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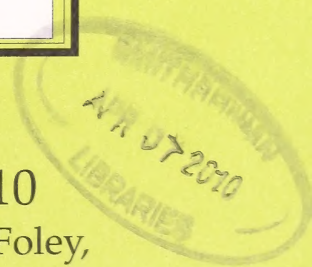
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The cover illustration of *Potentilla anglica* Hook. (Trailing Tormentil) was drawn by Rosemary Wise.

Conservation of Ireland's biodiversity: the status of two Irish endemic hawkweeds *Hieracium hartii* and *H. hibernicum* (Asteraceae)

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ABSTRACT

The National Parks and Wildlife Service, Dublin commissioned a review and survey of the conservation status of *H. hartii* and *H. hibernicum* which are endemic to Ireland. *Hieracium hartii* has been regarded as extinct, but about 50 plants were rediscovered on Slieve League, Co. Donegal in its only locality; records for Ben Bulbin and the Ox Mountains, both Co. Sligo, are errors. *Hieracium hibernicum* was originally described from Co. Down, but is extinct there and in one of its two Donegal localities; 41 plants were rediscovered in the other Donegal site, the Owengarve River, which is now its only extant site. Both species are IUCN threat category 'Critically Endangered'. Lectotypes are designated.

KEYWORDS: Hart's Hawkweed, Irish Hawkweed, Ireland, endemics, lectotype, rare species.

INTRODUCTION

There are seven *Hieracium* species endemic to Ireland: *H. argentatum* (Pugsley) P. D. Sell, *H. basalticola* Pugsley, *H. hartii* (F. Hanb.) P. D.

Sell & C. West, *H. hesperium* P. D. Sell, *H. hibernicum* F. Hanb., *H. scullyi* E. F. Linton and *H. sparsifrons* P. D. Sell & C. West (Sell & Murrell 2006). As there was little recent information available about them to direct conservation priorities, in 2006 the National Parks and Wildlife Service (NPWS) of the Department of the Environment, Heritage and Local Government, Dublin commissioned a review of their status. In this paper the statuses of *H. hartii* and *H. hibernicum* are summarised; full details are given in Rich (2008), which is available to bona fide researchers from M. Wyse Jackson on request. Details of other endemics are given in Rich *et al.* (2008b, 2010), while some interim results were presented in Rich *et al.* (2008a).

HIERACIUM HARTII, HART'S HAWKWEED

Hieracium hartii (= *H. cerinthiforme* var. *hartii* F. Hanb. (basionym); *H. anglicum* var. *cerinthiforme* forma *hartii* (F. Hanb.) W. R. Linton; *H. mougeotii* subsp. *anglicum* var. *cerinthiforme* forma *hartii* (F. Hanb.) Zahn; *H. anglicum* var. *hartii* (F. Hanb.) F. N. Williams) was first found by H. C. Hart in 1883 on Slieve League, Co. Donegal (Hart 1886). In 1891, F. J. Hanbury and H. C. Hart visited the mountain

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and found the plant in profusion and just coming into flower noting 'indeed it was the *Hieracium* of the mountain' [his italics; Hanbury 1892a]. Hanbury regarded it as an extreme form distinct from *H. cerinthiforme* F. Hanb. and *H. anglicum* Fr. and, following a comment from the Swedish *Hieracium* expert Marten Elfstrand that it looked like a good variety, Hanbury named it *H. cerinthiforme* var. *hartii* after Hart. Williams (1902–1903) transferred the variety to *H. anglicum* and Linton (1905) treated it as *H. anglicum* var. *cerinthiforme* forma *hartii*. It was finally raised to species status by Sell & West (1955). A lectotype for *H. cerinthiforme* var. *hartii* F. Hanb. was selected by Sell & West in 1957 but was unpublished, and is now hereby designated by P. D. Sell: Slieve League, Donegal, 16 July 1891, F. J. Hanbury (BM).

Hieracium hartii is a member of section *Cerinthoidea* Monnier (Sell & Murrell 2006). It is characterised by the obovate basal leaves which may be absent at flowering, the 2–5, large, ovate or obovate, acute, entire or minutely and acutely toothed, sessile and strongly amplexicaul stem leaves, and the 1.5–2.0 mm wide, rather obtuse, green, lax, softly hairy and pilose-tipped involucre bracts (Figs 1–3; Hanbury 1892a). It is most similar to *H. cerinthiforme* which differs in the narrower, 1.2–1.5 mm wide involucre bracts and 1–4, smaller stem leaves. It has been confused with *H. iricum* Fr., but that species is much more robust and hairy, often greyish, and usually has 3–6 stem leaves and involucre bracts 1.0–1.5 mm wide.

HIERACIUM HIBERNICUM, IRISH HAWKWEED

Hieracium hibernicum (= *H. norvegicum* subsp. *hibernicum* (F. Hanb.) Zahn) was first found in the Mourne Mountains, Co. Down by H. C. Hart in 1883. Hart sent material to J. Backhouse jnr, who noted 'possibly new, probably forms of *H. argenteum*, but very remarkable', and then to C. C. Babington who noted 'certainly the most remarkable form of *H. argenteum* Fr. I have ever seen' (Hart 1886). Hart (1886) also noted the similarity of the Mourne Mountains plants to material from Moynalt, near Laghy, East Donegal (v.c. H34), and with more typical *H. argenteum* from Galway. After S. A. Stewart had shown it to F. J. Hanbury at Broughnamaddy, Co. Down in 1891, *H. hibernicum* was described as a new species (Hanbury 1892b), the description covering both the Mourne Mountains and

Moynalt plants. After examining further material in DBN, Pugsley (1948) decided that the Donegal plants were sufficiently different to merit recognition as a distinct variety, and named them var. *vennicnorum* Pugsley, differing from the Mourne Mountains material in having the stem more hirsute below with spreading simple eglandular hairs, and the inflorescence sometimes with many (up to 22), smaller capitula with more simple eglandular hairs. Sell & Murrell (2006) do not separate the two varieties.

Hanbury (1892b) and Linton (1905) included *H. hibernicum* in section *Oreadea* (Fr.) Dahlst., but Pugsley (1948) thought it was better placed in section *Tridentata* (Fr.) Arv.-Touv., where it has been retained by Sell & Murrell (2006). It is characterised by its green colouration, the numerous, narrow stem leaves with 2–3 small, sharp teeth and semi-clasping bases, the lax, few-flowered inflorescence and discoloured styles (Figs 4–6). Sell & Murrell's (2006) description of *H. hibernicum* as having yellow styles and glaucous leaves is incorrect. A lectotype for *H. hibernicum* was selected by P. D. Sell and C. West in 1954 but is unpublished, and is hereby designated by P. D. Sell: Stream in Mourne Mountains, tributary of the Causeway Water, at about 900–1000 ft, Co. Down, 23 July 1891, F. J. Hanbury (BM). Praeger (1892) grew it in cultivation successfully.

METHODS

Historical records and information were combined from herbaria (BEL, BIRM, BM, CGE, DBN, E, LIV, NMW, OXF, RNG and TCD), the literature, databases, botanists and the internet. Material has been determined by H. W. Pugsley, P. D. Sell, D. McCosh or T. Rich.

Field work was carried out in 2006–2008 using the historical information to direct surveys. The main aim of the field work was to visit the historic sites to refine the endemic *Hieracia*, though the quality of the historical information did not always make this simple and we often had to use our intuition about *Hieracium* ecology to find suitable places to search. Kéry *et al.* (2006) showed at least two visits are usually required to be certain of refining most populations of rare plants, and up to four visits for species which are hard to find.

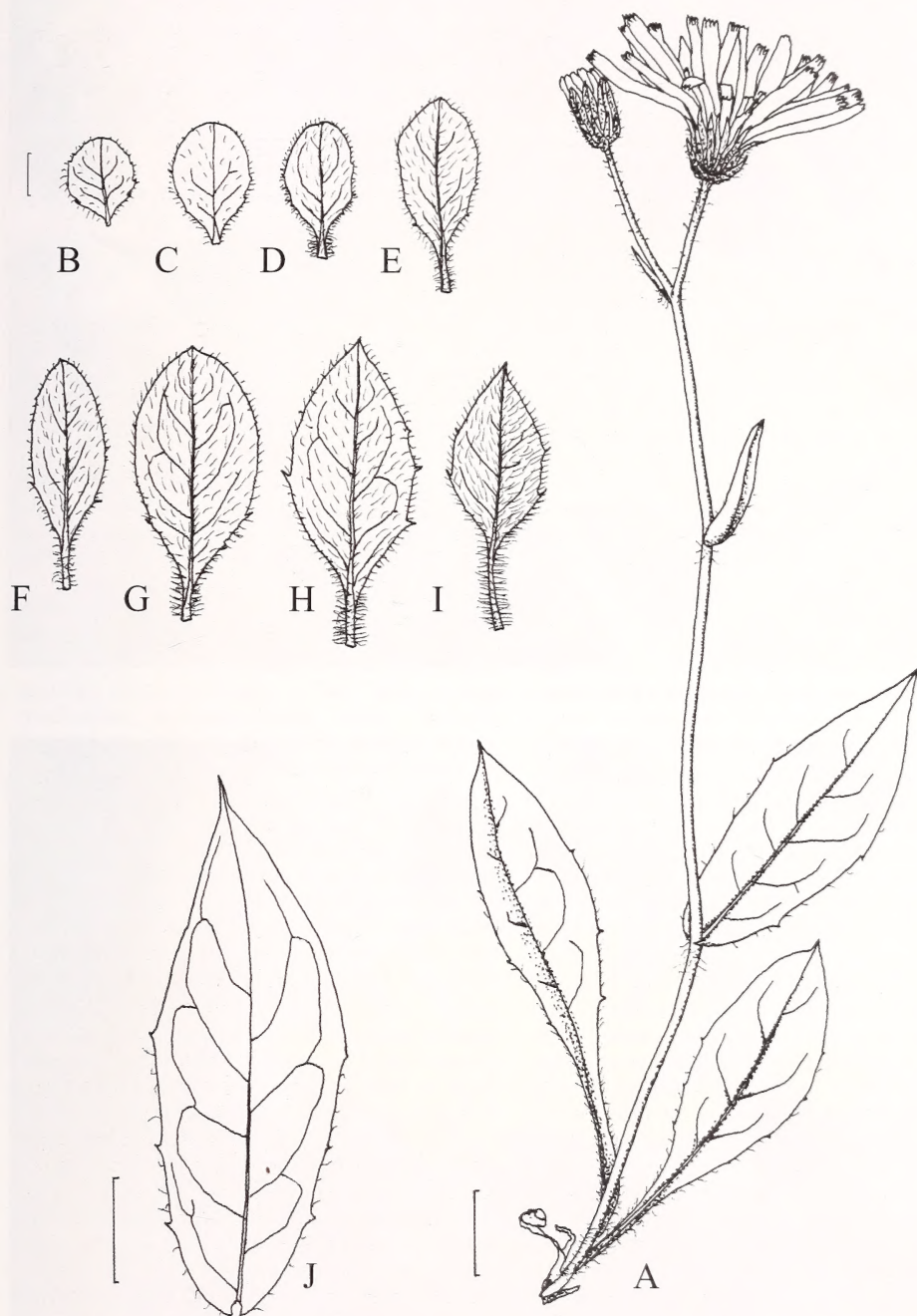


FIGURE 1. *Hieracium hartii*, Slieve League. A, plant. B-I oldest to youngest rosette leaves (cultivated material). J, middle stem leaf. Scale bars 1 cm.



FIGURE 2. *Hieracium hartii*, middle stem leaf, Slieve League.



FIGURE 3. *Hieracium hartii*, capitulum, Slieve League.

For each population found, an NPWS Rare/Threatened plant species recording form was completed with a general relevé form. Soil samples were taken from near the roots of the *Hieracia*; in the laboratory they were mixed 50:50 with distilled water and measured using a calibrated pHep2 Hanna pH meter. Voucher specimens have been placed in **DBN**.

RESULTS

HIERACIUM HARTII

Although a detailed description of *H. hartii* was given by Sell & Murrell (2006), the rosette leaves have not previously been described and are here described from material cultivated in Cardiff in 2007 (Fig. 1): Rosette leaves pale green when young, sparsely hairy above, below and on margins with long, white, simple eglandular hairs. Outermost rosette leaves $\pm$ orbicular to obovate, rounded at apex, rounded to cuneate at base with a broadly winged petiole, with sparse, slightly twisted, forward-pointing teeth on margins. Outer rosette leaves to 70×33 mm including the broadly winged petiole, elliptic-obovate, obtuse and weakly mucronate, cuneate, with long, twisted, forward-pointing teeth. Inner rosette leaves elliptic, acuminate, cuneate, with 3–5 teeth on margin. Petioles to 20 mm, winged.

Historical records for *H. hartii* from Ben Bulbin and the Ox Mountains in Co. Sligo (v.c. H28) were mapped in Sell & West (1968) but have been rejected following field work and re-identification of the voucher specimens in **BM** and **DBN** (all are *H. iricum*). *Hieracium hartii* is now regarded as endemic to Slieve League, Co. Donegal (Fig. 7) where despite being called ‘*the*’ *Hieracium* of Slieve League by Hanbury (1892a), it had not been reported since and was presumed extinct (Sell & West 1968). On 23 July 2006, a small population of about 21 *H. hartii* plants was found on mountain cliffs associated with the rich concentration of arctic-alpines on the north side of Slieve League at G552783. The population estimate is very crude due to the mountainous terrain (a full population census would require roped access by specialist climbers); twelve certain individuals were seen flowering, and nine possible others occurred but could not be accessed safely. During a second visit on 22 July 2008 in heavy rain, more plants were flowering and the population was estimated as about 50 individuals but no precise count was undertaken due to treacherous conditions. There were many vegetative *Hieracium* rosettes

of unknown identification in the turf grazed by sheep; *H. cerinthiforme* has also been reported to occur here, and *H. anglicum* was collected nearby in 2006.

Hieracium hartii occurred on Slieve League in a small area of base-rich soils (pH 6.9) associated with metamorphic rocks on steep, rocky, broken ground at c. 350 m altitude. It grew in quite closed grasslands c. 5–8 cm high associated with *Angelica sylvestris* L., *Carex flacca* Schreb., *Dryas octopetala* L. and *Succisa pratensis* Moench, and bryophytes such as *Breutelia chrysocoma* (Hedw.) Limpr., *Ctenidium molluscum* (Hedw.) Mitt., *Diurichum gracile* (Mitt.) Kuntze and *Leiocolea alpestris* (Schleich. ex F. Weber) Isov. It also grew on open rocks with sparser vegetation.

HIERACIUM HIBERNICUM

Hieracium hibernicum has been recorded historically in three sites: the Mourne Mountains, Co. Down (v.c. H38), and in two glens near Laghy, Co. Donegal (v.c. H34) and above Glenties, Co. Donegal (v.c. H35). A record for Carrick in Colgan & Scully (1898) is an error for *H. argenteum*, as originally recorded by Hart (1885).

Hart’s original 1883 locality was by the Causeway Water at Broughnamaddy in the Mourne Mountains. S. A. Stewart and R. L. Praeger visited the locality in 1889, and Stewart and F. J. Hanbury visited it in 1891. After another visit in 1895, Stewart wrote to W. R. Linton ‘I was at Mourne Mountains this day week and was rather disappointed I could not find any *H. hibernicum* at all – not a flower or leaf to be seen. I greatly fear that it has gone. There was very little of it, but last summer I saw 3 stems in flower, and some others with root leaves only. On that occasion I did not take any as I was afraid to reduce it in any way. It now appears to me that I might just as well have taken all away. The plant grew on the rocky walls of a ravenous gorge of a mountain stream, and I fear that either the severe frost of the winter has killed the plant, or else that portions of the rocks have been swept away by the recent heavy floods, and thus this plant has been destroyed. I saw that the river banks have suffered considerable damage’ (letter 10 August 1895, **BM**). P. D. Sell and C. West were unable to refind it in 1956, and P. Hackney was not able to refind it in 1986 (Hackney 1992). It was similarly not refound on a search on 18 July 2008 – indeed it was difficult to find any places where it might have occurred. *Hieracium hibernicum* must be regarded as extinct in Co. Down.



FIGURE 4. *Hieracium hibernicum* (left hand plant) by Owengarve River with *H. argenteum* (taller right hand plant).

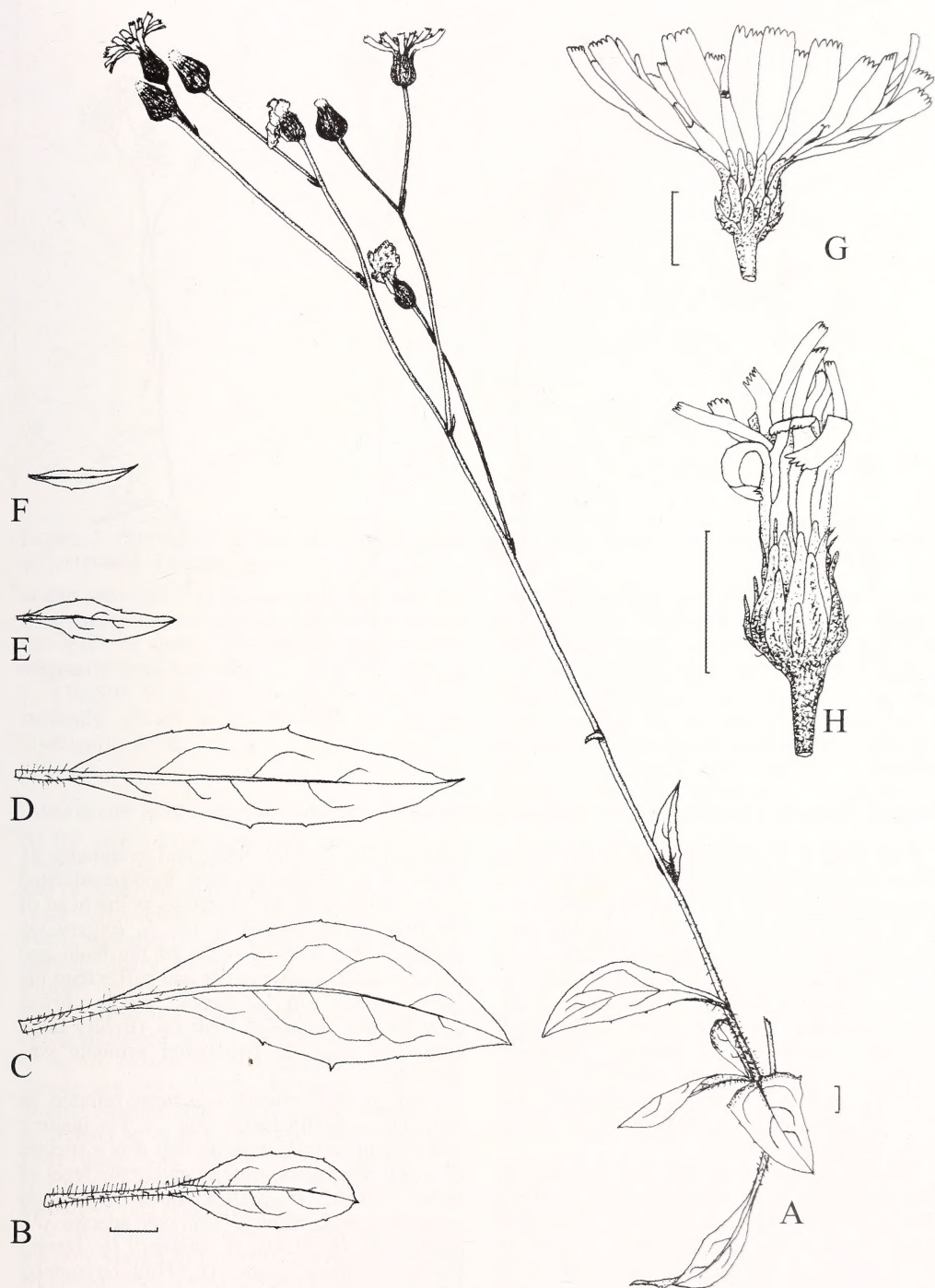


FIGURE 5. *Hieracium hibernicum*, Owengarve River. A, plant. B-F, stem leaves from lowest to upper. G, H capitula. Scale bars 1 cm.



FIGURE 6. Selection of *Hieracium hibernicum* plants showing variation in habit, Owengarve River. Not to scale.

Near Laghy, it was recorded in two glens above Moyne Bridge by H. C. Hart in 1898, and was seen again by J. E. Raven in 1954 on a steep, bushy river bank at Moynalt. The area was searched on 22 July 2006 and briefly on 16 July 2008 without success. We were unable to find any suitable places for *Hieracium* at all, and concluded that the river banks have changed significantly through increased shading by trees and shrubs. However, without knowing exactly where *H. hibernicum* had occurred originally, it is difficult to be certain of the reason for its loss.

Hieracium hibernicum was first collected on the Owengarve River above Glenties by H. C. Hart in 1894, though was not listed in his flora (Hart 1898). It was last seen there in 1955 by N. D. Simpson, but most of the details as to precisely where it occurred are decidedly vague. The river above McDevitt's Bridge was

searched on 22 July 2006, and eventually 41 plants of *H. hibernicum* were found associated mainly with rocks by waterfalls at the head of the river above G898935. The *H. hibernicum* plants on the exposed rocks by the main and upper waterfalls are smaller and stiffer than the larger plants in sheltered places lower downstream. A second visit on 16 July 2008 confirmed that the population estimate was reasonable.

Thus, *H. hibernicum* has been re-found in only one of its three sites (Fig. 7). The historic and current records indicate that it is a species of rocky riverbanks, usually above the level of flood waters. It prefers open vegetation associated with other *Hieracium* species (*H. argenteum*, *H. iricum*, *H. stewartii* (F. Hanb.) Roffey), *Calluna vulgaris* (L.) Hull, *Dryopteris dilatata* (Hoffm.) A. Gray, *Erica cinerea* L., *Solidago vulgaris* L. and *Succisa pratensis*, on



FIGURE 7. Distribution of Irish endemic *Hieracium* species. A, *H. hartii*. B, *H. hibernicum*. ● 2006–2008. ○ Not refund. × error.

acidic soils (pH 5.7). Being a tall leafy species, it is susceptible to grazing, and occurs out of the reach of sheep. The altitude range would originally have been from c. 50 m at Laghy to c. 275–305 m in the Mourne Mountains; it currently occurs at c. 200–240 m on the Owengarve River.

DISCUSSION

At the start of the Irish endemic hawkweeds project, *H. hartii* was considered to be extinct and *H. hibernicum* had not been seen for fifty years. *Hieracium hartii* had probably been overlooked due to confusion with the relatively sparsely hairy forms of *H. iricum* on Ben Bulbin which had been attributed to this species, resulting in the plants at Slieve League being attributed to *H. cerinthiforme* rather than *H. hartii*. *Hieracium hibernicum* had probably simply not been looked for due to the very limited amount of *Hieracium* work carried out in Ireland in recent years; the work that has been done was mostly by P. Hackney in Northern Ireland where *H. hibernicum* was already extinct (Hackney 1992).

Very small populations of both hawkweeds are now known in Donegal. There may also be additional sites which are as yet unknown, but it is impractical to search for them. The very small population sizes indicates that they are

both categorised as 'Critically Endangered' following the IUCN (2001) Red List criteria. Both hawkweeds would benefit from some relaxation of grazing pressure in their upland habitats. *Hieracium hartii* is relatively safe from grazing on its mountain rocks but a significant reduction in grazing pressure might allow it to increase and spread within its habitat. *Hieracium hibernicum* could expand along the riverbanks, but is at risk from scrub expansion which may have already resulted in losses downstream from its current site, and where it formerly occurred near Laghy.

A priority is to get secure *ex situ* collections of both species. Three plants of *H. hartii* are currently being cultivated at the National Botanic Gardens, Glasnevin. One 2006 collection of seed of *H. hibernicum* by R. Sheppard *et al.* is held in the Irish Threatened Plant Genebank at Trinity College Botanic Garden, Dublin. *Ex situ* collections would also allow further research on their biology; most British and Irish *Hieracium* species are polyploid and apomictic (Sell & Murrell 2006) which is likely to be the case for these species but this has not yet been tested experimentally.

The Slieve League site for *H. hartii* is included in a Special Area of Conservation (SAC) under the European Union Habitats Directive. The Owengarve River site for *H. hibernicum* is currently unprotected, but will be

considered for designation as a Natural Heritage Area (NHA) under the Wildlife (Amendment) Act, 2000. Both species are under consideration by the National Parks and Wildlife Service for inclusion on a revised Flora (Protection) Order under section 21 of the Wildlife Act, 1976.

Compared to other Irish endemic hawkweeds, these Donegal species are amongst the rarest. There are over 3950 plants of *H. basalticola* (Rich *et al.* 2010), at least 870 plants of *H. argentatum*, 210 plants of *H. scullyi* and 204 plants of *H. sparsifrons* (Rich *et al.* 2008b). The status of *H. hesperium* remains to be resolved.

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REFERENCES

- COLGAN, N. & SCULLY, R. W. (1898). *Contributions towards a Cybele Hibernica*. 2nd ed. Edward Ponsonby, Dublin.
- HACKNEY, P. (1992). *Flora of the North-east of Ireland*. 3rd ed. Institute of Irish Studies, Queen's University, Belfast.
- HANBURY, F. J. (1892a). Further notes on *Hieracia* new to Britain. *Journal of Botany (London)* **30**: 165–170.
- HANBURY, F. J. (1892b). Further notes on *Hieracia* new to Britain. *Journal of Botany (London)* **30**: 258–261.
- HART, H. C. (1885). Report on the flora of south-west Donegal. *Proceedings of the Royal Irish Academy, 2nd series* **4**: 443–469.
- HART, H. C. (1886). Irish hawkweeds. *Journal of Botany (London)* **24**: 45–47.
- HART, H. C. (1898). *Flora of the County Donegal*. Sealy, Bryers & Walker, Dublin & David Nott, London.
- IUCN (2001). *IUCN Red list categories and criteria. Version 3.1*. I.U.C.N., Gland.
- KÉRY, M., SPILLMANN, J. H., TRUONG, C. & HOLDEREGGAR, R. (2006). How biased are estimates of extinction probability in revisitation studies? *Journal of Ecology* **94**: 980–986.
- LINTON, W. R. (1905). *An account of the British Hieracia*. West, Newman & Co., London.
- PRAEGER, R. L. (1892). *Hieracium hibernicum* Hanb. *Journal of Botany (London)* **30**: 808–809.
- PUGSLEY, H. W. (1948). A prodromus of the British *Hieracia*. *Journal of the Linnean Society (Botany)* **54**: 1–356.
- RICH, T. C. G. (2008). Review and survey of the conservation status of Irish endemic hawkweeds (*Hieracium*). Final Report. Unpublished report from National Museum of Wales to National Parks and Wildlife Service, Dublin.
- RICH, T. C. G., WYSE JACKSON, M. B. & FITZGERALD, R. (2008a). Wildlife reports. Plants – Ireland. *British Wildlife* **19**: 214–216.
- RICH, T. C. G., HODD, R. L. I. B., MCCOSH, D. J., MHIC DAEID, E. C., MCVEIGH, A., SAWTSCHUK, J. & WYSE JACKSON, M. B. (2008b). Conservation of Ireland's biodiversity: a survey and assessment of the current status of three Irish endemic hawkweeds from Kerry, *Hieracium argentatum*, *H. scullyi* and *H. sparsifrons* (Asteraceae). *Biology and Environment: Proceedings of the Royal Irish Academy* **108B**: 143–155.
- RICH, T. C. G., COTTON, D. C. F., HODD, R. L. I. B., HOUSTON, L., MCCOSH, D. J. & WYSE JACKSON, M. B. (2010). Conservation of Ireland's biodiversity: status of the Irish endemic *Hieracium basalticola* Pugsley, Basalt Hawkweed (Asteraceae). *Irish Naturalists' Journal* **30**: (in press).
- SELL, P. D. & MURRELL, G. (2006). *Flora of Great Britain and Ireland*. Volume 4. Cambridge University Press, Cambridge.
- SELL, P. D. & WEST, C. (1955). Notes on the British *Hieracia* – I. *Watsonia* **3**: 233–236.
- SELL, P. D. & WEST, C. (1968). *Hieracium* L., in PERRING, F. H., ed., *Critical Supplement to the Atlas of the British flora*. B.S.B.I., London.
- WILLIAMS, F. N. (1902–1903). *Hieracium* in *Prodromus florae Britannicae*. Brentford.

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Variation in ripening years of seed cones of *Juniperus communis* L.

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ABSTRACT

Many *Juniperus communis* populations are in decline, often with poor reproductive performance. Biological and phenological studies have shown that seed cone ripening time takes between two and three summers after pollination, and occasionally four. Individual junipers differ: in samples from northern England some were almost entirely three year, some were two year and others had mixed proportions. The limited evidence suggests that two year ripening is commoner in warmer areas such as southern England, and three years more frequent in northern and mountainous parts of Europe. Suggestions about the causes of these differences include the effects of climate on pollen tube growth rates, phasing of the seed cone crop production and genetic background.

KEYWORDS: Berries, Maturation, Phenology, Reproduction, Fixed-point photography.

INTRODUCTION

The failure of regeneration in *Juniperus communis* L. in various areas of lowland Europe has been of concern for many years (Ward 1973; Burny 1985; Lejeune *et al.* 1986; Landolt 1994; Clifton *et al.* 1997; García *et al.* 1999; García & Zamora 2003; Verheyen *et al.* 2005). Some of the declines can be attributed to modern land use which no longer provides the necessary open nutrient-poor habitat conditions for seedlings. This may be compounded by heavy grazing by domestic animals or rabbits (Ward & King 2006). Additionally seed production can be very poor (García *et al.* 2000; Verheyen *et al.* 2009). The ecological and biological background to seed production is not completely understood however, and as part of a detailed study, this paper shows how sites and individuals may differ in seed cone (berry) ripening times.

Juniperus communis L. is wind-pollinated in late spring, and seed cones (Farjon 2005) ripen over two or three years (Adams 2004; Thomas *et al.* 2007; Tutin *et al.* 1993). Three year cycles have been recorded more often, with

seed cones remaining small until fertilized in the following spring (Ottley 1909; Stiles 1980; Roques 1983; Raatikainen & Tanska 1993; Chambers *et al.* 1999; García *et al.* 2002). These small green cones swell in their second summer and ripen to purple by the end of the third summer. However cones can ripen over two years (Tueller *et al.* 1975; Farjon 2005) and in southern England Ward (2007) found a correlation between abundant male pollen in spring the year before good cropping in females, but not two years before.

As this variation in ripening year was little understood, cones were counted on wood of different ages, contrasting two southern and one northern site in the UK. An earlier phenological study in southern England in 1988–1989 had utilized fixed point photography of twigs, but it is only now with the use of digital scanning that it has become practical to count the individual cones and to present relevant data about the cone life cycles.

The results will show whether the life cycles of seed cones lasted for two or three years (or more) and whether there were differences between individuals and sites. Some possible reasons for differences will be discussed.

MATERIALS AND METHODS

STUDY SITES

Samples for seed cone age studies were taken from (i) The Breck, Porton Ranges of the Defence Science Technology Laboratory (DSTL) on the Hampshire/Wiltshire border in southern England (Nat. Grid Ref. SU2103700) on 6/10/2006, a site where juniper populations have been monitored since 1983 (Ward 2007), (ii), Bulford Down SSSI (Wiltshire SU204443) on 16/8/2006, with junipers of the same age class as on the Breck (i.e. both colonized after myxomatosis destroyed browsing rabbits in 1954–1955), (iii) Mardale Banks in northern England in Cumbria (NY481128) on 17/10/2006.

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TABLE 1. SEED CONE TYPES RECOGNIZED IN THIS STUDY

Key	Colour	Size	Ripening stage
F	Green	very small	Conelets/'flowers' – receptive/just pollinated
GV	Green	small	Conelets after pollination but little swelling
G	Green	normal	immature unripe cones
PG	Purple/Green	normal	Colour change to purple ripe beginning
P	Purple	normal	Ripening/ripe (fully ripe when bloom appears)
Y	Yellow	normal	Abortion/dying (all stages except brown)
B	Brown	over-ripe	not dispersed or fallen
S	Shrivelling	all sizes	Shrivelling all ages, diseased or seeds not fertilized

The phenological study in 1988–1989 was of a young healthy population (modal age about 21 years) at Pepperbox Hill in the Brickworth Down and Dean Hill SSSI (Wiltshire SU212247).

On all the sampling sites there were more males than females, the sexes were growing close together, and the weather in spring was dry, so that pollination problems were unlikely to be limiting (Ward 2007).

WOOD AGE AND CONE DEVELOPMENT

At each of the three study sites, ten twigs of 15–25 cm with >75 green (immature) or purple (mature) cones were cut from ten individuals. The numbers of growing shoots over the last three years were counted, and cones assigned to the age of the wood to which they were attached, using the annual bud scars/scales and comparative leaf lengths (leaves are short near the annual scar). Some cone-bearing shoots stop growing, and their age was harder to assess, but could usually be determined by comparison to nearby similar shoots. Cones were assigned to different types (Table 1). Filled white seed, and empty and dead seeds and insect attack were also counted, and these results will appear elsewhere.

FIXED POINT PHOTOGRAPHY OF SMALL BRANCHES

At Pepperbox Hill a branch (c. 20–40 cm) with some purple cones was selected on each of 12 individuals, and these were subsequently

photographed on each of 14 monthly visits from August 1988 to November 1989. 1988: 8/8, 14/9 (Oct missed), 11/11, 14/12. 1989: 18/1, 14/2, 29/3 (April missed), 5/5, 8/6, 3/7, 16/8, 12/9, 19/10, 28/11. Owing to the growth of foliage in the second year, only seven branches provided photographs clear enough to be scanned for counting the same cones over all sampling dates. On some months cones were obscured because of slightly different photographic angles, but were visible in later scans and could be added back into the data. Similarly, more of the small undeveloped conelets were not seen until they started to swell, and these counts were therefore underestimated.

RESULTS

PHENOLOGY OF SEED CONE DEVELOPMENT

The detailed study at Pepperbox Hill shows the differing phenology during the ripening of two and three year seed cones (Fig. 1), using total counts of the numbers in the sampled seven branches (Fig. 2).

The very small seed conelets became receptive in late April and May when a small liquid drop (pollination droplet) appeared at the tip of the cone. Cones that will last for only two years swelled in June but many of these small conelets aborted and were shed.

FIGURE 1. (opposite) Seed cone ripening variation in *Juniperus communis* at Pepperbox Hill (Seed cone types Table 1). 1–4 in left column on two year cycle. 1. May – receptive conelets (F) on last year’s wood. 2. June – conelets swelling (GV), some aborting/falling. 3. July – normal green cones (G) in first year, others shrivelling (S). 4. November – green cones (G) typical size, and a two year purple cone (P). 5–6 in right column mixed two and three year cycles. 5. May – conelets/small cones (F and GV) from last spring swelling on last year’s wood, new current year conelets visible. 6. June – two year green cones (G) slightly larger and darker than the one year, many aborting cones (GYS). 7. July – some one year cones swollen (GV) others remain as conelets (F). 8. November – ripe cones purple (P-second and ?third years), green cones (G-first and second years) and a few conelets (GV).

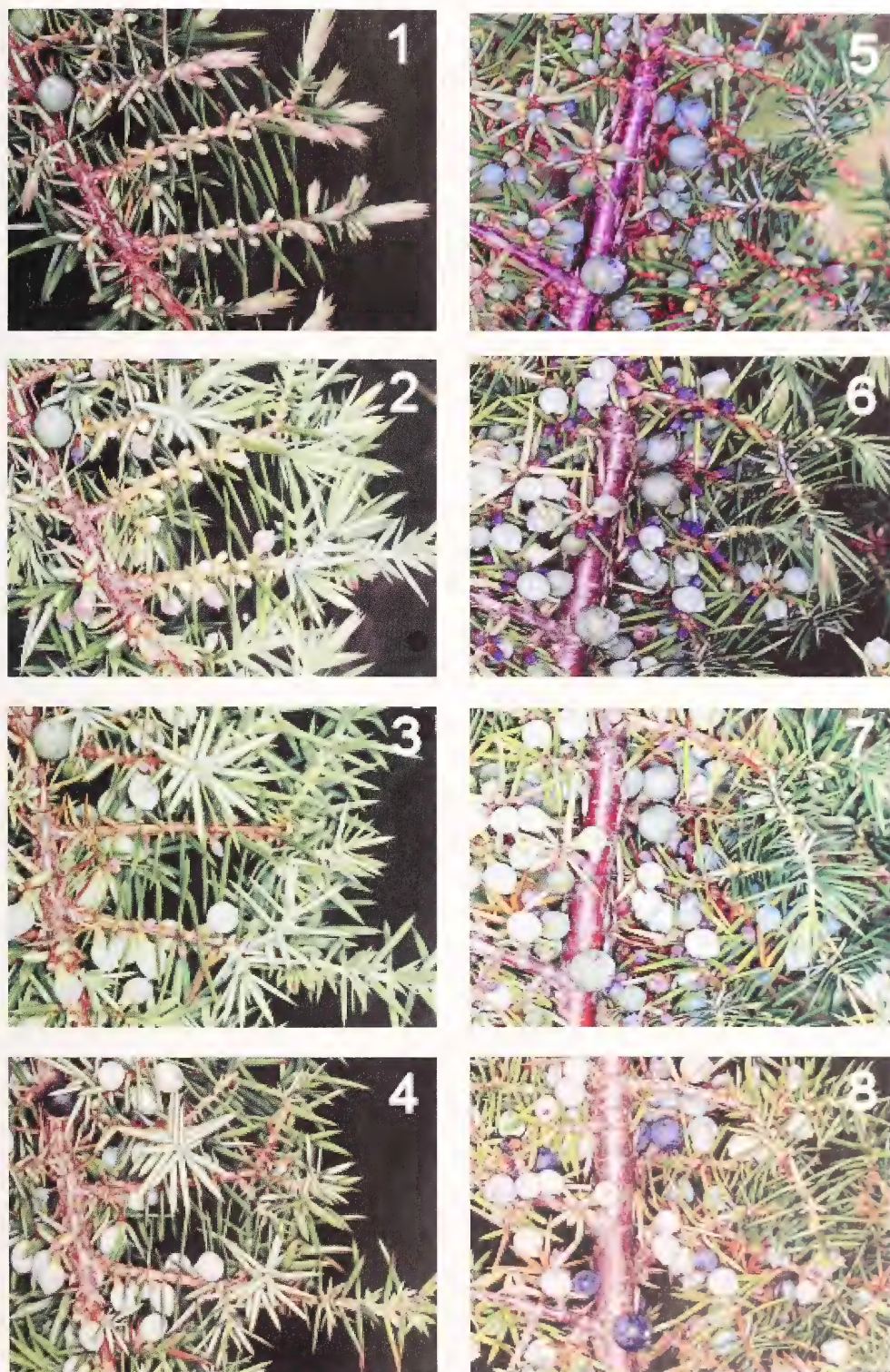


FIGURE 1.

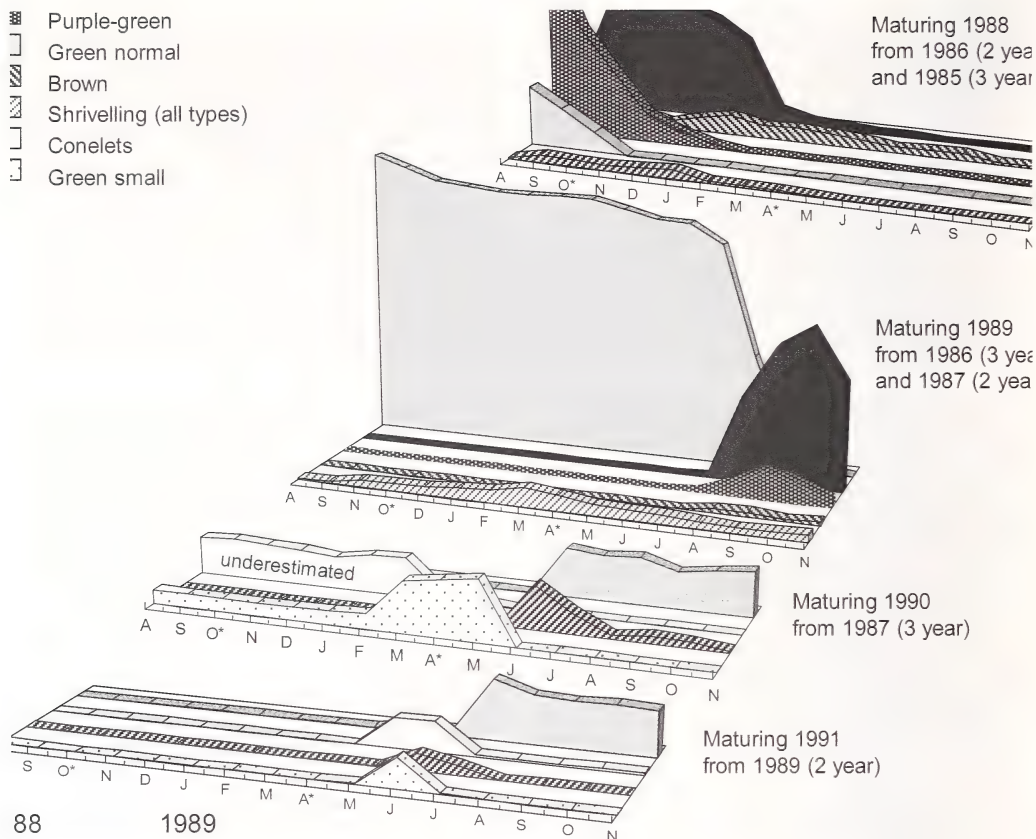


FIGURE 2 Monthly total counts of all seed cone types with years of pollination and ripening at Pepperbox Hill from fixed point photographs (Counts on a scale 0–80 cones on seven twigs from different individuals: no three year old cones to ripen in 1991: actual dates 1988 – 8/8, 14/9 (Oct missing) 11/11, 14/12; 1989 – 18/1, 14/2, 29/3, (April missing) 5/5, 8/6, 3/7, 16/8, 12/9, 19/10, 28/11): * missing values interpolated).

The surviving green cones swelled to a normal size by July/August. Cones that will last for three years developed slower, the tiny conelets hardly changed or they swelled slightly and remained much smaller than the normal larger green cones until about March of the following year. These one year old conelets began to swell just before the current year's conelets became receptive for pollination. In May and June quite a lot of these one year old conelets aborted, possibly due to lack of fertilization, and these shrivelled conelets were more conspicuous than the aborting conelets of the current year. By July of the second year these one year old cones looked like those that had swollen in the same year, but they were located on two year old wood. There were usually more second and third year green cones than

purple, but some of the green cones shrivelled, mainly in spring and early summer, because the seeds were unfertilized, aborted or were attacked by the juniper berry gall mite, *Trisetacus quadrisetus* (Thomas). Green cones enlarged slightly more at the beginning of their last season (observed also by Raatikainen & Tanska 1993), and in late summer or autumn usually became purple-green blotched, before turning to dark blue/purple, at times varying between individuals (Fig. 3). Cones were progressively shed or eaten by birds etc from September onwards, although a few persisted through the winter, eventually turning brown and shrivelling. A small proportion of these were serotinous with some filled white seeds (presumed viable).

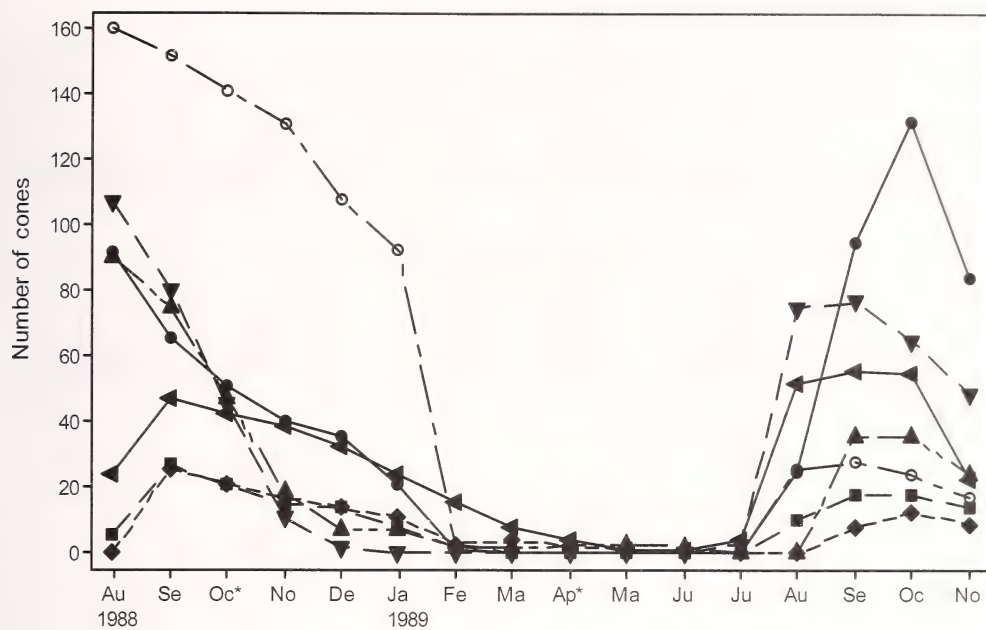


FIGURE 3. Timing of ripening and seed cone disappearance on seven individuals, with differences in successive years at Pepperbox Hill 1988–1989 (* = missing values interpolated).

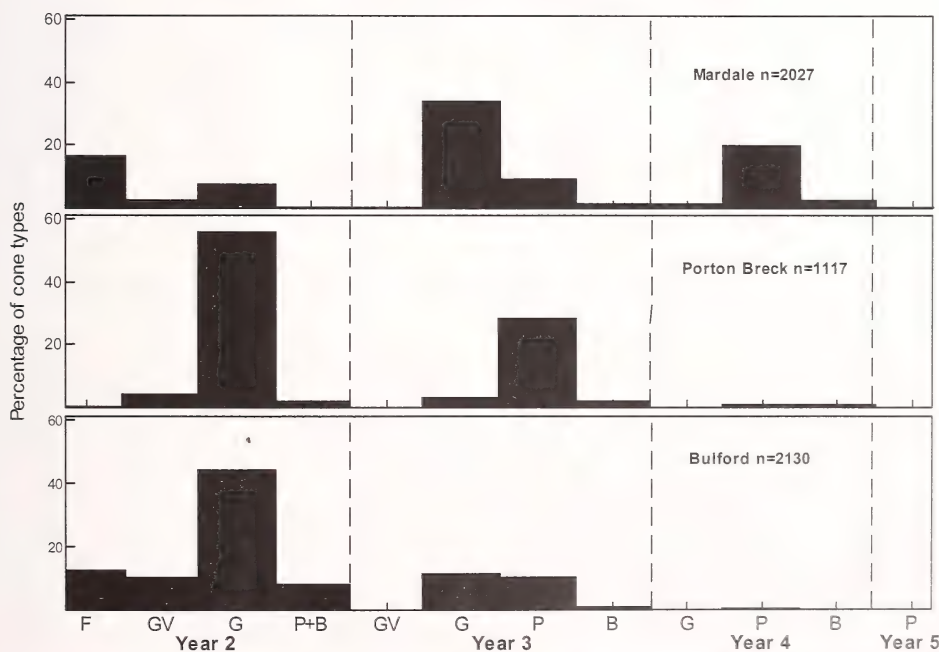


FIGURE 4. Percentage of total numbers of seed cone types on the years of growth of 10 sample twigs from each of Mardale, Porton Breck and Bulford in 2006 (see Table 1 for key to cone types).

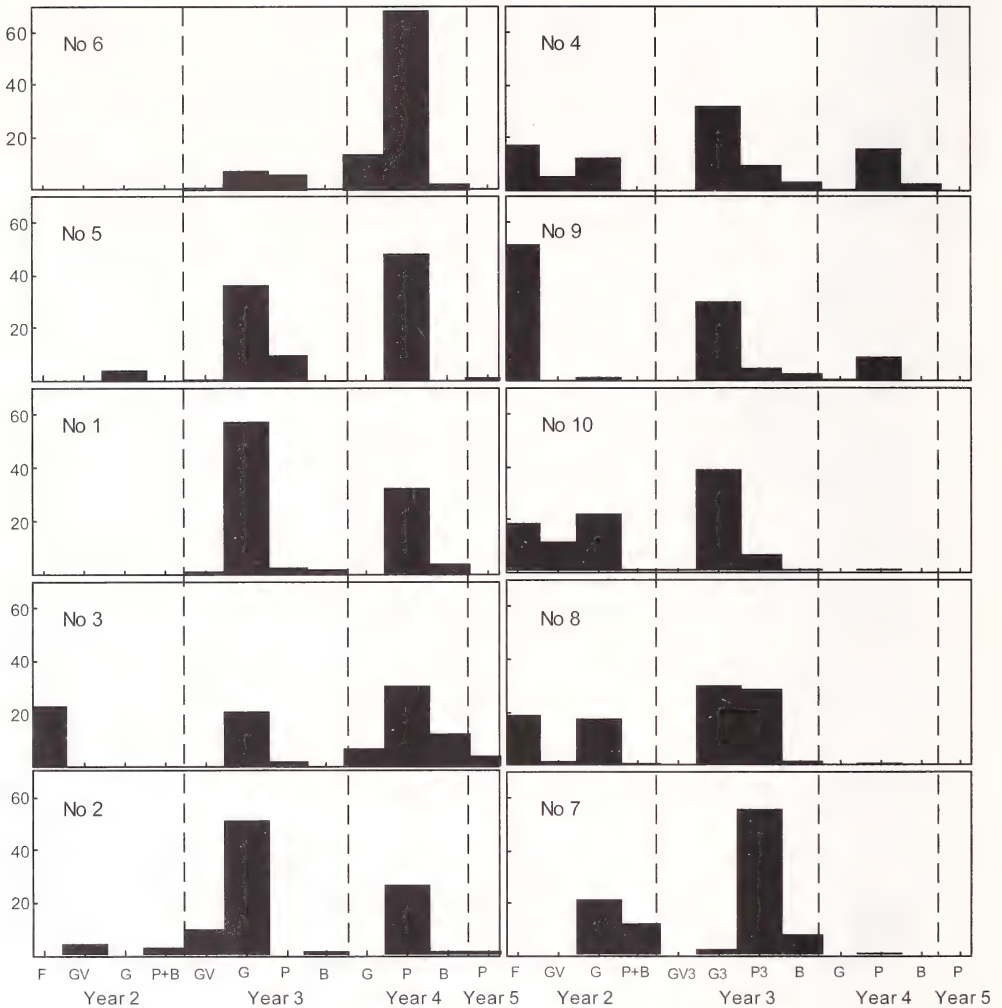


FIGURE 5. Percentage of seed cone types on the last five years of growth on 10 individual junipers - arranged from three year ripening top left to two year at bottom right (for cone types see Table 1).see

As the study progressed it was realized that the phenology of the year classes would be incompletely represented in Fig. 2 because the green and purple cones present at the start in 1988 could not be divided into their year classes. There were more two year cones than three in those that could be distinguished by the first year, and in the last summer of the recording there were apparently no three year cones to mature as the smaller numbers of green cones had swollen in their first year.

SEED CONE RIPENING TIME DIFFERENCES - NORTH AND SOUTH ENGLAND

The results from Pepperbox Hill first showed that the ripening period for seed cones of

Juniperus communis varied. In order to understand this cone development in relation to years more clearly, cones of different colours and stages of development were assessed by wood age from additional sites. At two southern sites, Porton and Bulford, almost all cones ripened over two years (Fig. 4) only 1.5% and 0.5% took three years. In contrast at the northern site, Mardale, 20.3% of cones ripened in their third year and 1.3% took four years to mature. All cones originated from the reproductive buds on second year wood, and at Mardale 16.9% of very small conelets for this first year appeared healthy and were expected to swell the following year reaching maturity in their third year. At Bulford there were 12.6%

of these small conelets, but nearly all were in poor condition (turning purple, shrivelling or damaged by Eriophyid mites), and so were expected to fall very soon. At Porton there were no small conelets, probably because the sampling date was slightly later (October) and these unhealthy conelets had already fallen. The ripening years of seed cones at Mardale varied in individual junipers (Fig. 5). Cones on No. 7 for example were two years and similar to those from the southern samples, while No. 1 had cones that nearly all matured over three years, as did No. 5 which also had a few purple cones of four years. It was not known how differences in ripening time affected survival of the seed cones, but the numbers of white, filled seed at Mardale was significantly higher in the green cones on the two year old wood (43.86%, $n=579$ seeds) than in those on the three year wood (30.29%, $n=1875$) (Chi-Sq = 17.334, DF = 1, P-Value = 0.000). There was no difference in seed numbers between ripe purple cones on three and four year old wood (19.6% and 19.3%).

DISCUSSION

The results show that the ripening period for seed cones of *Juniperus communis* varied between two and three years, with a few cones taking four years. Two southern sites in the UK were very strongly biased to two years, although a very young vigorous population at Pepperbox Hill had a slightly higher proportion of three years. At other southern sites the author has also noticed that the two year cycle is normal. The northern site (Mardale) had both two and three year cycle cones, but there were marked variations between individuals, some entirely following the two year pattern, while others were predominantly of three years. The limited evidence in this paper and in the literature (Lanzara & Pizzetti 1977; Raatikainen & Tanska 1993; García *et al.* 2002) suggests that three year cycle cones are more frequent in northern or mountainous locations in Europe than in warmer areas. After pollination, the pollen tube grows down to the ovule and fertilization can be delayed for up to a year (Ottley 1909; Schnarf 1933; Singh 1978). The growth of the pollen tube could therefore be a critical factor in ripening in relation to fertilization as this seems to trigger the swelling of the cone in either the first or second year. Indeed in various plants it is known that pollen tube growth increases with

temperature (Bertin 1988; Murcia 1990; Hedhly *et al.* 2005). In *J. communis* also seed viability decreases in warmer latitudes and with higher nitrogen content (Verheyen *et al.* 2009) and these variables affect the physiological and nutritional state of the ovule which is also important in reproductive biology.

Genotypes within plant species affect pollination and fertilization and are important in adaptation to environmental differences. *J. communis* is a very variable species (Van der Merwe *et al.* 2000, Oostermeijer & de Knecht 2004, Michalczyk *et al.* 2006), and has two main sub-species in England (Tutin *et al.* 1993, Thomas *et al.* 2007) although recent DNA analyses indicate that these are not clearly distinguishable and should be varieties (Adams & Pandey 2003; Filipowicz *et al.* 2006). Foliage at the northern study site was variable and some individuals tended to have smaller and more appressed leaves and slower growth, perhaps more like that of *J. communis* L. ssp. *nana* and these were apparently more likely to bear three year ripening seed cones. Intermediates between the sub-species *J. communis communis* L and *J. communis nana* (Hook.) Syme are frequent (Stace 1977) and in Cumbria there could be an altitudinal cline, so that Mardale at an altitude of 459 m could be expected to show some variation. Relatively little is known about the phasing of seed cone production in *J. communis*, although good crops in females at Porton were more often followed by a poorer crop and greater growth of the foliage than in males, and females only cropped well on average for 3.1 years (Ward 2007). Discontinuous production of cones is suggested in the phenological study at Pepperbox Hill where the sample branches in fixed photographs were initially chosen to have many cones, but by the second year most had far fewer cones on the same branches and there were fewer three year cycle cones. Probably there is competition between growth and cone production for nutrient resources, and up to a point this affects the whole individual and not just branches. It is quite common to see an individual with mostly green immature cones (at the start of a productive cycle) while another nearby has only purple cones. Possibly if the initial phase is vigorous with very many cones, as in young plants, there is a higher probability of 3 year cycles due to resource competition. This might explain the greater numbers of smaller cones which swelled slightly but not to normal size.

The timing of cone ripening in autumn is important in seed dispersal by birds, and especially to the migrant flocks of fieldfares (*Turdus pilaris*) and other Turdidae attracted to larger populations of juniper (Garcia *et al.* 2001). The blue waxy bloom that appears on mature cones has UV reflectance in *Juniperus virginiana* L. and is thought to be a signal making the cones more visible to birds (Burkhardt 1982, Willson and Whelan 1989). Although most cones are ripe for dispersal in September individual junipers vary so some cones are available to birds throughout the winter months.

The complexity of seed cone ripening years in *J. communis* will need to be taken into account in studies of its ecological and reproductive biology, for example, it is not

known how differences in ripening time affect the annual crop of seed cones. At Mardale there were more filled white seeds in the green seed cones on two year old wood than on three year old wood, but there was no difference in filled seed numbers in the ripe purple cones on three and four year old wood.

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The Centre for Ecology and Hydrology has provided valuable support for my juniper studies for many years. I thank the Defence Science Technology laboratory for permission to work at Porton Down, and also the National Trust at Pepperbox Hill. I acknowledge valuable help from D. Shackelton (Mardale), and also J. M. Bullock, S. Corbett and the late J. A. Grant.

REFERENCES

- ADAMS, R. P. & PANDEY, R. N. (2003). Analysis of *Juniperus communis* and its varieties based on DNA fingerprinting. *Biochemistry Systematics and Ecology* **31**: 1271–1278.
- ADAMS, R. P. (2004). *Junipers of the world: The genus Juniperus*. Trafford Publishing Co., Vancouver.
- BERTIN, R. I. (1988). Paternity in plants. in LOVETT DOUST, J. & LOVETT DOUST, L., eds. *Plant Reproductive Ecology. Patterns and Strategies* pp. 30–59. Oxford University Press, Oxford.
- BURKHARDT, D. (1982). Birds, berries and UV. A note on some consequences of UV vision in birds. *Naturwissenschaften* **69**: 153–157.
- BURNY, J. (1985). Het vroeger en huidige voorkomen van de Jeneverbes *Juniperus communis* L. op de Hoge Kempen (Provincie Limburg, België). *Wielewaal* **51**: 10–30.
- CHAMBERS, J. C., VANDERWALL, S. B. & SCHUPP, E. W. (1999). Seed and seedling ecology of piñon and juniper species in the pygmy woodlands of western North America. *Botanical Review* **65**: 1–38.
- CLIFTON, S. J., WARD, L. K. & RANNER, D. S. (1997). The status of juniper *Juniperus communis* L. in north-east England. *Biological Conservation* **79**: 67–77.
- FARJON, A. (2005). *A monography of Cupressaceae and Sciadopitys*. Royal Botanic Gardens, Kew.
- FILIPOWICZ, N., PIOTROWSKI, A., OCHOCKA, J. R. & ASZTEMBORSKA, M. (2006). The phytochemical and genetic survey of common and dwarf juniper (*Juniperus communis* and *Juniperus nana*) identifies chemical races and close taxonomic identity of the species. *Planta Medica* **72**: 850–853.
- GARCÍA, D. (2001). Effects of seed dispersal on *Juniperus communis* recruitment on a Mediterranean mountain. *Journal of Vegetation Science* **12**: 839–848.
- GARCÍA, D. & ZAMORA, R. (2003). Persistence, multiple demographic strategies and conservation in long-lived Mediterranean plants. *Journal of Vegetation Science* **14**: 921–926.
- GARCÍA, D., ZAMORA, R., GÓMEZ, J. M. & HÓDAR, J. A. (2001). *Juniperus communis* depends more on population characteristics than on individual attributes. *Journal of Ecology* **89**: 639–647.
- GARCÍA, D., ZAMORA, R., GÓMEZ, J. M. & HÓDAR, J. A. (2002). Annual variability in reproduction of *Juniperus communis* L. in a Mediterranean mountain: Relationship to seed predation and weather. *Ecoscience* **9**: 251–255.
- GARCÍA, D. *et al.* (2000). Geographical variation in seed production, predation and abortion in *Juniperus communis* throughout its range in Europe. *Journal of Ecology* **88**: 435–446.
- GARCÍA, D., ZAMORA, R., HÓDAR, J. A., & GÓMEZ, J. M. (1999). Age structure of *Juniperus communis* L. in the Iberian peninsula: Conservation of remnant populations in Mediterranean mountains. *Biological Conservation* **87**: 215–220.
- HEDHLY, A., HORMAZA, J. I. & HERRERO, M. (2005). The effect of temperature on pollen germination, pollen tube growth, and stigmatic receptivity in peach. *Plant Biology* **7**: 476–483.
- LANDOLT, E. (1994). Beiträge zur der Flora der Stadt Zürich. I Einleitung-Beschreibung der neuen Flora, Pteridophyten und Gymnospermen. *Botanica Helvetica* **104**: 157–170.
- LANZARA, P. & PIZZETTI, M. (1977). *Simon and Schuster's Guide to Trees*. Simon and Schuster Inc., New York.
- LEJEUNE, M., VERBEKE, W. & HEYVAERT, J. (1986). Jeneverbes (*Juniperus communis* L.) op de Sint-Pietersberg (Provincie Luik, België). *Natuurhistorisch Maandblad* **75**: 63–68.

- MICHALCZYK I. M. *et al.* (2006). Characterization of highly polymorphic nuclear microsatellite loci in *Juniperus communis* L. *Molecular Ecology Notes* **6**: 346–348.
- MURCIA, C. (1990). Effect of floral morphology and temperature on pollen receipt and removal in *Ipomoea trichocarpa*. *Ecology* **71**: 1098–1109.
- OOSTERMEIJER J. G. B. & DE KNEGT B. (2004). Genetic population structure of the wind-pollinated, dioecious shrub *Juniperus communis* in fragmented Dutch heathlands. *Plant Species Biology* **19**: 175–184.
- OTTLEY, A. M. (1909). The development of the gametophytes and fertilization in *Juniperus communis* and *Juniperus virginiana*. *Botanical Gazette* **48**: 31–46.
- PRESTON, C. D., PEARMAN, D. A. & DINES, T. D. (2002). *New Atlas of the British and Irish flora*. Oxford University Press, Oxford.
- RAATIKAINEN, N. & TANSKA, T. (1993). Cone and seed yields of the juniper (*Juniperus communis*) in southern and central Finland. *Acta botanica. Fennica* **149**: 27–39.
- ROQUES, A. (1983). *Les insectes ravageurs des cônes et graines de conifères en France* Institute National de la Recherche Agronomique (INRA), Paris.
- SCHNARF, K. (1933). *Handbuch der Pflanzenanatomie*, Bd. X2: Embryologie der Gymnospermen. Gebrüder Borntraeger, Berlin.
- SINGH, H., (1978). *Embryology of Gymnosperms*. Gebrüder Borntraeger, Berlin.
- STACE, C. (1977). *New Flora of the British Isles*. Second Edition. Cambridge University Press, Cambridge.
- STILES, E. W. (1980). Patterns of fruit presentation and seed dispersal in bird-disseminated woody plants in the eastern deciduous forest. *American Naturalist* **116**: 670–688.
- THOMAS, P. A., EL-BARGHATHI, M. & POLWART, A. (2007). Biological Flora of the British Isles: *Juniperus communis* L. *Journal of Ecology* **95**: 1404–1440.
- TUELLER, P. T. & CLARK, J. E. (1975). Autecology of pinyon-juniper species of the Great Basin and Colorado Plateau, in GIFFORD, G. F. & BUSBY, F. E. eds. *The pinyon-juniper ecosystem: a symposium* pp. 27–40. Utah Agricultural Experimental State Publication, Logan.
- TUTIN, T. G. *et al.*, eds. (1993). *Flora Europaea* 1: Cambridge University Press, Cambridge.
- VAN DER MERWE, M., WINFIELD, M. O., ARNOLD, G. M. & PARKER, J. S. (2000). Spatial and temporal aspects of the genetic structure of *Juniperus communis* populations. *Molecular Ecology* **9**: 379–386.
- VERHEYEN, K., SCHREURS, K., VANHOLEN, B. & HERMY, M. (2005). Intensive management fails to promote recruitment in the last large population of *Juniperus communis* L. in Flanders (Belgium). *Biological Conservation* **124**: 113–121.
- VERHEYEN, K. *et al.* (2009). *Juniperus communis*: victim of the combined action of climate change and nitrogen deposition? *Plant Biology*. Online publication date: 1-Jun-2009.
- WILLSON, M. F. & WHELAN, C. J. (1989). Ultraviolet reflectance of fruits of vertebrate-dispersed plants. *Oikos* **55**: 341–348.
- WARD, L. K. (1973). The conservation of Juniper I Status of juniper in southern England. *Journal of applied Ecology* **10**: 165–188.
- WARD, L. K. (1977). The conservation of juniper; the associated fauna with special reference to southern England. *Journal of applied Ecology* **14**: 81–120.
- WARD L. K. & KING, M. (2006). Decline of juniper in Sussex. *Quarterly Journal of Forestry* **100**: 263–272.
- WARD, L. K. (2007). Lifetime sexual dimorphism in *Juniperus communis* L. var. *communis*. *Plant Species Biology* **22**: 11–21.

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How well has BSBI chronicled the spread of neophytes?

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BACKGROUND

This paper is adapted from a Presidential Address delivered at a BSBI conference on *Understanding our Alien Flora* in London on 25 October 2008 that was illustrated using PowerPoint. It offers an overview and discussion partly supported by fieldwork. The graphical treatment of historical trends is deliberately simplistic, though reference is made to research papers with statistical content.

ABSTRACT

Following an overview of the main processes of dispersal, the limited chronicle available by considering two ‘snapshots in time’ in the spread of neophytes in Britain is considered in relation to the *New Atlas* and the *BSBI Local Change* project as reported in *Change in the British Flora 1987–2004*. In search of a ‘slow-motion movie’ of spread on a year-by-year basis, some dramatic recent changes observed by the author in Berwickshire are examined, especially colonisation by *Spergularia marina*. The chronicle of spread proves to be an inadequate to distinguish between the two main mathematical models, radial spread and exponential spread. A classical study of *Galinsoga* is re-examined. Generalisations are drawn on what can be expected from BSBI’s recording strategy. A detailed study of the colonisation of the Scottish Borders by a bird, *Sitta europaea* (Nuthatch), is used with the other studies as a basis for comment on the patterns of spread observed. *BSBI Local Change* is revisited in search of estimates of the time neophytes have taken to reach a mature distribution. The very modest extent to which the models can be used to predict the future is noted.

KEYWORDS: British Flora, Alien, Colonisation, Distribution, Mathematical Model.

INTRODUCTION

Our conference today is on alien plants, or incomers as I prefer to call them to avoid being judgemental. It’s the more recent arrivals or neophytes (species first recorded in Britain after 1500) that are the main focus of attention.

As one starts talking about them it is their spread that one soon comes to: how far and how fast? I find that this is a big subject to get one’s head round, and one that BSBI is not as good at as I’d thought. It’s not just maths: there’s botany too.

Questions one might like answers to include

- What are the main processes of dispersal?
- What distribution pattern can be expected as spread advances?
- Does the rate of spread change?
- How fast do species spread?
- Can distributions be estimated into the future?

I deal with these in turn.

THE PROCESSES OF DISPERSAL

The direct seed rain from a plant to the ground gives very limited dispersal and more effective dispersal depends on hitching lifts: from the wind, on water, on ants, animals (including us humans) or birds, on vehicles, packed in goods as seed impurities or as weeds in plant containers. In general one can only guess at which processes are most important for particular species as direct observation is difficult.

Some of these examples are rare events, but they nevertheless seem to be crucial in driving long-range dispersal. One may reflect further on the balance between short-distance and long-distance dispersal. Human dispersal is of various kinds. If a seed sticks to the outside of a vehicle, short-distance dispersal is likely to predominate. If a seed or seedling is carried in goods as a seed impurity or container-plant weed the dispersal area will depend on the product but may be Britain-wide.

From the point of view of the plant the optimum outcome for success is to be the crop itself, being a stowaway is a good second best. The suspected spread of *Anisantha diandra* in *Triticale* seed used as a game crop may be a current example of a successful stowaway (all Latin names follow Stace 1991).

THE DISTRIBUTION PATTERN AS SPREAD ADVANCES

BSBI specialises in snapshots in time of the distribution of a species, perhaps 40 years apart like the maps in the two *Atlas* surveys (Perring & Walters 1962; Preston *et al.* 2002). The snapshots are 'fuzzy' in time as the recording is done over a span of years.

Conyza canadensis is typical of species increasing between the dates of the two *Atlases*. Alas, this is not apparent in the *New Atlas* map which shows presence as an alien in 974 hectads in the 1987–1999 dateclass and only 95 hectads in earlier dateclasses as it is the most recent record that is mapped, so one must turn to the first *Atlas* as well to learn something of its spread. One finds it had been recorded in 571 hectads by 1962, so its range (the number of recording units in which it was found) has almost doubled in 40 years.

It is only because the inland records of *Spergularia marina* are treated as alien that one can infer the recent spread of this species from the coast along verges from the *New Atlas* map. It is shown as present in the 1987–1999 dateclass in 688 hectads as native and 366 as alien.

Studying the spread of plants is like studying how a horse gallops: one needs a slow-motion movie, not just snapshots, to understand the process. So the *Atlas* maps alone are insufficient for this purpose. *BSBI Local Change* (Braithwaite *et al.* 2006) was an improvement as each survey was a sharp snapshot in time, completed in just two years. But as yet, like the *Atlas*, it has only been repeated once so one doesn't have a data series over time. Nevertheless the eye is good at getting the feeling of a movie from just two snapshots and the *Local Change* maps do have a sense of movement.

Conyza canadensis doubled its range at tetrad scale in the 16 years between the two *Local Change* surveys (Fig. 1). The grey dots, observed in both surveys, are mainly clustered together but there are outliers also. The black dots, found in the second survey only, show infilling of the core range and spread. The spread is mainly outwards from the outliers (even allowing for some bias as the second survey was more intensive than the first). There are some new black outliers, but not many. So one has the impression of a species spreading by rare long-distance events of, say, 100 km



FIGURE 1. *Conyza canadensis*. ● 2003–2004 only, ○ 1987–1988 only, ● Both Surveys
Light grey background *New Atlas* survey 1987–1999.

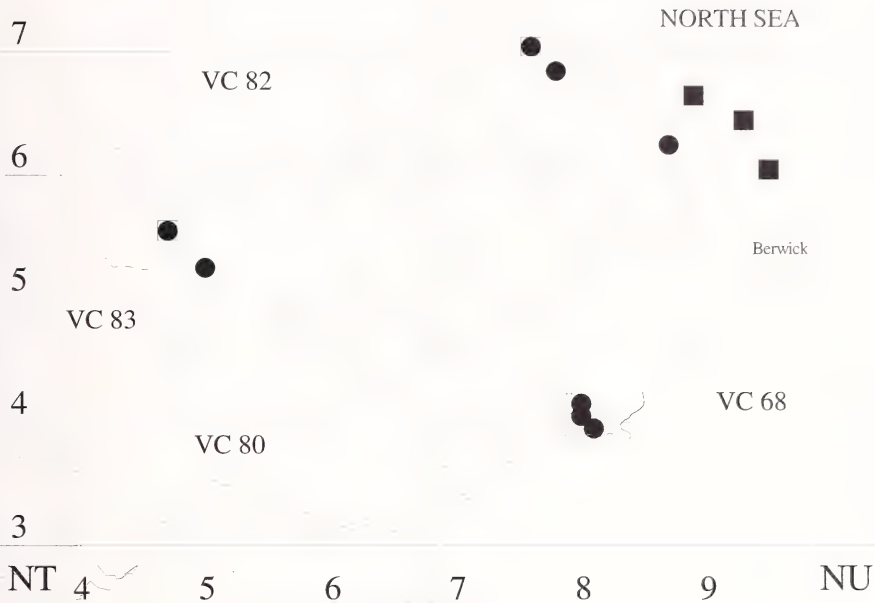


FIGURE 2. The distribution of *Spargularia marina* (Lesser Sea-spurrey) in v.c. 81. First recorded • 1992–1993 ■ 1994–1995 ○ 1996–1997 □ 1998–1999.

and much more frequent short-distance events, say up to 10 km.

But there is a degree of illusion because *Local Change* surveyed only a 1% sample of the countryside so the balance of long-distance events may be rather different to appearances.

I have searched the BSBI MapMate database for v.c. 81 Berwickshire and the wider BSBI literature for data that gives more of the feeling of a movie. Such data is hard to find. Here are some contrasting examples.

Spargularia marina has colonised Berwickshire in less than 10 years (Fig. 2). There is not much doubt that this annual species is spread by seeds hitching a lift on the outside of vehicles and as a contaminant of the road-salt itself. It is found at the road verge where large colonies can easily be seen from a car at 60 mph. If I had really wanted to, I could have surveyed all the main roads of Berwickshire each year as it spread. I wasn't as systematic as that as the record shows.

This species arrived in Berwickshire from the south, as that is where earlier records were made. All the 1992–1993 Berwickshire records are on main roads from the south. The extra records in 1994–1995 are on the A1, not by the shore. In 1996–1997 a special survey covered pretty much all the main roads, not every kilometre was searched but the plant was by no

means everywhere. By 1998–1999 the species became more or less ubiquitous on the main roads and began to spread to minor roads. The coverage in this period is far from complete.

This pattern of recording is, I believe, fairly typical of what BSBI recorders do. There is a flurry of interest after the first record in an area, often picking up spread that had occurred some time earlier, followed by a loss of interest. Thereafter the flow of records depends on the pattern of general recording activity in the v.c.

The mapped pattern of spread is striking: there has been a mixture of long-distance events and short-distance bulking up. One wonders what mathematical model best describes this pattern.

THE MATHEMATICS OF SPREAD

There are two basic mathematical models of spread:

- Radial spread, like the ripples on a pond after a stone is thrown in, models a species spreading outwards as a wave-front from a point of introduction
- Exponential spread models a species spreading at random within an area with new colonies not clustering together

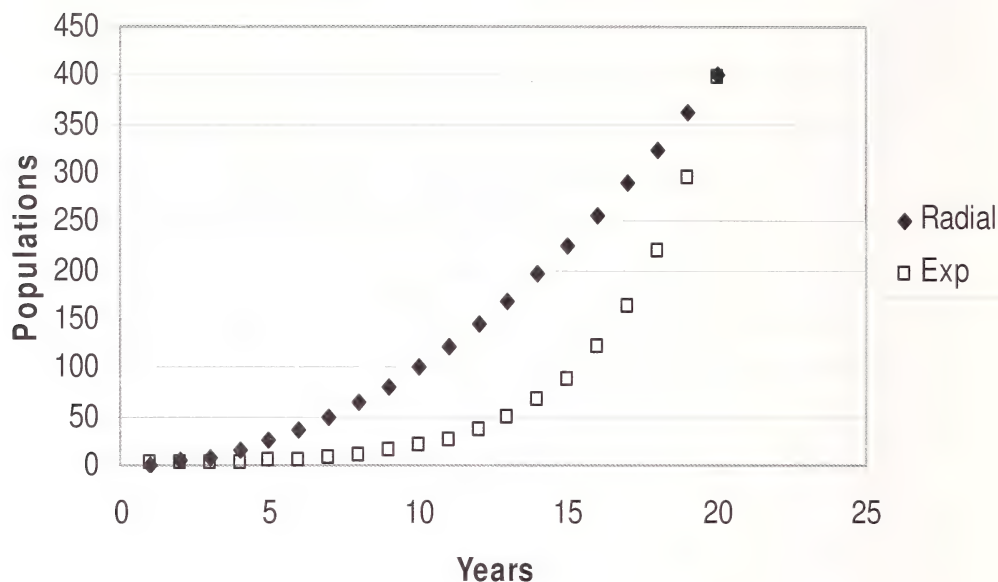


FIGURE 3. Radial and Exponential models compared.

There is some expectation that natural dispersal from a seed rain (even if assisted by wind or animals) will progress in a more or less radial manner. In contrast some sorts of human dispersal (whether intentional or unintentional) might be expected to be near-exponential, with distance no barrier (within Britain). A mixture of dispersal mechanisms might be expected to lead to a pattern of spread intermediate between these two extremes.

The chart (Fig. 3) compares growth from one population to 400 populations after 20 years for the two models. Radial growth reaches 100 populations after ten years while exponential growth is still down at about 20 populations. So there is quite a contrast in the pattern of growth predicted by the two models and one might expect to be able to distinguish them in survey data or to point to an intermediate.

Spread does not of course continue indefinitely. Sooner or later suitable uncolonised habitat begins to run out and spread slows. The mathematics to cover this is quite simple but need not detain us here as the outcome is much as one would guess. In practice it can be difficult to tell if spread is slowing because habitat is running out or because the pattern of recording has changed.

Returning to the spread of *Spergularia marina* in v.c. 81, the data is plotted in figure 4. One tests the fit of data to an exponential model by taking the log of the cumulative records and seeing if one gets a straight line, for a radial model one takes the square root. Note that in this chart the scale of the y-axis is different for the two sets of data. The division of the regression lines plotted into two is a speculation based on recorder behaviour: it is not supported statistically.

Disappointingly the data just isn't good enough to distinguish between the two models. The discontinuity after 1999 mainly reflects a change in recorder behaviour both because of loss of interest with the species and because the *New Atlas* survey was over. But there was a change in habitat too: the main roads were more or less fully colonised and the species adapted to colonise minor roads.

The apparent adaptation to colonise minor roads is highly intriguing. There is a possibility that it signals a real genetic change to enable the species to thrive in more eutrophic conditions. If true, this would imply a second wave of colonisation superimposed on the first. I have not observed this in *Spergularia* but have seen something of the sort in *Cochlearia danica*.

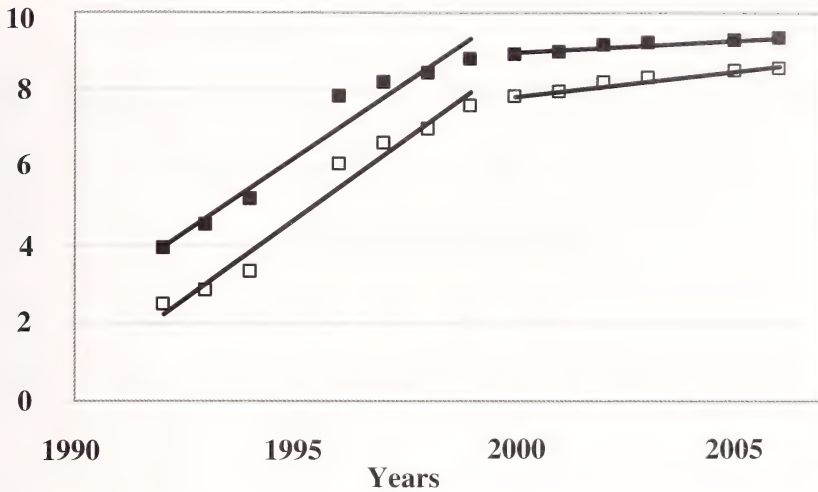


FIGURE 4. The spread of *Spergularia marina* in v.c. 81 (inland records only). ■ Fitting to an exponential model (y axis = $5 \times \log_{10}$ cumulative 1 km squares). □ Fitting to a radial model (y axis = square root cumulative 1 km squares).

Matricaria recutita is a species that has enjoyed a vogue of popularity with the highway authorities and has been sown in quantity along new roads and motorways (I have observed this by the A1 in Yorkshire and near Melrose and Hawick in the Scottish Borders). Not surprisingly it has turned up in arable land in areas where it was unknown, including v.c. 81. There it has sometimes prospered and its success may also owe something to warmer summers. Whether the

increase between the two *Local Change* surveys will be maintained is thus an open question.

The exponential graph appears to give a promising fit to the Berwickshire data (Fig. 5). But, as this is my own data, I know that my recording pattern changed in 1987 when a new cycle of recording commenced that ran to 1999. The radial plot seems to match that, so again the data is inadequate to separate the two models.

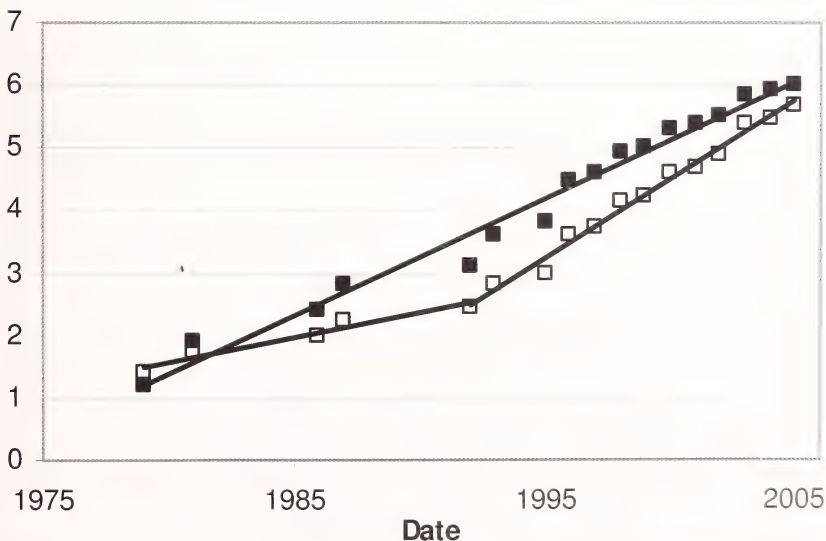


FIGURE 5. The spread of *Matricaria recutita* in v.c. 81. ■ Fitting to an exponential model (y axis = $4 \times \log_{10}$ cumulative 1 km squares). □ Fitting to a radial model (y axis = square root cumulative 1 km squares).

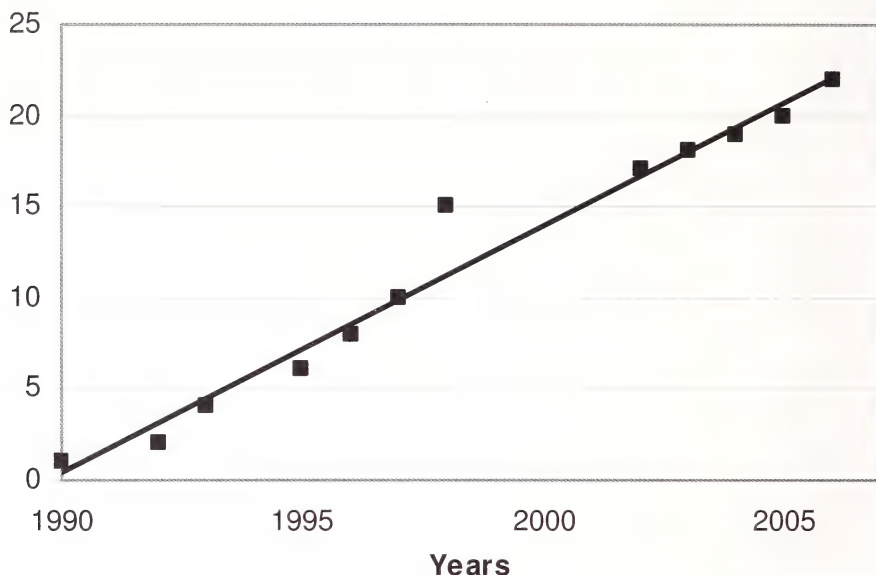


FIGURE 6. *Verbascum thapsus* in v.c. 81. ■ Fitting to an arithmetic model (y axis = cumulative 1 km squares).

Verbascum thapsus is quite scarce in v.c. 81 and suspected of being an incomer that is casual in at least some of its localities so I was interested to see if I had any evidence one way or the other.

The apparent fit to an arithmetic model (Fig. 6) points to a steady build up of records with no evidence of spread or decline. This could indicate either that the localities of this scarce plant were only gradually being discovered

over time or that the plant is a casual, new localities being picked up at random (with no field check as to whether old localities are still present). To investigate this I made a resurvey of a 50% sample of the sites in 2008. There was an almost equal divide between sites where the plant was still present and seemed more or less permanent and those where it was not still present and where the original occurrence seemed to have been casual.

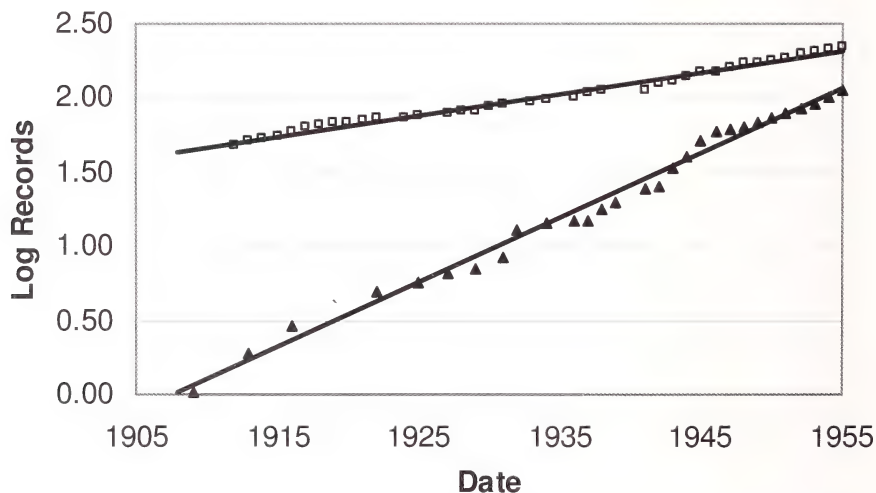


FIGURE 7. The spread of two alien *Galinsoga* species in Britain, 1909–1955 (after Lacey). Fitting to an exponential model □ *G. parviflora* ▲ *G. quadriradiata*.

LACEY'S STUDY OF *GALINSOGA*

Two *Galinsoga* species, *G. parviflora* and *G. quadriradiata*, naturalised in Britain have built up a considerable literature. W. S. Lacey (Lacey 1957) presented data on the spread of *Galinsoga* to a BSBI conference in 1957 (Fig. 7). It appears to show a good fit between the cumulative 'new locality' records for each of the two species and an exponential model.

Prof Mark Williamson, who has been studying the mathematics of spread for some years (Williamson *et al.* 1996, 2003, 2005), does not like this dataset at all. For one thing it goes against strong evidence for the radial spread for these species that he has found by studying a fine set of data from the Czech Republic where recording coverage has followed a steady plan continued over many years. For another thing he distrusts Lacey's 'Localities'. He thinks they are too imprecise to have much meaning. He seeks consistent repeat survey using hectads, tetrads or monads. BSBI does not have that sort of data, so I have been interested in seeing whether more can be read into Lacey's data despite its shortcomings.

I have now fitted the data to a radial model (Fig. 8). The result is interesting as it seems that a radial model is roughly supported if a discontinuity is accepted from 1939. This is highly probable as that is just when Lacey and his correspondents took up the study. They had noticed that *G. parviflora* had spread remarkably on bomb sites during the war. Interestingly

Salisbury suggested that the pappus on *Galinsoga* is rather inefficient and that it needed an explosion to lift the seeds high enough in the air to be wafted effectively by the wind. As is so often the case, real change on the ground led to increased recorder effort and the one confuses the other.

With regard to scale, I infer that Lacey's 'Localities' were not too far removed from tetrads, as that is my experience with historical records localised by place names. The trouble is that there is no suggestion that all tetrads in a given area were systematically surveyed year by year, quite the contrary.

But what Lacey and his correspondents did is just what BSBI recorders still do, so there is no point in blaming Lacey.

I have tried looking at the spread of *Galinsoga* at v.c. scale from first v.c. records. There is apparent support for a radial model, but the number of datapoints is low, and there is always the possibility that the failure of the log graph to hold straight may reflect the fact that uncolonised v.c.c. with suitable habitat may be running out.

Further studies of spread reported in BSBI journals include those of *Veronica filiformis* (Bangeter & Kent 1957) and *Epilobium ciliatum* (Preston 1988). They have similar limitations.

So what do we in BSBI need to do if we wish to chronicle the pattern of spread of neophytes more accurately? Maybe we need to examine our v.c. tetrad flora data to see if we have examples where a more or less constant

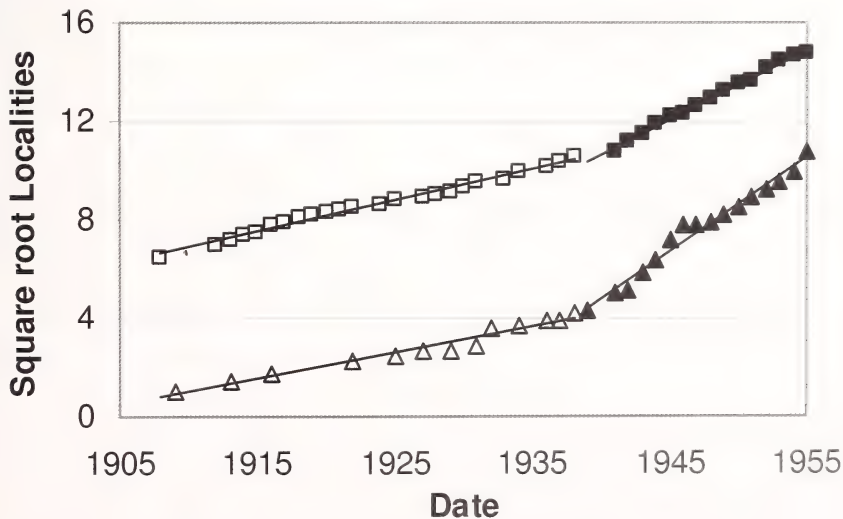


FIGURE 8. Fitting to a radial model. □ ■ *G. parviflora* △ ▲ *G. quadriradiata*.

number of tetrads were surveyed each year over a period and seek interesting trends for some of the increasing species. Success might encourage others to record more systematically in future. But we need to be very wary of the effects of changes in recorder effort as highlighted above and in a series of papers by T. C. G. Rich, starting with his report on the *BSBI Monitoring Scheme* 1987–1988 (Rich & Woodruff 1990). His 1996 paper in *Watsonia* begins with a useful overview (Rich & Smith 1996).

NUTHATCH IN THE SCOTTISH BORDERS

My search for better data has led me away from plants to a bird. *Sitta europaea* L. (Nuthatch) has colonised the Scottish Borders in less than 20 years. This is a very sedentary bird that prefers to spend its whole life in a single territory; even its brood won't disperse more than they have to. R. D. Murray and The Scottish Ornithologists' Club (Murray 2008) have chronicled its spread in amazing detail, though as it is found mainly in parks and gardens it is relatively easy to spot. Their data is so good that aggregate data for each three-year period between 1989 and 2006 gives six maps at tetrad scale with broadly complete coverage. These maps really do amount to a movie.

Nuthatch spread into the Scottish Borders from the south along the east coast as the Cheviot Hills block off almost all other points of entry for such a lowland bird. Nevertheless the new colonisation was soon surprisingly well-scattered across the region. As colonisation progressed there was a mix of scatter to new areas and filling-in around early records representing dense colonisation of favoured habitats. By 2006 nearly all suitable habitat had been colonised (189 tetrads in 43 hectads), so subsequent spread is bound to be more modest.

The parallel between the pattern of spread in nuthatch and in alien plants is striking. There is the same sort of mix between long-distance and short-distance dispersal. Plant seeds 'fly' a long way when they can hitch an especially good lift and fan out when they get more modest help in dispersal.

The Nuthatch data, unlike the plant data, did seem to be good enough to expect a fit to one of the two models. At hectad scale the radial model ($R^2 = 0.963$) fits much better than the exponential model ($R^2 = 0.890$) while at tetrad scale the two models give a similar fit ($R^2 =$

0.971 , $R^2 = 0.968$). This is difficult to interpret. One reason for the imperfect fit to the mathematical models may be the fact that the spread of Nuthatch is limited to river valleys which are not randomly distributed across the landscape. There is a suggestion in the tetrad data that the spread is initially exponential (random long-distance dispersal predominating) and then radial (short-distance dispersal predominating), but this has not been supported statistically.

The radial dispersal observed in plants and the nuthatch does not look very much like the ripple on a pond as there are outliers ahead of the main wave front, but mathematically it is still an expanding wave front, albeit one with what is known as a 'thick tail'. Williamson (Williamson *et al.* 2005) has demonstrated that some species do spread exponentially for a while if they get particularly good at hitching lifts, but they are the minority. But it may be unproductive to dwell too much on the mathematical issues: more interesting perhaps is the suggestion of a complex mix of long-distance and short-distance dispersal events. The complexity is reassuring: it would not be easy to believe that plant dispersal followed one or two simple patterns when so many processes are at play.

I suggest that the species most likely to spread exponentially for a limited period (and thus potentially very rapidly) are those that are cultivated, like *Veronica filiformis* in the past, or those that stowaway with cultivated plants either as weed seedlings in container-plants, like *Galinsoga* or *Cardamine corymbosa*, or as a seed impurity, like *Anisantha diandra* in *Triticale*.

BSBI LOCAL CHANGE

I have had a look at what *BSBI Local Change* can contribute to the subject of the spread of neophytes. It is not very much as there are only two surveys. However a third data point can be added as the date of first introduction.

At individual species level no statistically valid trends can be expected. However by looking for common patterns for a group of species points of interest emerge.

I have taken just the group of the best naturalised neophyte species, not affected by continuing introduction, separated as 'Group 1' in the *Local Change* report (Fig. 9). What one finds is that the spread of most of these species is slowing down or has stopped. Their

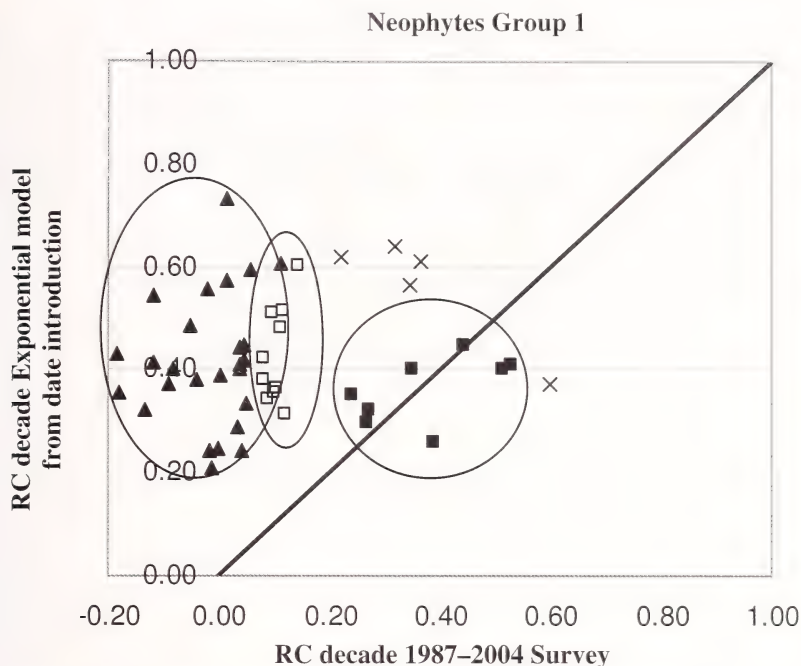


FIGURE 9. Fitting to an exponential model – Group 1. ▲ Mature ◻ Radial ■ Exponential × Other.

distribution is mature. This emphasises a limitation of the *Local Change* sample as it is only able to work with relatively widespread species. There is just not enough data in a survey of 1% of the countryside to learn anything about the spread of the very many scarce neophytes, and it is of course the scarce ones that one most wishes to study to see how fast they are spreading.

For those species in this group that are still spreading rapidly there is a suggestion in the data that some spread is exponential and that some spread is radial. However I cannot pick out any key characters that separate the two groups of species. So I will pass over this aspect and consider only the species with a mature distribution.

HOW FAST DO SPECIES SPREAD?

The 25 species in *BSBI Local Change* Group 1 Neophytes with a mature distribution have taken an average of 170 years to colonise Britain, or, to put it another way, a successful species might take between 100 and 200 years to spread across our country.

Their range at the end of that period will vary widely depending on the habitat colonised,

climate and other factors. The range of the 25 species in this sample is currently between 4% and 80% of British tetrads.

The average rate of radial spread is about 0.7 km/yr, but this is based on the assumption that all the tetrads occupied lie in a solid circle on the map. Real distributions are always more scattered than this so a better estimate might be double this or 1.4 km/yr.

For exponential spread the average time to double the range is about 16 years.

These figures are of the same order of magnitude as Williamson's estimates from his Czech hectad-scale data of 1 km/yr and 10 years to double (Williamson *et al.* 2005). Some discrepancy between tetrad data and hectad data would be expected.

PREDICTIONS OF FUTURE DISTRIBUTIONS

I finish with some wild speculation on what the future might have in store for three fast-spreading neophytes.

If *Claytonia sibirica* spreads at a radial rate of 1 km/yr it might reach 80% of the distribution of *Geum urbanum* by 2050, even though it is more restricted to woodland than that species.

If *Allium paradoxum* doubles its range every 16 years it might reach 80% of the distribution of *A. ursinum* by 2100, though it remains to be seen whether *A. paradoxum* will prosper in the west as it has in the east.

If *Lemna minuta* doubles its range every six years it might reach 80% of the range of *L. minor* by 2009, and every pond within a tetrad only a year or two later (though this provocative estimate relies on the validity of an estimate that *L. minuta* was so little known that it was recorded in 2003/2004 in only one third of the *BSBI Local Change* tetrads in which it was actually present).

CONCLUSIONS

Taken together, the Berwickshire studies of *Spergularia marina*, *Matricaria recutita* and *Verbascum thapsus* with Lacey's study of *Galinsoga* offer a sobering insight into the limitations of the usefulness of BSBI datasets in the study of spread in plants. BSBI has learned much about the current distribution of neophytes but less about the mode and pattern of spread. The Society relies on a body of volunteer recorders who perforce operate in ways that suit their circumstances. This leads to relatively short-term local flora projects at differing spatial scales that are not synchronised across Britain and Ireland. That is the reality and it leaves limited scope for the introduction of standardised recording practices. Neither of the two landmark *Atlas* projects relied exclusively on re-survey in a narrow date-class and at best can only provide two data points on a dispersal curve. Any attempt to look behind the summary data published to the underlying year-by-year records would be likely to come up against insurmountable inconsistencies.

Similarly the sample recording in Berwickshire has not been stratified sufficiently on a year-by-year basis across the vice-county to yield consistent results. Instead a hectad by hectad approach was adopted, and that only for the period 1987–1999 after which different survey priorities prevailed. If the study was extended to data from other vice-counties, further inconsistencies would be found.

However, it might be possible to sample data from those vice-counties that have undertaken long-term tetrad mapping projects so that a stratified sample of tetrads recorded in each of a series of years was examined. Whether the series of years available would as yet be long enough to yield valuable results remains to be demonstrated, but I hope this paper may stimulate such studies.

The *BSBI Local Change* project, like the two *Atlases*, only provides two data points, so it will be many years before further repeat surveys can be hoped to provide an adequate chronicle of the patterns of spread.

As suggested above, dates of first vice-county records are perhaps worthy of further study, but the spatial scale of a vice-county is too great for the finer detail of the patterns of spread to emerge. Then it is only a minority of neophyte species that have been recorded consistently over a long span of years. Many even of the widely naturalised neophytes were absent from Bentham and Hooker and were first treated in Clapham, Tutin and Warburg's *Flora of the British Isles* (1952). Many of the species of horticultural importance were widely ignored until Stace's flora (Stace 1991) was published and the coverage of such species remained notably patchy in the *New Atlas*.

While BSBI datasets do have limitations these should be set in perspective against the remarkable success of the two *Atlases*. Their maps of *Veronica filiformis*, for example, do provide striking visual evidence of spread in a way that no graph can hope to. Moreover, when looking at a map, one can with experience compensate by eye for many of the recording deficiencies.

ACKNOWLEDGMENTS

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REFERENCES

- BANGETER, E. B. & KENT, D. H. (1957). *Veronica filiformis* Sm. in the British Isles. *Proceedings of the Botanical Society of the British Isles*, **2**: 197–217. (1962). Further notes on *Veronica filiformis*. *Ibid.* **4**: 384–397. (1965). Additional notes on *Veronica filiformis*. *Ibid.* **6**: 113–118.

- BRAITHWAITE, M. E., ELLIS, R. W. & PRESTON, C. D. (2006). *Change in the British Flora 1987–2004*, Botanical Society of the British Isles, London.
- CLAPHAM, A. R., TUTIN, T. G. & WARBURG, E. F. (1952). *Flora of the British Isles*, Cambridge University Press, Cambridge.
- DEHNEN-SCHMUTZ, K. & WILLIAMSON, M. (2006). *Rhododendron ponticum* in Britain and Ireland: Social, Economic and Ecological factors in its successful invasion, *Environment and History* **12**: 325–350.
- HENGEVELD, R. (1989). *Dynamics of Biological Invasions*, Clapham & Hall, London.
- LACEY, W. S. (1957). The Spread of *Galinsoga parviflora* and *G. ciliata* in Britain, *Progress in the Study of the British Flora*, ed. LOUSLEY, J. E., 109–115, Botanical Society of the British Isles, London.
- MURRAY, R. D. (2008). The spread of Nuthatch in *Borders Bird Report No. 24, 2006*, Scottish Ornithologist's Club, Borders Branch, Galashiels.
- PERRING, F. H. & WALTERS, S. M., eds. (1962). *Atlas of the British Flora*. Thomas Nelson & Sons, London.
- PERRINS, J., FITTER, A. & WILLIAMSON, M. (1993). Population biology and rates of invasion of three introduced *Impatiens* species in the British Isles, *Journal of Biogeography*, **20**: 33–44.
- PRESTON, C. D. (1988). The spread of *Epilobium ciliatum* Raf. in the British Isles, *Watsonia* **17**: 279–288.
- PRESTON, C. D., PEARMAN, D. A. & DINES, T. D. (2002). *New Atlas of the British and Irish flora*, Oxford University Press, Oxford.
- PRESTON, C. D. *et al.* (2003). *The changing distribution of the flora of the United Kingdom: technical report*, Centre for Ecology and Hydrology, Huntingdon.
- RICH, T. C. G. & WOODRUFF, E. R. (1990). *The BSBI Monitoring Scheme, 1987–1988*. 2 vols. Nature Conservancy Council Report no. 1265, Botanical Society of the British Isles, London.
- RICH, T. C. G. & SMITH, P. A. (1996). Botanical recording, distribution maps and species frequency, *Watsonia* **21**: 155–167.
- SALISBURY, E. J. (1953). A Changing Flora as shown by the Study of Weeds of Arable Land and Waste places, in *The Changing Flora of Britain*, ed. LOUSLEY, J. E., 130–139, Botanical Society of the British Isles, London.
- STACE, C. A. (1991). *New Flora of the British Isles*, Cambridge University Press, Cambridge.
- STACE, C. A., ELLIS, R. G., KENT, D. H. & MCCOSH, D. J. (2003). *Vice-county Census Catalogue of the Vascular Plants of Great Britain, the Isle of Man and the Channel Islands*, Botanical Society of the British Isles, London.
- STEWART, A., PEARMAN, D. A. & PRESTON, C. D. (1994). *Scarce plants in Britain*, J.N.C.C., Peterborough.
- WILLIAMSON, M. (1996). *Biological Invasions*, Clapham & Hall, London.
- WILLIAMSON, M., PRESTON, C. D. & TELFER, M. G. (2003). *On the rates of spread of alien plants in Britain in Plant Invasions*, CHILD, L. *et al.*, eds., Backhuys Publishers, Leiden, The Netherlands.
- WILLIAMSON, M., PYSEK, P., JAROSIK, V. & PRACH, K. (2005). On the rates and patterns of spread of alien plants in the Czech Republic, Britain and Ireland, *Ecoscience*, **12**: 424–433.

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Ecology, distribution and fertility of *Carex recta* Boott (Cyperaceae) in the British Isles

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ABSTRACT

The rare sedge *Carex recta* is found on three estuaries in northeast Scotland. Field surveys and recording of associated species indicate that it thrives in different NVC communities, ranging from mires, through tall-herb fen, rush pasture and mesotrophic grassland to salt-marsh. Seed fertility is low and varies between populations, with the highest fertility detected in the population along the River Wick where introgression occurs. The distribution is updated with one new population and the re-discovery of another.

KEYWORDS: *Carex recta*, Cyperaceae, ecology, NVC, fertility, Scotland.

INTRODUCTION

Carex recta Boott (Estuarine Sedge) is a perennial sedge with creeping rhizomatous growth. It has flowering stems up to 100 cm high and leaves up to 130 cm long and 4.0–7.5 mm wide. The upper 2–6 spikes (typically 3–4) of the inflorescence are male. The lower 2–6 spikes (typically 2–3) are female. Female spikes are from 20–80 mm long with peduncles up to 35 mm long on the lowest spike. The female glumes have an acute, acuminate or awned apex, with the lower glumes of the lower female spikes almost always awned. Awns are short, usually 1–3 mm long. *C. recta* has two stigmas, a biconvex utricle and a nut with a strong invagination. It is a boreal-montane, suboceanic hemicryptophyte (Hill *et al.* 2004) and is designated as vulnerable (JNCC 2009).

This sedge has been little studied in the British Isles since the work by John Faulkner (1972, 1973) who investigated cytology alongside intra- and inter-specific experimental crosses on *C. recta* and other species in section *Phacocystis*. Disturbed meiosis and low intraspecific fertility suggested that *C. recta* in Scotland was of hybrid origin (Faulkner 1972, 1973). Higher seed set from cross-breeding to

both *C. aquatilis* Wahlenb. and *C. paleacea* Wahlenb. compared to the other section members implied that they were the probable parental species (Faulkner 1973), although only one of these parents, *C. aquatilis*, is recorded in the British Isles (Jermy *et al.* 2007). The same origin has been confirmed by karyology and isozymes in North America (Cayouette & Morisset 1986a, b; Standley 1990). The fertility of natural North American populations was assessed as good (Cayouette & Morisset 1985). The fertility of natural British populations has not previously been examined.

C. recta is recorded from only three estuaries in north-east Scotland (Wigginton 1999; Preston *et al.* 2002; Cheffings *et al.* 2005). The distribution of the sedge along each of these estuaries is different. The distribution given in an earlier study included only the briefest details of each site (Dean & Ashton 2006). More detailed accounts from fieldwork by MD are given here. In addition, recent work has discovered one new population and confirmed the presence of another population, thus updating the current distribution. A brief account of the ecology and associated species (Jermy *et al.* 2007) indicates that the sedge may be found in the S27 tall-herb fen community. However, this is an oversimplification and variation of the communities in which the species is found requires more detailed consideration. From surveys of the vegetation communities associated with the larger sedge stands a more comprehensive account is provided here.

The aims of this paper are therefore; to record associated species and determine the National Vegetation Classification (NVC.) plant communities associated with four large populations of *C. recta*, to record life history, to examine the fertility of *C. recta* and its backcross to *C. aquatilis* (*C. × grantii*) from percentage of seed set, and to update the distribution.

TABLE 1. SPECIMENS USED IN THE STUDY OF THE FERTILITY OF *CAREX RECTA* AND *C. × GRANTII* IN THE BRITISH ISLES

Taxon	No. of culms	Collection date	Location	Grid ref.	v.c.
<i>C. recta</i>	20	August 2002	Wick	ND354514	109
<i>C. recta</i>	20	September 2001	Beauly*	NH539465	96
<i>C. recta</i>	20	September 2001	Invershin*	NH578953	106
<i>C. recta</i>	20	September 2001	Bonar Bridge*	NH6091	106
<i>C. × grantii</i>	20	August 2002	Wick	ND358516	109

*specimens collected by C. B. Ballinger

METHODS

SURVEYS FOR RECORDING SPECIES ASSOCIATED WITH *C. RECTA* AND NVC PLANT COMMUNITIES

Four sites where *C. recta* is the dominant species were used in the vegetation study and were chosen because there is a large sedge stand present. *C. recta* is also found as a minor component of some communities but these were not surveyed. On the rivers Wick and Beauly the main stands are restricted to a relatively short length of river. Two sites, Invershin and Bonar Bridge, were chosen from the extensive range found on the Kyle of Sutherland/River Oykel. Bonar Bridge was split into west and east of the road bridge as the environmental conditions differ between the two close sites: the west side is relatively sheltered with river defence barriers and creeks, the east side is exposed. The species associated with *C. recta* were identified and recorded. MATCH (version 2.11) software from the Unit of Vegetation Science, University of Lancaster, was used to generate short lists of possible NVC communities from the species lists by site. These possible communities were examined against NVC descriptions to determine the most appropriate classification (Rodwell 1991a, 1991b, 1992, 1995, 2000). Distribution and life history details were also recorded during surveys.

FERTILITY

Culms from *C. recta* and *C. × grantii* were collected in August and September when nuts and utricles would have matured if they were fertile (Table 1). The utricles were removed then observed at 10× magnification under a microscope to determine whether they contained a mature nut. Many utricles were flattened and distorted in shape, and it was obvious that they did not contain a fertile nut. Only swollen utricles were tested for containing a potentially

fertile nut, by squeezing the utricle between watchmaker's forceps. Filled, and therefore potentially fertile, nuts within the utricles did not yield to pressure, but non-viable nuts squashed under pressure. Preliminary work in the department (unpublished), comparing this method with staining of embryonic tissue with tetrazolium dye, had established that this was a valid approach. Utricles were counted into two groups, potentially fertile and infertile utricles per culm. Samples were compared by Analysis of Variance (ANOVA) followed by the Tukey test (used when ANOVA has detected that at least one of the sample means is significantly different, to work out where the differences lie).

RESULTS

LIFE HISTORY

The rhizomes and roots of *C. recta* form a dense, entangled mat just below the substrate surface. In *Carex* generally the initial stages of a new vegetative or flowering shoot are protected by the outer, short, tough leaves (see Figure 2 in Jermy *et al.* (2007)). These short leaves are covered by cuticular wax, giving a pale glaucous colouration, and the tip of the tightly closed shoots forms a sharp point. New shoots are initiated in late summer and become dormant around November (Smith 1966). During winter the overwintering new shoot is often showing above the substrate by 2–3 cm, whereas the sedge leaves from the previous summer and vegetation of the associated species die back leaving an area covered with the remains of the dead vegetation.

In early May, the appearance of the tidal flats and marshes inhabited by *C. recta* indicates that the sedges have been completely covered by high tides or high river levels during the autumn or winter. *C. recta* and spring-flowering species such as *Caltha palustris* are the first

species to show signs of new growth. The flowering shoots of *Carex recta* start to grow earlier than the vegetative shoots. By early to mid May, at the tips of the culms, the male spikes of some specimens of *C. recta* are visible, but the anthers have not yet dehisced. The male glumes have the purple-brown – black-brown colour seen in mature specimens. On a few specimens the uppermost female spike is just emerging from the middle of the culm leaves which sheath the lower part of the culm. The female spikes are very immature, the utricles pale green and the female glumes pale-green/whitish and almost translucent, with the central nerve pale green. In the first half of May, the tallest vegetative leaves are up to 50–55 cm high at Wick and Beaully, up to 35 cm at Invershin, and up to 30 cm at Bonar Bridge East. In some stands the glaucous cuticular wax has not been abraded from the leaf surface, giving a pale blue-grey coloured tip to the normal matt mid-green/yellow-green colouration. During the spring, the sedges are the tallest species in their habitats, and show a pattern of growth assumed to maximise wind pollination. During the spring, some of the stands appear to consist almost entirely of *C. recta*. However, no *C. recta* seedlings were seen at any of the sites during the course of the fieldwork.

By the middle of July, the *C. recta* leaves have developed and are higher than the culms. At Wick, Beaully and Invershin other tall species have grown and are flowering, for example *Deschampsia caespitosa*, *Phalaris arundinacea* and *Filipendula ulmaria* (Table 2.). The sedges appear as an intrinsic part of the community, and in some places they are no longer dominant. As the female spikes develop, the colour of the female glumes changes to the purple-brown – black-brown typical of section *Phacocystis* in the British Isles. The utricles remain green until they mature to a pale brown – hay-colour in August or September. In some years the *C. recta* at Beaully is sparse-flowering with very few flowering spikes to be found. The sedge flowers more freely at Wick, Invershin and Bonar Bridge.

FIELD SURVEYS

The results of field surveys between 1999 and 2004 were summarised in an earlier paper (Dean & Ashton 2006). Detailed site descriptions



FIGURE 1. Distribution of *Carex recta* in Scotland in 10km squares

are given here, updated by surveys since 2004. On all three estuaries *C. recta* was found below the high water mark and at altitudes below 10 m (see Fig. 1).

RIVER WICK (V.C.109)

The north bank of the River Wick, immediately west of Wick, is broad and flat, with a few shallow channels, and is generally marshy. Several freshwater ditches drain the surrounding farmland. *C. recta* is found in the marshy areas and across the full width of the estuarine flats, encroaching into the ends of the fields if they are marshy. In some stands *C. recta* forms a dense mass of vegetation, and is almost the only species present (ND354514). In other areas there are *C. recta* and apparent *C. recta* backcrosses to *C. aquatilis* scattered among tall riverbank vegetation and from July onwards the sedges may be difficult to find amongst the taller marsh vegetation. *C. aquatilis* is also present, and whereas *C. recta* is typically found in the flat, marshy areas of the river bank, where there is a gentle slope into the river, *C. aquatilis* is found at the very edge of the river and may form a linear stand less than 1 m wide on the top of the bank where there is a drop to the river. The main area of river estuary on which *C. recta* was found is approximately 500 m long on the north bank. Sedge stands were found up to approximately 1 km further upriver, but these are mainly *C. aquatilis* or *C. × grantii*.

TABLE 2. SPECIES ASSOCIATED WITH *CAREX RECTA* IN THE BRITISH ISLES

Species	Wick	Beaulieu	Invershin	Bonar Bridge ¹		No. of locations	Estuarine species ²
				East	West		
<i>Achillia ptarmica</i>			+			1	
<i>Agrostis stolonifera</i>	+	+	+	+	+	5	
<i>Alnus glutinosa</i>			+			1	
<i>Alopecurus geniculatus</i>		+		+	+	3	
<i>Armeria maritima</i>				+		1	×
<i>Anemone nemorosa</i>			+			1	
<i>Angelica sylvestris</i>	+					1	
<i>Anthoxanthum odoratum</i>					+	1	
<i>Aster tripolium</i>		+	+			2	×
<i>Aster × salignus</i>		+				1	
<i>Arriplex glabriuscula</i>	+					1	×
<i>Bolboschoenus maritimus</i>				+		1	×
<i>Callitriche stagnalis</i>				+	+	2	
<i>Caltha palustris</i>	+	+	+		+	4	
<i>Calystegia sepium</i>			+			1	
<i>Cardamine pratensis</i>		+	+	+		3	
<i>Carex aquatilis</i>	+					1	
<i>Carex nigra</i>			+			1	
<i>Carex rostrata</i>			+			1	
<i>Centaurea nigra</i>	+					1	
<i>Cerastium fontanum</i>				+	+	2	
<i>Chamerion angustifolium</i>			+			1	
<i>Cochlearia anglica</i>				+		1	×
<i>Cochlearia officinalis</i>	+	+		+	+	4	×
<i>Crepis capillaris</i>				+		1	
<i>Crepis paludosa</i>			+			1	
<i>Cynosurus cristatus</i>					+	1	
<i>Deschampsia cespitosa</i>		+	+			2	
<i>Deschampsia flexuosa</i>		+		+		2	
<i>Eleocharis palustris</i>			+			1	
<i>Eleocharis uniglumis</i>				+	+	2	
<i>Elytrigia repens</i>	+					1	×
<i>Epilobium palustre</i>		+	+			2	
<i>Equisetum fluviatile</i>	+	+	+			3	
<i>Equisetum palustre</i>	+	+	+			3	
<i>Filipendula ulmaria</i>	+	+	+			3	
<i>Festuca arundinacea</i>				+		1	
<i>Festuca rubra</i>		+		+	+	3	×
<i>Galium aparine</i>	+	+	+			3	
<i>Galium palustre</i>		+	+		+	3	
<i>Glaux maritima</i>				+		1	×
<i>Heracleum sphondylium</i>		+				1	
<i>Holcus lanatus</i>	+	+	+	+	+	5	
<i>Holcus mollis</i>	+		+			2	
<i>Hydrocotyle vulgaris</i>		+				1	
<i>Iris pseudacorus</i>	+					1	
<i>Juncus articulatus</i>	+	+			+	3	
<i>Juncus bufonius</i>					+	1	×

TABLE 2. CONTINUED

Species	Wick	Beaulieu	Invershin	Bonar Bridge ¹		No. of locations	Estuarine species ²
				East	West		
<i>Juncus effusus</i>		+	+	+	+	4	
<i>Juncus gerardii</i>				+	+	2	×
<i>Littorella uniflora</i>			+			1	×
<i>Lolium perenne</i>					+	1	
<i>Lotus pedunculatus</i>		+				1	
<i>Lythrum salicaria</i>		+				1	
<i>Mentha aquatica</i>	+		+			2	
<i>Menyanthes trifoliata</i>			+			1	
<i>Montia fontana</i>				+		1	
<i>Myosotis scorpioides</i>	+	+	+			3	
<i>Oenanthe crocata</i>		+				1	
<i>Pedicularis palustris</i>			+			1	
<i>Phalaris arundinacea</i>	+	+	+			3	
<i>Phragmites australis</i>	+	+				2	×
<i>Plantago lanceolata</i>			+			1	
<i>Plantago maritima</i>	+			+		2	×
<i>Poa humilis</i>					+	1	
<i>Potentilla palustris</i>			+			1	
<i>Ranunculus ficaria</i>	+	+	+			3	
<i>Ranunculus flammula</i>		+	+	+	+	4	
<i>Ranunculus repens</i>			+			1	
<i>Rumex acetosa</i>		+				1	
<i>Rumex acetosella</i>		+	+			2	
<i>Rumex crispus</i>	+			+		2	×
<i>Rumex obtusifolius</i>	+	+				2	
<i>Sagina procumbens</i>				+		1	
<i>Salix</i> sp.			+			1	
<i>Schoenoplectus lacustris</i>	+					1	
<i>Scutellaria galericulata</i>			+			1	
<i>Senecio jacobaea</i>		+				1	
<i>Stachys palustris</i>	+					1	
<i>Stellaria graminea</i>		+	+			2	
<i>Succisa pratensis</i>		+				1	
<i>Taraxacum officinale</i> agg.				+		1	
<i>Trifolium repens</i>				+	+	2	
<i>Triglochin palustre</i>					+	1	×
<i>Triglochin maritimum</i>	+			+	+	3	×
<i>Typha latifolia</i>	+	+	+			3	
<i>Valeriana officinalis</i>	+	+	+			3	
<i>Viola palustris</i>			+			1	
Column total	29	37	41	26	22		17
				Bonar Bridge			
Location total	29	37	41	35			

Total number of species = 88

The two species found at all five locations are shown in **bold**

¹Bonar Bridge separated into East and West of roadbridge due to differences in habitat

²habitat description in Stace (1997) includes estuaries, salt-marshes or brackish habitat

RIVER BEAULY (V.C.96)

From the town of Beaulay eastwards along the north bank of River Beaulay there is a high river defence bank, and the flat area of the bank next to the river is narrow, only a few metres wide. Approximately 1 km east of Beaulay the river bends sharply northwards, the flat area widens, and a mudbank has formed in the river and is now a small, narrow, vegetated island. At this point there is one large stand on the flat area of the north bank (NH539465). Between *C. recta* and the muddy river edge there is a very narrow strip of *Juncus effusus*, then on the mud *Callitriche* sp. In the lagoon immediately north-east of the large *C. recta* stand there are several small patches of *C. recta* amongst the dominant *Phragmites australis*. On the north bank the *C. recta* was found within a length of 200–300 m. A population recorded on the south bank at Lentrán Point had not been detected until a very small population was re-found amongst the *P. australis* in 2007 at NH584459 by C. B. Ballinger. These populations are within the Moray Firth SSSI.

KYLE OF SUTHERLAND/RIVER OYKEL (V.CS. 106.107)

The total length of river estuary on which *C. recta* is found is approximately 17 km with large populations at two separated sites. In places the sides of the river are steep and unsuitable for *C. recta*. Part of the area is within the Kyle of Sutherland Marshes SSSI. Furthest upriver is the population near Ochto (NC486001) discovered in 2006 by C. B. and B. R. Ballinger. Furthest downriver are the populations on the north bank at Bonar Bridge (NH610914) and on the south bank at Kincardine (NH607894). Large populations can be found on both sides of the river near Invershin and on the south bank at Bonar Bridge. On the southwest bank below Carbisdale Castle there are stands of *C. recta* in a marshy area (NH578953) and around a small promontory (NH573958). On the opposite bank, near Invershin, the river widens as this bank curves away into a wide bay with a gently sloping bank. There is a narrow strip of *C. recta* all along the bank and in marshy areas. Some of the sedges on the north bank have the appearance of *C. recta* hybrids with *C. nigra* (*C. × spiculosa* Fries) and *C. nigra* is present. On the south-west bank at Bonar Bridge west of the bridge there are several small *C. recta* stands on the sides of the creeks (NH607917). In contrast to the east of the bridge there is a very large *C. recta* stand, approximately 95 m long by 75 m wide, situated where the south bank turns sharply south-west and the estuary widens (NH608913).

ASSOCIATED SPECIES AND NVC PLANT COMMUNITIES OF *CAREX RECTA* POPULATIONS

The associated species list shows that 88 associated species were recorded, 50 of them from one location only, and only two species, *Agrostis stolonifera* and *Holcus lanatus* recorded from all five locations (Table 2). Although *Carex recta* is found within the tidal range of estuaries and therefore is tolerant of at least low levels of salinity, only 17 of the associated species are noted as maritime or brackish habitat species in the British Flora (Stace 1997). Of these, ten were recorded from Bonar Bridge East. One additional associated species, a near threatened species in Britain, *Pilularia globulifera* (JNCC 2009), was found near Kilmachalmack (NH5099).

The associated species list for each location generated several possible NVC communities for each site. Following this process NVC communities for the five sites were analysed using familiarity with the dominant species within each community gained from the surveys and the community details given by Rodwell (1991a, 1991b, 1992, 1995, 2000). Wick was the most complex to resolve and the most appropriate NVC was M27a *Filipendula ulmaria*-*Angelica sylvestris* mire, though it might have elements of M22 *Juncus subnodulosus*-*Cirsium palustre* fen-meadow, OV26c *Epilobium hirsutum* community *Filipendula ulmaria*-*Angelica sylvestris* sub-community and S25 *Phragmites australis*-*Eupatorium cannabinum* tall-herb fen (Table 3.). The NVC for Beaulay was straightforward and was identified as a mire community M23b *Juncus effusus*-*Galium palustre* rush pasture. The highest number of associated species was found at Invershin (Table 2), for which two communities were ranked similarly by the MATCH software, S27a *Carex rostrata*-*Potentilla palustris* tall-herb fen and W3 *Salix pentandra*-*Carex rostrata* woodland. The S27a community was selected for two reasons: many of the herbs recorded from this community are components of the S27a tall-herb fen, and the *C. recta* population lies in the zone between *C. rostrata* in the edge of the river and the woodland behind and the S27 community is considered typical of this transition zone (Rodwell 1995).

The two populations at Bonar Bridge are at more exposed sites, and have NVC communities that are different from each other and from the other three sites. At Bonar Bridge West, upriver of the roadbridge, small stands of *C. recta* are dominant, mainly at the edges of creeks but

TABLE 3. NATIONAL VEGETATION CLASSIFICATION (NVC) COMMUNITIES ASSOCIATED WITH *CAREX RECTA* IN THE BRITISH ISLES

Location	NVC	NVC community	NVC sub-community
Wick	M27a	<i>Filipendula ulmaria</i> - <i>Angelica sylvestris</i>	<i>Valeriana officinalis</i> - <i>Rumex acetosa</i>
Beaully	M23b	<i>Juncus effusus</i> - <i>Galium palustre</i>	<i>Juncus effusus</i>
Invershin	S27a	<i>Carex rostrata</i> - <i>Potentilla palustris</i>	<i>Carex rostrata</i> - <i>Equisetum fluviatile</i>
Bonar Bridge West	MG8	<i>Cynosurus cristatus</i> - <i>Caltha palustris</i>	-
Bonar Bridge East	SM16c	<i>Festuca rubra</i>	<i>Festuca rubra</i> - <i>Glaux maritima</i>

TABLE 4. SEED SET FOR *CAREX RECTA* POPULATIONS IN THE BRITISH ISLES

Location (no. of specimens)	Wick (20)	Beaully (20)	Invershin (20)	Bonar Bridge (20)
Fertility details per specimen				
Number of mature utricles (mean±sd)	16.1 ± 11.5 a	2.0 ¹ b	0.0 ¹ b	4.9 ± 3.9 b
range	0-37	0-13	0-7	0-14
Total number of utricles (mean±sd)	555.8 ± 89.0 a	422.6 ± 98.6 b	552.6 ± 138.1 a	330.7 ± 110.0 c
range	411-716	245-580	329-753	169-634
Percentage fertile (mean±sd)	2.8 ± 1.8 a	0.4 ¹ b	0.0 ¹ b	1.5 ± 1.1 c
range	0.0-6.3	0.0-2.7	0.0-1.3	0.0-3.7
Total female spikes length/mm (mean±sd)	156.7 ± 26.9 a	128.4 ± 27.8 b	170.4 ± 33.4 a	101.0 ± 20.2 c
range	103-199	86-169	107-226	73-148
Mean density of utricles per mm of female spike	3.5	3.3	3.2	3.3

¹median shown if sd > mean

Variables followed by the same letter are not significantly different at $P = 0.05$

also encroaching on grazed meadows. The sedges are the tallest species due to the preferential grazing of the surrounding turf which is kept short (Table 2). The meadow community is an MG8 *Cynosurus cristatus* - *Caltha palustris* mesotrophic grassland (Table 3). At Bonar Bridge East the sedges dominate the habitat and other species are infrequent. However, as *C. recta* has not been used in the determination of any NVC community, the community was determined by the other species present and was determined as SM16c *Festuca rubra* salt-marsh. *

FERTILITY OF *CAREX RECTA* IN THE BRITISH ISLES

The number of filled utricles detected (the number of seed set) for *C. recta* ranged from 0 to a maximum of 37 per specimen at Wick (Table 4). Because the total number of utricles was high, the percentage seed set was very low at all locations, ranging from 0-6.3%. Wick had a significantly higher average number of

mature utricles and fertility rate (percentage fertile) than the other three sites. Both Beaully and Invershin had a significantly lower fertility rate than the other two sites. Although there were significant differences in total number of utricles and the total length of female spikes, these two variables varied proportionately. This is reflected in the mean density of utricles per mm of female spike, an indicator of how tightly the utricles are packed on the female spikes, which varied little, ranging from 3.2 (Invershin) to 3.5 (Wick) (Table 4). There were significant differences between the two sites on the same river system, Invershin and Bonar Bridge, for total number of utricles, percentage fertile and total female spikes length. The sample from Wick of *C. × grantii* had higher means than the sample of *C. recta* from Wick for all variables. Only the total number of utricles per specimen was significantly higher (Table 5) indicating that the utricles are more densely packed on the *C. × grantii* female spikes.

TABLE 5. SEED SET AT WICK: *CAREX RECTA* COMPARED TO *C. × GRANTII* (BACKCROSSES TO *C. AQUATILIS*)

Taxon	<i>Carex recta</i>	<i>C. × grantii</i>
Location (specimens)	Wick (20)	Wick (20)
Fertility details per specimen		
Number of mature utricles (mean $\pm$ sd)	16.1 $\pm$ 11.5 a	25.3 $\pm$ 17.8 a
range	0–37	3–65
Total number of utricles (mean $\pm$ sd)	555.8 $\pm$ 89.0 a	663.6 $\pm$ 108.1 b
range	411–716	452–834
Percentage fertile (mean $\pm$ sd)	2.8 $\pm$ 1.8 a	3.6 $\pm$ 2.3 a
range	0.0–6.3	0.6–9.4
Total female spikes length /mm (mean $\pm$ sd)	156.7 $\pm$ 26.9 a	158.8 $\pm$ 21.9 a
range	103–199	105–189
Mean density of utricles per mm of female spike	3.5	4.2

Variables followed by the same letter are not significantly different at $P = 0.05$

DISCUSSION

NVC DIFFERENCES BETWEEN SITES

Although *C. recta* is typically found in estuarine marshes and mud flats where there is a gentle slope from marsh to river, a different NVC community was determined for each of the five sites and included diverse habitat types including mires, tall-herb fen and saltmarsh. These differences may be attributed to recent history of the site, current use and local topography. Three locations, Wick, Beaulieu and Invershin are mire or fen type habitats, with tall herbs dominant (Rodwell 1991b, 1995). The River Wick has wide estuarine flats, dissected by run off ditches from grazed pasture, and is probably a complex of more than one habitat and community. Invershin has narrower flats and is situated below woodland. The River Beaulieu NVC is M23b *Juncus effusus* – *Galium palustre* rush pasture, and perhaps reflects recent history as it is below grazing land, and may have been the edge of such pasture before the high river defence was built. Bonar Bridge West is currently grazed and some grasses were found only on this site, for example *Anthoxanthum odoratum*, *Cynosurus cristatus*, and *Lolium perenne*. The MG8 community is characteristic of periodic inundation, which occurs here, and is considered the natural community of a traditional water meadow (Rodwell 1992). However, despite the other species being grazed, *Carex recta* is limited to the creek edges and spreads only sparsely into the edges of the meadow, indicating that it is outcompeted in that habitat, and is only a very minor constituent of the

MG8 grassland. At Bonar Bridge East, where other species are scarce, *C. recta* is particularly dominant and the community was assessed as a *Festuca rubra* saltmarsh, which is the most likely community for the surrounding saltmarsh.

REPRODUCTIVE DIFFERENCES BETWEEN SITES

The intraspecific differences in fertility showed that seed set in *C. recta* was low, and, excluding Wick where backcrossing may have occurred, the highest mean seed set was 1.5% at Bonar Bridge. This supports findings of similar low seed set from experimental intra-specific crosses, in which mean seed set was 1.9% (Faulkner 1973). The highest percentage of filled utricles came from Wick, the only British location where the parental species *C. aquatilis* is present. Generally, amongst plant hybrids, because most F_1 s are only partially fertile at best, most of the effective fertilizations in which a hybrid takes part will involve one of its parents as the other partner (Grant 1971). Therefore it is suggested that some of the pollinations were by *C. aquatilis*, and this has increased the fertility rate. A sample of *C. × grantii* from Wick had slightly higher fertility than *C. recta* from Wick, indicating that backcrossing to *C. aquatilis* increased fertility, but not significantly. No attempt has been made to germinate seed, but North American *C. recta* seeds are viable (Standley 1990). Bonar Bridge had the second highest fertility, and this may be further evidence that the habitat at Bonar Bridge East, despite being more severe, is beneficial to *C. recta* due to lack of competition.

HABITAT RESTRICTIONS WITHIN RIVER SYSTEMS

C. recta populations appear to be restricted to three estuaries and there appear to be limited opportunities for it to extend its range within these estuaries. On two estuaries, Rivers Wick and Beaully, there is little or no opportunity for *C. recta* to migrate to more ecologically favourable habitats. Although the River Wick has a large marshy habitat on the north bank, which currently supports a large population, downriver the river is canalised through the town centre, then opens into two harbours. The estuary sides and coastline east of Wick are rocky and unsuitable for *C. recta*.

River Beaully has the smallest population, one very small population on the south bank, one large stand on the north bank, and a few scattered sedges in one lagoon. Beaully has several similar lagoons, but the others are dominated by tall vegetation, mainly *Phragmites australis* and *Typha latifolia* and no *C. recta* was found there during surveys. Parts of the south bank opposite these populations are marshy and inaccessible, but are likely to be suitable habitats for *C. recta* and the sedge may be extant there. The north bank population has been recorded as reduced in size since the 1980s (Wigginton 1999; Preston *et al.* 2002). This population may be the one most at risk from localised changes. The habitat at Beaully is situated below a high river defence bank with the large sedge stand located on the flat riverbank, covering the width of the bank, opposite a small estuary island. The sedges are bordered by tall vegetation at both ends on the flat. The population appears unable to expand, and is more likely to contract. A narrow channel runs between the bank and the island. Estuary coastlines and estuary islands are relatively temporary, affected by, for example, water circulation, tidal circulation, sedimentation processes and human impact (Day *et al.* 1989). In the longer term, although there is a long estuary downriver of, Beaully, ordnance survey maps indicate mainly shingle or sand on the narrow estuarine flats, backed by manmade features, such as roads. There do not appear to be suitable habitats for migration.

By comparison the Kyle of Sutherland has several medium to large populations. It is not known if these populations are contemporaneous in origin, or if downriver (or possibly upriver) populations are of a later origin resulting from detached clumps or floated seed. There are several, small, satellite populations downriver from Bonar Bridge, and this suggests that

C. recta has successfully migrated downriver on the Kyle of Sutherland. However, no genetic work has been carried out to date to identify if there are genetic similarities between populations. The banks of the Kyle further downriver show a similar lack of potentially habitable sites as it also has roads close to the shoreline.

Although the surveys have been extensive, there are areas where access is difficult that have not been surveyed. Some fieldwork was undertaken at Loch Fleet, a large site with a long shoreline, from where the sedge has been recorded (Anthony 1976). In many parts the habitat does not appear correct for *C. recta* and surveys of other parts did not show any trace of the sedge. Between the river systems of the Kyle of Sutherland and River Beaully populations, there is the Cromarty Firth which was surveyed briefly along the north bank downriver from Dingwall, but there was no trace of the species.

NATURAL PROPAGATION OF *CAREX RECTA*

Although *C. recta* produces a small amount of potentially fertile seed, from observations, it reproduces entirely vegetatively. However, sexual reproduction and seedling recruitment cannot be ruled out and this is most likely along the Kyle of Sutherland, where populations are found on exposed estuary flats with adjoining areas of bare mud. Absence of seedlings does not necessarily mean the population is genetically uniform, because lack of seedling recruitment has been reported for *Carex* populations that have been genetically diverse, indicating that sexual reproduction has occurred in the past (McClintock & Waterway 1994; Jonsson *et al.* 1996; French *et al.* 2005). However, new genes allowing adaptations may arrive from related species by introgression, for example the introgression from *C. aquatilis* into the River Wick population leading to increased fertility. Such local introgression may also support the suggestion of genetic variation between populations and supports the possibility of sexual reproduction. Further support for genetic variation between populations comes from the intraspecific macro- and micro-morphological variation detected (Dean, 2006). Although there is little scope for further spread in its current locations, variation between populations resulting from introgression or hybridisation with close relatives may be occurring, leading to local adaptation following natural selection.

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REFERENCES

- ANTHONY, J. (1976). *Flora of Sutherland*. Aberdeen University Press, Aberdeen.
- CAYOUE, J. & MORISSET, P. (1985). Chromosome studies on natural hybrids between maritime species of *Carex* (sections *Phacocystis* and *Cryptocarpae*) in northeastern North America, and their taxonomic implications. *Canadian Journal of Botany* **63**: 1957–1982.
- CAYOUE, J. & MORISSET, P. (1986a). Chromosome Studies on the *Carex salina* Complex (Cyperaceae, Section *Cryptocarpae*) in Northeastern North America. *Cytologia* **51**: 817–856.
- CAYOUE, J. & MORISSET, P. (1986b). Chromosome Studies on *Carex paleacea* Wahl., *C. nigra* (L.) Reichenbach, and *C. aquatilis* Wahl. in Northeastern North America. *Cytologia* **51**: 857–883.
- CHEFFINGS, C. M., *et al.* (2005). *The Vascular Plant Red Data List for Great Britain. Species Status* **7**: 1–116. Joint Nature Conservancy Committee, Peterborough.
- DAY, J. W. J., HALL, C. A. S., KEMP, W. M. & YÁÑEZ-ARANCIBIA, A. (1989). *Estuarine Ecology*. John Wiley & Sons, New York.
- DEAN, M. (2006). *Morphological studies in genus Carex section Phacocystis in the British Isles*. Unpubl. Ph D thesis. University of Lancaster.
- DEAN, M., & ASHTON, P. A. (2006). A reassessment of the distribution of *Carex recta* Boott (Cyperaceae) in the British Isles. *Watsonia* **26**: 31–39.
- FAULKNER, J. S. (1972). Chromosome studies on *Carex* section *Acutae* in north-west Europe. *Botanical Journal of the Linnean Society* **65**: 271–301.
- FAULKNER, J. S. (1973). Experimental hybridization of north-west European species in *Carex* section *Acutae* (Cyperaceae). *Botanical Journal of the Linnean Society* **67**: 233–253.
- FRENCH, G. C., HOLLINGSWORTH, P. M., CORNER, R. W. M., ROBERTS, F. J. & TAYLOR, I. (2005). Clonal diversity in two recently discovered English populations of *Carex vaginata* Tausch (Cyperaceae). *Watsonia* **25**: 389–395.
- GRANT, V. (1971). *Plant Speciation*. Columbia University Press, New York.
- HILL, M. O., PRESTON, C. D. & ROY, D. B. (2004). *PLANTATT Attributes of British and Irish Plants: Status, Size, Life History, Geography and Habitats*. Centre for Ecology & Hydrology, Huntingdon.
- JERMY, A. C., SIMPSON, D. A., FOLEY, M. J. Y. & PORTER, M. S. (2007). *Sedges of the British Isles*. B.S.B.I., London.
- JNCC (2009). *Conservation designations for UK taxa*. Downloadable spreadsheet. J.N.C.C. website <http://www.jncc.gov.uk>. Accessed 6.1.2010.
- JONSSON, B. O., JÖNSDÓTTIR, I. S. & CRONBERG, N. (1996). Clonal diversity and allozyme variation in populations of the arctic sedge *Carex bigelowii* (Cyperaceae). *Journal of Ecology* **84**: 449–459.
- MCCLEINTOCK, K. A., & WATERWAY, M. J. (1994). Genetic differentiation between *Carex lasiocarpa* and *C. pellita* (Cyperaceae) in North America. *American Journal of Botany* **81**: 224–231.
- PRESTON, C. D., PEARMAN, D. A. & DINES, T. D. eds. (2002). *New Atlas of the British and Irish Flora*. Oxford University Press., Oxford.
- RODWELL, J. S. (1991a). *British Plant Communities Volume 1, Woodlands and scrub*. Cambridge University Press, Cambridge.
- RODWELL, J. S. (1991b). *British Plant Communities Volume 2, Mires and Heaths*. Cambridge University Press, Cambridge.
- RODWELL, J. S. (1992). *British Plant Communities Volume 3, Grasslands and Montane Communities*. Cambridge University Press, Cambridge.
- RODWELL, J. S. (1995). *British Plant Communities Volume 4, Aquatic Communities, Swamps and Tall-herb Fens*. Cambridge University Press, Cambridge.
- RODWELL, J. S. (2000). *British Plant Communities Volume 5, Maritime Communities and Vegetation of Open Habitats*. Cambridge University Press, Cambridge.
- SMITH, D. L. (1966). Development of the inflorescence in *Carex*. *Annals of Botany* **30**: 475–486.
- STACE, C. A. (1997). *New flora of the British Isles*, (2 ed.) Cambridge University Press, Cambridge.
- STANDLEY, L. A. (1990). Allozyme evidence for the hybrid origin of the maritime species *Carex salina* and *Carex recta* (Cyperaceae) in eastern North America. *Systematic Botany* **15**: 182–191.
- WIGGINTON, M. J. in WIGGINTON, M. J., ed. (1999). *British Red Data Books: 1 Vascular Plants, 3 ed.* Joint Nature Conservancy Committee, Peterborough.

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A novel approach to the determination and identification of *Juncus* × *diffusus* Hoppe and *J.* × *kern-reichgeltii* Jansen & Wacht. ex Reichg.

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ABSTRACT

The identity of *J. inflexus* L., *J. effusus* L. and *J. conglomeratus* L. have had a rather chequered past. The differences are now relatively well documented and there is less confusion, though there are still misidentifications, particularly in the latter two species. The hybrids *Juncus effusus* × *J. inflexus* (*J.* × *diffusus* Hoppe) and *J. effusus* × *J. conglomeratus* (*J.* × *kern-reichgeltii* Jansen & Wacht. ex Reichg.) present further difficulties in their identification. The former hybrid has been accepted for some time, but the latter has always been a difficult plant to identify with any certainty. Also, *J.* × *kern-reichgeltii* is said to be a fertile hybrid and therefore backcrossing (introgression) is likely with no certain recognition or distinctions that include the potentially introgressed individuals. This article aims to present information that may be useful in the determination of these 5 taxa using morphological and anatomical characteristics. In *J.* × *kern-reichgeltii* using both morphological and anatomical characters, there is evidence for hybrids and introgression; ultimately, these characters provide a more critical determination of not only the parent taxa, but also of their hybrids.

KEYWORDS: Sclerenchyma, epidermal ridge cells, introgression.

INTRODUCTION

Within this group of rushes, subgenus *Genuini*, *J. inflexus* appears to be the most distinct with stiff glaucous stems that have interrupted pith and lax, suberect branches, (Stace 1997). Two other species, *J. effusus* and *J. conglomeratus* have at times been difficult to separate with a suggestion that characters overlap (Stace 1970b, 1972). This is mainly due to these two species having forms in which the inflorescence can be effuse or compact in either species; *J. effusus* var. *subglomeratus* DC a compact form and *J. conglomeratus* var. *subuliflorus* (Drejer) Asch. & Graebn. having several stalked heads (Stace 1997). There are two sheets of in NMW which are labelled *J. conglomeratus* var. *laxus* A & G; Four

specimens on one sheet, No. 2442 – N. Woodhead and two on another sheet No. 4972 – 2428 – G. Claridge Druce. These specimens have been reviewed in MANCH, with the G. C. Druce specimens being attributable to *J. effusus* and the N. Woodhead specimens are *J. conglomeratus* (only one of which may vaguely be called, 'var. *subuliflorus*') The name 'var. *laxus*' appears to be misapplied. However, very lax forms of *J. conglomeratus* have been found, in which the pedicels are long, up to 8 cm with flower clusters at the distal ends; these are particularly found in woodland situations. This form needs further investigation. Some of these inflorescence types also occur in the hybrid *J.* × *kern-reichgeltii*, though more commonly it has a compact form of inflorescence as in *J. conglomeratus*.

The hybrid *J.* × *kern-reichgeltii* was considered on balance not to exist (Stace 1972) and Tweed & Woodhead (1949) reported they could not find evidence for hybrids in their studies. Ascherson & Graebner (1904) had reported *J.* × *kern-reichgeltii* (and *J. inflexus* × *J. conglomeratus*, for which there is no evidence at present) from various locations in Britain and Europe. Kriša (1962) considered that *J. effusus* and *J. conglomeratus* were just end points of the same species. However, Agnew (1968) looked at populations and graphed various characters, such as spathe length against ridge number, which appeared to suggest fertile hybrids existing in populations and that 'introgression' was occurring with *J. effusus*; given that fertility was high, this could have equally shown two end points of one species or two variable taxa. While Agnew's (1968) work did suggest a range of intermediates sometimes based on subjective qualities such as inflorescence colour, though there was no real way of differentiating any distinct evidence for hybridity, it could have been that one parent was very variable. Also to see and count the ridges in *J. effusus* the stems would have to be dry as it is more or less smooth stemmed in life.

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Fertility in *Juncus* can be interrupted even in the parental taxa as well as in hybrids often for different reasons. *Juncus* hybrids are often considered sterile or with very low fertility, (Stace 1970a, b, 1972). However, fertility is known in hybrid rushes ranging from partial fertility in some plants such as *Juncus articulatus* L. $\times$ *J. acutiflorus* Ehrh. ex Hoffm. (*J. $\times$ surrejanus* Druce ex. Stace & Lambinon), (Blackstock & Roberts 1986) to almost no fertility, e.g. *J. balticus* Willd. $\times$ *inflexus*, and *J. balticus* $\times$ *effusus* (*J. $\times$ obotritorum* Rothm.), (both these latter hybrids having approx <1% fertility and seeds produced in these two taxa do germinate into full sized phenotypes, which are $\pm$ sterile also – unpublished data M. Wilcox.) Due to this confusing situation, Stace (1975) comments, that misidentifications are still not that uncommon, though identifications are more defined today at least for the species (Stace 1997). In relation to the hybrids, *J. inflexus* $\times$ *J. effusus* is relatively widespread being the most frequently recorded hybrid of the two (Stace 1997, Preston *et al.* 2002) and is the only well known hybrid of these two with a few likely to be errors for odd or sterile *J. inflexus* (Stace 1975, 1997). The hybrid *J. $\times$ kern-reichgeltii* on the other hand has always been an uncertain hybrid (Stace 1972) and today it is said to be difficult to identify, though Stace (1997) now supports the idea that it occurs sporadically with the parents and also states that due to its high fertility it is difficult to determine other than in the field with its parents and that many records are likely to be erroneous. More recently, O'Mahony (2002) provided a more up-to-date key based on field observations of external morphological characteristics. This key is likely to be of some use in detecting potential hybrids, but errors are still likely and given there is little conclusive evidence for hybridity due to its fertility, this key again may be describing large scale variation in one of the parent taxa, namely *J. conglomeratus* due to the presence of ridged stems.

Initially, this project started in the winter of 2006 with the hybrid *J. $\times$ diffusus*, which was investigated to see if there were any characteristics that would help to confirm its identity from any odd forms of the parent taxa, especially from sterile *J. inflexus*. Stace (1970b), states that the use of micro-anatomical/morphological features in Juncaceae is clearly of immense taxonomic value not only at the level of subgenus but also at the specific

rank and for interspecific hybrids. The hybrid *J. $\times$ diffusus* is depicted in transverse section on the cover of Stace (1975) and is an excellent example of an intermediate between the two parents. Thus, while studying the parents of *J. $\times$ diffusus* and this hybrid, two main anatomical-morphological characteristics were noted and these were studied and compared between the parents and the hybrid. These characteristics relate to the form, arrangement and type of subepidermal sclerenchymatous girders, (SeSgs) and the shape (and other characteristics) of the epidermal ridge cells (Ercs) above these longitudinal strands; the latter appearing to be useful and novel in the identification of all these taxa. Therefore, the study was extended to *J. $\times$ kern-reichgeltii* as the characteristics noted may have had a similar type of inheritance thus possibly separating it from the parents and even putative introgressed individuals. The previous difficulties encountered in this latter hybrid may account for there being no mention of it and therefore a lack of any map in the new *Atlas of the British & Irish Flora* (Preston *et al.* 2002) with most records unsubstantiated and based on field comparisons. This study sheds light on the identification of the parent taxa and both hybrids but in particular *J. $\times$ kern-reichgeltii*. It shows a relationship between the patterns of the subepidermal sclerenchymatous girders and the epidermal ridge cell patterns and that these in turn will highlight the hybrids. In *J. $\times$ kern-reichgeltii*, it will show that this hybrid appears to be fertile and that back-crossing can be frequent in suitable places creating a hybrid range, though it appears there is a more distinct form of the hybrid, (variable in fertility) which is recognisable from the introgressed individuals.

METHODS

The methods employed in this study are relatively simple so that they can be repeated by the amateur botanist with access to a compound microscope with approximately $\times 20$ – 100 magnification; this can be less once familiar with the parts. The photographs illustrated here may have used magnifications higher than this but this was for illustrative purposes.

Material from different populations of approx 60–100 stems was used and other individual specimens from personal collections.

Many stems of the parents were also checked. A length of stem approximately 3 cm was cut from about 1–2 cm below the inflorescence. This material, and if dried, was rehydrated in warm distilled water until soft. These lengths were then sectioned for transverse and longitudinal sections (TS/s LS/s) each being numbered and labelled and kept separate in glass tubes. A normal shaving razor was used and sections were cut as thin as possible and stored initially in the distilled water then later in 70% Ethanol. For *J. x diffusus* ten plants each were viewed from 7 populations with 100 stems each of *J. effusus* and *J. inflexus*.

For population studies, (mainly in *J. x kern-reichgeltii*) several populations of c. 60 plants, most from Wales was received from Arthur Chater (AOC) BSBI recorder for v.c. 46. These populations for *J. x kern-reichgeltii* were considered by AOC as having potential hybrids and introgressants, an apparent 'hybrid swarm'. These plants (mostly) had already been measured for spathe length against the number of vascular bundles and graphed accordingly by AOC. This method is based on and modified from Agnew's (1968) work which mainly used ridge number against spathe (bract) length, and is said to suggest introgression within populations of the mixed species *J. effusus* and *J. conglomeratus*. This method was partly changed in this study and the spathe length was graphed against the number of subepidermal sclerenchyma girders (SeSgs), partly because they are generally easier to count and are not too different in number to vascular bundles and generally would form the basis of a ridge especially when dry. However, the main reason for the change is that in this study it is believed that the subepidermal sclerenchyma girders are linked to hybridity having a relationship with the shape of the epidermal ridge cells above them. For all taxa the longitudinal length of stem after sectioning was retained to view the epidermal ridge cell characteristics and the TSs for the form, arrangement and number of SeSgs.

RESULTS

In this novel approach, aspects of the species are highlighted here as they are important to the identification of the hybrids. These characteristics are the form, arrangement and number of subepidermal sclerenchyma girders (SeSgs) and the epidermal ridge cell patterns.

These lines of epidermal ridge cells, (Ercs) were found to be different from other epidermal cells and have no stomata. The shape of the Ercs above the SeSgs was found to be different for each species.

JUNCUS INFLEXUS:

This species generally stands out as being a pale somewhat grey-green glaucous rush. The stem is clearly ridged and rather stiff and has distinctly interrupted pith (Fig. 1d). The inflorescence is suberect with flowers well spaced out towards the ends of the long branches. The ridges in TS show up well and generally appear to be 'flat-topped' and few in number, c. 10–18 (commonly 15) and the subepidermal sclerenchyma girders are broadly triangular and large, (Fig. 1a–b). The SeSgs generally do not quite reach the main vascular bundles but a few rare smaller more band-like SeSgs can reach the sclerenchyma caps of the vascular bundles and fuse with them. Note that in the main larger ridges there are approximately 8–12 similar sized epidermal cells running over the base of the SeSgs, which are discernable from the rest of the epidermal cells; they are relatively uniform in shape and size, diminishing laterally (Fig. 1b). In a longitudinal plane the Ercs above the main SeSgs are thick walled 'mesh-like' cells, (Fig. 1c). In life, with a hand lens the ridges appear a very dull yellowish colour.

JUNCUS EFFUSUS:

It is generally not that difficult to recognise *J. effusus* which has a rather smooth, unridged outline, often glossy, waxy stems (Fig. 2d) and it often has a effuse relatively rounded (loose pom-pom-like) inflorescence, though in *J. effusus* var. *subglomeratus* the inflorescence is round-compact, which can cause confusion. With a hand lens, its numerous 'pinstripe' narrow, pale-whitish lines of the sclerenchyma can be seen (Fig. 2d); these show up when dry as very low ridges almost touching. In transverse section (TS) the arrangement of the sclerenchyma strands, (ridge formers), can be seen more clearly (Fig. 2a–b). These strands, which are very numerous, (36–62) show up in TS as more or less oblong-triangular shapes. In this species many are fairly narrow, flat-based and more band-like and they can frequently reach the top of the vascular bundles (VBs) and often fuse with the sclerenchyma caps of the VBs, giving them a superficial look of 'exclamation marks' as shown in Fig. 2a–b. In

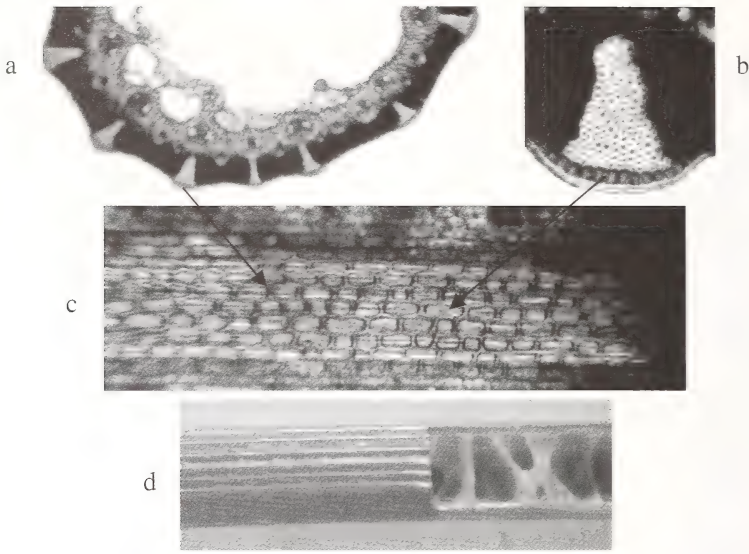


FIGURE 1. *J. inflexus*; a) TS, b) Ercs and 1 SeSg, c) 'mesh-like' cells longitudinally on ridges, d) ridged stem showing interrupted pith.

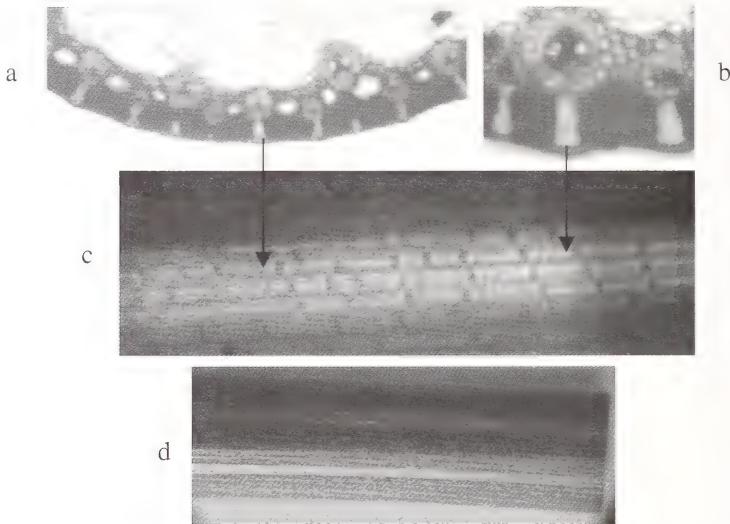


FIGURE 2. *J. effusus*; a) TS, b) Ercs and 1 SeSg, c) 'oblong cells' longitudinally on ridges, d) smooth, waxy stem showing narrow 'pin-stripe' pattern.

J. effusus, it was noted that from over 500 stems viewed the epidermal ridge cells above the SeSgs are thin walled cells and rectangular in shape and more or less flat having no discernable profile from the rest of the circumference, (see Fig. 2a and 2c). This pattern is relatively uniform for all the Ercs occurring above all the SeSgs and for this study they are termed 'oblong cells' here. The epidermal ridge cells over the base of the

SeSgs in TS are small rounded and usually only about 2–4 across (Fig. 2c) being small and only slightly larger than the rest of the epidermal cells. The number, form and arrangement of the 'exclamation mark' SeSgs and the 'oblong cells' that occur above all these SeSgs are the most important combined characteristics of all in relation to both hybrids. Bearing this in mind the other two species are quite different in all these characters.

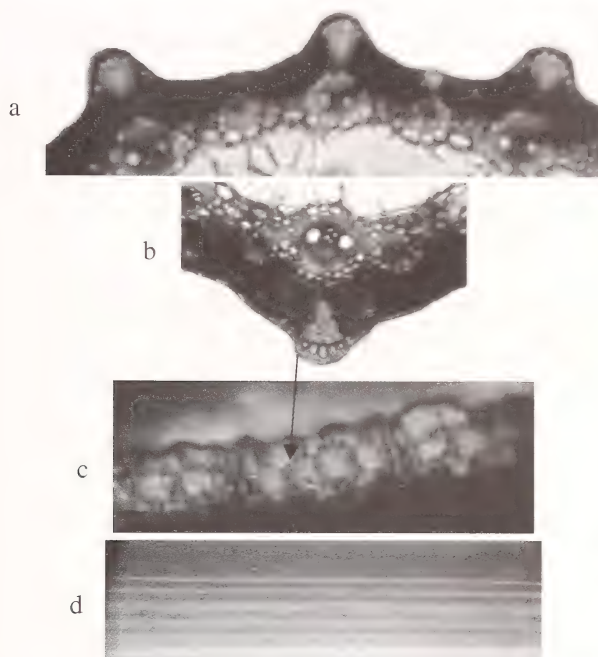


FIGURE 3. *J. conglomeratus*, a) TS, b) Ercs in TS show large cells, c) Ercs longitudinally showing uneven rugulose-wrinkled cells, d) distinctly ridged stem section – pith is not thick and slightly airy.

JUNCUS CONGLOMERATUS:

This species is difficult to define as there is evidence to suggest hybridisation and introgression, which may obscure the limits of the species. However, in what is assumed to be the species, the ridges in TS are highly elevated, peaked to rounded and very distinct for this species (Fig. 3a and 3b) and commonly with about 14–20(–25) distinct ridges. In considering specimens of *J. conglomeratus*, it was noted that in specimens thought to be closest to the species, the form and arrangement of the SeSgs became more distinct. It is suggested here that the SeSgs for this species are relatively round-based, often blunt-tipped triangles that are mainly isolated from the vascular bundles in all the distinctly elevated ridges, with (usually) no SeSgs in between (Fig. 3a–b), where only one to a few of these occur in between it may suggest a past hybridization history. The Ercs in this species are very distinct from the other two species in that they are of a 'rugulose-wrinkled' appearance (Fig. 3c). These cells are twisted and have rough projections on them. They appear translucent and often shiny in life and become brownish with age. In TS the cells are large in the middle of the ridge apex

diminishing in size laterally often with a rounded-triangle appearance (like 'cheese triangles' Fig. 3b) much larger than those of the rest of the epidermis and typically 4–8 in number. Late season plants, (i.e. October–December) show that the roughness is worn down (probably decay and abrasion etc) and these cells can appear less 'wrinkled' and appear square to rectangular in shape but clearly in general they are quite distinct from either of the other two species. Some of the variation in shape may be related to introgression, see the hybrid *J. × kern-reichgeltii* below. Thus, for each species there are three distinct TSs showing distinct form, arrangement and number of SeSgs and the patterns of the Ercs appear to be distinct.

POPULATION STUDIES – HYBRIDITY AND INTROGRESSION:

In relation to *J. × kern-reichgeltii*, hybridity and introgression can be artificially highlighted by looking at populations. Initially, Arthur Chater (AOC) sent material from Wales v.c. 46 as a 'hybrid swarm' indicating that hybrids occurred in a middle range between the two species by graphing the spathe (bract) length

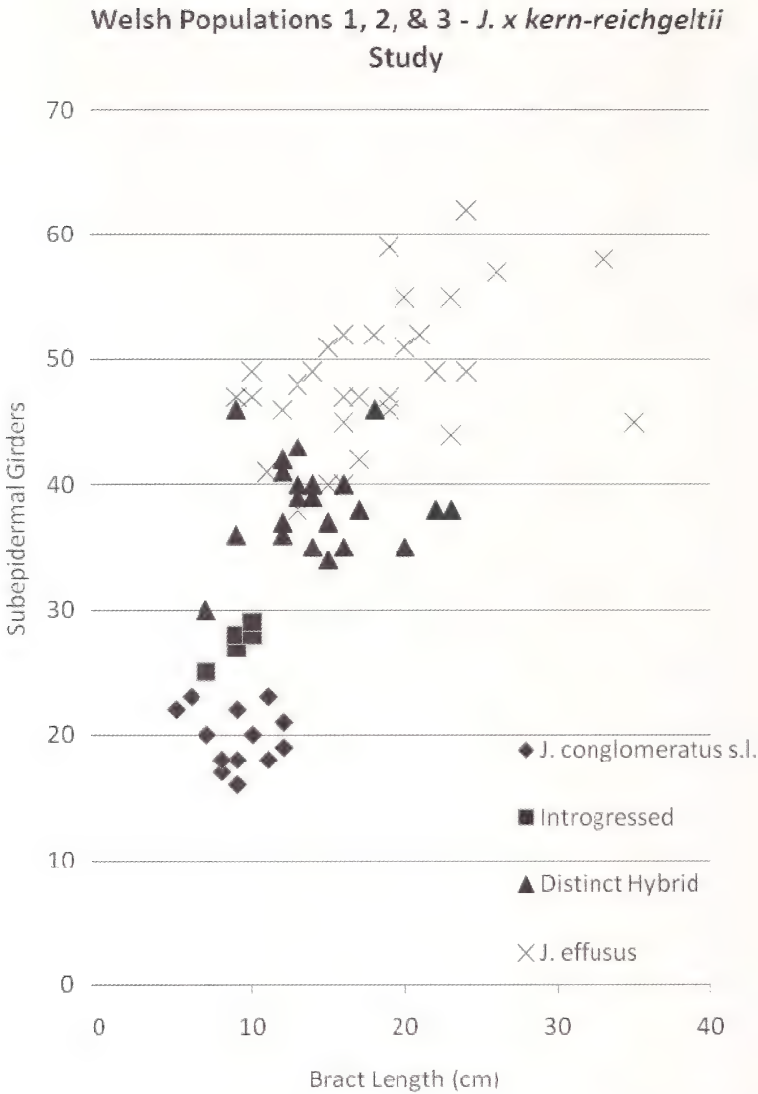


FIGURE 4a. SeSgs graphed against bract length to show variation in population; *J. effusus* is smooth-stemmed and stands alone; shows a relatively intermediate range for hybrids.

against the number of vascular bundles. Whilst this appears to be the case there was no distinction and any of the points on the graph could be a hybrid or even just variation in the two species or as noted by Tweed & Woodhead (1949) two end points in a continuum. In this study the specimens were graphed using the bract length against the SeSgs for the reasons mentioned above in the methods section. More populations from Wales were studied along with plants from other areas, e.g. from Gisburn

Forest Complex (GFC) v.c. 64 in the same way and further populations from elsewhere, e.g. Orkney Isles. Note that bract length is not significant but is a useful baseline character to graph against the number of SeSgs as it is very variable in both species.

Having analysed the specimens in the ways described above it is possible to show albeit arbitrary, how introgression appears to progress from one parent towards the other. Two graphs are given, Figs 4a and 4b to show two aspects

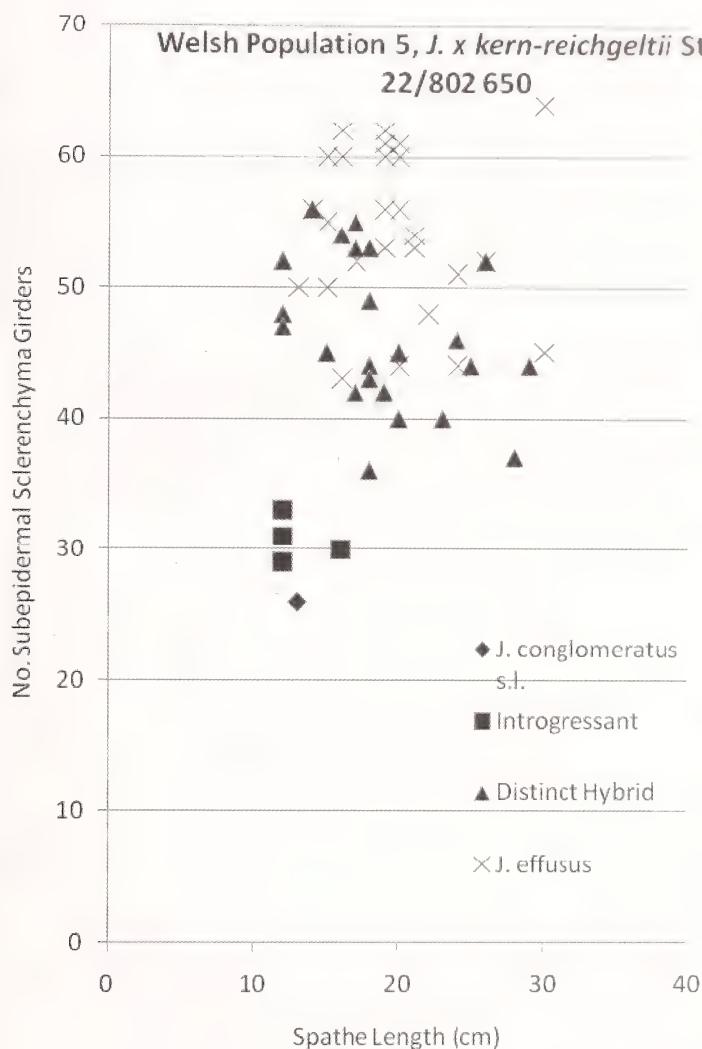


FIGURE 4b. SeSgs graphed against bract length to show variation in population; *J. effusus* is smooth-stemmed and stands alone but this shows a high incidence of introgression towards it in the range for hybrids, only one *J. conglomeratus* in this population.

of variation in SeSgs and bract length. The data points on the graphs for all plants are arbitrarily assigned a shape to show introgression but are in fact based on the form, arrangement and number of SeSgs and their relationship with the Ercs and can only be assigned a shape for graphical purposes when the differences were known, otherwise they would appear in some populations to be a relatively even spread of points; *J. effusus* is also assigned not only on the number of SeSgs but also by the fact that it has a smooth stem, all others have a

discernable ridged stem. Though there is overlap in the number of SeSgs in the main introgressed population, the distinct hybrids are those that have the 'oblong cells' of *J. effusus* above all the SeSgs longitudinally and ridged stems and are therefore assigned a different point on the graph; those with mixed features and more like *J. conglomeratus* are shown as introgressants; those with up to about 25 ridges (SeSgs) were retained as *J. conglomeratus*. Therefore, the initial population from Wales suggesting that hybrids occurred in a middle

band was essentially the case but the characters used here defined the populations further. Note that the points can not be assigned without prior analysis.

In Fig. 4a, there is some introgression towards *J. conglomeratus* but it also shows that there are a number of distinct hybrids sitting in a relatively intermediate position. In Fig. 4b, there are a lot of ridged stemmed plants that had high numbers of SeSgs.

Given the range of SeSgs found in smooth-stemmed *J. effusus*, 36-60 (commonly 48-50), it can be seen that the hybrid plants with

'oblong cells' longitudinally on the ridges have very high numbers of SeSgs, up to about 55 in this population (Fig 4b). This suggests introgression with *J. effusus*. It would appear that the hybrids can backcross both ways. Further information on the forms found in SeSgs and Ercs for hybrids is given in the next section. Therefore the range of SeSgs even when graphed for potential hybrids, in stems with ridges, show these can be lower—showing backcrossing with *J. conglomeratus* (Fig. 4a), and in the higher range showing backcrossing with *J. effusus*, (Fig 4b).

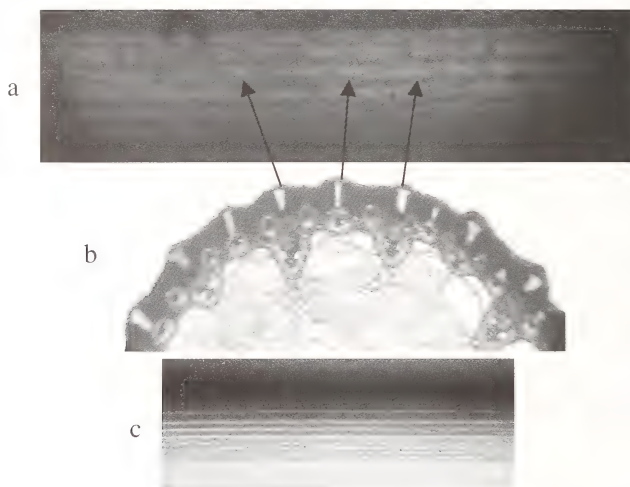


FIGURE 5. *J. x diffusus*, a) Ercs showing 'oblong-cells' inherited from *J. effusus* on distinct ridges longitudinally, ridges appear slightly flat-topped, b) TS which shows the more 'exclamation mark' like pattern and increased numbers of SeSgs, c) showing more finely ridged stem than in *J. inflexus*.

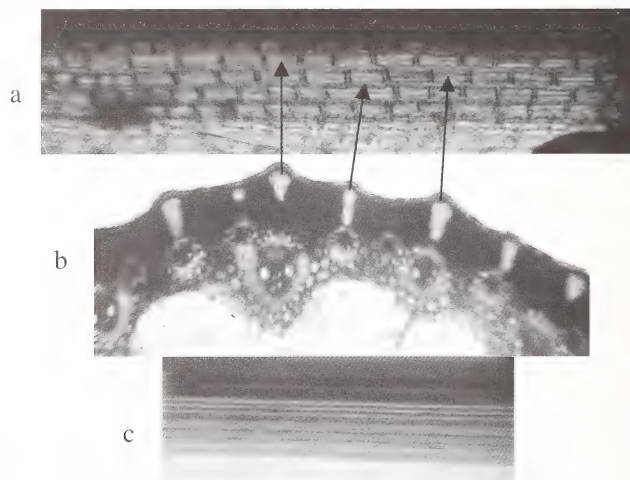


FIGURE 6. *J. x kern-reichgeltii*, a) Ercs showing 'oblong-cells' inherited from *J. effusus* on distinct ridges, which are more rounded at the apex, b) showing TS, again showing the more 'exclamation mark' like SeSgs and again an increase in SeSgs (ridges), c) distinctly ridged stem of the hybrid which can be uneven.

THE HYBRIDS:

J. × *DIFFUSUS*:

This hybrid in the field essentially looks like a somewhat less glaucous form of *J. inflexus*. It has a similar ridged stem, but more ridges and a similar inflorescence, though in Britain the inflorescence is usually ± sterile to very low fertility, (see discussion). In TS this hybrid clearly has a ridged stem with more ridges than *J. inflexus*, (up to about 42, compared to *J. inflexus* which has approx (10)12–18 ‘ridge formers’ = SeSgs). The TS (Fig. 5b) is almost identical to that of *J.* × *kern-reichgeltii* (Fig. 6b), but can clearly be separated on inflorescence type and the stiff semi-glaucous stems. The form, arrangement and number of the SeSgs looks intermediate between the two species with a somewhat more ‘exclamation mark’ look about them showing the influence of *J. effusus* (Fig. 5b). The ridges also appear somewhat more flat-topped like *J. inflexus*. The SeSgs, from the limited material, range from 30–42 at present and this number may change with more specimens. Whilst distinct, this internal feature should be enough to say that it is not a sterile form of *J. inflexus*. However, the Ercs above all SeSgs now have the ‘oblong cells’ of *J. effusus* (Fig. 5a – arrowed) not ‘mesh-like’ as in *J. inflexus*, (Fig. 1c). This combination of characters appears to be good evidence to define this hybrid from its parents. Being usually almost sterile, though partially fertile plants are known in Britain. The stems are finely and evenly ridged, (Fig. 5c)

J. × *KERN-REICHGELTII*:

This hybrid is essentially complicated by evidence of introgression. However, it is believed here that the same characters that are inherited in what is considered an F1 type in the *J.* × *diffusus* hybrid are similar for ‘F1-like’ plants in this hybrid; not strictly an F1 as it is partially to fully (?) fertile, and it would be unknown if some are not backcrosses with *J. effusus* as well, which seems to be the case – i.e. crossing both ways (from the hybrid stand point). Note that in TS, the form, arrangement and number of SeSgs are similar to the ‘exclamation mark’ type found in *J. effusus* and *J.* × *diffusus*, (Fig. 6b) but the stems are always ridged in some form, (Fig. 6c) so they are not the smooth stemmed *J. effusus*. Where the hybrid is thought to be a good cross the epidermal ridge cell character also shows that they have ‘oblong cells’ (Fig. 6a – arrowed)

that are clearly evident in *J. effusus* and *J.* × *diffusus* and just as importantly, these ‘oblong cells’ occur above ± all the SeSgs, therefore giving a distinct form of this hybrid. The cells often show some evidence of *J. conglomeratus* in that the cell walls are a little bit more ‘wrinkled’ but essentially ‘oblong cells’ in which the longitudinal profile is also relatively flat to slightly undulate, much less than the ‘rugulose-wrinkled’ very uneven prominently profiled cells of fresh in season *J. conglomeratus*. Generalised evidence for backcrosses with *J. effusus* seems apparent as shown in Figures 4a and 4b.

INTROGRESSION

One of the complications in this hybrid has always been related to the suggestion that the hybrid is fertile. Like most rushes the parent taxa and some of the hybrids can show at least some degree of sterility due to other factors, such as smut fungus and other environmental reasons. This hybrid from the study of the ‘F1-like’ plants noted above, show that it is fertile to partially fertile. Given this complication, it was noted that in plants more like *J. conglomeratus*, there was a scale of increasing ‘exclamation mark’ like forms of SeSgs towards *J. effusus*; (if one looks at it from the upper limits it might be a decreasing scale as *J. effusus* appears to remain distinct as a species easily identifiable with its smooth stems) but it may be crossing in various ways; *J. conglomeratus* with *J. effusus* or one of the resultant hybrids crossing with either species, but it usually has a visibly ridged stem even though it is fine ridging in the more distinct hybrids, (Fig. 6a–c)

It has been established above, that the distinct hybrids, with the ‘exclamation mark’ form, arrangement and number (30)35–42(–55) of SeSgs will have the ‘oblong cells’ of *J. effusus* in the Ercs. However, this form becomes more diluted from backcrossing especially when crossing with *J. conglomeratus*. An increase or decrease in the numbers of SeSgs is considered here a direct result of hybridization of varying stages in this taxon. Figure 7a shows a TS that looks like the hybrid with the form, arrangement and number of SeSgs, though slightly more elevated ridges. The difference is that this specimen shows that in the main more elevated ridges, the Ercs show a pattern closer *J. conglomeratus* as in Figure 3c but much less so. Apart from the



Figure 7. *J. x kern-reichgeltii* introgression patterns, a) showing high numbers of ridges (SeSgs) but highly elevated ridges showing Ercs becoming more like those of *J. conglomeratus* but the smaller ridges showing Ercs to be 'oblong-cells' as in *J. effusus*, b) shows backcrossing towards *J. conglomeratus* still with increased SeSgs but these occur as less distinct ridges and as in 8u, the Ercs are more like *J. conglomeratus* in the main ridges and some of the intermediate ridges but 'oblong-cells' in the smaller SeSgs.

SeSgs being more numerous, the evidence for backcrossing comes from the smaller ridge forming SeSgs between the main ones and the very small ones that do not appear to form ridges (in life) but show up when dried. The evidence shows that in these plants, the main Ercs have squarish wrinkled cells, but retain square-oblong cells similar to *J. effusus* in the smaller ridges and the very small strands longitudinally. Therefore these plants have a combination of the two types of Ercs in the same plant and suggest a backcross.

In Figure 7b, this pattern is much less with the main SeSgs elevated having the 'rugulose-wrinkled' cells of *J. conglomeratus* described above in the species section and as before the 'oblong cells' of *J. effusus* in the very small SeSgs that tend to occur between the *J. conglomeratus* type SeSgs. Also, the SeSgs between the main ridges are more 'exclamation-mark-like'. This pattern seems to continue. Therefore, there appears to be a continuum from the more distinct hybrids described above to *J. conglomeratus* suggesting a progression, a history of backcrossing. The crosses are almost impossible to say which generation as any could potentially cross with another. Those with higher numbers of SeSgs but still ridged may be backcrosses with *J. effusus*. The inheritance of the 'oblong cells' in the Ercs, is evident in both hybrids above the SeSgs and is

considered a useful diagnostic character for the main hybrid in *J. x kern-reichgeltii* with ridged stems and having 'exclamation mark' like SeSgs in TS. The high number of SeSgs on a decreasing scale combined with Ercs characteristics becoming more like *J. conglomeratus* is considered a sign of introgression within *J. x kern-reichgeltii*. Equally it seems any hybrid can cross either way with either parent.

DISCUSSION

From an initial study of the parents of *J. x diffusus* and this hybrid, it was clear that there were morphological and anatomical characters that were useful for their separation. The distinct epidermal ridge cells above all the subepidermal sclerenchyma girders were revealed in this study for each species. This novel character in association with the form, arrangement and number of SeSgs evidently provides useful taxonomic identification features. Extending these characters to the parents of *J. x kern-reichgeltii* showed a more complicated situation. This was due to the apparent unstable fertile nature of the hybrid in question. The morphological and anatomical characters were similar to the other hybrid studied here. It showed that there appears to be a relatively distinct hybrid where the Ercs are

all of the 'oblong cell' type longitudinally above the SeSgs which are more numerous than in *J. conglomeratus* and similar in number and form to those in *J. × diffusus*, approximately twice as many ridges in each hybrid. This fact should not be underestimated as it is the same character for both distinct hybrids inherited from the same parent, *J. effusus*; though *J. × diffusus* appears to be essentially often sterile in Britain, there is apparently some fertility in some populations and a segregating F2 hybrid is known in Europe, (pers. comm. Clive Stace). However, the study not only in the population studies but mainly in the morphological and anatomical study shows that there are many hybrids due to introgression, 'hybridization histories' in *J. × kern-reichgeltii*. All those with ridged stems on an increasing or decreasing scale, (depending on which way it is crossing) might be considered to be hybrids and though there is no distinct cut off point *J. conglomeratus* can be relatively assigned as described above where the SeSgs more or less only occur in the elevated ridges, though some minor ones in between might be acceptable to a certain level to cover variation, (though these additional SeSgs may be due to a history of introgression in an essentially variably fertile hybrid). The evidence points to possible introgression with *J. conglomeratus* and *J. effusus*, but the hybrid always has some kind of ridged stem. However, the graphical data have arbitrarily assigned *J. conglomeratus* and the other ridged stem specimens but it was based on form, arrangement and number of subepidermal sclerenchyma girders and epidermal ridge cell type, technically on a decreasing scale from the smooth stemmed *J. effusus* plants, (given that this species seems to stand apart) and this may be useful in retaining the species boundaries for the time being. *J. conglomeratus* can be retained with 15–24 ridges (SeSgs) as its main separation feature in conjunction with the form and arrangement of SeSgs and patterns of Ercs from any hybrids. Apart from the distinct hybrids defined above, the subsequent crosses are almost impossible to judge, though those closer to the more distinct hybrids are more distinctive and easily assigned as a hybrid as shown, with others being less distinct towards the presumed form of *J. conglomeratus*. However, even backcrosses are considered hybrids but it may always be difficult to assign some plants. The illustration Fig. 787 no. 3 (Stace 1997) is a reasonable example of *J. ×*

diffusus which is better illustrated on the jacket cover of Stace (1975) and is also comparable to the TS of *J. × kern-reichgeltii* in many respects, though inflorescence type and general colour and jiz would separate them. The illustration Fig. 787 no. 7 (Stace 1997) for *J. conglomeratus* appears to show a partially introgressed plant of the hybrid rather than being closer to the species as defined here, see Figs. 3a–d. At a very late stage of writing this, the author managed to get copies of Kirschner *et al.* (2002a, b, c) and as it includes important information is related here. This is an invaluable work in three volumes on Juncaceae including *Rostkovia* to *Luzula*, (Kirschner *et al.* 2002a) with two others being compilations covering species of *Juncus*, (Kirschner *et al.* 2002b, c). A good drawing of the TS of *J. conglomeratus* is depicted on p.86, of Kirschner *et al.* (2002c) and concurs with the findings here of what are considered the species limits. These latter two volumes raise *Juncus* to section level, and those of subgenus Genuini are placed in Section Juncotypus, (Kirschner *et al.* 2002c). Interestingly, the hybrid *J. × kern-reichgeltii* (the name is maintained here) and *J. × diffusus* are mentioned and illustrated in this third volume. The description for *J. × kern-reichgeltii* gives 25–35 ridges like *J. conglomeratus* in structure but not as prominent and with a similar but less dense inflorescence; it also mentions that the capsules are well developed, 'probably sometimes with ±reduced seed set,' and that, 'the frequency and properties of this hybrid need further investigation,' (Kirschner *et al.* 2002c). While this is a reasonable description, the range in ridge number basically covers most of the introgressed individuals (backcrosses to *J. conglomeratus*), though the ridges are likely to have been counted externally. The illustration associated with it, p.143 clearly depicts a transverse section, which is a clear backcross to *J. conglomeratus* probably of at least two generations based on the sclerenchyma pattern and epidermal ridge cells shown, (see Kirschner *et al.* 2002c).

One of the complications in N America is that the species *J. pylaei* Laharpe (2n=40) is very similar to *J. conglomeratus* (2n=42) and hybrids may be of the former species with *J. effusus* at least in N America and need further investigation. *J. conglomeratus* is a non-native introduction in N America but does occur in some similar areas to *J. pylaei*, (Kirschner *et al.* 2002c). Only one hybrid is recorded,

J. effusus ssp. *solutus* × *J. pylaei* from Ontario, Canada, though one of the differences in *J. pylaei* is that it is said to have no sclerenchyma girders above the main vascular bundles, but it is not illustrated, (Kirschner *et al.* 2002c).

The transverse section shown for *J. inflexus* in Kirschner *et al.* (2002c) seems to be incorrect. The hybrid, *J. × diffusus* is reasonably depicted in Kirschner *et al.* (2002c), but the illustration of the inflorescence is somewhat effuse! It may relate to partially fertile plants. The segregating hybrid in *J. × diffusus* said to occur in Europe needs to be studied as it is likely that it would show similar patterns of introgression as highlighted here but it is likely to retain a *J. inflexus* type inflorescence. Those in Britain appear to be more or less sterile with few or no segregating individuals known. With the evidence provided these two hybrids have been elucidated further and records can now be made for mapping purposes especially for *J. × kern-reichgeltii*. I would be interested in receiving specimens for determination in relation to recording both hybrids. Populations with ridged stems in the *J. × kern-reichgeltii* – *J. conglomeratus* group would be welcome either as individual specimens or no more than 100 stems per population and the bract intact to be analysed. It is likely that herbarium material can also be identified more readily for the parents but all suspected hybrids in *J. × kern-reichgeltii* may need confirmation using Transverse Sections of the stem as described in the methods section; some *J. × diffusus* may also require stem sections for confirmation but less so than the other hybrid. Other rushes would be welcome. The evidence presented for introgression suggests that *J. × kern-reichgeltii* is frequent to sporadic in some localised areas and is likely to occur throughout the range of the parent taxa but less common or not at all in some areas dominated by one parent, which is usually *J. effusus* in many areas with grazing pressures. It seems from AOC's studies that *J. × kern-reichgeltii* can be quite frequent in parts of Wales. Also, one population received from the Orkney Isles had 39 hybrids from 62 stems suggesting it can be frequent in other areas also, see records below.

RECORDS

CRITICALLY DETERMINED *J. × KERN-REICHGELTII*

RECORDS SO FAR:

The hybrid is likely to occur rarely-to-frequently throughout the range of both parents in suitable areas, records below are from Gloucestershire to the Orkney Isles.

WELSH MATERIAL: – QUOTED FROM ARTHUR

CHATER'S MATERIAL

"6 plants, notes, ? *Juncus conglomeratus* × *effusus*. Plants loose – Note – with *Juncus effusus* and *J. conglomeratus* in damp, flushed (....) pasture on SE facing slope, RHOS GARGOED SSSI, 700 m NE of CAEMADOG, STRATA FLORIDA, Cards. 290 m 22/758 668 7/9/1994 – v.c. 46 A. O. Chater." Some of these plants were determined as the hybrid, MW-2008.

23 plants, *J. effusus/conglomeratus*, 'Roadside verge in felled conifer plantation, 300 m NW of NW tip of NANT Y MOCH Reservoir, Cards. 350 m 22/736887, 2/7/2003, v.c. 46 A. O. Chater.' 3 plants were the distinct hybrid, MW-2008.

49 plants (labelled up to 50 but number 19 missing).

NOTES

These plants were for the **1998 BSBI Exhibition**, "Population from Rhos Llawr-cwt NNR, apparently of *J. conglomeratus*, *J. effusus* and the hybrid; no obvious hybrid swarm or introgression. The hybrid specimens (**marked H**) have their inflorescences clearly intermediate in colour and density. One stem from each of 50 clumps in fen just S of BWD RAM near E boundary of RHOS LLAWR-CWRT NNR, TALGARREG, Cards. 180 m, 22/415499, 15/7/1998, v.c. 46 A. O. Chater." All those marked 'H' were *Juncus × kern-reichgeltii* Jansen & Wacht. ex Reichg. MW-2008.

57 plants, "Population from Mynydd Bach of at least 4 plants of *J. conglomeratus*, and of *J. effusus* introgressed with the hybrid. Note the unusually high proportion of plants of hybrid origin with ridged stems that have 40 or more vascular bundles. – Level mire at NW corner of Mynydd Bach, 300 m ESE of PWLLDRAEN LLWYN, TREFENTER. 300 m., 22/616696, 28/6/1998, A.O. Chater, v.c. 46." Many distinct hybrids and some introgressants, MW-2008.

52 plants, "Upland population from Llyn Gynon, apparently of *J. effusus* introgressed with the hybrid; perhaps one plant of *J. conglomeratus*. Blanket mire N of LLYN GYNON, Cards. 440 m, 22/802650, 4/7/1998, A.O. Chater, v.c. 46." Some distinct hybrids, MW-2008

57 Plants, "*Juncus effusus/conglomeratus* from; Trackside in partially felled conifer plantation, LODGE PARK, TRE'R-DDOL, Cards; 50 m, 22/665936, 30/7/1997, v.c. 46, A.O. Chater." Only a few introgressants in this population, MW-2008.

70 Plants. Notes: Plants with a scattergram. Notes on paper; "Upland population from Camddwr valley, perhaps a hybrid swarm or perhaps just of the two species; cf. Diagram from Esgair-las; *Molinia* dominated, NNE facing slope with *Selaginella* flushes, CAMDDWR valley, 1.7 km NNW of SOAR Y MYNYDD, Cards; 350 m, 22/777548, 25/9/1998, v.c. 46, A.O. Chater." Some distinct hybrids present, MW-2008.

About 55 plants, "A lowland population from New Quay, apparently a hybrid swarm of *J. conglomeratus* and *J. effusus* – One stem from each of 60 clumps in a small fen enclosure 250 m SW of CEFNGWYDDIL, CROSS INN, NEW QUAY, Cards. 130 m 22/38625754, 24/8/1998, v.c. 46 – Arthur Chater." 5 distinct hybrids types with others introgressed, and *J. conglomeratus* det. MW 2007.

OTHER POPULATIONS & SPECIMENS:

Isle of Skye, 2 plants NG50 53, NG6008 and one from the Isle of Raasay, NG5641 v.c. 104 – all 3 plants collected and later determined as the hybrid (M. Wilcox July 2007) specifically collected while on the Bradford Botany Group long weekend away.

Hetchell Wood, Thorner, Leeds v.c. 64 – SE373427, Bradford Botany Group trip, originally identified in the field by Geoffrey Wilmore, 2005, (confirmed MW 2007) using the techniques here (a backcross but in TS clearly referable to the hybrid). Woodside Quarry, Leeds v.c. 64 M. Wilcox, July 2002, SE255 385 collected originally as *J. conglomeratus* var. *subuliflorus*. Determined 2007, (MW) clearly attributable to the hybrid. Other records of this variety could be this hybrid also.

Gisburn Forest Complex, v.c. 64 October 2007, SD744553 MW specimens 100 *J. effusus* and 100 with ridged stems. 4 Plants referable to the distinct hybrid were found in those collected with approximately 6 also distinct backcrosses.

Gloucester, woodland behind Michael Wood Service station, ST722950 v.c. 34, collected July 2002 Michael Wilcox as an unknown very odd lax form of *J. conglomeratus* var. *subglomeratus* or *J. × kern-reichgeltii*. Later confirmed as the hybrid (MW 2007) but considered as a backcross due to the variable combined Erce characters.

A record in Shropshire Botanical Newsletter on a Shropshire Botanical Group (BSBI) trip, *J. × kern-reichgeltii* found by Richard Pryce and det. by Arthur Chater; Wildmoor Pool [incorrectly cited as SJ424965 – should be SO424965] 16 September 2007.

J. × kern-reichgeltii; This record is from dampish grass-heath on Berron Downs on the E flank of the Malvern Hills at SO768386, 28.7.2002; those present Roger Maskew, Christopher Westall and Bill Thompson. Worcestershire Flora Project; Progress Report. Specimen sent to and confirmed by Arthur Chater, therefore accepted here.

Eric Meek – potential hybrids sent for determination: Orkney Isles, ND450882, v.c. 111; 62 stems arrived; the determinations (01/09/08) are as follows: 23 – *Juncus conglomeratus* (some of these showing some introgression) 39 – *J. × kern-reichgeltii* (very good hybrids) det. MW-2008.

Eric Meek, Orkney Isles, v.c. 111, NY323184, August 2008: 117 stems; 98= *J. effusus*, 15= *J. conglomeratus*, 4= *J. × kern-reichgeltii*, det. MW 18/08/08

Waddington Fell (Bradford Fell) SD720474, August 2008, MW

Stocks Reservoir, SD735561, August 2008, MW

Gt. Horton Country Park, Horton Bank Top, Bradford, v.c. 63, SE125308; Coll. B. A. Tregale & MW, v.c. 63, Sept 2008 det. MW Wagon Lane, Beckfoot, Bingley, v.c. 63, SE115381 Coll. MW & B.A. Tregale, Oct 2008, det. MW

Freshfield Dune Heath, SD293090, v.c. 59
Coll. MW & Phil Smith, 27 Aug 2008, det.
MW; *J. × surrejanus* also present.

Ireland – County Leitrim – Dromahair, (Droim
Dha Thiar) – Five Cross Roads, G813279,
H29, meadow, collector B. A. Tregale, 4–
5/08/08; det. MW, Oct 2008

Ireland, County Leitrim – Dromahair – Five
Cross Roads – G819275, H29, peat bog,
collector B. A. Tregale, 4–5/08/08; det. MW,
Oct 2008

Freshfield Dune Heath – SD293090, v.c. 59,
Phil Smith & MW, 27/8/08, det. MW, Sept/08

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REFERENCES

- AGNEW, A. D. Q. (1968). The interspecific relationships of *Juncus effusus* and *J. conglomeratus* in Britain. *Watsonia* **6**: 377–388.
- BLACKSTOCK, T. H. & ROBERTS, R. H. (1986). Observations on the morphology and fertility of *Juncus × surrejanus* Druce ex Stace & Lambinon in north-western Wales. *Watsonia* **16**: 55–63.
- KIRSCHNER, J. *et al.*, (2002a). Juncaceae: *Rostkovia* to *Luzula*. *Species Plantarum – Flora of the World*; **1**: 6 pp. 1–237.
- KIRSCHNER, J. *et al.*, (2002b) Juncaceae: *Juncus* subg. *Juncus*. *Species Plantarum – Flora of the World*; **2**: 7 pp. 1–336.
- KIRSCHNER, J. *et al.*, (2002c) Juncaceae: *Juncus* subg. *Agathyron*. *Species Plantarum – Flora of the World*; **3**: 8 pp. 1–192
- KRIŠA, B. (1962). Relations of the ecologico-phenological observations to the taxonomy of the species *Juncus effusus* L. s.l. *Preslia* **34**: 114–126.
- LOCKTON, A. (ed.) (2007). New Records. *Shropshire Botanical Newsletter* **16**: 6.
- O'MAHONY, T. (2002). The comparative morphology of *Juncus conglomeratus* L. (Compact Rush), *Juncus effusus* L. (Soft Rush) and their interspecific hybrid, *J. × kern-reichgeltii* Jansen & Watcher ex Reichg. *Irish Botanical News* **12**: 5–13.
- STACE, C. A. (1970a). Unique *Juncus* hybrids in Lancashire. *Nature* **226**: 180.
- STACE, C. A. (1970b). Anatomy and taxonomy in *Juncus* subgenus *Genuini*. *Botanical Journal of the Linnean Society* **63**: 75–81.
- STACE, C. A. (1972). The history and occurrence in Britain of hybrids in *Juncus* subgenus *Genuini*. *Watsonia* **9**: 1–11.
- STACE, C. A. (ed.) (1975). *Hybridization and the flora of the British Isles*. Academic Press, (Collaboration with BSBI), London.
- STACE, C. A. (1997). *The New Flora of the British Isles*. Cambridge University Press, Cambridge.
- TWEED, R. D. WOODHEAD, N. (1947). The taxonomy of *Juncus effusus* L. and *J. conglomeratus* L. *North Western Naturalist* **22**: 216–222.

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The British records of *Cystopteris alpina* (Lamarck) Desvaux; Woodsiaceae

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ABSTRACT

The Alpine Bladder Fern (*Cystopteris alpina* (Lamarck) Desvaux) is found in alpine regions of Europe and occurs from Norway to the Pyrenees and east to the Caucasus. It was found in Britain as a native species in North-west Yorkshire (v.c. 65), and in Essex (v.c. 18), where it had probably been introduced. Other British records exist for *C. alpina* and the status of some of these records, as well as the morphological characters were discussed in an earlier paper (Tennant 1995). The information is updated here, and the authenticity of further records, notably those from North Wales is discussed.

KEYWORDS: Alpine Bladder-fern, Britain, Wales, distribution, taxonomy, *Cystopteris regia*.

INTRODUCTION AND IDENTIFICATION

There is little difficulty in the recognition of typical material of *C. alpina* and in distinguishing this species from typical *C. fragilis*. *Flora Europaea* (Tutin *et al.* 1993) separates *C. alpina* by its more deeply dissected pinnae and linear-oblong ultimate pinnule segments. Classic examples are distinguished morphologically from *C. fragilis* by their more finely dissected fronds being tripinnate to almost quadripinnatifid, the pinnule segments linear-oblong, at least in the basal pair of pinnae, to linear-obdeltoid, and rather blunt, truncate or emarginate at the apex. Additionally, all or the majority of the veins of the ultimate segments usually end at the base of a distinct sinus, or in a notch between the teeth (not at the usually acute apical point of the teeth, as in typical *C. fragilis*) (Murphy & Rumsey 2005), as shown in Figure 1 by Tennant (1995: 48).

Specimens which do not conform to all of these characters, however, have caused much controversy. The variation which has been reported led to a suggestion by Stansfield (1929) that there were two distinct forms of *C. alpina*; forma *dissecta*, which corresponds to typical material, as described above, and in

which he included examples collected in North-west Yorkshire; and forma *obtusa*, which is bipinnate and has only slightly notched pinnule segments, in which he included the Essex plants and others described and illustrated on Plate 67 by E. J. Lowe (1876) as '*C. regia*'. Kestner (1930) had proposed three varieties of *C. alpina*; var. *alpina*, which more or less corresponded to Stansfield's var. *dissecta*; var. *deltoidea* Milde, which was confined to the Tyrol; and var. *regia* Milde, a lower altitude variant which he described as intermediate between typical *C. alpina* and *C. fragilis*, and which therefore, at least largely, corresponds to Stansfield's var. *obtusa*.

The epithet '*regia*' had been applied much earlier to British *Cystopteris* and the name *C. regia* auct. was considered by most 19th century authors, more recently in *Flora Europaea* (Tutin *et al.* 1993), and at present as a synonym of *C. alpina* (Lam.) Desv. A brief history of the epithet *regia* was given in more detail by Tennant (1995). Some of the specimens of *Cystopteris* which were collected in Britain and had been named as *C. regia*, or given the earlier name *Cyathea regia*, are included in the list of records given below.

BRITISH RECORDS

Cystopteris alpina certainly occurred as a native plant in Upper Teesdale (v.c. 65), where it was discovered at a single site in a limestone pavement in 1872. Details of its discovery and some of its records there were given by Tennant (1995: 46). Further records, which are almost certainly all from the same locality and correctly named, were by H. T. Mennell, 1880; A. J. Crosfield, 1880, 1884; J. Backhouse junior, 1886; C. E. Salmon, 1892; and finally by Salmon in 1911. Only three plants were reported and although the precise site is no longer known, repeated searches of the described area have failed to find the plant and it is very probably extinct there. These specimens are all in **BM**, with duplicates of some of them in **E**, **GL** and **K**.

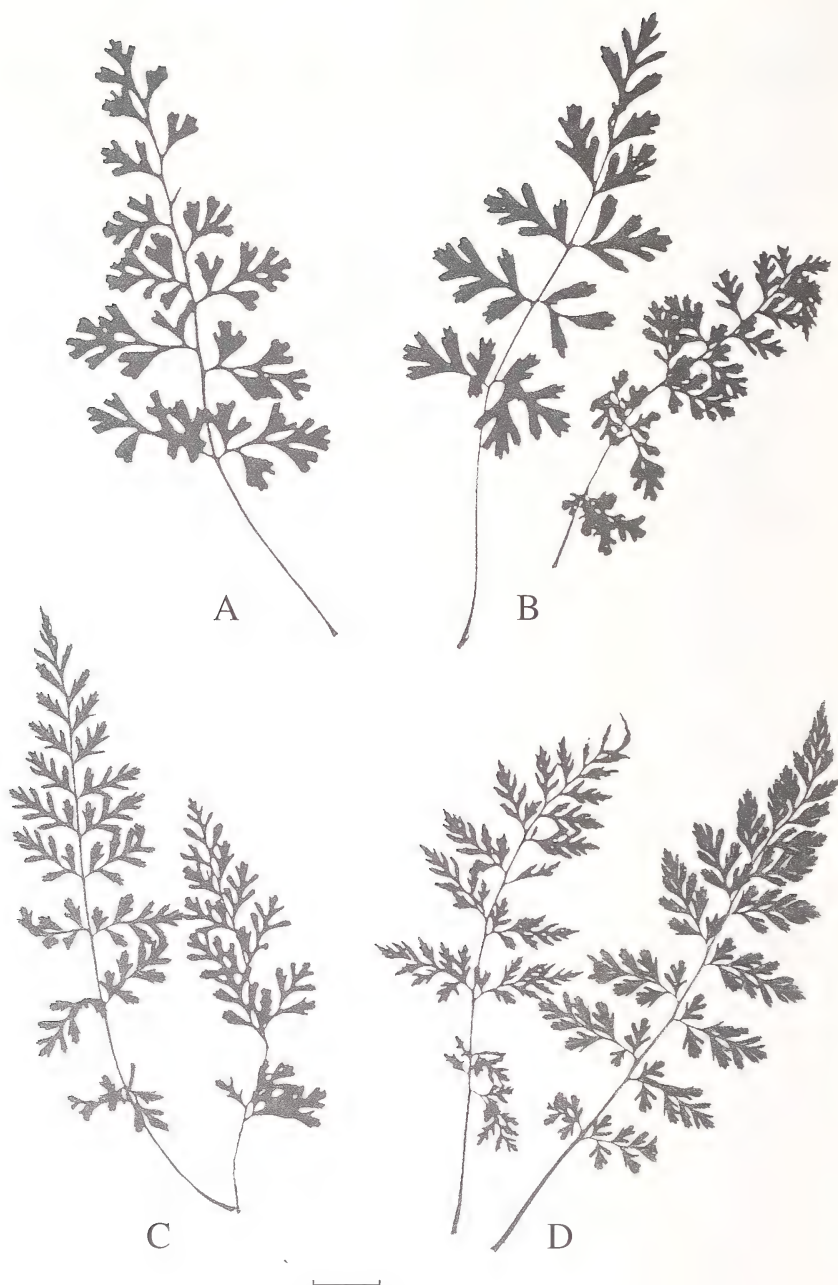


FIGURE 1. A. *Cystopteris alpina*. Illustrating the frond and pinnule morphology which develop in otherwise more typical finely dissected fronds with narrower pinnule segments; cultivated example, originally collected in Austria.

B, C, D. The *Cystopteris* taxon from North Wales. B. Illustrating fronds with pinnules very similar to those of *C. alpina* in illustration A. C. Young fronds showing linear-oblong pinnule segments, which are more typical of *C. alpina* than of *C. fragilis*. D. fully mature, fertile fronds showing morphology somewhat intermediate between these two species. Scale bar = 1 cm.

There are also specimens in the **BM**, which appear to be correctly named, collected by F. A. Lees, which are labelled 'Harwood' in Upper Teesdale, but in Durham (v.c. 66), dated 1874 and 1875. Lees also collected a specimen on the Yorkshire side of the Tees (v.c. 65) in 1874 which he labelled *C. alpina*, but the specimen is *C. fragilis*. Lees also published probable records for *C. alpina* at the head of Wharfedale, Yorkshire (v.c. 64) (Lees 1888; 1939), but no specimens from there have been traced.

J. E. Smith (1830) gives records for *C. regia* from Snowdon, collected by H. Davies and W. Wilson, and from Cwm Idwell (Idwal) by Griffith.

Griffith (1895) included two records for *C. alpina* from Snowdonia, Caernarvonshire (v.c. 49) in North Wales, and in **BM** both the *C. alpina* and the *C. fragilis* files contain several *Cystopteris* specimens collected in Wales which bear some resemblance to *C. alpina*, although none of these has apparently been confirmed recently as such with complete certainty. These specimens are as follows:

Snowdonia, 1824, collector unspecified, as *C. fragilis* (one plant of ten), in herb. W. W. Newbould (1829–1886).

A further two specimens collected in Snowdonia and labelled *C. fragilis* on the same sheet also approach *C. alpina*. These are labelled herb. H. & J. Groves (pre 1912), but could alternatively refer to another label marked Cwm Glas (Snowdon), 1874, W. R. Linton, on the same sheet.

Snowdon, 1826, William Wilson, as *C. regia* (record listed by J. E. Smith (1830)).

Snowdon, 1847, collector unspecified, as *C. fragilis* var. *angustata*, in herb. F. J. Hanbury.

Near Twll Du (Cwm Idwal), 1853, collector illegible, as *C. alpina*.

Castel Dinas, undated, Professor Hooker, as *Cyathea regia* (Assumed to be W. J. Hooker (1785–1865)), but later rejected by C. E. Salmon in 1928 (as a form of *C. fragilis*).

'Wales', period 1836–1860, Mrs Riley, in the *C. alpina* file, herb. J. Forbes Young (A further specimen in the *C. fragilis* file, as *C. regia*, is marked 'Mrs Riley, hort. ex spores', but without origin).

Cader Idris, 1875, J. Backhouse junior, as *C. fragilis* var. *angustata*.

Snowdon, 1890, J. Lloyd Williams, as *C. alpina* (later rejected by C. E. Salmon as a form of *C. fragilis*).

Cader Idris, 1928, S. P. Rowlands, as *C. fragilis* (Also in E).

Other records for *C. alpina* which are unsubstantiated or erroneous in Britain were given by Tennant (1995: 46). Some of the specimens in **BM** collected from Orkney (v.c. 111) in the 19th Century, however, bear a strong resemblance to *C. alpina*, and require further investigation, whereas others in **BM** which are labelled as *C. regia*, 1838, and 1872, Brecon (South Wales, v.c. 42) are clearly *C. fragilis*. Finely dissected *Cystopteris* plants are reported from Skye, v.c. 104 (A. C. Jermy in pers. comm.) which require examination.

FIELD STUDIES

Variant examples of *C. fragilis* which had been collected in Northern England, Wales, Scotland and Ireland, were re-examined and some of the localities were revisited. All of these variants, however, clearly belonged under *C. fragilis*, with some of them grading into more typical material of this species, making their taxonomic distinction difficult.

Extensive recent searches in Upper Teesdale (v.c. 65) and near Harwood (v.c. 66) did not reveal *C. alpina*. Field studies by me in Snowdonia (v.c. 49), North Wales in June and September 2008, and in 2009, however, revealed a *Cystopteris* which I had not seen elsewhere, and which is apparently confined to North Wales. *C. fragilis* and many of its variants are very abundant in Snowdonia, but the *Cystopteris* in question was very uniform, and no gradation was seen into any of the variants which occurred here or in any other British localities. Rather small populations of this plant were found in two separate locations in Snowdonia (v.c. 49), very locally in north-facing crevices or recesses on basic cliffs, in moderate shade. Other than bryophytes, there was little other vegetation in their habitats, although *Cochlearia pyrenaica* subsp. *alpina*, *Minuartia verna* and *Silene acaulis* were the most significant species seen nearby, and typical *C. fragilis* occurred not far away. These Welsh ferns, beyond any doubt, conformed exactly to the specimens in **BM** listed above (under records) from seven of the separate collections made in Snowdonia between 1824 and 1890.

All of these specimens in **BM** and the plants found in 2008 approached *C. alpina* in

morphological characters, and five of the **BM** specimens had been labelled originally as *C. regia* or as *C. alpina*, two of which had been placed in the *C. alpina* file; the status of these Welsh ferns is discussed below.

During the examination of *Cystopteris* specimens in **BM**, one sheet labelled *C. dickieana*, containing specimens collected in 1905 below Tomintoul, Banffshire (v.c. 94) by W. C. Barton confirms the prediction (Tennant 1996: 136) that it occurred there, and where it was subsequently rediscovered. Other specimens in the *C. fragilis* files in **BM**, also labelled as *C. dickieana*, were from Lanarkshire (v.c. 77), and one from Glen Clova (v.c. 90) dated 1834, and these require re-examination.

DISCUSSION AND STATUS OF RECORDS

The acceptance of *Cystopteris alpina* as a native British plant is beyond question, based on specimens from Upper Teesdale (v.c. 65), but despite several recent systematic searches it has not been seen for almost 100 years and is very probably extinct there. The Essex (v.c. 18) ferns have also been accepted as *C. alpina*, but these were almost certainly not native in that locality and are also now long extinct there. Specimens in **BM** collected by F. A. Lees dated 1874 and 1875 from Durham (v.c. 66), which are named as *C. alpina*, are possibly correctly named. Lees surprisingly, however, may not have published the records, and no other examples were collected there. Recent careful searches in the area have revealed few suitable habitats, and only *C. fragilis* was found in this area.

The ferns collected in North Wales in the 19th Century, and refound there by me in 2008, which approach *C. alpina* morphologically, are distinctive and uniform, and at present appear to be known only from North Wales. The specimens have largely gone un-noticed, or been left due to uncertainty in the *C. fragilis* files in **BM** and elsewhere, variously labelled as *C. fragilis*, *C. fragilis* var. *angustata*, *C. alpina*, *C. regia* or *Cyathea regia*. Smith (1830) had given records for *C. alpina* (as *C. regia*) from Snowdonia, and it is clear that W. J. Hooker, an expert on ferns, considered one of these, which he had collected in North Wales, was referable to *Cyathea regia*, a name which is now generally accepted as synonymous with *C. alpina*. Griffith (1895) accepted two records from Snowdonia as *C. alpina*, and although the specimens on

which these records are based were not specified, the localities given agree with at least two of the localities on the herbarium sheets in **BM** listed above and one locality in which I found plants matching the **BM** specimens; it is therefore possible that Griffith considered the **BM** specimens as one basis for his published records. All of these ferns from Snowdonia are very similar, but not identical to the Welsh specimen named by W. J. Hooker as *Cyathea regia*, and also not unlike the specimens of *C. alpina* which had been found in Essex. They do not, however, match the classic specimens from Upper Teesdale (v.c. 65) precisely, and although their characters are closer to the latter, they are also somewhat intermediate between these and *C. fragilis*. Backhouse may not have seen the Welsh specimens in **BM**, as most would have been presented there later from other private collections, but he referred one specimen which he had collected himself there to *C. fragilis* var. *angustata*. C. E. Salmon, in 1928, rejected Hooker's specimen of *Cyathea regia* as a form of *C. fragilis*, however, both Salmon, and Backhouse, may have taken this view as the specimens did not match those from v.c. 65 exactly. Hyde & Wade (1948) stated that *C. regia* Desv. records from North Wales were errors.

Stansfield (1929) and Kestner (1930) both considered that *C. alpina* was a more variable species and proposed subspecific names to distinguish its variants, although these names are not in general use now. They both considered that the epithet '*regia*' was applicable to certain variants of *C. alpina* which do not conform to the more classic material. Kestner stated that his var. *regia* was somewhat intermediate between *C. alpina* and *C. fragilis*, which also applies to the ferns of North Wales, but also suggested that the only reliable character for distinguishing the two species was the position of the vein-endings in the pinnules. Whereas the view that in *C. alpina* the veins should end in notches is generally accepted (Murphy & Rumsey 2005), it is in fact in conflict with some of the specimens which are now referred to *C. alpina*. The Essex specimens and many plants in horticulture named as *C. regia*, which, otherwise conform to *C. alpina*, do not consistently show this character, or only partially so. Additionally, Lowe (1876) described *C. alpina* as having 'veins ending in

notches or at teeth on both sides of notches', suggesting that this is a variable character, and *Flora Europaea* (1993) does not include this as a strictly diagnostic character. Similarly, the character of the veins ending in notches is sometimes seen in variants of *C. fragilis*, to a lesser or greater degree, especially in fronds which are not completely mature; it is also a character of *C. diaphana* (Bory) Blasdell (Murphy & Rumsey 2005) and often occurs in *C. dickieana* R. Sim, making the relevance of this as a constant, strictly diagnostic character in *Cystopteris* unclear. In cultivation, classic *C. alpina* from the Austrian Tyrol (which corresponds to the forma *dissecta* of Stansfield and the var. *alpina* of Kestner) develops less-dissected fronds with broader, narrowly obdeltoid (broadly wedge-shaped) pinnules (Fig. 1) and whereas such fronds are often semi-juvenile and sterile or bear fewer sporangia, they are often present, and persist in mature plants; a very similar specimen of *C. alpina* in BM was collected in Upper Teesdale (v.c. 65) by C. E. Salmon in 1911. This character was also noted in 2008 in the ferns growing in Snowdonia, this type of frond being virtually indistinguishable between Austrian *C. alpina* and the Welsh plants (Fig. 1). Similarly, when cultivated from spores, the very young sporophytes of *C. alpina* are distinctive and unlike those of *C. fragilis*, with well separated linear-oblong, blunt pinnule segments, but again closely approach juvenile plants seen in the populations found in Snowdonia. In the Welsh plants, the veins of the pinnules also end in shallow notches in young fronds, but unlike *C. alpina*, in the more dissected, fully mature fertile fronds of the Welsh plants the veins mainly end at the usually acute apex of the teeth of the pinnule segments.

Namings on two of the herbarium sheets in BM suggest that these Welsh ferns represent *C. fragilis* var. *angustata*, however there has clearly been some confusion in Britain regarding this variety. Smith (1830) stated that he had never received '*C. angustata*' from Wales (although he listed one old record for Llanberis), and considered none of the ferns which he had seen from Snowdonia were this taxon, referring the latter to *C. regia*; he also stated that the Welsh ferns which he had referred to *C. regia* are always distinct from *C. fragilis* and unquestionably distinct from every other British fern. Hooker (1842) also considered that the Welsh ferns which Smith

had named as *C. regia* were correctly named, and, as well as a fern he had collected himself in North Wales, placed these under *C. alpina* Desv., whereas he treated '*C. angustata*' separately as a variant form of *C. dentata* (Sm.) Desv. (*C. fragilis* var. *dentata* Hook.) Neither author therefore considered the specimens from North Wales which match the ferns refound there in 2008 should be referred to the taxon '*angustata*', whereas the illustration in Moore (1859–1860) of *C. fragilis* var. *angustata* shows morphology not unlike that of those ferns. Additionally, *C. fragilis* examples recorded as var. *angustata* from elsewhere in Britain, e.g. v.c. 64 (Miall & Carrington 1862; Smith 1830) and others from v.c. 65 which I have seen, do not appear to match the Welsh ferns closely, the latter possibly being a taxon confined to North Wales.

I have examined Norwegian material in the herbarium of the University of Tromsø, collected or recently determined as *C. alpina* by local experts. Some of these specimens of *C. alpina* collected near Tromsdalen, where Backhouse had also reported it, had considerably less-divided pinnae and much broader pinnule segments when compared with those collected by Backhouse in Yorkshire, and were therefore quite unlike the latter. None of the Norwegian specimens, however, corresponded to the ferns from Snowdonia which are discussed in this paper, but their morphology confirms the high degree of variation found in *C. alpina*.

The chromosome number of British examples of *C. alpina* is unknown, but in mainland Europe plants have been reported to be hexaploid ($2n = 252$), for example, Jermy & Harper (1971); Vida (1974) (both as *C. regia*), whereas *C. fragilis* is usually tetraploid ($2n = 168$), but hexaploids have been reported (Stace 1997). Vida (1974) further suggested that hybrids between these two species were frequent in Europe, were intermediate in morphology between the parents, and were pentaploid. Page (1982) stated that pentaploid examples of *C. fragilis* had been found in Britain.

CONCLUSIONS

Definite specimens of *Cystopteris alpina* have not been collected in Britain since 1911, but ferns which were found in 2008 at two localities in North Wales share several characters with this species, and bear considerable resemblance to it. The Welsh

ferns, however, do not conform to the classic British specimens of *C. alpina* from Upper Teesdale (Tennant 1995: Fig 1) in all of their characters, whereas in some characters the two are virtually indistinguishable. The most significant difference being the acute teeth of the pinnule segments and the vein-endings in mature fronds, although the latter character has not always been universally accepted in a strictly diagnostic sense for *C. alpina*. Backhouse and Salmon had both rejected some Welsh specimens as *C. alpina*, whereas earlier, Hooker and Smith had accepted others, the former perhaps as they had a narrower concept of this species than that adopted later by Stansfield, Kestner and others, although it is not known whether the Welsh plants fall within the range of *C. alpina* found in mainland Europe. If the character of the vein-endings is of paramount importance diagnostically for *C. alpina*, then the Welsh plants can not be accepted as this species. The Welsh populations are uniform and from their morphology appear to be confined to North Wales, although the specimens referred to above from Orkney and Skye require to be compared. The Welsh plants either represent a variety of *C. fragilis* which may be confined to this area, or a variant of *C. alpina*. At least two similar specimens collected in Wales in herbaria were proposed to be *C. fragilis* var. *angustata* auct., but British experts had clearly disagreed about whether the ferns from North Wales were referable to this taxon or not. If the Welsh ferns in question do represent a variety of *C. fragilis*, whether the var. *angustata*, or an undescribed variety which is confined to that area, then most, if not all of the old Welsh records for

C. alpina (e.g. Griffith 1895) would be incorrect. The Welsh ferns, however, share so many characters with the true *C. alpina* that they are likely to be affiliated with it in some way. They could represent an extreme variant of *C. alpina*, but as their morphology is somewhat intermediate between this species and *C. fragilis*, a more plausible explanation might be that the Welsh plants originated as hybrids, which arose as a cross between *C. alpina* and *C. fragilis*. In this case *C. alpina* formerly occurred in Wales, but is probably now only extant in the form of a hybrid. The chromosome number of such a hybrid would be most likely to be pentaploid (Vida 1974), and now that two localities have been rediscovered in Wales, chromosome studies are desirable as an initial step to resolve the identity of these Welsh ferns.

Additional locations for this taxon are very likely to occur in North Wales, and further British and European herbarium collections should be examined to establish whether they contain similar material, and how such specimens have been treated.

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REFERENCES

- GRIFFITH, J. E. (1895). *The Flora of Anglesey and Carnarvonshire*. Bangor.
- HOOKE, W. J. (1842). *The British Flora*. Vol. 1. Longman, London.
- HOOKE, W. J. (1861). *The British Ferns*. Lovell, Reeve & Co., London.
- HYDE, H. A. & WADE, A. E. (1948). *Welsh Ferns*. 2nd ed. National Museum of Wales, Cardiff.
- JERMY, A. C. & HARPER, L. (1971). Spore morphology of the *Cystopteris fragilis* complex. *British Fern Gazette* 10: 211–213.
- KESTNER, P. (1930). *Cystopteris alpina* Desv. *British Fern Gazette* 6(2): 33–37.
- LEES, F. A. (1888). *The Flora of West Yorkshire*. Lovell, Reeve & Co., London.
- LEES, F. A. (1939). *The vegetation of Craven in Wharfedale*. T. Buncle & Co., Arbroath.
- LOWE, E. J. (1876). *Our Native Ferns*. Volume 2. G. Bell, London.
- MIAL, L. C. & CARRINGTON, B. (1862). *The Flora of the West Riding*. W. Pamplin, London.
- MOORE, T. (1859–1860). *The Nature Printed British Ferns*. Volume 2. Bradbury & Evans, London.
- MURPHY, R. J. & RUMSEY, F. J. (2005). *Cystopteris diaphana* (Bory) Blasdell (*Woodsiaceae*) – an overlooked native new to the British Isles? *Watsonia* 25: 255–263.
- PAGE, C. N. (1982). *The Ferns of Britain and Ireland*. Cambridge University Press, Cambridge.
- SMITH, J. E. (1830). *The English Flora*, edn. 2, 4: 289. Longman, London.

- STACE, C. A. (1997). *New Flora of the British Isles* (2nd edn). Cambridge University Press, Cambridge.
- STANSFIELD, F. W. (1929). *Cystopteris alpina* Desv. *British Fern Gazette* **6** (1): 15–19.
- TENNANT, D. J. (1995). *Cystopteris fragilis* var. *alpina* Hook. in Britain. *The Naturalist* **120**: 45–50.
- TENNANT, D. J. (1996). *Cystopteris dickiana* R. Sim in the central and eastern Scottish Highlands. *Watsonia* **21**: 135–139.
- TUTIN, T. G., BURGESS, N. A., CHATER, A.O., EDMONDSON, J. R., HEYWOOD, V. H., MOORE, D. M., VALENTINE, D. H., WALTERS, S. M., & WEBB, D. A., eds (1993). *Flora Europaea*. Volume 1, edn 2. Cambridge University Press, Cambridge.
- VIDA, G. (1974). Genome analysis of the European *Cystopteris fragilis* complex. *Acta Botanica Academiae Scientiarum Hungaricae* **20**: 181–192.

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Long-term changes in the size of an Alpine Gentian, *Gentiana nivalis* L., population in Scotland

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ABSTRACT

The density of *Gentiana nivalis* (Alpine Gentian) plants in herb-rich grassland at Ben Lawers, Perthshire had been much reduced after ten years of artificial protection from summer grazing by large herbivores. The restoration of summer grazing from 1997 resulted in a partial recovery by 2006. The recovery of this annual species was associated with an increase in the amount of bare soil, so providing seed beds essential to the establishment of new plants. Thus grazing and trampling are clearly important elements in the conservation of *G. nivalis* populations in herb-rich grassland.

Where sheep had been allowed to graze each summer from 1987 to 2006, an overall decline in the *G. nivalis* population size was coincident with a progressive increase in the height of perennial plants. Over the same period, the climate became warmer, wetter and there was less snow. There is no convincing evidence of a direct effect of this climate change on the *G. nivalis* population. However, warm, wet springs have apparently encouraged the growth and spread of perennial vegetation to the detriment of *G. nivalis* establishment. Plants on incompletely vegetated cliff ledges have not been so affected, presumably because they are less exposed to competition from perennials.

KEYWORDS: climate change, grazing, herb-rich grassland, montane annual, competition.

INTRODUCTION

This paper documents changes observed in the size of a *Gentiana nivalis* L. (Alpine Gentian) population in grazed herb-rich grassland and considers possible causes. *G. nivalis* is a rare montane annual, regarded as 'vulnerable' (Wigginton 1999). The main British population is located near to the summit of Ben Lawers, Perthshire, Scotland (56°33'N, 4°14'W). Here it grows on partially vegetated cliff ledges

as well as on grazed, herb-rich grassland below. Geddes (1996) identified the cliff vegetation as the *Dryas octopetala*-*Silene acaulis* ledge community, CG14 in the National Vegetation Classification (Rodwell 1992), whilst the grassland is the *Festuca ovina*-*Alchemilla alpina*-*Silene acaulis* dwarf herb community, CG12. Other small *G. nivalis* colonies occur on nearby hills as well as at a more distant site, Caenlochan Glen, Angus.

Grazing by sheep is a major cause of mortality amongst *G. nivalis* plants in the grassland at Ben Lawers (Batty *et al.* 1984). Despite this, it appeared that sheep might actually help to sustain the population by repeatedly cropping perennials and by creating seed beds through their trampling. Confirmation came from an experimental study in 1987–1996 (Miller *et al.* 1999) which showed that protection from summer sheep-grazing resulted in an appreciable reduction in *G. nivalis* numbers. Plant numbers on the 'control' plots grazed by sheep each summer also declined over the ten years of the experiment, though the trend was less conspicuous and not statistically significant.

Sheep-grazing was restored from 1997 onwards and changes in *G. nivalis* population size were recorded for a further ten years. The aims here were (a) to establish the extent of any recovery on the previously ungrazed 'test' plots, and (b) to investigate further the apparent decline on the 'control' plots which were always grazed.

At Caenlochan Glen, many years of heavy grazing by red deer (*Cervus elaphus* L.) are thought to have caused the decline and recent disappearance of *Gnaphalium norvegicum* Gunnerus (Highland Cudweed) and *Cicerbita alpina* (L.) Wallr. (Alpine Blue-sow-thistle) in an adjacent glen (Geddes & Payne 2006).

In view of the vulnerability of *G. nivalis* at this location, a small population has been counted annually from 1982 to 2006. These observations are also recorded here and compared with those from Ben Lawers.

METHODS

BEN LAWERS

The study area has been described by Miller *et al.* (1999) in terms of its location, vegetation, soils and vertebrate herbivores.

Data recording in 1997–2006 was similar to that already described (Miller *et al.* 1999) for the preceding ten years. In summary, eight pairs of permanently-marked plots, established in July 1987, were examined every summer over a period of 3–5 days in late-July or early-August. Each plot was 70 cm × 50 cm. One plot of each pair remained as the 'control', i.e. open to sheep-grazing each summer since 1987. The nearby 'test' plot was no longer protected from grazing by sheep, i.e. previously-ungrazed plots were now exposed to the same treatment as the control plots. In each plot, *G. nivalis* plants were recorded and their flowers counted. In addition, the mean height of the perennial vegetation was obtained from 20 measurements per plot and the percentage cover of bare soil, as defined by Miller *et al.* (1999), recorded.

CAENLOCHAN GLEN

At Caenlochan Glen the location of the small *G. nivalis* population under study is on a steeply sloping west-facing outcrop that is not readily accessible to sheep or red deer. Perennial vegetation occupies about 60% of the site whilst bare soil, gravel and rock accounts for the remaining 40%.

A 1 m × 1 m permanent plot was established here in August 1982. The number of *G. nivalis* plants was counted in late-July or early-August every year from then until 2003. In 2004–2006, counting was in late-August or early-September.

ANALYSIS AND PRESENTATION OF DATA

Trends in the population size of *G. nivalis* with the passage of time were examined by linear regression analysis. On the Ben Lawers test plots, the ungrazed period, 1987–1996, and the subsequent grazed period, 1997–2006, were analysed separately. On the control plots, the entire data set for 1987–2006 was used in a single calculation. In these analyses, the

number of years that had elapsed since 1987 was taken as the independent variable, with *G. nivalis* density (transformed to log_e) as the dependent variable. The data for the single plot at Caenlochan Glen were analysed in the same way.

The significance of the regression coefficients was assessed by t-test. Similar analyses were undertaken for vegetation height and for the amount of bare soil at Ben Lawers.

RESULTS

DENSITY OF *GENTIANA NIVALIS* PLANTS

In 1987–1996, when protected from sheep-grazing, the mean density of *G. nivalis* plants on the test plots at Ben Lawers decreased steeply, at a rate of 0.24 plants per plot per year (Fig. 1a). After restoration of grazing in 1997, plant density increased over the following nine years at a rate of 0.08 plants per plot per year (Fig. 1a). Thus recovery was much slower than the decline.

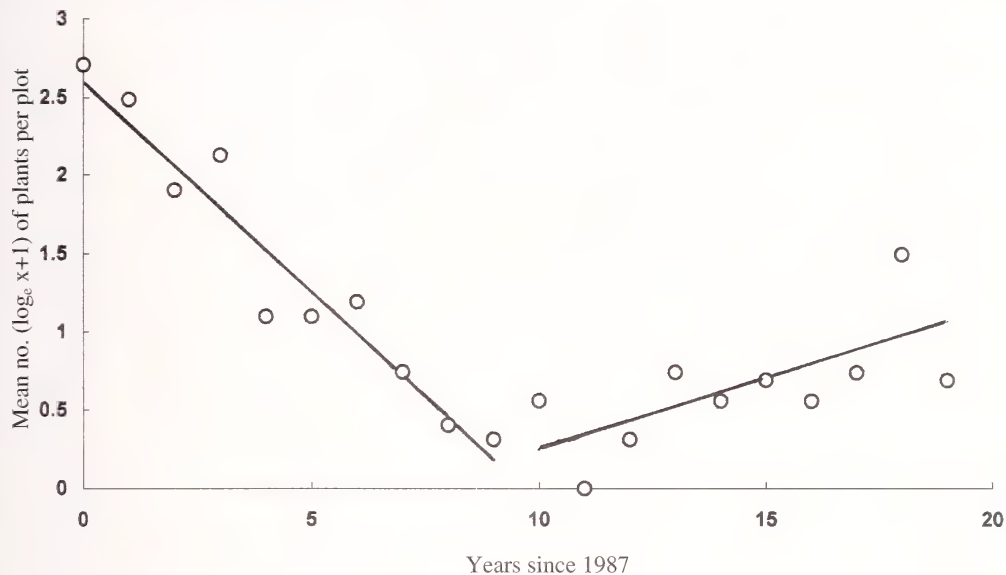
Figure 1b shows that fluctuations in mean *G. nivalis* density at Ben Lawers had greater amplitude on the control plots than was the case on the test plots. Nevertheless the steady decline previously observed in 1987–1996 continued through 1997–2006. There is no significant difference in the slopes of the regressions for these two periods and the overall rate of decline over 20 years is 0.6 plants per plot per year.

As on the control plots at Ben Lawers, the number of *G. nivalis* plants on the single plot at Caenlochan Glen fluctuated widely, from none in 1995–1996 to 73 plants in 1982 (Fig. 2). In fact the population fluctuations at these two sites are broadly synchronous as they are positively correlated ($r = +0.46$, $p = 0.040$). However, at Caenlochan Glen there is no evidence of any consistent reduction in population size over the 25-year period.

AMOUNT OF BARE SOIL AT BEN LAWERS

When protected from sheep-grazing, the mean cover of bare soil in the test plots decreased sharply, from 4.3% in 1987 to 0.25% in 1996 (Fig. 3a). Restoration of grazing resulted in an equally rapid increase to 7.7% in 2006, although the extent of this recovery was exaggerated due to a massive rock fall at one of the plots early in 2006. By contrast there was no consistent trend in the amount of bare soil in the control plots where it varied between 5.3% and 11% (Fig. 3b).

(a) Ungrazed 1987–1996, grazed 1997–2006



(b) Grazed 1987–2006

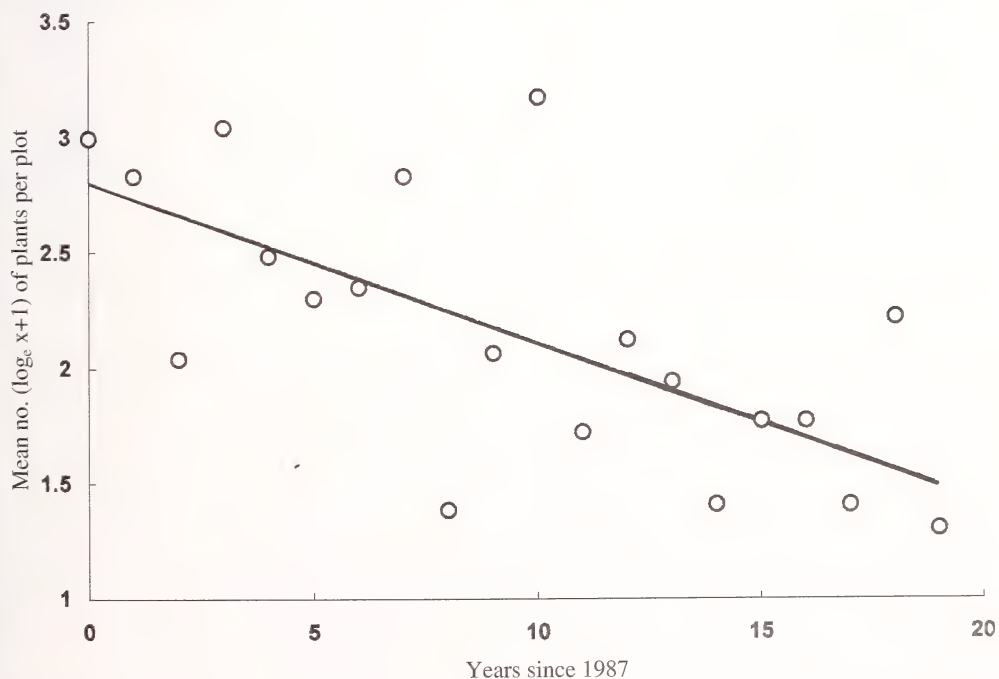


FIGURE 1. Regression analyses of *Gentiana nivalis* density at Ben Lawers against time on (a) plots ungrazed from 1987 to 1996 ($b = -0.27$, $p = 5.9 \times 10^{-6}$) and then grazed from 1997 to 2006 ($b = +0.082$, $p = 0.043$), and (b) plots grazed from 1987 to 2006 ($b = -0.066$, $p = 0.0013$).

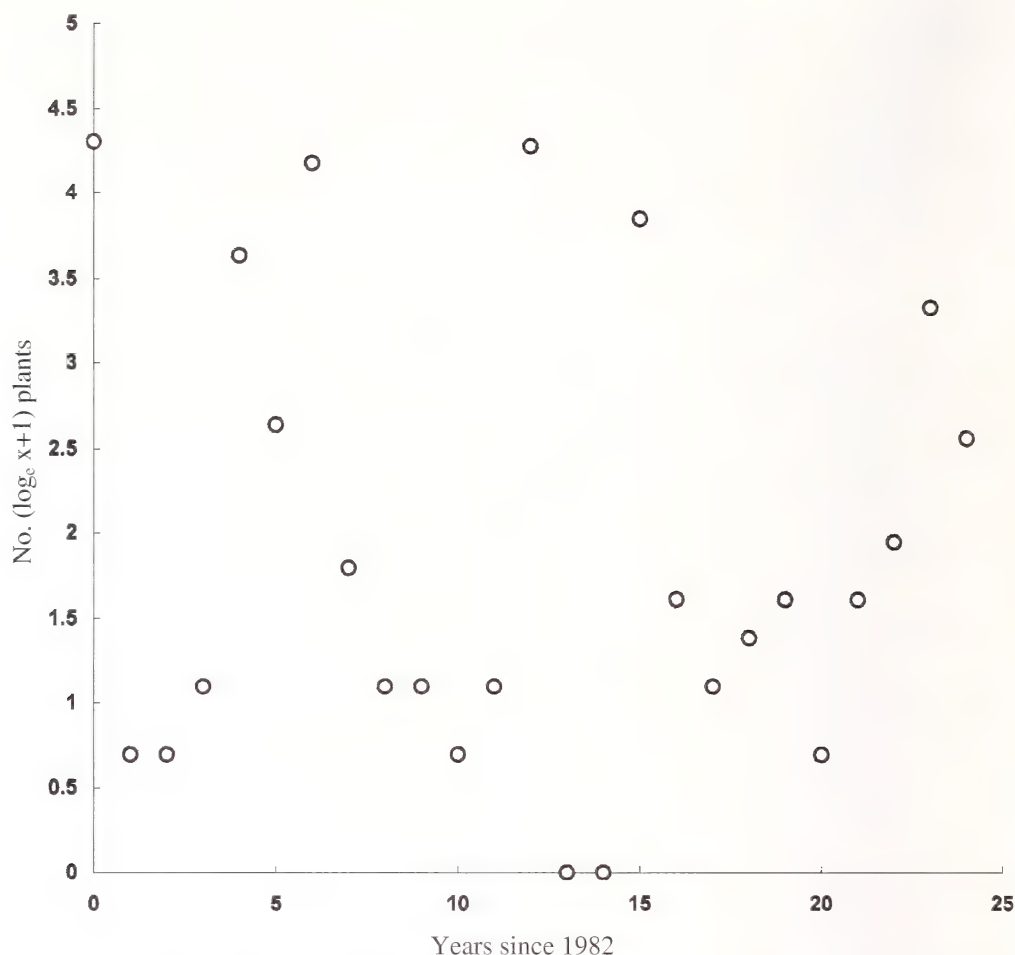


FIGURE 2. Regression analysis of *Gentiana nivalis* density at Caenlochan Glen against time on a single plot open to grazing from 1982 to 2006 ($b = -0.075$, $p = 0.72$).

HEIGHT OF PERENNIAL VEGETATION AT BEN LAWERS
Protection from sheep-grazing resulted in an almost doubling of the mean height of perennial vegetation between 1987 and 1996 (Fig. 4a). Restoration of grazing reversed this trend. On the control plots, a sustained increase in height of approximately 1 mm per year occurred so that by 2006 the perennial vegetation stood approximately 20 mm taller than it did in 1987 (Fig. 4b).

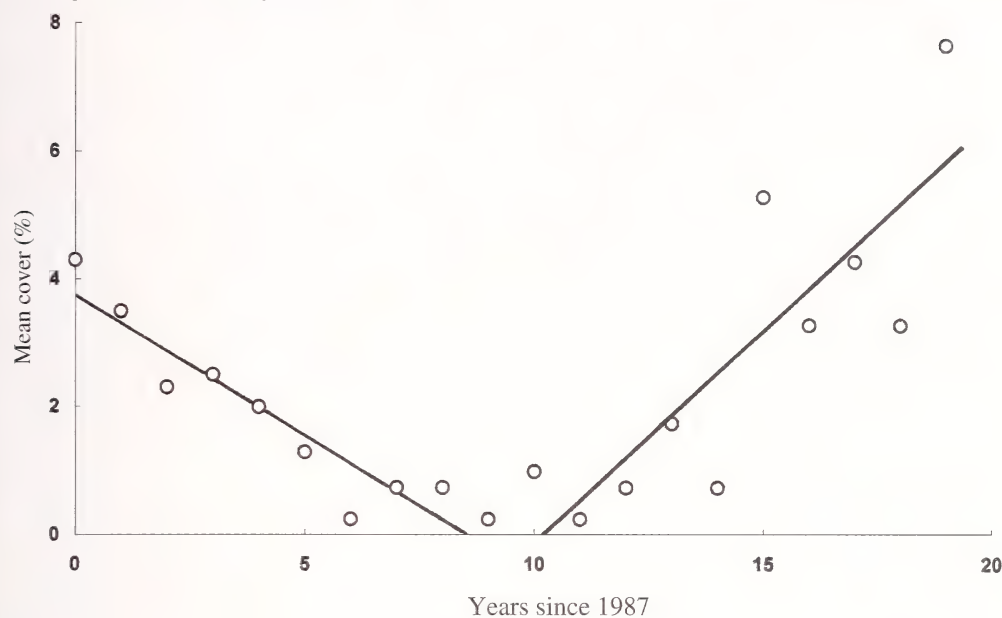
DISCUSSION

BEN LAWERS TEST PLOTS

Miller *et al.* (1999) concluded that losses from the *G. nivalis* population on plots protected from sheep-grazing might have been caused

primarily by a decline in the amount of bare soil, thus resulting in the decreased availability of suitable seed beds. The number of seed capsules formed in the previous year was another possible factor. Although seed availability is clearly important, large numbers are produced annually (Miller *et al.* 1999; Miller & Geddes 2004) and there is a large long-lived seed bank (Miller 2004). Thus it seems likely that it was the rapid increase in the amount of bare soil following the restoration of grazing on the test plots (Fig. 3a) that accounted for the partial recovery of the *G. nivalis* population. This confirms a previous conclusion (Miller *et al.* 1999) that grazing and trampling by sheep, and possibly also by red deer, are crucial in sustaining this species in herb-rich grassland.

(a) Ungrazed 1987–1996, grazed 1997–2006



(b) Grazed 1997–2006

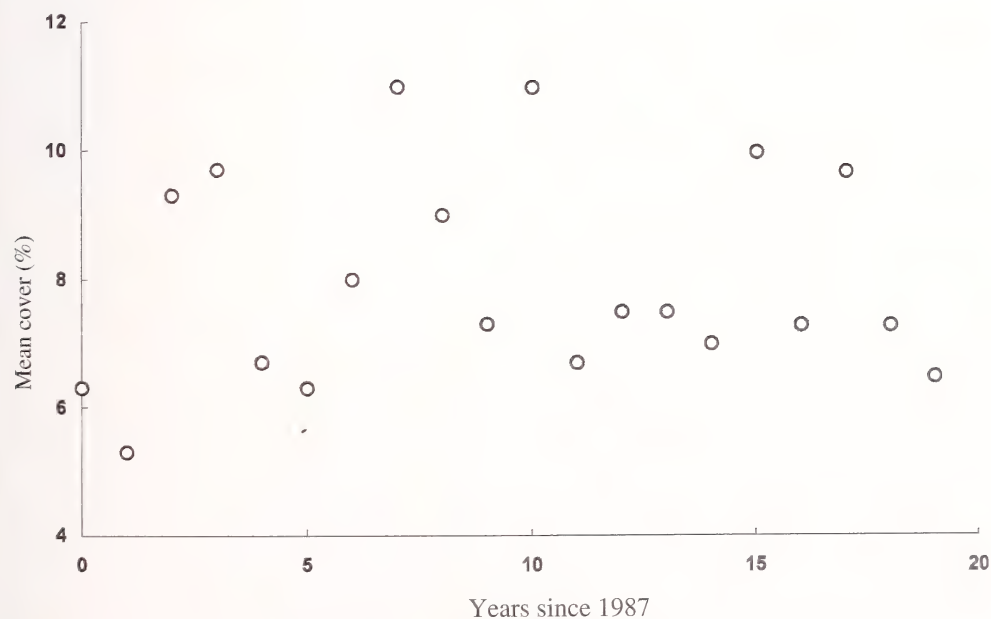
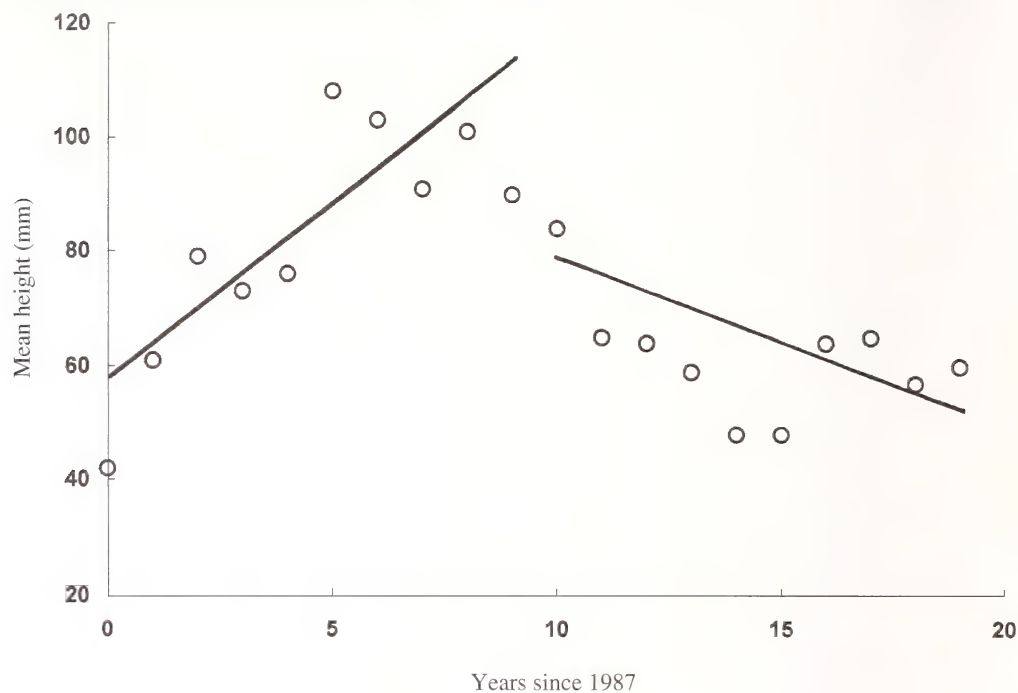


FIGURE 3. Regression analyses of amount of bare soil in July at Ben Lawers against time on (a) plots ungrazed from 1987 to 1996 ($b = -0.43$, $p = 0.00047$) and then grazed from 1997 to 2006 ($b = +6.6$, $p = 0.0032$), and (b) plots grazed from 1987 to 2006 ($b = +0.023$, $p = 0.73$).

(a) Ungrazed 1987–1996, grazed 1997–2006



(b) Grazed 1997–2006

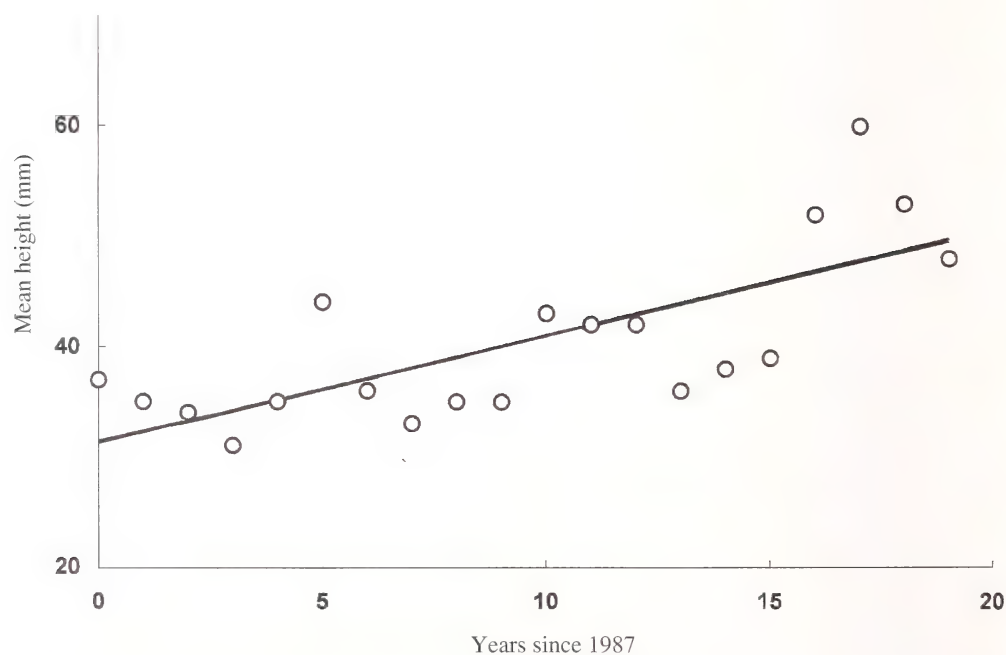


FIGURE 4. Regression analyses of height of perennial vegetation in July at Ben Lawers against time on plots ungrazed from 1987 to 1996 ($b = +5.4$, $p = 0.0055$ and then grazed from 1997 to 2006 ($b = -2.4$, $p = 0.039$), and (b) plots grazed from 1987 to 2006 ($b = +0.93$, $p = 0.00034$)

The incomplete recovery of *G. nivalis* numbers on the test plots is perhaps unsurprising given that numbers were simultaneously decreasing on the control plots. Presumably factors causing these losses must have been operating on both sets of plots.

BEN LAWERS CONTROL PLOTS

Big fluctuations in *G. nivalis* numbers have long been recorded from Ben Lawers and from the adjacent hills (Batty *et al.* 1984; Geddes 1992; Miller *et al.* 1999). However, the variability at Caenlochan Glen in 1982–2006 seems to be around a long-term mean level which neither increased nor decreased (Fig. 2). In contrast, the 20-year decline in the population size of *G. nivalis* at Ben Lawers (Fig. 1b) is indisputable and may threaten the long-term survival of the species in the herb-rich grassland.

Where grazing had continued normally in 1987–1996, Miller *et al.* (1999) concluded that variations in seed production in the preceding autumn and the height of the perennial vegetation in the current year may have controlled *G. nivalis* establishment. The possible role of seed availability has been discussed and discounted above. On the other hand, competition from tall vegetation for space, light, water and nutrients is likely to reduce germination and seedling establishment. On the control plots, perennial vegetation became steadily taller from 1987 to 2006 (Fig. 4b) as the density of *G. nivalis* declined. Indeed, there is a broad inverse correlation between these two parameters ($r = -0.42$) but it is barely significant ($p = 0.064$).

INFLUENCE OF GRAZING

Signs or sightings of red deer were never noted at the Ben Lawers study area and those of mountain hares (*Lepus timidus* L.) rarely so. Grazing impacts were largely due to sheep. Records of sheep density on Ben Lawers during the last few decades have always remained as 'estimates', ranging from 1.0 to 2.5 animals ha⁻¹ throughout July–August (Batty *et al.* 1984; Miller *et al.* 1999; Dayton 2007). At the study area 2–4 ewes, each with a single lamb, were usually seen from 1987–2006 during each summer visit of 3–5 days. But single period visits do not provide reliable counts of animals present throughout the summer. On the grazed plots, additional observations of sheep activity (trampling, dunging and the presence of uprooted *G. nivalis* plants)

varied little over the 20-year period of summer visits. Furthermore, Dayton (2007) reported a high long-term herbivore impact on those samples of vegetation located nearest the study area and this was attributed mainly to sheep. It has been concluded, therefore, that grazing pressure did not change significantly at the study area during 1987–2006.

INFLUENCE OF PERENNIAL VEGETATION

Small annual species such as *G. nivalis* are likely to be vulnerable to competition from taller perennial species. Thus Kelly (1989) found that short-lived species germinated poorly where the height of surrounding grassland vegetation exceeded 30 mm and that subsequent plant survival was also inversely related to vegetation height. At Ben Lawers, the height of perennial vegetation on the control plots increased steadily from about 30 mm in 1987 to about 50 mm by 2006 (Fig. 4b).

G. nivalis germinates and establishes itself at two separate seasons (Batty *et al.* 1984). Plants that establish in autumn, when perennial vegetation is fully grown and competition is maximal, survive over winter and mostly develop into tall, multi-flowered individuals in the following year. Spring establishment, on the other hand, usually yields small, single-flowered plants which will be less subject to competition from perennial vegetation that is yet to begin to grow.

Correlations between the numbers of single- and multi-flowered *G. nivalis* plants and the height of perennial vegetation in the same and in the previous July are all negative (Table 1). The association between multi-flowered plants and the previous summer's vegetation is significant, implying that competition from tall perennial vegetation might limit autumn establishment. All other correlations are insignificant although that between single-flowered plants and the current summer's vegetation is suggestive. However a strong correlation here would be unexpected as the height of perennial vegetation in July would not closely reflect its height in the spring of the same year when growth is just beginning.

Therefore increasing competition from perennial vegetation seems the most likely explanation for the gradual loss of *G. nivalis* plants. Indeed, no overall decrease in *G. nivalis* density was recorded at two other sites with much bare ground and only scattered perennial vegetation – Caenlochan Glen (Fig. 2) and an ungrazed rock outcrop at Ben Lawers (Geddes 2008).

TABLE 1. CORRELATIONS BETWEEN HEIGHT OF PERENNIAL VEGETATION IN JULY AND DENSITY OF SINGLE-FLOWERED AND OF MULTI-FLOWERED *GENTIANA NIVALIS* PLANTS

No. of flowers per plant	Height of perennial vegetation in			
	current July		previous July	
	r	p	r	p
1	-0.38	0.097	-0.25	0.29
2+	-0.34	0.14	-0.56	0.013

INFLUENCE OF CLIMATE

Associations between the fluctuations in *G. nivalis* density in 1987–2006 and climatic variation at Ben Lawers were explored using data from Ardtalnaig Meteorological Station (56°32'N, 4°07'W). Although located some 7 km from the study area and 900 m lower in altitude, it has been assumed that the meteorological data would reflect differences amongst years near the summit of Ben Lawers. Three climatic variables were examined – air temperature, precipitation and number of snow/sleet days (Meteorological Office, pers. comm., 2008). These parameters showed clear trends during 1987–2006 of warming temperature, increasing precipitation and fewer days with snow, which accords with climate scenarios predicted for the UK (Hulme & Jenkins 1998).

Climatic variation could influence the population size of an annual species in three ways (Levine *et al.* 2008): (i) direct effects on germination and establishment, (ii) direct effects on established plants, and (iii) indirect effects mediated by the surrounding vegetation. Hence correlations were sought between the mean number of single-flowered and of multi-flowered *G. nivalis* plants on the Ben Lawers control plots and (a) temperature and rainfall during the two main germination periods, August–September and May–June (Batty *et al.* 1984), (b) temperature and rainfall during the main growing period, May–August, and (c) the number of snow/sleet days in October–May, which might influence the survival of plants established in autumn (Miller & Geddes 2004). Despite the general warming trend concurrent with the decline in *G. nivalis* numbers, none of these climatic variables, either singly or in combination, provide a statistical explanation.

No specific information on the amount and duration of snow cover is available for either the Ben Lawers or the Caenlochan Glen study areas. However, a survey of the number and

size of summer snow patches in north-east Scotland (Watson *et al.* 1994) includes data for 1982–1989 when *G. nivalis* plants were counted at Caenlochan Glen. There is no evidence of any relation between snow cover and *G. nivalis* density during that period. Yet the synchrony between the fluctuations at Ben Lawers and those at Caenlochan Glen, about 65 km away, suggests that some aspect of year-to-year climatic variation is a contributory factor. Unmeasured variables such as soil temperature or the depth of winter snow-lie might be important here.

There is, however, a clear association between annual variations in the height of perennial vegetation in the grazed plots at Ben Lawers in 1987–2006 and the mean minimum temperature ($r = +0.62$, $p = 0.0035$) and total precipitation ($r = +0.50$, $p = 0.026$) in April–June, the beginning of the growing season at 1000 m altitude. Increasing heat and moisture in spring seems a plausible explanation for the long-term increase in vegetation height on the study area.

It therefore seems reasonable to conclude that some unknown climatic factor might account for the year-to-year fluctuations in the population size of *G. nivalis* plants. However the overall decline in population size in the Ben Lawers control plots can be explained as an indirect effect of climate change mediated by the enhanced growth of perennial vegetation. Climate change during the 20-year monitoring period seems to have had an impact similar to that produced by protection from grazing in 1987–1996, namely an increase in the height of perennial vegetation with a consequent loss of *G. nivalis* habitat. If the present climatic trends continue, the survival of the *G. nivalis* population in herb-rich grassland at Ben Lawers must be in doubt. By contrast, plants on partially vegetated cliff sites appear to have been unaffected so far.

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REFERENCES

- BATTY, P. M., BATTY, B. D. & MILLER, G. R. (1984). Population size and reproduction of *Gentiana nivalis* L. at Ben Lawers N.N.R. *Transactions of the Botanical Society of Edinburgh* **44**: 269–280.
- DAYTON, N. (2007). An assessment and evaluation of herbivore impacts on designated habitats in the Breadalbane hills. Commissioned report (ROAME No. R07AC208). Scottish Natural Heritage, Inverness.
- GEDDES, C. (1992). Records of numbers of *Gentiana nivalis* plants: Ben Lawers range 1987–1992. Unpublished report. The National Trust for Scotland, Killin, Perthshire.
- GEDDES, C. (1996). Vegetation survey of Ben Lawers cSAC. Unpublished report. Scottish Natural Heritage, Battleby, Perthshire.
- GEDDES, C. (2008). Records of numbers of *Gentiana nivalis* plants on an isolated rock outcrop below the southwest crags of Ben Lawers (2000–2008). Unpublished report. The National Trust for Scotland, Killin, Perthshire.
- GEDDES, C. & PAYNE, A. G. (2006). Loss of *Gnaphalium norvegicum* from Angus Scotland. *BSBI News* **102**: 26–27.
- HULME, M. & JENKINS, G. (1998). *Climate change scenarios for the UK: scientific report*. UKCIP Technical report 1. Norwich Climate Research Unit.
- KELLY, D. (1989). Demography of short-lived plants in chalk grassland. II. Control of mortality and fecundity. *Journal of Ecology* **77**: 770–784.
- LEVINE, J. M., MCEACHERN, A. K. & COWAN, C. (2008). Rainfall effects on rare plants. *Journal of Ecology* **96**: 795–806.
- MILLER, G. R. (2004). Size and longevity of seed banks of alpine gentian (*Gentiana nivalis* L.). *Botanical Journal of Scotland* **56**: 93–102.
- MILLER, G. R. & GEDDES, C. (2004). Seed-setting by alpine gentian (*Gentiana nivalis* L.). *Botanical Journal of Scotland* **56**: 85–92.
- MILLER, G. R., GEDDES, C. & MARDON, D. K. (1999). Response of the alpine gentian *Gentiana nivalis* L. to protection from grazing by sheep. *Biological Conservation* **87**: 311–318.
- RODWELL, J. S., ed. (1992). *British Plant Communities. Vol 3. Grasslands and montane communities*. Cambridge University Press, Cambridge.
- WATSON, A., DAVISON, R. W. & FRENCH, D. D. (1994). Summer snow patches and climate in northeast Scotland, U.K. *Arctic and Alpine Research* **26**: 141–151.
- WIGGINTON, M. J., ed. (1999). *British Red Data Books. I. Vascular Plants*. Appendix 2. 3rd edition. Joint Nature Conservation Committee, Peterborough.

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Further notes on some of J. H. Penson's Scottish records

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ABSTRACT

Entries in his field note-books suggest that J. H. Penson considered he had discovered several *Carex* taxa new to the British Isles. Until recently no specimens were known which supported this view but some have recently come to light and provide an opportunity to examine his assertion.

KEYWORDS: *Carex* hybrids, *Carex bicolor*, *Carex capitata*, *Carex divisa*, *Carex livida*, Cairngorms, *Saxifraga caespitosa*, Scotland, *Veronica fruticans*.

INTRODUCTION

In a previous paper (Foley 2006) an account was given to the background and botanical work of the previously little-known British botanist John Hubert Penson (1893–1979). Attention was drawn to some of his plant records of special interest and to others which appeared somewhat contentious, especially of *Carex* taxa. Since publication of the paper further specimens collected by Penson have now been located and examined.

Penson was a very thorough and enthusiastic botanist who usually worked alone and never published anything. Only rarely was he in contact with a few contemporary associates such as Robert Mackechnie, Alan Stirling and Basil Ribbons. His early life in government circles was spent in England, followed by a military period abroad during World War 1. Later, he was in America and Newfoundland on behalf of the British government and details of his time there is covered elsewhere (Foley 2006). During his early years he botanised in England but, following a move across the Atlantic in the 1930s, his interest transferred to the plants of the east coast of North America. Notes and specimens of his which are relevant to this period are retained in three major herbaria: the Herbar Marie-Victorin, Montréal (MT), the Smithsonian Institute, Washington (US) and the New York Botanical Garden (NY). These were considered by his contemporaries to be of major significance for the American flora. Around the mid-1950s, on his retirement from government work, he moved to

Scotland and it was there that for the rest of his life his main botanical activities lay. Based in the Glasgow area and presumably aided by his new, itinerant type occupation (he was still described as a 'Sales Representative' on his (re-) marriage certificate at the age of 81), he spent much time exploring the plants of the Scottish mountains as well as other areas closer to his home.

Wherever Penson botanised, he was always on the look-out for rarities or for possible new additions to the British flora. However, apart from his relatively un-detailed notebooks, it has been difficult to substantiate his claims in respect to new records, as his modest collection of voucher specimens has become scattered in various locations, with many of them thought to be lost. Recently, following the discovery of an overlooked package in the Glasgow herbarium (GL), some of his claims regarding *Carex* taxa as possibly being new to the British Isles, have been examined.

PENSON'S MORE CONTENTIOUS *CAREX* RECORDS

All the specimens quoted below are currently held in GL. It is possible that ultimately these may be combined with his other material in E.

CAREX BICOLOR:

An abnormally small specimen of *Carex atrata* collected by Penson from Ben Heasgarnich, Mid-Perth (v.c. 88), at 3100 feet, on 5 July, 1973, is described on the sheet as "*Carex* sp. resembling *C. bicolor*". His note-book for that day also states: "*Carex bicolor* (?) (group of plants on rock and on open marshy ground at 3000', NE of summit, ½ mi, needs confirmation as fruits at early stage)". Apart from the specimen's size (which is similar to *C. bicolor*) it is clearly *C. atrata*. *C. bicolor* exhibits a much greater colour contrast between utricle and glume, a more compact inflorescence, and distinctly glaucous leaves. *C. bicolor* is not recorded for the British Isles other than the erroneous one resulting from Heslop-Harrison's infamous introduction on the Isle of Rhum (v.c. 104).

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CAREX CAPITATA:

Three sheets purporting to be *C. capitata* are all clearly referable to *C. dioica*. They were collected by Penson from the west side of Ben Hope, W Sutherland (v.c. 108) at an altitude of 700 feet on July 30, 1973. One sheet contains Penson's taxonomic notes in support of his determination whilst a letter from Penson to Basil Ribbons written a week later revised the site's altitude to 500 feet and gave the approximate grid reference as NC465512 (i.e. the same as for his "*Carex livida*" locality, see below). *C. capitata* is a readily-recognised plant, frequent in Scandinavia and elsewhere, but has not been reliably confirmed from the British Isles. The discovery of these specimens confirms the conclusion regarding their identity drawn previously (Foley 2006).

CAREX DIVISA:

There are two sheets which bear one and two specimens respectively collected by Penson from the shores of Loch Lomond at Balmaha, Stirlingshire (v.c. 86) on the 2, 16 & 30 June 1973. Both sheets are labelled "*Carex divisa*" by Penson who indicated that the population had been damaged by flooding soon after he had found it. His notebook for June 2 & 16 makes no mention of these collections but on 30 June he stated "*Carex divisa* [and also confirming] plants damaged in flood-water but 2 heads recovered and recognisable, generally confirmed". However, his specimens are in fact *C. disticha*.

CAREX LIVIDA:

There are five sheets collected by Penson, all of which he considered to be *Carex livida*. Four are collections from the western side of Ben Hope, the fifth contains two more Ben Hope specimens mixed with a collection from wet pine woods below Ben Dubhcraig, Mid-Perth (v.c. 88). The Ben Hope plants were collected on 12 September, 1973 at an altitude of c. 700 feet where they were described as "abundant" (his notebook entry for that date also stating somewhat enigmatically "As before. *C. livida* (rather abundant)". On the herbarium sheets, one collection is said to be from an altitude of c. 400 feet whilst that on the mixed sheet, which also contains a specimen collected a year earlier (20 September, 1972), was from wet ground at c. 500 feet. No mention of *C. livida* is made in his notebook for the latter date. The Ben Dubhcraig plant were also collected in the previous year on 13

September, 1972 but again there is no mention made of *C. livida* in his notes. In a letter to Basil Ribbons (6 August, 1973) regarding his (erroneous) find of "*C. capitata*" (see above), Penson gave the approximate grid reference for that as being at NC465512, and stated that the *C. livida* locality is "almost the same".

C. livida is unknown in the British Isles but quite widespread in Scandinavia. It belongs to a species group containing *C. panicea* and *C. vaginata* and is morphologically quite close to the former. An examination of Penson's specimens ruled out *C. vaginata* since, amongst other characters, they lack the characteristic acuminate leaf tip of that species. Although showing a fairly close similarity to typical *C. panicea*, before dismissing them as such, they were compared with a limited number of preserved specimens of Scandinavian *C. livida*. This was still not totally conclusive, so images were sent to colleagues in Norway who know both species well. The resulting consensus was that Penson's plants were most definitely *C. panicea* and not *C. livida*. The latter is a less elongated and less slender plant, has stems which are shorter than the longest leaves, much denser, more contiguous spikes, and glumes with a very distinct whitish nerve. This is clearly not the case in Penson's material. In addition, *C. livida* is a plant of extremely wet mire pools, i.e. much wetter than perhaps can be inferred from Penson's simply "wet ground".

CAREX SAXATILIS × *C. NORVEGICA* (OR *C. SAXATILIS* × *ATRATA*):

A collection (two specimens) which Penson referred to this hybrid was made in "Glen Fee, [alt.] 2200', 25 July, 1961". Again however, his notebook gives no indication of the find, nor of his having actually visited Coire Fee (v.c. 90) on that day although he had spent time on nearby Craig Rennet and the Dounalt recording *C. capillaris*, *C. vaginata* and others. The utricles of Penson's purported hybrid specimens appear flat and empty and the plants are small and immature. They show a distinct similarity to *C. atrata* and are probably that taxon, although, due to their immature state, it is not possible to be certain.

There are three further specimens on a single sheet which he collected as "perhaps hybrid *saxatilis* × *norvegica* L. (or *saxatilis* × *atrata*)" on Ben Heagsarnich, at 2400 feet, on 5 July 1973. However, his notebook for this date doesn't mention these, only recording 80–100

flowering spikes of *C. norvegica* at an altitude of 2400 feet. These were growing amongst rather long grass at a point one mile east of the summit of the mountain and 300 yards north of an 'erratic block'. There is no mention in the notes of any potential hybrid and even his note on the sheet appears to have been an afterthought. The utricles of the specimens appear to be well developed and exhibit no real evidence of hybridity although they superficially resemble certain specimens of Scandinavian hybrids of this parentage (but in those cases the utricles were empty). The conclusion is that Penson's specimens are simply *Carex saxatilis*.

Penson, whilst searching for the saxifrage at Mackechnie and Wallace's 1930s site in Coire nan Clach (Beinn a'Bhuird), recorded *Veronica fruticans* there. His notebook states: "a few plants at 3400 ft". This plant is very scarce in the Cairngorms, apparently otherwise known only from Creag an Dhail Beag and, as with *S. caespitosa*, favours base-rich intrusions in the rock. Penson failed to find the latter in the coire but he did re-locate it near to the Sneck of Slochd Mhor, Beinn A'an, his notebook entries for August 7 and September 24, 1970, recording 5 and 18–20 plants respectively. No specimen of either of these species has been traced and it is unlikely that Penson collected any.

PENSON'S RECORDS FOR *SAXIFRAGA CAESPITOSA* AND
VERONICA FRUTICANS IN THE CAIRNGORMS

In 1970, Penson made two visits to the Beinn A'an and Beinn a'Bhuird area of the Cairngorms. These must have been long, tiring days for a man approaching his eighties as he searched for the very scarce *Saxifraga caespitosa*. He, no doubt, would have obtained details of the plant's previously known localities from Robert Mackechnie who, along with Ted Wallace, had seen the plant there many years earlier. On September 24, 1970,

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REFERENCE

FOLEY, M. J. Y. (2006). J. H. Penson: mystery man and mystery record. *Watsonia* **26**: 171–178.

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Notes

AN OVER-LOOKED POPULATION OF *PULSATILLA VULGARIS* MILL.
IN SOUTH LINCOLNSHIRE (V.C. 53)

On 25 April 2009, a single flowering plant of *Pulsatilla vulgaris* was discovered at a new site by Richard Jefferson and Fiona Hart on a west-facing slope of Swinstead Valley Site of Special Scientific Interest (S.S.S.I.), near Swinstead, South Lincolnshire (v.c. 53, TF007222). The site was visited again on the 4 May, when a further patch was located close-by and on 6 May when a more detailed search by Richard Jefferson and Kevin Walker revealed a total of four “plants”. Two had flowered but in both cases the inflorescences had been removed by sheep or rabbits. The other two plants were small and had not flowered. All were located within a 20 × 5 m area on an exposed “shoulder” of limestone grassland on the east side of a narrow valley. The plants were on a moderately steep (c. 30°) west-facing slope (280–310°N) where the vegetation had been kept very short by rabbit and sheep grazing (2.0 ± 0.2 cm based on 10 measurements adjacent to each clump). The vegetation was species-rich (20–30 species m⁻²) and had good fit to *Brachypodium pinnatum*-*Bromus* [*Bromopsis*] *erectus* grassland (74% fit to CG5a, typical sub-community) as described by the National Vegetation Classification (NVC) (Rodwell 1992). The most abundant species were *Bromopsis erecta*, *Festuca ovina*, *Helianthemum nummularium*,

Sanguisorba minor and *Thymus polytrichus* (Table 1). This appeared to be the only area of short-turf CG5a as the majority of slopes supported taller CG5a (*Brachypodium pinnatum*-*Bromus* [*Bromopsis*] *erectus*) grassland. The only other threatened species (after IUCN 2001) present was *Astragalus danicus*, a few patches of which occurred within a few metres of the *Pulsatilla*. The slope forms part of the Swinstead Valley S.S.S.I., notified in 1989 for its species-rich limestone grassland, although *Pulsatilla* and *Astragalus* are not mentioned in the citation.

This appears to be the first discovery of a new population of *Pulsatilla* in England for over 100 years as the majority of new twentieth century records appear to be rediscoveries of old sites or simply the first published accounts of long known sites (Walker *et al.* in prep). Of the 120 or so known populations only 18 survive in 19 10-km squares (Table 2). Half of these sites hold less than 100 plants whereas the three largest populations support around 150,000 in total (Therfield Heath, Barnack Hills and Holes, Barnsley Wold).

In Lincolnshire, Gibbons (1975) noted that *Pulsatilla* was “formerly widespread on [Jurassic] limestone grassland in the County”. This is likely to be an over-estimate as the

TABLE 1. % COVER OF SPECIES GROWING WITH *PULSATILLA VULGARIS* IN SWINSTEAD VALLEY, LINCOLNSHIRE (1M² QUADRATS)

Species	Q1	Q2	Species	Q1	Q2
<i>Brachypodium pinnatum</i>	4	8	<i>Leontodon hispidus</i>	2	12
<i>Briza media</i>	+	+	<i>Linum catharticum</i>	+	+
<i>Bromopsis erecta</i>	15	12	<i>Lotus corniculatus</i>		3
<i>Campanula glomerata</i>	+	1	<i>Medicago lupulina</i>		2
<i>Campanula rotundifolia</i>	+	1	<i>Picris hieracioides</i>	+	
<i>Carex caryophylllea</i>	+	+	<i>Pilosella officinarum</i>	2	5
<i>Carex flacca</i>	4	1	<i>Primula veris</i>	+	1
<i>Carlina vulgaris</i>		+	<i>Pulsatilla vulgaris</i>	+	+
<i>Cirsium acaule</i>	10		<i>Sanguisorba minor</i>	15	25
<i>Crataegus monogyna</i>		+	<i>Scabiosa columbaria</i>	2	2
<i>Festuca ovina</i>	20	15	<i>Senecio jacobaea</i>		+
<i>Galium aparine</i>		+	<i>Succisa pratensis</i>	+	
<i>Galium verum</i>	1	+	<i>Taraxacum officinale</i>	1	+
<i>Helianthemum nummularium</i>	15	5	<i>Thymus polytrichus</i>	10	12
<i>Helictotrichon pratense</i>		+	<i>Viola hirta</i>		+
<i>Koeleria macrantha</i>	+	+	Number of species	23	28

TABLE 2. EXTANT SITES FOR *PULSATILLA VULGARIS* IN ENGLAND WITH INDICATION OF GEOLOGY, MANAGEMENT & POPULATION SIZE

Site	VC	10-km	Geology/Management	Size
Church Hill, Therfield Heath	20	TL33	Chalk, winter grazing	E
Aston Upthorpe Down	22	SU58	Chalk, ungrazed enclosure	B(R)
Steps Hill, Incombe Hole	24	SP91	Chalk, intermittent grazing	B
Devil's Dyke-Newmarket Heath	29	TL66	Chalk, part grazed/ungrazed	C
Barton Hills	30	TL03	Chalk, grazed exc. 1-3	D
Ravensburgh Castle, Barton Hills	30	TL02	Chalk, ungrazed	B
Deacon Hill	30	TL12	Chalk, part grazed/ungrazed	A
Knocking Hoe	30	TL13	Chalk, grazed	D
Barnack Hills and Holes	32	TF00	Limestone, grazed exc. 3-9	E
Barnsley Wold Warren	33	SP00	Limestone, grazed exc. 3-5	E
Beaumonts Hay	33	SP12	Limestone, irregular grazing	A
Bourton Downs	33	SP13	Limestone, grazed exc. 4-8	C
Hornsleasow Roughs	33	SP15	Limestone, grazed exc. 3-5	C
Taylor's Hill, Hilcot	33	SP01	Limestone, grazed	C
Rodborough Common, Minchinampton	34	SO80	Limestone, light mowing/grazing	B
Ancaster Valley	53	SK94	Limestone, winter grazed	B(R)
Swinstead Valley	53	TF02	Limestone, summer grazed	A
Ledsham	63	SE43	Limestone, winter grazed	A(R)

Code for population sizes: A, 1-10; B, 11-100; C, 101-1000; D, 1001-10000; E, 10000-100000; (R), total includes reintroduced plants.

TABLE 3. RECORDED SITES FOR *PULSATILLA VULGARIS* IN LINCOLNSHIRE WITH INDICATION OF THE YEAR OF FIRST AND LAST RECORD WHERE POPULATIONS ARE NOW KNOWN TO BE EXTINCT. LISTED IN ORDER OF THE YEAR OF LAST RECORD

Site	VC	10-km	First record	Last record
Lincoln Heath (Blackstone Hill)	53	SK96	1746	1746
Ropsley Heath	53	SK93	1790	1790
Colsterworth (part of Lincoln Heath)	53	SK92	<1800	1800
Ashby-de-la-Launde	53	TF05	1836	1836
Brauncewell	53	TF05	1800	1855
Billinghay	53	TF15	1873	1873
Great Ponton, Stoke Rochford, between	53	SK93	1886	1886
Great Ponton	53	SK93	1886	1891
Grantham	53	SK93	1893	1893
West Willoughby Quarry (Copper Hill), Ancaster	53	SK94	1886	1894
Temple Bruer	53	TF05	1900	1900
Stamford, near	53	TF00	1928	1928
Byard's Leap, near	53	TF04	1944	1967
Heydour Warren, Ancaster	53	SK94	1967	1967
Holywell Mound	53	TF01	1948	1988
Honington Camp	53	SK94	1914	1992
Ancaster Valley	53	SK94	1886	Extant
Swinstead Valley	53	TF02	2009	Extant
Glentham, near	54	SK99	1878	1878
Stainton le Vale	54	TF19	1878	1878
Epworth	54	SE70	1895	1895
Castlethorpe	54	SE90	1857	1903
Broughton Far Wood	54	SE91	1875	1969

records for v.c. 53 and 54 show that it has always been a localised plant (Table 3). It was last recorded in North Lincolnshire at Broughton Far Wood (Clapgate Pits) in 1968. It was formerly more widespread in South Lincolnshire where there are records for 18 sites, although some of these may be synonymous. Most were lost during the eighteenth and nineteenth centuries due to the ploughing up of downland following Parliamentary Enclosure (Wells 1968, 1969; Jones 1969). More recent losses, such as at Holywell Mound and Honington Camp, occurred due to agricultural improvement or the loss of grazing on isolated grassland sites. It currently survives on two sites, including the site described in this note. The population at Ancaster Valley faced extinction in the 1980s due to the encroachment of gorse scrub. This has since been removed and grazing re-introduced. A few of the original plants have survived and seed from these have been used to produce plants for reintroduction onto the same slope.

Pulsatilla vulgaris is classed as Vulnerable in Great Britain under IUCN criteria (IUCN 2001), and is a priority species under the UK Biodiversity Action Plan [<http://www.ukbap.org.uk/PrioritySpecies.aspx?group=9>]. The discovery of the Swinstead population therefore represents a very significant new discovery both locally and at a national level.

It is intriguing to speculate as to why the *Pulsatilla vulgaris* population on this site has been over-looked until now. Its early flowering time, perhaps when many botanists are less active, combined with a small population on a part of the site with no public access until relatively recently (access permitted to open country (downland) following enactment of the Countryside & Rights of Way Act 2000) may be possible explanatory factors. It is very probable though, given the habitat, location and association with *Astragalus danicus* that this is a truly native locality for this most charismatic of grassland species.

A more thorough survey of the slope and the whole site is planned for 2010 will hopefully reveal a more extensive population.

ACKNOWLEDGMENTS

We thank James Marshall of Natural England for seeking formal access permission to undertake a detailed assessment of the population and to describe the associated vegetation. Permission was granted by the Grimsthorpe Estate (Chris Howes) to whom we are very grateful. We are also grateful to Clare Pinches and Phil Horton for their comments on an earlier version of this note.

REFERENCES

- GIBBONS, E. J. (1975). *The Flora of Lincolnshire*. Lincolnshire Natural History Brochure No. 6, Lincolnshire Naturalist's Union, Lincoln.
- JONES, F. (1969). The decrease of *Pulsatilla vulgaris* in England. *Biological Conservation* 1: 327–328.
- IUCN (2001). *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission, IUCN, Gland, Switzerland and Cambridge, UK.
- RODWELL, J. S., ed. (1992). *British Plant Communities. Volume 2. Grassland and montane communities*. Cambridge University Press, Cambridge.
- WALKER, K. J., PINCHES, C. E. & WELLS, T. C. E. (in prep). Under-grazing and the decline of *Pulsatilla vulgaris* Mill. (Ranunculaceae) in England, UK.
- WELLS, T. C. E. (1968). Land use changes affecting *Pulsatilla vulgaris* in England. *Biological Conservation* 1: 37–44.
- WELLS, T. C. E. (1969). The decrease of *Pulsatilla vulgaris* in England – A reply to Dr E. F. Jones. *Biological Conservation* 1: 328–329.

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THE FIRST BRITISH RECORDS OF *POTAMOGETON COMPRESSUS* L.
AND *P. FRIESII* RUPR.

During the fieldwork for his *Catalogus plantarum circa Cantabrigiam nascentium*, John Ray (1660) came across a number of plants which did not appear to have been described in the existing literature. Several of these species were aquatics, perhaps a reflection of the relative lack of attention paid to these by earlier authors and of the richness of the aquatic flora around Cambridge. Amongst these was a species he listed on p. 124 as *Potamogeton ramosum caule compresso, folio graminis canini, nondum descriptum*, which can be translated as 'Branched *Potamogeton* with a flattened stem, and the leaf of *Gramen caninum*, not yet described'. (*Gramen caninum* is also listed in the *Catalogus*, p. 66, with the English name 'Common Quich-grasse' and is the plant we currently call *Elytrigia repens*, the Couch or Couch Grass of gardeners.) Smith (1797) and Babington (1860) interpreted Ray's plant as the pondweed we now call *Potamogeton friesii* Rupr., although confusingly their name for this species was *P. compressus* (Smith) or *compressus* (Babington). Most later authors have followed suit, including Clarke (1900) and Druce (1932), who both cite Ray's plant as the first British record of *P. friesii* (although Druce unaccountably dates it as 1590 rather than 1660), Perring *et al.* (1964) and Ewen & Prime (1975).

An alternative treatment of Ray's name is in the account of Potamogetonaceae which J. E. Dandy & G. Taylor contributed to Evans' (1939) *A Flora of Cambridgeshire*. They include the following entry:

[**P**[otamogeton] **acutifolius** Link. The only evidence of this as a Cambridgeshire species rests on a specimen in Buddle's herbarium at the British Museum, which, along with a specimen of *P. Friesii*, was described by Ray ("Hist. Pl.," i., 189 (1686)) under the name *Potamogiton caule compresso, folio Graminis canini*, and stated to occur copiously in the Cam near Cambridge and in many other rivers.]

Raven (1942) attributes the name to a third species, *P. zosterifolius* (the current *P. compressus*) though his note that "Ray's description suits this species better than *P. compressus*, the obscure form with which

Babington, l.c. [1860] p. 250, identifies it" suggests that Babington's *P. compressus* was a segregate of *P. zosterifolius* rather than the then accepted name for *P. friesii*.

In their draft monograph 'British species of Potamogeton L.', Dandy & Taylor make a detailed and (I think) incontrovertible case for regarding Ray's Cambridgeshire plant not as *P. friesii* or *P. acutifolius* but as *P. compressus*, as Raven had suggested. However, not many botanists interested in Ray's plants, or in the first records of British plants, or in the Cambridgeshire Flora, are likely to come across this unpublished manuscript. There were at least two copies in existence. Dandy's is now in the Archives of the Natural History Museum (DF 440/66). Taylor's was in his possession at the time of his death but is not specifically mentioned in the catalogue of his papers in the National Library of Scotland (Acc. 9533). It therefore seems desirable to make Dandy & Taylor's revised opinion more widely available.

Dandy & Taylor withdraw their earlier suggestion that Ray's plant was *P. acutifolius* in a footnote:

Our statement in A. H. Evans's "Flora of Cambridgeshire" (1939), p. 167, that specimens of *P. acutifolius* and *P. Friesii* were described by Ray (Hist. Pl. i: 189 (1686)) under the name *Potamogiton caule compresso folio Graminis canini* was due to the mistaken belief that Ray's descriptions (1686) were based on plants in Buddle's herbarium. Actually, of course, the *Potamogiton caule compresso* etc. of 1686 was based directly on the *Potamogeton ramosum caule compresso* etc. of 1660, and we know of no existing specimen which could be the basis.

Their main argument is given in the text dealing with *P. compressus* as follows:

The earliest definite record of this species from Britain is in Ray's "Catalogus Plantarum circa Cantabrigiam nascentium" (1660), though there is an undated and unlocalised specimen in the herbarium of R. Uvedale (1642–1722)¹. Ray described the species (op. cit.: 124, 125) under the name *Potamogeton*

¹Uvedale's herbarium is "one of the best-preserved in the Sloane Herbarium [BM], of which it forms volumes H.S. 302-315" (Dandy 1958).

ramosum caule compresso, folio graminis canini, and it is worth while reproducing his description in full because it has been generally misinterpreted as a description of *P. Friesii*, perhaps because it was confused with that species (*Potamogeton perpulchrum* etc. Plukenet) in the third edition of Ray's "Synopsis" (1724), p. 149. Ray's original description (1660) runs as follows:- *Caules cubitum & nonnunquam sesquicubitum excedunt, ramosi & valde compressi. Folia longa, angusta, graminis canini foliorum æmula, præterquam quòd ubique ferè ejusdem latitudinis sint, & in obtusum mucronem desinant, alternatim posita, nisi unde spicarum pediculi oriuntur, ubi bina ex adverso; in singulis nervi tres insigniores per folii longitudinem² decurrunt. Sub unoquoque folio membrana tenuis & pellucida caulem investit. Spica brevis, flores dilutè virides sustinens, quatuor foliolis constantes ad stylum incarnatis. Stylus duobus ut plurimum apicibus terminatur. Seminis vasculū ex altera parte rectā, ex altera circulari linea clauditur. Small branched Pondweed with a flat stalk. In the river Cam in many places.*

It might be useful to insert here a translation of Ray's description, kindly prepared by P. H. Oswald:

The branched & strongly flattened *stems* exceed a cubit & sometimes a cubit and a half. The *leaves* are long, narrow, approaching the leaves of couch-grass except that they are of almost the same width throughout & end in a blunt point, arranged alternately, except at the point whence the stalks of the flower-spikes arise, where they are two opposite each other; on each three more significant veins run along the whole length of the leaf. Under each leaf a thin & translucent membrane invests the stem. The flower-spike is short, bearing washed-out green *flowers*, consisting of four tepals which are flesh-pink near the style. The *style* ends in two points at most. The *seed* vessel is enclosed by a line that is straight on one side and curved on the other.

Dandy & Taylor's text continues:

It would be difficult to imagine a clearer short description of *P. compressus*, when we remember that the allied *P. acutifolius* was unknown to Ray. Most of the description, it is true, inevitably agrees also

with *P. Friesii*, but certain significant characters rule out that species. The expression "*Folia ... graminis canini foliorum æmula*" could rightly be used only of *P. compressus* and *P. acutifolius* (which is not known from the Cam), as these, with their many-nerved narrow leaves, are the only two British species which could possibly be said to have leaves like those of *Agropyron repens* (*Gramen caninum*). Further, the statement "*nervi tres insigniores*" implies three nerves more strongly marked than others, and this admirably fits *P. compressus*, for though the leaves of this species have five true vascular nerves interspersed with a large number of fine sclerenchymatous ones, the two outer vascular nerves are faint and it is the middle three which show up prominently. The description of the fruiting-carpel (*seminis vasculum*) applies much better to *P. compressus* than to *P. Friesii*; but it is the statement "*Stylus duobus ut plurimum apicibus terminatur*" which clinches the identity of Ray's plant, because in *P. compressus* the flowers usually have only two carpels, whereas in *P. Friesii* they have the normal complement of four. *P. compressus* has since Ray's time been collected in several places in the Cam about the Cambridge district.

The next species in Ray's "Catalogus" is *Potamogeton pusillum gramineo folio, caule rotundo* (= *P. Berchtoldii*) and in his description of this Ray states that it differs from the preceding species in size, "*quæ huic decuplò minor est*". Now *P. Berchtoldii* could scarcely be said to be ten times smaller than *P. Friesii*, but, allowing for some exaggeration, it might be described as ten times smaller than *P. compressus*.

There is little which needs to be added to Dandy & Taylor's text. *P. compressus* survived in the vicinity of Cambridge until 1848; it may have been one of the few plants to succumb to the notorious pollution of the river which resulted from the expansion of the city and the construction of sewers running into the river in the Victorian period (Preston 2008). There are also records downstream of Cambridge, until the species was last collected in 1912 at Roswell Pits, Ely, by the River Great Ouse downstream of its confluence with the Cam. Rather surprisingly, *P. compressus* reappeared

²This appears as 'longitudinem' in the monograph, clearly a typing error as Ray's original reads 'longitudinem'.

in the county in 2004 and 2005 in a quite different river system, the River Nene and the nearby Morton's Leam near Peterborough (Leslie 2006). Dandy & Taylor do not explain why they identify Ray's smaller species as *Potamogeton berchtoldii* rather than *P. pusillus*. Their decision was presumably based on the later specimens they had seen (Dandy & Taylor 1940 a, b), which would have suggested that *P. berchtoldii* was the commoner plant in Cambridgeshire and the only one recorded south of the Fens. Recent records suggest that *P. pusillus* is now more frequent.

The attribution of Ray's plant to *P. compressus* leaves *P. friesii* without an accepted first record. There are four very early specimens in the Sloane herbarium (BM) which are unlocalised and undated, all confirmed as *P. friesii* by Dandy & Taylor. They almost certainly date from the 17th or very early 18th century, and are in the herbaria of C. Merrett (1614–1695), H.S. vol. 19, fol. 125, J. Banister (1654–1692), vol. 168, f. 280, L. Plukenet (1642–1706), vol. 97, fol. 122 and A. Buddle (c. 1660–1715), vol. 117, fol. 27 n. 35 (in part). The Plukenet specimen may be the basis for his (1696) *Potamogeton perpulchrum nostras lucens angustissimus longis & obtusis foliis pallide virentibus*, which is also unlocalised and which Dandy & Taylor considered the first published record. As Dandy & Taylor mention in their account of

P. compressus, Plukenet's name was included as a synonym of Ray's Cambridge taxon in Dillenius' edition of Ray's *Synopsis methodica Stirpium Britannicarum* (1724). These species continued to be confused until the late 18th century, and the first clear account of *P. friesii* appears to be Smith's text and Sowerby's accompanying plate of '*P. compressum*' in *English Botany* (Smith 1797), although (as mentioned above) Smith cites Ray's name in synonymy. He describes the species as "not very uncommon in ditches and slow streams about London, and other parts of Great Britain". The oldest localised British specimen appears to have been one labelled Eton, July 1796 (BM), with no collector, which is listed in Dandy & Taylor's card index of checked specimens, but it is no longer present in BM and was presumably damaged or destroyed with many other *Potamogeton* specimens when the Natural History Museum was blitzed in the Second World War.

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REFERENCES

- BABINGTON, C. C. (1860). *Flora of Cambridgeshire*, p. 250. John van Voorst, London.
- CLARKE, W. A. (1900). *First records of British flowering plants*, ed. 2, p. 155. West, Newman & Co., London.
- DANDY, J. E. (1958). *The Sloane herbarium*. British Museum (Natural History), London.
- DANDY, J. E. & TAYLOR, G. (1940a). Studies of British Potamogetons. – XII. *Potamogeton pusillus* in Great Britain. *Journal of Botany Britain and Foreign* 78: 1–11.
- DANDY, J. E. & TAYLOR, G. (1940b). Studies of British Potamogetons. – XIII. *Potamogeton Berchtoldii* in Great Britain. *Journal of Botany Britain and Foreign* 78: 49–66.
- DRUCE, G. C. (1932). *The Comital Flora of the British Isles*. T. Buncle & Co., Arbroath.
- EVANS, A. H. (1939). *A Flora of Cambridgeshire*, p. 167. Gurney & Jackson, London & Edinburgh.
- EWEN, A. H. & PRIME, C. T., trans. & ed. (1975). *Ray's Flora of Cambridgeshire* (Catalogus Plantarum circa Cantabrigiam nascentium), p. 98. Wheldon & Wesley, Hitchin.
- LESLIE, A. (2006). Vascular plant records. *Nature in Cambridgeshire* 48: 91–96.
- PERRING, F. H., SELL, P. D., WALTERS, S. M. & WHITEHOUSE, H. L. K. (1964). *A Flora of Cambridgeshire*, p. 225. Cambridge University Press, Cambridge.
- PRESTON, C. D. (2008). The aquatic plants of the River Cam and its riparian commons, Cambridge, 1660–1999. *Nature in Cambridgeshire* 50: 18–37.
- PLUKENET, L. (1696). *Almagestum botanicum*, p. 304. London.
- RAVEN, C. E. (1942). *John Ray naturalist: his life and works*, p. 93. Cambridge University Press, Cambridge.
- [RAY, J.] (1660). *Catalogus plantarum circa Cantabrigiam nascentium*. Cambridge.
- RAY, J. (1686). *Historia plantarum. Tomus Primus*, p. 189. London.
- RAY, J. (1724). *Synopsis methodica Stirpium Britannicarum*, ed. 3, p. 149. London.
- SMITH, J. E. (1797). *Potamogeton compressum*, in *English Botany*, volume 6, t. 418. London.

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Plant Records

Records for publication must be submitted to the appropriate Vice-county Recorder (see *BSBI Year Book*), and not to the Editors. Following publication of the *New Atlas of the British & Irish Flora* and the *Vice-county Census Catalogue*, new criteria have been drawn up for the inclusion of records in *Plant Records*. (See *BSBI News* no. 95, January 2004 pp10 & 11). These are outlined below:

- First records of **all** taxa (species, subspecies and hybrids) included in the VCCC, designated as native, archaeophyte, neophyte or casual.
- First record since 1970 of the taxa above, except in the case of *Rubus*, *Hieracium* and *Taraxacum*.
- Records demonstrating the rediscovery of all taxa published as extinct in the VCCC or subsequently.
- Newly reported definite extinctions.
- Deletions from the VCCC (e.g. through the discovery of errors, the redetermination of specimens etc.) **NB** – only those errors affecting VCCC entry.
- New 10km square records for Rare and Scarce plants, defined as those species in the *New Atlas* mapped in the British Isles in 100 10km squares or fewer. (See *BSBI News* no. 95, January 2004 pp 36-43).

Records for the subdivisions of vice-counties will not be treated separately; they must therefore be records for the vice-county as a whole. However, records will be accepted for the major islands in v.cc. 100, 102-104, 110 and 113.

In the following list, records are arranged in the order given in the *List of Vascular Plants of the British Isles* and its supplements by D. H. Kent (1992), from which the species' numbers, taxonomy and nomenclature are taken. The Ordnance Survey national grid reference follows the habitat and locality. With the exception of collectors' initials, herbarium abbreviations are those used in *British and Irish Herbaria* by D. H. Kent & D. E. Allen (1984). Records are field records if no other source is stated. For all records 'det.' or 'conf.' appear after the herbarium if the determination was based on material already in an institutional herbarium, otherwise before the herbarium.

The following signs are used:

- * before the vice-county number: to indicate a new vice-county record.
- † before the species number: to indicate that the plant is an archaeophyte.
- ‡ before the species number: to indicate that the plant is a neophyte.
- © before the species number: to indicate that the plant is a casual.

The above 3 signs may also be used before the vice-county number to indicate the status of the plant in that vice-county.

® before the vice-county number: to indicate that this is an additional hectad for a Rare or Scarce plant.

Ø at end of entry: established taxon not in Vice-County Census Catalogue. Name of authority provided.

[] enclosing a previously published record: to indicate that that record should be deleted or changed.

Records are now published in two separate sections – 1) NATIVES (including archaeophytes) and 2) ALIENS (neophytes and casuals).

The following list contains the first set of records up to and including the year 2009. Further records including the year 2009 will be published in the next issue of *Watsonia*.

ARCHAEOPHYTES AND NATIVES

Huperzia selago 1/1.1. ©81, Berwicks.: one plant on forestry trackside, Hartside Hill, NT445543, M. E. Braithwaite, 2009. 1st record since 1896.

Lycopodium annotinum 1/3.2. @106, E. Ross: wet heath at 530m, Meall na Speireig, NH304700, B. R. & C. B. Ballinger, 2009. Site extends into NH36 at NH309699.

Equisetum xrothmaleri (**E. arvense** × **palustre**) 4/1.5×8. *62, N. E. Yorks.: large patch on waste ground of a long-abandoned nursery, near Love Lane, Pickering, SE802847, V. Jones & W. A. Thompson, 2008, conf. P. J. Acock, **herb. V. Jones, herb. P. J. Acock**.

Dryopteris affinis subsp. **cambrensis** 17/3.3b. *62, N. E. Yorks.: steep wooded slope below cliffs, Kay Nest, Tripsdale, SE583986, V. Jones & K. Trewren, 1996.

Dryopteris affinis subsp. **borreri** 17/3.3c. *106, E. Ross: Orrin Bridge, NH504532, A. C. Jermy & R. M. Walls, 1996. Omitted from VCCC. Further record made by R. Golding in 2009 at edge of pine plantation near Munlochry at NH647520.

Dryopteris xdevereri (**D. carthusiana** × **dilatata**) 17/3.8×9. *106, E. Ross: Orrin Bridge, NH504532, A. C. Jermy & R. M. Walls, 1996. Omitted from VCCC. Further record made by R. Golding in 2009, confirmed by K. Trewren, at edge of pine plantation near Munlochry at NH647520.

Dryopteris xsarvelae (**D. carthusiana** × **expansa**) 17/3.8×10. *62, N. E. Yorks.: five plants (possibly one connected plant) in damp deciduous woodland, East Arnecliffe Wood, Glaisdale, NZ791047, K. Trewren, 2007. Confirmed by chromosome count.

Dryopteris xambroseae (**D. dilatata** × **expansa**) 17/3.9×10. *62, N. E. Yorks.: single plant, edge of boggy patch in deciduous woodland, East Arnecliffe Wood, Glaisdale, NZ792048, K. Trewren, 1995. Confirmed by chromosome count. About 200 plants known in the wood in 2008.

Juniperus communis subsp. **communis** 21/4.1a. *52, Anglesey: coastal ravine, Holyhead Mountain, SH2182, B. Jones, 2004, det. J. Squirrell & P. M. Hollingsworth. Subspecies determined using molecular markers in 2008. Species 1st recorded by I. Bullock in 1978 and variously identified as subsp. *nana* and subsp. *hemispherica* but these records should be deleted.

Ranunculus parviflorus 28/13.7. 29, Cambs.: thousands of small plants on gravelly waste ground beside Chesterton Hospital, Union Lane, Cambridge, TL460599, A. C. Leslie, 2008, CGE. 1st record since 1928.

†**Ranunculus arvensis** 28/13.8. 41, Glam.: about 130 plants in arable field mostly near edge, Flemingston, St Athan, ST013694, J. P. Woodman, 2004-08. 1st record since 1970.

Ranunculus peltatus 28/13.24. *29, Cambs.: ditch, Chear Fen Engine Drain, Cottenham, TL466710, N. P. Millar, 2008, **BM**, conf. R. V. Lansdown. R. V. Lansdown commented that the abortion of many carpels, as well as the occurrence of lamina leaf shape instability, suggests a degree of hybridisation may be involved.

Fumaria capreolata 31/5.1. †81, Berwicks.: a few plants at foot of village wall, Cockburnspath, NT774710, M. E. Braithwaite, 2009. 1st record since 1878.

Ulmus xvegeta (**U. glabra** × **minor**) (Loudon) Ley 33/1.1×3. *‡52, Anglesey: single tree (possibly planted) in roadside hedge, Llandegfan, SH5673, A. Dixon, 2008, det. P. Denne. Ø

Beta vulgaris subsp. **maritima** 43/4.1a. *©81, Berwicks.: one large plant on sand and boulder beach, Ewelairs, NT789713, M. E. Braithwaite, 2009. Recent colonisation.

Montia fontana subsp. **amporitana** 45/3.1c. 45, Pems.: plants growing on cattle-poached muddy margins to ponds, Cromlech valley, Longhouse, Abercastle, SM849336, S. B. Evans & A. E. Evans, 2008. 1st record since 1970.

†**Polygonum rurivagum** 47/4.6. *62, N. E. Yorks.: abundant on boundary of arable at edge of Outgang Lane, near Thornton-le-Dale, SE844838, V. Jones & C. Wilson, 2007, **herb. V. Jones**.

†**Rumex pseudoalpinus** 47/8.6. @39, Staffs.: at 340m on edge of regraded limestone quarrying area, adjacent to road, Caldonlow, SK078481, I. J. Hopkins, 2008.

Rumex xlingulatus (**R. hydrolapathum** × **obtusifolius**) 47/8.10×19. 29, Cambs.: one vigorous clump on the north bank of the R. Nene, just west of the bypass bridge, March, TL402970, A. C. Leslie, 2008, CGE.

Rumex xruhmeri (**R. conglomeratus** × **sanguineus**) 47/8.14×15. *39, Staffs.: SE side of fishing lake, Clay Mills, SK261258, M. E. Smith, 2008.

Hypericum humifusum × **linariifolium** 51/1.10×11. *46, Cards.: rough grass by fence. MoD site, Aberporth, SN246515, A. O. Chater, 2008, det. N. K. B. Robson, NMW. *H. linariifolium* has not yet been seen in the vice-county.

Viola × **bavarica** (**V. riviniana** × **reichenbachiana**) 57/1.4×5. *39, Staffs.: quite frequent in a dry plateau under *Fraxinus*, Roughpark Wood, Herons Gate, SO808841, I. C. Trueman & E. V. C. Cohn, 2008.

Frankenia laevis 59/1.1. *‡62, N. E. Yorks.: 18 patches hanging over kerbstones, S side of A170, E of lay-by, Howkeld, W of Kirbymoorside, SE686856, W. A. Thompson, 2008, conf. E. J. Clement, herb. V. Jones. This was confirmed as the native plant and not a garden cultivar.

Rorippa islandica 62/12.3 *47, Monts.: about 12 plants at pool edge with more scattered around same pool (by west hide), Dolydd Hafren, SJ205003, A. O. Chater, 2008. *49, Caerns.: riverbank west of Afon Glaslyn, Beddgelert, SH5947, M. Wilcox & B. A. Tregale, 2008.

†**Diplotaxis tenuifolia** 62/33.1. *‡81, Berwicks.: several plants by harbour buildings, Cove Harbour, NT784717, M. E. Braithwaite, 2009. Relic from former cultivation.

Crassula tillaea 73/1.1. *‡46, Cards.: Ynys-las, SN69, W. Williams, 1947. Annotation in copy of Salter's *Flora* then belonging to Watkin Williams, UCW Aberystwyth, later Professor of Agricultural Botany at University of Reading, per G. Hutchinson. The earliest record from Wales, and doubtless introduced here by the military vehicles that used the dunes during the Second World War.

Rubus adenantoides 75/8.222. *57, Derbys.: trackside above Valehouse Reservoir, SK0397, D. P. Earl, 2008. Locally abundant. Known from other side of valley in Cheshire.

Potentilla × **mixta** (**P. anglica** × **reptans**) 75/9.14×15. *81, Berwicks.: a few plants in a woodland ride near Lithtillum Loch, NT804409, M. E. Braithwaite, 2009, conf. B. Harold.

Medicago minima 77/18.3. *©57, Derbys.: disturbed soil near Dore, Sheffield, SK286815, K. Balkow, 2007, det. B. A. Tregale & M. Wilcox. Ground disturbed by wall building next to road.

Trifolium glomeratum 77/19.5. *©57, Derbys.: disturbed soil near Dore, Sheffield, SK286815, K. Balkow, 2007, det. B. A. Tregale & M. Wilcox. Ground disturbed by wall building next to road.

Trifolium suffocatum 77/19.6. *©57, Derbys.: disturbed soil near Dore, Sheffield, SK286815, K. Balkow, 2007, det. B. A. Tregale & M. Wilcox. Ground disturbed by wall building next to road.

†**Lythrum hyssopifolia** 81/1.2. *‡49, Caerns.: in an area where grass turves had been removed and the resulting bare sandy earth had become colonised by annuals such as *Anagallis arvensis*, *Matricaria discoidea*, etc., North Wales Golf Course, Llandudno, SH776807, W. McCarthy, 2008, det. C. D. Preston.

Epilobium × **limosum** (**E. parviflorum** × **montanum**) 84/1.2×3. 29, Cambs.: one plant on road verge, Milton Road, Cambridge, TL458600, M. Wilcox & B. A. Tregale, CGE, conf. G. D. Kitchener. 1st record since 1913.

Epilobium × **palatinum** (**E. parviflorum** × **tetragonum**) 84/1.2×5. *46, Cards.: ditch, Tyrrhos farm, New Quay, SN378591, J. H. Salter, 1937, NMW, det. G. D. Kitchener. Determined in 2006.

Epilobium × **dacicum** (**E. parviflorum** × **obscurum**) 84/1.2×6. *29, Cambs.: on an area of waste land, High Fields, Basingbourn, TL333422, P. D. Sell, 2004, CGE, det. G. D. Kitchener.

[**Epilobium** × **dacicum** (**E. parviflorum** × **obscurum**) 84/1.2×6. *46, Cards.: rough track by new houses, Cefn-Illan, Llanbadarn Fawr, SN599815, S. P. Chambers, 2006, det. T. D. Pennington. The existing record for the v.c. in Wade (1952) and in the VCCC, and provisionally given in Ellis (1968), was based on a 1937 Salter specimen in NMW which is in fact *E. xpalatinum*.]

Circaea × **intermedia** (**C. lutetiana** × **alpina**) 84/6.1×2. *41, Glam.: wood edge / stream bank, Abercanaid, SO042041, J. P. Woodman, 2003. 1st confirmed record.

†**Mercurialis annua** 91/1.2. *50, Denbs.: Minera, SJ25, J. A. Green, 2007.

Euphorbia serrulata 91/2.7. *‡49, Caerns.: wall-base, Beddgelert, SH64, A. Showler, 2008.

Frangula alnus 92/2.1. 44, Carms.: several plants seen on lane sides, Llyn Llech Owain, SN565150, BSBI Glynhir Meeting, 2008. 1st record since 1970.

Bupleurum tenuissimum 107/26.3. 41, Glam.: 58 plants on upper edge of saltmarsh. West Aberthaw, ST013664, V. & A. Marshall (BSBI meeting), 2004, conf. J. P. Woodman. 1st record since 1970.

Centaureum erythraea 108/3.2. *106, E. Ross: forestry track, Benmore Forest, NC296083, B. R. & C. B. Ballinger, 2009, **herb. B. B.** Also found by forest track at Inveroykel West, NC473003.

Gentianella campestris 108/5.2. 41, Glam.: over 400 plants in dune grassland, Sker, Kenfig, SS789799, M. J. Clark, 2008, conf. J. Curtis. 1st record since 1970.

Gentianella amarella subsp. **septentrionalis** 108/5.4c. 106, E. Ross: sand dunes, Morrich More, NH807838, B. R. & C. B. Ballinger, 2009, **herb. B. B.** Confirms unlocalised BRC record for NH88 in 1971. Also found at Benmore Forest on 09/08/09 at NC297084 and on 05/10/09 at NC303090.

[†**Vinca minor** 109/1.1. 48, Merioneth. Delete. The record from Mallwyd, SH8.1, in *Watsonia* 27(3): 263(2009) is the first recent record for the hectad, not for the vice-county.]

Nymphoides peltata 113/2.1. *‡47, Monts.: a very small quantity in canal, near Wern Reserve, SJ2514, A. K. Thorne, 2008.

Myosotis ×suzae (*M. scorpioides* × *laxa*) 116/15.1×4. *47, Monts.: pool edge, Dolydd Hafren, SJ206003, A. O. Chater & M. Rand, 2008.

Hippuris vulgaris 119/1.1. *‡47, Monts.: a stand of 1 square metre in Montgomery Canal, Arddleen, SJ261159, A. K. Thorne, 2008. May have been introduced.

Verbascum ×brockmuelleri (*V. nigrum* × *phlomoides*) Ruhmer 124/1.9×5. *45, Pembs.: limestone quarry, Black Rock Quarry, Tenby, SN1200, F. L. Rees, 1942, NMW, det. V. Johnstone. In July 2008, the referee, V. Johnstone, determined the 1942 NMW specimen as this hybrid, as titled on the original label. *Fl. Pl. Wales* includes the record as erroneous. Ø

†**Kickxia elatine** 124/12.1. ‡48, Merioneth: garden weed at Penhelig, Aberdyfi, SN69, P. M. Benoit, 1985. A modest updating from pre-1970 in this, the only Merioneth site.

Euphrasia anglica × **nemorosa** 124/20.3×7. *48, Merioneth: sand dune turf, Morfa Harlech, SH53, G. Halliday, 1993, det. A. J. Silverside, LANC.

Campanula trachelium 129/1.12. *©45, Pembs.: green waste in paving slabs, St. David's Recycling Centre, SM785267, S. B. & A. E. Evans, 2008. Among a host of casuals seeded into the crevices between the paving in a little used part of the green waste temporary storage area.

Cirsium ×celakovskianum (*C. palustre* × *arvense*) 135/6.9×10. *52, Anglesey: rough grassland, Lligwy, SH496866, C. Aron, 2008, conf. K. Walker, **herb. I. R. Bonner**. *81, Berwicks.: damp grassland, Longcroft, NT531538, M. E. Braithwaite, 2002. Large colony, determined and confirmed in 2009.

†**Centaurea cyanus** 135/11.3. 46, Cards.: among dense growth of arable weeds from seed bank in turnip field, 600m NNW of Pen-rhiw, Capel Dewi, SN435422, A. O. Chater & B. & G. Harrison, 2008. 1st record as an arable weed since 1936.

Taraxacum hamiferum 135/25.90. *62, N. E. Yorks.: edge of woodland, Home Wood, Thirkleby, SE473795, V. Jones & W. A. Thompson, 2007, det. V. Jones, conf. A. J. Richards, **herb. V. Jones**.

Taraxacum pruinaum 135/25.97. *62, N. E. Yorks.: road verge, Ingleby Greenhow, NZ583065, V. Jones, 2008, det. A. J. Richards, **herb. V. Jones**.

Taraxacum stenacrum 135/25.201. *62, N. E. Yorks.: road verge, Green Lane near Hutton Rudby, NZ452057, V. Jones, 2007, conf. A. J. Richards, **herb. V. Jones**.

Taraxacum subundulatum 135/25.210. *62, N. E. Yorks.: grassland, road to Station Farm, Ingleby Greenhow, NZ579073, V. Jones, 2008, det. A. J. Richards, **herb. V. Jones**.

Hieracium virgultorum 135/28.1.2. *44, Carms: wall and railwayside, E of Burry Port Station, SN448007, G. Hutchinson, 1989, NMW, det. D. J. McCosh. 1st record since 1970. Also at SN449007.

[**Hieracium pollichiae** 135/28.7.58. 46, Cards.: disused railway cutting, Penyrangor, Aberystwyth, SN581808, A. O. Chater, 1993, NMW. Error. Delete. Specimen renamed as *H. spilophaeum*.]

Hieracium aviicola 135/28.7.avi. *44, Carms: limestone quarry, Coygan Quarry, Laugharne, SN285092, G. Hutchinson & R. D. Pryce, 1986, NMW, det. D. J. McCosh. Ø

Hieracium scanicum 135/28.7.sca. *44, Carms: grassy bank, Bethlehem, SN687253, J. Bevan, R. Burton, G. Hutchinson & R. D. Pryce, 1986, NMW, det. D. J. McCosh. Ø

Hieracium scotostictum 135/28.8.115. *44, Carms: limestone quarry, Banc-y-Mansel Quarry, Foelgastell, SN534149, T. & V. Lewis & K. A. & R. D. Pryce, 2005, det. D. J. McCosh, NMW.

- Hieracium clivicola** 135/28.8.cli. *44, Carmar: Bannau Sir Gaer, ?SN72orSN82. H. J. Riddelsdell, 1902, NMW, det. D. J. McCosh. Ø
- Hieracium sylvularum** 135/28.8.syu. Jord. ex Boreau *44, Carmar: roadside bank. S. of Llanarthne, SN530192. R. D. Pryce & K. A. Cottingham, 2002, det. D. J. McCosh, NMW. Ø
- Aster tripolium** 135/41.6. *©81, Berwicks.: one plant in saltmarsh, Ramsheugh Bay, NT777722, M. E. Braithwaite, 2009. Recent colonisation.
- †**Anthemis arvensis** 135/55.2. 41, Glam.: arable field, Bonvilston, ST061745, J. P. Woodman, 2006, herb. **J. P. W.** 1st record since 1971.
- Luronium natans** 137/3.1. ®39, Staffs.: Rushall Canal, Yew Tree, SP033960, C. R. Parry, 1998.
- Hydrocharis morsus-ranae** 138/1.1. 47, Monts.: extensive stands along canal margins extending across 3 monads, Montgomery Canal, Arddleen, SJ2515, A. K. Thorne, 2008. 1st record for 30 years; was thought to have become extinct.
- Potamogeton trichoides** 142/1.16. *©57, Derbys.: submerged in fishing pond, Darley Abbey, SK3538. T. Taylor, 2005. Pond has been stocked with fish & plants by an angling club.
- Arum italicum** 147/5.2. ‡44, Carmar: naturalised, presumably originally planted in curtilage hedge bank, Pentremeurig Road, Carmarthen, SN394205, R. D. & K. A. Pryce, 2008. 1st record since 1970.
- Lemna gibba** 148/2.1. 52, Anglesey: shallow pool, Glyn Dwr, Valley, SH2879, R. Lansdown, 2008. 2nd record and 1st since 1964.
- Juncus ×surrejanus (J. articulatus × J. acutiflorus)** 151/1.13×14. *39, Staffs.: fields S of Castle Road, Holly Bank, Walsall Wood, SK054027, I. C. Trueman, 2008. *62, N. E. Yorks.: dominant in wet flush, E side of moorland track, near Castleton, NZ675094, V. Jones, 2008, conf. M. Wilcox.
- Juncus ×kern-reichgeltii (J. effusus × conglomeratus)** 151/1.26×27. *44, Carmar: acid laneside banks, ENE of Penllwydcoed, Alltwalis, SN459329, R. D. & K. A. Pryce, 2008.
- Cyperus longus** 152/11.1. *‡47, Monts.: on edge of pool at Dolydd Hafren, SJ201001, R. A. Dawes, 2004. Non-native site. Refound at SJ201001 and a second clump located at Dolydd Hafren, SJ207003, both by BSBI, 2008.
- [**Cyperus fuscus**, 152/11.3. *8, S. Wilts.: ditches and marsh, Breamore Marsh, SU1518, C. Chatters, 2002. Error. Delete. This record refers to v.c.11]
- [**Carex paniculata** 152/16.1. 48, Merioneth. Delete. The plants at Dolgoch, SH6.0, recorded in *Watsonia* 27(3): 263(2009) were the first recent record for the hectad, not for the vice-county.]
- Carex ×pseudoaxillaris (C. otrubae × remota)** 152/16.5×15. *44, Carmar: roadside bank, Waun-y-gwail-fach, Four Roads, Kidwelly, SN450088, A. Stevens, 2008, conf. A. O. Chater, NMW.
- Carex muricata subsp. muricata** 152/16.8a. *23, Oxon: two small clumps under sycamore, Warburg Reserve, SU718878, A. Showler, 2002, conf. M. S. Porter.
- Carex pallescens** 152/16.47. *50, Denbs.: forest road verge near Pont Petryal, Clocaenog, SJ038521, J. A. Green, 2008.
- Carex pilulifera** 152/16.55. 29, Cambs.: at least five clumps just to the west of the main hollow at Gamlingay Cinques, TL226529, D. J. Barden, A. C. Leslie & C. Turner, 2008. 1st record since 1956. C. Turner indicated that he had noted its reappearance 'a year or two ago'.
- Festuca rubra subsp. juncea** 153/12.7b. *‡39, Staffs.: gravel track off Collis Street, Amblecote, SO900857, M. E. Smith, 2001, conf. C. A. Stace. Presumably accidentally introduced with the gravel. Cultivated at recorder's home in Stourbridge prior to its confirmation.
- Festuca rubra subsp. litoralis** 153/12.7c. *62, N. E. Yorks.: locally frequent on N bank of R. Esk, E of Ruswarp, NZ891091, V. Jones & M. J. Yates, 2008.
- Festuca ovina subsp. hirtula** 153/12.8b. *39, Staffs.: on an old wall, Tutbury Castle, SK209290, M. E. Smith, 2008, det. C. A. Stace.
- Festuca arundinacea × Lolium multiflorum** 153/12×13.2×2. *©39, Staffs.: in shade on side of path through a small park, E of Sedgley, SO929935, C. B. Westall, 2008. Apparently from bird-seed.
- Agrostis ×murbeckii (A. capillaris × stolonifera)** 153/39.1×4. *39, Staffs.: pasture, NW of Tutbury, SK205296, M. E. Smith, 2008, det. T. A. Cope. Cultivated at recorder's home in Stourbridge prior to its confirmation.

Bromus hordeaceus subsp. **longipedicellata** 153/50.4lon. *39, Staffs.: roadside, King's Bromley, SK1216, L. Spalton, 2000.

†**Bromus secalinus** 153/50.7. ®©39, Staffs.: disturbed, re-seeded fringe of a new recreation field, Little Aston, SK093006, J. E. Hawksford, 2008. ®©39, Staffs.: edge of rape field, Staffordshire Way, N of Abbot's Bromley, SK090269, J. E. Hawksford, 2008. ®©39, Staffs.: near edge of wheat field, SW of Hoar Cross, SK114218, J. E. Hawksford, 2008. ®©39, Staffs.: in a wheat field, S of Tutbury, SK208278, R. D. Martin, 2008, det. J. E. Hawksford. 41, Glam.: frequent in large wheat field near coast, South of Boverton, SS981669, J. P. Woodman, 2002. 1st record since 1970 and only extant v.c. record.

Typha xglaucula (**T. latifolia** x **angustifolia**) 155/1.1x2. *57, Derbys.: emergent on side of pond, McGregor's Pond, SK386689, N. Law, 2007, det. P. R. & I. P. Green.

Convallaria majalis 158/13.1. *81, Berwicks.: patch 3x2m near *Sorbus rupicola* on ledge near top of crag, Gaitheugh, NT592343, L. W. Gaskell, 2009. Very possibly native.

Cephalanthera longifolia 162/2.2. 47, Monts.: two flowering plants and 7 very young plants with *Pteridium aquilinum* in oak woodland near Kerry, SO150880, M. Jannink, 2008. Found close to the original and only site. Not seen for 30 years.

Spiranthes romanzoffiana 162/7.3. *75, Ayr.: damp runnel within plateau bog, S of Barrhill, South Ayrshire, NX228808, M. Bates, 2009, conf. G. Walker. As with other *Orchidaceae* found in the VC for the first time in recent years and outwith their normal range, there is some speculation that seed may be blown in on the prevailing SW wind from populations in NE Ireland. Only one plant found so left entire and *in situ*. Photograph with VCR.

Corallorrhiza trifida 162/11.1. ®106, E. Ross: under willows and birches in bog woodland, Lochanan nan Tunnag, Kildary, NH764761, B. R. & C. B. Ballinger, 2009.

Platanthera xhybrida (**P. chlorantha** x **bifolia**) 162/13.1x2. *46, Cards.: riverside pasture, S end of Cors Caron NNR, SN674616, A. O. Chater, 2008, det. R. M. Bateman. Two plants confirmed in population of c.30 *P. chlorantha* or the hybrid; *P. bifolia* grows nearby.

Orchis purpurea x **simia** 162/20.5x7. *23, Oxon: about 10 plants at edge of wood, Hartslock, Goring, SU616795, C. Raper, 2006, conf. R. M. Bateman. The *O. purpurea* parent had been introduced.

NEOPHYTES AND CASUALS

‡**Cystopteris diaphana** 16/5.dia. *49, Caerns.: walls and banks, Glynllifon, SH45, M. Rickard, 2006, conf. F. J. Rumsey. Martin Rickard comments - Known here for many years as *C. sempervirens* and described by the *British Fern Gazette* Vol.5, p.96, 1925 as 'thoroughly naturalised here and seedlings are appearing in hundreds'.

‡**Polystichum munitum** 17/1.mun. *62, N. E. Yorks.: single plant in scrubby woodland, NE edge of Brotton, NZ694200, K. Trewen, 2008.

‡**Pseudotsuga menziesii** 20/2.1. 29, Cambs.: two self-sown plants on edge of ride, Ditton Park Wood, TL664571, D. J. Barden & A. C. Leslie, 2008. 1st record for self-sown Douglas Fir.

‡**Tsuga heterophylla** 20/3.1. *29, Cambs.: scattered self-sown saplings in open grassy areas near the north side of Little Widgham Wood, TL663550, British Bryological Society, 2008, det. M. O. Hill & S. Damant.

‡**Thuja plicata** 21/3.1. 50, Denbs.: Ruthin, SJ15, J. A. Green, 2007. 3rd record & 1st since 1970.

‡**Laurus nobilis** 24/1.1. *48, Merioneth: several young plants flourishing amongst gorse and bramble, Dinas Oleu, Barmouth, SH61, P. M. Benoit, 2008.

‡**Houttuynia cordata** Thunb. 24B/HOU.cor. *46, Cards.: abundant by path in wet woodland, below Llwyn-teg, 2km SE of Brynhoffnant, SN352504, A. O. Chater, 2008, det. E. J. Clement, NMW. Ø Surprisingly for such a vigorous garden plant, the first record of it naturalised in Britain.

‡**Trollius xcultorum** Bergmans, 28/2.cul. *©63, S. W. Yorks.: disused railway line, Thackley, SE168384, B. A. Tregale, 2004. Ø

‡**Berberis aggregata** 29/1.5. *81, Berwicks.: forestry track, Lumsdaine Moor, NT862681, M. E. Braithwaite, 2009. Small group planted, with two seedlings on track.

‡**Berberis darwinii** 29/1.9. 113(S), Channel Is. (Sark): on outside of garden wall, La Chaumière Guest House, Aval du Creux, WV471759, R. M. Veall, 2009, **herb. Société Sercquaise**. Self-seeded from top of roadside bank.

- ‡**Papaver pseudoorientale** 30/1.1. *62, N. E. Yorks.: well-established on roadside bank and wall, Stonegrave, SE656779, W. A. Thompson, 2008.
- ‡**Ficus carica** 35/2.1. *48, Merioneth: edge of car-park by ex-Woolworth store, Barmouth, SH61, P. M. Benoit, 2009. Frequently chopped back but reasserts itself. Known there for many years. Updating the site to 2009
- ‡**Juglans regia** 37/1.1. *48, Merioneth: one large old tree at Arthog Hall Farm, SH61, P. M. Benoit. Was declining in the 1950s and is now (2009) gone.
- ‡**Pterocarya fraxinifolia** 37/2.1. *41, Glam.: Bargoed, ST144992, A. O. Chater & P. A. Smith, 2005.
- ‡**Alnus cordata** 40/2.3. *45, Pembs.: several saplings or young trees regenerating on wet waste ground, derived from amenity planting on a bank nearby, West Llanion Pill, Pembroke Dock, SM967039, S. B. Evans, 2008.
- ©**Atriplex sagittata** Borkh. 43/3.sag. *18, S. Essex: about 500 plants, with *Puccinellia fasciculata* on S verge of A13, N of Bloomfield Farm, Grays, TQ620810, T. Pyner, 2006, **STDCM**. Still persisting in 2007. Ø
- ‡**Amaranthus powellii** 44/1.pow. *29, Cambs.: frequent as a weed in asparagus field, Hauxton, TL435522, J. D. Shanklin, 2008, **CGE**, conf. E. J. Clement.
- ‡**Lychnis coronaria** 46/18.1. *©45, Pembs.: green waste in paving slabs, St. David's Recycling Centre, SM785267, S. B. Evans & A. E. Evans, 2008. Among a host of casuals seeded into the crevices between the paving in a little used part of the green waste temporary storage area.
- ‡**Lychnis chalconica** 46/18.cha. 41, Glam.: edge of wood, Leckwith, Cardiff, ST157753, B. McDonald, 2005. 1st record since 1970 and the only recent East Glamorgan record.
- ‡**Saponaria ocymoides** 46/22.2. *©62, N. E. Yorks.: single plant self-sown in gutter, South Back Lane (East), Terrington, SE671705, V. Jones, W. A. Thompson & M. J. Yates, 2008. Still there in 2009.
- ‡**Dianthus barbatus** 46/25.6. 44, Carm: single self-sown plant (pink flowered) in unmanaged dune grassland, Ashburnham Golf Course, near The Links, Pembrey, SN430005, Llanelli Naturalists meeting, 2008. 1st record as neophyte and 3rd v.c. record.
- ©**Cucurbita pepo** 60/CUT.pep. *62, N. E. Yorks.: single self-sown fruiting plant, waste ground between B1257 and Stokesley School, Stokesley, NZ532083, V. Jones, 2008.
- ‡**Cardamine raphanifolia** 62/14.4. *©57, Derbys.: disturbed soil near Dore Sheffield, SK286815, K. Balkow, 2007, det. B. A. Tregale & M. Wilcox. Ground disturbed by wall building next to road. *81, Berwicks.: six plants on riverside, Gledswood, NT586341, L. W. Gaskell, 2009.
- ©**Lunaria rediviva** L. 62/17.red. *35, Mons.: one large plant (possibly planted) near brook, Manor Brook valley, Whitebrook, SO531063, T. G. Evans & D. Green, 2008. Ø
- ‡**Cochlearia megalosperma** (Maire) Vogt 62/23.meg. *81, Berwicks.: shaded river bank, Tweedmill, NT863426, G. Hargreaves, 2006, det. D. German & M. E. Braithwaite, E. By 2009 plentiful over 150m. Originally identified as *Peltaria alliacea*. Ø
- ‡**Camelina sativa** 62/24.1. ©39, Staffs.: at 205m on edge of Alsopps Hill Quarry, Tuppity Green, SO968878, S. Timms, 1998.
- ©**Conringia orientalis** 62/CON.ori. 39, Staffs.: amenity grassland, Crown Meadow, Stone, SJ903335, R. N. Hill, 2002. 1st record since 1930.
- [‡**Peltaria alliacea** Jacq. 62/PEL.all. *81, Berwicks. Delete. Re-identified as *Cochlearia megalosperma*.]
- ‡**Rhododendron arboreum** W.W. Sm. 65/2.arb. *52, Anglesey: woodland, Beaumaris, SH5975, N. Brown, 2008. Ø
- ‡**Primula denticulata** Wight 69/1.den. *62, N. E. Yorks.: single flowering plant in waste ground on E bank of stream, Stainsacre Beck, E of Ruswarp, NZ894092, V. Jones, 2008. Ø
- ©**Primula xpruhonicensis** Zemmann ex Bergmans 69/1.pru. *49, Caerns.: 1 clump with reddish/purple flowers on roadside verge E of Crug House, Bethel, SH5165, W. McCarthy, 2008. Ø
- ©**Primula xpruhonicensis 'Wanda'** Zemmann ex Bergmans 69/1.pru. *63, S. W. Yorks.: growing in pavement, Old Windhill Road, Thackley, Bradford, SE163381, B. A. Tregale & M. Wilcox, 2009. Ø
- ‡**Cyclamen coum** 69/3.2. *©63, S. W. Yorks.: established in field, Thackley, Bradford, SE163381, B. A. Tregale, 2009.

- ‡*Pittospermum tenuifolium* 70/1.2. *49, Caerns.: established on steep wooded slope, Bangor, SH5873, S. P. Chambers, 2005.
- ‡*Escallonia ×langleyensis* Vilm. & Bois (*E. macrantha* × *virgata*) 72/1.1×vir. *63, S. W. Yorks.: scrub near Boar's Well, Bradford, SE164357, B. A. Tregale, 2009. Ø
- ‡*Ribes odoratum* 72/2.5. *44, Carms.: roadside verge on E side of new bypass, Ammanford, SN638125, J. Poland & M. Stead, 2008, det. J. Poland.
- ‡*Sedum kamtschaticum* 73/5.kam. *62, N. E. Yorks.: three small, spreading patches on the churchyard wall of the Catholic Church, Lealholm, NZ763077, V. Jones & W. A. Thompson, 2008, conf. E. J. Clement, herb. V. Jones.
- ‡*Bergenia ×schmidtii* (*B. crassifolia* × *ciliata*) (Regel) Silva Tar 74/3.1×cil. *29, Cambs.: several plants established on garden refuse site, Stetchworth, TL642584, A. C. Leslie, 2008, CGE. *63, S. W. Yorks.: old reservoir setts, Horton Bank, Bradford, SE126310, B. A. Tregale & M. Wilcox, 2009. Ø
- ‡*Bergenia cordifolia* (Haw.) Sternb. 74/3.cor. *63, S. W. Yorks.: by woodland path, Hirst Wood, Shipley, SE130377, B. A. Tregale, 2004. Ø
- ‡*Tolmiea menziesii* 74/7.1. *52, Anglesey: roadside, Beaumaris, SH5975, I. R. Bonner, 2008.
- ‡*Tellima grandiflora* 74/8.1. *47, Monts.: one plant in shade in scrub and grassland, Llanymynech Hill, SJ260217, R. A. Dawes, 2008. *48, Merioneth: one plant in fertile woodland, Coed Cors-y-gedol, Dyffryn Ardudwy, SH52, P. M. Benoit, c.2005. Known there for many years.
- ‡*Rubus tricolor* 75/8.2. *44, Carms.: well established and spreading on A40 embankment slope, Abergwili, SN434212, R. D. & K. A. Pryce, 2008. From original landscape plantings in scrub. *49, Caerns.: by coast path, Pwllheli, SH33, J. & H. Lowell, 2007.
- ‡*Sorbus 'Pearly King'* Hedl. 75/28. *63, S. W. Yorks.: near allotments, Myrtle Park, Bingley, SE105385, B. A. Tregale, 2008, conf. H. McAllister. Bird-sown. Ø
- ‡*Sorbus commixta* Hedl. 75/28.com. *63, S. W. Yorks.: scrub by River Aire, Hirst Mill, Shipley, SE131384, B. A. Tregale, 2006, conf. H. McAllister. Ø
- ‡*Sorbus vilmorinii* C. K. Schneid. 75/28.vil. *62, N. E. Yorks.: probably bird-sown on railway embankment, Yarm-on-Tees, NZ421109, J. Cox, 2008, det. V. Jones, conf. E. J. Clement, herb. V. Jones. Ø
- ‡*Cotoneaster congestus* 75/32.15. *46, Cards.: many self-sown plants on walls of long-abandoned walled garden, Highmead, Llanybydder, SN500430, A. O. Chater, 2002, NMW.
- ‡*Cotoneaster fangianus* 75/32.fan. *29, Cambs.: one plant, bird-sown in hedge by 21 Wisbech Road, March, TL410971, A. C. Leslie, 2007, CGE, det. J. Fryer.
- ‡*Cotoneaster mairei* 75/32.mai. *62, N. E. Yorks.: bird-sown in open hedge on waste ground near Love Lane, Pickering, SE801846, V. Jones & W. A. Thompson, 2008.
- ‡*Cotoneaster vestitus* (W. W. Sm.) Flinck & Hylmö 75/32.ves. *29, Cambs.: one large plant, bird-sown on the top of a tall, brick garden wall, Dullingham House, Dullingham, TL627580, A. C. Leslie, 2008, det. J. Fryer, CGE. A specimen from the parent shrub growing elsewhere in the garden has been determined by J. Fryer. Ø
- ‡*Crataegus crus-galli* 75/35.4. *50, Denbs.: Denbigh, SJ06, J. A. Green, 2007.
- ‡*Vicia faba* 77/14.fab. *©44, Carms.: one plant, likely to have germinated from past year's arable crop in re-seeded pasture, Pant-Hywel, Pwll, SN482015, R. D. & K. A. Pryce, 2008. 1st localized record.
- ©*Medicago laciniata* 77/18.lac. *57, Derbys.: disturbed soil near Dore, Sheffield, SK286815, K. Balkow, 2007, det. B. A. Tregale & M. Wilcox. Ground disturbed by wall building next to road.
- ‡*Trifolium resupinatum* 77/19.9. *©57, Derbys.: disturbed soil near Dore, Sheffield, SK286815, K. Balkow, 2007, det. B. A. Tregale & M. Wilcox. Ground disturbed by wall building next to road.
- ©*Trifolium nigrescens* Viv. 77/19.nig. *57, Derbys.: disturbed soil near Dore, Sheffield, SK286815, K. Balkow, 2007, det. E. J. Clement. Ground disturbed by wall building next to road. Ø
- ©*Trifolium tomentosum* 77/19.tom. *57, Derbys.: disturbed soil near Dore, Sheffield, SK286815, K. Balkow, 2007, det. B. A. Tregale & M. Wilcox. Ground disturbed by wall building next to road.

- ©*Dorycnium mixtum* Mill.77/DOR.mix. *23, Oxon: one plant in garden on clay, Middle Barton, SP435258, G. Allen, 2002, conf. C. A. Stace. Not cultivated anywhere nearby. Ø
- ‡*Myriophyllum aquaticum* 79/2.2. *47, Monts.: a clump 1m across in canal, near Walls Bridge, SJ263208, R. A. Dawes, 2008.
- ©*Cornus sanguinea* L. subsp. *australis* (C.A.Mey.) Jáv. 85/1.1aus. *57, Derbys.: ornamental flower bed, University of Derby, SK340378, A. Willmot, 2007. Self-sown bush in shrubbery. Ø
- ‡*Euonymus japonicus* 88/1.3. *29, Cambs.: one bird-sown plant at base of railings, St John's College playing fields, Maddingley Road, Cambridge, TL443589, A. C. Leslie, 2008.
- ‡*Euphorbia dulcis* 91/2.5. *©62, N. E. Yorks.: very locally frequent, self-sown in cobbled alley immediately E of Halifax Building Society, Normanby, NZ547183, V. Jones & W. A. Thompson, 2008, conf. E. J. Clement, **herb. V. Jones.**
- ‡*Acer macrophyllum* Pursh 99/1.mac. *62, N. E. Yorks.: several planted and some showing natural regeneration by forestry track, just W of Pry Rigg Farm, N of Ampleforth, SE591801, V. Jones & B. Walker (Forestry Commission), 2008, **herb. V. Jones. Ø**
- ‡*Oxalis debilis* 102/1.10. *81, Berwicks.: a few plants at foot of village wall, Cockburnspath, NT774711, M. E. Braithwaite, 2009. 1st record since 1878.
- ‡*Geranium 'Johnson's Blue'* (G. pratense × himalayense) 103/1.7×14. *©63, S. W. Yorks.: self-seeded on footpath, Frizinghall, Bradford, SE147361, B. A. Tregale, 2009, det. E. J. Clement. Ø
- ‡*Geranium procurrens* Yeo 103/1.pro. *45, Pembs.: well established garden escape on roadside hedgebank, Pen-y-bont, Cilgwyn, Newport, SN074362, C. A. Stace, 2008. Owner introduced it to garden from a Hampshire nursery about 15 years ago; now spreading along a few yards of roadside hedgebank. Ø 1st v.c. and probably the first British record.
- ‡*Fatsia japonica* 106/FAT.jap. *29, Cambs.: one bird-sown plant at base of wall, Brandon Court, Cambridge, TL457584, A. C. Leslie, 2008.
- ‡*Anthriscus cerefolium* 107/6.cer. *©62, N. E. Yorks.: single self-sown plant at base of wall, Terrington, SE669708, V. Jones, W. A. Thompson & M. J. Yates, 2008, conf. E. J. Clement, **herb. V. Jones.**
- ‡*Levisticum officinale* 107/38.1. *©44, Carms: waste ground, N end Jacksons Lane, Carmarthen, SN412201, R. D. & K. A. Pryce, 2008. 1st record since 1970. Probably originating from bird seed.
- ‡*Ferula communis* 107/FER.com. *©18, S. Essex: road verge, Dennise's Lane, London Borough of Havering, TQ581841, M. F. Smith, 2008. Single plant present 2004-2008 but no seed set.
- ‡*Solanum physalifolium* 110/8.3. *©44, Carms: weeds on sparsely vegetated verge of new roundabout, Welsh Wildfowl Centre, Penclacwydd, Llanelli, SS532987, BSBI Glynhir Meeting, 2008, det. G. M. Kay, NMW.
- ‡*Nicotiana ×sanderæ* (N. alata × forgetiana) 110/NIC/alaxfor. *©62, N. E. Yorks.: single self-sown plant on waste ground between B1257 and Stokesley School, Stokesley, NZ532083, V. Jones, 2008, conf. E. J. Clement, **herb. V. Jones.**
- ‡*Nicotiana glauca* R. C. Graham 110/NIC.gla. *29, Cambs.: one self-sown flowering plant on a tall brick wall, Wordsworth Grove, Cambridge, TL442577, A. C. Leslie, 2008. Ø
- ‡*Anchusa azurea* 116/6.3. *©39, Staffs.: cleared residential waste ground E of A454/B4464 traffic island, Portobello, SO955982, I. C. Trueman, 2008. 1st record since 1946.
- ‡*Amsinckia micrantha* 116/12.2. *©41, Glam.: 30 plants in disturbed ground, Caerphilly, ST156886, A. Jones, 2003, conf. J. P. Woodman. 1st record since 1970.
- ©*Cerinth major* L. 116/CER.maj. *29, Cambs.: two plants on imported soil on a recently reconstructed railway bridge bank, W of Toft, TL351557, A. C. Leslie, 2008, CGE. These plants were of the cultivar '*Purpurascens*'. Ø
- ©*Verbena bonariensis* 117/1.bon. *57, Derbys.: two plants both well in flower on waste ground by pit head, Upper Pleasley, SK499644, A. Willmot, 2008.
- ‡*Mentha ×villosa* var. *alopecuroides* (M. spicata × suaveolens) 118/23.3×4alo. *81, Berwicks.: near farmstead, Kelphope, NT512584, M. E. Braithwaite, 2009. Established from throw-out.
- ‡*Mentha requienii* 118/23.6. *50, Denbs.: Denbigh, SJ06, J. A. Green, 2007.
- ‡*Jasminum beesianum* 123/JAS.bee. *62, N. E. Yorks.: small established patch on rough grassland, W of Tees Barrage, NZ461188, V. Jones, 2008, conf. E. J. Clement, **herb. V. Jones.**

‡**Verbascum bombyciferum** 124/1.4. *62, N. E. Yorks.: ten self-sown plants on stone wall and steps in village, Nunington, SE666794, V. Jones & W. A. Thompson 2008, conf. E. J. Clement, **herb. V. Jones**.

‡**Phygellus capensis** 124/3.1. *62, N. E. Yorks.: naturally regenerating on edge of grassland, Nunthorpe, NZ530156, E. Gendle, 2008, conf. E. J. Clement, **herb. V. Jones**. *©63, S. W. Yorks.: rough pasture, Allerton Bullroyd, Bradford, SE133338, B. A. Tregale & M. Wilcox, 2009, conf. E. J. Clement.

‡**Chaenorhinum origanifolium** 124/8.1. *29, Cambs.: one plant flowering in gutter in front of 3 Sleaford Street, Cambridge, TL464563, A. C. Leslie, 2008, **CGE**.

‡**Cymbalaria hepaticifolia** 124/11.3. *46, Cards.: garden steps and paths (not planted), Winllan, Trefilan, SN567574, I. W. Callan & A. O. Chater, 2008, **NMW**.

‡**Linaria aeruginea** (Gouan) Cav. 124/13.aer. *29, Cambs.: self-sowing on waste ground (now built over) at the junction of Union Lane and Scotland Road, Cambridge, TL462599, A. C. Leslie, 2003, det. E. J. Clement. Ø

‡**Hebe** × **franciscana** (**H. elliptica** × **speciosa**) 124/17.ell×spe. 48, Merioneth: shrub on bank facing the sea at Llanaber, SH61, J. A. Webb, 1941. Missed in the *New Atlas*. It was severely damaged in the hard winters of 1946-7 and 1962-3 but each time eventually recovered. Still there and flourishing 2008, (*Fl. Pl. Wales*, p.133).

‡**Odontites jaubertianus** (Boreau) D. Dietr. ex Walp. subsp. **jaubertianus** 124/21.1jau. *19, N. Essex: calcareous grassland, Gosfield airfield, ex WW2, TL783315, D. Hulkes & K. J. Adams, 2006, **BM**. Patch several metres long. Ø

©**Nemesia strumosa** Benth. 124/NEM.str. *39, Staffs.: a few plants on a tip, High Carr, SJ837512, I. J. Hopkins, 2008. Ø

‡**Acanthus mollis** 127/1.1. *46, Cards.: roadside bank, Aberporth, SN256515, A. O. Chater & J. P. Poland, 2008. Self-sown from adjacent garden.

‡**Campanula portenschlagiana** 129/1.9. *52, Anglesey: sea wall, Beaumaris, SH6075, E. Penna, 2008.

‡**Campanula garganica** Ten. 129/1.gar. *62, N. E. Yorks.: several plants self-sown on wall, 37 Crescent Avenue, Whitby, NZ895111, V. Jones & A. Ritson, 2008, det. V. Jones, conf. E. J. Clement, **herb. V. Jones**. Ø E. J. Clement says probably second British record.

‡**Pratia pedunculata** Benth. 129/8.ped. *62, N. E. Yorks.: scattered in mown grass outside Monks House, Ingleby Arncliffe, NZ446008, V. Jones, 2008, conf. W. A. Thompson, **herb. V. Jones**. Ø

‡**Galium spurium** 130/6.12. 41, Glam.: large quantity in 10×20m plot in game cover crop, arable, Dyffryn, ST097718, J. P. Woodman, 2006-07, conf. A. O. Chater. Rediscovery of taxon published as extinct in VCCC.

‡**Leycesteria formosa** 131/5.1. *©81, Berwicks.: one plant, self-seeded on wall top, Cockburnspath, NT773710, M. E. Braithwaite, 2009.

‡**Lonicera xylosteum** 131/6.4. 46, Cards.: mixed deciduous estate woodland, Old Warren Hill Wildlife Trust Reserve, Nanteos, SN612786, A. O. Chater, 2008, det. J. P. Poland. 1st record since before 1935.

‡**Valeriana pyrenaica** 133/2.2. *46, Cards.: marsh in sloping pasture, 400m E of Moelhedog, Rhydownen, SN450462, A. O. Chater, 2008, **NMW**.

©**Knautia macedonica** Griseb. 134/3.mac. *63, S. W. Yorks.: waste ground, disused mill site, Fairweather Green, Bradford, SE133334, B. A. Tregale & M. Wilcox, 2009, det. E. J. Clement. Ø

©**Sonchus tenerrimus** L. 135/21.ten. *18, S. Essex: housing estate shrubbery, Bancroft Chase, Rainham, TQ517867, R. A. Creber, 2008, conf. M. Spencer, **BM**. Several plants among *Hebe* species. Ø

‡**Taraxacum aequilobum** 135/25.106. *62, N. E. Yorks.: road verge E of Hilton, NZ475111, V. Jones, 2008, det. A. J. Richards, **herb. V. Jones**.

‡**Taraxacum exsertiforme** 135/25.134. *62, N. E. Yorks.: road verge E of Hilton, NZ475111, V. Jones, 2008, det. A. J. Richards, **herb. V. Jones**.

‡**Taraxacum interveniens** 135/25.144. *62, N. E. Yorks.: waste ground, Wilton Works, NZ577203, V. Jones, 2007, conf. A. J. Richards, **herb. V. Jones**.

‡**Taraxacum lacerifolium** 135/25.146. *62, N. E. Yorks.: road verge, Lamb's Lane, Ingleby Greenhow, NZ582055, V. Jones, 2007, conf. A. J. Richards, **herb. V. Jones**.

- ‡*Taraxacum pannulatum* 135/25.182. *62, N. E. Yorks.: grassland, industrial estate, Stokesley, NZ534078, V. Jones, 2007, det. A. J. Richards, **herb. V. Jones**.
- ‡*Taraxacum pseudoretroflexum* 135/25.189. *62, N. E. Yorks.: waste ground, Co-op car park, Stokesley, NZ527087, V. Jones, 2007, conf. A. J. Richards, **herb. V. Jones**.
- ‡*Taraxacum coarctatum* 135/25.coa. *62, N. E. Yorks.: grassland, industrial estate, Stokesley, NZ534078, V. Jones, 2008, det. A. J. Richards, **herb. V. Jones**.
- ‡*Pilosella praealta* subsp. *thauasia* 135/27/4b. *62, N. E. Yorks.: locally common in waste ground between the railways, Potash Terminal, Teesport, NZ550235, V. Jones, 2008, **herb. V. Jones**.
- ‡*Hieracium spilophaeum* 135/28.74. *46, Cards.: disused railway cutting, Penyrangor, Aberystwyth. SN581808, A. O. Chater, 1993, **NMW**, det. D. J. McCosh. Correction of error, formerly named as *H. pollichiae*. Ø
- ‡*Solidago canadensis* 135/40.3. *81, Berwicks.: small colony at foot of village wall, Swinton, NT836475, M. E. Braithwaite, 2009.
- ‡*Erigeron glaucus* 135/43.1. *29, Cambs.: self-sown and naturalised around graves in Cambridge city cemetery, Newmarket Road, Cambridge, TL458600, J. D. Shanklin, 2008, **CGE**.
- ‡*Conyza canadensis* 135/44.1. 113(S), Channel Is. (Sark): edge of building site, Maison Rouge Art Gallery, WV462766, R. M. Veall, 2009, **herb. Société Sercquaise**. Present in Sark for several years. 1st localized record with voucher.
- ‡*Conyza sumatrensis* 135/44.2. *62, N. E. Yorks.: several self-sown on and at base of walls, each side of lane, Oswaldkirk, SE625790, V. Jones & M. J. Yates, 2008, det. V. Jones, conf. E. J. Clement, **herb. V. Jones**.
- ‡*Senecio inaequidens* 135/62.3. *©51, Flints.: garden weed, in crack between wall and tarmac, Trelogan, SJ118799, J. Phillips, 2008. *©52, Anglesey: beside buildings, Gallows Point, Beaumaris, SH598753, J. Bratton, 2008, conf. W. McCarthy, **herb. N. Brown**. *©57, Derbys.: waste ground by lorry park, Black Hole Mine, Eyam Edge, SK203774, J. & V. Middleton, 2008, det. K. Balkow. Looks well established on site.
- ‡*Calendula officinalis* 135/73.1. *©45, Pems.: green waste in paving slabs, St. David's Recycling Centre, SM785267, S. B. & A. E. Evans, 2008. Among a host of casuals seeded into the crevices between the paving in a little used part of the green waste temporary storage area.
- ‡*Osteospermum jucundum* 135/OST.juc. *46, Cards.: well-naturalised in hedgebank around churchyard, Llandysiliogogo, SN363574, A. O. Chater, 2008, **NMW**.
- ‡*Aponogeton distachyos* 139/1.1. *©44, Carms: pond choked with this species (originally planted), Trip Farm, W of Meidrim, SN267215, L. Wilberforce, 2008.
- ‡*Lysichiton americanus* 147/2.1. *52, Anglesey: streamside, Talwrn, SH4978, I. R. Bonner, 2008. Spreading downstream from a pool in SH4878.
- ‡*Zantedeschia aethiopica* 147/4.1. *©57, Derbys.: flowering in emergent stream-fed pond in fields near Totley, SK309792, K. Balkow, 2007. Unlikely to have been planted due to poor access to site.
- ‡*Arum italicum* subsp. *italicum* 147/5.2b. *62, N. E. Yorks.: several patches established on waste ground, Low Kilburn, SE511797, V. Jones & W. A. Thompson, 2008. 113(S), Channel Is. (Sark): roadside bank at foot of wall, Clos de la Tour, WV467759, R. W. Waterman, 2008, **herb. Société Sercquaise**. 1st record for Sark. Unknown source; none seen in nearby garden. Recorded in 2009 by S. Synnott.
- ‡*Lemna minuta* 148/2.4. *81, Berwicks.: large colony in recently dug pond, Lithillum Loch, NT803409, M. E. Braithwaite, 2009.
- ‡*Cyperus eragrostis* 152/11.2. 35, Mons.: one tufted fruiting plant at foot of roadside wall of 'Wind Rush', Bayfield, ST519933, T. G. Evans, 2008-09. 1st record since 1970.
- ‡*Melica altissima* L. 153/25.alt. *29, Cambs.: several plants on waste ground in front of old Unwins site, Impington Lane, Histon, TL443634, J. D. Shanklin, 2008, **CGE**. These plants were of the cultivar '*Atropurpurea*'. Ø
- ‡*Polypogon viridis* 153/46.2. 41, Glam.: frequent weed in front gardens, Llandaff North, Cardiff, ST148793, T. C. G. Rich, 2006. 1st record as a neophyte. *49, Caerns.: wall base, Abergwyngregyn, SH6572, W. McCarthy, 2008.
- ‡*Bromopsis inermis* 153/51.4. 35, Mons.: large clump (present for at least 3 years), upside of bypass bridge over R. Monnow, Monmouth, SO506122, D. Green, 2007. 1st record as a neophyte.

©**Triticum aestivum** 153/60.1. *52, Anglesey: laneside, Llanfair PG, SH534725, P. Denne, 2008. Does not seem to have been formally recorded before.

©**Setaria adhaerens** 153/70.adh. *29, Cambs.: one plant at base of railings in front of 10 Fitzwilliam Street, Cambridge, TL4557, A. C. Leslie, 2008, **CGE**.

‡**Anemathele lessoniana** (Steud.) Veldkamp 153/ANE.les. *©62, N. E. Yorks.: single self-sown plant in pavement crack, N side of Manor Close, Topcliffe, SE402760, V. Jones, W. A. Thompson & M. J. Yates, 2008. Ø

©**Secale cereale** 153/SEC.cer. *46, Cards.: new road verge, A486, 1.2 km SSE of Croes-lan, SN388433, A. O. Chater, 2008. 1st record as a casual although it has been grown as a crop in the past.

‡**Hyacinthus orientalis** 158/21.1. *46, Cards.: white-flowered plants established from throw-outs in rough grass on cliff top above sea, S end of Borth, SN605888, A. O. Chater, 2008.

‡**Allium subhirsutum** 158/24.5. *35, Mons.: a square metre patch on barish waste ground, E side South Dock, Newport, ST317841, T. G. Evans & S. J. Tyler, 2008. *63, S. W. Yorks.: wetland, Chellow Dean, Bradford, SE131339, B. A. Tregale & M. Wilcox, 2009.

‡**Allium carinatum** 158/24.12. *62, N. E. Yorks.: scattered clumps and individuals over 60m of N road verge just E of ford, Caydale Mill, SE543867, V. Jones, 2008.

‡**Tristagma uniflorum** 158/28.1. *©35, Mons.: several plants on minor roadside near hedge and Bowleaze Reen, ST377855, H. V. Colls, 2006-08.

‡**Camassia quamash** (Pursh) Greene, 158/CAM.qua. 113(S), Channel Is. (Sark): in damp ground among *Oenanthe crocata* in the upper part of Vallon d'Or, WV472756, S. Higgins, 2009, **herb. Société Sercquaise**. Seed or bulb washed down from garden at top of valley? 1st record for Sark and possibly v.c.113. Ø

‡**Sisyrinchium bermudiana** 159/2.1. *©39, Staffs.: ex coal mine spoil heap and tip, Chatterley Whitfield, SJ884252, C. Hayes, 2007.

‡**Sisyrinchium californicum** 159/2.3. *©63, S. W. Yorks.: pavement weed, Allerton Bullroyd, Bradford, SE133338, B. A. Tregale & M. Wilcox, 2009.

‡**Iris germanica** 159/5.1. *©52, Anglesey: old heap, Lleiniog marsh, SH619793, E. Phenna, 2008. *81, Berwicks.: ruderal in village, Horndean, NT897495, M. E. Braithwaite, 2009. Established from throw-out.

‡**Crocus vernus** 159/8.1. *©49, Caerns.: one plant with purple tepals on roadside verge, near Bethel, SH5165, W. McCarthy, 2008.

‡**Crocsmia paniculata** 159/13.1. *49, Caerns.: wet heath, Rhosgadfan, SH5056, W. McCarthy & J. Bratton, 2008.

‡**Cordyline australis** 160/3.1. *63, S. W. Yorks.: self-seeded seedlings below planted tree in Ashbourne Road, Bradford, SE164349, B. A. Tregale, 2009.

Book reviews

Akeroyd, John. *A beginner's guide to Ireland's wild flowers*. Sherkin Island Marine Station, Co. Cork, 2008. €7.50. ISBN 972-1-870492-23-2 p/b.

Multum in parvo! Here is a palm-sized, pocket guide with 162 different flowering plants, representing 49 families, illustrated with colour photographs by Robbie Murphy. There is an imaginative key at the start, and an illustrated glossary at the end. Common English names are used as the main headings, with Latin and Irish names beneath. A brief description is placed above a photograph of the plant and the species' habitat is illustrated by a sketch (explained at the front). This is certainly not intended for people who already have a

modicum of botanical knowledge, yet for a beginner or a casual visitor in the Irish countryside, it is portable and can only make any ramble more rewarding. Its design, shape and size are the same as the earlier *A beginner's guide to Irelands seashore* (ISBN 1 87 049296 X) which contains seaweeds and coastal lichens as well as marine creatures. The two books are ideal as holiday 'companions' on any Irish beach.

E. CHARLES NELSON

Butler, Ken and Crossan, Ken. *Wild flowers of the North Highlands of Scotland*. Birlinn, Edinburgh, 2009. £14.99. ISBN 978-1-84158-832-2 p/b.

A collaboration between two Caithness residents, one the B.S.B.I. recorder for East Sutherland and Caithness, the other a talented photographer, this book presents the flora of northernmost mainland Scotland through a narrative of the different habitat types. These range from sea coasts through peatlands and 'other wet places', woodlands, grasslands and uplands to waysides and farmland. In terms of historic counties, the book covers Sutherland and Caithness plus part of Easter Ross. It is a brave undertaking to encompass an area extending from Lochinver in the west to Wick in the east and from Dingwall to Cape Wrath. A comparable area in the north of England would extend from the Mersey to Hadrian's Wall.

Each chapter is subdivided into further habitat sections such as 'dune links and machair', and the most conspicuous flowering plant species in each section are described and illustrated. There is a mixture of habitat photographs, whole plant views and close-ups of flowers and fruits; there are also one or two drawings, perhaps the least effective part of the

book. The standard of photography is high, and the printers have achieved a good level of consistency of colour reproduction. The final chapter provides an overview of 'The context' and deals with such factors as climate, geology and agricultural practices.

By revealing much of the undisturbed natural beauty of the region, the book makes a strong case for the conservation of its habitats, though I would have liked to see a little more discussion of vegetational changes. The book is designed in landscape format with three columns of text per page, and has a good index containing grid references to the principal sites mentioned. It is unusual for a well-illustrated wild flower book to have a regional focus, but this work is aimed at a more general reader than is the case with vice-county floras. Given the remoteness of the region from centres of population the market for this book is not as clear-cut as would be the case for a vice-county Flora, but it will be appreciated by local residents, visitors and armchair naturalists alike.

JOHN EDMONDSON

Harrap, Anne & Simon. *Orchids of Britain and Ireland – a field and site guide*. A. & C. Black, London, 2009. 2nd edition. £24.99. ISBN 978-1-408-10571-9 p/b.

Wild orchids are renowned worldwide for exciting passionate interest and also some of the worst traits of human behaviour, so that the production of this highly attractive book could be seen as encouraging both camps.

The writing style is easy to absorb, the layout pleasing, and the quality of the photographs is consistently superb. The authors have garnered a wealth of exotic information, with fascinating new data on the relationship of the various

species to mycorrhizal activity. The notes on growth and reproduction are excellent, clarifying life histories which can guide our efforts at conservation. Particularly interesting were the observations on the longevity of *Anacamptis morio*, although the tracking year by year of individual plants within huge colonies is fraught with difficulty. Similar studies of presumed monocarpic *Ophrys apifera* have found individuals flowering for seven consecutive years.

I particularly enjoyed the historical notes on first occurrences of species, where the authors have discovered some fascinating early records and other notes, such as the introduction and spread of *Epipactis helleborine* in North America. Recent work on *Spiranthes romanzoffiana* has shown that its seeds possess adhesive coats, which revives the possibility that they reached the U.K. on the plumage of migrating birds.

Taxonomy tends to be a contentious subject, but the authors have adopted a rational approach. They deal clearly with the three forms of the Fragrant Orchid and also the Spotted and Marsh Orchids, although they incline to split the latter into too many varieties. Similarly, they subdivide *Epipactis phyllanthos*, while at the same time noting that "between the two extremes the range of variation is almost continuous" and "variation seems to be determined by the local environment". The placing of Frog Orchid among the *Dactylorhiza* satisfies many criteria, although it

may not satisfy all minds. Likewise the placing of Burnt Orchid within the genus *Neotinea* may in time become acceptable, although many of us have reservations at present. The later-flowering form in this country should not have the varietal name var. *aestivalis*, which applies correctly to plants of Continental origin. Both European forms have been found existing side by side on the same flowering spike in Sussex. The name var. *serotina* is preferable, although subspecific rank may be merited.

Throughout the book the authors lament the persecution that orchids have suffered in Britain in the past, both at the hands of collectors and at the feet of visitors to their sensitive habitats; see for example p. 39 *Cephalanthera rubra*. Most of us are aware of the increase of 'botanical twitchers' on a par with their bird-watching counterparts, and in both cases the 'twitchers' exhibit scant interest in the subject except to tick it off on a list. For this reason the detailed description of sites, with map references, seems perverse in the extreme. One can imagine the howl of protest from the R.S.P.B. if a book on raptors listed their nesting sites in similar detail. During this year in Sussex we have seen newly discovered rarities vanish within days of their discovery being made public. It could be argued that the data in this book is already publicly available somewhere, but to set it out in this fashion – as the book's subtitle implies – verges on the reprehensible.

DAVID C. LANG

O'Mahony, Tony. *Wildflowers of Cork City and County*. Pp. 456. The Collins Press, Cork. 2009. £26.99, €29.99. ISBN 978-1-84889-020-6, h/b.

County Cork has received considerably less botanical study than it deserves. This large county, which takes in the Republic of Ireland's second city, an East and West Riding and three Watsonian vice-counties, has never had a proper County Flora. As well as being large (c. 750,000 ha), Cork possesses a wealth of mountain and moorland, numerous small lakes and associated habitats, rivers and wooded river-valleys, 18th-century hedgerows, and indented coastlines, peninsulas and islands. Allin's *The Flowering Plants and Ferns of County Cork* (1883), although most useful and packed with plant records made by himself and the best botanists of the day, is but a slim annotated checklist. Thus Tony O'Mahony's substantial, informative and handsomely

produced book is a welcome documentation of what botanists have achieved in Co. Cork over the last three centuries. It is to the great credit of Cork City Council and Cork County Council that they have supported its publication. That is a real service to biodiversity, a precious resource in a region so economically dependent upon tourism and farming, rather than the production of some vague conservation strategy. They, author and publisher should be proud of what they have achieved. Credit is also due to Matt Murphy of Sherkin Island Marine Station, who initiated the idea and pressed hard for it to become reality.

Here is a book that not only summarizes available information on the Cork flora – a checklist at the end includes some 1200 native,

naturalized and casual taxa of flowering plants, conifers and ferns recorded since 1745 – but also takes the county and Cork City's wealth of wild plants to a wider readership, showing why they are important and need to be conserved. Co. Cork, especially its south-western peninsulas and islands, holds a substantial component of Atlantic and amphi-Atlantic, Cantabrian and Mediterranean floristic elements. The text is steeped in O'Mahony's knowledge, passion and enthusiasm, and lavishly illustrated with evocative photographs of plants and often wild and spectacular scenery. He is the ideal guide, and his most readable descriptive prose, freed from the conventions of a County Flora or field guide, brings common and rare wildflowers and their habitats to life. He weaves his own 40-year botanical contribution into the story, and includes enough detail to satisfy the botanist while presenting the information that familiarizes readers with species in an accessible manner. There is plenty of valuable up-to-date information on grasses, sedges and hybrids, many interesting references to medicinal and other plant uses, and he describes the flora throughout the year.

O'Mahony is ever conscious of the fascinating historical legacy he has inherited. He loves an old record, but is never quite satisfied unless somebody has followed it up, more than once, and he can be sure the plant is still there today. He always gives credit to those who have gone before, including sporadic visitors from the UK, and it was good to read his tributes to former county recorder Maura Scannell, with whom he collaborated closely, and to the young botanists with whom I have worked for so many years – the team that gave us *The Wild Plants of Sherkin, Cape Clear and adjacent Islands of West Cork* (1996), much cited here – on the islands and coasts of West Cork. By remarkable serendipity, the recent publication in English (edited by Denis C. O'Sullivan, Cork University Press, 2009) of *The Natural History of Ireland* by 16th century scholar Philip O'Sullivan Beare, a West Cork chieftain's son exiled to Spain, takes the first Cork plant records back to the early 17th century.

The section on Cork City (Chapter 2) is particularly significant, for a surprising number of fragmented native habitats survive within the city limits. Some 570 plant taxa have been recorded and there are some ecologically important sites such as the city's many old walls and Mount Desert Wood on an Old Red

Sandstone escarpment above the River Lee. The Cork City plant *par excellence* is Little Robin (*Geranium purpureum*), rediscovered by O'Mahony in 1969 well over a century since it had last been recorded and which doggedly persists on walls and waysides. The largely built-up areas of the great inlet of Cork Harbour (Chapter 3), are also plant-rich, especially on limestone outcrops, including Little Island, where another of O'Mahony's major discoveries, Dense-flowered Orchid (*Neotinea maculata*), occurs far south of its Burren heartland.

Other chapters include accounts of the floral riches of the far south-west, the coasts, the rivers, the still relatively unexplored mountains, the famous Mediterranean-Atlantic floristic elements, and the ferns, aliens and orchids. Chapter 15 presents the conservation challenge for botanists and decision-makers in the county. This includes a plea to control Winter Heliotrope (*Petasites fragrans*), which has spread with the building boom and now threatens stands of rare ferns and other plant communities. The book ends with a glossary, full references and general and botanical indices. Several notable rarities and phytogeographical curiosities are profiled, such as Strawberry Tree (*Arbutus unedo*), Spotted Rockrose (*Tuberaria guttata*) and Pale Dog-violet (*Viola lactea*). The heart of the work is where O'Mahony guides us around the wide variety of botanical sites on his patch. Some of these are pleasant public amenity walks such as along the riverside track bed of the old Carrigaline – Crosshaven railway. Others are small wetlands or sand or shingle strands on the coast, and a good many are unique and astonishing. One such, the Gearagh on the River Lee near Macroom, is an almost inaccessible area of woodland-covered islands in a complex of braided channels (apparently once a haunt of *poteen* makers!). It was largely submerged when the river was dammed in the 1950s, but a portion somehow has survived; as does another alluvial woodland near Dunmanway. The author repeatedly draws attention to areas and places that are little known and would repay investigation. I have no doubt that this most stimulating and inspiring book will be followed by a new wave of discovery.

It is difficult to find fault with this book. The maps at the beginning could have had more detail, with more place names, but writers of local and county Floras do tend to assume the

reader is no stranger to their patch! My only botanical quibble is that O'Mahony, in company with some other Irish botanists, disputes the native status of *Dianthus armeria* on Horse Island near Schull. Not only does this rarest of Irish plants persist there in somewhat disturbed grassland, as it does, for example, on a large scale in southern Transylvania, but also in the 19th century it was collected near The Ovens, just west of Cork City. It certainly needs legal protection in Ireland, as do Irish Spleenwort (*Asplenium onopteris*), Little Robin (*Geranium purpureum*) and other rarities for which O'Mahony rightly draws attention to a lack of official recognition.

Irish field botany is apparently thriving, although perhaps not to the same degree as in the latter part of the 19th century when the Rev. Thomas Allin published his little *Flora*. In 2008 we saw the publication of an exemplary Irish County Flora, *Flora of County Waterford* by Paul Green, and now Tony O'Mahony has presented us with an elegant account, a repository of riches, of the results of four busy decades of field botany in his native city and county. Cork keeps yielding new botanical surprises, not least a regular trickle of taxa new to Ireland, and this largest and most botanically fascinating of Ireland's counties now has a solid foundation for future studies.

JOHN AKEROYD

Sell, Peter & Murrell, Gina. *Flora of Great Britain and Ireland*, Vol 4., Campanulaceae – Asteraceae. Cambridge University Press, Cambridge, 2006. £146. ISBN 978 0 521 55338 4 h/b.

This exceptionally detailed tome was published in 2006, since when I have found it an invaluable work of reference. However, its origins go further back. Volume 5, the first of the series to be published, appeared as long ago as 1997. Volumes 4 and 3 have awaited publication for some years (the foreword to the present volume by the late Max Walters is dated 1996), and I believe that the volumes that still await publication were largely completed some time ago. This has not helped to give this massive work a modern feel. The classification and arrangement of higher taxa predates even 'APG I' (APG III appeared in 2009), although it does harmonise with 'Stace', as the reviewer of volume 5 noted (*Watsonia* 22: 122-3).

Now that more than half of Sell & Murrell has been published, why do we not hear more of it? Why is it that British and Irish botanists still tend to consult, and quote, Stace (1999)? Why do most of us still maintain *Carex viridula*, *Zostera angustifolia* and *Dactylorhiza lapponica* 12 years after they were sunk by Sell & Murrell? Why do we usually consider that we have two species of native *Arctium*, not one as Sell & Murrell would have us believe? Why do we not maintain *Carduus acanthoides* separate from *C. crispus*, talk of *Scorzoneroideis autumnalis* for Autumn Hawkbit or *Helminthotheca echoideis* for Bristly Ox-tongue?

The reasons are complex, but the scholarship, dedication, industry and authority of the authors cannot be doubted. Partly, our disavowal reflects the expense of the volumes

(Volume 4 is now 2.4 times as expensive as the original price for Volume 5), and the fact that two volumes have yet to be published. But chiefly I think the reason is exactly that given as the avowed *raison d'être* of the work, the sheer thoroughness (and consequent indigestibility) of the descriptions. These are invaluable to the academic botanist, but make no concessions to those wishing to find the correct name for a plant, surely the primary purpose of a *Flora*.

The keys are mostly very successful, but there are no other clues as to which are the important characters or pitfalls in identification, so that it is very difficult to discern exactly how related species differ from one another. Compare the almost over-brief but succinct and non-repetitive diagnoses in Stace, miracles of relevance and brevity. There are few illustrations in Sell & Murrell, but those give little help, being without scale or any indications of comparative size and are crudely drawn. There are no series of microphotographs, which were so successfully employed by Stace.

Nevertheless, Sell & Murrell has become invaluable and even irreplaceable to the British and Irish botanist, particularly as it is by far the most complete and authoritative account of neophytes and aliens yet published. Where else will you find such a detailed and accurate account of our *Conyza*, alien *Senecio* or *Artemisia* for instance? Another special feature is the detailed subspecific treatments. Many of these minor taxa are trivial and some

are meaningless, but they are nevertheless a record of genetic biodiversity, mostly recognised by an earlier generation of taxonomists, which was in danger of becoming lost.

If you are not a fan of apomictic microspecies, you will wish to ignore considerably more than half of this volume, which is dedicated to 412 *Hieracium* species (55 of which are diagnosed *de novo* in an appendix, and are thus essentially non peer-reviewed) and 232 *Taraxacum*. It is especially valuable to have a modern version of Peter Sell's treatment of British hawkweeds all in one place, but faced with a ferocious key (I have no idea if it works, but the comparable *Taraxacum* key doesn't) and no illustrations, I pine for a more user-friendly version to ease me into hawkweeds, similar to Tennant & Rich (2008). As a taraxacologist, I am struck by how many of our hawkweeds have only a single locality. An informal *modus operandi* has long since been practised by batologists and taraxacologists, whereby a new entity must be known from a number of localities over a reasonable area before it rates diagnosis as a new 'species'. All the hawkweeds and dandelions have been given English names. Coming up with nearly 700 new 'handles' must have exercised the authors' ingenuity considerably.

It is inevitable that such a complex work will have its mistakes, but the proof reading seems to have been very thorough. Lead 42 of the Asteraceae key has *Crepis* without rhizomes, but three of the first four species are correctly stated to be rhizomatous. Humphrey Head is in Cumbria, but not in Cumberland, while *Linnaea borealis* still flourishes in England. Most Australian taxonomists (and the DNA) would have *Cassinia* included within *Ozothamnus*, while 'Ben Lawes' and 'Glen Dole' are recognisable typos.

I have left the best to last. Rather to my surprise, I found many of the habitat descriptions superlative. I have been chasing *Crepis mollis* recently, and was simply bowled over by the accuracy and artistry of the ecological treatment for this fugitive species. Many others are equally good. Truly, these are authors who really know their British and Irish flora, almost too well!

JOHN RICHARDS

REFERENCES

- Stace, C. A. (1999). *New Flora of the British Isles*. 2nd ed. Cambridge University Press, Cambridge.
- Tennant, D, & Rich, T. (2008). *British Alpine Hawkweeds*. BSBI, London.

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