Teesdale's Special Flora

Places, plants and people

Margaret E. Bradshaw

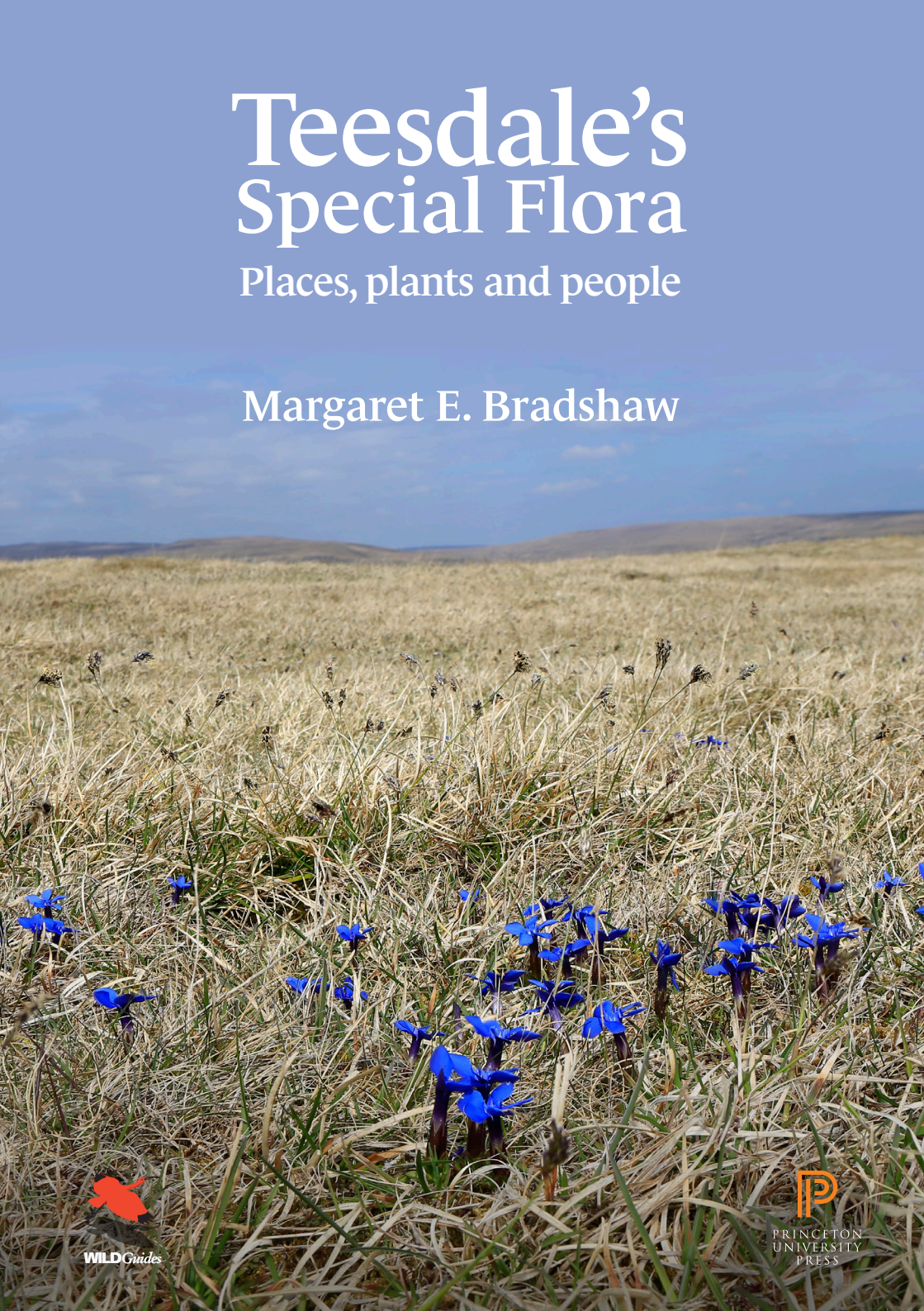
WILDGuides

NATURAL ENGLAND

Teesdale's Special Flora

Places, plants and people

Margaret E. Bradshaw



WILD Guides

PRINCETON UNIVERSITY PRESS

DEDICATION

To S. Max Walters

Published by Princeton University Press,
41 William Street, Princeton, New Jersey 08540
99 Banbury Road, Oxford OX2 6JX
press.princeton.edu

British Library Cataloging-in-Publication Data is available

Library of Congress Control Number: 2022951309
ISBN 978-0-691-25133-2
ISBN (ebook) 978-0-691-25134-9

Printed in Great Britain

10 9 8 7 6 5 4 3 2 1

COVER Spring Gentians; FRONTISPIECE Spring Gentians *both MR*

Contents

Foreword

Teesdale's Special Flora

Upper Teesdale has been revered by generations of British naturalists and for good reason. As the author Dr Margaret Bradshaw clearly points out here "*The Teesdale Assemblage is unique. Nowhere else in the UK do these particular species grow together in a comparatively small area*."

With seventy years' experience in the area, Dr Margaret Bradshaw may be the latest in a long line of botanists drawn to the plant communities of Upper Teesdale but the publication of this important book is particularly timely. A recent survey has revealed that this unique flora has markedly decreased in both quantity and distribution over the last forty years.

'Teesdale's Special Flora' looks at the why as well as the what, and provides valuable context on the area. There is much here for both the professional botanist and the layperson, not least through the identification guide with its excellent photographs of plants that do not always advertise their presence.

Perhaps unusually for a botanist, the author comes from a farming background, having originally grown up on a mixed farm on the Yorkshire Wolds. This has clearly informed her thinking on the relationship between animals and plants along with her genuine interest in those who live and work on the land and their impact on Teesdale's special flora.

As a landowner, I have often seen Margaret at the local agricultural shows for she is well known to the farming community here. She is not shy about proffering botanical advice when asked or even when not, for the viability of rare plant populations is often dependent on land management practices by farmers in the dale. As discussed in the book, small changes in grazing regimes can have a profound effect on plant communities.

Margaret Bradshaw wrote in 2003 "*I have hope that the dale will support the largest number of rare plants in a limited space in Britain after I am gone for we hold in trust the country's oldest heritage in the Dale*." I see Teesdale's Special Flora as part of that legacy along with her establishment of the Teesdale Special Flora Research and Conservation Trust. This will bring huge benefits in providing essential data across the whole of the Tees catchment area in Upper Teesdale to enable this remarkable flora to be conserved for the future. Margaret has studied the flora of Teesdale in more detail than anyone else and over her long career has taught and encouraged new generations of botanists.

When I think of the special flora of Upper Teesdale it is of Margaret in her nineties striding across Widdybank, eyes fixed to the ground, with companions in her wake struggling to keep up. All about her are those big skies, the distinctive moorland air, and a vast seemingly empty landscape that is anything but desolate, for it hides the many botanical treasures that Margaret reveals here. Her boundless enthusiasm for the subject is infectious and I hope that this book will inspire future botanists to safeguard the populations of special plants that are now threatened.

The Lord Barnard DL

FACING PAGE Mountain Avens *MR*.

Preface

This book has had a long gestation of ten years, longer than that of an elephant! Its origin was a request put to me following a weekend meeting of the then English Nature Regional Botanists led by Dr Jill Sutcliffe. I find writing difficult so initially I turned down the request. But, after some thought and wondering who else might write it and how I would feel if someone else was the author, I agreed.

It is a very personal book, including a little of my origin on a farm on the Yorkshire Wolds. Yes, I am an 'incomer' as the locals would say. I appear to have had an inherited attraction to plants from my maternal grandmother. The first I remember were the beautiful flowers of Bogbean, and Water Mint with its very distinctive scent and, in the wood, Great Horsetail, all near Bradshaw's flour mill, once driven by a water wheel. At my first school I was given a buttercup to draw; my effort caused a stir amongst the teachers but no one explained why to me. At Bridlington High School, whilst my usual biology teacher was on sick leave, for one day a week I was taught by Miss Heafford who opened my eyes to the marvellous structures and life of plants. So, the die was cast in favour of plants over art or agriculture (75 years ago, what was offered to a girl at agricultural college other than learn to make cheese or keep poultry?).

At Leeds University I did a Joint Hons Degree in Botany and Zoology (it was wartime so a single subject course was not available). Encouragement there came from Dr H. G. Baker. The ecology course consisted of four large blackboards full of lists of plants taken directly from *The British Islands and their Vegetation* by A. G. Tansley (1939), in the neat hand-writing of Dr Arthur Sledge. Enough to put off any potential field botanist, but, not me.

In my second year I missed out on joining a small group of the staff, including Prof. Irene Manton, on a visit to search for special ferns in Teesdale, which made me wonder what was so special about the plants there. After graduating I became a teacher, first in Derbyshire for one year, then to Bishop Auckland to be within easy reach of Teesdale's special flora. Why it attracted and intrigued me I do not know. At school everybody knew where the 'Blue Gentian' grew in Teesdale, and pupils would bring in a baking-tin filled with moss and studded with Blue Gentian flowers – a local tradition. Bird's-eye Primrose was also familiar but it was not easy to find out what the other species were, nor where they grew. There was one book: *Teesdale* by Douglas M. Ramsden (1947) that did have an Appendix: *Flora of Upper Teesdale* with the times of flowering and their habitats. This was a start for weekend excursions by bus and foot. Fortuitously, the following year I met Dr S. Max Walters of Cambridge who suggested I look for *Alchemilla* species in Teesdale as he had found rare taxa there and offered to send his recent paper on the genus in Britain published in the *Proceedings of the Botanical Society of the British Isles* (BSBI) (Walters, 1947). I switched concentration to this critical group and eventually produced maps of the distributions of five of the nine species in Teesdale and Weardale including one new to Britain. I had become an active member of BSBI soon after meeting Max. Max was my support, inspiration and friend, and I stayed many nights with him, Lorna and their family in Cambridge, at Cory Lodge in the Botanic Gardens; and lastly in Grantchester.

The threat of a reservoir in Teesdale turned my attention back to the rare plants and the need for factual evidence of which of the rare species grew where below the critical, top-water-line of 1,603 ft (489 m) and crucially the percentage of the whole populations of key rare species on Widdybank Fell.

As the world knows, the case was lost and the Cow Green Reservoir was built. ICI donated £100,000 for research in Upper Teesdale. I obtained grants to finance two Research Assistants to do a phytosociological survey of Widdybank Fell and start studies of the population dynamics of several rare species; most of the plots were still being recorded in 2022. A smaller grant supported groups of volunteers, who spend three separate weeks each July mapping the locations of 25 rare species on the sugar-limestone grassland and some flushes on Widdybank Fell. This became the baseline record that was used by J. O'Reilly for comparison with his records of 2017–19.

I am aware that this book has many shortcomings – some critical taxa are not covered, *e.g. Taraxacum*, *Hieracium*, *Salix*, and some aquatic species: some sections written in the early years have not been revisited.

I wish to thank Lord Barnard and the Earl of Strathmore and Kinghorne for access to their Estates, and all other landowners, tenant farmers and gamekeepers who have allowed me to roam over much of Teesdale; also the currently named Natural England for access to the two National Nature Reserves, now combined into the Moor House-Upper Teesdale NNR: and Linda Robinson, Jeremy Roberts, Rod Corner for watershed records and botanical information of vegetation at the higher altitude of the Tees watershed – Cross, Little and Mickle Fells.

I almost succeeded in obtaining photographs of the species taken in Teesdale; apparently it is a rare botanist who likes to photograph aquatics, so thank you John Crellin. Many of the photographs are mine. I knew exactly the shot I wanted: some are historical and unrepeatable, *e.g.* the Cow Green area before flooding; plant communities that have evolved, *e.g. Sesleria–Calluna* heath ravaged by Heather Beetle; and short sedge-marsh overrun by tall rush species. I am grateful for the generous provision of photographs by Martin Rogers, Dave Mitchell, Jeremy Roberts and Geoff Herbert and several others whose names are attached to their pictures. I valued discussions with Ken Park (Researcher), Dennis Coggins (High Force Hotel), Ken Bainbridge (Langdon Beck Hotel), Alan Scott (farmer from Widdybank), Alec Tarn (farmer from Cronkley and Mickle Fells), George Horn (shepherd), John Wearmouth (gamekeeper), all no longer with us, and Christine Bell (farmer Cronkley Fell and Pasture). Thanks are also due to Ken and Mabel Bainbridge and Mary for their kindness to me over many years, and for their hospitality and forbearance when I filled the hotel and used the dining room for studies every evening (the table to be re-set for breakfast afterwards!) for three weeks in each July for almost five years, and Marion at the Youth Hostel. Does any reader remember those happy days?

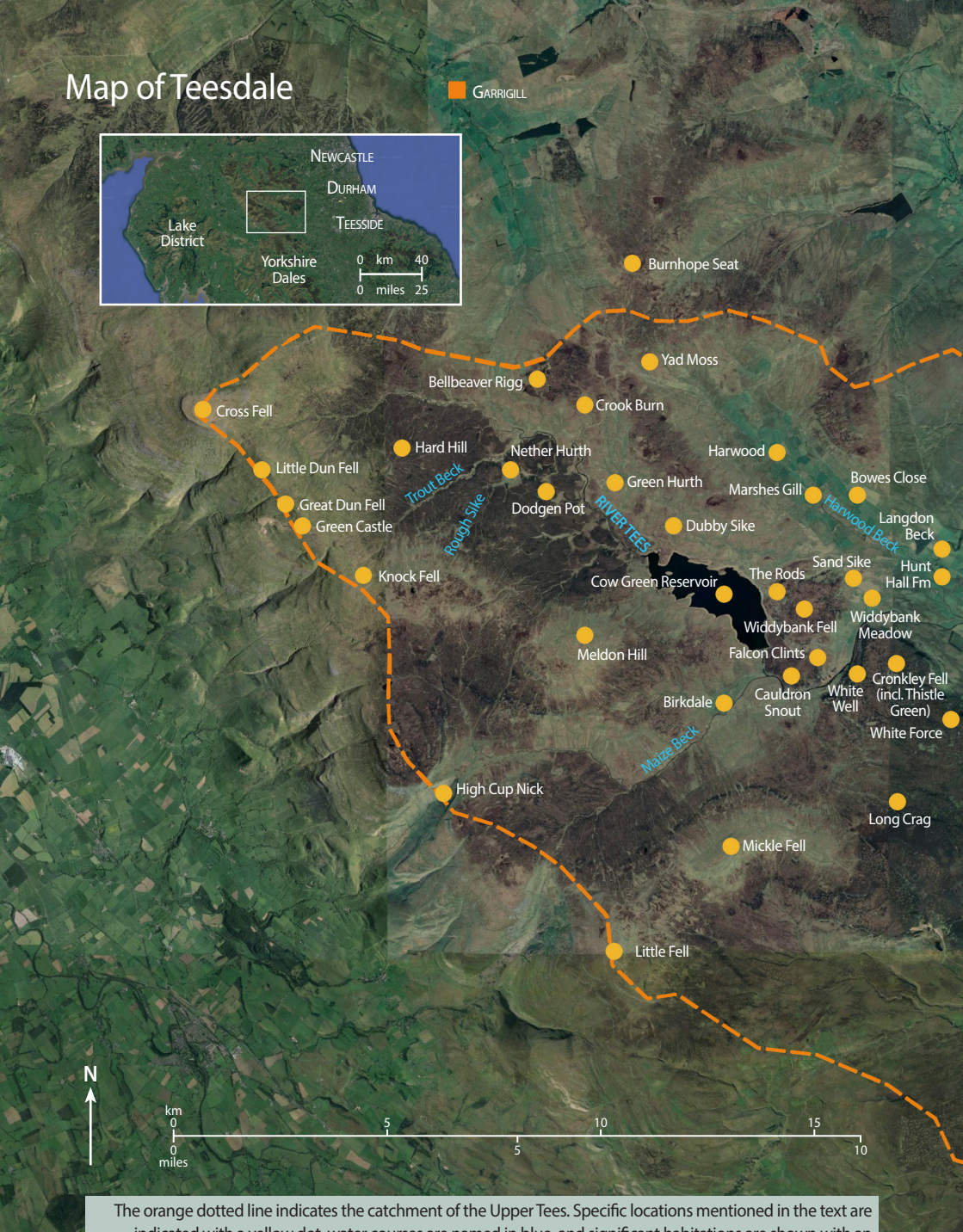
My thanks to the Durham Wildlife Trust for permission to use the map in *The Natural History of Upper Teesdale* (2018) and to Ian Findlay for his input to the section on Weather and Climate on *pages 23–31*.

Lastly, I add my grateful thanks to Jill Sutcliffe, friend and editor, for her patience in staying with me and keeping **WILD***Guides* interested in designing the book, and also for her many pages of contributions to this book.

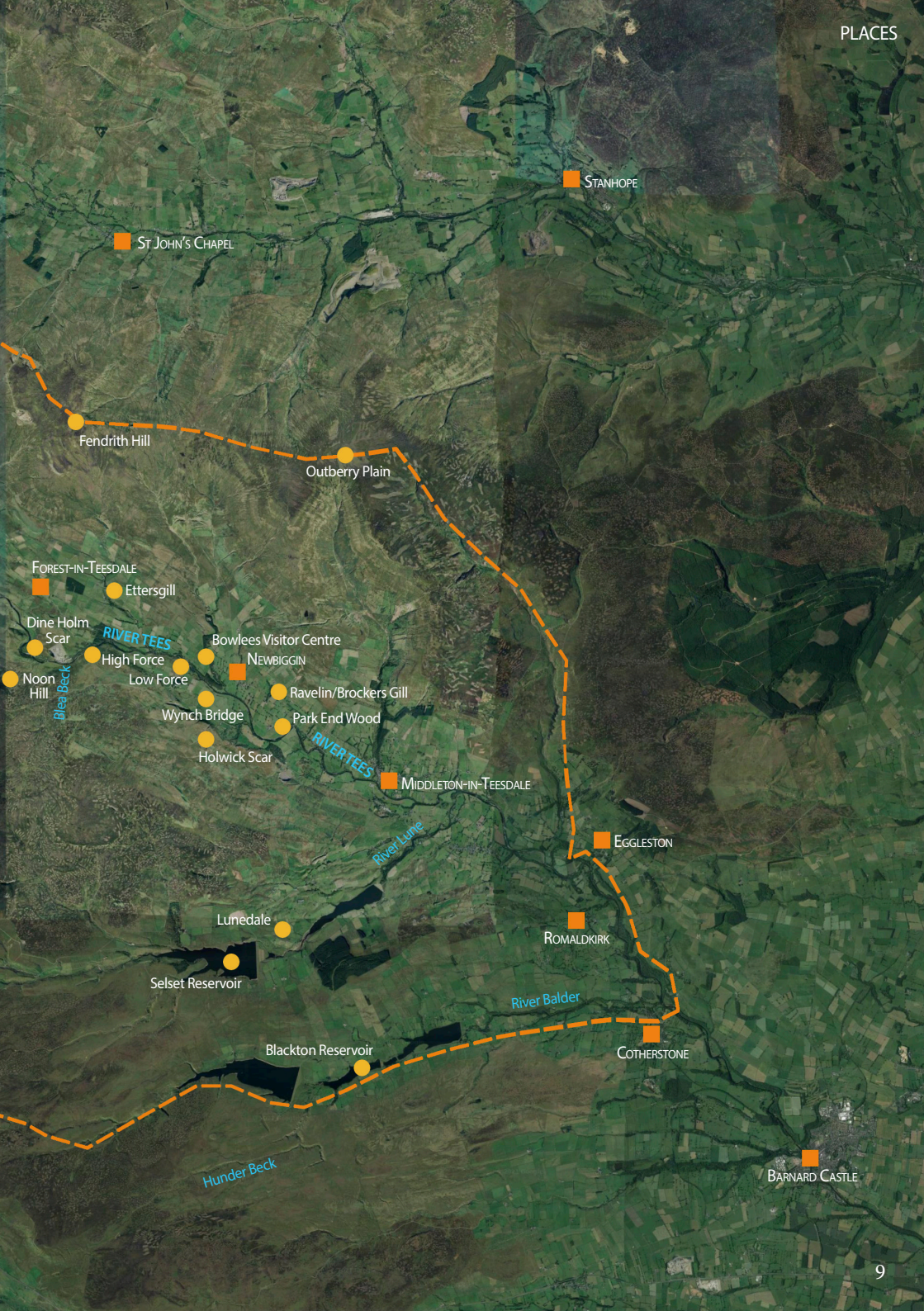
Thank you, Jill.

Margaret E. Bradshaw MBE

Map of Teesdale



The orange dotted line indicates the catchment of the Upper Tees. Specific locations mentioned in the text are indicated with a yellow dot, water courses are named in blue, and significant habitations are shown with an orange square. The *Gazetteer* on *page 277* gives the Ordnance Survey grid reference for each location. See also *page 17* for map showing the extent of the Moor House-Upper Teesdale NNR. *Map based on Google Maps.*


Stanhope
St John's Chapel
Fendrith Hill
Outberry Plain
Forest-in-Teesdale
Ettersgill
Dine Holm Scar
River Tees
Bowlees Visitor Centre
Newbiggin
High Force
Low Force
Noon Hill
Blea Beck
Ravelin/Brockers Gill
Wynch Bridge
Park End Wood
Holwick Scar
River Tees
Middleton-in-Teesdale
River Lune
Eggleston
Lunedale
Romaldkirk
Selset Reservoir
River Balder
Blackton Reservoir
Cotherstone
Hunder Beck
Barnard Castle

Introduction and significance of the Teesdale flora

To the author, Upper Teesdale means blue sky, white clouds and a landscape of many shades of green and brown, air like mountain spring water and a very special place of rare and fragile plants, plant communities and renewal.

Please halt, switch off radio, mobile phone, etc. Now look around at the sky…the landscape… the vegetation; now look again…what more can you see? Listen…what can you hear…what can you not hear? What do you smell…what can you not smell? What do you feel under your feet? Is it hard – is it soft – is it soggy – is it wet – is it dry? Remember and repeat all of these at home, in a supermarket carpark or town centre!

There is a core of vascular plant species traditionally known as the Teesdale Assemblage, and a halo of noteworthy plants. All are rare to some extent, one grows only here, and others are on the edge of their range in Britain. Here is my personal selection from among these special plant species.

This assemblage is unique; nowhere else in the UK do these particular species grow together in such a comparatively small area. It is generally understood that the majority of them are relics of a flora that was widespread in Britain at the end of the Ice Age, 12,000–15,000 years ago. Fragmentation of their original distribution patterns took place during the subsequent warmer, and later wetter, periods. These plants had originally formed a more or less continuous land cover up to then.

Just consider – from the evidence available – it is thought that some of these species have had a continuous presence in Upper Teesdale since the late glacial times. This means they are part of our oldest heritage and a good reason why these flowering plants should be treasured and protected. Many are small and fragile and the habitats in which they grow are themselves unstable: crumbly sugar-limestone, shallow stony streams, eroding river margins, soft damp marshes and cliffs, all of which can be easily damaged by trampling and climbing. Even closed, species-rich turf can be worn out, like a carpet. Therefore, great care is needed if they are to survive this century and beyond.

In 1950, I moved to County Durham, having heard that this place, Teesdale, had a particularly interesting flora. With no contact with anyone who knew these plants, it was not easy to discover the identity of this flora and where it grew. In his book Teesdale (1947), D.M. Ramsden aimed 'to give a picture of Teesdale' as it was in 1946, and included a list of the plants in an Appendix. So, with this list and a flora (pre-Clapham, Tutin & Warburg's *Excursion Flora of the British Isles*, 1959) I started to visit Wynch Bridge, Widdybank and Cronkley Fells at weekends, using the bus service to Bowlees (High Force in summer), thus reducing the great distances walked by those active explorers of the early 19th century. I well remember meeting two gentlemen in long gabardine coats at the east end of the sugar-limestone and trying in vain to get confirmation that the violet I was looking at was *the* Teesdale Violet and, on another occasion, that I had found the Dwarf Milkwort on Widdybank Fell, said at that time to be only on Cronkley Fell. My dedication to the plants of Teesdale really took off a year later when I was fortunate to meet the late Dr S. Max Walters who suggested, in characteristic style, that I might like to 'look at' lady's-mantles. That very first summer of 1951, with the luck of a beginner, I found a meadow species which he identified for me as new to Britain. This was an inspiring result given my ignorance of the classical localities for the recognized rarities and of botanising elsewhere in the dale.

Plant assemblages An assemblage of plants is a collection of rare and local species, each strongly, sometimes exclusively, linked to an area. Other places that famously have particular botanical interest include the Brecks in Norfolk/Suffolk, Ben Lawers in Perth and Kinross, the Burren in Co. Clare, Ireland and the Lizard Peninsula in Cornwall. The species within the assemblage plants do not all grow in the same plant community, or even habitat, but within a defined geographic area. The members of the Teesdale Assemblage are to be found in a number of different habitats and plant communities; some occur in several, whilst others can be very specific and limited to one habitat, feature or locality. The species listed below form the core of the Teesdale Assemblage. These and the other species that can be considered to be part of the assemblage are the subject of species accounts in this book.

Why is the flora of Upper Teesdale so special?

Today, we know that the botanical 'hotspot' of Teesdale is home to a unique assemblage of plants in Britain, including the 21 notable taxa listed in the table *below*.

The only location in the world for one subspecies:		**Page**
Hoary Rock-rose	*Helianthemun oelandicum* ssp. *levigatum*	*134*
The only location in the UK for two species:		
Teesdale Sandwort	*Sabulina stricta*	*145*
Spring Gentian	*Gentiana verna*	*156*
Aalmost the only location in the UK for one species:		
Large-toothed Lady's Mantle	*Alchemilla subcrenata*	*117*
The only location in England for five species (although these also occur in Scotland):		
Scottish Asphodel	*Tofieldia pusilla*	*177*
False Sedge	*Carex simpliciuscula*	*206*
Alpine Foxtail (HIGH-LEVEL)	*Alopecurus magellanicus*	*211*
Alpine Forget-me-not (HIGH-LEVEL)	*Myosotis alpestris*	*159*
Sheathed Sedge (HIGH-LEVEL)	*Carex vaginata*	*198*
The northern end of the range of four species found in England:		
Horseshoe Vetch	*Hippocrepis comosa*	*101*
Hoary Rock-rose	*Helianthemun oelandicum*	*134*
Rare Spring-sedge	*Carex ericetorum*	*200*
Dwarf Milkwort	*Polygala amarella*	*103*
One of only four sites in the UK for one species:		
Teesdale Violet	*Viola rupestris*	*124*
One of only three sites for a hybrid in the UK:		
Teesdale × Common Dog-violet	*Viola* × *burnatii*	*126*
At, or almost at, the southern end of the range of the UK range for six species:		
Alpine Rush	*Juncus alpinoarticulatus*	*183*
Dwarf Birch	*Betula nana*	*123*
Shady Horsetail	*Equisetum pratense*	*73*
Alpine Bartsia	*Bartsia alpina*	*166*
Mountain Avens	*Dryas octopetala*	*104*
Marsh Saxifrage	*Saxifraga hirculus*	*93*
One of only two sites for one species in England:		
Shrubby Cinquefoil	*Dasiphora fruticosa*	*110*

So, Teesdale supports a mixture of plants not usually seen growing together. In Upper Teesdale there are plants that are at, or almost at, the **southern** end of their range in Britain and species that are at the **northern** end, as well as plants that have a distribution across the **north of England** and out to the **west of Ireland**. Nowhere else in Britain are so many species of different phyto-geographical patterns found together as in the comparatively small triangle of the catchment of the Tees from just east of Wynch Bridge to the tops of Cronkley and Widdybank Fells which, in turn, form the nucleus of the larger triangle comprising the head of Teesdale and the hills immediately surrounding it.

In 1868, J. G. Baker wrote of this area: "*There is probably no ground in Britain that produces so many rare species within a limited space as Widdy Bank Fell.*" He listed 32 acknowledged rarities from an area of approximately 10 km^2 (4 sq. mi.) of Upper Teesdale that is very well-known to botanists today. To many, this richness in rare and local species has remained a very valid attraction, but with the development of botany as a science, the original 'floristic' approach stimulated studies of greater depth and wider importance over the last century. Comparative plant geographical studies have shown that the Teesdale Assemblage is outstanding not only in terms of its British distribution, but also its Eurasian and total world-spread, representing a remarkable mixture of diverse phyto-geographical elements.

Table 1 (*opposite*) gives a short list of the Teesdale Assemblage plants (Matthews, 1955); a longer list that includes the Geographical Elements of all 96 species described in this book is in Preston & Hill (1997).

Thus, growing in Teesdale are northern and montane species, *e.g.* Alpine Bartsia and Mountain Avens, which are centred in the Alps and the Arctic, and others that are found predominantly in one region or the other – *e.g.* Alpine Foxtail in the Arctic, Spring Gentian in the Alps. Teesdale Sandwort and the more abundant Cloudberry are Arctic-Sub-Arctic, although the Teesdale Sandwort may now be extinct in the Alpine foothills thereby making Teesdale its most southern location. Also occurring on Widdybank Fell are Teesdale Violet, Rare Spring-sedge, Bird's-eye Primrose, Dwarf Milkwort and the Wrinkle-leaved Feather-moss – all continental northern species not particularly associated with high altitudes or high latitudes. Finally, and perhaps most remarkably, is the presence of the continental southern species Hoary Rock-rose and Horseshoe Vetch, at their most northerly and highest British locations.

The real significance of the co-existence of so many geographical elements is better appreciated when viewed in the context of the surrounding vegetation, which is characterized by such typically western European heath and bog species as Heather, Cross-leaved Heath and Bell Heather, Bog Asphodel, Heath Rush and Hare's-tail Cottongrass.

On a national scale, the distribution patterns of the Teesdale Assemblage show a similar diversity. For example, Widdybank Fell is the only location for Teesdale Sandwort and one of only three for the hybrid Teesdale Violet × Common Dog Violet, although the rarer parent, Teesdale Violet, is also known in three other localities on unaltered limestone or glacial-drift deposits. The Teesdale population of False Sedge far exceeds the sum of the populations in its only other British locations, which are in the Central Highlands of Scotland. Teesdale provides an unusually *low-altitude* location (< 540 m) at or near the southern end of the range of many northern and montane members of the Teesdale Assemblage. This is particularly so for Scottish Asphodel, for which there are no other extant records south of the Highland Fault.

Table 1 | The Geographical Elements in the Teesdale Assemblage of Flowering Plants
(Matthews, 1955)

CONTINENTAL SOUTHERN	
Hoary Rock-rose	*Helianthemum oelandicum*
Horseshoe Vetch	*Hippocrepis comosa*

CONTINENTAL NORTHERN	
Rare Spring-Sedge	*Carex ericetorum*
Northern Bedstraw	*Galium boreale*
Dwarf Milkwort	*Polygala amarella*

NORTHERN MONTANE	
Starry Lady's-mantle	*Alchemilla acutiloba*
Velvet Lady's-mantle	*Alchemilla monticola*
Large-toothed Lady's-mantle	*Alchemilla subcrenata*
Mountain Everlasting	*Antennaria dioica*
Shrubby Cinquefoil	*Dasiphora fruticosa*
Bird's-eye Primrose	*Primula farinosa*
Small-white Orchid	*Pseudorchis albida*

OCEANIC NORTHERN	
Thrift	*Armeria maritima*

ARCTIC-SUB-ARCTIC	
Rock Lady's-mantle	*Alchemilla wichurae*
Alpine Foxtail	*Alopecurus magellanica*
ARCTIC-ALPINE	
Bearberry	*Arctostaphylos uva-ursi*
Alpine Bartsia	*Bartsia alpina*
Dwarf Birch	*Betula nana*
Alpine Bistort	*Bistorta vivipara*
False Sedge	*Carex simpliciuscula*
Hoary Whitlowgrass	*Draba incana*
Mountain Avens	*Dryas octopetala*
Teesdale Sandwort	*Sabulina stricta*
Spring Sandwort	*Sabulina verna*
Yellow Saxifrage	*Saxifraga aizoides*
Marsh Saxifrage	*Saxifraga hirculus*
Scottish Asphodel	*Tofiedia pusilla*
Teesdale Violet	*Viola rupestris*

ALPINE	
Spring Gentian	*Gentiana verna*
Alpine Forget-me-not	*Myosotis alpestris*
Alpine Penny-cress	*Noccaea caerulescens*

With regard to the southern species, Teesdale provides an unusually *high-altitude* location (540 m) at the northern extremity of the range of the three species with southern affinities – Rare Spring-sedge, Hoary Rock-rose and Horseshoe Vetch. A fourth group consists of species mainly absent from Scotland and southern England but also found in western Ireland; it includes Spring Gentian, Shrubby Cinquefoil and Blue Moor-grass (very rare in Scotland). To this group also belong the three meadow Lady's-mantle species, Starry, Velvet and Large-toothed, which are almost confined to Durham county. Other notable rare and local species include Hair and Slender Sedges, Tall Bog sedge, Bog-sedge, Hoary Whitlowgrass, Variegated Horsetail, Three-flowered Rush, Spring Sandwort, Alpine Bistort, Yellow and Marsh Saxifrages and five species of moss. A further special feature of interest exhibited by several species is that taxonomically they are represented by local varieties in Teesdale.

Pigott & Walters (1954), curious to know why certain localities in Britain supported 'assemblages' of rare plants, analysed 20 locations where high frequencies of rare species occur today, and noted they had only two features in common – freedom from tree competition and relatively high base status of the soil, *i.e.* containing basic salts (*e.g.* lime). They listed seven groups of habitats which (it is reasonable to suppose) have continuously provided a soil of sufficient base status; since the end of the last Ice Age, and even in the warmest Forest Maximum period, they could never have carried closed woodland over their whole area. These groups are as follows:

1) mountains above the tree limit (which was higher than it is today) allowing high light intensity giving only partial shade;
2) inland cliffs and screes;
3) sea cliffs;
4) river gorges, eroded riverbanks, river shingles, alluvium, *etc.*;
5) sand dunes and dune slacks;
6) shallow soils over chalk and limestones, especially on steep slopes; and
7) certain marsh and fen communities, lake shores.

It is yet another remarkable character of Teesdale that no fewer than five (1, 2, 4, 6 and 7) of these seven groups of habitats are present, and these do support high frequencies of the rare species. Examples of all these five types can be found in the Tees Catchment. The highest parts of Teesdale comprise the 'mountains above the tree limit' habitat (Group 1) although, it is now known that there were scattered small trees on the summit of Cross Fell. These still support the Alpine Forget-me-not, Alpine Foxtail and Sheathed and Water Sedges. On inland cliffs and screes (Group 2) of Whin Sill and limestone from Scorberry Bridge to Cauldron Snout are Rock Whitebeam, Aspen (surely a relict species here), Common Juniper, Bearberry and many small herbs found also in other habitats – Alpine Cinquefoil (very scarce), Hoary Whitlowgrass, Mossy Saxifrage and Rock Lady's-mantle. The habitats of Group 4 are numerous by the Tees and its tributaries and support very many species. The shingle and rocks of the bed of the Tees are well known as the habitat of the Shrubby Cinquefoil, a species with a disjunct distribution in two arcs across Eurasia from its centre of origin in East Asia. The northern arc linking populations in western Ireland, Lakeland, Teesdale and Öland (Sweden) is of dioecious (separate male and female) plants, whilst the flowers of the southern are all hermaphrodite. These riverside sites are becoming increasingly important as modern refugia.

Large-toothed Lady's-mantle *MEB*.

Cross Fell summit polygons, A. V. Jones, *c.* 1969 *MEB*.

Shallow soil on sugar-limestone *MEB*.

Metamorphosed (sugar-)limestone rock and sand *TS*.

Eroded riverbank with **Water Sedge**, 2016 *MEB*.

Cliffs and screes, Holwick Scar *MEB*.

Short sedge-marsh *MR*.

A recent study of Globeflower in two areas, one just higher than the other, has shown that although the species is still quite widespread in the higher area, it is now virtually restricted to the banks of the Tees and near some small streams below High Force. Above High Force, river erosion of the drumlins has produced a fine series of habitats showing varying degrees of instability and colonisation. Undercutting by the river is just sufficient to maintain a state of instability, which prevents the development of a closed community – here, many of the rare species find a niche. Sites like this will have been continually available since the pre-forest period. When the course of the river has changed following catastrophic floods, new eroded banks have formed, although some older banks have become completely grassed over and without rare species. Others have been so strongly undercut that large lumps of loosely aggregated vegetation have slipped off the over-steepened slope, leaving an extensive bare face. These communities of the eroding drumlins are variants of the 'turfy marshes' (Group 7) which occur on the slopes and hollows in the undulating moraine deposits in Widdybank and Cronkley Pastures. Frequently these develop under the influence of trampling in the unstable zone below the springs and seepage-lines on the drumlins. The characteristic vegetation contains many small sedges (including Hair Sedge) and other Cyperaceae, with Spring Gentian, Bird's-eye Primrose, Common Butterwort, Lesser Clubmoss, Northern and Early Marsh-orchids and Scottish Asphodel. Here too, is Alpine Bartsia, a Durham species absent from the Cronkley area today. These habitats belong to Pigott & Walters' (1954) 'certain marshes' of Group 7. Finally, the other habitats belonging to Groups 6 and 7 are confined to, or mainly associated with, the sugar-limestone and flushes on the higher parts of Cronkley and Widdybank Fells. These support Spring Gentian, Mountain Everlasting, Hair Sedge, Alpine Bistort, Mountain Avens, Bird's-eye Primrose, Scottish Asphodel, False Sedge and many others.

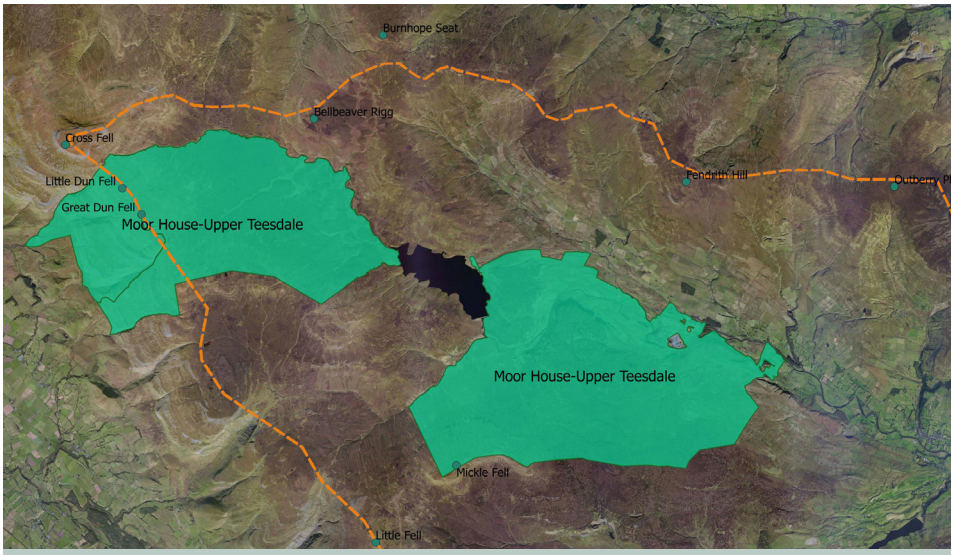
Of equal scientific significance and interest is the mosaic of rare and common plant communities. Those with large numbers of rare species (rare communities themselves) are interspersed amongst vegetation characteristic of the British uplands and indeed the western seaboard of Europe, that is blanket bog and upland heath.

Fen, Wheysike House *MEB*.

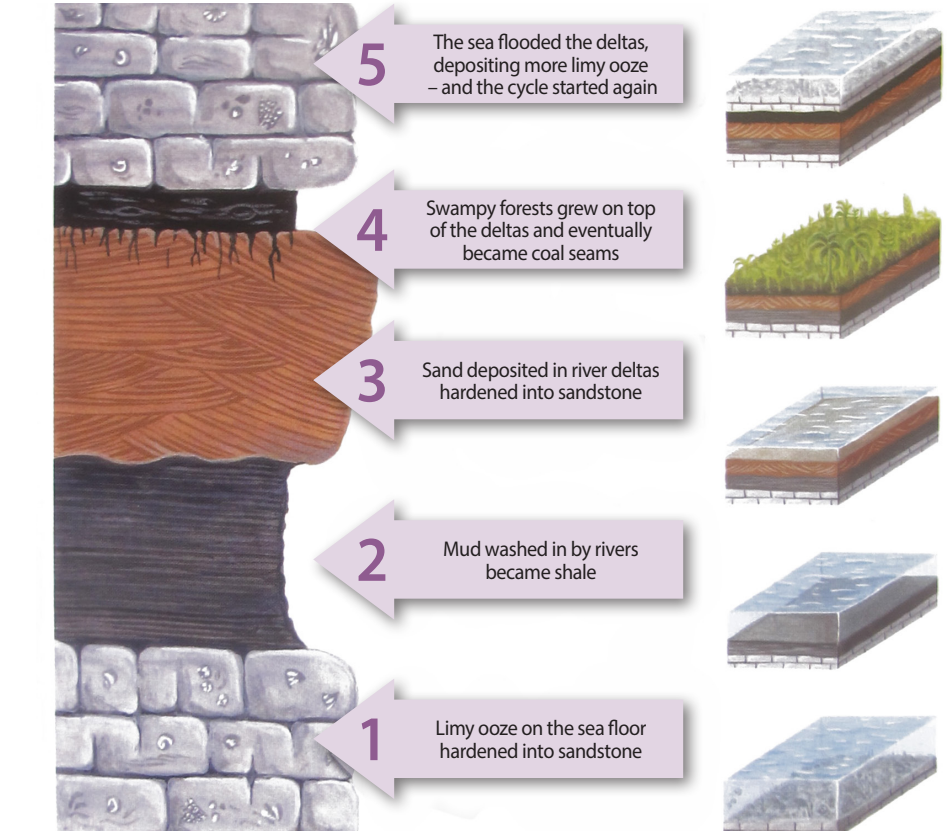
The area, geology and soils

The area of interest covers the broad valley of the Tees in the North Pennines west of the north/south National Grid line NZ915 through the junction of the Balder and the Tees. It is bounded by the watershed on the south-west above the Eden escarpment, from the north side of the Balder to the watershed, then via Mickle Fell (797 m), Little Fell (753 m), High Cup Nick (550 m), Meldon Hill (767 m), the two Dun Fells – Great (842 m) and Little (848 m) – to the summit of Cross Fell (893 m) and on to the NW via Bellbeaver Rigg (620 m) and the watershed with Weardale in the north-east from Burnhope Seat (746 m), Fendrith Hill (696 m) to Outberry Plain (675 m) and the west side of Eggleston Burn to the Tees Fell, Cross Fell, Burnhope Seat and Fendrith Hill. The major tributaries of the Tees are the Maize Beck, Harwood Beck, the Lune, the Balder and the lesser Eggleston Burn, to the north.

The River Tees is unique in its upper reaches. It rises from the eastern slope of Cross Fell at approximately 760 m and, as a typical mountain stream, rushes down to Trout Beck Foot (530 m). Then, it meanders slowly like a lowland stream between drumlins to the top of Cauldron Snout, a gentle fall of only 36·6 m over eight kilometres (almost five miles) creating the Weel, now submerged in the Cow Green Reservoir. From there it cascades down Cauldron Snout (61·5 m fall over 180 m), and on to High Force (21 m vertical fall) and Low Force (5·5 m near-vertical fall) over a rocky bed often between hard rock cliffs and then under Wynch Bridge and between more drumlins and flood plains to Cotherstone and beyond. In places, the moraines are eroded into steep banks and in others shingle-beds have formed to the inside of bends. Two major tributaries join the Tees – the Maize Beck below Cauldron Snout and about six kilometres further on the Harwood Beck, and thence by numerous becks, burns and sikes. Between the meanders of these smaller streams mini-flood plains have formed. Since the building of the Cow Green Reservoir the flow of the river is more constant, but impressive spates still occur, especially when the Maize Beck



Map of Upper Tees catchment showing the Moor House-Upper Teesdale NNR. *Map based on Microsoft (Bing) Maps.*



Typical Yoredale series of cyclical rock strata
(reproduced with permission from *Reading the Rocks* (*p. 13*), www.landscapesforlife.org.uk).

has received heavy rain when the reservoir is full and water overflows the dam, and also following periods of heavy, prolonged snowfall followed by a rapid thaw.

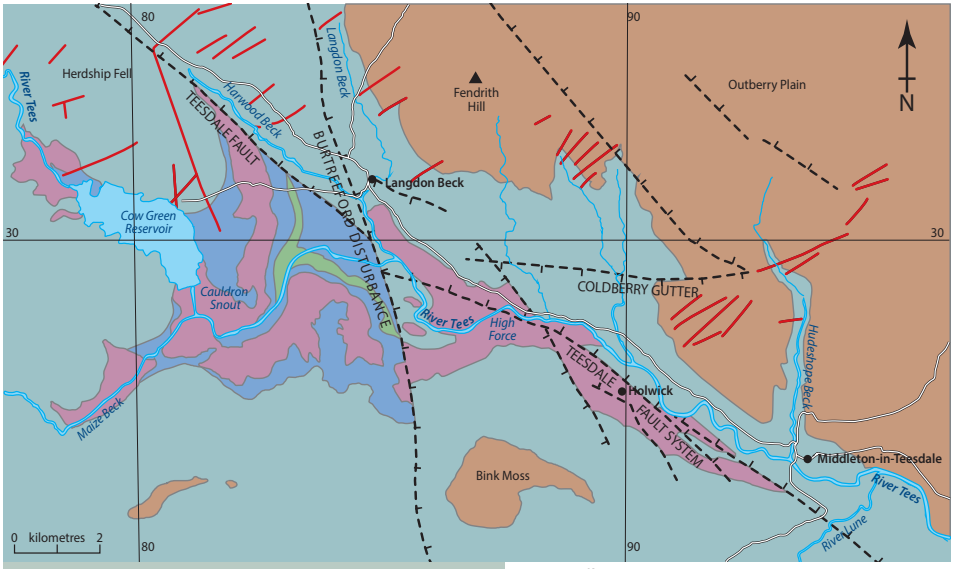
Geology

The Carboniferous lithostratigraphical classification of northern England, including the North Pennines, has endured some changes in recent years. Many make good sense and better assist the classification, correlation and description of these rocks. The bedrock (solid geology) of most of Upper Teesdale comprises from the lowest levels the Marsett, Melmerby, Alston and Stainmore formations within the Ravenstonedale, Great Scar Limestone Group and Yoredale Group. The Ravenstone Group contains the basal conglomerate and associated shales and sandstones seen at the foot of Falcon Clints and on Cronkley Scar. Under these is the Teesdale Inlier, a small exposure of the oldest rocks – the Ordovician (Palaeozoic) – near the Tees below Cronkley Scar; this is insufficient to be of floristic significance.

The Melmerby Scar and Robinson limestones are our local representatives of the Great Scar Limestone Group (characteristic of/and familiar in the Craven area) the former is the sugar-limestone of Widdybank and Cronkley Fells and the latter forms the skyline on the North side of

the track to Birkdale south of Slapestone Sike. All of the remaining Carboniferous succession up to the base of the Coal Measures is now termed the Yoredale Group and is subdivided into the Alston Formation (beds between the top of the Robinson and the top of the Great Limestone) 18 m thick and prominently exposed on the north side as High Hurth Edge, and the Stainmore Formation from here to the base of the Coal Measures. Here are some very coarse sandstones, as on Cross Fell, but they are not the true Millstone Grit of the South Pennines.

The light-coloured Melmerby Scar Limestone, about 40 m thick in total, is a particularly pure limestone where the absence of carbon contributed to it being metamorphosed into crystalized marble known as sugar-limestone. This has been and is of great, botanical significance. It was split into lower thin and upper thick layers in the early Permian (radiometric dates *c.* 295 million years ago) by hot magma from the Earth's centre intruding into these rocks in northern England and gradually cooling to form the quartz-dolerite rock known as Whin Sill (quarried as whinstone). This igneous rock baked the adjacent rocks producing, for example, the famous metamorphosed limestone, known as sugar-limestone and mudstone/whetstone from small pockets of clay within the limestone. The North Pennine mineralization was emplaced very soon after the intrusion of the Whin Sill. The main pattern of faulting, with many of the conjugate pattern of faults occupied by mineral veins must post-date the Whin Sill emplacement/intrusion, but very soon afterwards, as in Teesdale, there are examples of North Pennines mineral veins that have been interpreted as having formed whilst the Whin Sill was very hot and cooling. The most important minerals include galena (lead sulphide), baryte (heavy spar), fluorite, which is scarce in Teesdale, and quartz – all of economic importance and some botanical significance. Also present are small quantities of pyrite ('fool's gold') and sphalerite (zinc sulphide, 'blackjack'). The Burtreeford Disturbance is



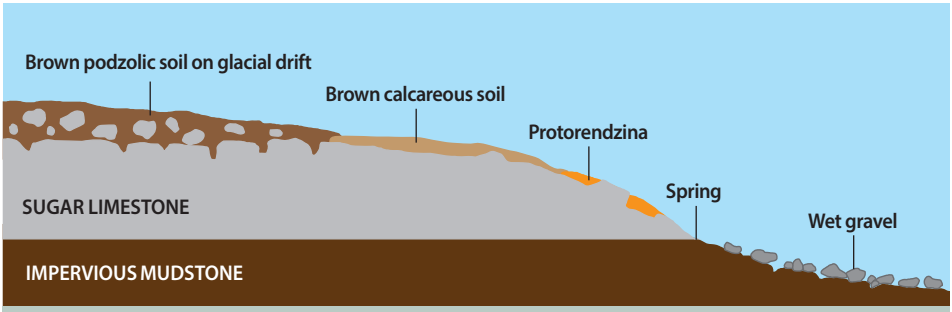
Simplified geological map depicting the bedrock of Teesdale. NB for clarity, many mineral veins and some fault lines have been omitted. Quaternary Research Association (permission to reproduce has been given by D. J. A. Evans, Editor of the QRA publication that contains this illustration).

a rather unusual north–south-orientated fracture zone where faulting was accompanied by some folding. There is plausible evidence for it being initiated pre-Whin Sill, but it has clearly moved again post-Whin Sill. This part of the Pennines is criss-crossed by many faults, resulting in the British Geological Survey 1:25,000 map no. 36, *sheet NY82* and *part of NY92 Middleton-in-Teesdale* (1974) being a fascinating mosaic of colour.

More recently in the geological timetable, successive glacial periods of the Pleistocene Great Ice Age covered the country's rocks with thick sheets of ice. When the ice of the final Ice Period melted, glacial drift had been deposited in successive occasions over all but the steepest slopes on the dip slope that is the Tees catchment area (Upper Teesdale). This is made of the ground-up remnants of only the local rocks (limestone, sandstone and Whin Sill and the shales which became clay) and minerals, as it is only in Baldersdale and to the east that there is evidence of glacial deposits from outside the area. Geologists claim the various blanket and basin peats as the youngest geological deposits. These are formed from plants, the most important being the Imbricate Bog-moss that can still be found in very small quantities on Widdybank Fell today. Depending on the topography the peat bogs lie mainly between approximately 455–670 m. At lower altitudes are lateral moraines and many drumlins easily seen in the floor of the dale below and above High Force and also evidence of a former course of the Tees, as can be seen in the photograph of Holwick Scar (*below*). These are of great botanical importance.

Holwick Scar *MR*.

Two mosses from Widdybank Fell – both are relict species: Imbricate Bog-moss (LEFT) and Rusty Bog-moss (RIGHT) *both MEB*.



Profile of calcareous soils on Widdybank Fell (after Clapham, 1978).

Soils

On the exposed outcrops subject to erosion very shallow grey or almost black rendzina soils have developed. These differ from soils on unaltered limestone in the frequency with which they become dry and, if unprotected by vegetation, are subject to wind-erosion. In a strong wind I have experienced blown loose 'sand' to a depth of 20–30 cm on Cronkley Fell. Away from the eroding edges, the limestone is covered with various depths of glacial drift material. Where this is very shallow it is usually well-drained and greatly influenced by the limestone to give a brown loamy soil, known as a mull rendzina or calcareous brown soil. Earthworms are plentiful and attract Moles, which provide yet another cause of extensive surface disturbance. As the drift becomes deeper the influence of the limestone diminishes and brown podsolic soils develop. Where deep drift impedes drainage typical peaty gleys and organic soils are formed.

Where the metamorphosed limestone (sugar-limestone) rests directly on the impermeable dolerite, or there is a thin layer of metamorphosed mudstone within the limestone, springs emerge at the junction to form spring-heads and the calcareous water flows over the impermeable surface to form small or extensive areas of wet gravel – the so-called gravelly flushes. It is on these shallow rendzina soils that the rarest of the Teesdale species grow together: Teesdale Violet, Mountain Avens, Hoary Rock-rose, Rare Spring-sedge and in damper places False Sedge.

An issue under sugar-limestone onto Whin Sill rock. Widdybank Fell *MEB*.

Rendzina soils overlying sugar-limestone rock at Widdybank Fell *MEB*.

Weather and climate

AUTHOR'S NOTE: Most of this chapter appeared in *The Natural History of Upper Teesdale*, 5th edn. (2018) edited by Steve Gater. It was written by Ian Findlay, who gave me permission to include, modify and update it prior to the book's publication.

Manley noted that the mean May temperatures at the summit station were similar to the mean January temperatures in London and he considered the climate in Upper Teesdale similar to that at sea level in Iceland!

Introduction

The weather in Teesdale has changed since I started to visit nearly 70 years ago. As for the first 50 winters, these were 'proper winters' – cold with lots of snow and ice. For several years I remember seeing a patch of snow on Cross Fell that had lasted all summer. When I returned in 1998 after nearly 20 years in Devon changes were on the way; I did not believe the locals who said "*we do not get the snow and blocked roads we used to*" – they were almost correct, as can be seen from the data in Ian Findlay's outline.

Geographically, the Pennines are unique within England, because they are the only significant upland area that is not close to the sea. This fact has implications for the climate and, given that the River Tees has its source close to Cross Fell (the highest summit in the Pennine chain), Upper Teesdale has its own climatic conditions.

The dale is also unique in having more data and long-term weather stations than any other UK upland area. A continuous temperature record is available from 1931 (Holden & Adamson, 2001). Gordon Manley, of Durham University, began recording at Moor House at 550 m in the 1950s, using a hut close to the summit of Great Dun Fell (at 850 m, the second highest Pennine summit). Designation of the area as a Site of Special Scientific Interest (SSSI) in 1948, then as a National Nature Reserve (NNR) in 1952, led to Moor House being established as a Nature Conservation field station and daily recordings were made for almost 30 years.

Reservoirs built in Selset and Lunedale (1955) and Baldersdale (1960) took advantage of the heavy local rainfall and, despite strong opposition, Cow Green Reservoir was built in the late 1960s. Significant funding was provided for research to monitor any changes associated with the reservoir, including the effect such a large body of water might have on the micro-climate. A weather

High wind and snow *MR*.

Icicles in Teesdale *MR*.

Weather station at Widdybank Fell (510 m) *MR*.

Relocated weather station at Langdon Beck (370 m) *MR*.

station was set up on Widdybank Fell (510 m) for daily recording, the data being analysed by local universities and sent to the Met Office, which took over the recording in 1974. Records were mostly made by Ian Findlay until his retirement in 1996, when he relocated the weather station to his home at Hunt Hall Farm, Langdon Beck (370 m). He has continued recording ever since.

What are conditions like?

> *"We therefore form a conception of excessively windy and pervasively wet autumn, a very variable and stormy winter with long spells of snow cover, high humidity and extremely bitter wind, alternating with brief periods of rain and thaw. April has a mean temperature little above the freezing point and sunny days in May are offset by cold polar air, while the short and cloudy summer is not quite warm enough for the growth of trees. Throughout the year, indeed, the summers are frequently covered in cloud."* GORDON MANLEY (Pigott, 1956)

This cool, wet climate has been central in dictating the range of vegetation and associated fauna in Upper Teesdale. Blanket bog, rare in a global context, is common above 500 m on the top of the limestone and other rock types. Climatic conditions allow some plant growth, but only partial decomposition of dead material, the latter forming peat to a depth of around 2 m.

At the altitudes of 350–800 m in the dale, the growing season is very short, even with 'the best weather', with implications for wildlife and hill farmers.

And the characteristic weather of uplands is the occurrence of extreme climatic events, such as the severe winters of 1916, 1940, 1947 (all with late winter and heavy snowfall); 1963 (prolonged snow cover and very cold); and 1978–79. Weather dictated the rate of farming practice, particularly up to 1960 when the horse was relied upon rather than the tractor. As late as 1979, the four-wheel-drive tractor was a rare vehicle in the dale.

For the past 25 years, the Environment Agency (EA) has asked all upland weather stations to record snowfall and to measure the depth and weight of snow, as well as rainfall during the winter. Such data are used in flood forecasting for the lowlands.

Records 1931 to 1999

Across this period the average temperature was 5·3 °C, ranging from -18·5 °C (31 January 1972) to 28·0 °C (4 August 1990). On 23 August 1976, at Widdybank Fell, the maximum temperature was 23·0 °C, followed by a minimum of –1·5 °C, a range of 24·5 °C. On average, there was some rain on

Extreme weather events

1976: A very dry, hot summer reaching 18·6 °C mean maximum in July and August. A wet autumn, with a total of 45·5 cm of rain (September 21·8 cm, October 23·6 cm). For the effect on two rare plant species and their response to the wet autumn see Case Study 9 (*p. 240*) This was followed by low temperatures, high snowfall and heavy drifting in November and December.

1978: Snowfall in late December and two days of blizzards to end the year.

1979: A dreadful winter. Four separate periods of blizzards for two or three days, and 129 consecutive days on cross-country skis to cross Widdybank Fell. Local roads were blocked for long periods, Birkdale Farm was cut off by snow from 28 December to 16 April, local schools were closed and people couldn't get out of the dale to their jobs. A very difficult time for the farming community.

1983: 8 July, following a thunderstorm a 1–1·5 m-high roll on Maize Beck, two more later and then a final roll in late July – four rolls within three weeks! Rain fell at the rate of 15·2 cm per hour, washing peat off high ground, destroying two bridges and washing away walls.

1985: Very wet (58·4 cm) in July and August, delaying hay making until September/ October (first use of big bales).

1986: Much freezing rain (30 cm) in January with several days of ice, nine days of blizzards and severe drifting in February, with a mean maximum temperature of –2·5 °C and a mean minimum air temperature of –6·4 °C. There was up to 35 cm of snow in February/March. Five different thermometer readings (maximum, air minimum, grass minimum, wet and dry bulb) were below zero for 31 days – a record. Total rainfall of 203·7 cm. One of the coldest months of the century.

1992: Severe gales on 2–3 January, average wind speed 60 mph over 2–4 hours (gusts 80 mph) caused severe tree damage at High Force and felled 700+ trees. Yet, unbelievably, later in the month seven days were completely calm!

1995: 10 cm of rain fell over 48 hours on 30–31 January. A rapid 7 °C rise in temperature triggered a sudden thaw of large amounts of snow on the fells, producing the biggest becks and River Tees since 1968. The Environment Agency issued flood warnings for the lowland areas.

Low rainfall totals for June, July and August combined (only 1·5 cm, the lowest on record), high sunshine totals and high temperatures (August mean maximum temperature 19·9 °C). Many areas with shallow soils were burnt out, Cow Green Reservoir was so low that the ruins of the mine shop and construction road were exposed in late summer. Did these drought conditions contribute to the huge decrease in the populations of the rare species that had occurred between 1983 and 2000 whilst the author was in Devon?

1996: The January sunshine total of 6·9 hours was a record low (the average is 35·0 hours for the month).

Fig. 1 | Weather data for Upper Teesdale 2000–19

Table 2 | Weather notes for Upper Teesdale 2000–19

Year	Snow (1)				Temperature (No. of days > 20 °C)				Snow (2)			Notes
	J	F	M	A	M	J	J	A	O	N	D	
2000	2	9	5	–	2	3	1	1	–	–	–	RAINFALL very wet: November 307·3 mm; SUNSHINE below average
2001	9	9	15	1	3	2	9	4	–	–	–	RAINFALL average; very dry summer; SUNSHINE average
2002	5	6	15	–	–	–	2	7	–	–	1	RAINFALL dry: February 373·4 mm [record low]; SUNSHINE very low
2003	12	6	11	–	2	3	8	13	–	–	–	RAINFALL low; TEMPERATURE high; SUNSHINE high
2004	10	8	5	–	–	2	6	7	–	1	6	RAINFALL very wet: August 274·3 mm; SUNSHINE below average
2005	5	9	10	–	–	5	7	3	–	4	4	RAINFALL average; SUNSHINE average, but low in summer
2006	1	6	14	1	2	10	22	3	–	–	–	RAINFALL above average: December 335·0 mm; TEMPERATURE July very warm; SUNSHINE high: July 299.6 hrs [record high]
2007	6	4	4	–	–	4	–	2	–	–	1	RAINFALL very wet June and July
2008	7	1	7	3	2	1	6	–	1	3	14	RAINFALL very wet June, July and September
2009	13	14	1	–	2	7	3	1	–	1	15	RAINFALL very wet: November 432·5 mm [record high]
2010	27	17	1	–	4	7	2	1	–	6	25	RAINFALL below average; SNOWFALL very high January, February, December; TEMPERATURE very cold December (max 0·9 °C; min –5·4 °C), River Tees frozen with 15–20 cm of ice
2011	8	6	2	–	–	4	5	1	–	–	13	TEMPERATURE quick thaw January; SUNSHINE below average summer
2012	4	7	–	3	6	–	–	4	–	–	10	RAINFALL wet summer, autumn and winter; SUNSHINE low total: May 218·6 hrs, June 94·7 hrs [record low]
2013	15	14	22	5	1	–	19	5	–	–	1	RAINFALL average early year, wet end to the year; TEMPERATURE very cold March (max 2·8 °C; min –2·8 °C), very warm July; SUNSHINE June 269 hrs [2nd highest recorded]
2014	3	6	1	–	1	1	12	1	–	–	6	RAINFALL very wet January and February; very dry June (33 mm), July (38·1 mm), and September (15·2 mm) – total rainfall only 38 mm more than 2013
2015	12	13	1	–	–	3	4	1	–	3	3	RAINFALL 2nd highest post-2000: December (492·7 mm) – highest since 1968; SNOWFALL high number of snow days; TEMPERATURE above average winter, below average summer
2016	8	4	3	3	2	3	4	4	–	5	–	RAINFALL low; SNOWFALL recorded in 5 months for short periods; SUNSHINE average
2017	6	5	3	–	4	5	2	1	–	1	14	RAINFALL below average: very dry April and May, wet June–October; TEMPERATURE cold: December 14 snow days, 18 ground frost days, 17 air frost days
2018	14	15	15	4	6	8	21	3	–	–	1	RAINFALL very dry May and June; SNOWFALL above average; TEMPERATURE a lot of air and ground frosts
2019	9	3	3	2	–	3	9	8	–	–	3	RAINFALL very dry January, very wet June–September (>125 mm each month); thunderstorms July and August

244 days of the year and 45 days per year were considered to be foggy. The average number of days with air frost was 126 per year, with frost occurring in every month.

Records in the new millennium

Weather patterns from 2000 changed slightly, as the summary (*Table 2, p.27*) shows. The figures on the following tables must be read with the understanding that they reflect the weather patterns only in Upper Teesdale, which covers large areas of the uplands varying in height from 350 m to 700 m. At these altitudes the growing season is very short. The facts and figures highlight that in any given year wildlife/farming has to cope with complex weather conditions.

The implication of change

Since 2000 the weather pattern has altered, with extremes of rainfall, sunshine and strong winds. Winters have had less snowfall and the period of snow cover is now measured in weeks, not months. Climate change is not new, but it does impact on the flora and other wildlife, and affects the farming year with implications for the farming community, flora and fauna.

Wet, open winters with a high rainfall delay ground warming in the spring, affecting invertebrate eggs and overwintering pupae, including those of moths, which provide food for the chicks of early nesting waders. Slow growth of vegetation delays suckler cows and their calves being turned out into pastures by two or three weeks, at extra feed cost to the farmer.

Table 3 (*below*) shows the occurrence of months with rainfall exceeding 14 inches (355·6 mm) – it seems to be getting wetter. This view is supported by very recent records of total rainfall and rain days over the three consecutive months of November 2015–January 2016 (*Table 4, below*).

Table 3 | Months with rainfall > 14 inches (355·6 mm)

Years	Months	Rainfall inches (mm)
1968–99 (31 years)	December 1994	14·3 (363·2 mm)
2000–16 (17 years)	February 2002	14·7 (373·4 mm)
	November 2009	17·0 (431·8 mm)
	December 2015	19·4 (492·8 mm)

Table 4 | Rainfall November 2015–January 2016

Month	Rainfall (mm)	Rain days
November 2015	11·5 (363·2 mm)	27
December 2015	19·4 (492·8 mm)	30
January 2016	9·2 (233·7 mm)	27

The vascular plants are in a dormant state in the winter, and their growth and flower-production can be affected by the absence of a really cold period. Even though wet, cold soils delay growth in the spring, the indigo spikelets of Blue Moor-grass, in particular, will be produced in March. Bird's-eye Primrose rosettes will be expanding and, by the end of the month, Spring Gentian and Teesdale Violet may be in flower. However, the latter two species flower best in May, when Rare Spring-sedge, Dwarf Milkwort and Bird's-eye Primrose will also be in bloom.

Rainfall is shown in *Fig. 2g* (*opposite*); any months falling below the highlighted level may be insufficient to maintain springs and flushes. Growth and flowering of Three-flowered Rush has been poor on the west side of Widdybank Fell in recent years, where most springs have been almost dry.