ISSN 1476-1580

North West Geography

Volume 8, Number 1, 2008

Extreme Flood Events in Upland Catchments in Cumbria since 1600: the evidence of historical records

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Abstract

This paper uses a range of historical sources to identify 34 major floods which affected in upland catchments in Cumbria since the early seventeenth century. Problems, limitations and advantages relating to the sources are discussed. Eighteen of the floods resulted from intense convectional storms, mostly in summer. Sixteen were due to precipitation associated with slow moving or stationery frontal systems. The occurrence of the floods varied over time with concentrations in the late seventeenth century, mid-late eighteenth century, early and late nineteenth century and 1920s-1960s. The distribution matches closely the evidence derived from adjacent areas using radiocarbon dating and lichenometry. The distribution of flood locations identifies some expected concentrations in the central Lake District but also others areas, such as Longsleddale, Dentdale and Stainmore which are less obvious. The use of historical records to pinpoint locations where geomorphological evidence of major floods might be identified is proposed.

Keywords

Floods, Uplands, Cumbria, Lake District, Pennines, Historical sources.

Introduction

In recent years there has been increasing interest in the study of extreme flood events in small upland catchments in Britain, including recent episodes (Carling 1986, Harvey 1986, Johnson & Warburton 2002) and ones in the more distant past (Acreman 1989, 1991, Archer 1992, Carling & Glaister 1987, Macklin & Rumsby 2007). The flood at Boscastle in August 2004 recalls earlier disasters such as Lynmouth in 1952 but also suggest the possibility that the incidence of extreme events in upland catchments may increase in the future as a result of changing patterns of precipitation associated with global warming. It is important for hydrologists to know whether the incidence and magnitude of such floods has increased in recent decades compared with earlier times. The length of gauged records for upland catchments in Britain is, however, rarely more than 50 years and often much less.

Floods which occurred before the period of gauged records have been dated from geomorphological evidence using lichenometry on boulder berms and debris flows (Carling & Glaister 1987, Johnson & Warburton 2002, Macklin & Rumsby 2007) while radiocarbon dating has also been used on organic material in flood sediments (Macklin, Passmore & Rumsby 1992). The problem with this approach is that such events cannot be dated precisely unless detailed historical sources are available. There is also the drawback that boulder berms tend to record only the largest floods in any catchment and that the evidence of previous episodes may be buried or destroyed by erosion. In addition, for some areas like the Lake District and the Southern Uplands of Scotland, dates established from lichenometry are still few or entirely lacking (Macklin & Rumsby 2007).

The scale and dynamics of some major flood events in upland catchments, such as those of 1749 in Mosedale and the Vale of St. John and 1927 at Glenridding have been studied using a combination of physical and historical evidence (Carling 1997, Carling & Glaister 1987). However, many studies have made relatively little use of historical records of on floods to supplement data from other sources (e.g. Johnson & Warburton 2002). The use of documentary sources for reconstructing flood chronologies was pioneered by Creer (1892) and developed by Potter (1978), McEwen (1987), Bayliss & Reid (2001) and Brazdil *et al*. (1999, 2006) so that it has become an established approach (Archer 1999, Williams & Archer 2002, Black & Law 2004, Macdonald *et al*. 2006). Research using historical sources has often been able to establish chronologies of flooding dating back to the seventeenth century or even earlier (Brazdil *et al*. 1999).

But most of these relate to the lowland sections of major river basins, often based on data from the archives of major towns (McEwen 2006). The full potential of historical sources to provide details of the occurrence of severe flooding in upland areas has not been realised (Macdonald 2006).

Cumbria provides an interesting case study for the identification of such floods using historical sources. The region contains the Lake District, the most rugged upland area in England with the highest rainfall totals and the steepest stream gradients (Barker *et al.* 2004, Malby *et al.* 2007), as well as the steep western escarpment of the North Pennines and other upland areas such as the Howgill Fells. Cumbria has a long history of recording extreme floods. In particular the area has generated scientific interest since it became a focus for picturesque tourism in the later eighteenth century. Guidebook authors and topographers like William Gilpin (1786), William Hutchinson (1794) and Thomas Pennant (1774) provide detailed accounts of the geomorphological and human impacts of severe floods such as the Vale of St. John (1749) and Vale of Lorton (1760). More generally the valleys of the Cumbrian uplands have been well populated since medieval times (Winchester 1987, 2000), with good historical records compared, for example, to the Scottish Highlands, from the seventeenth century onwards. The gauged record in Cumbria, like most parts of Britain, is quite short. Out of 50 stations only two have records commencing in the 1950s and one in the 1930s (http://www.environment_agency.gov.uk/highflowsuk/maps/northwest/).

The aim of this paper is to use documentary evidence to provide a detailed chronology of severe floods in upland catchments in Cumbria while critically evaluating the sources used. The research examines how the incidence of such floods has varied over time, whether the chronology supports those established from geomorphological evidence (Macklin & Rumsby 2007) and the possible causes of temporal fluctuations.

Data Sources and Analysis.

An initial list of floods was obtained from the British Hydrological Society's online database (Black & Law 2004), though this was found to be very incomplete and patchy for the area under study. Epigraphic evidence is limited in Cumbria and is even rarer for upland catchments. Further information came from other published sources including *British Rainfall.* As part of a wider study of the historic impact of floods in Cumbria a search was undertaken of a range of manuscript and published sources in archives and local history libraries throughout the region. Nearly 600 flood events at various scales were identified between AD1600 and 2005.

Previous studies have noted the trend for the quantity and quality of information on flooding derived from historical sources to increase through time towards the present (Bayliss & Reed 2001). Similar problems are evident for Cumbria. In particular, data become more abundant with the appearance of regional newspapers in the early nineteenth century. However, the focus of the present research on major episodes rather than all recorded floods reduces the chance of missing key events. It is considered that all major floods in the region from the later eighteenth century onwards have been identified and most of those from the seventeenth and early eighteenth centuries.

No single source provided a complete picture of flooding, for each category had limitations of temporal and/or geographical coverage (Table 1). Newspapers were the most voluminous and detailed source of evidence from the late eighteenth century onwards and 15 local newspapers were examined on microfilm[(1)]. Data for the seventeenth and early eighteenth centuries, before the advent of regional newspapers, guide books and detailed topographical accounts, were more limited than for later periods in both the quantity of material and the amount of detail (Brazdil *et al.* 1999). It is possible that one or two major floods for this early period may have been missed. However, by using as wide a range of sources as possible the chances of this have been greatly reduced.

The value of combining information from a range of sources is shown from the example of 22nd August 1749. The 'waterspout' which burst over the fells north of Helvellyn causing flash floods and serious damage in Mosedale and the Vale of St. John is well recorded (Figure 1) (Carling & Glaister 1987). However, petitions to the Westmorland Quarter Sessions indicate that there was a second, near contemporary, storm which badly affected Longsleddale, several miles to the south east, demolishing a series of bridges and causing other serious damage[(2)].

(1) These were: Carlisle Journal, Carlisle Patriot, Cumberland Evening News, Cumberland Journal, Cumberland News, Cumberland Pacquet, Cumberland and Westmorland Herald, Kendal Mercury, Kendal Times, Lancashire Evening Post, Lancaster Gazette, The (London) Times, Penrith Observer, Westmorland Advertiser, Westmorland Gazette.

(2) Cumbria Record Office (Kendal) WQ/SP 213/8, 213/19, 215/23, 220/11)

Table 1: *Historical sources used in the study and their coverage.*

Source	Chronological span	Geographical coverage	Quality of data
Newspapers	Late C18 – modern	Whole area by early C19: tendency to focus on lowlands, towns	Very detailed for much of the C19; often poorer in later C20
Quarter sessions records	Late C16 – C19	Whole area	Indirect – mainly relating to petitions for money for bridge repairs
Parish registers	Early C17 onwards	Whole area	Very sporadic
Guides and topographical descriptions	1770s onwards	Focus on Lake District and surroundings	Some very detailed near contemporary accounts; others derivative
Estate papers	c.1600 onwards	Localised	Mentions of damage to property
Diaries & correspondence	C17 onwards	Very localised	Occasional detailed descriptions: very variable in quality
Directories	C19 onwards	Whole area	Occasional references
Periodicals	C18 onwards	Whole area	Occasional references
Local histories	C19 – C21	Sporadic	Very variable in quality

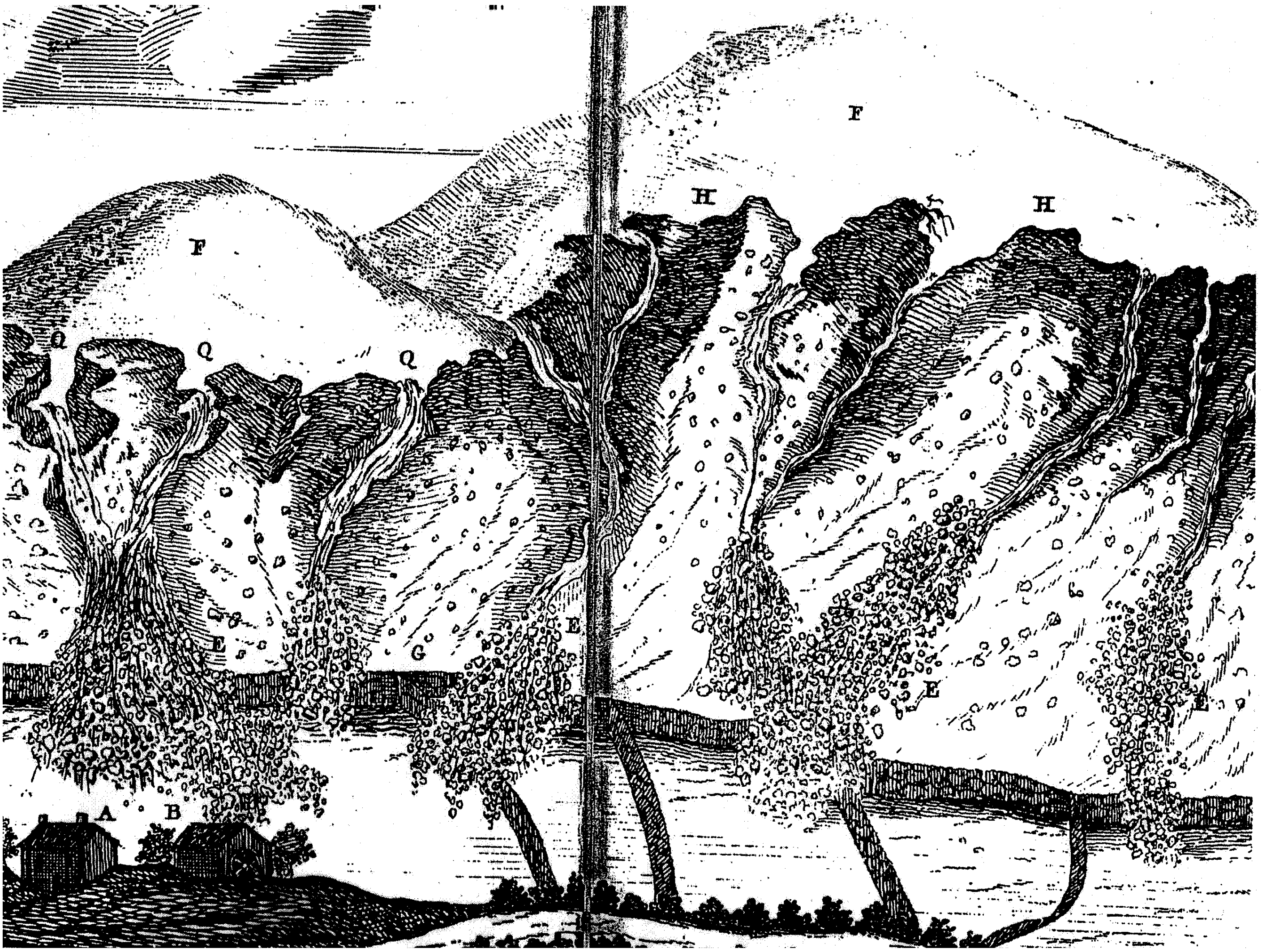

Figure 1: Near-contemporary sketch of the damage done by the 1749 flood on the east side of the Vale of St. John, with erosion gullies above and fans of deposited debris below.

Data Analysis

To identify those floods which could be classified as extreme events in upland catchments the descriptions in the various sources listed were analysed. 'Upland catchments' were defined as the headwaters and upper sections of the main Lake District and Pennine valleys without a specific range of catchment areas being used. There were problems in assessing the severity of some floods when, as was often the case in newspaper reports, regional-scale floods resulting from precipitation associated with frontal systems were described mainly in terms of their level and impact in the lower reaches of the main Cumbrian drainage basins, especially in the vicinity of towns like Carlisle or Kendal. Such descriptions might provide little or no information on the severity of flooding at the headwaters of the main catchments. Floods were only included in the present study when there was specific information relating to their severity in upland catchments.

Floods were identified as having been major events when they met two or more of the following criteria:

1. Data on peak discharges and their ranking from the Environment Agency with estimated return periods of more than once in 60 years.
2. Estimated peak discharges and their ranking for the period before gauged data from modern published sources.
3. Extreme rainfall totals over periods of 1-2 hours for thunderstorms (70mm or more within two hours) and 100mm or more within 24-48 hours from floods resulting frontal systems accompanied by evidence of serious flooding.
4. For floods in the period before gauged data, contemporary information on flood height and estimated ranking of severity from contemporary accounts, though descriptions like 'the worst flood in living memory' were treated with considerable caution as it has been shown (Bayliss & Reed 2001) that in practice this might only extend back for 20 years or so.

Failing these, particularly for early floods, qualitative details were used;

5. Descriptions of major geomorphological impacts such as erosion, gullying, landslides, bog bursts, deposition of sediment, creation of boulder berms and changes of stream courses drawn from contemporary or near contemporary sources.
6. Descriptions of large-scale damage to features in the cultural landscape including houses, industrial sites, weirs, dams, bridges, roads, railways, walls and fences. Descriptions of the depth of floodwater in particular locations.

Floods which were due to hushing, the deliberate damming and release of water for mineral prospecting, were not included although this activity was causing problems as early as the mid-eighteenth century (Curwen 1932).

Using these criteria a total of 34 severe flood events in upland catchments was identified (Table 2). This is a substantially larger number than identified in previous research. For example, Acreman's (1989) study of 69 extreme historical UK floods lists only two of those identified here. Orr and Carling (2006), focusing on the catchment of the River Lune, mention only two of the five floods for that drainage basin listed here. Eighteen floods were the result of intense conventional storms, mostly in summer. Sixteen were due to precipitation associated with slow-moving or almost stationery frontal systems in either summer or winter. At least three of these had an identifiable snowmelt component. One or two floods resulted from unusual sets of circumstances such as the flood/avalanche in Dentdale in 1752 (Sedgwick 1868) which was due to a combination of heavy rain and snowmelt and the bursting of a slightly modified natural moraine dam above Glenridding in 1927 (Carling & Glaister 1987).

Interpretation and Discussion

Figure 2 shows the occurrence of floods by decade, distinguishing between those due to local convectional storms and larger scale events due to frontal precipitation. Clusters of events are evident in the later seventeenth, later eighteenth, early and late nineteenth, early twentieth and mid twentieth centuries. These match well with the patterns found from limited lichenometric dating for the Lake District, apart from the lack of a peak in the 1950s and 1960s, and even more closely with widespread evidence from the North Pennines (Macklin & Rumsby 2007). The match is particularly good with data from lichenometry in Coverdale, Yorkshire (Merrett & Macklin 1998). These periods were also more generally 'flood rich' with concentrations of less severe events. They also correspond closely with negative phases of the North Atlantic Oscillation (NAO). Both highly localised summer storms under anticyclonic conditions and slow moving or stationary fronts tend to develop when the westerly circulation is weaker with negative NAO values. This confirms the evidence from lichen-dated deposits. The fit with the more detailed time series for the Thinhope Burn in the North Pennines and Coverdale in the Yorkshire dales is even closer (Macklin & Rumsby 2007). The period between the 1920s and the 1960s, characterised by extreme events in these areas, is also seen in the graph presented here. Although the incidence of extreme flood levels in the last three decades is higher than in some earlier periods – for much of the nineteenth century for example – it is substantially less than during most of the twentieth century. On a secular time scale there has been a perceptible shift from thunderstorms to frontal precipitation as the main cause of floods. To what extent this is a genuine trend or is a product of the source material requires further research. Within the twentieth century Figure 2 indicates a peak of flood episodes in the 1960s but a reduced occurrence of flooding in more recent decades. This matches Macklin &

Table 2: List of severe floods in upland catchments.

Date	Location	Cause	Note
1686 10 June	Claife	Thunderstorm	1
1686 10 June	Hawkshead	Thunderstorm	2
1689	Stainmore	Thunderstorm	3
1749 22 August	Mosedale, Vale of St. John	Thunderstorm	4
1749 c.22 August	Longsleddale	Thunderstorm	5
1752 2 January	Upper Dentdale, Mallerstang	Frontal + snowmelt	6
1760 7/9 September	Grassmoor	Thunderstorm	7
1771 13 October	Upper Kent, upper Eden	Frontal	8
1821 1 November	R. Greta, Threlkeld	Frontal	9
1822 1-3 February	Upper Eden	Frontal	10
1829 14 October	Upper Kent, Longsleddale, Upper Eden.	Frontal	11
1831 8/9 February	Upper Kent	Frontal + snowmelt	12
1870 9 July	Upper Dentdale	Thunderstorm	13
1888 24 July	R. Raven and Kirkoswald	Thunderstorm	14
1889 8 Aug	Garsdale	Thunderstorm	15
1890 30 September	Langdale, Grasmere	Frontal	16
1894 9 August	Geltsdale	Thunderstorm	17
1898 1-2 November	Longsleddale, Kentmere, Troutbeck, Grasmere, Patterdale, Langdale, Borrowdale, Vale of St. John	Frontal	18
1926 6 October	Longsleddale	Thunderstorm	19
1927 28-29 October	Glenridding	Frontal + failure of moraine dam	20
1930 18 June	Stainmore, Knipe Moor	Thunderstorm	21
1931 3 November	Glenridding, Patterdale	Frontal	22
1938 August	Lingmell Gill	Thunderstorm.	23
1942 4-5 September	Upper Kent, Borrowdale	Frontal	24
1953 25 June	Troutbeck, Wansfell, Kirkstone Pass	Thunderstorm	25
1954 2 December	Upper Kent	Frontal	26
1966 13 August	Langdale	Frontal	27
1966 4 September	Borrowdale, Langdale	Frontal	28
1967 8 August	Wray, R. Hindburn & R. Roeburn	Thunderstorm	29
1968 23-24 March	Upper Eden	Frontal + snowmelt	30
1982 6 June	Howgill Fells: Bowderdale and Langdale	Thunderstorm	31
1985 20-21 December	Upper Kent	Frontal	32
1995 31 January	Upper Lune, Kent, Longsleddale, Troutbeck, Grasmere, Dunmail Raise, Thirlmere	Frontal	33
2005 8-9 January	Upper Eden, Derwent, Kent	Frontal	34

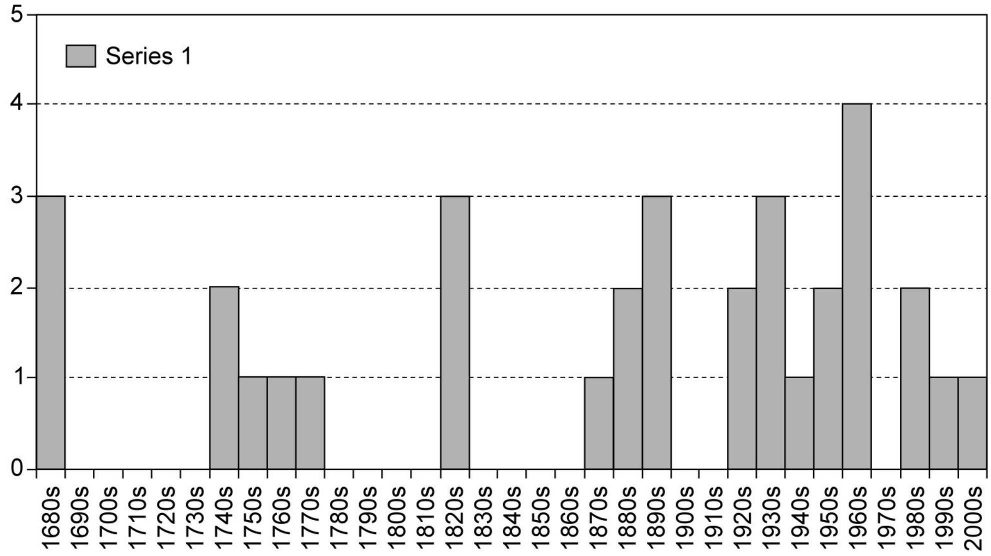

Figure 2: Frequency of floods per decade.

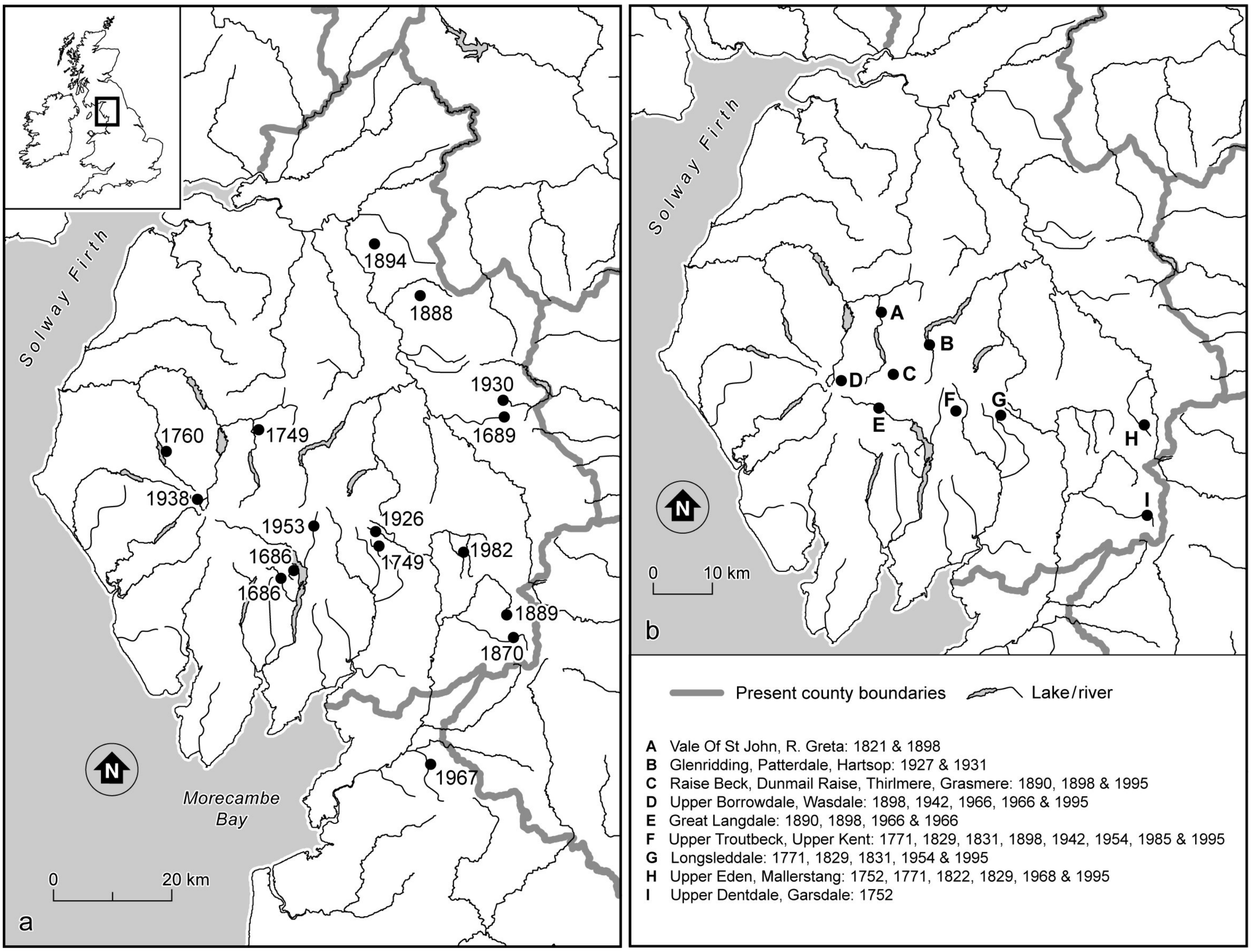

Figure 3: (a) Locations of floods caused by convectional storms,
(b) Locations of floods caused by frontal precipitation.

Rumsby's suggestion that the number of severe floods in upland catchments in the last few decades has been less than for most of the twentieth century although the trend for the Lake District is not as marked as they found in their study.

Figure 3a shows the locations of the flood events caused by severe convectional storms. Their distribution is widely scattered and it is notable that half of them occur in the Pennines and outliers like the Howgill Fells and the Forest of Bowland rather than the Lake District. It is likely that the extensive plateau areas of the Pennine summits are particularly suited to the development of thunderstorms while the steep gradients of streams draining westwards from them form ideal conditions for damaging floods.

The distribution of floods resulting from frontal precipitation (Figure 3b) is more closely focused on the valleys radiating from the central mountain core of the Lake District. Nevertheless the number of floods occurring in the upper Eden suggests that there is a significant snowmelt component from the Pennine plateaus which provide a more extensive gathering ground than the fells of the Lake District. It is likely that the contribution of snowmelt to the winter floods in Table 2 has been underestimated. Combining the two categories of flood a band of country from Grasmoor in the west eastwards through the heads of Wasdale, Borrowdale and Langdale to Dunmail Raise and the Kirkstone Pass has about half the floods recorded for the region. Nevertheless there are other areas with notable concentrations of floods. These include Longsleddale, the valleys around Dent, and the head of the Eden over Mallerstang and Stainmore.

Conclusion

This study has demonstrated the value of historical sources in supplementing data derived from scientific techniques such as lichenometry and radiocarbon dating. For Cumbria it was possible to identify 34 extreme floods which affected upland catchments since AD1600. The evidence supports the information derived from geomorphological approaches indicating that there have been marked changes in the frequency of such floods in the last 400 years, but that the frequency of such floods in the last three decades is not unusual and has fallen markedly from the mid-twentieth century. The occurrence of extreme flood events in upland areas appears to be linked closely with negative NAO values. Given the problems in identifying major floods before the later eighteenth century because of the limitations of contemporary descriptions is gratifying to note that the qualitative methodology adopted here for identifying such events has produced such a good fit with data from environmental sources.

In particular a number of upland valleys have been identified in which serious floods have a tendency to recur. Some, such as Borrowdale and Langdale are hardly unexpected. Others, like Longsleddale, Dentdale and the upper Eden valley are less obvious. The identification of these floods from historical sources makes it possible to pinpoint the locations of extreme events allowing a more focused search for geomorphological evidence. It also provides an indication of some of the most vulnerable locations within the broader range of upland environments where flood damage might be expected to recur in the future.

Acknowledgements

We would like to express our gratitude to the Leverhulme Trust for funding under grant F00 185L which allowed the research on which this study is based. We would also like to thank Simon Chew at the Department of Geography, Lancaster University, for drawing the maps.

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