CONSERVATION OF BRITAIN'S BIODIVERSITY IV: *FILAGO PYRAMIDATA* (*ASTERACEAE*), BROAD-LEAVED CUDWEED

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This paper summarizes conservation work carried out on *Filago pyramidata* L. (*Asteraceae*), broad-leaved cudweed, between 1993 and 1996 in Britain. It was formerly native in 125 10km squares in about 240 localities. In 1993–1996 it was recorded in eight 10km squares (94% decline) in eight localities (97% decline). Historically its main habitats were arable fields, road and track sides, and heaths, commons and quarries. It has declined in arable field habitats owing to changes in agricultural practices, and from tracks and roadsides because of reduced disturbance. The decline occurred gradually before the 1970s. Populations show marked variations from year to year and marked differences between sites, owing to climate and management. The best conservation management based on practical experience is annual digging or rotavation in early autumn. The plant is under severe threat in Britain; four sites are designated as SSSIs, but two of the four largest populations are unprotected.

Keywords. Distribution, ecology, habitat management, Plantlife, population sizes.

INTRODUCTION

Filago pyramidata L. (*Asteraceae*), broad-leaved cudweed, is a rare species in Britain. It is one of five species of *Filago* native to Britain which occur in open skeletal habitats, all of which are declining. *F. lutescens* Jordan (*F. apiculata* G.E. Sm. ex Bab.) is also very rare and statutorily protected under the Wildlife and Countryside Act 1981 (Rich, 1999), and *F. gallica* L. has recently 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 1930–1960 and 1987–1988 (Rich & Woodruff, 1996).

Although *F. pyramidata* has been known to be declining in Britain for over twenty 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 pyramidata, F. gallica* and *F. lutescens* were amongst the most threatened plants in Britain. All three 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 twenty 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 the conservation work carried

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out on *F. pyramidata* up to 1996; full details (which have been updated here) can be found in Rich (1994, 1995b,c,d, 1996). Further information about the 'Back from the brink' project can be obtained from Plantlife, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

Taxonomy of *F. pyramidata* follows Holub (1976). This taxon is somewhat polymorphic and several variants have been described at specific rank, but intermediates occur and much of the variation seems to be phenotypic. Three fairly well-marked variants occur (Wagenitz, 1969): var. *prostrata* (Fiori) Wagenitz, var. *gussonei* (Nyman) Wagenitz, and var. *obovata* (Pomel) Wagenitz; these may be worthy of subspecific rank but have not been seen in Britain.

DISTRIBUTION

As *Filago* species have been regularly confused in Britain, a review of the historical records was first carried out. Records of *F. pyramidata* have been compiled from the literature, herbaria (BM, BRISTM, BTN, CGE, E, GL, GLAM, IPS, K, LIV, LTR, MNE, NWH, NMW, OXF, RAMM, RNG, SLBI, TTN and US), 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. 455 records have been traced, representing at least 240 localities in 125 10km squares.

F. pyramidata was first reported in Britain from near Saffron Walden by Gibson (1848), though Babington (1848) noted that it had been found prior to this in Sussex and Dorset. Watson (1848) provided a good review of the taxonomy which set out the differences between the various species, and *F. pyramidata* was subsequently fairly widely recorded (though not always correctly).

An updated distribution map distinguishing 1990 onwards, 1950 to 1989 and older records is given in Fig. 1. About one quarter of the records on the map shown by Perring & Walters (1962) are erroneous (especially those in south-west England, e.g. Rich, 1995e), and many more have been added. The species has been fairly widely recorded in south-east England.

The distribution of *F. pyramidata* in Europe and around the Mediterranean is shown in Fig. 2 (after Meusel & Jäger, 1992). It is widespread from south and west Europe north to south-eastern England, and around the Mediterranean in North Africa and east to central Asia. It has been recorded three times as a casual in North America (Wagenitz, 1976).

F. pyramidata appears to be still widespread in western and southern Europe, but is rare and declining in the east. For instance, it was locally abundant in fields, maquis and on waste ground in the Algarve, Portugal in 1996. In Germany, there are only five post-1945 records from along the Rhine on the French border, with another six pre-1945 records scattered elsewhere in the south (Haeupler & Schönfelder, 1989). In the Netherlands, it has been found seven times: it was first

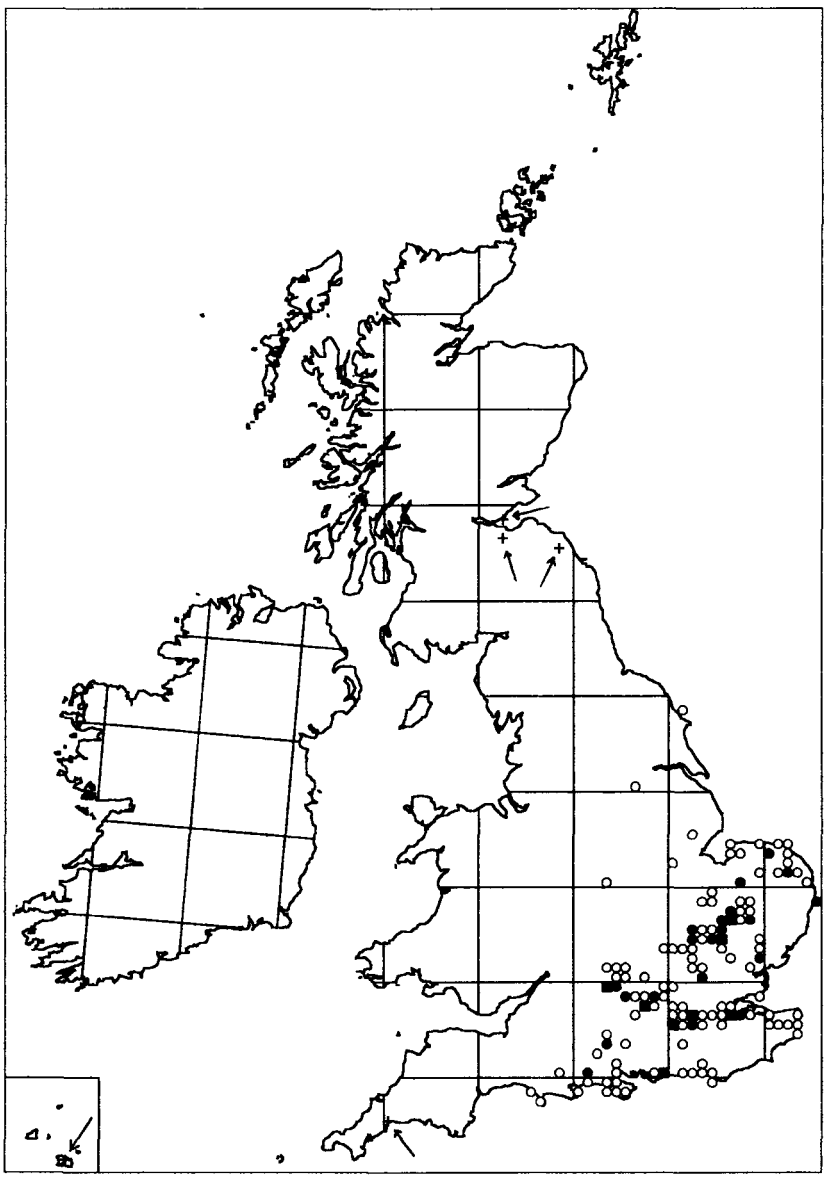

FIG. 1. Distribution of *Filago pyramidata* in Britain. ■, 1990 onwards; ●, 1950 to 1989; ○ pre-1950 and undated records; +, introduced records, pre-1950.

recorded in 1839 near Wamel, and was last recorded in 1927 near Gennep, but there is no known reason for its disappearance (Mennema *et al.*, 1980). In Belgium and Luxembourg, it was recorded in 32 localities before 1930, but only four since (van Rompaey & Delvosalle, 1972). In Switzerland, there are 31 historical herbarium records, one literature record and two modern field records (Welten & Sutter, 1982).

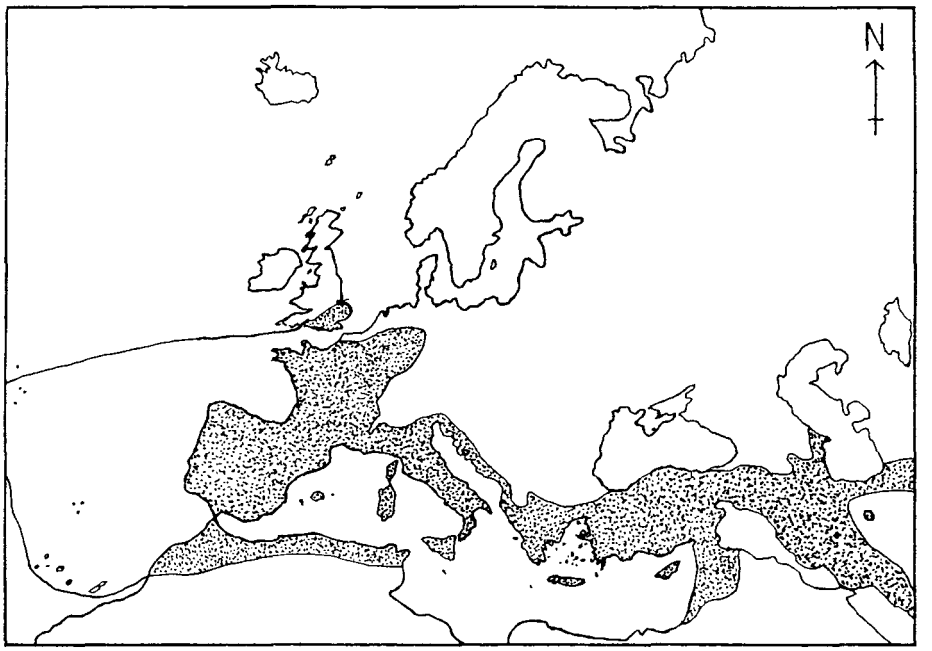

FIG. 2. Distribution of *Filago pyramidata* in Europe and around the Mediterranean (redrawn from Meusel & Jäger 1992).

STATUS IN BRITAIN

Changes in the number of records with time

A conservative approach has been taken in analysing the records to determine changes in the status of the species with time, because of the inherent inconsistencies of the records and the recorders. Introductions have not been included in the analysis. Some records lack dates, some localities cannot be traced, and it is unclear if some records refer to the same or different sites. It has been recorded only once in 181 sites (79%), and for periods of more than 25 years in only 24 sites (10%), indicating that it is significantly under-recorded. 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 occur. Changes in the records with time thus indicate the general trends but not the full situation.

Table 1 summarizes the records by decade, 10km square and locality. Because about 20% of the historical records have no date information, the number of records for each decade is underestimated. The number of records shows typical variations which are probably related to botanical activity rather than real changes in frequency. For instance, it was well recorded in the 1840s following Watson's (1848) account,

TABLE 1. Summary analysis of records of *Filago pyramidata* in Britain. Figures for each decade are underestimated owing to undated records. There may be many records for the same 10km square or locality each decade.

Decade	Total no. records	No. 10km squares	Extrapolated no. localities
Undated	88	28	71
1840–9	27	14	19
1850–9	23	15	24
1860–9	26	14	29
1870–9	26	21	30
1880–9	31	28	35
1890–9	18	14	27
1900–9	33	21	32
1910–9	13	12	25
1920–9	19	14	23
1930–9	7	3	18
1940–9	15	7	19
1950–9	36	15	23
1960–9	16	11	18
1970–9	18	8	11
1980–9	26	7	8
1990+	31	8	8
	453 records	125 10km squares	240 localities

and the dip in records in the 1890s is likely to be because of the collapse of the Botanical Exchange Club, with a peak in the 1900s following its recovery. However, there are oddly few records in the 1930s. The peak in the 1950s may result from the recording for the *Atlas of the British flora*. The large numbers of records from the 1980s and 1990s are a consequence of regular monitoring of known sites.

The number of 10km squares recorded is a widely used measure of relative frequency in Britain (e.g. Perring & Farrell, 1983). The number of 10km squares recorded per decade shows a similar pattern to the number of records (Table 1); however, because not all sites were regularly recorded or persist there is a considerable turnover of 10km squares between decades. The species was recorded in 121 10km squares before 1950, 27 squares between 1950 and 1989, and eight squares after 1990 (Fig. 1).

A better measure of change than the number of 10km 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 plant to be present at each site for all decades between the first and last record (Table 1). There has been a gradual decline in the number of sites to the current eight. The figures again underestimate the decline, since many localities are poorly recorded. The plant has been recorded since 1990 in only eight out of at least 240 localities (3.3%).

Most of the decline appears to have taken place by the 1970s, and to have occurred

as a gradual loss of sites randomly across the range. 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 for the 57% of sites where at least some habitat information is available (Table 2). Whilst some records do not indicate exactly in which habitat the plants were growing, the main trends can be discerned.

The most frequent habitat from which *F. pyramidata* was recorded historically was arable land, especially in cornfields and stubble, but also in pea and turnip fields. It was also regularly recorded from roadsides, paths and tracks where cart wheels, animals and human feet created a mosaic of suitable patches of open, disturbed ground. It was only occasionally recorded from heaths and commons (some of these records may be from sand pits), and from quarries and spoil.

In 1993 to 1996, the habitat profile was quite different from that of pre-1990, and is related to changes in arable and roadside habitats (Table 2). The changes in the number of records for each habitat indicate that the main reasons for decline are loss from arable fields, and from road and track sides. The main habitat now is quarries and spoil.

The cause of the plant's decline in arable fields is the use of selective herbicides and fertilizers and changes in the timing of agricultural operations (Wilson, 1990, 1992). Loss of other habitats such as roadsides owing to paving of roads, and the decline in grazing and disturbance on heathlands, possibly coupled with the spread of myxomatosis, have also taken their toll.

According to Meusel & Jäger (1992), *F. pyramidata* and *F. vulgaris* are in danger of extinction in central Europe owing to changes in the farming practices. In the

TABLE 2. Habitats of *Filago pyramidata* in Britain compiled from records for each site. Repeated records from the same habitat at each site are not included.

Habitat	Number (%) of pre-1990 sites	Number (%) of post-1990 sites
Arable, stubble, cornfields	75 (24%)	2 (25%)
Roadside, path, hedge bank	24 (7.6%)	1 (12.5%)
Quarry, spoil, gravel pits	10 (3.1%)	4 (50%)
Heaths, commons	9 (2.8%)	0
Casual	5 (1.6%)	0
Wood (presumably on rides)	5 (1.6%)	0
Railway	4 (1.3%)	1 (12.5%)
Waste ground, tip	3 (1%)	0
Sandy ground	3 (1%)	0
Garden	1 (0.3%)	0
Not stated	176 (56%)	0

past, both species were able to colonize nutrient-poor, open soils. In the present century, land has been extensively limed and fertilized and plants sensitive to competition have declined. These authors proposed creating refuges for these and other similarly threatened species on special plots.

Population sizes 1993 to 1996

The population sizes of all post-1990 sites where access was granted were monitored between 1993 and 1996 (Table 3). The best time of year to monitor populations is in late summer (August–September), though some arable field populations may need to be counted before harvest. Counts up to about 200 plants are probably reasonably reliable, but above this estimates are based on counts of small areas extrapolated to the whole site. In addition, considerable time has been spent by many volunteers and T.C.G. Rich searching numerous old sites across the country, without any success (Rich, 1995b). The only new locality found during this period was during an environmental impact assessment. It is probable that there are still a few more undiscovered sites.

The population sizes vary enormously between sites, and to some extent between years depending on management and climate. The decline at Berkshire 1 is owing to lack of management after the site was changed from an arable field to a golf course, but there is no obvious reason for loss at Cambridgeshire 1 and 2. The populations at Kent 1 vary with conservation management of the arable field for a range of rare species, and present no current cause for concern. The small increases at Surrey 1 result from active conservation work. The large population in Sussex currently appears stable. Three of the remaining populations are so small that they are under significant threat (Table 3).

TABLE 3. Population sizes of *Filago pyramidata* at all known sites in Britain 1993–1996. Sites are located only to county. Counts above 200 plants are approximations.

Site	1993	1994	1995	1996
Berkshire 1	few	111	5	13
Cambridgeshire 1	40	0	0	not counted
Cambridgeshire 2	2,000	not counted	0	0
Kent 1	many thousands	60,000	20,000	10,000
Oxfordshire 1	50	not counted	212	1,000
Surrey 1	147	200	177	300
Surrey 2	—	—	500	2,000
West Sussex 1	20,000	20,000	20,000	not counted
Total	22,237+	80,311+	40,894	13,313+
Number of sites	7	7?	6	7?

ECOLOGY

Life cycle

F. pyramidata is an annual completing its life cycle within 2–10 months, as are all its close relatives. Observations in the field show that seeds germinate throughout most of the year, sometimes in abundance in warm autumns, but it appears to behave as a summer annual in most years in most sites. If seeds germinate in the autumn, the young plants over-winter as small rosettes, and there may be high mortality in spring in wet years. Wilson (1990) found experimentally that peak germination occurred between October and December with a lesser peak around March. A peak in July 1988 coincided with a period of high rainfall, suggesting the poor germination during the summer was a result of lack of available water, and not because of a dormancy mechanism; in the hot summer of 1989 no seedlings were observed in June, July or August. In contrast, in the Mediterranean it usually behaves as a winter annual.

There appears to be a persistent seed bank, with plants germinating in abundance after disturbance or suitable climatic conditions. Some plants at the Surrey 1 site appeared after clearance of closed scrub which was between 10 and 15 years old, but there are no data on long term seed longevity.

Seeds are dispersed by the wind. In dry and warm weather the mature heads open and the phyllaries recurve exposing the receptacle and its seeds. Each seed has a small pappus, which is readily detached, and most seeds probably fall within 1–2m of the parents, but potentially over much longer distances in strong winds. Late in the season, mature heads may remain closed and fall to the ground; seeds subsequently germinate in the decaying head resulting in tight clusters of plants.

The stems elongate from about May onwards. It flowers from early July to November. Plants cultivated in 1995 in Sussex flowered in the first week of July, a week after *F. vulgaris* and *F. lutescens* and two weeks after *F. gallica*. A few plants were still in flower in Kent in November in 1993 and 1994 though they may not have set viable seed. No pollinators have been observed visiting the plants and it is probably self-pollinated.

Plant vary markedly in size and number of flowering heads, related to time of germination and age. Summer-germinating plants may be only 2cm tall with one head. Over-wintering plants may be nearly 20cm across with many branches and many heads. Densities vary from about 1 to 200 plants m^{-2}.

Vegetation and soils

The most important feature of the habitat is that *F. pyramdiata* requires open ground and disturbance (i.e. freedom from competition), and does not tolerate shade or closed vegetation. Thus the edges of arable fields which are not sprayed, track edges and bare chalk in quarries are now its characteristic habitats (cf. Table 2). It is most frequently associated with species such as *Anagallis arvensis* L., *Arenaria serpyllifolia*

L., *Centaurium pulchellum* (Sw.) Druce, *Hypericum perforatum* L., *Medicago lupulina* L. and *Veronica arvensis* L., which are characteristic of disturbed, open places (Rich, 1995b). None of its current communities fits well in the National Vegetation Classification accounts published to date (Rodwell, 1991 *et seq.*).

Data for the historical communities are very incomplete but *F. pyramidata* appears to have been a member of 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. *F. pyramidata* has regularly been recorded with *F. minima* and *F. vulgaris* in Britain, and in at least two sites also with both *F. gallica* and *F. lutescens.* Other species characteristic of this vegetation type in Europe are *Aira caryophyllea, A. praecox, Filago arvensis, Hypochaeris glabra, Moenchia erecta, Myosotis discolor, Nardurus lachenalii, Ornithopus perpusillus* (a weak associate), *Scleranthus polycarpos, Teesdalia nudicaulis, Trifolium striatum, Tuberaria guttata, Vulpia bromoides* and *V. myuros.*

F. pyramidata usually grows on well-drained soils, frequently on chalk and limestone but may also grow on light sandy soils. Those sites where the soil pH was measured indicate that most are highly calcareous, but it also grows on soils with a pH as low as 5.0 (Rich, 1995b).

Climate

Climate probably plays an important part in the life cycle of *F. pyramidata* in Britain where it is at the northern edge of its range (Fig. 2). For instance at Surrey 1 it is largely confined to south-facing slopes on chalk spoil. Thousands of seedlings were present in autumn 1995 but had all but disappeared the following spring, presumably 'damping off' in the damp winter, although the winter did not affect plants at Kent 1.

Climate probably also plays an important part in determining the distribution in both Britain and worldwide. *F. pyramidata* occurs in the warm and dry parts of south-east England, especially in areas with a mean July temperature of 16.5°C or more, a maximum mean temperature of over 30°C and with 6 or more hours average sunshine in July (peak flowering time). It is present in areas with a mean winter temperature of above 0°C. It is favoured by dry sites and occurs only rarely in areas with more than 800mm mean annual rainfall. It has survived the severe droughts recently observed in Britain (e.g. 1995, Table 2).

Similarly in central Europe it grows in areas with warm summers (July mean higher than 17°C) and mild winters (January mean above 1°C), and the sensitivity to winter temperature limits its distribution in the North Caucasus (Meusel & Jäger, 1992). Worldwide it is absent from arid areas, and in dry areas such as Palestine is confined to the Mediterranean region where there is relatively more precipitation. It is virtually absent from summer-wet areas.

Espigares & Peco (1995) studied the effects of autumn droughts on the dynamics of Mediterranean annuals in pastures, including *F. pyramidata.* They found that simulated autumn drought after germination had no effect on mortality of *F. pyramidata* plants, but it did markedly affect other associated annual species.

Herbivory

Field observations indicate that plants are generally tolerant of light grazing by horses and cattle. Rabbits may nibble the young inflorescences off, resulting in branching of the stems. Slug and snail damage appears uncommon.

CONSERVATION

Site management

Traditionally, sites required disturbance to maintain open habitats as occurred during cultivation of arable fields and during use of roads and tracks. The survival of the species where it now occurs may be enhanced by annual cultivation or disturbance (Rich, 1994, 1995b, 1996). At Kent 1 the species has been maintained by annual ploughing and rotovation, the numbers of plants depending on the time of management as well as climate. Manual soil disturbance at Surrey 1 has maintained and may be increasing the population. The best conservation management based on practical experience is thus thought to be annual disturbance by digging or rotavation in early autumn. Some quarry sites with very shallow soils are unlikely to need management in the short term.

In order to achieve maximum numbers, soil disturbance to create suitable open ground should be carried out before large numbers of seedlings begin to germinate in October. Cultivation after October might encourage a limited spring germination, or germination in the following autumn in sites which had become overgrown or otherwise unsuitable for these species (P.J. Wilson, pers. comm. 1993).

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 *et al.*, 1995a,b). It is thus proposed that conservation management should aim to achieve at least 172 plants of *F. pyramidata* at each site each year. On this basis, half of the sites have populations consistently above the minimum sizes but only two have healthy populations (Table 3).

Monitoring and research

It is essential that populations are monitored each year to determine the results of the conservation work, assess natural variation associated with weather and to establish new threats to sites. Between 1993 and 1996 monitoring was carried out cost-effectively by counting of plants, photographs and observations on management. Further research into factors controlling population size, including replicated management experiments, is urgently required.

Seed from four of the extant sites and an extinct site in Cambridgeshire is held at the Millennium Seed Bank at Wakehurst Place (J. Terry, pers. comm. 1997). Collections from Surrey 1 and 2 and Cambridgeshire 1 and 2 are urgently required

TABLE 4. Site protection and threats to *Filago pyramidata* sites, as at 1996.

Site	Site protection and threats
Berkshire 1	SSSI; no management carried out since designation.
Cambridgeshire 1	None; precarious site, owner not known.
Cambridgeshire 2	None; owner sympathetic.
Kent 1	SSSI; well managed arable site.
Oxfordshire 1	None; quarry with fly-tipping and small-scale quarrying, owner unresponsive and site under threat.
Surrey 1	SSSI; prone to neglect and scrub invasion but conservation work being carried out by Plantlife.
Surrey 2	None; proposed development as waste disposal site.
West Sussex 1	SSSI; excessive disturbance by motor bikes and four-wheeled drive vehicles.

to ensure conservation of the genetic resource and to provide material for reintroduction programmes if necessary.

Statutory protection

F. pyramidata is statutorily protected under Schedule 8 of the Wildlife and Countryside Act 1981 (as amended). Table 4 summarizes the protection and threats to each site. Four sites have an additional degree of protection as designated Sites of Special Scientific Interest (SSSIs). Three of these sites were designated specifically for *F. pyramidata*, though it is currently extinct at one of these owing to lack of management and occurs only on a track nearby. Another SSSI designated for its grassland and scrub communities has a population which is being conserved. The other four sites have no protection and are currently unmanaged, which is a particular cause for concern.

This species is still under severe threat in Britain. It is desirable that all populations over 1000 plants, and at least one population in each county, should be given statutory protection to maintain local biodiversity. A Species Action Plan is currently being drawn up by Plantlife for English Nature as part of the *United Kingdom Biodiversity Action Plan.*

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