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Changes in the distribution and abundance of *Carex ericetorum* in Britain since the 1970s

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Abstract
British populations of *Carex ericetorum* Poll. (Rare Spring Sedge) were visited between 2008 and 2015 to assess size, habitats, associated vegetation, management, threats and changes in abundance since the 1970s. *C. ericetorum* was relocated at 40 of the 64 sites visited, mainly in northwest England (24 sites) and East Anglia (nine sites); most populations that couldn't be relocated were in southern and eastern England. Population sizes were usually small (<100 individuals) and had remained relatively stable or had increased in size since the 1970s. In southern and eastern England, *C. ericetorum* was restricted to species-rich calcareous grassland overlying chalk or limestone dominated by *Festuca ovina* and *Bromopsis erecta.* In northwest England, it was confined to limestone grassland dominated by *Sesleria caerulea*. Ideal management for *C. ericetorum* comprised autumn and winter grazing to maintain a short sward (<6 cm), although it had persisted in the absence of grazing where the growth of dominants was restricted by exposure and/or soil infertility. The main threat to its survival is now a lack of grazing leading to increased competition with tall grasses, although agricultural intensification had caused losses in the lowlands. Nitrogen deposition is also likely to have compounded these threats on some sites. Its survival on many sites will require the maintenance or reinstatement of grazing.

Keywords: calcareous grassland; management; threats; under-grazing.

Introduction

Carex ericetorum Poll. (Rare Spring Sedge) is a Boreo-temperate sedge that occurs throughout northern and central Europe from Scandinavia and northern Russia (to 68 °N), as far south as northern Spain, central France, northern Italy, the Balkans, Bulgaria and the Caucasus. Its range extends as far east as the Siberian Urals and reaches its western limit in England (David, 1981). As the common name implies, it is a rare species in Britain, confined to East Anglia, the Midlands and northern England where it reaches its altitudinal limit at 545 m OD on Cronkley Fell, Upper Teesdale. Due to its restricted range and recent declines it has been assessed as 'Vulnerable' in Great Britain and England (Cheffings & Farrell, 2005; Stroh et al., 2014). It has also declined in Continental Europe and is assessed as 'Critically Endangered' in Belgium and the French regions of Burgundy, Centre-Val de Loire and Champagne-Ardenne. It is categorised as 'Endangered' in the Czech Republic, Germany and the Parisian region of Île de France, and, as in England, it is 'Vulnerable' in Hungary and the regions of Auvergne in Central France and Picardy in northern France (Stroh et al., 2014).

In the 1970s David (1981) surveyed British populations of *C. ericetorum* in order to update the distribution map included in a revised monograph of British sedges (Jermy et al., 1982). His paper included information on historic and extant sites, based on a review of historical records, herbarium specimens, and field surveys. The presence of *C. ericetorum* was confirmed at 35 of 48 historical sites, with losses attributed to agricultural improvement, quarrying and trampling by visitors. Between 2008 and 2013 Botanical Society of Britain and Ireland (BSBI) recorders re-visited a sample of these sites as part of the BSBI's *Threatened Plants Project* (TPP), in order to assess the species' status and inform its future conservation; during these visits volunteers collected information on population size and extent, regeneration, associated species, habitats, management and threats (Walker et al., 2017). Given the good coverage achieved by TPP recorders, the authors extended this survey to include all currently known sites, with a few notable exceptions (see text below).

In this paper we present the results of this survey; specifically, we summarise (1) the past and present distribution of *C. ericetorum* in Britain including changes in the number and size of populations since the 1970s, (2) its habitats and management, and (3) the threats to its survival or reasons for its loss on sites where it is no longer present. Nomenclature follows Stace (2019) for vascular plants and Rodwell (1991-2008) for National Vegetation Classification (NVC) communities.

Methods

Between 2008 and 2013 BSBI recorders visited 23 historic sites, selected at random from those held in the BSBI's distribution database as part of the TPP survey (Walker et al., 2017). An additional 41 sites not included in this sample were identified from David (1981), BSBI records, unpublished reports (e.g. Blakemore, undated) and through correspondence with botanists familiar with the species. All these sites were visited by the authors or TTP recorders, except 11 sites where *C. ericetorum* was known to be extinct and four East Anglian sites with restricted access due to military activities (Bodney Warren) or breeding Stone Curlews (*Burhinus oedicnemus*) (Lakenheath Warren, Foxhole Heath, Deadman's Grave). However, the presence of *C. ericetorum* was confirmed at three of these sites during brief surveys in 2008 (Nick Gibbons, pers. comm.). Details of all the sites included in this survey are given in the Appendix.

Field surveys were carried out between April and July when *C. ericetorum* was in flower or fruit. On sites where *C. ericetorum* was refound its distribution was mapped to 10 × 10 m resolution using a handheld GPS, the size and the extent of the population estimated and notes taken on topography (slope and aspect), habitats, management and threats that were obvious at the time of the survey. The abundance of associated vascular plants was also recorded using the DAFOR scale in at least one 2 m diameter circular quadrat located in an area of representative vegetation containing *C. ericetorum*. The probable reasons for loss were also recorded on sites where *C. ericetorum* could not be refound.

Quadrat data, including additional samples taken from Fearn (1971), were assigned to NVC communities using Tablefit (Hill, 2015) and differences in community composition were explored using Detrended Correspondence Analysis carried out in Vegan for R (Version 2.5-6; Oksaninen et al., 2019), with rare species downweighted.

Results

Discovery

The early history of *C. ericetorum* in Britain is rather confused. A specimen collected in 1833 (not 1838 as originally described) from the Gog Magog Hills near to Cambridge was not correctly identified as *C. ericetorum* until 1861, when its discoverer, Charles Babington, determined specimens collected by him and John Ball from the same site as *C. ericetorum* (Babington, 1861; Bennett, 1910). Subsequently a specimen collected from Mildenhall Heath, West Suffolk, in 1829, and originally identified by Sir W. C. Trevelyan as *C. pilulifera*, was also found to be *C. ericetorum* (David, 1981). A possibly earlier record, however, is Sir John Cullum's record of *C. montana* from Newmarket Heath in 1775-76. The two species are very similar but *C. montana*, as currently understood, is confined to south-west England and Wales, and *C. ericetorum* is known to have occurred at the site till 1954 (Leslie, 2019). *C. ericetorum* is, therefore, the more likely species connected with the Cullum record (Bennett, 1910), although unfortunately no specimen has been traced. All other discoveries in the late nineteenth and early twentieth century were from East Anglia, with a first record for East Norfolk in 1880 and additional sites for West Suffolk and Cambridgeshire (Table 1).

C. ericetorum was discovered in northern England in 1943 when Ted (E.C.) Wallace found a small colony in limestone grassland near to Burton Leonard, Mid-west Yorkshire (Wallace, 1943). In the following decade it was found at a range of sites on limestone elsewhere in northern England, as predicted by Wallace (1943), including Scout Scar, Westmorland in 1944, Markland Grips, Derbyshire in 1945, Lindrick Common, South-west Yorkshire in 1945 (Brown, 1945) and, most notably, Widdybank Fell in Upper Teesdale, where T.G. Tutin discovered it growing with *Viola rupestris* on sugar limestone outcrops in 1949 (Wallace, 1951).

Table 1. The number and current status of populations of *Carex ericetorum* (*n* = 64) recorded in British vice-counties listed in order of the year of discovery.

Vice-county (v.c.)	First record	Extant	Extinct	Total	% lost
Cambridgeshire (29)*	1775	1	4	5	80
West Suffolk (26)	1829	5	2	7	29
East Norfolk (28)	1880	4	6	10	60
Mid-west Yorkshire (64)	1943	2	3	5	60
Westmorland (69)	1944	14	1	15	7
Derbyshire (57)	1945	1	0	1	0
South-west Yorkshire (63)	1945	2	1	3	33
Durham (66)	1949	1	1	2	50
South Lincolnshire (53)	1950	0	1	1	100
North-west Yorkshire (65)	1950	5	0	5	0
North Lincolnshire (54)	1951	0	1	1	100
North Lancashire (60)	1951	4	4	8	50
Northamptonshire (32)	1978	1	0	1	0
Total		40	24	64	38

* 'Newmarket Heath' straddles the boundary of Cambridgeshire and West Suffolk but the area most likely to have supported *C. ericetorum* is in v.c.29.

Between 1950 and 1980, 30 new populations were discovered, 23 of which were in the Midlands or northern England, including first records for South and North Lincolnshire (Ancaster, 1950; Broughton, 1951), North Lancashire (Hawes Water, 1951), North-west Yorkshire (Cronkley Fell, 1950) and Northamptonshire (Barnack Hills and Holes, 1978) (Fig. 1). Further populations have been found since 1980, mainly on the limestones near to Morecambe Bay (North Lancashire, Westmorland) and above Orton in Cumberland. Three new populations were discovered during the current survey (Ledsham, Mid-west Yorkshire; Heathwaite, Westmorland; Pott Rigg, Cumberland).

Number of populations

Since its discovery in 1775, *Carex ericetorum* has been found in 64 sites in 13 vice-counties in England, with unconfirmed records from a further six sites (Table 1; Appendix). These sites are located within 32 hectads (10 × 10 km grid squares), 19 of which contain extant populations (Fig. 2). The number of populations has increased dramatically since its discovery in northern England in 1943, with 53 populations discovered since then (Fig. 1). The main strongholds for the species are the limestones around Morecambe Bay, above Orton in Westmorland, Upper Teesdale, and the chalk-heaths of the Breckland region of East Norfolk and West Suffolk (Table 1). In comparison, only single populations survive in Cambridgeshire (Devil's Ditch), Northamptonshire (Barnack Hills and Holes), Derbyshire (Markland Grips) and Durham (Widdybank Fell), and the species has not been recorded in North or South Lincolnshire since 1993 and 1996 respectively.

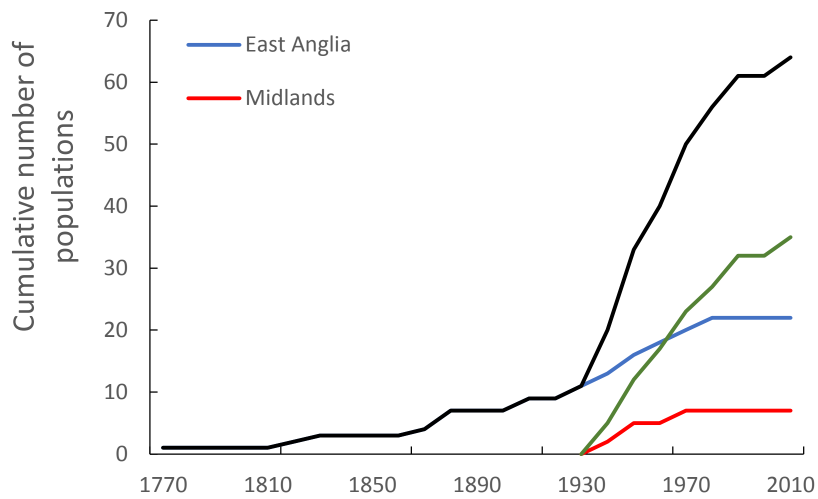

Figure 1. Cumulative number of *Carex ericetorum* populations discovered in England shown by region.

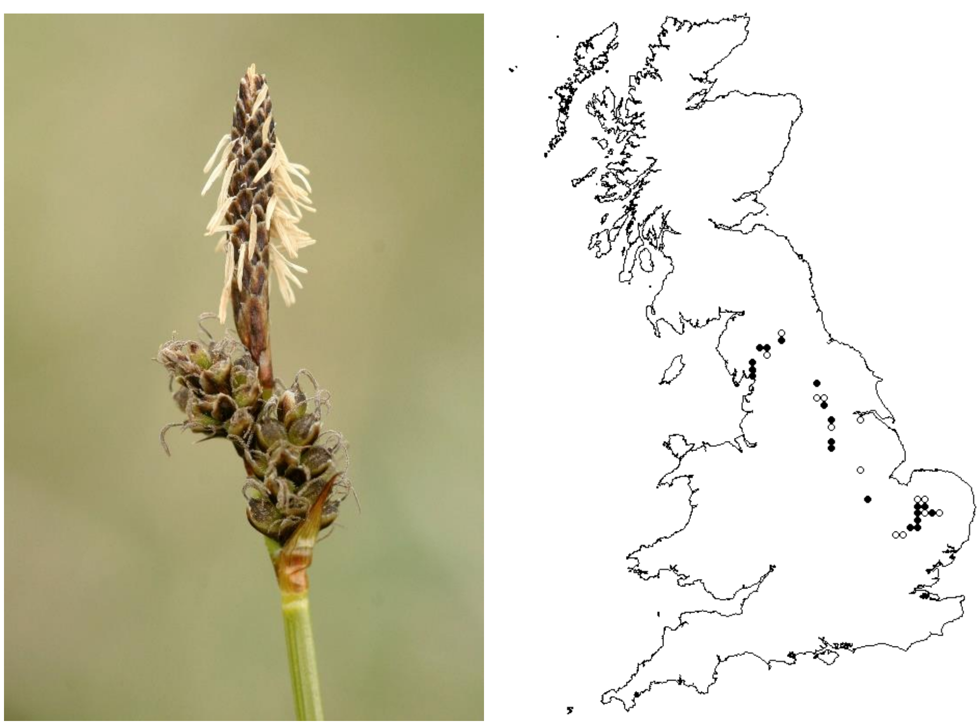

Figure 2. *Carex ericetorum.* Inflorescence (left) and hectad distribution in Great Britain (right). Solid black dots are 10 × 10 km grid squares (hectads) in which *C. ericetorum* has been recorded since 2000; open circles indicate hectads with records before 2000 but not since.

Losses
Carex ericetorum has been lost from 24 sites (38%) (Table 1), mainly in the lowlands of southern and eastern England. Populations in Cambridgeshire have been worst affected by changes in land-use (see below), with post-2000 records from only one site on the Devil's Ditch, although it has not been seen here since 2010 despite careful searching each year, and it seems likely that it is now extinct in the vice-county (Leslie, 2019). It is extinct in both North and South Lincolnshire, has been lost from six of 10 sites in East Norfolk (Cockley Cley, Cranwich, East Harling, Garboldisham, Gooderstone Common, Jubilee Wood), and three of five sites in Mid-west Yorkshire (Hetchell Crags, Jackdaw Crag Quarry, Linton Common). The majority of these localised extinctions have occurred since the 1940s, and losses continued into the current century.

Most of these losses occurred on lowland chalk grasslands and chalk grass-heaths due to ploughing, agricultural intensification or land abandonment following the cessation of grazing (Table 2). Populations in lowland limestone grasslands also suffered relatively high losses, for the same reasons as well as the quarrying of limestone for roadbuilding and construction. In comparison, most upland populations have survived (Table 2), presumably because their remoteness and topography have made them more difficult to intensify for agricultural purposes. Furthermore, nearly most upland sites have been designated as SSSIs and are now managed for conservation objectives, although changes in grazing regimes in recent years have led to local declines (see below).

Table 2. Populations of *Carex ericetorum* in relation to habitat.

Habitat	Extant	Extinct	Total	% lost
Chalk grassland	2	5	7	71
Chalk grass-heath	8	7	15	47
Limestone grassland - lowland	16	10	26	38
Limestone grassland - upland	14	2	16	13
Total	40	24	64	38

Size of populations
Population size was estimated by David (1981) and during this survey using broad abundance categories (Table 3). By the 1970s a quarter of populations had been lost whereas two-thirds supported fewer than 100 plants (n = 27) and only three had more than 1000 individuals. During the current survey the number of losses had almost doubled to 40%, due to the loss of many of the populations that were identified as being critically small by David (1981) (e.g. Ancaster, Brodsworth, Broughton, West Wratting). In comparison, proportion of larger populations increased from 11-17% due to the discovery of some very extensive populations in upland areas of northern England (e.g. Long Scar Pike,

Scout Scar, Ravensworth Fell) whereas the proportion of the largest populations (>1000 individuals) stayed the same at 7%.

Table 3. Number and percentage (in parentheses) of British *Carex ericetorum* populations according to population size class in 1970s (n = 46) and during current survey (n = 58).

Population size	1970s	2008-2015
Extinct	11 (24)	23 (40)
1-20 individuals	11 (24)	5 (9)
21-100 individuals	16 (35)	16 (28)
101-1000 individuals	5 (11)	10 (17)
>1000 individuals	3 (7)	4 (7)

*Population sizes were not estimated on six sites during the current survey (Bodney Warren, Crosby Gill, Deadman's Grave, Lakenheath Warren, Foxhole Heath, Gooderstone Common).

The numbers of individuals appear to have increased at nine sites since the 1970s, mainly in northern England, whereas five have remained the same (Table 4). Two populations in East Anglia have declined but are still extant (Grime's Graves, Knettishall Heath) and five have declined to extinction, including three in the Midlands (Ancaster, Brodsworth, Broughton). Eleven populations thought to be extinct in the 1970s were revisited during the current survey, mainly in East Anglia, and no plants were relocated confirming the local extirpation of *C. ericetorum* at these sites (Table 4).

Table 4. Number of populations of British *Carex ericetorum* according to region and trend in population size. Final column is total numbers and the percentage of British populations according to trend in population size.

Trend	East Anglia	Midlands	North	Total	%
Increase	2	3	4	9	28
Stable	2	0	3	5	16
Decline – still extant	2	0	0	2	6
Decline - extinct	1	3	1	5	16
Extinct - pre-1970	8	0	3	11	34
Total	15	6	11	32	100

Vegetation communities

Carex ericetorum was recorded in all but one of the lowland calcareous grassland types recognized by the National Vegetation Classification (NVC), as well as a single lowland acid grassland type (Fig. 3). In East Anglia *C. ericetorum* is a characteristic member of the Breck grass-heath community first described by Watt (1940, 1957) that occurs on sandy soils overlying chalk where soil reaction either exceeds pH 6 (Watt's so-called 'Grassland B'), now referable to *Festuca* *ovina-Hieracium pilosella-Thymus praecox/pulegioides* chalk grassland (NVC CG7), or where soil pH is lower (Watt's 'Grassland C'), *Festuca ovina-Agrostis capillaris-Rumex acetosella* acid grassland (NVC U1) (Pakeman & Marshall, 1997). These dry grasslands are often associated with periglacial 'patterned ground' that formed at the end of the last glaciation (Watt et al., 1966) and now support alternating 'stripes' of calcicole and calcifuge vegetation (David, 1994). A good example of this habitat type survives at Grime's Graves where *C. ericetorum* occurs locally on the edge a small chalk pit and along ridges of calcareous grassland running away from it into the adjacent heathland (see Fig. 4, top left). This vegetation type forms a distinct cluster on the second axis of the DCA diagram below with a single sample assigned to U1 grassland recorded on Lakenheath Warren (Fig. 3). Elsewhere on the East Anglian chalk *C. ericetorum* occurs in species-rich calcareous grasslands dominated by *Festuca ovina* and *Bromopsis erecta* (NVC CG1/2/3); these communities also occur sporadically on carboniferous and magnesian limestones throughout the lowland range of the species including Jack Scout in North Lancashire, Markland Grips in Derbyshire and Burton Leonard in Mid-west Yorkshire.

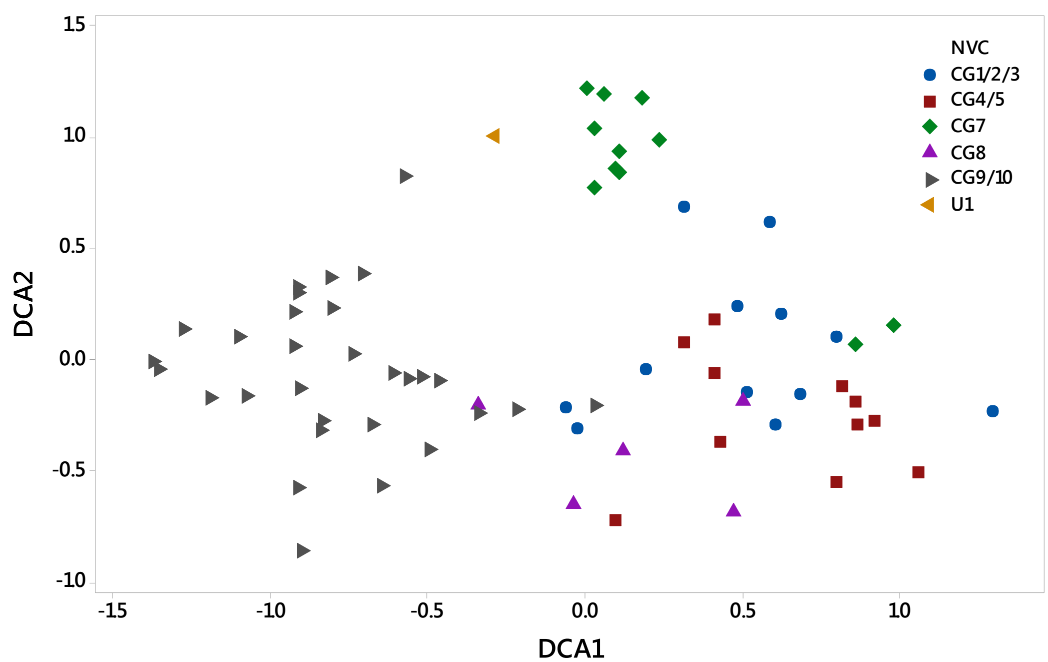

Figure 3. Ordination diagram of species abundance in 1 × 1 m vegetation quadrats containing *Carex ericetorum*. Sample scores were calculated using Detrended Correspondence Analysis (DCA) with rare species downweighted. Eigenvalues for axes: DCA1 = 0.32; DCA2 = 0.19. Axis lengths: DCA1 = 2.68; DCA2 = 2.08. NVC types are superimposed on sample scores.

In eastern England *C. ericetorum* occurs on limestone in grasslands dominated by *Bromopsis erecta* and/or *Brachypodium pinnatum* (NVC CG4/5) that are similar in composition to NVC CG1/2/3 and therefore show a high degree of overlap on the first and second axes of the DCA (Fig. 3). These include the isolated populations in ancient quarry workings at Barnack Hills and Holes in Northamptonshire and Lindrick Common near to Worksop and Ledsham and Madbanks SSSI in Yorkshire where *C. ericetorum* was discovered during this survey in 2013.

On carboniferous limestones in northwest England *C. ericetorum* occurs exclusively in *Sesleria albicans-Galium sterneri* grassland (NVC CG9), usually on shallow soils around limestone outcrops and more locally on the sunnier aspects of ant-hills (Walker & Jefferson, 2019). In Upper Teesdale it is also a characteristic member of the 'Teesdale assemblage' growing in CG9 grassland on the eroded edges of sugar limestone outcrops on both Widdybank and Cronkley Fells (Bradshaw, 1985). Nearer to sea-level around Morecambe Bay it also occurs very locally within *Sesleria albicans-Scabiosa columbaria* grassland (NVC CG8) and at Burnbarrow Scar near to Kendal it occurs within *Festuca ovina-Agrostis capillaris-Thymus praecox* grassland (NVC 10).

Management

Like many threatened plants of unimproved grasslands, *Carex ericetorum* is reliant on grazing to reduce the dominance of more competitive species (Walker & Jefferson, 2019). This is usually achieved by grazing with hardy breeds of sheep or cattle, in combination with low soil fertility and/or exposure on sites at higher altitudes. Ideally grazing should occur during the late summer, autumn and winter months allowing *C. ericetorum* time to flower and set seed. However, it survives in taller swards through the production of elongated leaves (Watt, 1974), and in the absence of grazing where the soils are very shallow and infertile (Watt, 1957). For example, it has persisted for decades in grazing exclosures in Breckland (Watt, 1981) and on Cronkley Fell in Teesdale (Elkington, 1981).

On lowland sites where grazing has been lost cutting in the late summer has also being used to maintain short swards (e.g. Burton Loenard Lime Quarries in Yorkshire). At other sites periodic removal of scrub or trees has been carried out where these have threatened populations (e.g. Barnack Hills and Holes NNR, Northamptonshire). On a few lowland sites, however, scrub encroachment has been so severe that populations have been completely lost (e.g. Broughton, Fleam Dyke, Ancaster Valley).

Threats

In recent decades the main threat to *Carex ericetorum* has been reductions in grazing leading to the replacement of short turf by taller more competitive swards and scrub (Table 5). This has been particularly prevalent on limestone grasslands, especially in the lowlands, where surviving fragments of species-rich grassland are no longer grazed as frequently as they once were due to the difficulties of sustaining livestock on small, isolated sites often 'managed' as nature reserves. Lack of grazing is also the sole reported threat to populations in the uplands due to a general decline in numbers of sheep (following Foot-and-Mouth disease) and in some areas a shift to more extensive cattle grazing. On some sites (e.g. Orton Scar, Widdybank Fell) this has led to the development of much taller swards dominated by *Sesleria caerulea* amongst which it is becoming increasingly difficult to find *C. ericetorum.*

Figure 4. Some habitats of *Carex ericetorum* in the British Isles (white markers indicate where the plant occurs): top left, grass-heath at Grime's Graves, Breckland; top right, limestone grassland dominated by *Sesleria ablicans* on Cunswick Scar, Westmorland; bottom left, *Bromopsis erecta* grassland in medieval limestone quarries at Barnack Hills and Holes NNR, Northamptonshire; bottom right, sugar limestone outcrop on Cronkley Fell, Upper Teesdale.

As in the 1970s (David, 1981) agricultural intensification (e.g. fertilisation, re-seeding, over-stocking) remains a threat to some populations in the lowlands as are afforestation and competition with invasive species although the latter may be a symptom of a lack of management mentioned above on some sites. All others threats were very local and included the loss of grassland to housing developments, quarrying and, perhaps most famously, the construction of Cow Green Reservoir in Upper Teesdale, which led to the loss of *c.*40% of the Widdybank Fell population (including an outlying population at Slapestone Syke) during its construction (Bradshaw, 1985).

Although not explicitly mentioned by surveyors, it seems likely that eutrophication may be contributing to these declines in areas where deposition of atmospheric pollutants from human sources is high. Evidence for this has been shown experimentally in Upper Teesdale where *C. ericetorum*, along with other rare species, were almost entirely eliminated through competition with tall grasses on plots treated with phosphorous and nitrogen (Jeffrey & Pigott, 1973). More generally long-term monitoring of plots within calcareous grasslands in Britain, including some supporting populations of *C. ericetorum* (e.g. Cronkley Fell), has shown a general decline in plant diversity including the loss or rare and scarce species in response to increases in N deposition over recent decades (Van Den Berg et al., 2010).

Table 5. Threats to populations of *Carex ericetorum* assessed during field visits 2008-2015.

Threat	Chalk		Limestone		Total
	grass-heath	grassland	lowland	upland	
Lack of grazing	3	4	14	8	29
Agricultural intensification	3	2	3	0	8
Afforestation	1	0	4	0	5
Invasive species	0	1	3	0	4
Recreation	1	0	1	0	2
Burning	0	0	1	0	1
Development	0	0	1	0	1
Quarrying	0	0	1	0	1
Reservoir	0	0	0	1	1
Disturbance	1	0	0	0	1

Conclusions

Carex ericetorum remains one of Britain's rarest sedges and the decline first quantified by David (1981) has continued albeit modestly till the present day. Whereas in the past most of these losses were due to the ploughing-up of grassland for cultivation or the intensification of grassland management for livestock production, more recently lack of management has become the main threat. This is because many of its sites are managed as nature reserves by organisations that often lack the resources and livestock to maintain grazing regimes. These effects are likely to have been compounded by increased eutrophication from human and agricultural sources (e.g. atmospheric pollution, fertilizer drift, etc.). Having said that, these losses in the lowlands have been mitigated to some extent by the discovery of large populations in the uplands, some extending over very large areas (e.g. Scout & Cunswick Scar, Crosby Ravensworth Fell, Widdybank and Cronkley Fells). Large populations also persist in Breckland although its status there seems more precarious due to greater pressures from human and agricultural activities. Away from these strongholds *C. ericetorum* remains critically endangered with tiny populations isolated on one or two sites in six vice-counties, including Cambridgeshire where it may already be extinct (Leslie, 2019). The fact that all surviving populations occur on SSSIs means that hopefully funding will be made available to maintain or restore grazing to the levels needed to ensure its long-term survival.

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Appendix. Details of the 64 British populations of *Carex ericetorum* included in this study. Populations sizes for the 1970s were taken from David (1981). See notes below this table for an explanation of the codes used for populations sizes, habitat and National Vegetation Classification communities (NVC).

Locality	VC	First	Last	Habitat	NVC	Population size	
						1970s	2008-15
Deadman's Grave	26	1877	-	CGH	CG7	B	P
Foxhole Heath	26	1829	-	CGH	CG7	B	P
Knettishall Heath	26	1977	-	CGH	CG3	B	A
Lakenheath Warren	26	1930s	-	CGH	U1	D	P
Risby Black Ditches	26	1888	-	CGE	CG7	B	C
Weather Heath	26	1884	1983	CGH	-	X	X
Worlington	26	1983	1983	CGH	-	NV	X
Bodney Warren	28	1980	-	CGH	?	B	P
Cockley Cley	28	1916	<1968	CGH	-	X	X
Cranwich	28	<1968	1968	CGH	-	X	X
East Harling	28	1949	<1970	CGH	-	X	X
Foulden Common	28	1946	-	CGH	CG2	B	C
Garboldisham	28	1957	1975	CGE	-	X	X
Gooderstone Common	28	1977	?	CGH	?	B	?
Grime's Graves	28	1951	-	CGH	CG7	C	B
Jubilee Wood	28	1880	1968	CGH	-	X	X
Weeting Heath	28	1956	-	CGH	CG7	D	D
Devil's Ditch	29	1911	-	EWC	CG3	A	A
Fleam Dyke	29	1965	1972	CG	-	X	X
Gogmagog Hills	29	1833	1896	CG	-	X	X
Newmarket Heath	29	1775	1954	CG	-	NV	X
West Wratting	29	1936	1974	CG	-	A	X
Barnack Hills & Holes	32	1978	-	LGQ	CG5	NV	B
Ancaster Valley	53	1950	1996	LG	-	A	X
Broughton	54	1951	1993	LG	-	A	X
Markland Grips	57	1945	-	LG	CG3/5	A	B
Silverdale Golf Course	60	1974	-	LG	CG3/8	-	B
Hawes Water	60	1951	-	LG	CG8/9	-	A
Jack Scout	60	1967	-	LG	CG1/2/9	-	C
Jack Scout, opposite	60	1988	-	LG	CG8	-	B
Red Rake	60	1979	2000	LG	-	-	X
The Row	60	1980	2000	LG	-	-	X
The Trough, below	60	1980	1990s	LG	-	-	X
Yealand Hall Allotment	60	1980	2000	LG	-	-	X
Brodsworth	63	1977	1990s	LG	-	A	X

Appendix. Continued

Locality	VC	First	Last	Habitat	NVC	Population size	
						1970s	2008-15
Lindrick Common	63	1945	-	LGQ	CG3/5	A	B
Wentbridge	63	1953	-	LG	CG4	B	C
Burton Leonard	64	1943	-	LG	CG2	B	C
Hetchell Crags	64	1958	c.1976	LG	-	X	X
Jackdaw Crag Quarry	64	1946	c.1965	LG	-	X	X
Ledsham	64	2013	-	LG	CG5	NV	B
Linton Common	64	1946	c.1965	LG	-	X	X
Black Ark, south	65	1950	-	LGS	CG9	-	B
Black Ark, north	65	1950	-	LGS	CG9	-	B
Greenway	65	1950	-	LGS	CG9	-	C
Thistle Green	65	1950	-	LGS	CG9	-	B
White Well Green	65	1950	-	LGS	CG9	-	C
Slapestone Syke	66	1960s	1970s	LGS	CG9	B	X
Widdybank Fell	66	1949	-	LGS	CG9	C	C
Burnbarrow Scar	69	1974	-	LG	CG10	NV	B
Crosby Gill	69	1978	?	LG	?	C	P
Cunswick Scar	69	1998	-	LG	CG9	NV	C
Long Scar Pike	69	1974	-	LG	CG9	B	D
Orton Scar	69	1967	-	LG	CG9	A	B
Pott Rigg	69	2013	-	LG	?	NV	A
Ravensworth Fell	69	1999	-	LG	CG9	NV	D
Scout Scar	69	1944	-	LG	CG9	C	D
Arnside Knott	69	1960s	-	LG	CG8/9	B,C	C
Far Arnside	69	1977	1990s	LG	-	-	X
Far Arnside, coast	69	1990s	-	LG	CG4/8	-	B
Hazelslack Tower	69	1960s	-	LG	CG2	B	B
Hazelslack, E of road	69	1990s	-	LG	?	-	B
Hazelslack, W of road	69	1990s	-	LG	?	-	B
Heathwaite	69	2013	-	LG	?	-	A

Notes. Habitat: CG – chalk grassland; CGE – chalk earthwork; CGH – chalk grass-heath; LG – limestone grassland; LGQ – limestone grassland in disused quarry; LGS – sugar limestone grassland. **NVC**: CG1 – *Festuca ovina-Carlina vulgaris* grassland; CG2 – *Festuca ovina-Avenula pratensis* grassland; CG3 – *Bromus erectus* grassland; CG4 – *Brachypodium pinnatum* grassland; CG5 – *Bromus erectus-Brachypodium pinnatum* grassland; CG7 – *Festuca ovina-Hieracium pilosella-Thymus praecox/pulegioides* grassland; CG8 – *Sesleria albicans-Scabiosa columbaria* grassland; CG9 – *Sesleria albicans-Galium sterneri* grassland; CG10 – *Festuca ovina-Agrostis capillaris-Thymus praecox* grassland; U1 – *Festuca ovina-Agrostis capillaris-Rumex acetosella* grassland. **Population size codes**: A – 1-20; B – 21-100; C – 101-1000; D – >1000; X – not present; P – present but no estimate of size made; NV – not visited.