

# The distribution and conservation of *Eriophorum gracile* Koch ex Roth (Cyperaceae), Slender Cotton-grass, in Ireland

J. P. CONAGHAN\*<sup>1</sup>

11 Dun Ard, Craughwell, Co. Galway

and

M. SHEEHY SKEFFINGTON\*<sup>2</sup>

Department of Botany, National University of Ireland, Galway

## ABSTRACT

*Eriophorum gracile* is a rare semi-aquatic plant which has a very local distribution throughout most of western Europe. The distribution and current conservation status of known Irish populations are presented in this paper. Floating rafts of vegetation which develop along the margins of lakes in the Connemara region of Co. Galway constitute the most important habitat for the species in Ireland. Small populations also occur in habitats such as flushed areas of lowland blanket bog, the lagg areas of raised bog and calcareous basin fen; however, populations in such habitats are generally small in size. The main threats to the existing populations of the species are site drainage and surface water eutrophication, which are primarily caused by farming-related activities on land in close proximity to sites. It is clear that the future survival of the species in Ireland will depend on the safeguarding of favourable hydrological and edaphic conditions.

**KEYWORDS:** Protected plant species, Connemara, bog flush, scragh, *E. gracile*.

## INTRODUCTION

*Eriophorum gracile* W. D. J. Koch ex Roth (Cyperaceae), Slender Cotton-grass is a member of a widespread, mainly circumpolar genus which in Europe is represented by seven species (Tutin *et al.* 1980). Although the species is superficially similar to a number of other members of the genus, it is relatively easy to distinguish by the combination of rather slender leaves (0.5–2 mm), short “cotton” (1–2.5 cm), minutely scabrid peduncles and the presence of a short, erect uppermost leaf on the flowering stem (Clapham *et al.* 1987). The species occurs throughout northern Eurasia and

North America and is very rare south of the latitude 45° N (Hultén 1962). In Europe it reaches its southern limit along a line extending from the Pyrenees, through northern Italy to southern Bulgaria. The species is found throughout northern Asia, occurring as far east as the Kamchatka Peninsula and northern Japan; however, it appears to be rather rare in central Asia (Hultén 1962). In North America *E. gracile* has a widespread, though local, distribution throughout the northern states of the United States of America and the southern states of Canada (Decker *et al.* 2006).

Throughout much of its range *E. gracile* grows in habitats which are constantly wet, such as flushed areas of bogs, calcareous fens and lake margins (Tutin *et al.* 1980). Even within these wetland areas the species often grows in the wettest areas of floating rafts of vegetation close to open water (Winship 1994). Such habitats are very vulnerable to drainage and there has been a substantial population decline in the recent past, particularly in western Europe. In England, for example, there has been a drastic decline of the species from 26 sites to only 3 sites since the species was first recorded in 1838 (Winship 1994; Cox 1995). This decline is thought to have been brought about by drastic changes in the habitat of the species due to modification of the water supply and quality. Such modification is generally the result of drainage and/or eutrophication of surface waters. As a result of the species' rarity and decline throughout western Europe, *E. gracile* is categorised as vulnerable within the European Community (Council of Europe 1983) and is protected by law in a number of countries including the United

\*<sup>1</sup>e-mail: enviroscope@indigio.ie

\*<sup>2</sup>e-mail: micheline.sheehy@nuigalway.ie

TABLE 1. DETAILS OF *ERIOPHORUM GRACILE* SITES IN IRELAND

Site location	Grid ref.	Habitat	First reported	Confirmed by the authors in the period 1990–1995
South Kerry (v.c. H1)				
Broaghnbinnia	V7981	Flush in blanket bog	J. Ryan 1977 (unpublished record)	No
North Kerry (v.c. H2)				
Sheheree bog	V9888	Lagg of raised bog	M. Sheehy Skeffington 1983 (unpublished record)	Yes
West Cork (v.c. H3)				
Derreenatra	V9531	Cutover blanket bog	FitzGerald 1993 (unpublished record)	Not surveyed
West Galway (v.c. H16)				
Killarone	M1540	Marsh	Scannell <i>et al.</i> (1968)	No
Lake N.W. of Maam Cross	L9746	Lake scragh	Scannell <i>et al.</i> (1968)	Yes
Buncanniff	L9445	Flush in blanket bog	This study	Yes
2.5 km E. of Cashel	L8242	Flush in blanket bog	This study	Yes
Lettershinna	L8543	Flush in blanket bog	Douglas and Grogan (1987)	No
1.5 km E. of Cashel	L8142	Flush in blanket bog	This study	Yes
Loughanillaun	L8540	Flush in blanket bog	Scannell <i>et al.</i> (1968)	No
Callaherick Lough	L7938	Lake scragh	Scannell <i>et al.</i> (1968)	Yes
	& L8038			
N. of Carna	L7833	Flush in blanket bog	This study	Yes
Dohola Lough	L7833	Lake scragh	This study	Yes
Letterdife	L7142	Flush in blanket bog	This study	Yes
Lough Nalawney	L6941	Flush in blanket bog	This study	Yes
Cregduff Lough	L7139	Lake scragh	Rose and McClintock (1967)	Yes
W. of Errisbeg Hill	L6839	Flush in blanket bog	Donald (1980)	Yes
	& L6840			
Lake W. of Lough Rannaghaun	L6640	Lake scragh	This study	Yes
Lake S. of Glinsk	L7835	Lake scragh	This study	Yes
Murvey Lough	L6639	Lake scragh	van Groenendael <i>et al.</i> (1979)	Yes
Namanawaun Lough	L6639	Lake scragh	van Groenendael <i>et al.</i> (1979)	Yes
Aturtaun Lough	L6739	Lake scragh	van Groenendael <i>et al.</i> (1979)	No
Cloonagat Lough	L6947	Lake scragh	Scannell <i>et al.</i> (1968)	Yes
Lake N.W. of Cloonagat Lough	L6847	Lake scragh	This study	Yes
Lake N.E. of Doo Lough	L6848	Lake scragh	This study	Yes
Tonabrucky	M2526	Lake scragh	J. Conaghan 2000 (unpublished record)	Discovered in 2000
Offaly (v.c. H18)				
Sharavogue bog	S0498	Fen in cutover bog margin	J. Conaghan 1997 (unpublished record)	Discovered in 1997
Westmeath (v.c. H23)				
Scragh bog	N4559	Basin fen	Scannell <i>et al.</i> (1968)	Yes
West Mayo (v.c. H27)				
Cloonoragh	G0720	Flush in blanket bog	J. Conaghan 2002 (unpublished record)	Discovered in 2002

Kingdom (Wigginton 1999) and Ireland (Curtis & McGough 1988; Flora (Protection) Order 1999). Despite the rarity and the apparent recent decline of the species there is a paucity of research into the distribution and ecology of *E. gracile* throughout Europe. Although the status of the species in England has been addressed (Winship 1994; Cox 1995), in Ireland there is an urgent need to assess its status and to anticipate the threats which may affect populations of the species in the future. In the following account, the status of previously reported Irish sites is outlined and details are given of additional sites discovered by the authors. The population size and habitat of the species at each site is described and the conservation status of these sites is considered.

#### THE HISTORY OF THE DISCOVERY OF *ERIOPHORUM GRACILE* IN IRELAND

*E. gracile* was discovered in Ireland in the summer of 1966, coincidentally by two separate groups (Scannell, Synnott & Webb 1968). In July of that year the species was noted by Dr V. Westhoff at Cregduff Lough, some 2 km to the south of Roundstone village, Co. Galway. The species was subsequently noted in September of that year by Dr Francis Rose in the same lake. The subsequent paper (Rose 1967) was the first documented account of the species in Ireland. Its belated discovery in Ireland is somewhat surprising when one considers that the Connemara region had been one of the most intensively studied regions of Ireland, both by Irish and British botanists. Previously C. C. Babington had collected a specimen named *E. gracile* from the Cong area in 1836 (Stelfox 1970). However, the herbarium specimen was subsequently determined to be a small specimen of *E. angustifolium* Honck. (Kertland 1971). The eventual location of the correct species in 1966 alerted other botanists to its presence and within two years, details were published of a further six sites; five from the Connemara region of West Galway (H16) and one at Scragh bog, Co. Westmeath (H23) (Scannell *et al.* 1968). Between 1968 and 1990, a further seven sites were discovered in the Connemara region; three in lakes to the west of Roundstone village, (van Groenendael *et al.* 1979) and one north-west of Cashel (Douglas & Grogan 1987). In 1977, the range of *E. gracile* in Ireland was extended southwards when the species was recorded

from the MacGillicuddy's Reeks mountain range in South Kerry (H1) (J. Ryan, pers. comm.). Six years later a site was added in the neighbouring vice-county, North Kerry (H2) by the second author.

#### METHODS

During the period 1990 to 1993 all previously recorded sites for *E. gracile* in Ireland, listed in the Protected Plant Species database held by the National Parks and Wildlife Service, were visited with a view to confirming the presence of the species and to documenting the habitat conditions at each site. In addition to visiting previously reported sites, an extensive survey of lake and bog habitats was carried out in areas of counties Galway, Mayo and Kerry, in an effort to locate further sites for the species. At each site in which *E. gracile* was found, a range of data were recorded; including grid reference, the habitat composition and land use surrounding the site, percentage of lake surface covered by a scragh (i.e. a floating raft of vegetation), distance from the sea and the size of the *E. gracile* population present. During 1992 an estimate of population size at each site was obtained by counting the number of flowering heads present. At larger sites the population size was estimated by counting the number of flowering heads within a given area (usually 2 × 2 m) and multiplying this figure by the area of the site in which the species was observed to occur; the numbers are quoted to the nearest hundred.

Because of the relatively small size and vulnerability of populations, site locations are described in terms of four-figure grid references. More precise details have been lodged with the National Parks and Wildlife Service, Dublin. Nomenclature follows Stace (1997) for vascular plants, Smith (2004) for mosses and Paton (1999) for liverworts.

#### RESULTS

The distribution of *E. gracile* in Ireland as shown on a hectad basis (Fig. 1) illustrates the rarity of the species on the island and its western bias. The Connemara region of west Galway is the main centre of distribution with a small number of outlying stations scattered along the western seaboard and in the midlands. Table 1 lists all sites in which *E. gracile*

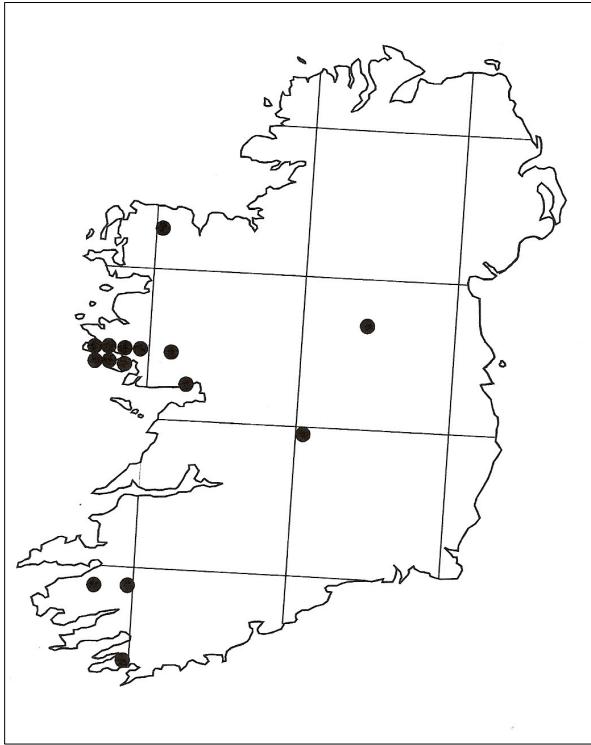


FIGURE 1. The distribution of *Eriophorum gracile* in Ireland, on a 10-km square basis.

has been recorded in Ireland. Of the 14 sites recorded before the onset of this survey in 1990, ten were confirmed. Where populations were not re-found, it was often difficult to identify suitable habitat for the species, but it is possible that the populations could have been missed if flowering at that site was poor at the time of visit, or if the populations are very small. In addition to confirming ten sites, the species was recorded from eleven new locations in the Connemara region of West Galway during 1990–1992. Another site was discovered in West Cork (H3) by R. FitzGerald in 1993, constituting a new vice-county record for the species. Between 1997 and 2002 a further three important populations were discovered by the first author in West Galway (H16), Offaly (H18) and West Mayo (H27). The last two are new vice-county records (Scannell & Synnott 1987).

#### DISTRIBUTION IN SOUTH KERRY (V.C. HI)

In 1977 a population of *E. gracile* was reported by J. Ryan from a small flush in lowland blanket bog to the south of the Caragh river in Broaghnaibinnia townland which lies on the western side of the MacGillycuddy's Reeks

mountain range. Although the population was not re-found during this survey, it was re-found during a rare plant survey of Co. Kerry conducted by R. FitzGerald in the mid-1990s.

#### DISTRIBUTION IN NORTH KERRY (V.C. H2)

A small population of *E. gracile* grows in the lagg which surrounds Sheheree Bog, a small raised bog to the S.E. of Killarney, Co. Kerry. The bog and associated wet lagg system lie at an altitude of approximately 60 m, occupying a hollow surrounded by good quality agricultural grassland. A large proportion of the lagg is colonised by carr woodland in which *Alnus glutinosa*, *Betula pubescens* and *Salix* spp. are dominant. *E. gracile* is largely confined to low-growing marsh vegetation dominated by *Carex rostrata*, *Juncus articulatus* and *Calliergonella cuspidata* which occurs along the edge of wet woodland.

#### DISTRIBUTION IN WEST CORK (V.C. H3)

In 1993 a population of *E. gracile* was discovered by R. FitzGerald growing in an area of revegetating cutover bog in Derreenatra townland, approximately 3.5 km SW of Ballydehob village. This is the most southerly known population in the country.

## DISTRIBUTION IN WEST GALWAY (V.C. H16)

This vice-county is the headquarters of *E. gracile* in Ireland. Between 1966 and the onset of this study, *E. gracile* had been recorded from eleven sites in the Connemara region (T. Curtis, pers. comm.). The species has been confirmed from seven of these previously reported sites and has been discovered in twelve previously undocumented locations. This brings the total number of recently confirmed sites in the Connemara region to 19 (Fig. 2).

All of the Connemara sites for *E. gracile* occur below an altitude of 60 m, with the majority of sites lying below 30 m. The majority of sites are also located within 8 km of the sea (Fig. 2), with the exception of the unnamed lake N.W. of Maam Cross. In the Connemara region *E. gracile* grows in two different habitat types; quaking rafts of vegetation which develop in the margins of lakes (known as scraghs in Ireland) and flushes in lowland Atlantic blanket bog. Both of these habitats remain in a very wet condition throughout much of the year and the scragh

habitat in which *E. gracile* is found, is invariably treacherous. The lake habitats can be further subdivided into coastal lakes, which are located in close proximity to the sea (<1.5 km) and generally have a large amount of their surface (60% or more) covered with scragh and 'inland' lakes in which the scragh cover is generally less than 5% (Table 2). These lake types also differ in terms of the dominant vegetation types present. The vegetation in which *E. gracile* occurs in the coastal lake habitat tends to be more luxuriant and is typically dominated by *Phragmites australis*, *Equisetum fluviatile*, *Menyanthes trifoliata*, *Potentilla palustris* and *Mentha aquatica*, while at the inland lake habitats, the species typically occurs in scragh vegetation dominated by *Cladium mariscus*, *Molinia caerulea*, *Menyanthes trifoliata*, *Eleocharis multicaulis* and *Eriocaulon aquaticum*. There is also a marked difference in the habitats surrounding the different lake types. Lake sites in close proximity to the coast are more usually surrounded by dry heath and rough grazing land,

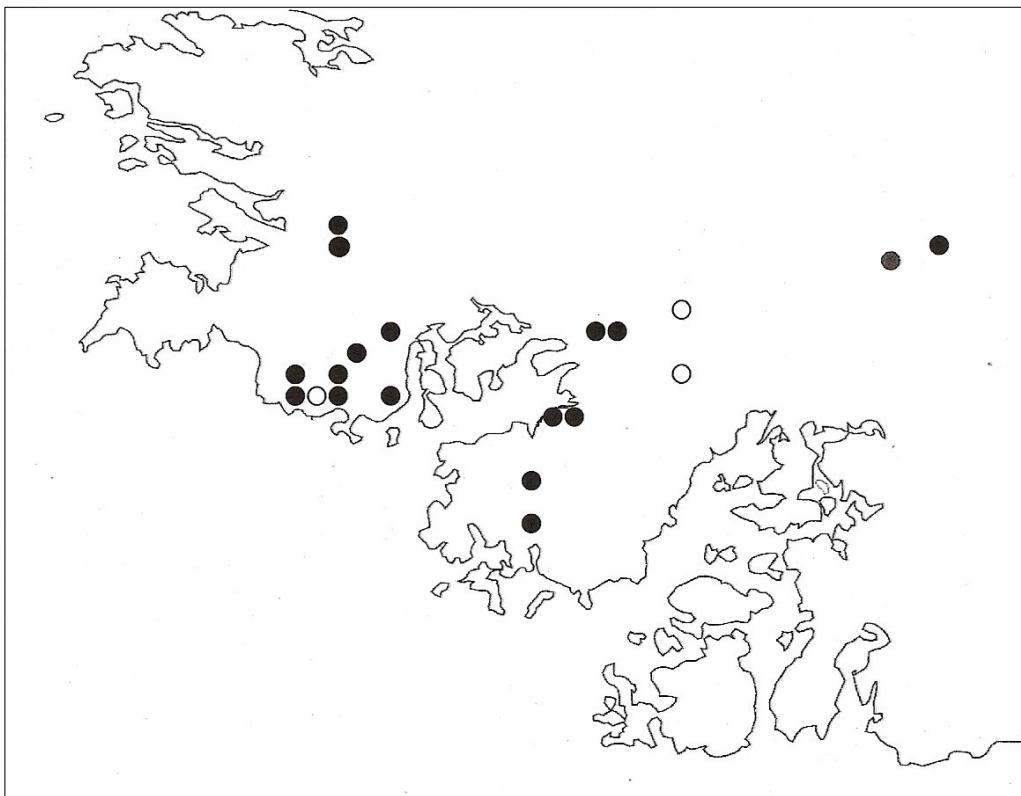


FIGURE 2. The distribution of *Eriophorum gracile* in the Connemara region of West Galway (H16), on a 1-km square basis. ● = records confirmed during this study. ○ = previous records not confirmed during this survey. NB The Killarone and Tonabrocky sites lie within H16 but occur east of the map area.

TABLE 2. SURROUNDING LAND COVER, APPROXIMATE NUMBER OF FLOWERING HEADS AND % OF LAKE SURFACE COVERED BY SCRAW, FOR *ERIOPHORUM GRACILE* SITES SURVEYED IN IRELAND

Site name	Surrounding land cover	Approximate number of flowering heads present	% of lake surface covered by a scragh
Coastal lake sites (within 1.5 km of sea)			
Cregduff Lough	Dry heath	>4000	50
Callaherick Lough	Dry heath and road	>2000	85
Murvey Lough	Dry heath & semi-improved pasture	1200	60
Namanawaun Lough	Dry heath & semi-improved pasture	500	50
Inland lake sites (1.5 km to 10 km of sea)			
Lake north-west of Maam Cross	Lowland blanket bog and road	800	50
Cloonagat Lough	Lowland blanket bog	450	<5
Lake west of Lough Rannaghaun	Lowland blanket bog	400	<5
Lake south of Glinsk	Cutover lowland blanket bog and road	100	65
Dohola Lough	Lowland blanket bog	300	<5
Lake north-east of Doo Lough	Lowland blanket bog	25	30
Lake north-west of Cloonagat Lough	Lowland blanket bog	20	<5
Blanket bog flush sites			
West of Errisbeg Hill	Lowland blanket bog	400	-
Tonabrocky	Dry heath & lowland blanket bog	350	-
Letterdife	Lowland blanket bog	190	-
2.5 km east of Cashel	Lowland blanket bog	150	-
Cloonooragh	Lowland blanket bog	50	-
North of Carna	Lowland blanket bog	25	-
Buncanniff	Lowland blanket bog	15	-
Lough Nalawney	Lowland blanket bog	13	-
1.5 km east of Cashel	Lowland blanket bog	3	-
Other sites			
Scragh bog	Improved agricultural grassland	250	-
Sheheree bog	Improved agricultural grassland	170	-
Sharavogue bog	Raised bog	25	-

whereas sites further inland are generally surrounded by unmodified Atlantic blanket bog.

The flush habitat in which *E. gracile* grows, occurs in areas of intact Atlantic blanket bog where there is some convergence of water flow due to topography. There are eight of these sites, which also tend to be confined to the coastal fringe of the Connemara region (Fig. 2). At some of these sites, e.g. the flush north-west of Letterdife House, *E. gracile* grows in a

quaking raft of vegetation which has developed along the margins of a narrow bog stream, while at others, e.g. the flush north-west of Errisbeg hill, the species grows in old drainage channels which have become filled with an unconsolidated, soupy peat. The dominant species in these flushed areas of bog are generally *Carex lasiocarpa*, *Carex limosa*, *Juncus subnodulosus*, *Schoenus nigricans* and *Potamogeton polygonifolius*.

The population size of *E. gracile* in Connemara varies with habitat (Table 2). Bog flush sites generally contain the smallest populations of the species, ranging from 3 to c. 400 flowering heads per site; the inland lake sites generally support larger populations, from 20 to c. 800 flowering heads. Populations found in coastal lakes are the largest, ranging from 500 to >5000 flowering heads per site.

#### DISTRIBUTION IN OFFALY (V.C. H18)

In August 1997 a small population of *E. gracile* was found growing along the margins of a base-rich pool in the cut-over edge of a raised bog at Sharavogue, Co. Offaly. This bog is notable in that it is one of the few remaining raised bogs in Ireland which retains lagg-type vegetation along its margins. This population of *E. gracile* is one of only two known east of the river Shannon.

#### DISTRIBUTION IN WESTMEATH (V.C. H23)

*E. gracile* occurs in Scragh Bog, one of the best remaining examples of a calcareous basin fen in Ireland (O'Connell 1981). This population was first reported by Scannell *et al.* (1968) and it remains the most easterly known population on the island. At this site *E. gracile* occurs in quaking scragh vegetation dominated by *Schoenus nigricans*, *Menyanthes trifoliata*, *Scorpidium revolvens* and the nationally rare bryophyte *Cinclidium stygium*.

#### DISTRIBUTION IN WEST MAYO (V.C. H27)

The most northerly population of *E. gracile* in Ireland occurs at Cloonooragh, north-west of the town of Crossmolina in County Mayo. At this location the species grows in a very wet flush, dominated by *Carex limosa*, which is surrounded by intact lowland blanket bog. This population was discovered in August 2002.

#### DISCUSSION

*E. gracile* is now known to be much more common than previously thought, especially in the Connemara region of county Galway. The recent discovery of additional sites for *E. gracile* outside Connemara suggests that further populations may exist in more remote areas of western Ireland. As *E. gracile* was re-found in many of its previously reported Irish sites, this suggests that the habitats of the species have not been subject to the same scale of degradation which has taken place in England over the past 150 years (see Winship 1994). However, the failure to re-find the

species at five previously documented Irish sites gives cause for concern. It is also likely, given the comparatively recent discovery of *E. gracile* in Ireland, that many sites were destroyed prior to its discovery in 1966. Although documentary proof is lacking, many wetland areas which may have supported *E. gracile* have been lost in the past 150 years (Irish Peatland Conservation Council 1992). This loss is especially pronounced in the midlands and east of the country, which have experienced a greater level of agricultural intensification and peatland exploitation than in the west, particularly over the past 100 years.

For Britain, it is presumed that *E. gracile* depends largely on vegetative spread as a means of population expansion at sites (Winship 1994). This is also apparent at many Irish sites. The spread of the species is most clearly seen in lakes where *E. gracile* grows in very sparsely vegetated areas e.g. Dohola Lough and the lake west of Cloonagat Lough. At these locations extensive networks of *E. gracile* rhizomes can be observed in shallow water close to the lake shores, spreading out from the scragh surface and colonising deep muddy peat. Although seeds of *E. gracile* germinate easily on moistened filter paper at 20°C (Conaghan 1995), seedlings of the species were not observed in the field during this survey. Indeed, little is known about the ability of seeds of *E. gracile* to germinate and establish in field conditions, and it seems likely that the establishment of seedlings in the wild is a comparatively rare event. What is apparent, however, is that once the species has become established at a site, it can spread well by means of vegetative growth, providing there is suitable habitat available to colonise. Hence it is likely that only a very low rate of seedling establishment may be necessary in order to ensure the survival of the species at a particular site.

The occurrence of the species at certain sites suggests that it may be part of a relict community of early post-glacial times. If many of the populations encountered are relict populations, then conditions at the sites at time of establishment may have been quite different. Its occurrence on Scragh Bog, alongside several other nationally rare species of current more northerly distribution such as *Pyrola rotundifolia*, *Dactylorhiza traunsteineri* and the moss *Tomentypnum nitens*, indicates that this fen is a refuge for such species in the Irish midlands, a region where many fens have long

since given way to raised bog (O'Connell 1981). In the rare occasions where a lagg remains relatively intact around a raised bog, it supports a 'relict' fen community dominated by species such as *Carex rostrata*, *C. lasiocarpa* and *Potentilla palustris*. It is in such a community that *E. gracile* occurs in the N. Kerry and Offaly sites. It is also notable that a suite of rare bryophytes, with current boreal distributions, such as *Tomentypnum nitens*, *Paludella squarrosa* and *Leiocolea rutheana*, have been located at a number of blanket bog flush sites in Co. Mayo (Lockhart 1999) which are within 5 km of the recently discovered *E. gracile* site in that county.

The different types of habitat in which *E. gracile* was located contain populations which vary greatly in size. These differences in population size are primarily related to the size of suitable habitat available to the species. For example, the larger scragh systems found in the Connemara coastal lake sites contain a large area of suitable habitat, i.e. scragh edge, for *E. gracile* to colonise and therefore they contain the largest populations of the species. Since it is likely that many of the populations which occur in bog flush, calcareous fen and raised bog lagg habitats are relict populations, they may be remnants of much larger populations which occurred when there was more open water present in these locations.

Although it may be argued that the habitats in which *E. gracile* grows often represent comparatively short-lived stages in seral succession, there is little doubt that drainage and/or eutrophication of water can accelerate the rate of succession from low-growing, species-rich plant communities to taller, species-poor ones (Tallis 1983; Wheeler 1983). The observed ecological preferences of *E. gracile* at its Irish sites, coupled with recent experiences in England (Winship 1994) and North America (Decker *et al.* 2006), suggest that the species is one of the first to disappear when open water conditions are eliminated. Therefore it is imperative that protective measures, such as the prevention of site drainage and surface water eutrophication, be imposed in order to slow down the rate of seral progression at sites. This safeguarding of the water quantity and quality at sites will ultimately result in a much longer "life span" of *E. gracile* populations.

Although all the different *E. gracile* habitats are potentially threatened by drainage and eutrophication, the extent of these threats

differs between sites. At present, lake sites occurring in the Connemara region are the least threatened because it is unlikely that they will be drained or otherwise interfered with in the near future. However, van Groenendael *et al.* (1993) noted that the rate of seral progression in coastal lakes in southwestern Connemara accelerated in the time period between the mid-1970s and the early 1990s due to the increased use of artificial fertilisers on land within the lake catchments. This could accelerate the disappearance of *E. gracile* along with the open water.

Populations of *E. gracile* which occur in blanket bog flush sites are more susceptible to drainage than those in lakes because their hydrology is intimately linked with that of the surrounding blanket bog and thus they are at a greater risk from the effects of damaging operations such as peat-cutting or afforestation in adjacent areas of land. This is further compounded by the fact that these populations are generally very small, both in flowering head number (Table 2) and extent and are therefore less likely to survive a damaging event such as drainage than a larger, more widely dispersed population. The sites where *E. gracile* occurs in Westmeath and North Kerry are both nature reserves and are thus legally protected from drainage and reclamation. However, the adjoining land is not protected at present and there is a danger that drainage or fertiliser application on this land may damage the ecology of the sites.

From the point of view of species conservation, one of the most crucial questions that needs to be addressed is at what point in the succession process does *E. gracile* disappear from a site. Winship (1994) has implicated the encroachment of dense reed swamp vegetation dominated by *Phragmites australis* in the elimination of *E. gracile* from English sites; however, in at least one of the Irish lake sites, the species is demonstrating the ability to persist for some time after open water conditions have disappeared. In the northern half of Cregduff Lough the species is common in an area of lake scragh, dominated by the tall reed swamp species *Phragmites australis*, *Carex lasiocarpa* and *Schoenoplectus lacustris*, in which there is no open water present. This suggests that the species may survive for a considerable time in areas of closed swamp vegetation which are still sufficiently wet. The future monitoring of *E. gracile* at this site will reveal much about the ability of the species to persist in habitats where open water is absent.

## CONCLUSIONS

Although this survey suggests that there may have been a small decline in the number of Irish *E. gracile* sites in the past quarter of a century, it has also shown that the species is more common than was previously thought. Further intensive searches of the unconfirmed sites are recommended before it can be stated categorically that these populations have become extinct. Although this paper records 13 new sites for *E. gracile* in Ireland, it is felt that the species should remain on the Irish list of protected plant species. The main reasons for the continued protection of the species are (1) the decline of the species throughout the rest of Europe (Curtis & McGough 1988), (2) the relatively threatened nature of the species' habitat in Ireland and (3) the fact that many populations are small and vulnerable to habitat interference. It is imperative that the remaining Irish sites be monitored on a regular basis to ensure that they are protected from damaging

operations. Experiences in other countries (Winship 1994; Decker *et al.* 2006) have shown that protection of the existing hydrological balance within sites is needed in order to ensure the long-term survival of *E. gracile*.

## ACKNOWLEDGMENTS

We wish to thank Jim Ryan and Lady Rosemary Fitzgerald for permitting the use of their unpublished records. Thanks are also due to Dr Tom Curtis of the National Parks and Wildlife Service, Dublin who provided much help throughout the survey. Much of this research formed part of a Ph.D. thesis at the National University of Ireland, Galway and thanks for financial support are due to the National Parks and Wildlife Service, the National University of Ireland Galway and Donegal County Council. We are indebted to an anonymous referee for useful comments on an earlier draft of the paper.

## REFERENCES

- CLAPHAM, A. R., TUTIN, T. G. & MOORE, D. M. (1987). *Flora of the British Isles* (3rd edn). Cambridge University Press, Cambridge.
- CONAGHAN, J. P. (1995). *The ecology of Eriophorum gracile Koch ex Roth and Eriophorum latifolium Hoppe in Ireland*. Ph.D. Thesis, National University of Ireland.
- COUNCIL OF EUROPE (1983). *List of rare, threatened and endemic plants in Europe*. Nature and Environment Series, No. 27, Strasbourg.
- COX, J. R. (1995). *The conservation and management of Slender Cottongrass Eriophorum gracile in England*. Hampshire and Isle of Wight Wildlife Trust, Eastleigh.
- CURTIS, T. G. F. & MCGOUGH, H. N. (1988). *The Irish Red Data Book. 1. Vascular Plants*. Stationery Office, Dublin.
- DECKER, K., CULVER, D. R. & ANDERSON, D. G. (2006). *Eriophorum gracile W. D. J. Koch (slender cottongrass): a technical conservation assessment*. [Online]. U.S.D.A. Forest Service, Rocky Mountain Region.
- DOUGLAS, C. & GROGAN, H. (1987). *Survey to Locate Lowland Blanket Bogs of Scientific Interest in Connemara, Co. Galway*. Internal Report, National Parks and Wildlife Service.
- FLORA (PROTECTION) ORDER 1999 S.I. No. 94/1999. Government Publications, Dublin.
- HULTÉN, E. (1962). *The Circumpolar Plants. 1. Vascular Cryptogams, Conifers, Monocotyledons*. Almqvist and Wiksell, Stockholm.
- IRISH PEATLAND CONSERVATION COUNCIL (1992). *Irish Peatland Conservation Council Policy Statement and Action Plan 1992–1997*. Irish Peatland Conservation Council, Dublin.
- KERTLAND, M. P. H. (1971). *Eriophorum gracile* Roth. in Ireland. *Irish Naturalists' Journal* **17**: 62.
- LOCKHART, N. D. (1999). *Paludella squarrosa* (Hedw.) Brid., a Boreal relic moss new to Ireland. *Journal of Bryology* **21**: 305–308.
- O'CONNELL, M. (1981). The phytosociology and ecology of Scragh Bog, Co. Westmeath. *New Phytologist* **87**: 139–187.
- PATON, J. A. (1999). *The liverwort flora of the British Isles*. Harley Books, Colchester.
- ROSE, F. (1967). *Eriophorum gracile* Roth. new to Ireland. *Irish Naturalists' Journal* **15**: 361–362.
- SCANNELL, M. P. J. & SYNNOTT D. M. (1987). *A Census Catalogue of the Flora of Ireland* (2nd edn). The Stationery Office, Dublin.
- SCANNELL, M. P. J., SYNNOTT D. M. & WEBB, D. A. (1968). *Eriophorum gracile* in Ireland. *Irish Naturalists' Journal* **16**: 12.
- SMITH, A. J. E. (2004). *The Moss Flora of Britain and Ireland*. Cambridge University Press, Cambridge.

- STACE, C. (1997). *New Flora of the British Isles*. 2nd ed. Cambridge University Press, Cambridge.
- STELFOX, A. W. (1970). A possible early record for *Eriophorum gracile* from West Galway by C. C. Babington in 1836. *Irish Naturalists' Journal* **16**: 282.
- TALLIS, J. H. (1983). Changes in wetland communities, in A. P. J. GORE, ed. *Ecosystems of the World; 4A, Mires: Swamp, Bog, Fen and Moor* pp. 311–347. Elsevier, Amsterdam.
- TUTIN, T. G., HEYWOOD, V. H., BURGESS, N. A., MOORE, D. M., VALENTINE, D. H., WALTERS, S. M. & WEBB, D. A. (1980). *Flora Europaea, Volume 5*, Cambridge University Press, Cambridge.
- VAN GROENENDAEL, J. M., HOCHSTENBACH, S. M. H., VAN MANSFELD, M. J. M. & ROOZEN, A. J. M. (1979). *The influence of the sea and of parent material on wetlands and blanket bog in west Connemara, Ireland*. M.Sc. Thesis, Catholic University Nijmegen.
- VAN GROENENDAEL, J. M., VAN MANSFELD, M. J. M., ROOZEN, A. J. M. & WESTHOFF, V. (1993). Vegetation succession in lakes in the coastal fringe of West Connemara, Ireland. *Aquatic Conservation: Marine and Freshwater Ecosystems* **3**: 25–41.
- WHEELER, B. D. (1983). Vegetation, nutrients and agricultural land use in a north Buckinghamshire valley fen. *Journal of Ecology* **71**: 249–256.
- WIGGINTON, M. J., ed. (1999). *British Red Data Books 1: Vascular Plants*. 3rd ed. Joint Nature Conservation Committee, Peterborough.
- WINSHIP, H. (1994). *The conservation of Slender Cottongrass Eriophorum gracile Koch ex Roth in England*. Hampshire and Isle of Wight Wildlife Trust, Eastleigh.

(Accepted December 2008)