

Looking after

Broad-fruited Cornsalad

Valerianella ramosa

Ecology and Conservation Portfolio

**BACK
FROM THE
BRINK**



At a glance

Common name: Broad-fruited Cornsalad

Scientific name: *Valerianella rimosa*

Habitat types: found almost exclusively in arable habitats, specifically the margins of fields sown with winter and spring cereals

Soil type: free-draining acidic shales and sands, and slightly calcareous heavy clay soils

GB status: Endangered

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Species description

Broad-fruited Cornsalad is a hairless, slender plant up to 30 cm tall. It is usually branched with opposite, narrow, spear-shaped stem leaves. The basal leaves form a flat cluster close to the ground. The tiny white to pink-tinged flowers have five petals and are about 2 mm in diameter and borne in clusters at the end of stems (Figure 1). Usually there are additional single flowers in the forks of the stem branches, and it is these single flowers that develop into the first seeds. Each flower produces a single seed which is nearly spherical, about 1.5 mm in diameter and has a single terminal tooth. The clusters of seeds at the ends of the stems can be quite eye-catching when large numbers of well-grown plants are present¹. Most of the seed capsule is hollow.

All cornsalads are quite similar in appearance but the best way to distinguish them is by their seeds. Broad-fruited Cornsalad seeds are like small grape pips and swollen (2 mm long by 1.5 mm wide). There are small teeth (the remains of the calyx) at the top of the seed which are equal in length (Figure 2). The most similar species is Narrow-fruited Cornsalad *Valerianella dentata* which has much narrower seeds (0.75 mm wide), with a single tooth on top, whilst Hairy-fruited Cornsalad *Valerianella eriocarpa* also has narrow seeds (0.75 mm wide) with small hairs and the calyx remnant forming a 'crown' with six distinctive teeth (Figure 3).

Lifecycle and ecology

Broad-fruited Cornsalad is an annual herb, flowering from June to August (Figure 4). It mainly germinates in autumn with a rosette of leaves overwinter. It can also germinate after spring cultivation¹, but then tends to be smaller and less-branched, and produces less seed. In experimental studies of germination, most seedlings appeared between September and December, and in a field study, plants were most abundant in plots drilled between mid-October and the end of November². It is possible that autumn-germinating plants flower earlier in the year than spring-germinating plants and may be more productive. Seed is usually shed from July onwards³. Broad-fruited Cornsalad is probably best classified as a stress-tolerant ruderal.

Little is known about breeding systems in this species. Flowers are bisexual and it is likely both cross- and self-pollination occurs, as happens in related cornsalad species⁴. The flower structure suggests pollination is carried out by small insects such as hoverflies and flies.

Figure 1: Like all cornsalads, Broad-fruited Cornsalad has small whitish flowers © Cath Shellswell



Figure 2: Broad-fruited Cornsalad seeds (left) and Hairy-fruited Cornsalad seeds (right) showing the significant difference in size and shape © Hannah Gibbons

It is not known how long Broad-fruited Cornsalad seeds can remain dormant within the soil. Other cornsalad species are said to have long-lived seeds (over 30 years) and this might be the case for Broad-fruited Cornsalad. The introduction of suitable management at sites where there were historical populations could encourage germination of seeds from the soil seed bank¹.

Germination usually occurs immediately after seed is shed from the parent plant and is suppressed by low

temperatures in the winter. This is typical behaviour of autumn-germinating annuals of temperate regions.

The Royal Botanic Gardens (RBG) Kew's Millennium Seed Bank (MSB) holds germination testing data for five UK collections of Broad-fruited Cornsalad. These data suggest that plants will germinate without pre-treatment at temperatures of greater than 10°C and alternating temperatures of 25°C and 10°C, although the germination rate varies between collections from different populations. In one collection, germination was promoted by a period of cool incubation at 10°C for four weeks followed by an alternating temperature regime of 25/10°C. Separate germination peaks were observed at each temperature, with the first within two weeks of incubation at 10°C and the second two weeks into incubation at the alternating temperature regime. Variation within and between collections of the same native species is not uncommon and may be influenced by factors including environmental conditions at the collecting site, the time of collection, post-harvesting handling and storage³. Further research on dormancy mechanisms of Broad-fruited Cornsalad would be beneficial to fully understand the seed biology.

Habitat

Broad-fruited Cornsalad is found almost exclusively in arable habitats in Britain, specifically the margins

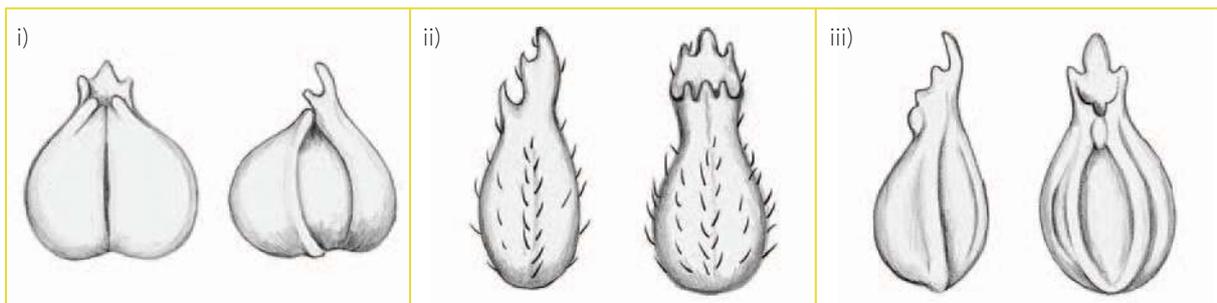


Figure 3: Illustrations of seeds of: i) Broad-fruited Cornsalad; ii) Hairy-fruited Cornsalad; and iii) Narrow-fruited Cornsalad. Illustrations by cvansgraphic.co.uk © Plantliff

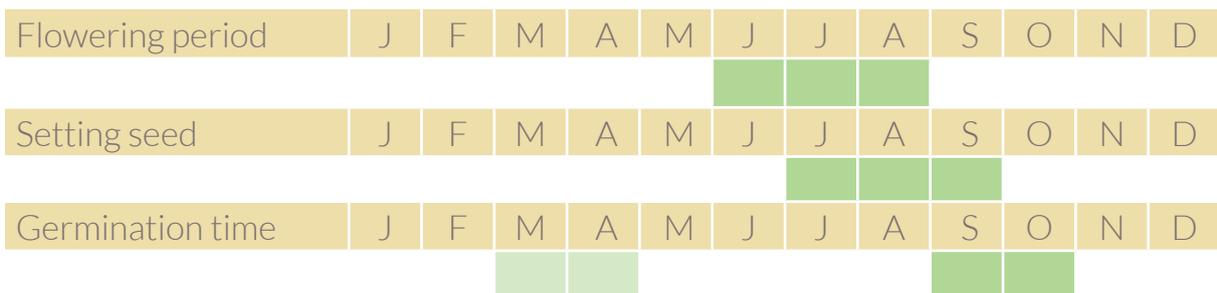


Figure 4: Flowering, germination and seed-setting periods for Broad-fruited Cornsalad

Broad-fruited Cornsalad population fluctuations at Fivehead Arable Fields

Fivehead Arable Fields is owned and managed by Somerset Wildlife Trust and is one of just three SSSIs notified for their assemblage of rare arable plants.

Crops have not been grown on the reserve since 2017-2018 when the site was entirely given over to cornfield flowers. Fivehead Arable Fields has three fields with one large field split into two management units (four units in total). Each year, three management units are autumn-cultivated and one spring-cultivated, and this management is rotated around the four units.

The cornfield flowers at Fivehead Arable Fields have been monitored using a Rapid Assessment method since 1997. This is a simplified version of Common Standards Monitoring. Usually, this survey for annual plants is undertaken every year, but there are some breaks in the data and the survey list has evolved over time to include more positive indicator species, as well as negative indicators. The purpose of this monitoring is gauge the efficacy of the management and make adjustments as necessary. For example, in 2017, Onion Couch *Arrhenatherum elatius* var. *bulbosum*, Barren Brome *Bromus sterilis*, Soft Brome *Bromus effusus* and Black-grass *Alopecurus myosuroides* had reached levels that were damaging populations of positive indicator species, and a spring graminicide spray was undertaken in 2018 to reduce the level of grass. Perennial Rye-grass *Lolium*

perenne was also present in many of the units following the sowing of grass leys as a method of controlling some of the more competitive problem plants.

Broad-fruited Cornsalad appears to grow better in areas with lower grass cover

The population of Broad-fruited Cornsalad fell by 48% between 2010-2017 and, during the same period, Onion Couch *Arrhenatherum elatius* increased by 30% in unit 3. Broad-fruited Cornsalad responded favourably to the graminicide in 2018, increasing in all autumn-

cultivated fields. However, the problem grasses and pernicious weeds have since increased between 2018-2020. The consistently largest population of Broad-fruited Cornsalad between 2010-2019 was in unit 2 with plants present in 80-95% of quadrats (Figure 5). Lower levels of grasses were also recorded in this unit which may explain why Broad-fruited Cornsalad was able to grow so prolifically.

Rapid Assessment monitoring will be continued to monitor the population sizes of positive and negative indicator species. Broad-fruited Cornsalad has not been recorded in any spring-cultivated areas between 2017-2020, and at this site it appears very strongly associated with autumn cultivation.

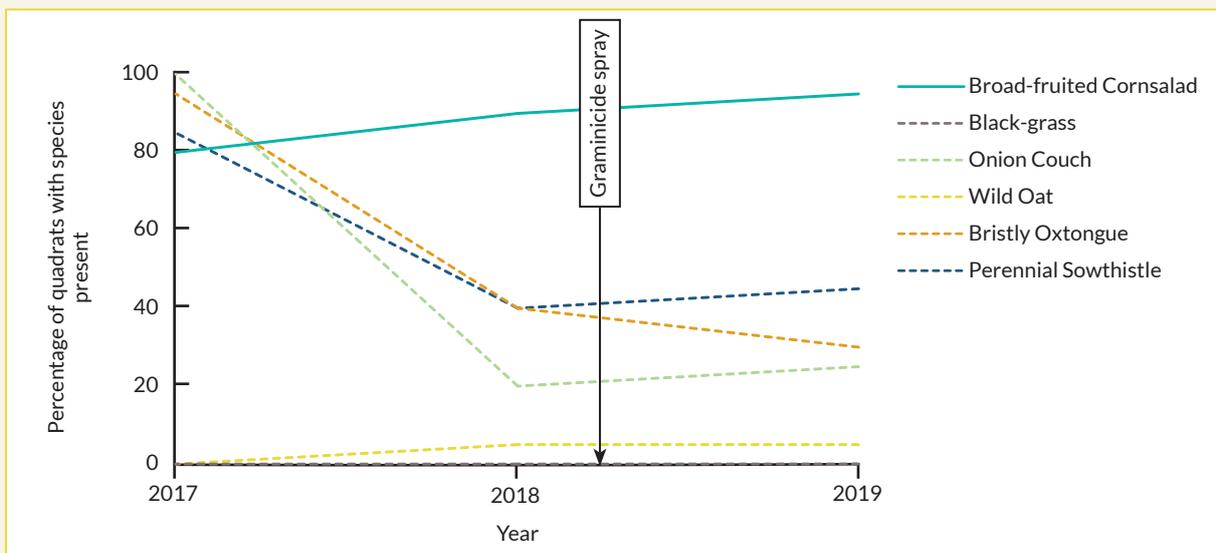


Figure 5: Percentage of quadrats with Broad-fruited Cornsalad and negative indicator species from 2017 to 2019 in unit 2

of fields sown with winter and spring cereals. It also occurs rarely in disturbed sites adjacent to arable land and on former arable land until the associated perennial vegetation becomes too dense.

Traditionally, the species is considered to favour areas that are poor in nutrients, often where the crop canopy is very sparse and where there is relatively little competitive pressure⁵. Surveys have found Broad-fruited Cornsalad growing in contradictory situations; in fairly open, short swards where there is enough surrounding vegetation to enable the branching plants to sprawl and in areas of denser vegetation with higher than expected soil nutrient levels.

Broad-fruited Cornsalad has been found at four non-arable sites since 1987. At two locations, north of Padstow in Cornwall, it has been found on wind-blown sand on cliff-tops next to arable land. No plants were seen here during a survey in 2018, though it is possible that it might reappear here, perhaps following erosion or other disturbance. In Gloucestershire, it has been recorded on quarry spoil. It may still occur at a quarry in mid-Somerset where all five British cornsalad species and Perfoliate (Cotswold) Penny-cress *Microthlaspi perfoliatum* have also been recorded.

Soil profile

Broad-fruited Cornsalad occurs on free-draining acidic shales and sands, and on heavy clay soils that may be slightly calcareous. It is also associated with light calcareous soils at a handful of locations.

In a survey of six sites, it was present on acidic shales, possibly with the influence of more base-rich intrusions and deposits of wind-blown sand. Four sites were on Jurassic limestone, three on chalk, one on chalky boulder clay and one on acidic Tertiary sand⁵.

The following information about soil texture and nutrients is derived from six populations studied for this publication. One in Cornwall and another in Devon on free-draining soils, sands and shales; and the third population in Somerset which is spread across four fields on clay loams. This restricted sample does not encompass the entire variety of soils supporting Broad-fruited Cornsalad, and testing soil taken from other populations is recommended to provide a greater body of evidence about growing conditions for this species.

The whole range of soil conditions where Broad-fruited Cornsalad grows is not fully known

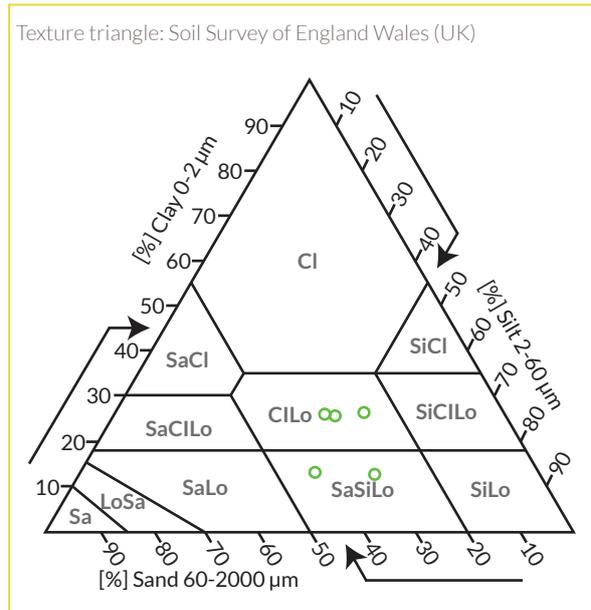


Figure 6: Soil triangle showing the proportions of clay, silt and sand present at the six Broad-fruited Cornsalad populations

Soil pH

Soil pH ranges from neutral 6.5 to neutral-calcareous 7.9. The clay loams in Somerset, which overlie limestone bedrock, are more calcareous than the sandy silt loams of Cornwall and Devon which are influenced by the acid bedrock.

Soil texture

There were two distinct soil textures at the six sites with Broad-fruited Cornsalad populations (Figure 6). The Devon and Cornwall populations were both on sandy silt loams which are characteristic of southwest England. These are free-draining soils and retain little water with a high-moderate leaching rate for soil nutrients. They also warm rapidly in the spring which may boost growth early in the season for this generally

autumn-germinating plant. The Somerset site is on clay loams with medium to slow drainage and moderate to low leaching rate for soil nutrients. There, soil fertility is inherently medium to high, but this depends on historic management. The warming rate is medium which may delay the growth of plants more than soils which warm faster.

Proportion of bare ground

The proportion of bare ground varied between 5-65% within a radius of 0.5 m of a plant. The average amount

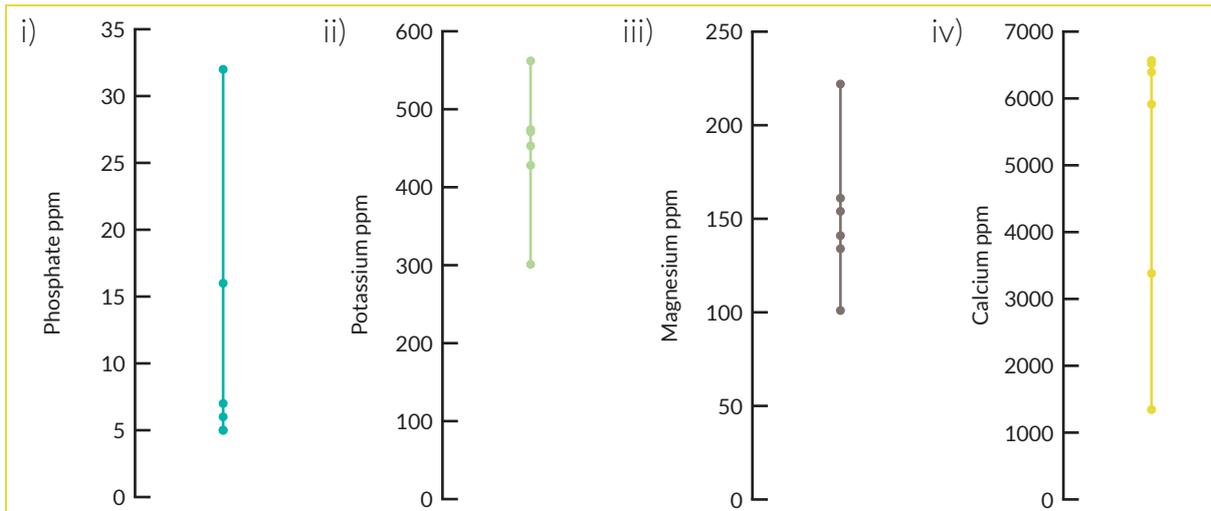


Figure 7: Major plant nutrients present in the soil at six populations of Broad-fruited Cornsalad: i) Phosphate, ii) Potassium, iii) Magnesium and iv) Calcium

of bare ground within 0.5 m of plants was 36%, and the height of surrounding vegetation varied between 15-60 cm. This suggests that Broad-fruited Cornsalad may, in certain circumstances, compete with relatively dense and tall vegetation once plants are established.

Soil nutrients

Broad-fruited Cornsalad grows mainly on arable land across England and Wales and is thus subject to a range of soil nutrient conditions (Figure 7).

The Devon population of Broad-fruited Cornsalad is in a cultivated margin next to an arable field managed conventionally. There have been recent periods when the whole field has been conventionally farmed, which has included the use of fertiliser and herbicide. During this period, the cultivated margins (and Broad-fruited Cornsalad) were not present.

The Cornwall population persists in an annually cultivated field margin which has not received any fertiliser applications for at least five years. Furthermore, the population is at the top of a slope and drainage through the free-draining sandy loam may have further lowered soil nutrient levels at this location.

The entire Somerset population has been sympathetically managed for arable plants for a long period and has not received any fertiliser application during this time. Prior to being managed for arable plants, the fields were inconsistently managed as part

Broad-fruited Cornsalad is associated with arable habitat across England and Wales, so is subject to a range of soil nutrient conditions

of an agricultural holding and fertiliser may not have been routinely applied.

Phosphate varied between 5 ppm (Index 0.5) to 32 ppm (Index 3.3). The average phosphate level was 12 ppm (approximately Index 1.2). The population with the highest phosphate was under conventional arable management in Devon.

Potassium varied between 301 ppm (Index 3.3) at the free-draining Cornwall site to 562 ppm (Index 4.8) at the free-draining Devon site. Average potassium was 448 ppm (Index 4.2).

Magnesium varied between 101 ppm (Index 3.0) at the free-draining Cornwall site to 222 ppm (Index 4.6) at the free-draining Devon site. The average magnesium level was 152 ppm (Index 3.7).

Soil calcium levels ranged from 1344 ppm at the Devon population which also had the lowest pH, to 6568 ppm in one of the Somerset fields, which was at the top of a slope and therefore may have thinner clay loams overlying the limestone bedrock (all of the soil calcium levels were greater than 5900 ppm in Somerset).

It is notable that in separate experiments with Broad-fruited Cornsalad growing under different nitrogen applications, the mean number of plants per 4 m² plot was found to vary from 11.8 with no additional nitrogen, to 6.8 with a half-rate application and 2.1 with a full-rate application⁵.

Discovery of a new Broad-fruited Cornsalad population in Cornwall

In 2016, the National Trust revised the management of the farm at Pentire Head in North Cornwall in line with their strategy of farming for nature.

They began work developing 6 m wide cultivated margins around all the arable fields to encourage wildlife associated with this habitat. Although a few arable plant surveys had been undertaken in some of the fields in the past, none of the surveys had been comprehensive and the arable rotation meant that different fields were under cultivation or in grass leys each year.

To develop a stronger baseline, the National Trust commissioned Plantlife to survey the entire farm in 2016. It was at this point that both Narrow-fruited Cornsalad *Valerianella dentata* and Broad-fruited Cornsalad were found, with their identity later confirmed by the Botanical Society of Britain and Ireland referee for this group of plants (Figure 8). The population was estimated to comprise 15-20 large plants bearing many seeds. Although the species was reported to be present in 2017, a population count was not undertaken.



Figure 8: The photograph used to confirm the identification of Broad-fruited Cornsalad at Pentire Head © Mike Simmonds



Figure 9: Rabbit grazed Broad-fruited Cornsalad © Hannah Gibbons

		2018	2019	2020
Number of plants recorded during summer survey		4	53	5
Stature of plants seen		Short and stocky	Tall and branched	Short and stocky
Timing of cultivation		Spring	Autumn	Autumn
Monthly rainfall recorded at Rock, Cornwall* (inches)	February	1.60	2.49	3.17
	March	5.24	2.71	1.88
	April	2.64	1.70	1.30
	May	1.28	0.39	0.47
	June	0.18	3.78	4.93

Table 1: Differences in population number, plant stature, cultivation timing and monthly rainfall in 2018, 2019 and 2020 at Pentire Head, Cornwall. *Data from <https://www.wundcrground.com/dashboard/pws/!ROCK/graph/2020-07-31/2020-07-31/monthly>. Last accessed 25/01/2020.

This field was cultivated in April 2018 following a failed crop that had been sown in October 2017, and the spring cultivation of the margin may have influenced the population size. In the summer of 2018, four plants were recorded at Pentire Head, but these plants were fairly small (maximum 10 cm tall) and densely branched, unlike the open, spreading plants typical of this species. Some of plants appeared to have been grazed by rabbits, which could have led to the shorter, stockier growth (Figure 9).

The field was next cultivated in autumn 2018 and 53 plants were found the following summer within the same part of the field as the original 2016 population. The plants were tall with open, spreading branches. In contrast, the autumn 2019 cultivation resulted in just five short, compact plants, recorded in summer 2020.

Table 1 highlights the differences in population number, plant stature, timing of cultivation, and monthly rainfall in 2018, 2019 and 2020. In 2018 and 2020, small numbers of plants were recorded with a stocky stature, apparently unrelated to the timing of cultivation. Also, population size and stature appear unrelated to rainfall, suggesting that there are complex and poorly understood influences on the population size of this species.

There is still much to learn about available soil nutrients and uptake by plants. It appears that Broad-fruited Cornsalad can survive in a range of conditions and that soil nutrients are not necessarily harmful. However, comparing soil nutrients present at other surviving populations across the UK would help us form a more rounded picture of the conditions that this species prefers. The lower population sizes under increased nitrogen levels might be a factor in the decline of this species as atmospheric nitrogen has increased in recent years, which could increase overall soil fertility.

Vegetation communities

Broad-fruited Cornsalad (Figure 10) is typically associated with species-rich arable plant communities supporting other rarities such as Spreading Hedge-parsley *Torilis arvensis*, Corn Buttercup *Ranunculus arvensis* and Narrow-fruited Cornsalad *Valerianella dentata*.

To date there has been little analysis of British plant communities containing Broad-fruited Cornsalad, which is likely to be due to the small number of extant populations. In the National Vegetation Classification⁶ there are no plant communities where Broad-fruited Cornsalad is a consistent feature, and this species is not listed once within the 18 arable plant communities in volume 5 of British Plant Communities. As such, it was not recorded at all within the 583 survey samples collected and analysed to identify these 18 communities.

The population at Fivehead Arable Fields SSSI, in Somerset, is found within the NVC community OV15 Scarlet Pimpernel *Lysimachia arvensis* – Common Field-speedwell *Veronica persica* community, showing closest affinities with the OV15b Venus’s-looking-glass *Legousia hybrida* – Small Toadflax *Chaenorhinum minus* sub-community. This community is characterised by the dominance of small ephemeral species such as Scarlet Pimpernel, Common Field-speedwell and Knotgrass *Polygonum aviculare* agg. In late summer, Sharp-leaved Fluellen *Kickxia elatine* and Round-leaved Fluellen *Kickxia spuria* often become noticeable within this plant community, with their downy shoots carpeting the ground. OV15 is typically characteristic of cereal crops on base-rich soils of the south-east of Britain. At Fivehead Arable Fields SSSI this vegetation community occurs on very heavy clay over Jurassic limestone and is botanically diverse.

There are no plant communities where Broad-fruited Cornsalad is a consistent feature



Figure 10: Broad-fruited Cornsalad © Cath Shellswell

The OV15b sub-community is typically characterised by frequent Dwarf Spurge *Euphorbia exigua*, Venus’s-looking-glass, Small Toadflax and Narrow-fruited Cornsalad. Shepherd’s-needle *Scandix pecten-veneris* can also be present within this sub-community.

Pentire Head in Cornwall also supports a population of Broad-fruited Cornsalad within vegetation showing affinities with OV15, more specifically OV15a, the Common Chickweed *Stellaria media* – Field Bindweed *Convolvulus arvensis* sub-community. This sub-community is typified by the presence of less habitat-specific and more competitive arable plants. Grasses such as Wild Oat *Avena fatua*, Black-grass *Alopecurus myosuroides* and Creeping Bent *Agrostis stolonifera* are often common. OV15a tends to be found where soil nutrient levels are higher (relative to other OV15 sub-communities), often due to fertilisation, albeit historical.

At Lower Bowden in South Devon, the plant community supporting Broad-fruited Cornsalad is quite different, showing affinities with OV4 Corn Marigold *Glebionis segetum* – Corn Spurrey *Spergula arvensis* and, more specifically, OV4b the Creeping Buttercup *Ranunculus repens* – Prickly Sowthistle *Sonchus asper* sub-community. OV4 occurs widely throughout Britain on light, fertile, acidic soils, although it is most frequent

on less intensive arable land in the west. The most distinctive feature of this community is the constancy of Corn Spurrey and Corn Marigold, the latter often being abundant and very conspicuous with its large yellow flower heads. Knotgrass and Annual Meadow-grass *Poa annua* are also constant species with frequent Common Couch *Elymus repens*, Shepherd's-purse *Capsella bursa-pastoris* and Common Chickweed. At Lower Bowden, Broad-fruited Cornsalad was noticeable in that it was more vigorous and abundant where the vegetation was opener, and Corn Marigold was sparser.

Below are vegetation descriptions of three additional sites that support Broad-fruited Cornsalad.

- Near Burford in Oxfordshire, it occurs in large quantities in at least three fields on heavy clay soils over Cotswold limestone. Associated species include Shepherd's-needle, Narrow-fruited Cornsalad, Venus's-looking-glass, Night-flowering Catchfly *Silene noctiflora* and Blue Pimpernel *Lysimachia foemina*.
- In mid-Hampshire, large numbers occur in two field margins with Narrow-fruited Cornsalad, Rough Poppy *Roemeria hispida*, Prickly Poppy *Roemeria argemone* and Rough Mallow *Malva setigera*.
- It is known from a single field near the coast of the Gower Peninsula, where it occurs in a species-rich community including Small-flowered Catchfly *Silene gallica* and Corn Marigold.

Distribution

This species has been present in Britain since the Iron Age and is therefore classed as an archaeophyte (a plant naturalised in Britain before 1500AD). Broad-fruited Cornsalad was previously much more widespread, with a scattering of records from southern England as far north as central Scotland, although it has never been abundant (Figure 11).

In mainland Britain, most sites are located south of a line between the Wash and Severn Estuary with a concentration of sites in south-west England and a single site in Wales on the Gower Peninsula. In the New Atlas of the British Flora⁶, Broad-fruited Cornsalad has a high negative change index of -2.55. The total number of 10 km squares (hectads) from which it was recorded before 1970 was 149, but it was only known from 38 hectads between 1950 and 1970. Numbers of records fell to 14 hectads between 1970 and 1986, and it has been recorded from 14 hectads between 1987 and 2006. Although a few new sites have been found in recent years (one in Norfolk and another at a coastal location in Cornwall), local extinctions continue with changes in land management, such as conversion of arable land to pasture. There appears, therefore, to

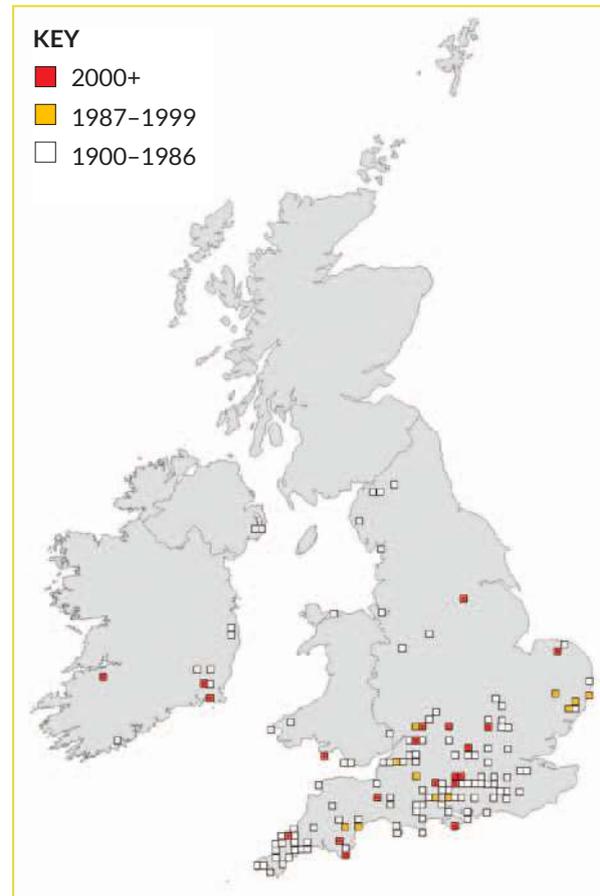


Figure 11: Broad-fruited Cornsalad distribution across Britain and Ireland. The data used to create this map has been provided under licence from the Botanical Society of Britain and Ireland (BSBI) and accessed from the Society's online database.

have been a serious decline of this species, although as with many annuals, caution must be observed in the interpretation of these figures, as this is a species with a history of erratic appearance. A review of its status in 1997⁷ concluded that there were only four extant sites, but more recent examination of records from between 2000-2020 indicates that there are just fewer than 20 populations remaining. Further clarity should be added with the publication of the next UK Plant Atlas.

In Ireland, there are a handful of populations in Co. Wexford and one in Co. Limerick.

Beyond the British Isles, the species occurs in southern-central Europe, and is threatened in Germany, the Netherlands and Switzerland.

Some of the apparent rarity of this species in the past may have been due to confusion with the closely related Narrow-fruited Cornsalad *Valerianella dentata*, from which it is only reliably distinguishable by the shape of the seed. The diagnostic features of the various

Cornsalad species are now better understood, but even so, small populations can be easily missed or confused with related species.

Reasons for decline

Broad-fruited Cornsalad is especially vulnerable to changes in land management and particularly to several common practices associated with intensive farming. The widespread use of broad-spectrum herbicides is likely to have inflicted the greatest impact on Broad-fruited Cornsalad populations and it is also likely to have been affected (though perhaps to a lesser extent) by the development of competitive cereal crop varieties combined with an increase in nitrogen application, so that the species is quickly outcompeted by closing the cereal sward, preventing light from reaching the seedlings. Broad-fruited Cornsalad grows poorly where surrounding vegetation is thick and tall.

Winter-sown cereal crops tend to be more intensively managed than spring-sown crops, typically with far higher nitrogen and herbicide application rates, aimed at improving the crop yield. As Broad-fruited Cornsalad tends to prefer autumn cultivation, this management is likely to negatively affect this species.

A more recent threat is the loss of arable habitat to grassland and/or vegetable production. As small-scale arable farms become less profitable in Britain, the fields where Broad-fruited Cornsalad is present are likely to be turned over to different management. The first parts of fields to be withdrawn from cultivation are usually the less productive field margins which are also the last refugia of many rare arable plants. These are converted to grassland, sometimes as part of agri-environment schemes designed to benefit farmland wildlife. It is essential that the management of field margins under agri-environment schemes is planned using the available information on distribution of uncommon arable plants.

Non-arable sites are at risk from successional processes. These involve the development of closed grassland communities and scrub. Coastal sites may be vulnerable to cliff erosion.

The seeds of Broad-fruited Cornsalad are medium-sized, lacking projections that would help in dispersal, and they would have been easily removed from cereal seed even with the most primitive seed-cleaning technology. They have no obvious aids to transport by animals or wind,

though dispersal by wind or water might be assisted by the large and mostly hollow seed capsule.

Historical records of this species suggest that it was never common in the UK. For example, in Cornwall, a stronghold for this species, there are 48 records at different locations between 1835 and 2016. This species was recorded at 13 locations between 1835-1900, 27 locations between 1901-1930, one location between 1931-1999, and at seven locations between 2000-2016. Before 2017, there are only five records of this species occurring at the same location in different years, though the variation

in records may be due to under-recording or lack of monitoring.

Broad-fruited
Cornsalad is especially
vulnerable to changes
in land management

GB status and rarity

Endangered.

Protection under the law

Broad-fruited Cornsalad is included as a species of principal importance for the purpose of conserving biodiversity under Section 41 (England) of the Natural Environment and Rural Communities Act 2006.

Cultural connections

The greatest use for *Valerianella* is as a salad crop using the species Lamb's Lettuce or Common Cornsalad *Valerianella locusta*. Seeds of the plant have been found at Neolithic and Bronze Age sites. It was first taken into cultivation in Western Europe during the seventeenth century where it was especially valued as a winter salad crop. Healing properties attributed to cornsalad include regulation of bowels, preventing infection, cleansing of blood and preventing spring fatigue⁸.

Survey method

Individual plants should be counted in smaller populations of fewer than 100 individuals. Larger populations should be estimated, or an alternative strategy would be to map the extent of the distribution. Other factors could also be recorded, such as the method and depth of cultivation, the application and type of any fertiliser or herbicide, soil texture and

nutrient levels if a soil test was undertaken. As Broad-fruited Cornsalad grows within a community of plants, it is useful to record associated species. An example of a recording form is contained within the appendix.

Habitat management

Ideal management, on arable land, requires annual cultivation preferably in autumn (between October and

early December) or spring (between February and early April), and then little disturbance until the following autumn by which time the plants will have set seed. Autumn cultivation is more suitable for heavier clays where there may be difficulties cultivating in the spring if the soil becomes saturated overwinter.

Broad-fruited Cornsalad readily germinates from seed, and needs soil disturbance, such as ploughing, to bring buried seed to the soil surface and trigger germination.

Survey methodologies for different population sizes

There are three recommended methods for assessing population size depending on the general abundance of the plant being surveyed.

These methods have all been used to estimate Broad-fruited Cornsalad population sizes. It is important to ensure that the survey is carried out at the optimal time of year, when the seeds have started to mature, but are not so mature that they have fallen from the plant.

1 Counting: If there are few plants or if they are scattered and easy to count, it is recommended that a simple count is made. This is likely to be most suitable if walking around the margin of a field. As the species is quite branched, it can be difficult to identify individuals growing in close proximity. Giving a plant a wiggle can help identify if more than one plant is present or if a single plant is branched.

2 Scaling-up using quadrat data: If plants are scattered evenly throughout the vegetation it might be worth counting the number of plants within quadrats, taking an average and then scaling up. The size of the quadrat used will depend on the frequency of the target plant. This methodology is probably best suited when Broad-fruited Cornsalad is not just restricted to the margin but found in a wider area, such as a wide cultivated margin, and if only one or a few people are surveying the population.

For ease, the quadrat size should be no more than 2x2 m. For example, ten 1x1 m quadrats were surveyed within the 6 m wide cultivated margin where Broad-fruited Cornsalad seemed evenly distributed. An average of 3 plants were found per m². The plants occurred within a 20 m length of the margin, therefore within an area of 120 m². As such, the estimated population for the site was 3x120=360 plants.

3 Scaling-up using transects: This is a method for populations which are scattered over a large area. It requires a small to large team of people to walk over the area where the plants are present to estimate population size.

In order to estimate the population, first examine a few plants to get a feel for the size and shape that an individual plant occupies and covers. This enables all members of the survey team to get an eye for the stem branches, fruits and spread of plants which can be very different sizes. It is especially useful to do this when Broad-fruited Cornsalad is growing with other members of the same family, such as Narrow-fruited Cornsalad *Valerianella dentata*. In addition, it gives a rough visual baseline of expectations when counting.

Each person should then walk in a straight line at an agreed distance apart from one side of the area to the other trying to keep pace with one another. As a guide, stationing surveyors 3-4 m apart allows for a comfortable field of vision, whilst attempting to avoid double counting. Each surveyor needs to keep a record of the number of plants of the target species that they see within their strip of the field. Once the population has been walked, all individual tallies are totalled to give a population count for the area covered. This process can be repeated in another part of the population area (if not all covered in one go) or scaled up.

Box 1: Survey methodologies for Broad-fruited Cornsalad populations

In cultivation depth trials, ploughing was found to increase densities of Broad-fruited Cornsalad compared to minimum tillage. It will grow within a crop, such as an autumn- or spring-sown cereal, oil-seed rape or field beans, or within an uncropped cultivated area or plot (Figure 12).

It is susceptible to broad-spectrum herbicides and their use will reduce population sizes. However, if required, treatment of problematic weed species could be undertaken by using targeted herbicides. Fertiliser can encourage problem weeds. It is not usually applied to uncropped areas for arable plants and is limited on cereal headlands and wildlife cover crops^{9,10}. The number of Broad-fruited Cornsalad plants surviving under a winter wheat canopy with a normal farm level of nitrogen application was less than 20% of the numbers surviving where no nitrogen had been applied⁵.

Using a reduced seed-sowing rate and/or a crop variety that has fewer tillers on conservation headlands, alongside a reduction in the application of nitrogen, will also benefit Broad-fruited Cornsalad, as it is a poor competitor. If Broad-fruited Cornsalad is growing

Broad-fruited Cornsalad readily germinates from seed

within a crop, the crop should be harvested after the plant has set seed, usually from late July onwards.

In non-arable habitats, open ground should be restored and maintained annually through rotavation in autumn or spring if natural processes do not facilitate open ground.

As Broad-fruited Cornsalad seed is believed to be at least moderately long-lived in the soil seed bank, there is a good chance that reinstatement of suitable management could provide enough germination and establishment niches where populations have been recorded in the recent past. If the species has not been recorded recently, or has failed to return under a favourable management regime, reintroduction is likely to be required.

Reintroduction

Sowing seed in autumn mimics natural seed dispersal and provides an opportunity for autumn germination and the establishment of larger and more productive plants (Table 2). Seed which does not germinate in



Figure 12: Broad-fruited Cornsalad will grow within a crop or in an uncultivated area © Cath Shellswell

How do herbicide applications, season and depth of cultivation affect rare cornsalads?

A series of trials undertaken at Fivehead Arable Fields SSSI investigated the effect of season and depth of cultivation and herbicide application on the arable flora, including Narrow-fruited Cornsalad *Valerianella dentata* and Broad-fruited Cornsalad.

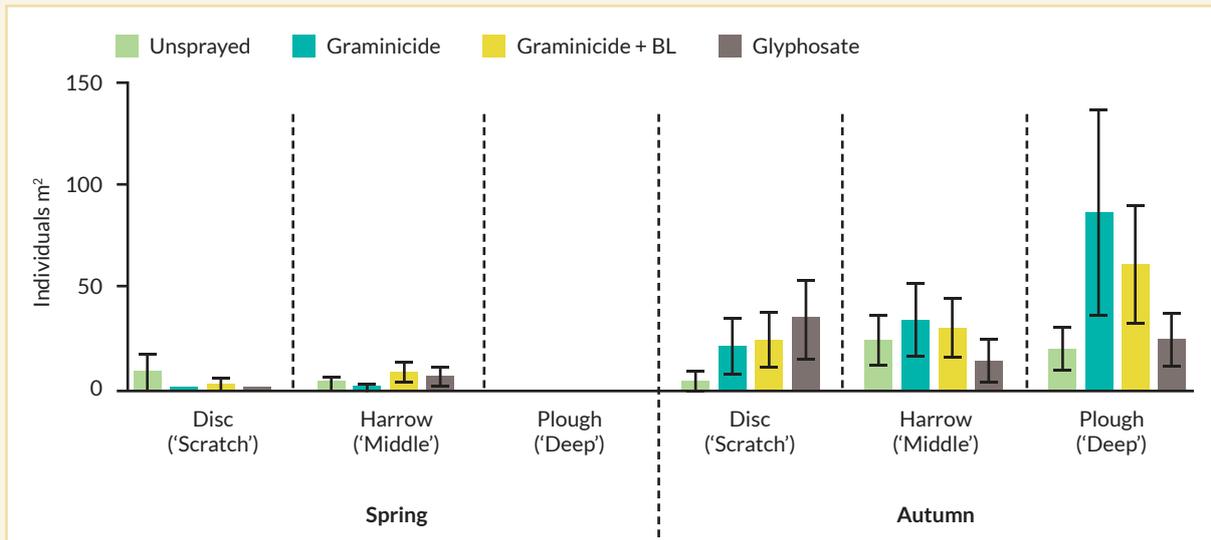


Figure 13: Densities of cornsalad plants within the experimental plots at Fivehead Arable Fields SSSI under: i) different timing of cultivation (spring or autumn), ii) depth of cultivation (discing which disturbs the soil surface and is used for initial seed bed preparation; power harrowing which is a non-inversion method of cultivation creating a tilth to a depth of 10 cm; and ploughing which is inversion tillage, turning over the soil to a depth of 30 cm with a subsequent pass over with a power harrow to create a fine seed bed), and iii) herbicide treatment (untreated; treated with graminicide; treated with graminicide and broad-leaved herbicide; treated with Glyphosate, which kills both grasses and broad-leaved weeds.)

These two species are impossible to distinguish before they produce seeds and the surveyors did not distinguish between the species to prevent count errors.

In this experiment, cornsalads had an almost exclusive preference for autumn cultivation (Figure 13). Ploughing also increased densities of cornsalads compared with discing and harrowing. This was irrespective of soil seed bank densities which were high across all experimental plots. There was also a combined effect of herbicide treatment and cultivation depth, with densities of cornsalads twice or three times higher on graminicide-sprayed, autumn-ploughed plots than on unsprayed autumn-disked or harrowed plots. This alludes to the impact of autumn-germinating grasses on cornsalad populations.

At the outset of the trials, the soil seed bank was found to be unevenly distributed across the herbicide treatment plots. There were fewer cornsalad seeds in the plots with the combined graminicide and selective broadleaved herbicide application than in the plots that received just glyphosate. However, depth of cultivation was found to be a more significant factor influencing the

soil seed bank, with more cornsalad seed in combined graminicide and herbicide plots that had either been harrowed or ploughed. Lower numbers of cornsalad seed were found in the soil of disked plots that had just received either graminicide or combined herbicide.

The graminicide application had a potentially controlling effect on more competitive problem species. At Fivehead Arable Fields SSSI, cultivation in autumn was associated with the undesirable grasses Creeping Bent *Agrostis stolonifera*, Black-grass *Alopecurus myosuroides*, Onion Couch *Arrhenatherum elatius* var. *bulbosum*, Wild Oat *Avena fatua* and Smooth Brome *Bromus racemosus*. In addition, several undesirable weed species were associated with the less intensive cultivation methods of discing and harrowing. This included Smooth Brome, Italian Rye-grass *Lolium multiflorum* and Bristly Oxtongue *Helminthotheca echioides*. The benefit to cornsalads of ploughing and graminicide application in the autumn shows that this management could boost populations of Broad-fruited Cornsalad whilst simultaneously reducing the populations of undesirable species.

The highs and lows: how Broad-fruited Cornsalad can bounce back

Broad-fruited Cornsalad had been recorded at Lower Bowden Farm, South Devon in 1997, 1999 and 2005.



Figure 14: Cultivated margin in South Devon containing tens of thousands of Broad-fruited Cornsalad plants © Hannah Gibbons

It was surveyed thoroughly in 2018, but the species was not found, although a single Narrow-fruited Cornsalad plant was seen within a gateway. The field had been sown with a winter cereal crop and managed conventionally with herbicide. In autumn/winter 2018, the field was cultivated as normal, but a 2.5 m uncropped cultivated margin was put in around the perimeter of the field. A survey in the summer of 2019 revealed tens of thousands of Broad-fruited Cornsalad plants creating a mat of growth amongst Narrow-fruited Cornsalad *Valerianella dentata*, Common Poppy *Papaver rhoeas* and Corn Marigold *Glebionis segetum* (Figure 14).

Areas of dense Corn Marigold had fewer Broad-fruited Cornsalad plants, suggesting it may be disadvantaged by its growth

The wet weather of autumn and winter 2019 prevented the field from being cultivated again until spring 2020, and in summer 2020 the cultivated margin supported approximately 55 plants, significantly fewer than 2019. The cultivation timing might provide some reason

for the lower population size in 2020, though there may also be other variables involved. It was very clear in 2020 that areas of dense Corn Marigold supported few or no Broad-fruited Cornsalad plants. This suggests that Broad-fruited Cornsalad may be disadvantaged when the growth of Corn Marigold is favoured.

Activity	Timing (month)
Autumn cultivation and sowing	
Prepare the seed bed to create a fine tilth e.g. light cultivation or disking.	September-October.
Mark out the corners of the plot(s).	September-October.
Hand-sow seed (use a combination of seed with lime-free silver sand) at a rate of approximately 100 seeds per m ² (see Broadcast Sowing Method in <i>Further reading</i>).	September-October.
If conditions allow, roll the reintroduction plot(s) to press the seeds onto the soil surface. This creates the right conditions for germination.	September-October.
Survey and ongoing management	
Adult/flowering plant survey.	June-July.
Continued autumn cultivation of the reintroduction site.	September-October and ongoing if the reintroduction is successful.
Annual adult/flowering plant survey.	June-July and ongoing to monitor the population.

Table 2: Recommended Broad-fruited Cornsalad reintroduction plan

autumn may persist in the soil and germinate in spring, when further sowing could also be undertaken if seeds are collected and stored in suitable conditions (see Storing Wild Flower Seed in *Further reading*). Seed should be sown onto bare, recently cultivated ground.

The recommended sowing rate for cornfield annuals like Broad-fruited Cornsalad is 100 seeds per m²¹¹. The germination behaviour of Broad-fruited Cornsalad appears to be variable, making it hard to predict germination and establishment success. Whilst high levels of germination are possible, to establish a large, healthy population it may be prudent to sow at the recommended rate or higher where the supply of seed permits. Although each seed capsule is swollen and looks like it might contain more than one seed, actually there is

just one seed per capsule and two empty compartments (Figure 15). It is unknown why the seed capsule has developed in this manner, and all cornsalads seem to have sterile locules.

1 g of dried Broad-fruited Cornsalad seed contains approximately 814 individual seeds³.

Areas for further research

Seed longevity and dormancy

Given the high conservation value of Broad-fruited Cornsalad and the importance of the soil seed bank in the recovery and persistence of annual plant populations, it would be useful to conduct some longevity or seed aging experiments on this species³. Similarly, a study to elucidate the dormancy behaviour of the species could be particularly useful to improving understanding and therefore conservation efforts.

Genetic diversity

No studies on genetic diversity within this species have been carried out. Such a study would be desirable to elucidate relationships between populations, especially as there are so few populations surviving and they are very fragmented across England and Wales.



Figure 15: Broad-fruited Cornsalad seed cross-section showing the full compartment containing the seed at the top and two empty compartments. © RBG Kew

Increasing the number of Broad-fruited Cornsalad populations in Devon

Two Broad-fruited Cornsalad reintroductions were carried out in South Devon during November 2019 and February 2020 (Figure 16).

The first site, Ash Tree Farm, was sown by hand with 2,500 Broad-fruited Cornsalad seeds in November 2019 at an approximate rate of 100 seeds per m². This site is very close to an existing population of Broad-fruited Cornsalad and was cultivated in autumn specifically for the purpose of reintroduction. In the summer of 2020, the reintroduction plot was searched and a well-branched single Broad-fruited Cornsalad plant was found, bearing about 40 seeds.

The second site, at Lincombe Farm, was not ploughed until February 2020 as the ground was too wet for heavy machinery. Broad-fruited Cornsalad seed was sown into two separate fields on the farm. The seeds were sown by hand at a rate of approximately 100 seeds per m² a few days after the fields were cultivated.

This site is very close to an existing population of Broad-fruited Cornsalad, so was cultivated for reintroduction

2,500 seeds were sown onto two narrow strips within two existing cultivated margins. The margins had been walked in summer 2019 and the openest parts of the margins were chosen for the reintroduction. Five plants were found (one in the first plot and four in the second plot) during a survey in summer 2020. The single plant was found to be short and densely branched, yet the

four plants in the second margin were tall and openly branched. There were no obvious differences in the growing conditions between the two plots to cause the different growth statures.

The long-term success of these reintroductions is as yet unknown, but if the populations become established they could double the known number of existing Broad-fruited Cornsalad sites in Devon.



Figure 16: Cultivated margin at a reintroduction site in South Devon ©Hannah Gibbons

Habitat type and condition: broad habitat, crop, soil type, NVC, flooding etc.				Threats or reason for the null record: (✓)		Aquatic plants only: (✓)		
				Afforestation		Water-body margin grazed		
				Agricultural improvement		Water-body recently cleared		
				Burning		Water-body margin affected by drainage		
Is there an agri-environment scheme option? (i.e. wild bird mix, wildflower margin, cultivated area?)				Lack of management		Soil nutrients:		
				Invasive species		Soil test taken?	Yes	No
				Mineral extraction		pH		
Is the species growing within a crop?				Overgrazing		Phosphorus (mg/l or index)		
Yes		No		Pollution / eutrophication		Potassium (mg/l or index)		
What is the type of crop?				Recreation		Magnesium (mg/l or index)		
None		Barley		Species transient		Clay content (%)		
Wheat		Potato		Under-grazing		Silt content (%)		
Roots (i.e. beet, parsnips, carrots). Please state:				Urban/road development		Sand content (%)		
Brassicas (i.e. cabbage, sprouts, radish). Please state:				Other:		Textural class i.e. clay loam		
Other. Please state:						Other:		

Reproduction potential: Are the plants in seed? Are there any young plants?	
Is the site suitable for germination of seeds? Provide a percentage cover of bare ground.	
Describe the vegetation around and among the plants:	
Are there any aggressive species suppressing the plants? e.g. bracken, bramble, coarse grasses	
Are the plants being shaded out by trees or shrubs? e.g. conifers, bramble, hawthorn thickets	
Is there any disturbance/activities which are affecting the plants in a good or bad way? e.g. horse riding, motor-bikes, dog walking, tree-felling	
Please list any other nationally rare species present	

Type of cultivation/disturbance?				
None		Min till (0-4 cm/0-1.5 in)		
Plough (4-8 cm/1.5-3 in)		Deep plough (8 cm+/3 in+)		
Other - state depth of disturbance (i.e. disturbance by vehicle movements)				
Month and year of last cultivation/disturbance			Month	
			Year	
Type of herbicide?				
None		Graminicide		
Broad-leaved		Graminicide and broad-leaved		
Month and year of herbicide application			Month	
			Year	
Type of fertiliser?				
None		Organic		
Inorganic		Other?		
Month and year of fertiliser application			Month	
			Year	
Percentage of bare ground within 5 1 x 1 m quadrats centred on plants of the target species				
Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5
Height of vegetation within 5 1x1m quadrats centres on plants of the target species				
Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5

Glossary

- Locule** – A small compartment or chamber, as within a seed capsule or a pollen containing cavity within an anther.
- Minimum tillage** – A soil cultivation system with the goal of minimum soil manipulation necessary for successful crop production.
- Rotavation** – The process of breaking up the surface of the earth, or an area of ground using a rotavator.
- Tiller** – In grasses, a lateral stem produced from near the base of the stem.

Case studies

- *Broad-fruited Cornsalad fluctuations at Fivehead Arable Fields* by Alison Mitchell (Plantlife)



- *Discovery of a new Broad-fruited Cornsalad population in Cornwall* by Hannah Gibbons (RSPB)
- *How do herbicide applications, season and depth of cultivation affect rare cornsalads?* by Cath Shellswell (Plantlife)

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- *The highs and lows: how Broad-fruited Cornsalad can bounce back* by Hannah Gibbons (RSPB)
- *Increasing the number of Broad-fruited Cornsalad populations in Devon* by Hannah Gibbons (RSPB)

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Further reading

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Contributors



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Back from the Brink is the first time ever that so many conservation organisations have come together with one focus – to bring back from the brink of extinction some of England’s most threatened animals, plants and fungi. Natural England is working in partnership with Rethink Nature, and the entire project is made possible thanks to funding from the National Lottery.

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