AUTHORS' PREFACE

THE ESTABLISHMENT of controlled areas in Britain in which the indigenous plants and animals could be preserved for study was made possible with the founding, by H.M. Government, of the Nature Conservancy after the Second World War. The original list of British National Nature Reserves did not include any area of upland moors with blanket-peat cover. The acquisition of the Moor House area in 1951 has made available such an area, covering a variety of habitats and vegetation types associated with open fells and mountain tops.

Geologically, little detailed work had been carried out in this area though research on the Carboniferous sequence goes back to 1809 when Westgarth Forster examined and published the section in Crowdundle Beck. The region was surveyed on the 6-in. scale by the primary surveyors of the Geological Survey during the latter part of the 19th century but no descriptive memoir was published. Thus, when detailed ecological work began at Moor House the imperfect knowledge of the geological setting and soils of the region was a severe handicap. Following recommendations from the University Department of Geology in Durham a geological re-survey of the region was started in 1954.

Early during this study, contact with biologists working in the area resulted in a better appreciation of the geological problems encountered by ecologists. The need for a detailed survey and laboratory studies of the superficial deposits of the region, the peats, mineral soils and drift deposits, was soon apparent and these aspects of the geology have received special attention. Survey on the 6-in. scale of solid bedrock, drift deposits and soils was completed on the Reserve and laboratory studies were carried on in Durham. The survey at Moor House and the descriptive memoir on the geology of the area is mainly the work of G. A. L. Johnson but Chapters 12 and 13 are due to K. C. Dunham who has also directed the survey and edited the memoir.

We have received assistance from many quarters during the survey at Moor House. In particular Dr. C. J. Stubblefield, F.R.S., Mr. W. S. Bisat, F.R.S., Dr. W. H. C. Ramsbottom and Dr. A. J. Sutcliffe have kindly advised on problems of palaeontology and stratigraphy. The late Mr. E. Crompton assisted greatly in the study of the soils of the Moor House area and kindly checked Chapter 15. We were fortunate in having the services of Mrs. M. E. Smeeton (née Johnson) to undertake laboratory studies of peats in Durham and her detailed and painstaking work is described in Chapter 16. We are also indebted to Dr. V. M. Conway for advice and assistance on the peat studies. Professor E. Birley, F.S.A., Professor M. Degerbol and Dr. T. G. Manby have given special advice on the prehistoric and Roman remains found on the Reserve (Chapter 17) and Mr. R. Phillips and Dr. R. P. Hollingworth have made valuable contributions to the mineralogy (Chapter 9). We acknowledge with thanks the permission of Professor F. W. Shotton, F.R.S., and the Council of the Geological Society of London to reproduce text-figure 3

and the late Mr. K. J. F. Park who supplied photographs from which Plates I, III and V have been made. To the directors of Laporte Industries Ltd. we are indebted for permission to publish information on the mineral deposits being exploited on their lease. We also tender grateful thanks to the Director of the Geological Survey of Great Britain and the Director of the Macaulay Institute for Soil Research, Aberdeen, for technical assistance and access to records; also to the Curators of the British Museum (Natural History), the University Zoological Museum, Copenhagen, and the Tolson Memorial Museum, Huddersfield, for allowing access to collections in their care. Mr. J. B. Cragg, formerly Professor of Zoology at Durham, and Professor D. H. Valentine have given frequent advice on ecological and biological problems during the survey which we gratefully acknowledge. Laboratory facilities for the survey have been provided by the University of Durham in the Durham Colleges Geology Department and Department of Botany; the University has also provided much technical and financial assistance. In particular we gratefully acknowledge the receipt of a grant from the Durham Colleges Research Fund to cover draughtsmanship costs in the preparation of the 6-in. geological maps of the Reserve.

Finally we wish to acknowledge the grant generously provided by the Nature Conservancy and the kindly help and advice freely given by their officers throughout the period of the survey and in the publication of the work. To all of these, and many others who have given invaluable assistance, we tender our grateful thanks.

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October, 1962.

Chapter 1

INTRODUCTION

THE Moor House Nature Reserve comprises some 10,000 acres of high moorland and fell country in Upper Teesdale and the Westmorland Pennines just to the south of Cross Fell (2930 ft. O.D.) the highest point in the Pennines (Fig. 1). The Reserve lies centrally in a long tract of uninhabited country between the east-west Stainmore Pass and Hartside Pass across the Pennines. There is no road across the Reserve from east to west and the old bridle-way marked on the official maps is largely impassable except on foot. Access to the Moor House Field Station, the Reserve Headquarters situated on the eastern side of the Reserve, is from Garrigill. This small village near the market town of Alston, Cumberland, is seven miles distant from Moor House. A mountain road also leads from

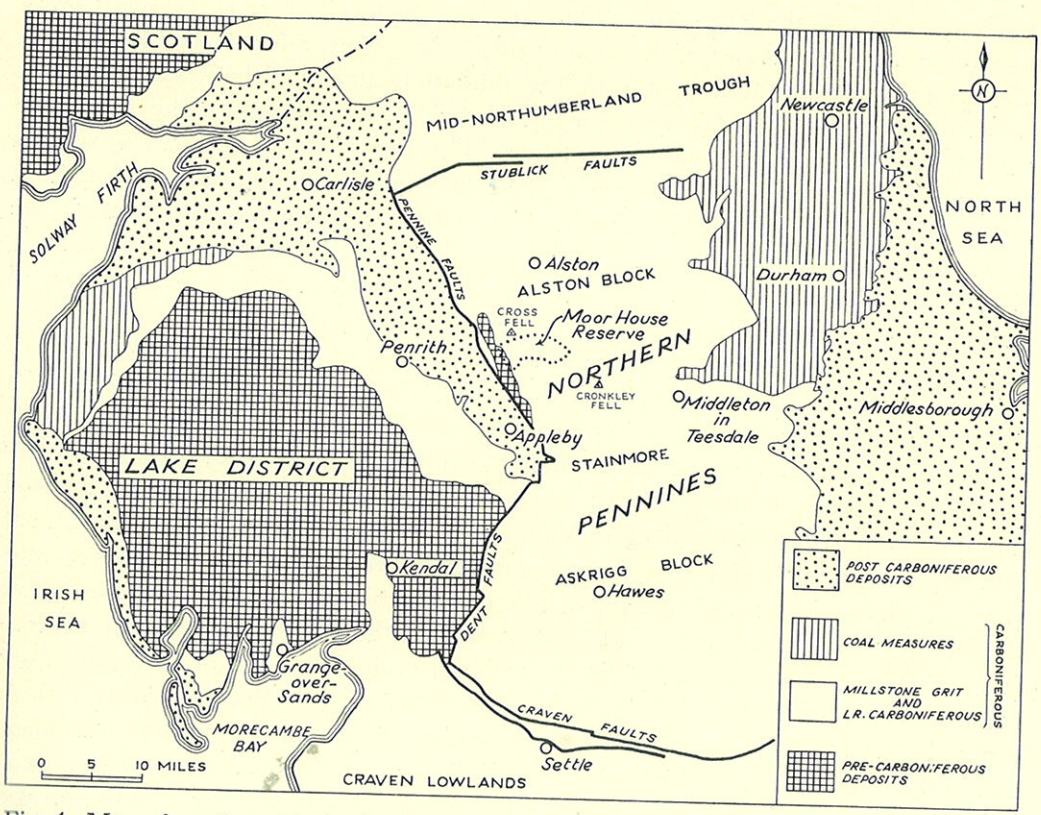

Fig. 1. Map of northern England and the Borders showing the position of the Moor House National Nature Reserve. The geological boundaries are taken mainly from the maps of the Geological Survey.

the village of Knock, in the Eden Valley, to the western boundary of the Reserve and continues to the summit ridge of the Pennine Escarpment. This road is kept open by the Ministry of Aviation who have established a radio-station on the top of Great Dun Fell (2777 ft. O.D.). The four radio-masts on the top of this rounded peak are a conspicuous landmark throughout the region (Plate II). The road from Knock Village to the summit ridge, called the Dun Fell Road in this work, is steep and precipitous but access is allowed as far as Knock Ore Gill Head; beyond this point use of the road is restricted to travellers on foot. The Pennine Way, part of the bridle-way which runs the length of the Pennines, crosses the Reserve from north to south along the summit ridge of the escarpment and is much used by parties of walkers during the summer months.

The Reserve is situated in the north-east corner of Westmorland and the northern boundary, along Crowdundle Beck and the River Tees, is also the county boundary between Cumberland and Westmorland. At Crookburn Foot on the Tees the county boundaries of Cumberland, Westmorland and Durham meet and the eastern boundary of the Reserve, again along the River Tees, is the county boundary between Westmorland and Durham. On the west of the Reserve lies the Pennine Escarpment (Fig. 2) which rises steeply in a series of benches from the low-lying ground of the Vale of Eden. The western boundary of the Reserve lies below the fell wall at the foot of the escarpment. The summit ridge (Fig. 2) of the escarpment is formed by the rounded tops of Great Dun Fell, Little Dun Fell and Knock Fell which are continuous with Cross Fell (Frontispiece). The summit ridge is the watershed between the drainage flowing west into the River Eden and east into the River Tees. The Tees rises on the Reserve at Teeshead below Little Dun Fell. To the east of the summit ridge a long spur, called Knock Ridge, runs into the Tees Valley and the crest forms the southern boundary of the Reserve. Another spur runs eastwards from Great Dun Fell and divides the drainage of the Tees from that of its tributary to the south, Trout Beck. The Tees Valley is normally broad and rounded in the region about the Reserve but forms a wider amphitheatre near its head between Hard Hill and Little Dun Fell. A similar but wider amphitheatre occurs in the Trout Beck drainage area between Knock Ridge, Knock Fell, Great Dun Fell and Hard Hill. Low rounded hills in the Tees Valley at the eastern and north-eastern margin of the Reserve are drumlins and moraines of glacial origin.

Though the Reserve is primarily dedicated to the study of animal and plant ecology of upland peat moors it is most happily sited also from the geological point of view. Within the confines of the Reserve there is exposed the almost complete stratigraphical succession of the Carboniferous rocks of the northern Pennines (Fig. 4). Furthermore, the only continuous sequence of the upper part of the Carboniferous beds in this region is exposed on Great Dun Fell. The Carboniferous succession outcrops on the western escarpment and dips eastwards forming level benches and dip-slopes to the east of the summit ridge (Fig. 2). The ancient foundation rocks, below the Carboniferous sequence, outcrop at the foot of the western escarpment and small areas of these rocks lie within the Reserve (Fig. 1). These rocks are part of the Lower Palaeozoic succession of the geologically famous Cross Fell Inlier. The intrusive Great Whin Sill of quartz-dolerite rock is exposed on the Reserve within the Carboniferous succession on the western escarpment and in the Tees Valley. In this region the sill displays its transgressive nature particularly well. Several mineral veins of lead, zinc, fluorite and barytes are exposed on the Reserve and, owing to the inaccessibility of the region, some of these deposits have never been mined. The Force Burn Vein, carrying barytes with galena (lead ore), is exposed

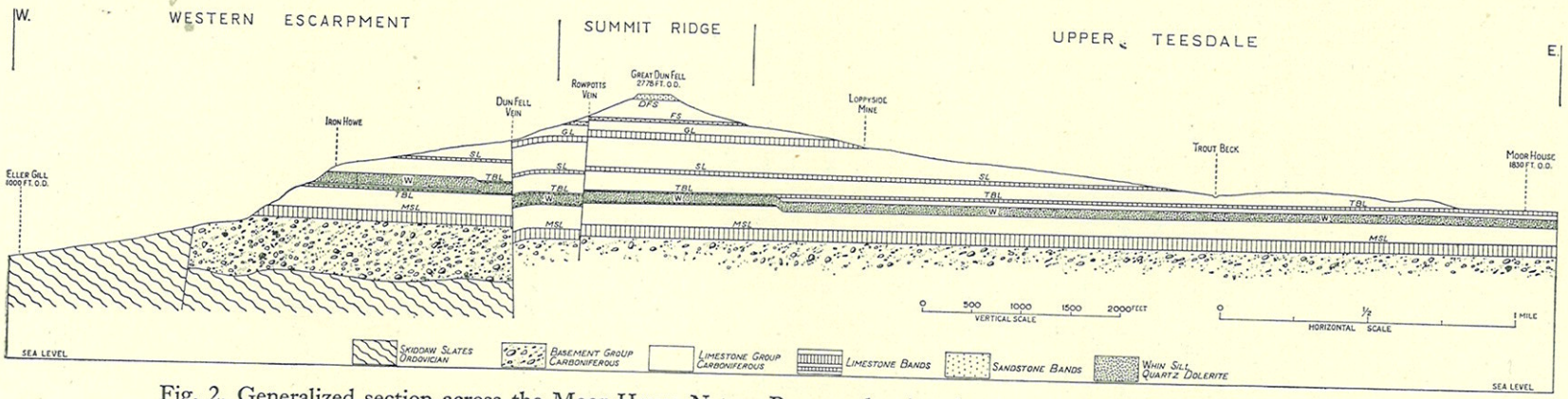

Fig. 2. Generalized section across the Moor House Nature Reserve showing the disposition of the geological formations.

for 500 ft. in the bed of Force Burn near the south-eastern boundary of the Reserve. This vein is one of the very few of these deposits in the northern Pennines which are well exposed at the surface yet unspoiled by mining operations. Glacial deposits of boulder clay and morainic gravel are well developed in the region about the Reserve including moraines left by the last small corrie glaciation of the Pennines which only ended some 10,000 years ago. Peat deposits are developed throughout the region and reach over 12 ft. in thickness in some areas of level or gently sloping ground. Examination of peat stratigraphy shows that periods of widespread birch forest, reed swamp and blanket bog occurred in the area during Post-glacial times. Two deep peat filled basins which give a full record of the Post-glacial vegetational history of the Reserve occur in the vicinity of the Moor House Field Station.

The present-day climate of the region about the Reserve is severe. The annual rainfall at Moor House amounts to an average of 76·3 in. which inevitably means a high number of rain days each year. Average summer and winter temperatures at 55° F and 29·3° F respectively are low and strong winds are common on the exposed fells throughout the year. Under this wet cool climate waterlogged soils are widespread and on these the characteristic peat deposits of the region have formed. The typical present-day mantle of vegetation is made up of ling (*Calluna*), cotton grass (*Eriophorum*) and *Sphagnum* moss together with other bog plants which, however, are less plentiful. Moorland animal and bird life are protected in the region as much as possible and the normal Pennine species are present in the area. Foxes are fairly abundant and have to be kept in check. Sheep grazing takes place over the entire region of the Reserve but the poor pasture will only support one sheep to the acre. Much of the scientific work started on the Reserve is concerned with the native flora of the region and botanical enclosures have been erected at several places. Experiments in obtaining better grazing for stock in the area have begun and trees have been planted in some sheltered places. An account of this and other research which is now in progress on the Moor House Nature Reserve is given in Conway (1955) and Conway *et al.* (1958).

Prior to the year 1951 the area of the Moor House Reserve was a grouse-moor and part of the Appleby Castle Estates. But the region was more important economically for sheep grazing and the mineral deposits it contains. Lead, zinc, barytes and a little coal have been mined in the area and limestone has been worked in large quarries.

Geological Sequence

In describing the geology of the Moor House National Nature Reserve reference will be made to the following formations:

SUPERFICIAL FORMATIONS

Recent and Post-glacial:
- Blanket-peat
- Basin-peat
- Alluvium
- Alluvial fans

Glacial and Periglacial:
- Solifluxion deposits; sandy and stony clays.
- Boulder clay

SOLID FORMATIONS

Upper Carboniferous:

Upper Limestone Group; sandstones, grits and shales with coal seams and limestone bands.

Lower Carboniferous:

Middle Limestone Group; a rhythmic sequence of limestones, shales, sandstones and coal seams.

Lower Limestone Group; massive limestones overlain by thin bands of shale, sandstone and limestone.

Basement Series:

Upper division; sandstones and shales with thin limestones.

Lower division; massive conglomerates with interbedded sandstones.

Great Unconformity

Ordovician:

Skiddaw Slate Series; slates, flags, tuffs and lavas.