PATTERN OF BELTS IN PART OF ZONE II IN 1828, BEFORE THE RAILWAY WAS BUILT & AT PRESENT

part of Zone II (Figure 29), the line affected belts and other woods that were all established prior to 1812 (Knox's map). The most serious consequence was almost certainly that railway cuttings and embankments isolated parts of the Linhouse Estate shelterbelt system from the policy woods; the only access routes being under the bridges $\frac{3}{4}$ mile apart at NT 057631 and NT 065640. Belt management probably slowed down partially because of difficulty of access and partially because the acreage remaining for timber production after physical destruction of parts of the system, may have been insufficient to make forestry worth retaining as an estate enterprise. This theory is supported by the disappearance of all the sites that were parallel to the wind, while only five normally oriented sites have survived, are now in D condition, and are still valued for the shelter they provide (e.g. on Unit 21, mentioned above in Chapter VI). Similarly the long, B condition site (NT 065645, 8 acres) was clearfelled before 1898. It had been a boundary marker for Lord Torphichen's land (Knox's map) and its dereliction followed the earlier (pre-1853) deforestation of the large wood alongside Linhouse Water.

iii) Airfield: The Second World War led to the direct loss of 230 acres of farm land including 25 acres of shelterbelts. It had belonged to the proprietor of Unit 1, but is not included in the study area. Certain production woods and wide shelterbelt sites still on Unit 1 also suffered, thus assorted buildings now occupy part of Edgehead wood[1] and two normally

---

1. The proprietor said some excellent oak was selectively felled during the Second World War in this wood and adjoining boundary shelterbelts. The timber was used for the construction of Motor Torpedo Boats.

oriented, E condition belt sites (NT 113653, 3 acres; and NT 116653, 6 acres) and to the north of the airfield, two swathes were cut through a 6.6 acre site (NT 120661) for flight paths to the landing strips. The two patches have subsequently been regenerated, but the loss of shelterbelt acreage to buildings has not been made good. A subsidiary cause of dereliction of two sites on the adjoining farm (Unit 3; I, O, b) was their use for Nissen huts for airforce personnel. The concrete bases still occupy spaces in D condition belts where trees could be growing at NT 115645 and NT 115647.

The airfield was never used for flying, the railways are unlikely to require more land, but road extensions and improvements are likely to continue to damage shelter belts, for instance: an M-class ring road is scheduled to skirt the Livingston New Town Designated Area (Lothians Regional Survey and Plan, 1966). A number of affected farms in Zone II are to be bought by the Midlothian County Council for use as industrial estates, but Units 31 and 32 (the former Westfield Estate) are likely to lose several shelterbelts during its construction. As dereliction of belt sites is already far advanced in this area (NT 0463) and both units are small, this development will not have the same far-reaching consequences that the railways had in the nineteenth century.

Fly-tipping in roadside belts, because they are near centres of population will probably continue so long as shelterbelts look like disused scrub-land.[1] e.g. motor-car tyres in D condition belt at NT 034623.

---

1. See footnote p. 125

A bag of cement dumped in a drain beside another D condition belt caused some windthrow due to waterlogging (NT 165643). Burning cigarette ends thoughtlessly discarded from vehicles are another hazzard: a recently planted, 8 acre woodland strip (NT 203592) on the windward boundary of Unit 71 was severely damaged by fire on a windy night "about two years ago" (1964). The blaze was attributed to this cause.

The Effect of Public Utility Services on Shelterbelt Condition

Conduits and conductors for each of the public utility services, water, gas, and electricity, have cut across the study area. In various places their installation has been either a direct or a contributory factor in the dereliction of certain shelterbelt sites. Like the damage due to those factors dealt with above, reservoirs, mains pipe lines, overhead cables and wires, are unusual agencies of destruction, and the very fact that they have affected shelterbelts at all is yet another expression of the proximity of urban centres. The effect of public utilities may be dramatic and sudden, as when trees have to be felled to allow their passage; or gradual and insidious, because some ecological or economic balance has been upset. Only where belt management is active has the public authorities responsible for a particular service had to outlay capital in compensation for damage done to shelterbelts on the scale the

---

1. (see p.124) Even farmers in whatever Woodland Management Type they are classified, are likely to treat certain parts of belts as suitable sites for rubbish dumps (Type a, NT 207595); a dung heap (Type c, NT 163647); a tip for stones (NT 140685, outwith s.a. unclassified) or analagous purposes.

Caledonian Railway Company had to do when they cut through thriving plantations a hundred years ago. And in each case where really adequate compensation has been paid, the proprietor or estate manager is possessed on considerable business acumen. The effects of the services concerned are:

i) Reservoir and watermains.

The large catchment areas of the Pentland Hills and other high ground in the western lobe of the study area led to reservoir construction, for town water supply and for stream compensation,[1] on several suitable upland sites. Nearly all these are at a distance from shelterbelt systems; only on Unit 60 has any reservoir adversely affected shelterbelts. In this case approximately two acres of belt site were submerged by extension of the Thriepmuir Reservoir in the mid nineteenth century, and 1.2 acres of a windward belt (NT 158632) on the boundary of these old policy parks is in E condition as a result of waterlogging and subsequent wind throw.

Reservoirs have had a very beneficial effect on certain farms where land was given up by an estate on rigidly prescribed terms. Thus, with regard to Roseberry Reservoir (? NT 3056, ca. 1880), the following was recorded:

---

1. Stream compensation was most necessary in the nineteenth century, especially in summer, because springs had been tapped for water supply. The stored winter rainfall was used to drive water wheels and for maintaining the level of the Union Canal, by metred release at specified times into the stream courses.

> "The Water Company to build a five foot dry stone dyke on the march of the lands they take and to plant all the land between the dyke and their reservoir. This will prevent the stock from going down into the reservoir and being drowned and will give fine safe shelter and will greatly improve the Estate both for look and occupation. It will provide...earlier grass and shelter.../and/ ... lesten the risk of stock being drowned... during storms." [1]

It was the Earl of Morton's factor at Dalmahoy who arbitrated in this case and it is likely that he or his successor also negotiated for planting in connection with Harlaw Reservoir (NT 181649) on Malleny Estate and also with Morton Reservoir on his laird's property (NT 075635). None of these plantingsshas been included in the shelterbelt survey, though they have many similar roles both in providing shelter and fencing off dangerous low ground.[2] In the study area, the only shelterbelt associated with a reservoir is the B condition site designed to keep picnicers from a supply stream (NT 215641) but is most useful during lambing to the tenant of Unit 65 (see above, Chapter VI).

Physical damage to shelterbelts by watermains connected with Livingston New Town is inconsiderable at first sight. Thus in spring 1966, only a few trees were cut down in two D condition belts near the road on Unit 35 (NT 022613) and (NT 024615), yet many roots of standing trees must have been cut. This will also apply where the pipes were laid close up against roadside hedgerows (e.g. between Units 17 and 18, from

---

1. S.R.O., GD 150, Volumes of Estate Reports and Farm Valuations 1863-1880. Vol. 13 (1878-1880), p. 95.

2. Cattle may be excluded from parts of hill farms where there are sheep drains for channeling water to a reservoir, e.g. on Unit 85.

NT 057640 to NT 060645). It may take years before the trees exhibit any effects; whether by better growth following root pruning and provision of new rooting space, or by death following pathogenic attack, or even by windthrow. If the shelterbelt trees grow well then the canopy gap should close but the gap at trunk level will probably remain open over where the water main lies buried.[1]

The proprietor of Unit 35 pointed out the problem of interference with underdraining in certain fields (notably that in the lee of an E condition windward boundary belt at NT 031620). He said that mole drains which had been functioning in the clay soil for 30 years, had been affected. Small bore plastic draining pipes had been laid in various places, but the Water Department would only undertake to uphold them for one year. In spring 1966, the end of a leeward boundary belt (NT 045629) in E condition and parts of adjacent fields on Units 31 and 36 were badly waterlogged along the line of the new watermain. This had apparently occurred because the pipeline lay between the fields and the original outfall drains alongside the farms' road of access. Had the latter belt site carried trees, there would have been a real danger of local windthrow because of the excessive wetness of the soil.

ii) Gas Mains.

Similar damage, as that found to be due to water mains could arise from gas mains laid underground. But the only sites that had been affected were on well drained ground on the down hill side of belt on Unit 86.

---

1. Data available for a Forestry Commission wood (NT 056584) indicates that a 16 ft. strip must not be planted with trees along a watermain. Shrubs may be permitted.

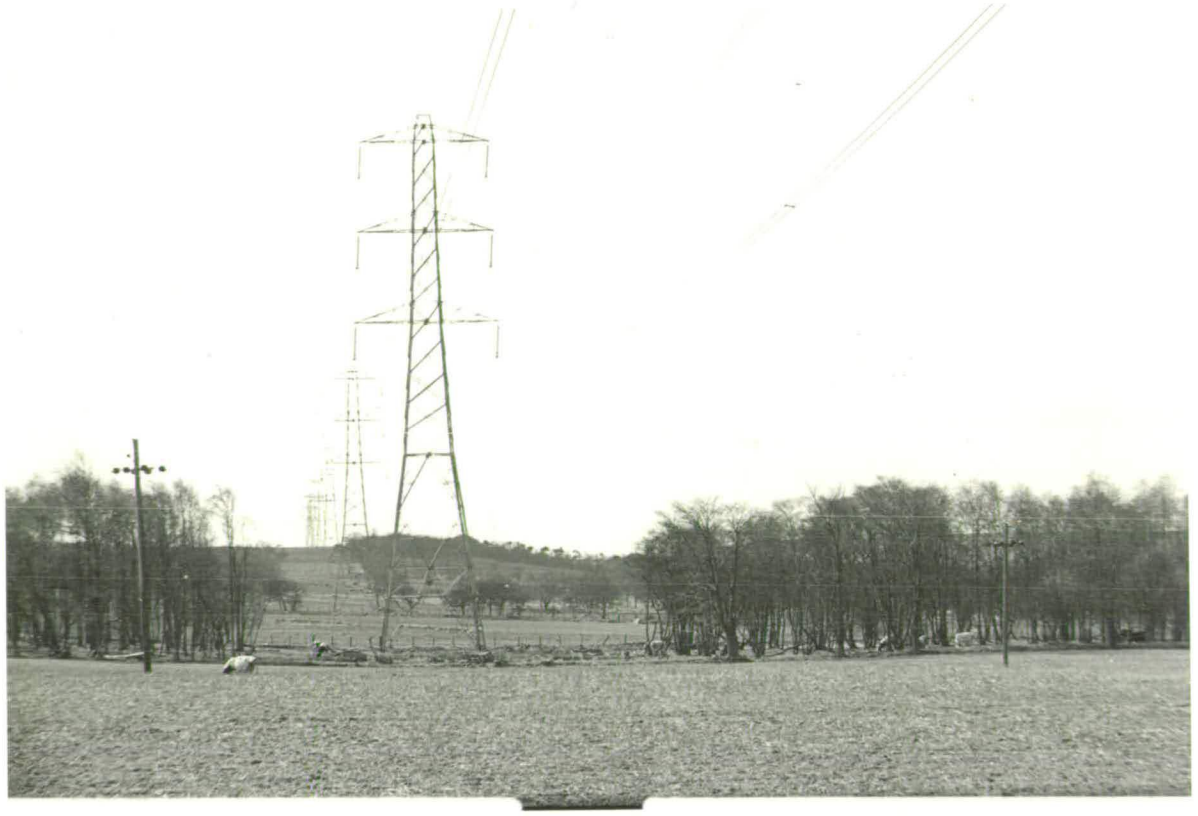
Gaps about ten feet wide had been cut through the points where normally oriented D condition belts joined this belt (at NT 175667 and 177668, respectively). There was some evidence that windthrow had widened the gap on the former, more exposed site.

iii) Electricity transmission and distribution lines.

A 275 kV. transmission line runs the full length of the western lobe of the study area from ST 974596 to NT 248674, where it skirts the suburbs of Edinburgh. It crosses two dozen units and its irregular course was determined after wayleave and compensation had been negotiated with each of the proprietors and with certain tenant farmers. The location of each metal tower was determined in accordance with engineering principles, but also with the concurrence of the farmers. On small farms in Zones II and III where the belts are already in poor condition, it was not surprising to find that the farmers considered preferable the further destruction of a belt site to having a tower in one of their small fields. The Electricity Board also prefer to use shelterbelt sites (in poor condition) for these towers because both compensation and annual rent for non-arable ground so occupied are less than if arable land is used.

In Zone III, where the route passes down the length of a SW-NE ridge, certain sites on Units 26, 35 and 39 have been particularly badly affected (Figure 30). It was necessary to cut a gap about 36 yards wide through each belt. A swath of this dimension along a site on the ridge crest (NT 021605) has rendered it derelict, though it would otherwise have been in D condition (stump evidence) like most of the other sites

Three miles of 275 kV line - from NT011597 (910') to NT034616 (700') - telephoto picture.



Part of D condition boundary belt of Unit 26 (NT031615). Oak coppice & birch. Unlimited stock entry (cereal crop stubble only in field). Single fence on march. Rems. of hedge bank & ditch at field margin.

FIG. 30. ELECTRICITY TRANSMISSION TOWERS IN SHELTERBELTS IN PART OF ZONE III

are at present.[1]

Those proprietors classified in Woodland Management Type a have a very different attitude to transmission lines. In the case of Unit 12, the Electricity Board were denied wayleave. This accounts for the northward course of the transmission line across Zones III and II. In Zone VI however, rather than inflict their neighbours with the inconvenience of the power line the proprietors on Unit 53 acquiesced to the Board's request and granted wayleave upon strict terms of agreement. With the help of S.W.O.A. officials, claims were submitted for the following, in respect of damage to 2.1 acres of shelterbelts and other woods on three sites:

a.	Felling compensation	Devastation value of growing stock (almost mature). Loss due to premature felling of immature woodland. Loss due to clearance of recent planting.
b.	Replanting reimbursement	Cost of establishment of immature woodland. Loss due to replacement of high shelter with low shelter.[2]
c.	Sterilization payment	Compensation for land sterilized by tower plinths.

In addition to a clause for possible future claims should wind damage occur alongside the newly felled sites, the Board agreed to entertain a claim for loss of shelter to the fields. A valuer set the sum

---

1. The belt forms the stem of a T-shaped plantation that had been established presumably for amenity before 1812 and prior to the construction of the neat grid of plantation on this estate. (Additional evidence of amenity planting, post 1828, is given in S.R.O., R.H. Plan 726).

2. See footnote 2, p. 131.

for permanent loss of shelter at £1,240. The Board eventually paid slightly less than half this amount and called it the equivalent of "a general sum for further disturbance". They would neither acknowledge perpetual shelter to have such a high value nor create a precedent by paying specifically for such a nebulous concept as "shelter effect".

Similarly, the Factor of Malleny Estate produced figures of the compensation paid to his laird in respect of damage to production woodland and shelterbelts. In making the valuation, a belt that was important for shelter was treated differently from another where shelter was not a very important function. For this estate also there was a windblow clause. Under it, the factor was to make a claim because of gale damage to Norway spruce at NT 189663 during 1965-66 and 1966-67 winters.

Tree felling in connection with Electricity Board installations[1] is kept to a minimum. Supply lines that follow fences and hedgerows need only to be kept clear of branches that could fall on the cables. This is no problem in Scotland because of the slow growth of trees in hedgerows (c.f. article by N. Harris in "Electrical Times" 29 September 1966 concerning line maintenance in England). For new 33 kV. distribution mains that traverse shelterbelts it is necessary to clear all trees

---

2. (see p. 130) This refers to the possibility of growing a low crop under the conductors but allows for the frequent refelling and regeneration that will be required if the trees are not to interfere with them. It does not refer to shelter effect.

1. Pers. Comm. Mains Engineer, S.S.E.B., Stirling Area, Bathgate, W.Lothian.

CORSTON HILL

AUCHINOON HILL
1029'

Part of D condition belt of mixed Sh. composition - (NT 049620)

FIG. 31. 60 YD. - WIDE GAP IN A SHELTERBELT FOR ELECTRICITY TRANSMISSION TOWER & DISTRIBUTION LINE POLE

that could fall across the lines if they were to blow down, which is obviously most necessary in spruce stands, but is also practiced in all old belts as a precautionary measure. Thus at NT 015609, there was a 16-yard wide gap through a 30 ft. high broadleaf stand in D condition (Unit 39). Gaps for the recently installed 275 kV. lines have been found as narrow as 36 yards and as wide as 60 yards (NT 032614 on Unit 26 and NT 049620 on Unit 23, Figure 31). The area of ground cleared is influenced by the mechanics of erecting the tower and manoeuvering the conductors into position. Most of it can subsequently be replanted with trees but this has only happened where the proprietor is so inclined e.g. Unit 53 where Norway spruce has already been planted in a leeward boundary site (NT 156645) that is severely exposed in spring time. Groups of a variety of species have been established on a less exposed site (NT 153644).

The proprietor of Unit 17 said that he deplored the way public bodies were able to devastate woodland with importunity when proprietors in the designated area of Livingston New Town were prevented under the terms of a Tree Preservation Order,[1] that had been served upon them from

---

1. Midlothian County Council, Tree Preservation Order No. 2, 23 April 1965. In a statement giving their reasons for making the order, the council wrote: "The designated area..of Livingston New Town..contains many attractive woods and shelter belts and Forestry Commission Plantations ..this tree coverage is vital to the present character of the site, is essential for protection against wind, and forms an important enclosure and screening of various areas suitable for early development". This advice originated in the "Background Notes" prepared by the Scottish Development Department.

effective maintenance of mature woodland. He quoted an instance of wanton destruction, three hedgerow oaks that might have been felled for a telephone line. When he raised objections, the men found a satisfactory route that required the removal of only one or two branches.

Regarding the Tree Preservation Order itself, he remarked that its strictures were such that he had almost lost interest in his amenity woods following a year of unsuccessful attempts to obtain permission to remove certain heavy limbs from ageing ornamental hardwoods.[1]

---

1. The desire to retain all old trees has led the Livingston Development Corporation to include strict penalty clauses in all contracts for constructional work; ca £50 is payable for physical damage to a tree. In 1965 there was a scheme for the rehabilitation of old belts at 15 acres/annum for 15 years, and establishment of 10 acres of new belts per year for ten years. Unfortunately regeneration methods then in use seemed doomed to failure, e.g. underplanting in a beech strip (NT 055675) without clearing any gap; even though shade tolerant species were used, evidence from Units 53 and 62 suggests that adequate light and absence of root competition are essential for survival.
(Personal Communication, Mr. Drummond, L.D.C. and field observations).

The Effects of Mining for Oil Shale and Coal on Shelterbelt Condition

The boundary of the study area was chosen so as to exclude land that was largely given over to non-agricultural uses. On certain units, however, mining for oil shale and coal has directly or indirectly affected a few belt sites. Belts on Unit 35 (III, M, c) have been rendered derelict or damaged as follows:

A mineral railway obliterated a site at NT 032634. Buildings belonging to the Scottish Oil Company in a field resulted in neglect of 0.7 acres of narrow belts to north and east of it. These are now in E condition (NT 033628), as are two sites near the old pit head (NT 028621 and NT 030623). Other woods in the vicinity are also rather neglected. Subsidence has resulted in waterlogging of part of a site beside the driveway to the mansion (NT 028628), but maintenance of drains and felling of dead trees has been carried out in the interests of amenity, which has evidently always been considered important near the mansion on this estate, whatever the fortunes of belts outwith the policies. Thus in the main approach to the house, built about 1770, there are some magnificent trees in an avenue oriented parallel to prevailing winds. One elm stump on this D condition site (NT 033635) provided the highest ring count of any in the study area; 183 years, i.e. planted about 1783. An oak in the belt damaged by subsidence proved to be approximately 170 years old.

A coal bing (spoil heap) on Unit 42 (IV, O, c) has obliterated part of a belt at NT 004611 and because the pithead workings occupy most of a field near the steading, the condition of the Z-shaped belt (ST 999-608) to windward of the field has been allowed to deteriorate and is now in E condition.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

This Report on the present condition of shelterbelts on farms in the vicinity of the Pentland Hills, in Midlothian, was prepared from:

(a) information on the origin of, reasons for and methods of shelterbelt construction and maintenance

(b) data collected during a field survey of shelterbelt sites

(c) information provided by the farmers, obtained during interviews with interested parties, and during excursions with foresters and others interested in production from the land

1) From historical evidence, it appears that shelterbelts as such were not introduced into the lowlands of Scotland, but that they were the product of a favourable conjuncture of tree planting in strips and avenues for ornament, and the construction of hedge fences for enclosure in the early years of the eighteenth century. It was then that numbers of young, well-educated Scotsmen, who had gained knowledge of these matters in England and on the Continent of Europe, returned to Scotland. Some of these gentlemen held well-paid and influential governmental posts, and others amassed small fortunes by trading or working in the professions. They were stimulated to invest this money

in the land through membership of The Society of Improvers in the Knowledge of Agriculture in Scotland.

In the years between the Jacobite Rebellions, more than two hundred years before mechanisation of agriculture, plentiful and relatively cheap labour made it possible for the lairds to implement their improvement schemes.

2) On low ground, where soils had been seriously impoverished by successive cereal crops, enclosure with strips of trees was principally for stock. Previous to the introduction of new methods in animal husbandry, it had only been possible to maintain a few breeding cows through the winter. It may be concluded that enclosed and sheltered fields or parks meant that animals could be kept in good form throughout the year on the produce of pastures sown with improved grasses and clover; excellent winter fodder contributing enormously to their welfare. It should be noted, however, that shelter was only one factor in successful stock rearing. Wherever there was enough ready money to invest in shelterbelts, capital expenditure was not spared in other matters, e.g. fields were often underdrained, limed and dunged, to encourage the growth of the introduced forage plants. Farm steadings were also built and tenants' houses improved. Fields enclosed with fences were used for cropping in Norfolk-type rotation with use of lime and dung. Productivity was increased to such an extent that the tenants were usually well able to afford increased rents and to pay interest on

the laird's investments.

3) Before enclosure evidence points to the virtual absence of trees on farmland in Lowland Scotland. When saplings were planted in hedges between the fields it was thought that they would grow into hedgerow trees and would provide shelter from wind, improve the appearance of the countryside and eventually yield timber, as was the case in Southern England. However, hedgerow trees did not grow well, whereas strips of trees that were planted for the same reasons and in similar situations thrived comparatively well. Towards the end of the eighteenth century agriculturalists concluded that wind was the main cause of failure of hedgerows, and that the mutual shelter provided by trees in belts was the reason they survived. Consequently these men advocated shelterbelts for enclosure during the Agricultural Revolution in Scotland.

4) Since major topographical features are approximately parallel to prevailing and Spring wind directions, it may be concluded that orientation of belts was principally determined by topography and that this was so whether the spread of shelterbelts coincided with enclosure or followed it.

Width of belts appears to have been a matter for arbitration, proportional rent remissions applied only where good land was taken. Steep, rocky and sandy slopes, boggy hollows and stream courses were frequently considered suitable for trees. Other belts were deliberately placed where wind conditions were severe or to divide ground that could be improved for pasture from rough grazings on blanket bogs or mosses.

Edaphic and/or climatic locality factors were therefore harsh and it would appear that only by careful planting and constant maintenance could shelterbelt trees be grown satisfactorily in such situations. Failure to maintain these belts in times of economic difficulty has led to failure of the trees, and thus to a decline in site condition.

5) Regarding species choice, evidence from library research and from the field survey points towards increasing use of conifers with time. Planting pattern is seen to be a function of date establishment; first grid-planting and later systems of parallel belts. Tracts of ground remained unplanted where proprietors were not concerned to plant trees or where they limited their activities to a small part (usually the policy grounds near the mansion house) of a large estate.

6) Changes in ownership of properties have resulted either in new or continuing silvicultural activities, or in neglect of shelterbelts. In the former case the proprietor was usually rich and was able to increase the productivity of the land in traditional ways. This invariably included the establishment or maintenance of belts for stock shelter and amenity. Provision of cover for pheasants was a reason for planting trees with undershrub species. Conifer belts over two chains wide were probably intended for timber production.

New proprietors who neglected existing belts either because they disliked trees or were unfamiliar with silvicultural techniques were generally former tenants who were able to purchase their farms when an estate was split up. This occurred mainly on small farms on better soils

where cropping became a major occupation. The shelterbelts concerned were composed of either old hardwoods or of mixed species which were mature or overmature when the farm was taken over. Neglect of such belts appears to be because they affect cropping in various ways, notably: shading by the large trees; root competition, especially where former open drains have been tiled or filled with stones; and laying of crops due to unfavourable wind conditions in the lee of belts. It is possible, however, that if the same farmers were to have experience of narrow belts uniformly penetrable to wind they might revise their opinions of trees. But on the evidence of the field survey it seems likely that the condition of these old belts will continue to deteriorate.

7) In the past it is possible that, once the trees were well grown, the tenants' stock may have been allowed access to certain shelterbelts. Today farmers are generally glad to have such access for cattle and for sheep too if there are no branches to damage the fleece. Sometimes overhead shelter is deemed valuable and at others rough forage beneath the trees is the reason for allowing animals into belts, e.g. in spring time. This practice appears to occasion little damage if access is limited or if soils are well drained and the belt composed of deep rooted trees. Unlimited access is undoubtedly harmful to the trees and may cause windthrow especially on soils that are readily puddled by trampling. Failure to regard trees as living things or to consider that belts are viable complexes is probably one reason behind such neglect. Second fences are rarely maintained on small farms, especially if

cropping is important. It is therefore likely that either shortage of capital or of land, or both, is the reason why belt condition is allowed to deteriorate.

8) Unusual causes of dereliction of shelterbelt sites may be found in connection with urbanization and industrial sites. Developments in communications, particularly railways in the mid-nineteenth century, are shown to have affected systems of belts on certain estates. Much more serious than the physical damage was the effect of fragmentation of farms and fields and the isolation of some belts from the estate policy woods. From this fact and from the abundance of conifer belts in C condition (stand completeness 60-79%) associated with extensive Other Woods on a number of estates, it may be deduced that a certain area of woodland is necessary to make it economically feasible to employ a forestry staff, even at the present level of Small Woods Grants.

Of the utility services that supply townships, electricity transmission lines have been a major cause of site dereliction. Metal towers may be located in belts, but whether or not this is so, wide gaps were cut across every belt along the course of transmission line to facilitate the laying out of the conductors and the raising of them into position. Only in instances where the present proprietor is actively engaged in maintaining shelterbelts has compensation been paid for damage done as well as for loss of shelter to fields.

Spoil heaps from mining have obliterated some belts and others

have been allowed to fall into disrepair because they would only shelter such a tip if in good condition.

9) It is evident that belts can only be maintained in good condition if they are ring-fenced to exclude all stock and carefully tended, particularly as regards drainage. The only proprietors who are investing in belts at the present time are those who still own family estates run in the traditional manner, or who own country houses or farms supported in part with money from external sources. All the new belt-sites and all those sites recently rehabilitated are on farms where stock is the main enterprise. It will be instructive to watch developments in shelter planting for sheep. It seems that belts carefully sited on hill farms to provide storm refuges, without interfering with the natural rake of the flock, may be able to contribute to intensification of sheep rearing in a manner analogous to that in which they made for advances in cattle husbandry during the eighteenth century.

10) If it can be shown that crop yields can be improved by use of shelter, it might be possible to rehabilitate several of the old sites on lower ground. Many of these belts, however, are too close together, and it would require considerable capital expenditure to reorganize field layout and drainage. If amenity is a major consideration (and the serving of a Tree Preservation order suggests that this is the case) then it will be important to allocate further public funds and probably personnel also to tree planting and

maintenance on farm lands in the vicinity of the Pentland Hills.

APPENDIX I

Basic date for the eighty-six farm units in study area: Tenure; Woodland Management Type; Number and Area of Shelterbelts in five condition classes; and areas of: Other Woods; Arable/Pasture Fields; Rough Grazing.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
1	O[1]	a	- (-)	- (-)	11.5 (4)	27.5 (8)	11.5 (4)	51 (16)	128	579	-	758
2	O	c	- (-)	- (-)	- (-)	9.5 (6)	9.3 (5)	19 (11)	1	269	-	289
3	O	b	- (-)	- (-)	2.7 (1)	39.1 (17)	3.2 (3)	45 (21)	7	256	-	308
4	O	b	- (-)	- (-)	5.6 (2)	4.9 (3)	- (-)	11 (5)	-	289	-	300
5	O[2]	b	0.7 (1)	- (-)	1.8 (1)	13.2 (5)	- (-)	16 (7)	23	861	300	1200
38	T	c	- (-)	- (-)	- (-)	7.1 (4)	1.8 (2)	9 (6)	6	140	-	155
48	T[3]	a	2.0 (1)	- (-)	- (-)	2.8 (1)	- (-)	5 (2)	14	1027	794	1840
Totals acres			2.7 (2)	- (-)	21.6 (8)	104.1 (44)	25.8 (14)	156 (68)	179	3421	1094	4850

1. Proprietor and owner-occupier of home farm has 2 tenants at present; boundaries vary from year to year.

2. Owner of two farms but tenant of two others in this large unit.

3. Tenant also heir apparent to this farm and other lands.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
12	O	a	8.8 (4)	2.1 (1)	- (-)	28.1 (13)	2.6 (1)	42 (19)	124	584	450	1200
15	O[1]	c	- (-)	- (-)	- (-)	- (-)	0.5 (1)	1 (1)	8	220	-	229
16	O[1]	c	- (-)	- (-)	- (-)	- (-)	8.1 (1)	8 (1)	5	810	97	920
18	O[1]	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	-	80	-	80
19	O[2]	c	- (-)	- (-)	- (-)	2.3 (3)	- (-)	2 (3)	4	316	-	322
20	O	a	- (-)	- (-)	- (-)	0.9 (1)	- (-)	1 (1)	27	16	-	44
21	O	c	- (-)	- (-)	- (-)	5.1 (2)	- (-)	5 (2)	-	103	-	108
22	O	c	- (-)	- (-)	6.3 (1)	- (-)	- (-)	6 (1)	-	194	-	200

1. Proprietors to be bought out by Midlothian County Council in connexion with Livingston New Town developments.

2. Two owners; one who is resident leases extra fields to north of his farm; 96 acres south east of railway owned by a grazier since the 1950's.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
23	O[1]	c	- (-)	- (-)	- (-)	1.2 (1)	- (-)	1 (1)	-	123	660	784
24	M[2]	a	1.5 (1)	- (-)	0.9 (1)	1.8 (2)	- (-)	4 (4)	11	130	-	145
28	O[3]	c	- (-)	- (-)	- (-)	0.5 (1)	2.8 (2)	3 (3)	4	148	215	370
Totals acres			10.3 (5)	2.1 (1)	7.2 (2)	39.9 (24)	14.0 (6)	73 (38)	183	2724	1422	4402

1. Owner-occupier of 23a is tenant of 23b, a beltless 660 acres moorland farm south east of Zone IV.

2. Grieve runs woods but fields let annually.

3. Proprietor and owner-occupier runs about 100 acres as a golf course.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
17	O	b	- (-)	- (-)	- (-)	7.7 (3)	- (-)	8 (3)	8	65	-	81
25	O	c	- (-)	- (-)	- (-)	6.2 (4)	2.1 (2)	8 (6)	-	139	-	147
26	O	c	- (-)	- (-)	- (-)	3.5 (2)	- (-)	4 (2)	-	73	7	84
27	O	c	- (-)	- (-)	- (-)	3.3 (2)	- (-)	3 (2)	-	107	-	110
30	O	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	-	60	-	60
31	O[1]	c	- (-)	- (-)	- (-)	2.0 (3)	1.5 (1)	4 (4)	7	224	-	235
32	O	b	- (-)	- (-)	2.6 (1)	24.2 (9)	13.2 (7)	40 (17)	17	197	-	254
33	O	c	- (-)	- (-)	- (-)	9.5 (5)	- (-)	10 (5)	-	70	-	80
34	M	b	- (-)	- (-)	0.6 (1)	15.3 (7)	6.7 (7)	23 (15)	42	332	32	429

1. Part on study area boundary to be bought by Midlothian County Council for industry.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
35	O	b	0.8 (1)	- (-)	- (-)	19.9 (9)	6.0 (4)	27 (14)	16	212	45	300
36	T	c	- (-)	- (-)	- (-)	3.0 (1)	4.0 (1)	7 (2)	-	18	-	25
39	T	c	- (-)	- (-)	- (-)	15.2 (9)	13.8 (5)	29 (14)	-	55	32	116
Totals acres			0.8 (1)	- (-)	3.2 (2)	109.8 (54)	47.3 (27)	163- (84)	90	1552	116	1921

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelts Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
37	0	b	- (-)	- (-)	5.5 (1)	- (-)	- (-)	6 (1)	-	229	815	1050
40	0	c	- (-)	- (-)	- (-)	- (-)	11.1 (2)	11 (2)	2	179	18	210
41	0	b	- (-)	- (-)	1.6 (1)	13.6 (5)	1.1 (1)	16 (7)	-	334	-	350
42	0	c	- (-)	- (-)	5.8 (2)	5.6 (3)	3.9 (2)	15 (7)	-	295	-	310
43	0	c	- (-)	- (-)	- (-)	18.1 (12)	1.1 (2)	19 (14)	-	211	-	230
44	0	c	- (-)	- (-)	- (-)	15.4 (6)	- (-)	15 (6)	-	158	-	173
45	0	c	- (-)	- (-)	- (-)	16.7 (3)	4.2 (1)	21 (4)	-	195	109	325
46	0	c	- (-)	- (-)	- (-)	1.4 (1)	- (-)	1 (1)	-	92	557	650
Totals acres			- (-)	- (-)	12.9 (4)	70.8 (30)	21.4 (8)	104 (42)	2	1693	1499	3298

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
6	M	b	- (-)	- (-)	- (-)	3.6 (2)	0.8 (1)	4 (3)	2	145	149	300
7	O	c	- (-)	- (-)	- (-)	6.0 (5)	- (-)	6 (5)	2	300	892	1200
8	O	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	8	150	1252	1410
9	O	a	13.2 (5)	- (-)	- (-)	3.9 (4)	0.8 (1)	18 (10)	40	1940	1942	2000
10	O	b	- (-)	- (-)	- (-)	8.5 (2)	- (-)	9 (2)	22	163	1506	1700
11	O	b	- (-)	0.3 (1)	- (-)	10.2 (2)	- (-)	11 (3)	53	200	516	780
13	M	a	14.0 (2)	- (-)	- (-)	- (-)	- (-)	14 (2)	2	16	818	850
14	O [1]	c	- (-)	- (-)	- (-)	0.8 (1)	- (-)	1 (1)	1	21	677	700

1. Owner at time of Field Survey bought out by Forestry Commission in 1967: Now scheduled for planting.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
29	O[1]	c	- (-)	- (-)	- (-)	2.0 (1)	1.8 (2)	4 (3)	1	102	700	807
49	T[2]	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	-	200	750	950
50	T	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	-	60	1030	1090
Totäs acres			27.2 (7)	0.3 (1)	- (-)	35.0 (17)	3.4 (4)	67 (29)	91	1397	10232	11787

1. Owner to be bought out; unit scheduled for development as a Country Park (Lothians Regional Survey and Plan, 1966).

2. Two tenants of one proprietor on adjacent, beltless farms.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
51	O	a	40.0 (2)	- (-)	8.3 (2)	- (-)	- (-)	48 (4)	8	394	1000	1450
52	O	c	- (-)	6.0 (2)	8.8 (2)	- (-)	54.2 (7)	69 (11)	4	324	-	397
53	O	a	20.7 (14)	13.0 (5)	16.6 (9)	1.6 (2)	- (-)	52 (30)	9	450	-	511
54	O	c	- (-)	- (-)	- (-)	6.2 (4)	1.0 (1)	7 (5)	5	250	-	262
55	T	c	- (-)	- (-)	- (-)	4.4 (2)	20.7 (7)	25 (9)	11	135	-	171
56	M	b	-	0.9	-	-	-	1 (1)	-	12	-	13
57	O	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	8	372	-	380
58	M	a	- (-)	4.5 (3)	22.7 (9)	2.6 (2)	3.0 (1)	33 (15)	38	383	-	454
59	T	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	-	174	16	190
60	M	b	- (-)	- (-)	7.2 (3)	6.8 (8)	5.0 (4)	19 (15)	59	710	2672	3460

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
81	T	a	10.2 (1)	- (-)	11.4 (1)	8.1 (2)	- (-)	30 (4)	-	320	75	425
82	T	a	- (-)	- (-)	1.1 (1)	2.4 (1)	- (-)	4 (2)	7	77	-	88
83	T	a	- (-)	- (-)	10.0 (4)	- (-)	- (-)	10 (4)	35	200	372	617
84	T	a	- (-)	- (-)	11.8 (2)	8.6 (1)	- (-)	20 (3)	-	180	-	200
85	T [1]	a	- (-)	- (-)	11.8 (3)	- (-)	- (-)	12 (3)	9	274	780	1075
86	T	a	- (-)	- (-)	- (-)	10.6 (6)	- (-)	11 (6)	12	217	-	240
Totals acres			70.9 (17)	24.4 (11)	109.7 (36)	51.3 (28)	83.9 (20)	341 (112)	205	4472	4915	9933

1. Tenant of two proprietors.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
61	T	b	- (-)	- (-)	- (-)	10.5 (10)	- (-)	11 (10)	2	141	-	154
62	M	b	4.2 (5)	10.7 (7)	2.0 (2)	22.7 (16)	0.8 (2)	40 (32)	69	500	700	1309
63	O	b	- (-)	- (-)	- (-)	7.9 (3)	6.7 (3)	15 (6)	45	356	450	866
64	T	a	5.4 (2)	12.5 (1)	- (-)	15.5 (9)	- (-)	33 (12)	27	180	-	240
65	T[1]	a	- (-)	4.1 (1)	- (-)	0.2 (1)	0.4 (1)	5 (3)	47	90	2266	2408
66	O[1]	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	19	80	-	99
67	O	a	2.9 (1)	- (-)	- (-)	1.3 (1)	- (-)	4 (2)	4	32	-	40
68	T[2]	c	- (-)	2.4 (1)	0.8 (1)	18.9 (10)	- (-)	22 (12)	30	447	580	1079

1. Two owner-occupiers since recent sale of 60 acres without woods to former tenant.

2. Proprietors of Unit 62 lease the fields.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
78	T[1]	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	8	15	250	673
79	T	a	1.1 (1)	- (-)	- (-)	10.6 (2)	- (-)	12 (3)	99	234	664	1009
80	T[2]	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	11	76	-	87
Totals acres			13.6 (9)	29.7 (10)	2.8 (3)	87.6 (52)	7.9 (6)	142 (80)	361	2551	4910	7964

1. The two golf courses are under different management.

2. Tenant of two proprietors.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
47	T	d	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	-	150	110	260
69	T	c	- (-)	- (-)	- (-)	- (-)	9.4 (2)	9 (2)	-	75	-	84
70	O [1]	a	6.3 (2)	- (-)	- (-)	- (-)	- (-)	6 (2)	11	337	105	459
71	M	a	9.2 (2)	6.9 (1)	- (-)	13.2 (6)	- (-)	29 (9)	514	458	17	1018
72	O	a	5.8 (4)	2.0 (1)	0.5 (1)	9.2 (2)	- (-)	18 (8)	1	208	77	304
73	T	b	- (-)	- (-)	- (-)	8.9 (3)	5.1 (2)	14 (5)	-	202	84	300
74	T	b	1.5 (1)	- (-)	- (-)	- (-)	- (-)	2 (1)	5	235	1158	1400
75	T	b	- (-)	- (-)	1.9 (1)	14.9 (2)	2.6 (1)	19 (4)	3	400	978	1400

1. Owner-occupier of 70b is tenant of 70a.

Unit No.	Land Tenure	Wood Mgt. Type	Shelterbelt Condition Class A Acres (No.)	B Acres (No.)	C Acres (No.)	D Acres (No.)	E Acres (No.)	Belts Acres (No.)	Other Woods Acres	A/P Fields Acres	Rough Graz. Acres	Total Acres
76	T	b	- (-)	- (-)	- (-)	19.2 (5)	- (-)	19 (5)	-	255	300	574
77	O	b	0.8 (1)	- (-)	- (-)	4.4 (3)	6.2 (5)	11 (9)	-	142	132	285
Totals acres			23.6 (10)	8.9 (2)	2.4 (2)	69.8 (21)	23.3 (10)	127 (45)	534	2462	2961	6084

APPENDIX II

Area and Number of belts associated with Watercourses; Farm Boundaries; and Roads, by orientation and by zones.

	ZONE I Acres (No.)	II Acres (No.)	III Acres (No.)	IV Acres (No.)	V Acres (No.)	VI Acres (No.)	VII Acres (No.)	VIII Acres (No.)	S.A. Acres (No.)
Normal & Oblique Belts									
Watercourse on windward side:	7.3 (3)	- (-)	0.9 (1)	0.8 (1)	10.3 (2)	42.8 (4)	4.2 (5)	4.3 (1)	70.6 (17)
Watercourse inside belt:	0.8 (1)	5.1 (2)	3.8 (2)	8.1 (2)	3.0 (3)	21.5 (7)	7.0 (3)	- (-)	49.3 (20)
Watercourse on leeward side:	- (-)	7.8 (2)	- (-)	- (-)	0.8 (1)	2.7 (3)	3.6 (2)	- (-)	14.9 (8)
Parallel Belts									
Watercourse alongside belt:	7.6 (2)	2.7 (2)	9.8 (6)	1.4 (1)	2.2 (2)	2.7 (2)	15.2 (4)	- (-)	41.6 (19)
Watercourse inside belt:	1.2 (1)	- (-)	- (-)	3.3 (1)	- (-)	3.5 (1)	6.3 (2)	5.8 (1)	20.1 (6)
Totals acres	16.9 (7)	15.5 (6)	14.5 (9)	13.6 (5)	16.3 (8)	73.2 (17)	36.3 (16)	10.1 (2)	196.5 (70)

A. Area and Number of Belts Associated with Natural and Artificial Watercourses

	ZONE I Acres (No.)	II Acres (No.)	III Acres (No.)	IV Acres (No.)	V Acres (No.)	VI Acres (No.)	VII Acres (No.)	VIII Acres (No.)	S.A. Acres (No.)
Normal Belts									
March on windward side:[1]	8.5 (8)	14.4 (5)	25.8[1] (10)	24.5 (7)	13.1 (3)	38.9 (9)	7.5 (5)	13.1 (5)	145.8 (52)
March on leeward side:	6.4 (3)	- (-)	18.6 (11)	2.3 (2)	- (-)	22.1 (6)	12.0 (3)	12.5 (4)	73.9 (29)
Oblique Belts									
March alongside:	5.0 (3)	13.0 (3)	8.1 (4)	6.4 (3)	- (-)	31.0 (3)	21.4 (6)	- (-)	84.9 (22)
Parallel Belts									
March alongside:	33.5 (10)	2.7 (2)	21.3 (11)	14.2 (3)	- (-)	47.5 (15)	15.9 (8)	7.4 (2)	142.5 (51)
Totals acres	53.4 (24)	30.1 (10)	73.8 (36)	47.4 (15)	13.1 (3)	139.5 (33)	56.8 (22)	33.0 (11)	447.1 (154)

1. March along centre of one belt: 9.0 acres, ST 982599.

B. Area and Number of Belts on Farm Boundaries.

	ZONE I Acres (No.)	II Acres (No.)	III Acres (No.)	IV Acres (No.)	V Acres (No.)	VI Acres (No.)	VII Acres (No.)	VIII Acres (No.)	S.A. Acres (No.)
Normal & Oblique Belts									
Road on windward side:	8.3 (5)	2.4 (4)	16.4 (5)	7.5 (4)	- (-)	24.6 (4)	7.6 (7)	9.7 (4)	76.5 (33)
Road within belt (avenue):	3.9 (2)	0.3 (1)	- (-)	- (-)	- (-)	2.5 (2)	- (-)	- (-)	6.7 (5)
Road on leeward side:	1.6 (1)	- (-)	16.6 (8)	2.0 (2)	- (-)	2.0 (1)	2.9 (1)	3.2 (1)	28.3 (14)
Parallel Belts									
Road alongside belt:	16.8 (9)	- (-)	8.5 (6)	2.6 (1)	1.5 (2)	28.0 (10)	9.9 (10)	- (-)	67.3 (38)
Road inside belt (avenue):	4.6 (2)	- (-)	7.2 (1)	- (-)	- (-)	- (-)	- (-)	- (-)	11.8 (3)
Totals acres	35.2 (19)	2.7 (5)	48.7 (20)	12.1 (7)	1.5 (2)	57.1 (17)	20.4 (18)	12.9 (5)	190.6 (93)

C. Area and Number of Belts Associated with Roads and Avenues.

APPENDIX III

Number and size of units in four Woodland Management Types by tenure and by zones.

Zone	Wood Mgt. Type	Owner-Occupier No. Units	Owner-Occupier Total Area (ac.)	Manager No. Units	Manager Total Area (ac.)	Tenant No. Units	Tenant Total Area (ac.)
I	a	1	758	-	-	1	1840
	b	3	1808	-	-	-	-
	c	1	289	-	-	1	155
	d	-	-	-	-	-	-
II	a	2	1244	1	145	-	-
	b	-	-	-	-	-	-
	c	7	2933	-	-	-	-
	d	1	80	-	-	-	-
III	a	-	-	-	-	-	-
	b	3	635	1	429	-	-
	c	5	656	-	-	2	141
	d	1	60	-	-	-	-
IV	a	-	-	-	-	-	-
	b	2	1400	-	-	-	-
	c	6	1898	-	-	-	-
	d	-	-	-	-	-	-
V	a	1	2000	1	850	-	-
	b	2	2480	1	300	-	-
	c	3	2707	-	-	-	-
	d	1	1410	-	-	2	2040

Tenure and Management Type.

APP. III

Zone	Wood Mgt. Type	Owner-Occupier No. Units	Owner-Occupier Total Area (ac.)	Manager No. Units	Manager Total Area (ac.)	Tenant No. Units	Tenant Total Area (ac.)
VI	a	2	1961	1	454	6	2645
	b	-	-	2	3473	-	-
	c	2	659	-	-	1	171
	d	1	380	-	-	1	190
VII	a	1	40	-	-	3	3657
	b	1	866	1	1309	1	154
	c	-	-	-	-	1	1079
	d	1	99	-	-	2	760
VIII	a	2	763	1	1018	-	-
	b	1	285	-	-	4	3674
	c	-	-	-	-	1	84
	d	-	-	-	-	1	260
Study Area	a	9	6766	4	2467	10	8142
	b	12	7474	5	5511	5	3828
	c	24	9142	-	-	6	1630
	d	5	2029	-	-	6	3250
Total		50	24,411	9	7978	27	16,850

Tenure and Management Type.

APP. III
(cont.)

APPENDIX IV

The bird species associated with Whiteside Plantation (NT 189661), with notes on their status and their exploitation of the habitat.
(Rawcliffe, C.P., personal communication reproduced with permission.)

Species	Common Name	Status and Exploitation
1. Carduelis carduelis	Goldfinch	Very occasional; suspect breeding (canopy) 1962.
2. Carduelis flammea	Lesser Redpole	Resident; suspected breeding (canopy), feeds in canopy.
3. Certhia familiaris	Treecreeper	Visitor from nearby; feeds in and on trees, song perches.
4. Chloris chloris	Greenfinch	Resident; suspected breeding (in canopy), song perches.
5. Columba palumbus	Woodpigeon	Resident; breeds (in canopy), song perches.
6. Corvus corone	Carrion crow	Resident; breeds in vicinity (may breed eventually in canopy - area disturbed), perches.
7. Erithacus rubecula	Robin	Resident; breeds, song perches, some feeding.
8. Fringilla coelebs	Chaffinch	Resident; breeds, feeds, song perches.
9. Fringilla montifringilla	Brambling	Winter visitor; feeds.
10 Loxia curvirostra	Crossbill	Very occasional (winter); feeds on Scots pine cones.
11 Muscicapa striata	Spotted flycatcher	Summer visitor; suspected breeding; song perches.
12 Parus ater	Coal tit	Resident; breeds, feeds on and in trees, song perches.

Birds in Whiteside Plantation

APP. IV

Species	Common Name	Status and Exploitation
13 Parus caeruleus	Blue tit	Resident; breeds, feeds on and in trees, song perches.
14 Parus major	Great tit	Visitor from nearby; feeds in and on trees, song perches.
15 Passer domesticus	House sparrow	Resident; suspected breeding (canopy), feeds.
16 Passer montanus	Tree sparrow	Resident; suspected breeding (canopy), feeds.
17 Phasianus colchicus	Pheasant	Resident; breeds in undergrowth and loppings, roosts in canopy.
18 Phoenicurus phoenicurus	Redstart	Summer visitor; breeding not proved.
19 Phylloscopus trochilus	Willow warbler	Summer visitor; breeds, feeds on and in trees, song perches.
20 Pica pica	Magpie	Visitor from nearby; perches.
21 Prunella modularis	Dunnock	Resident; breeds among loppings and in undergrowth, feeds, song perches.
22 Pyrrhula pyrrhula	Bullfinch	Visitor from nearby; feeds.
23 Regulus regulus	Goldcrest.	Resident; suspected breeding, song perches, feeding on and in trees.
24 Scolopax rusticola	Woodcock	Very occasional

Birds in Whiteside Plantation

Species	Common Name	Status and Exploitation
25 *Strix aluco*	Tawny owl	Resident; breeds in vicinity on ground.
26 *Sturnus vulgaris*	Starling	Resident and Winter Visitor; suspected breeding (in canopy), song perches.
27 *Troglodytes troglodytes*	Wren	Resident; breeds (sides and canopy at twenty-five feet once), feeds mainly in undergrowth, song perches.
28 *Turdus ericetorum*	Song thrush	Resident; breeds among loppings, undergrowth and fallen trees, song perches.
29 *Turdus merula*	Blackbird	Resident; breeds among loppings, undergrowth and fallen trees, song perches.
30 *Turdus viscivorus*	Mistle thrush	Resident (partially); suspected breeding (in canopy).

Birds in Whiteside Plantation

BIBLIOGRAPHY

I MANUSCRIPT SOURCES

Edinburgh Corporation, Central Library, Edinburgh

"Genealogy of the Argyll Family" by Niel MacEWEN, 1776

The Company of Merchants of the City of Edinburgh, The Merchants' Hall, Edinburgh

Minute Books, 1817-1834 (Entries regarding Cockburn Estate)

J.C. & A. Steuart, W.S., Edinburgh

(Misc. papers regarding the former Baads Estate)

National Library of Scotland, Edinburgh

Whim Estate, Salton Papers

Correspondence between Lord Ilay (3rd Duke of Argyll) and Andrew Fletcher

Scottish Record Office

1. Dalmahoy Estate, Morton Papers (GD 150)

   (a) GD 150, Box 120 (Reports on Farms, 1771, 1789, 1790, 1814 and Offers for farms, 1790-1799). "Book of Workman's Days at Dalmahoy 1748-49".

   (b) GD 150, (Volume indexed after Box 124) "Survey, Valuation and Report of the Woods ... of Dalmahoy" by Robert MONTEATH, 1825".

   (c) GD 150, Box 125, (Misc. papers and letters relating to farms and estate matters, 1732-1805).

      i. "Articles of agreement between the Earl of Morton and/Tenant" 1792

      ii. Letters from the factors to the Earl of Morton, 1788-1813.

(a) Andrew Cunningham

(b) Mackenzie and Matthew Stobie

(c) John Tait

(d) GD 150 (ADDITIONAL) (Volumes of Farm Valuations, 1863-1880) Vol. IV (including reference to Westfield Estate) and Vols. IX and XIII.

2. Penicuik Estate, Clerk of Penicuik Muniments (GD 18)

(a) GD 18/1480, "Methode of Improving the Baronie of Penicuik" by Sir John CLERK, 1728.

(b) GD 18/1487, "Report regarding the Estate of Penicuik" by Alexander LOW, 1797

(c) GD 18/1693, "A few memorandums about inclosing of grounds" by Sir John CLERK, 1739

3. Extracted Processes, Court of Session, 1840, March, No. 1992 "Process in the division of Calder Cleir Commonty"

University of Edinburgh, Forestry and Natural Resources Dept.

1. BORISSOW, N.G., "The Use and Management of Woodlands for the Out-wintering of Farm Stock", M.Sc. Thesis, 1963

2. CABORN, J.M., "Shelter Planting on the Hill Farm", 1958.

3. Messrs Dickson & Bell, London (Typescripts by Fowler, R.C.A. of material relating to the former Baads Estate)

(a) Letter to Messrs Dunn & Wordsworth, Edinburgh, 1835, (extracts)

(b) "A Terrier of the Rev. Alex. Houston Douglas's Estates in the County of Midlothian ..." 1835 (Extracts)

4. HOPKINS, P.O., "The Condition of Shelterbelts in Parts of South East Scotland" M.Sc.Thesis, 1965

University of Edinburgh, Social Sciences (Geography) Dept.

1. KIRBY, R.P., "The Glacial Geomorphology of The Esk Basin, Midlothian" Ph.D. Thesis, 1966

2. THIRD, Betty M.W., "The Changing Rural Geography of the Scottish Lowlands, 1700-1820" Ph.D.Thesis, 1953

II MAPS AND PLANS

Company of Merchants of the City of Edinburgh, The Merchants' Hall, Edinburgh.

BRUCE & CUNNINGHAM M.S. Plan of Cockburn Estate, 1854

J.C. & A. Steuart, W.S., Edinburgh

(Ordnance Survey) Plan of Baads Estate n.d. but prepared from 6" sheets of Edinburghshire and Lanarkshire published between 1853 and 1864.

National Library of Scotland

1. KNOX, J. "Map of The Shire of Edinburgh and County of Midlothian" 1½" to one mile. 1812

2. 'ROY' (General Roy's "Military Survey of Scotland) Positive photostats of MS., 1000 yards to 1 inch, 1747-55

3. Ordnance Survey sheets covering Study Area, as follows:

(a) 25" to 1 mile (2nd Edn) 1907-08

(b) 2½" to 1 mile 1955-58

(c) 1" to 1 mile 1853-58 (incl. Natchused Edn.)

(d) 1" to 1 mile 1898

(e) 1" to 1 mile 1965 (with additions from Field Survey of Shelterbelts, 1965-67)

4. SHARP, GREENWOOD & FOWLER "Map of the County of Edinburgh" approx. 1" to 1 mile

5. (Salton Papers) "Old Plan of Gilchriston" MS., 1803

6. (Anon) "Plan of Westfield and Wester Murieston ...", 1824 (Photo copy of original MS plan)

Scottish Record Office

1. RH Plan 533 "Plan of Calder Cleir Commonty" (BAUCHOP, 1807)

2. RH Plan 726 (includes details of belts on Horwood Estate)

3. RH Plan 1012 "A Plan of the Lands of Dalmahoy without the Inclosiers" MS (Thomas WINTER, 1749)

4. RH Plan 6064 27 photostats of Penicuik Estate farm plans, MS., (AINSLIE, 1797)

III Printed Works

ADAMS, I.H., 1966, "Descriptive List of Plans", Vol. 1, Edinburgh H.M.S.O.

AITON, 1811, "A Treatise on the Origin, Qualities and Cultivation of Moss Earth with Directions for Converting it into Manure". Wilson and Paul.

ALLARDYCE, A., 1888, "Scotland and Scotsmen of the Eighteenth Century", 2 Vols., Blackwood, Edinburgh.

ANDERSON, M.L., 1925, "The Importance of a Knowledge of Glacial Geology" to Scottish Foresters"., Trans. R. Scot. Arb. Soc., Vol. 39, 9 - 28.

ANDERSON, M.L., 1957, "The Ecological Approach to Shelterbelt Formation in the Planned Use of Land", Proceedings and Papers of the Sixth Technical Meeting of the International Union for Conservation of Nature and Natural Resources, Edinburgh 1956.

ANDERSON, M.L., Ed. Taylor, C.J., 1967, "A History of Scottish Forestry" 2 Vols, Nelson, Edinburgh.

ANDERSON, M.L., and FAIRBAIRN, W.A., 1955, "Division of Scotland into Climatic Sub-Regions as an Aid to Silviculture", Edinburgh University Bulletin, No. 1.

CABORN, J.M., 1957, "Notes on Shelter Research in North America", Dept. of Animal Husbandry, Institute of Rural Science, University College of Wales, Aberystwyth.

CABORN, J.M., 1957, "Shelterbelts and Microclimate", Forestry Commission Bulletin, No. 29, H.M.S.O.

CABORN, J.M., 1965, "Shelterbelts and Windbreaks", Faber & Faber, London.

CHAPMAN, R.W., Ed. 1948, "Johnson's Journey to the Western Isles of Scotland" (1795) and Boswell's "Journey of a Tour to the Hebrides with Samuel Johnson, L.L.D." (1786), O.U.P.

COLVILLE, J., Ed. 1904, "Letters of John Cockburn of Ormistoun to his Gardener, 1727 - 1744", Scot. Hist. Soc., Vol. 45, T. & A. Constable, Edinburgh.

COPPOCK, J.T., 1965, "The Cartographic Representation of British Agricultural Statistics/Geography". Vol. 50. (2)

DONEY, J.M., 1963, "The Effects of Exposure in Blackface Sheep with Particular Reference to the Role of the Fleece", J. Agric. Sci., Vol. 60.

DOUGLAS, Sir R., et al., 1798, "The Baronage of Scotland". Edinburgh.

EDLIN, M.L., 1956, "Trees, Woods and Man", Collins New Naturalist Series.

ELLISON, W., 1953, "Marginal Land in Britain", Geoffrey Bles, London.

FINDLATER, Rev. Charles, 1802, "General View of the Agriculture of the County of Peebles", Edinburgh.

GEIKIE, J., 1894, "The Great Ice Age", 3rd Edition, London.

GRAHAM, J.M. Ed., 1875, "Annals and Correspondence of the Viscount and the First and Second Earls of Stair", 2 Vols., Blackwood, Edinburgh.

GREY, J.M. Ed. 1892, "Memoirs of the Life of Sir John Clerk of Penicuik, Baronet, Baron of the Exchequer: Extracted by Himself from His Own Journals, 1676 - 1755", Scot. Hist. Soc., 12, T. & A. Constable, Edinburgh.

GREY, John M., Ed. 1892, "Memoirs of the Life of Sir John Clerk of Penicuik... from his own Journals, 1676-1755", Scot. Hist. Soc. 13, Edinburgh.

HALDANE, A.R.B., 1952, "The Drove Roads of Scotland".

HANDLEY, James E., 1953, "Scottish Farming in the Eighteenth Century". Faber & Faber, London.

HANDLEY, James E., 1963, "The Agricultural Revolution in Scotland", Burns, Glasgow.

"Highland and Agricultural Society" 1878, Report of the Present State of the Agriculture of Scotland; Neil, Edinburgh.

HOME, J.H.M., 1921, "Farm Forestry", Trans. Highland and Agricultural Society of Scotland, Series 5, 33, 43-55.

KIRBY, R.P., 1966, "The Glacial Geomorphology of the Esk Basin, Midlothian", Social Sciences Ph.D. Thesis, University of Edinburgh.

LAMB, H.H., 1964. "Trees and Climatic History of Scotland", Quarterly Journal of the Royal Meteorological Society, Vol. 90, No. 386.

LAMB, H.H., 1965, "Britain's Changing Climate", Ed. C.G. Johnson and L.P. Smith, Institute of Biology Symposia, No. 14, Academic Press, London.

LANDALE, S.E.A., 1961, "Shelter for Profit in the Hills of South East Scotland", Scottish Agricultural Society, 40 (4), 197-204

LINDESAY, Patrick, 1733, "The Interest of Scotland Considered", R. Fleming and Co., Edinburgh.

The Lothians Regional Survey and Plan 1966. Vol. II, Physical Planning Aspects, H.M.S.O.

LOUDON, J.C. 1838, "Arboretum et Fructicetum Britannicum", 8 Vols., London.

MANELY, Gordon, 1952, "Climate and the British Scene", Collins New Naturalist Series, No. 22, London.

Midlothian County Council 1965, "The County of Midlothian Tree Preservation Order No. 2".

Ministry of Agriculture, Fisheries and Food, 1961. Leaflet No. 15. "Shelterbelts for Farmland". H.M.S.O.

MORRIS, N., 1966. "Tree Clearance for Line Safety", Electrical Times, 29 September 1966.

MUNRO, Joan, 1962, "The Use of Natural Shelter by Hill Sheep", Animal Production, Vol. 4, pp. 343-349.

MURRAY, J.L., and MUTCH, W.E.S., 1961. "Shelterbelt Classification", Bulletin of the Forestry Dept., University of Edinburgh, Scotland, No. 8.

NAGELI, W., 1953, "Untersuchlingen uber die Windverhaltnisse im berlich von Schilfohrwanden", Mitt. Schweiz. Anst. f.d. forstl. Versuchw. 29 (2).

New Statistical Account of Scotland, Vol. I, "Edinburgh" 1845. Blackwood, Edinburgh.

Old Statistical Account, First Vol. 9, 1793, Kirknewton, pp. 407-417.

PEARSALL, W.H., 1950. "Mountains and Moorlands", Collins New Naturalist Series. London.

PLANT, J.A., 1966, "The Climate of Edinburgh", Meteorological Office, Climatological Memorandum No. 54.

READ, R.A., 1958. "The Great Plains Shelterbelt in 1954", Great Plains Agricultural Council Publication, 16.

READ, R.A., 1964. "Tree Windbreaks for the Central Great Plains" Agric. Handbook U.S. Dept. Agric. No. 250.

ROBERTSON, George, 1793. "General View of the Agriculture of the County of Midlothian with Observations on the Means of Its Improvement". J. Anderson, Edinburgh.

ROBERTSON, James, 1794. "General View of Agriculture in the Southern Districts of the County of Perth", London.

SINCLAIR, The Right Hon. Sir John, Bart., 1814. "General Report of the Agricultural State and Political Circumstances of Scotland", Vol. II, Edinburgh.

SKELTON, R.A., 1967. "The Military Survey of Scotland, 1747-1755", Scottish Geog. Magazine, 83 (1), 5.

SMOUT, T.C., 1964, "Scottish Landowners and Economic Growth" 1650-1850. Scottish Journal of Political Economy II, pp. 218-234.

STEELE, A., 1826. "The Natural and Agricultural History of Peat-Moss or Turf-Bog", Edinburgh.

THIRD, Betty M.W., 1957. "The Significance of Scottish Estate Plans and Associated Documents", Scottish Studies, 1, Edinburgh.

YEATES, J.S., 1942. "Farm Trees and Hedgerows", Massey Agricultural College, Bulletin No. 12, Palmerston North, N.Z.

ZEHETMAYR, J.W.L., 1954. "Experiments in Tree Planting on Peat", Forestry Comm. Bulletin No. 22, H.M.S.O., London.

STUDY AREA

FARM UNITS & SHELTERBELTS

- STUDY AREA BOUNDARY
- ZONE BOUNDARIES
- FARM UNIT BOUNDARIES
- 500', 1000' CONTOURS

OTHER SIGNS & SYMBOLS AS ON 1" ORDNANCE MAP