Conservation of Britain's biodiversity: *Filago lutescens* Jordan (Asteraceae), Red-tipped cudweed

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ABSTRACT

This paper summarizes the conservation work being carried out on *Filago lutescens* L. (Asteraceae), Red-tipped cudweed, a rare, statutorily protected species in Britain. It is a winter or spring annual, germinating mainly in the autumn, and flowering from June to October. Its habitats are mainly arable fields, tracks and path sides, open sandy ground, sand pits and commons or heathland usually in *Thero-Airetalia* vegetation. It has been recorded in a total of at least 212 sites in 86 10-km squares in south-eastern England, but has been seen in only 14 sites in ten 10-km squares since 1990. It appears to have declined in arable field habitats owing to changes in agricultural practices, and in tracks and heathland owing to reduced disturbance. Much of the decline took place before the 1960s. Population counts for all extant sites between 1993 and 1996 show marked variation from year to year and marked differences between sites. The best conservation management is currently thought to be annual disturbance by digging or rotavation in early autumn. This species is still under severe threat in Britain; only two extant sites have statutory protection and the two largest populations are unprotected.

KEYWORDS: population size, ecology, distribution, habitat management, rare species.

INTRODUCTION

Filago lutescens Jordan (*F. apiculata* G. E. Sm. ex Bab.; Asteraceae), Red-tipped cudweed, is a rare species in Britain. It is one of five species of *Filago* native to Britain all of which occur in open skeletal habitats, and all of which are declining. *F. pyramidata* L. is very rare and statutorily protected; its conservation is described by Rich (1999a). *F. gallica* L., recently reassessed as a native species (Rich 1994), has subsequently been reintroduced from native stock to mainland Britain from where it has been extinct since the 1950s (Rich 1995a). *F. vulgaris* Lam. and *F. minima* (Sm.) Pers. have also shown significant declines between 1930 to 1960 and 1987 to 1988 (Rich & Woodruff 1996).

Although *F. lutescens* has been known to be declining in Britain for over 20 years (e.g. Perring & Farrell 1983), virtually nothing was known about its ecology or the reasons for the decline. In 1994, the wild-plant conservation charity Plantlife became concerned that *Filago lutescens, F. gallica* and *F. pyramidata* were amongst the most threatened plants in Britain. The species were therefore included in their 'Back from the brink' project, which aims to conserve critically endangered plant species through research and management work. About 20 rare plant species have been included in this project between 1992 and 1996, which represents a significant contribution to the conservation of biodiversity in Britain by the voluntary sector. The aim of this paper is to summarize and update the conservation work carried out on *F. lutescens* up to 1996; full details can be found in Rich (1995b, 1996) and Rich & Davis (1996). Further details about the 'Back from the brink' project can be obtained from Plantlife.

DISTRIBUTION

DISTRIBUTION IN BRITAIN

As *Filago* species have often been confused in Britain, a review of the historical records was first carried out. *F. lutescens* is relatively easily distinguished from the other species by the red tips to

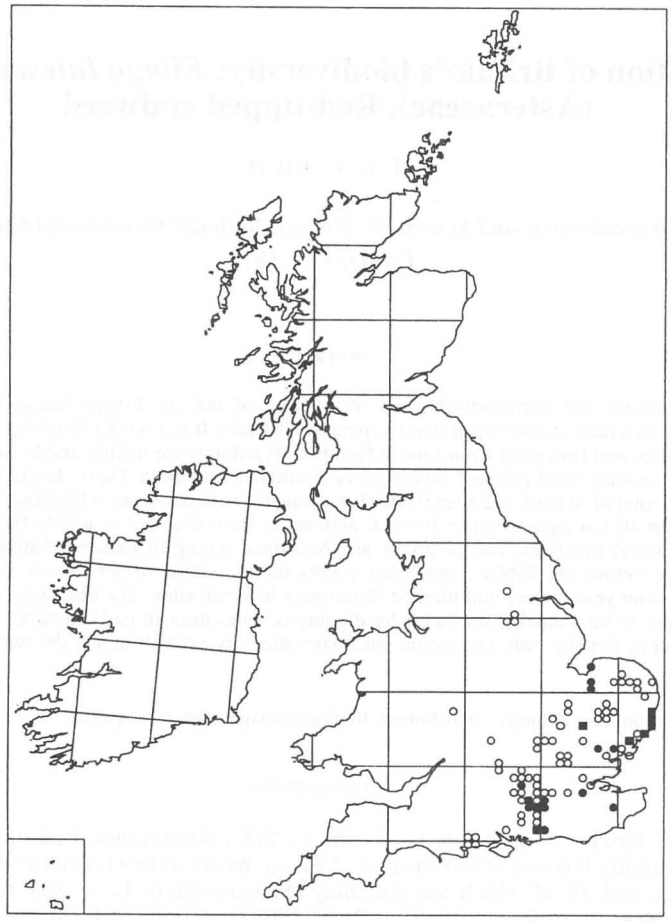

FIGURE 1. Distribution of *Filago lutescens* in the British Isles. ■ 1990 onwards. ● 1950–1989. O Pre-1950 and undated records.

the young phyllaries – in older flowers these fade to straw-coloured, resulting in confusion with *F. vulgaris* and *F. pyramidata*. There are two subspecies of *F. lutescens* (Holub 1976): subsp. *lutescens* is widespread and occurs in Britain and Europe, and subsp. *atlantica* Wagenitz occurs in Portugal and the Azores.

F. lutescens was first reported in Britain by Smith (1846) from sandy borders of fields, hedgebanks and roadsides in Yorkshire. Watson (1848) clarified the distinction between it and the other species, and it was subsequently quite widely recorded (not always correctly) in southern England. It has slowly declined, and is now very rare and unknown to most British botanists.

Records have been compiled from the literature, herbaria (**BM, BRISTM, BTN, CGE, E, GL, GLAM, IPS, K, LIV, LTR, MNE, NMW, NWH, OXF, RAMM, RNG, SLBI, TTN** and **US**; abbreviations following Kent & Allen 1984), field survey, correspondence with botanists and from information held by English Nature and the Biological Records Centre, Monks Wood. Most of the records are supported by herbarium specimens determined by T. C. G. Rich or J. Holub. Doubtful records have been rejected. About 400 records have been traced, representing at least 212 localities in 86 10-km squares in 24 vice-counties.

A distribution map distinguishing 1990 to 1996, 1950 to 1989 and older records is shown in Fig. 1. The species has been fairly widely recorded in south-eastern England. All the records are accepted as native as there are no records of any introduced localities. Note that a number of the records in Perring & Walters (1962, 1990) have been revised here and many more added.

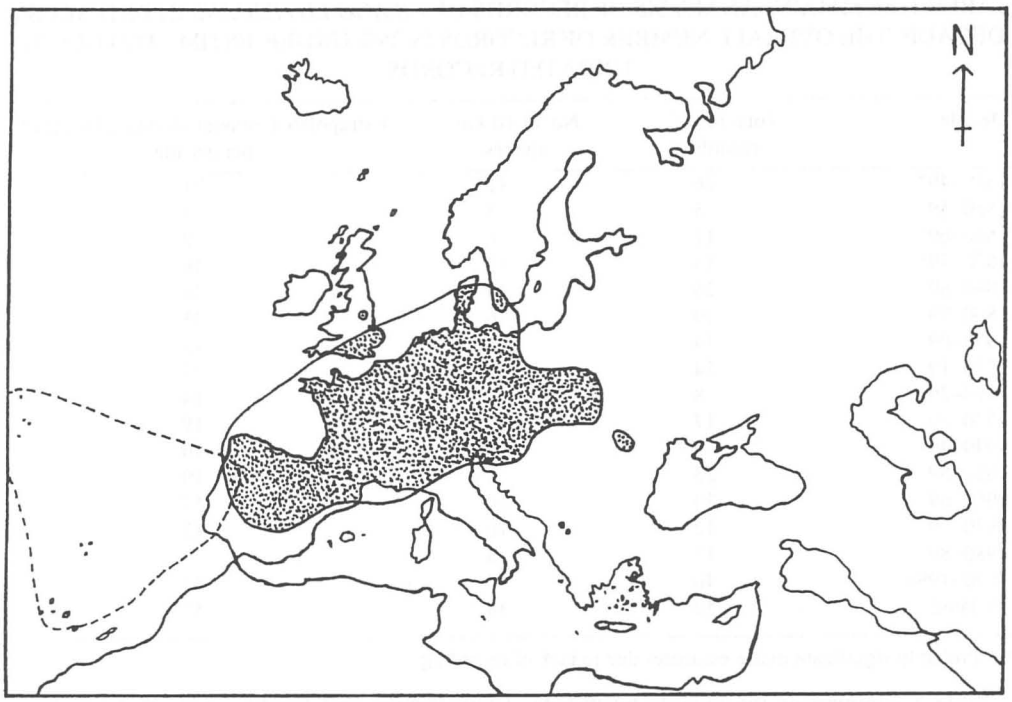

FIGURE 2. Distribution of *Filago lutescens* (redrawn from Meusel & Jäger 1992). The distribution of subsp. *atlantica* is enclosed by a dotted line.

WORLD DISTRIBUTION

The world distribution is shown in Fig. 2; it is widely recorded in western Europe, with scattered records in the former Yugoslavia (Holub 1976; Meusel & Jäger 1992).

It is still reasonably widespread in Spain, Portugal and France but becomes rarer eastwards in Europe. In Holland, it has been long-neglected and is probably extinct (Adema 1976), and there is no known reason for its disappearance (Mennema, Quene-Boterenbrood & Plate 1980). In Belgium and Luxembourg, it was recorded 18 times before 1930, and only once since (van Rompaey & Delvosalle 1972). In Germany, it is scattered and rare, mainly in the south and also in an area around the Baltic; there are relatively more pre-1945 records suggesting that it has declined (Haeupler & Schonfelder 1989). In Switzerland, there are 28 historical records mainly in the north-west of the country (Welten & Sutter 1982). In the Czech Republic, it is very rare and is statutorily protected. In the former U.S.S.R., it is treated as a variety of *F. vulgaris*, and is described as rare (Smol'yaninova 1990). It is extinct in Sweden (Holub 1976).

STATUS IN BRITAIN

CHANGES IN THE NUMBER OF RECORDS WITH TIME

A conservative approach has been taken to analysing the records to determine changes in the status with time, due to the inherent inconsistencies of the records and the recorders. Some records lack dates, some localities cannot be traced, and it is unclear if some records refer to the same or different sites. Whilst the general quality of most post-1950 records allows individual sites to be identified, this becomes increasingly difficult with older records. A site with the same name is assumed to be the same locality unless the habitats are obviously different (e.g. arable field or gravel pit). The absence of a record from a locality does not necessarily mean that the plant did not

TABLE 1. SUMMARY ANALYSIS OF RECORDS OF *FILAGO LUTESCENS* IN BRITAIN BY DECADE. THE OVERALL NUMBER OF RECORDS IS 25% UNDER-ESTIMATED DUE TO UNDATED RECORDS

Decade	Total no. of records	No. of 10-km squares	Extrapolated number of extant localities per decade
1840–49*	26	12	21
1850–59*	5	5	7
1860–69*	11	6	8
1870–79*	15	12	16
1880–89	26	15	20
1890–99	29	16	25
1900–09	14	8	23
1910–19	24	15	23
1920–29	8	7	14
1930–39	17	10	19
1940–49	9	6	16
1950–59	23	8	19
1960–69	20	10	17
1970–79	12	10	12
1980–89	17	5	9
1990–1996	40	10	14
Undated	59	18	52

* = Probably significant under-estimates due to lack of recording.

Table 1 summarizes the records by decade, 10-km square and locality. Note that because a quarter of the historical sites have no date information, the number of records is under-estimated. The total number of records per decade varies according to the botanical activity of recorders rather than changes in the frequency of the plant, as is well known for other plants (e.g. *Thlaspi perfoliatum;* Rich 1999b). The publication of the first record in 1846 stimulated many other records from the Botanical Society of London, which was very active at the time, but the records drop in the 1850s when the Society collapsed. Collecting by its successor, the Botanical Exchange Club, in the 1860s and 1870s again resulted in many records with a peak in the 1890s, by which time the main features of the distribution were known. The troughs in the 1920s and 1940s may be due to the Depression and Second World War respectively. The influence of the agricultural revolution in the 1950s and 1960s is seen with a subsequent decrease in the number of records, the rise recently being due to field work for the Nature Conservancy Council in the late 1980s and the survey work in the 1990s reported below.

The number of 10-km squares recorded is a widely-used measure of relative frequency in Britain (e.g. Perring & Farrell 1983). The number of 10-km squares recorded per decade shows a similar pattern (Table 1); note that because not all sites persist there is a considerable turnover of 10-km squares each decade.

A better measure of change than the number of 10-km squares is the change in the number of sites with time. As not all sites will have been continuously recorded, the number of sites present has been extrapolated by assuming the species was present at each site for all decades between the first and last record. The number of sites present for each decade was then totalled (Table 1). There is a decline in the number of sites to the current 14 by gradual loss of sites randomly across the whole range, and most of the decline appears to have taken place by the 1960s. The plant has been recorded since 1990 in 14 out of at least 212 localities (6·6%), and many of the remaining populations are so small that they could be threatened in poor years (see below). Further losses are to be expected unless the remaining populations are conserved.

REASONS FOR THE DECLINE

The reasons for the decline have been investigated by analysing changes in the habitats in which the plant has been recorded (Table 2). Whilst some records do not indicate exactly in which habitat the plants were growing, the main trends can be discerned.

TABLE 2. HABITATS OF *FILAGO LUTESCENS* IN BRITAIN COMPILED FROM RECORDS WITH HABITAT DATA. REPEATED RECORDS FROM THE SAME SITE ARE NOT INCLUDED. 114 RECORDS (43% OF ALL HISTORIC RECORDS) HAVE NO HABITAT NOTED

Habitat	Number (%) of records up to 1989	Number (%) of records 1990–1996
Fields or arable	65 (43%)	4 (29%)
Roadsides, lanes, paths, tracks	24 (16%)	3 (21%)
Gravel and sand pits	12 (8%)	2 (14%)
Commons and heathland	12 (8%)	1 (7%)
Sandy or gravelly ground	12 (8%)	1 (7%)
Fallow or stubble fields	7 (5%)	1 (7%)
Railways	6 (4%)	1 (7%)
Gardens	3 (2%)	0
Woods (presumably on tracks)	2 (1%)	0
Chalk pit	2 (1%)	0
Meadow	1 (0·7%)	0
Clay pit	1 (0·7%)	0
Golf links	1 (0·7%)	0
Rubbish tip	1 (0·7%)	0
Market garden	1 (0·7%)	1 (7%)
Total	150 (100%)	14 (100%)

Historically, *Filago lutescens* was most commonly reported from arable fields, associated with a wide range of crops including rye, corn, barley, wheat, clover, sainfoin, roots and potatoes (Table 2). Often the fields are described as sandy, and sometimes as gravelly. Interestingly, it was much less commonly reported from fallow or stubble fields than its two rare relatives, *F. pyramidata* and *F. gallica*, perhaps owing to the plant's growing and flowering earlier than the other species. The decline in records from arable fields is striking.

It was also widely reported from paths, tracks and roadsides (Table 2). Before roads were paved and covered with tarmac, road and tracks were regularly disturbed by carts and animals which must have created suitable habitats. Most road verges today tend to support unsuitable tall, closed grassland communities. Some unpaved tracks and paths still maintain suitable short, open habitats.

The next most suitable habitats are sand or gravel pits, sandy ground, and commons and heathland. These reflect the suitability of the soils and the disturbance created by grazing or small-scale mineral extraction. The railway habitats include a range of sites from cuttings to tracks and station yards. The plant is only rarely recorded from other habitats, and has only occasionally been recorded from closed communities where it does not persist.

The main reason for decline is undoubtedly the loss of populations in arable fields, probably due to the use of selective herbicides, fertilisers and changes in the timing of agricultural operations (Wilson 1992). This is a similar story to many other arable weeds in Britain such as *Scandix pecten-veneris* and *Agrostemma githago*. Loss of other habitats such as roadsides, and the decline in grazing and disturbance on heathlands, possibly coupled with the decline of rabbits through myxomatosis, have also taken their toll.

POPULATION SIZES 1993 TO 1996

The population sizes of all post-1990 sites were monitored between 1993 and 1996 (Table 3; the population at Suffolk 5 was last seen in 1991). In addition, a considerable amount of time has been spent by many volunteers and the author searching old sites across the country (Rich 1995b). During this search one old site was rediscovered and two new sites found, and it is probable that there are still a few more undiscovered sites.

The number of plants differs markedly between sites, with four sites holding on average over 90% of the plants (Table 3). The number of plants also varies markedly between years at some sites,

TABLE 3. ESTIMATED POPULATION SIZES OF *FILAGO LUTESCENS* AT ALL KNOWN SITES IN BRITAIN 1993–1996. SITES ARE LOCATED ONLY TO COUNTY

Site	Population size 1993	1994	1995	1996
Cambridgeshire 1	'frequent'	'frequent'	Unsurveyed	Unsurveyed
Essex 1	25	59	20	7
Hampshire 1	114	135	26	11
Suffolk 1	10	0	0	0
Suffolk 2	30	3	0	0
Suffolk 3	1 seedling	0	0	0
Suffolk 4	-	5	1000	5700
Suffolk 5	0	0	0	0
Surrey 1	17	35	10	110
Surrey 2	2000	2000	2000	2000+
Surrey 3	2000	1000	5000	61
Surrey 4	1000	23142	No access	No access
Surrey 5	-	-	300	100000
Sussex 1	200	500	40	20
Total	5397+	26879+	8400+	107909+
Number of sites	11	10	10 (+2?)	8 (+2?)

while staying relatively stable at others. Although some increases were responses to conservation management others were not, and there is no obvious link between population size and general management or climate; the only consistent pattern appeared to be an increase on arable fields in the second year of fallow. Were it not for exceptional increases in populations at two sites, the total British population in 1996 would be a matter of significant concern.

ECOLOGY

LIFE CYCLE

Filago lutescens is an annual, as are all its close relatives. Observations in the field and in cultivation show that seeds germinate throughout the autumn, winter and spring (Rich 1995b). Moss carpets provided a good micro-site for germination in Essex, but plants were later more prone to drought (C. Gibson, pers. comm. 1994). Müller (1995) studied germination at different temperatures, and found 100% germination at 15, 18, 20 and 22°C, without and with chilling (8 days in a freezer) treatments. Significant germination was found in all treatments within 6 days. Germination was a little slower at cooler temperatures, while treatment with Gibberellic acid resulted in enhanced rates of germination. No seeds in the dark at 15°C had germinated after 7 days, but once given light they germinated rapidly. Subsequently, seedlings not given the chilling treatment appeared to survive significantly better than seedlings given the chilling treatment; why is not known but it may reflect some aspect of the species' ecology as it is noticeably western in distribution in Europe (cf. Fig. 2).

Seeds thus seem to have little innate dormancy, and there is rapid germination of all viable seed when they grow in suitable conditions. There is unlikely to be a large, long-term seedbank. However, after clearance of *Ulex europaeus* scrub at the Hampshire site plants re-appeared after an absence of six years (C. Hall, pers. comm. 1995), and its appearance in arable fields in Surrey (J. E. Smith, pers. comm. 1996) also suggests that a small seed bank may be present in some sites.

The plants over-winter as small rosettes, the stems elongating from about May onwards. The main flowering period is July to October. Plants in cultivation in Sussex flowered in the last week of June with *F. vulgaris*, a week after *F. gallica* and a week before *F. pyramidata*. On a still sunny July day, the heads of cultivated plants smelled sweet but no insects were observed to visit them.

Plants are very variable in size in the field, perhaps related to time of germination and soil

conditions. Plants observed severely droughted in July 1994 in Sussex were noted to have 'greened up' again in August 1994 after rains (C. Murray, pers. comm. 1994). Plants which had flowered in autumn 1993 in Essex were still present in December 1993 and over-wintered but died the following spring and did not set more seed (C. Gibson, pers. comm. 1994).

VEGETATION AND SOILS

Historically in Britain, *F. lutescens* would have primarily been a species of weedy fields, but due to its decline in such habitats, it now appears to be a member of the annual communities of sandy, open places. The sites are usually disturbed and variable in composition. It is usually associated with species like *Aira praecox, Myosotis discolor, Filago minima, F. vulgaris* and strikingly, in most sites, *Scleranthus annuus*. In at least two British sites it has also been associated with both *F. pyramidata* and *F. gallica*.

The vegetation is typically the *Thero-Airetalia* as it is in central Europe (Ellenberg 1988). This is a short-lived hairgrass community, one of a number of communities of heaths and grassland determined by human and animal activity. Other species characteristic of this vegetation type in Europe are *Aira caryophyllea, Filago arvensis, Hypochaeris glabra, Moenchia erecta, Nardurus lachenalii, Ornithopus perpusillus* (a weak associate), *Scleranthus polycarpos, Teesdalia nudicaulis, Trifolium striatum, Tuberaria guttata, Vulpia bromoides* and *V. myuros*. The species does not tolerate shade.

Most of the sites have fine, sandy, well-drained soils. pH measurements ranged from pH (5·1–) 5·7 – 6·7 (–8·0), neutral to basic in terms of plant growth (Rich 1995b). Interestingly, in Hertfordshire, Webb & Coleman (1849) described it as occurring on "light but moister soil than its congeners". All of the current sites are freely drained, and now only *F. pyramidata* can be found on moister clays.

CLIMATE

The distribution in south-eastern England suggests a requirement for warm summers and low rainfall. Most of the sites fall in the area with a mean daily July air temperature of above 16°C, and an annual rainfall of less than 800 mm (sites in Sussex and Hampshire may have up to 1000 mm a year). In Europe it is mainly distributed to the west of the 16°C July isotherm north to Denmark, with a sharper cut-off in distribution in central Europe and only minor extensions to the east (Meusel & Jäger 1992).

In wet years it is likely that plants will dampen off as happens with other *Filago* species. Seedlings over-watered in a greenhouse in spring 1995 damped off (P. Angold, pers. comm. 1995). Plants were observed to have survived snow for a period of at least one week during the winter of 1995/1996. Further observations are required.

HERBIVORY

Plants do not seem to be systematically grazed by rabbits, although the young inflorescences may be nibbled off, and they also tolerate minor damage from horse and cattle grazing. It is possible that the plants are distasteful and are avoided by large herbivores. Slug damage appears uncommon.

CONSERVATION MANAGEMENT

SITE MANAGEMENT

It is essential that sites are appropriately managed each year to maintain open conditions as the plant appears to have only a limited seed bank. Traditionally, disturbance occurred during cultivation of the fields, but sites may now need rotavating on an annual basis. The best conservation management is currently thought to be annual disturbance by digging or rotavation in early autumn, but further research is required. Some of the current sites are unmanaged and the fact that the plants survive in some of them is amazing.

Digging or rotavation of sites has been successful at the sites Sussex 1, Surrey 1 and Essex 1 (see Table 3), but attempts to resurrect ailing or recently extinct populations using this technique at Suffolk 1, 3 and 5 have failed. Some preliminary data for Surrey 3 suggest that in arable field situations harrowing is a better option than ploughing, presumably because it creates the open ground necessary without burying seeds too deeply in the soil. Clearance of *Senecio jacobaea* has been carried out at Sussex 1 and Suffolk 4 to eliminate the need for weed control by herbicide. The Surrey 1 site was nearly destroyed by unauthorized spraying of the protected roadside verge.

An experiment designed to determine the best time for management work was carried out in the Sussex site in 1994–1995 by C. Murray, S. Dipper and T. C. G. Rich (Rich 1996). Replicated 1 m² squares were dug over by hand at monthly intervals from September 1994 to April 1995 and the number of plants counted in each plot in July 1995. Plants of *F. lutescens* appeared in plots dug over in all months. An analysis of variance showed that there were no significant differences ($p = 0{\cdot}07$) between plots dug over in different months, indicating that the timing of management work is not critical. However, to ensure maximum population potential it is suggested that management work should be carried out in August or September depending on the season and occurrence of existing healthy populations.

Calculations have shown that a minimum sample size of 172 plants is required to preserve all, or very nearly all, polymorphic genes with frequency over 0·05 in a population (Lawrence, Marshall & Davies 1995a, b). It is thus proposed that conservation management should aim to achieve at least 172 *F. lutescens* plants at each site each year. On this basis, five sites have populations with long-term averages consistently above this minimum size but the others are distinctly threatened (Table 3).

This species is still under severe threat in Britain. It is desirable that all populations of over 1000 plants, and at least one population in each county, should be given statutory protection to maintain local biodiversity.

STATUTORY PROTECTION

Filago lutescens is statutorily protected under Schedule 8 of the *Wildlife and Countryside Act 1981* (as amended), which should prevent plants at all sites being picked or uprooted. The current protection of and threats to sites are summarized in Table 4. The Suffolk 2 and Surrey 3 sites are protected as statutory Sites of Special Scientific Interest (S.S.S.I.) specifically for *F. lutescens*, though it is currently extinct at one of these. Another S.S.S.I. designated for its bird populations has had two *F. lutescens* populations in the recent past (Suffolk 3 and 5). Surrey 1 and Sussex 1 have non-statutory nature conservation designations. The other seven sites, including the two largest, have no protection and are currently have no conservation management which is a particular cause for concern.

MONITORING AND RESEARCH

It is essential that populations are monitored each year, not only to establish new threats, but also to determine the results of the conservation work and assess natural variation due to weather. Between 1993 and 1996 monitoring was carried out cost-effectively by simple counts of plants, photographs and observations on management. Further research work into the factors controlling population size is urgently required.

TABLE 4. SITE PROTECTION AND THREATS TO *FILAGO LUTESCENS* SITES IN 1996

Site	Site protection and threats
Cambridgeshire 1	No protection. Privately owned; owner aware of plant.
Essex 1	No protection; threatened by fly-tipping and encroachment of vegetation. Management working.
Hampshire 1	Local designation only; managed appropriately by local Wildlife Trust.
Suffolk 1	No protection; appropriate management not working.
Suffolk 2	S.S.S.I.; inappropriately managed.
Suffolk 3	S.S.S.I.; appropriate management not working.
Suffolk 4	No protection; co-operative owner.
Suffolk 5	S.S.S.I.; appropriate management not working.
Surrey 1	Protected road verge subject to regular catastrophes but otherwise sympathetically managed.
Surrey 2	No protection; co-operative owner.
Surrey 3	S.S.S.I.; appropriate management not working.
Surrey 4	No protection and no access to assess threats.
Surrey 5	No protection; horse grazed with potential threat of 'improvement' of grass.
Sussex 1	Local designation only; co-operative owners

S.S.S.I. = Site of Special Scientific Interest.

EX-SITU CONSERVATION

Seed from five extant sites and one extinct site is held at the Royal Botanic Gardens Seed Bank at Wakehurst Place (J. Terry, pers. comm. 1997). Collections from the other sites are urgently required to ensure conservation of the genetic diversity and allow for reintroduction programmes if needed.

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REFERENCES

ADEMA, F. (1976). De *Filago vulgaris*-groep in Nederland. *Gorteria* **8**: 41–47.

ELLENBERG, H. (1988). *Vegetation ecology of Central Europe,* 4th ed. Cambridge University Press, Cambridge.

EVERETT, S. (1987). *Rare plant survey of South Region.* Confidential report to N.C.C., Peterborough.

HAEUPLER, H. & SCHONFELDER, P. (1989). *Atlas der Farn- und Bluten-pflanzen der Bundesrepublik Deutschland.* Ulmer, Stuttgart.

HOLUB, J. (1976). *Filago* L., in T. G. Tutin *et al.*, eds. *Flora Europaea* **4**. Cambridge University Press, Cambridge.

JERMYN, S. T. (1974). *Flora of Essex.* Essex Naturalists' Trust Ltd, Colchester.

KENT, D. H. & ALLEN, D. E. (1984). *British and Irish Herbaria,* 2nd ed. B.S.B.I., London.

LAWRENCE, M.J., MARSHALL, D.F. & DAVIES, P. (1995a). Genetics of genetic conservation. I. Sample size when collecting germplasm. *Euphytica* **84**: 89–99.

LAWRENCE, M.J., MARSHALL, D.F. & DAVIES, P. (1995b). Genetics of genetic conservation. II. Sample size when collecting seed of cross-pollinating species and the information that can be obtained from evaluation of material held in gene banks. *Euphytica* **84**: 101–107.

MENNEMA, J., QUENE-BOTERENBROOD, A. J. & PLATE, C. L. (1980). *Atlas of the Netherlands flora. 1. Extinct and very rare species.* W. Junk, The Hague.

MEUSEL, H. & JÄGER, E. J. (1992). *Vergleichende Chorologie der Zentraleuropaischen flora.* Gustav Fischer Verlag, Jena. Stuttgart.

MÜLLER, S. (1995). *Seed germination and dormancy breaking.* B.Sc. thesis. University of Sussex, Brighton.

PERRING, F. H. & FARRELL, L. (1983). *British red data books, 1. Vascular plants.* R.S.N.C., Lincoln.

PERRING, F. H. & WALTERS, S. M. eds (1962). *Atlas of the British flora.* B.S.B.I., London.

PERRING, F. H. & WALTERS, S. M. eds (1990). *Atlas of the British flora.* 3rd ed. B.S.B.I., London.

RICH, T. C. G. (1994). *Narrow-leaved cudweed* (Filago gallica) *in Britain.* Back from the brink project report no. 22. January 1994. Plantlife, London.

RICH, T. C. G. (1995a). Extinct is forever... unless you happen to be very lucky! *Sanctuary* **24**: 35.

RICH, T. C. G. (1995b). *Red-tipped cudweed* (Filago lutescens) *in Britain.* Back from the brink project report no. 28. January 1995. Plantlife, London.

RICH, T. C. G. (1996). *Red-tipped cudweed* (Filago lutescens) *in Britain in 1995.* Back from the brink project report no. 68. January 1996. Plantlife, London.

RICH, T. C. G. (1999a). Conservation of Britain's biodiversity IV: *Filago pyramidata,* Broad-leaved cudweed. *Edinburgh journal of botany* (in press).

RICH, T. C. G. (1999b). Conservation of Britain's biodiversity I: *Thlaspi perfoliatum* L. (Brassicaceae) Cotswold Pennycress. *Biodiversity and conservation* (in press).

RICH, T. C. G. & DAVIS, R. (1996). *Red-tipped cudweed* (Filago lutescens) *in Britain in 1996*. Back from the brink project report no. 84. November 1996. Plantlife, London.

RICH, T. C. G. & WOODRUFF, E. R. (1996). Changes in the floras of England and Scotland between 1930–1960 and 1987–1988: The B.S.B.I. Monitoring Scheme. *Biological conservation* **75**: 217–229.

SMITH, G. E. (1846). Botanical Society of London Report. *Phytologist* **2**: 575–576.

SMOL'YANINOVA, L. A. (1990). *Flora of the USSR* **25**: 336–349. ed. B. K. Shishkin. (English Translation) Koeltz Scientific Books, Koenigstein.

VAN ROMPAEY, E. & DELVOSALLE, L. (1972). *Atlas de la flore Belge et Luxembourgeoise*. Jardin Botanique National de Belgique, Brussels.

WATSON, H. C. (1848). Some account of the alleged species included under the name of *Filago germanica* Linnaeus. *Phytologist* **3**: 313–318.

WEBB, R. H. & COLEMAN, W. H. (1849). *Flora Hertfordiensis*. William Pamplin, London.

WELTEN, M. & SUTTER, H. G. R. (1982). *Atlas de distribution des Pteridophytes et des Phanerogames de La Suisse*. Birkhäuser, Basel.

WILSON, P. J. (1992). Britain's arable weeds. *British wildlife* **3**: 149–161.

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