Conservation of Britain's biodiversity: *Carex depauperata* With. (Cyperaceae), Starved Wood-Sedge

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ABSTRACT

Fifteen years conservation work on the rare, statutorily protected species *Carex depauperata* With. (Cyperaceae), Starved Wood-sedge in Britain are summarised. In the British Isles it has been recorded historically from 14 sites in v.cc. 6, 9/11, 16, 17, 52, 83, 90 and H5. About 60 plants are currently known in two native sites in England and one in Ireland, and it has been transplanted to two more sites. It is widespread in Europe and Asia though rare in many countries, with the greatest frequency of records in France and Spain. It is a distinct species showing little variation. It is a polycarpic perennial that usually grows in dry, deciduous woodlands on a range of soil types, and is often associated with tracks. It is a woodland gap plant that responds to opening of woodland canopies through coppicing and disturbance, and declines if management is neglected and shade increases. Periodic (c. every five years) disturbance of its woodland habitat by coppicing or scrub clearance is recommended as management for conservation.

KEYWORDS: Rare species, habitat management, critically endangered species, distribution, ecology.

INTRODUCTION

Carex depauperata With. (Cyperaceae), Starved Wood-sedge, is a very rare plant in the British Isles. It is currently known from two sites in Britain and one in Ireland, all with small populations. In Britain it is listed as Critically Endangered (the highest I.U.C.N. threat level), and is protected by Schedule 8 of the Wildlife and Countryside Act 1981 (Wigginton 1999). In the Republic of Ireland it is listed on the Flora (Protection) Order, 1999. It is also reputed to be rare and scattered across much of its European range, and often occurs in tiny populations. It is extinct in Germany and Luxembourg, and is described as rare in Belgium, Corsica, Italy, Switzerland and Turkey (Blab *et al.* 1984; Delvosalle *et al.* 1969; G. Aymonin, pers. comm., 1989; Landolt 1989; Nilsson 1985).

Although apparently once reduced to a single plant and on the verge of extinction, British populations of *C. depauperata* are now recovering and increasing through a combination of restocking, research, appropriate habitat management and pure chance. In this paper, we summarise the data from about 15 years detailed work so that other conservation projects may benefit from our experience. Full details are given in Birkinshaw (1990, 1991), Rich (1992, 1994a, b), Rich & Fairbrother (1994, 1995, 1996) and McDonnell (1997).

DISTRIBUTION AND CONSERVATION IN THE BRITISH ISLES

Data have been abstracted from the literature, herbaria (**ABD**, **BM**, **BRISTM**, **BTN**, **CGE**, **CLE**, **DBN**, **DEE**, **E**, **GLAM**, **K**, **LIV**, **LTR**, **NMW**, **OXF**, **PTH**, **RNG**, **SLBI** and **TCD**), field survey and correspondence with botanists.

1. Axbridge, North Somerset (v.c. 6)
Plants were first found in a wood between Axbridge and Cheddar in June 1860 by T. B. Flower (**BM**) but the locality was later reported to have been destroyed (White 1912). In 1911 H. W. Pugsley re-discovered it by a lane in the same area (but possibly in a different site) occurring thinly on an open grassy bank over 100 yards long (White 1912). H. S. Thompson found more, with an abundance of fruiting spikes, in 1915 (**E**).

The site has since been visited many times and its changes in population are well documented. A photograph taken by J. E. Lousley in 1937 shows *C. depauperata* on an open, flowery bank without scrub or hedges (**RNG**). The site gradually became overgrown, and by the late 1950s one last plant remained on a shaded bend of the lane which was continually being damaged by farm vehicles (R. M. Harley, pers. comm., 1981). The number of plants increased slightly during the next two decades, and in 1974 R. S. Cropper found six plants. Concerned for their conservation, he began to monitor them annually and initiated restocking, possibly single-handedly maintaining the species in the wild in Britain for the next decade.

Cropper's detailed monitoring notes were kindly provided to Rich & Fairbrother (1994), and are briefly summarised, with unpublished notes by R. A. Jarman, as follows. By 1977, the six plants were reduced to two due to damage from tractors, and there was no further change until 1981. There was light clearance of *Rubus* around the plants in the winters of 1977/78 and 1978/79, and the hedge opposite the plants was cut back in winter 1978/79. In October 1981, several plants grown from a cutting taken a few years earlier were re-introduced. Between 1982 and 1990, between four and six plants were counted annually, and in the winter of 1991/1992 or 1992/1993 a second transplant took place, with nine plants being present in 1994. The hedge on the east side of the lane was cut again in 1990.

In 1993 following the success at Ockford Wood (see below), Plantlife became involved in management of the site in consultation with English Nature and Somerset Wildlife Trust. In 1994, the large evergreen *Quercus ilex* which was shading the plants was cut down and a carpet of *Hedera helix* and invasive *Prunus spinosa* suckers removed along a 40 m stretch. One year later the average diameter of the plants had increased by c. 50% and plants were much more floriferous. C. Hancock noted heavy grazing of inflorescences, so a small deer track was blocked resulting in a ten-fold increase in the number of inflorescences in 1996. By 1999, there were at least 55 plants with many seedlings with several dense patches (one patch c. 7 × 1 m dominated by *C. depauperata* alone), and a new plant occurred about 50 m further down the lane.

2. Leigh Woods, North Somerset (v.c. 6)
A single immature specimen was gathered 1886 by H. S. Thompson, but was not identified until a few years later by A. Bennett, by which time Thompson could not remember the exact place he had gathered it (**BRISTM**; White 1912). This is still the only record for a very well-recorded National Nature Reserve.

3. Templecombe, North Somerset (v.c. 6)
Murray (1896) reported it from Templecombe but it has not been seen again and no further information is available.

4. Cranborne to Damerham, Dorset (v.c. 9)/South Hants (v.c. 11)
A herbarium specimen collected in the 1920s by H. H. Haines from hedgebanks between Cranborne and Damerham was discovered in **LTR** in 1984. The area concerned has been searched without success, though the exact site is not known (Pearman 1994).

5. Charlton Wood, Greenwich, West Kent (v.c. 16)
Carex depauperata was described as new to science from Charlton Wood after being found by Mr Woodward in 1787. It was last recorded there by R. R. Hutchinson in 1830 (**SLBI**). This area has now been built over.

6. Effingham chalk pit, Surrey (v.c. 17)
"Two or three tufts only" were first seen by W. W. Reeves in 1874 (Reeves 1874) and last recorded in 1881 by F. W. Ward (**RNG**). This is presumed to be the same site as "Bookham".

7. Ockford Wood (Westbrook Copse), Godalming, Surrey (v.c. 17)
Plants were first found at Godalming by W. Borrer in 1807 (**E**), though the exact site is not known. It was first reported by J. D. Salmon at "Westbrook Woods" in 1843 (**CGE**) and was well-documented until its demise in the 1970s.

E. C. Wallace photographed the plant on an open flowery bank in 1936 (**RNG**). In the 1940s, the plant was locally frequent in the wood, along the track side, on the bank, at the top of the bank and on the slopes above (F. Rose, pers. comm., 1992). J. E. Lousley saw "five fine plants by lane" in 1949 (**RNG**). R. W. David and O. Polunin saw five plants "one plant in gutter, two on bank above, and two more just into the wood at the top of the bank and 10 yards downhill" in 1961. By 1970, one plant remained on the edge of a precarious bank which Mrs J. E. Smith and W. E. Warren took measures to shore up. F. Rose and E. C. Wallace last saw one vegetative plant inside the wood in 1972. This plant seems to have disappeared from the site about this time under a landslide (J. E. Smith, pers. comm., 1993).

J. E. Lousley and Mrs J. E. Smith searched all the known sites in 1973 without success (Lousley 1976) and R. W. David failed to find the plant in 1974. In 1975 the Surrey Flora Committee again searched all the old localities and placed a request for information with a picture of the sedge in a local paper (one *Carex sylvatica* was the only response). Thorough searches by Mrs J. E. Smith with other botanists in 1986 and 1987 of many suitable areas around Godalming failed to find any plants. C. Birkinshaw failed to find it in 1989.

It was thus something of a surprise when one flowering plant was found in 1992 by F. Rose, P. Marren and T. C. G. Rich in exactly the same spot as where it was last seen. During the Great Storm of 1987, a large branch had been blown down from a *Tilia* × *vulgaris* tree directly above the old site which had opened up the canopy and probably stimulated buried seeds to germinate (Rich 1994b). The plant had remains of inflorescences from 1991, suggesting that it was in at least its third year.

In November 1992, the canopy and hedge were thinned and the *Hedera helix* and *Rubus fruticosus* in the ground layer removed taking care not to damage the plant. A local botanist Mrs A. Fairbrother was recruited to keep an eye on the plant and keep the surrounding vegetation down, which has proved very successful for growth of the plant to the present day.

8. Frith Hill, Godalming, Surrey (v.c. 17)
Plants were found in c.1842 by J. D. Salmon (Brewer 1863) and by many botanists up to 1891.

9. Charterhouse (Milton Wood), Godalming, Surrey (v.c. 17)
This site was first reported in c. 1843 as "copse near Hurtmore Cottages" by J. D. Salmon (Brewer 1863). Lousley (1976) recorded that he last saw it in 1938 and that it disappeared during the war, probably after timber extraction.

10. Farnham, Surrey (v.c. 17)
There is a specimen in **DBN** collected by W. McIvor from "near Farnham" in August 1846 (Rich *et al.* 2000).

11. Porth-y-felin, Holyhead, Anglesey (v.c. 52)
In 1936 A. G. and W. Holder discovered *C. depauperata* on rocks below the sea wall at Porth-y-felin, Holyhead (**LIV;** correspondence in **NMW**). In 1967 W. E. Hughes visited the site using the Holder's directions and found one plant. This site appears to have been erroneously reported as on the edge of a quarry by Ellis (1983) which has misled many botanists.

Searches in 1998 and 1999 by T. C. G. Rich, S. Ellis and R. A. Jones of the exact site have failed to refind the plant. Aerial photographs taken by the Luftwaffe in 1940–41 show the area around the rock to have changed little, though there is now an invasion of *Fallopia japonica* and a small concrete ramp has been constructed. Clearance and disturbance might regenerate the plant from the seedbank.

12. Bonaly, Edinburgh (v.c. 83)
A specimen from "Wood above Bonelly" (assumed to be Bonaly) was collected by W. R. McNab probably sometime between 1860 and 1869 (**DBN**; Rich *et al.* 2000). This area, now largely a Regional Park, was searched by Mr C. Dixon without success in 1999 (pers. comm., D. McKean, 1999).

13. Forfar (v.c. 90)
There are two records which require confirmation, but which could refer to the same site. Hooker (1821) cited "woods near Forfar, G. Don", which was accepted by Gardiner (1848) but rejected as doubtful by Ingram & Noltie (1981) as the origin could have been Don's garden (the source of several other confusing records). Another specimen from "Forfarshire" collected by T. McFarlane (ex herb. Rev. H. G. Carroll, **DBN**) appears to have been collected independently suggesting the species has indeed occurred in the county (Rich *et al.* 2000).

14. Killavullen, East Cork (v.c. H5)
Plants new to Ireland were discovered in scrubby open woodland on a rocky Carboniferous limestone outcrop by T. O'Mahony in 1973 (O'Mahony 1976), and a total of twelve plants were found on more detailed searches in 1974 and 1975. In 1984, these original plants were found to have gone extinct, but a new sub-population of six plants was found to the west. Two further sub-populations with two and three plants respectively were found in 1992. By July 1994, the sub-population of two plants had gone (despite being large vigorous plants in 1992), but the other two sub-populations survived though fluctuating in numbers.

The site has a dense field layer of *Hedera helix* through which there are many small animal tracks with which the plant is associated. Some limited canopy clearance work took place in 1982. In 1989, although the canopy was beginning to close, 20 plants were recorded. The plant has since declined and by 1998 the population had declined to five small tussocks of which only three were fruiting (O'Mahony 1999). The site has been monitored regularly, and a full account of this site is in preparation by T. O'Mahony.

Errors or probable errors

A specimen in **DBN** labelled "Leith Hill, Surrey, 30 June 1890, per J. Leitch" may be a corruption of Frith Hill (Rich *et al.* 2000).

There is a second Frith Hill in Surrey at SU9058. It appears that the Godalming Frith Hill records have been erroneously plotted in SU95 in Perring & Walters (1990) and Wigginton (1999) (A. Lockton, pers. comm., 2000); all records are assumed to belong to the one at Godalming (SU9744).

There is a specimen from Ranworth, Norfolk collected by W. Curnow in 1878 in **E** whose status is currently in doubt. The soils in this area are predominantly coarse loams or unsuitable wet fen land. There is currently no ancient woodland of more than 2 ha size in the parish, and the woods that are present are predominantly semi-natural woods managed for pheasant shooting, though there is some hazel coppice and oak woodland on the valley sides (R. Handley, R. Ellis, pers. comms., 2000). Curnow was an acute observer of natural history and specialised in lower plants, and made some outstanding collections (Davey 1909), but he seems to have botanised predominantly, though not exclusively, in Cornwall. Letters he wrote in 1876 indicate he was trying to obtain sedges and grasses for his collection from other botanists, and it may be that the specimen is of cultivated origin and Curnow confused the original locality (R. J. Murphy, pers. comm., 2000).

It has thus been recorded from 14 sites in v.cc. 6, 9/11, 16, 17, 52, 83, 90 and H5. A distribution map summarising the records is given in Fig. 1. It has a somewhat disjunct distribution in the British Isles, characterised by a few long-known and persistent sites contrasting with the nearly half which are represented by one historical herbarium specimen only. In 1999 it was only known as a native in two sites in England and one in Ireland. Population counts for the last ten years for these sites are summarised in Table 1.

TRANSPLANT SITES

1. Cheddar Wood
On 30 October 1977 C. E. D. Smith and R. A. Jarman, as part of a project with the Somerset Trust for Nature Conservation and Bristol Conservation Corps, transplanted 15 plants from Bristol and Cambridge University Botanic Gardens (both grown from seed collected at Axbridge in 1965 by D. E. Coombe) into each of two 10 m × 10 m quadrats, one cleared of ground, understory and overhanging vegetation, and the other under closed overgrown canopy nearby. The plants were reported heavily grazed soon after they had been planted. On 22 July 1979, all 15 plants had

FIGURE 1. Distribution of *Carex depauperata* in the British Isles. ● 1990+. ○ pre-1990. ? exact location uncertain. × error or probable error.

TABLE 1. NUMBER OF MATURE PLANTS AT *CAREX DEPAUPERATA* NATIVE SITES 1990–1991

Site	Godalming	Axbridge	Cork
1989	0	6	20
1990	1	4	-
1991	1	5	-
1992	1	6	15
1993	3	-	17
1994	3	14+	17
1995	3	14+	10
1996	3	15+	7
1997	4	18+	7
1998	4	51+	5
1999	4	55+	-

Data for Godalming by extrapolation, counts for Axbridge include transplants at native site only; data for Cork courtesy of T. O'Mahony.

survived in the cleared plot, but only five small vegetative plants remained in the overgrown plot. One plant, probably a survivor from the original transplants was seen in the clearing in the mid-1980s (R. Corns, pers. comm., 1995), but the exact location of the other plot is not now known. No plants were found by C. Birkinshaw in 1988 or 1989, or by T. C. G. Rich in 1993 and 1994 but, surprisingly, two plants were found in the clearing in 1995 by T. C. G. Rich, four in 1996, and nine in 1999.

2. Edge of Cheddar Wood

In April 1988, 100 divisions of *C. depauperata* from Cambridge University Botanic Garden (origin as above) were planted inside and outside an exclosure in ungrazed pasture/woodland edge on the edge of Cheddar Wood to investigate the light, grazing and disturbance requirements. Eighteen months later all plants were still alive, though varying in performance. Plants subject to grazing were less fecund than those protected from grazing, plants placed in disturbed vegetation were much larger than those in undisturbed vegetation suggesting a benefit from reduced competition, and optimum fecundity occurred on the woodland edge (Birkinshaw 1990). By October 1991, 86 plants were still alive (the losses mostly due to competition from *Hedera*), and the main trends observed by Birkinshaw had continued (Edgington 1991). By 1993 plants in the enclosure were shaded by dense *Rubus fruticosus*, and fewer plants survived within it than outside. The fence was removed in 1998. At least 17 plants survived in 1999, mainly those planted outside the original enclosure indicating that competition affected survival.

WORLD DISTRIBUTION

There is little recent information available on its distribution or frequency in Europe. Data were compiled from herbarium specimens and literature to give a basic assessment of its distribution. Information was abstracted from non-British specimens at the following herbaria: **BM**, **COI**, **FI**, **K**, **L**, **LTR**, **LIV**, **MA**, **NMW**, **OXF**, **P** and **RNG**. Information was also abstracted from relevant Floras held in the library at the National Museum of Wales, although the Flora holdings are patchy and incomplete.

The European records traced are mapped in Fig. 2. It has been recorded from Albania, Belgium, Bulgaria, Corsica, Croatia, England, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Romania, Scotland, Sicily, Spain, Switzerland and Wales. In addition, it has been recorded from Iran, Iraq, Turkey and the former U.S.S.R. (Caucasus, Ukraine, Pamir, Tien-Shan) (Nilsson 1985), but the records are too fragmented and unlocalised to merit plotting. The records traced show it is widely scattered across Europe and near Asia, though these are likely to be biased towards western European sources. France and Spain appear to be its main strongholds, and it is certainly still widespread in the latter.

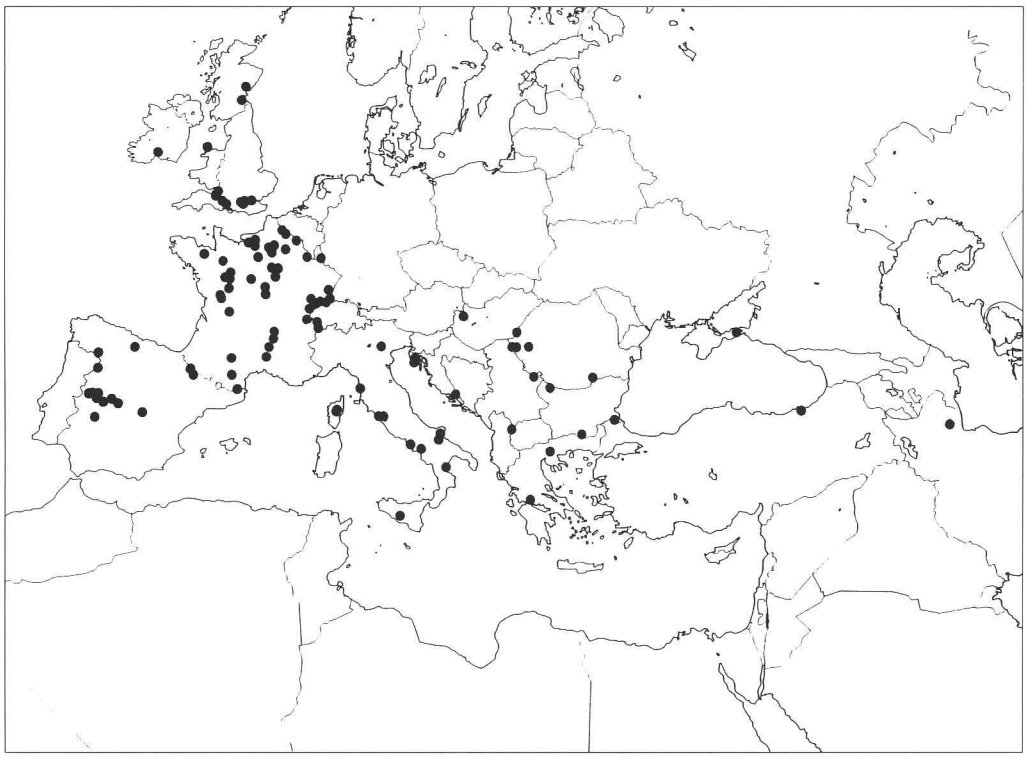

FIGURE 2. European distribution of *Carex depauperata* compiled from herbarium specimens and the literature (all dates).

ECOLOGY

LIFE CYCLE

Carex depauperata is a distinctive sedge, instantly recognisable across its range by its few flowers and large utricles. Vegetatively it is less distinct, and can be similar to *C. sylvatica* when young, but usually differs in forming dense clumps with more erect leaves which droop at the tips to form a "fountain". The red coloration of the basal sheaths is distinctive when present; it is often more pronounced on herbarium specimens than in live material. Vegetative plants can be very difficult to find, and young plants are difficult to distinguish from other *Carex* species. No hybrids are known.

Material from the two British, one Irish and one French site (the latter originally collected in southern central France by P. A. Harmes) was cultivated in an open herbaceous border on clay soils in a garden in Surrey by Mrs J. E. Smith between 1995 and 1999. After two years in cultivation, no significant morphological differences could be detected between the plants. Similarly, examination of a range of herbarium material from the western part of its range shows that it varies little morphologically, except a little in size due to local growth conditions. Davies (1956) reported a haploid chromosome number of n = 22 from a plant from Axbridge.

Carex depauperata is a polycarpic hemicryptophyte. The diameter of clumps and the number of inflorescences can increase or decrease between years depending on growth conditions. Leaves are usually green though the winter. In cultivation and in the wild plants have been observed to flower in their second or third year. Although some plants in cultivation in Britain have lived for at least 25 years, wild plants may have shorter lives, e.g. in the Cork population the maximum life-span recorded was 13 years and many individuals survived for only 2–5 years (T. O'Mahony, pers. comm., 2000).

Large tussocks in well-lit sites may produce up to 200 inflorescences, each consisting of a terminal male spike and 1–4(–5) female spikes. Heavily shaded plants may not flower. Flowering begins in April and usually continues until June. The inflorescences are protandrous and wind-pollinated. Isolated plants have been observed to set fruit, and it is thus presumably self-compatible. Observations at Cambridge Botanic Gardens found an average of 4·96 ± 0·8 (s.d.) nutlets per spike (n = 40), one of the lowest figures for a British sedge outside the Subgenus *Primocarex*. The nutlets are large (c. 4·5 × 2·1 mm) and heavy (average weight air-dry nutlets excluding utricles 0·0099 mg, n = 125). Fruit set is usually high; it sets abundant fertile seed in both extant British sites and many ripe fruits have been observed on herbarium specimens. Fruiting stems tend to droop around the plant late in the summer onto the soil, and may persist with fruits intact through the winter. It is usually possible to find at least some of the previous year's inflorescences at the next flowering.

The method of seed dispersal is unknown. Wind dispersal is unlikely because the nutlets are heavy and lack adaptations normally associated with this method of dispersal (e.g. wings). However, it is possible that the nutlets have evolved for dispersal by graminivores such as rodents (that could collect and cache the nutlets, and then sometimes fail to exploit these caches; for examples of species dispersed by rodents see Janzen 1983), or by herbivores that could swallow the nutlets when eating the foliage and at least sometimes pass them in a viable condition (for discussion of this method of dispersal see Janzen 1984). In addition, the nutlets will certainly sometimes be dispersed by the surface flow of water following rain. Failing all else, the long infructescence culm (up to 1·5 m) allows nutlets to be deposited some distance from the parent plant.

Fresh nutlets may take a long time to germinate. Experiments showed samples took 18–29 months after sowing to germinate, suggesting an after-ripening requirement like many other sedges (Birkinshaw 1990; Jermy *et al.* 1982). Dormancy appears to be partly controlled by the pericarp; 30% germination (n = 20) occurred within 3–5 months when the pericarp was nicked. Germination is also almost certainly controlled by environmental conditions such as light.

Seeds may remain dormant for long periods. This has been demonstrated experimentally by Birkinshaw (1999), who showed that at least some seeds in samples buried deeply in the soil germinated when brought to the surface after an interval of nine years. Observations of the Godalming site suggest dormancy of nearly 20 years between the last plant being seen and the new one re-appearing.

HABITATS

Birkinshaw (1991) summarised its habitat in Britain. It usually occurs in dry, deciduous woodland, often in south-facing sites, but also occurs along the base of an old hedge in Somerset, and has been recorded from scrubby rocks by the sea on Anglesey. It is often associated with rocky woodland in Europe, but not exclusively so.

Carex depauperata will prosper in conditions of full sunlight (provided that it is not out-competed by more vigorous heliophytes) to semi-shade. It grows well in full sunlight in the "Rare Plants Flower Bed" outside the English Nature Headquarters in Peterborough, and in gardens elsewhere. It is tolerant of shade, but plants may become moribund and cease to flower in deep shade. However, this sedge is probably best considered as a woodland gap plant adapted to the cycle of gap formation followed by secondary succession that is a feature of natural forests. In particular, it is hypothesised that the seeds of *C. depauperata* in the soil seed bank are stimulated to germinate by environmental changes associated with the formation of a gap in the forest; these seedlings grow rapidly to maturity in the conditions of high illumination and low competition within the gap and replenish the seed bank with new seeds; then as woody plants colonise the gap and close the forest canopy once again, the sedge declines and finally disappears leaving seeds waiting for the formation of a new gap, maybe several decades in the future. In support of this hypothesis is the long dormancy of *C. depauperata* seeds and various observations showing that the plant increases in abundance following coppicing or localised felling (woodland management operations that simulate gap formation; e.g. Lousley 1976; pers. comm., T. O'Mahony 1989). At Fontainebleau, it was formerly plentiful in woods near the River Seine but the population declined to a handful of plants until coincidentally the French Forestry Department felled the *Fagus* trees and churned up the soil during forestry operations, after which hundreds of plants re-appeared (F. Rose, pers. comm., 1992).

The soils associated with *C. depauperata* range from acid podzols to calcareous brown earths (full soil analyses from five sites are given in Birkinshaw 1990). In Somerset it occurs on a calcareous brown earth (pH 7·4), in Surrey on weakly calcareous sandy soils, in Cork on a Mull rendzina (pH 6·2–6·6), at Fontainebleau, France it occurs on a podzol (pH 3·4–4·5), at Chantilly, France on sandy brown earth (pH 5·8–7·2) and at Ohrid, Yugoslavia on a clay-rich terra fusca. It is also reported from schistes in France. Soil type *per se* does therefore not seem to be critical provided they are free-draining (Birkinshaw 1991), though oddly Hegi (1980) also records it associated with damper soils with trickles of fresh water and notes a preference for nutrient-rich soils in central Europe.

The populations at Axbridge, Godalming and Cork occur in rather patchy W8d *Fraxinus excelsior - Acer campestre - Mercurialis perennis* woodland *Hedera helix* sub-community of the national vegetation classification (Rodwell 1991). The site at Anglesey was probably in W24 *Rubus fruticosus - Holcus lanatus* underscrub. At Fontainebleau is occurs in managed beech woods equivalent to the NVC community W15 *Fagus sylvatica - Deschampsia flexuosa* woodland and at Chantilly in woodland equivalent to the W8 *Fraxinus excelsior - Acer campestre - Mercurialis perennis* woodland, *Primula vulgaris - Glechoma hederacea* sub-community. In general these equate to the order *Fagetalia* and it is typically recorded from such woodlands and in *Quercus pubescens* woodland of the order *Quercetalia pubescenti-petraeae* through most of Europe (Hess *et al.* 1967; Oberdorfer 1979; Hegi 1980; Ellenberg 1988). In Spain it occurs in *Pinus pinaster* woodland, *Quercus pyrenaica* woodland, *Castanea* woodland and *Corylus avellana* scrub (data from herbarium labels in **MA**).

It is often associated with tracks ranging in size from small animal tracks to rough vehicle tracks (Birkinshaw 1991). This may be due to slightly enhanced light levels and its ability to tolerate crushing (it can tolerate even quite heavy trampling and even some crushing by vehicles) which competitive heliophytes may not be able to do.

Observations at all three extant sites indicate grazing damage, especially to the inflorescences, presumably by rabbits, deer and/or horses. M. and C. Kitchen have observed deer eating plants in their garden in Gloucestershire (pers. comm., 1994). The exclosure experiment on the edge of Cheddar Wood showed plants subject to grazing by rabbits and deer were significantly less fecund than those protected from grazing (Birkinshaw 1990). It is tolerant of at least light grazing, but the number of inflorescences and consequently seed production may be significantly reduced.

In Britain it is a lowland plant, being recorded from ± sea level on Anglesey to c. 50 m at Axbridge and Godalming. In Europe it also occurs from near sea level in the Aegean (R. M. Harley, pers. comm., 1981) to at least 500–950 m in Spain and 1260 m in the mountains of central Europe (Hegi 1980).

CONSERVATION

Carex depauperata is a fully protected species under Schedule 8 of the Wildlife and Countryside Act 1981. The Cheddar Wood site is part of a S.S.S.I. but the Ockford Wood site is not. In Ireland it is protected under the Flora (Protection) Order, 1999. Plantlife monitor the species annually, and have prepared a species action plan (Davis 1999).

Of the 14 sites from where it has disappeared or declined, there is no information on the causes of the decline for ten. The main cause of decline at three others appears to be lack of appropriate woodland management and increase in shade, with one recorded as probably being lost due to forestry operations. The main current threats to the plant are lack of appropriate management which may result in either dense shade or competition from other species, damage by vehicles, potentially too much grazing, and, at Godalming, landslides which have caused temporary extinction in the past. Whilst there are many specimens in herbaria, collecting by botanists has probably been only a very minor part of the decline, and has not been responsible for extinction at any sites as far as we are aware. Further visits to known historic sites may result in it being rediscovered, as at Godalming.

Both native populations at Godalming and Axbridge have increased following conservation management of opening up the canopy and/or coppicing with disturbance of the ground flora. Such management, repeated perhaps every five years or so, is recommended for all sites, depending on

growth of the canopy and competing species. Where populations are critically small, more regular visits to clear competing vegetation around individual tussocks may be required and proved very successful at Godalming. Some protection from heavy grazing may be required at some sites.

The potential for restoration of old sites in England from the seed bank has been investigated by McDonnell (1997), who concluded that there was insufficient detailed historic data to merit disturbance to regenerate it from the seedbank at any sites, and proposed reintroductions at Milton Wood, Godalming and Effingham. The recently rediscovered locality details suggests that restoration of the Anglesey site would be worthwhile.

Material from Somerset, Surrey and Cork is held in cultivation in several botanic gardens and private gardens, and seeds from both English sites have been deposited in the Millennium Seed Bank. It grows readily in cultivation and increases from seed in at least some gardens, contrary to the statement by White (1912).

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