

Dispersal of *Calluna vulgaris* (L.) Hull. seeds on severely burnt upland moorland

J.A. Gilbert and K.R. Butt

School of Built and Natural Environment, University of Central Lancashire, UK

SUMMARY

From natural and manipulated experiments at 460 m a.s.l., traps were used to record the dispersal range of *Calluna vulgaris* seeds on an unvegetated post-wildfire site. Seeds were trapped to 50 m from source, although most (73%) were deposited within one metre of the parent plant. *C. vulgaris* seeds were not dispersed as far in these experiments as recorded in previous workers' experiments on lowland grassland.

KEY WORDS: heather, peat, regeneration, seed trap, wildfire.

INTRODUCTION

Uncontrolled fires (wildfire) on moorland are relatively common, particularly in drought years, and the effects may prove severe and long-lasting. Fires that burn for lengthy periods destroy the stands of *Calluna vulgaris*, burn deeply into the underlying organic horizons and may destroy the soil seedbank. Post-wildfire management may consist of liming, fertilising and sowing with seeds of selected nurse grasses and *C. vulgaris*. However, many post-wildfire moorland sites receive little or no management and are left to recolonise naturally from the surrounding vegetation. The process is often slow and many badly burnt sites have remained bare for decades after wildfires (Radley 1965, Maltby *et al.* 1990, Gilchrist *et al.* 2004).

Many aspects of heather ecology have been investigated to try and assist re-vegetation. Amongst these, seed dispersal may be critical. This was examined by Bullock & Clarke (2000) who reported that *C. vulgaris* seeds were dispersed up to 80 m from a translocated source plant within a lowland grassland setting, although 91% of such seeds fell within 0.8 m of the parent plant. Nordhagen (1937) had previously suggested that *C. vulgaris* seeds may travel up to 250 m in winds of 30–40 m s⁻¹.

The aim of the current work was to follow up that of Bullock & Clarke (2000) by assessing seed dispersal of *C. vulgaris* in the more pertinent setting of burnt moorland. Specific objectives were (1) to measure seed dispersal distance and (2) to quantify dispersal in terms of seed density over the given range. Two field experiments were set up; the first examined a natural situation and the second involved translocation of seed-producing plants to a large burnt area of moor.

METHODS

Site details

The upland moorland study site (53° 30' 58.94" N, 1° 59' 36.34" W) is 4 km north-east of Stalybridge, on the northern edge of the Peak District National Park, at an altitude of 380–460 m a.s.l. Climatic conditions are characteristic of an oceanic regime, dominated by cool, wet and cloudy weather. A severe wildfire in 1980 completely destroyed all vegetation over an area of 16 ha. Subsequent management involved liming, fertilising and seeding with grass. Bales of cut heather were spread to provide a supply of *C. vulgaris* seed. The site was fenced to prevent entry of sheep, but much degraded moorland (from post-fire erosion and peat deposition) remains outside such protection. Deep gullies eroded by water run through the site, exposing mineral soil and large stones of the underlying Millstone Grit parent rock. Results from a vegetation survey in 2000 (Gilbert 2008) revealed that ground cover on the research site was 77% unvegetated, 6% grasses (predominantly *Deschampsia flexuosa*) and only 17% *C. vulgaris*.

Seed trap design

C. vulgaris seeds are elliptical (0.55–0.65 mm x 0.35–0.45 mm), have a dry mass of about 25 mg, and are yellowish-red in colour (Fagundez & Izco 2004). The seed traps had to ensure seed capture, but avoid flooding or losses to wind. We used similar experimental methodology and seed trap design (see Figure 1) to those used by Bullock & Clarke (2000) in their work on lowland grassland to allow direct comparisons to be made. Traps were also similar to those evaluated by Chabrierie & Alard (2005). Two 9 cm diameter plastic plant pots were

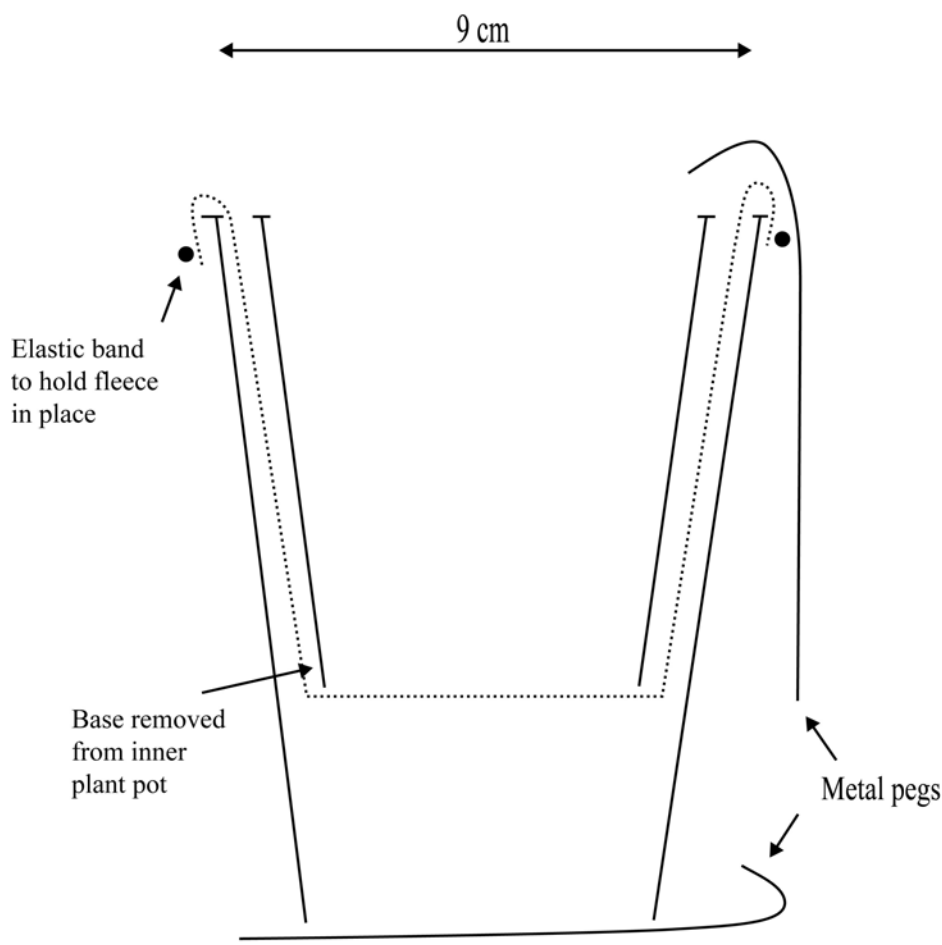


Figure 1. Seed trap design (not to scale), showing the inner and outer plant pots (unlabelled solid lines), fleece (dotted line) and securing arrangements.

used, one inside the other, with the inner pot shortened and its base removed. A 30 cm circle of 17 g m⁻² horticultural fleece was placed between the pots and held in position with a durable elastic band. The trap was dug into the peat and pegged down through the lower pot. Peat was replaced around the trap and tamped down. The upper part of the trap remained 1 cm above the peat surface so that seeds could not be blown across the surface and indirectly into the trap (Bullock & Clarke 2000). A second metal peg held the inner plant pot and trap firmly in position. At times of sampling, the fleece and contents were removed and a replacement circle of fleece inserted into the trap. Fleece samples were collected into individual plastic bags, sealed and labelled appropriately. Samples were air dried to aid seed identification; seeds and capsules were counted and recorded. Seed numbers for each trapping distance were combined and mean number of seeds m⁻² calculated.

Experimental design

Environmental conditions on site, due to the wildfire and subsequent regeneration, enabled two experiments to be undertaken in successive years. The first (natural) was on unvegetated peat between two large banks of re-established *C. vulgaris*, separated by a distance of 90 m. This experiment was used primarily to examine the efficacy of seed trap design. Here, seed traps were placed along three pairs of parallel transects (1 m apart) between the *C. vulgaris* plants. In late September, seed traps were placed at the edge of the *C. vulgaris* plants (0 m) and at 1, 2, 3, 4, 5, 10 m and thereafter at every 5 m to 45 m. Trap contents were collected after 4, 8 and 12 weeks, well within the reported seed-shedding period (Legg *et al.* 1992, Barclay-Estrup & Gimingham 1994).

The second (translocation) experiment was made in a large area of unvegetated peat with traps radiating away from the central seed source. No

C. vulgaris plants were present within the experimental site (circle with a radius of 100 m), which ensured that seeds travelled at least the stated distance from the seed source to seed trap.

C. vulgaris plants (approximately 0.75 m in diameter x 0.3 m high) were translocated from an unburnt part of the site in early October to act as a seed source. These plants had intact roots and were covered in well formed capsules, which were ripening but had not split to release seeds. Experimental timing was selected to ensure a reliable crop of seeds, despite manipulation during the translocation process. Seed traps were placed along transects, in eight compass-determined directions from the translocated plants, around the edge of the planted area (0 m) and at 0.5, 1, 2, 3, 4, 5, 10, 20, 30, 40 and 50 m along the N, S, E and W transects. On the NE, NW, SE and SW transects,

traps were placed only to 10 m. One trap was positioned at each distance on each transect to 5 m, two traps were placed at 10–30 m and four at 40 and 50 m ($n = 112$) (Figure 2). Contents of traps were collected after 4 and 14 weeks. The peat removed to enable seed trap insertion was also examined for existing seeds or capsules.

No replication of the translocation experiment was possible due to the large bare area required.

Data analysis

Counts from seed traps and peat samples are expressed as densities (m^{-2}). We tested the idea that the number of seeds moving further is proportional to the number that have moved thus far (a simple decay process) by fitting a linear relationship between log (propagule density) and distance from the source.



Figure 2. Seed traps radiating from translocated *C. vulgaris* plants on a burnt section of Stalybridge Moor in 2003. The inset shows trap layout diagrammatically.

RESULTS

All seed traps remained in place during the natural experiment, which demonstrated trap design to be suitable for use on upland moorland. A few *C. vulgaris* seeds were trapped at most collection points from the seed source to 35 m, with capsules trapped to 25 m. However, most seeds (57%) and capsules (76%) were trapped within 1 m of the seed source and 91% and 95% of seeds and capsules respectively within 5 m of the source (Figure 3). At the translocation site, distribution of trapped seeds and capsules followed a similar pattern to the natural experiment, with most seeds (73%) and

capsules (94%) deposited within 1 m of the translocated plant and 96% of seeds and capsules collected within a distance of 5 m (Table 1).

Seeds and capsules were unevenly distributed around the translocated plant. Only on the northern transect were captures recorded more than 5 m from the translocated plant with 40 m the maximum distance reached. The greatest density of seeds trapped was on the south-east transect (1572 m⁻²) at 0 m. Twenty-nine percent of all seeds collected up to 1 m from seed source were trapped at the first collection (four weeks). No *C. vulgaris* seeds or capsules were found in peat samples removed to facilitate seed trap insertion.

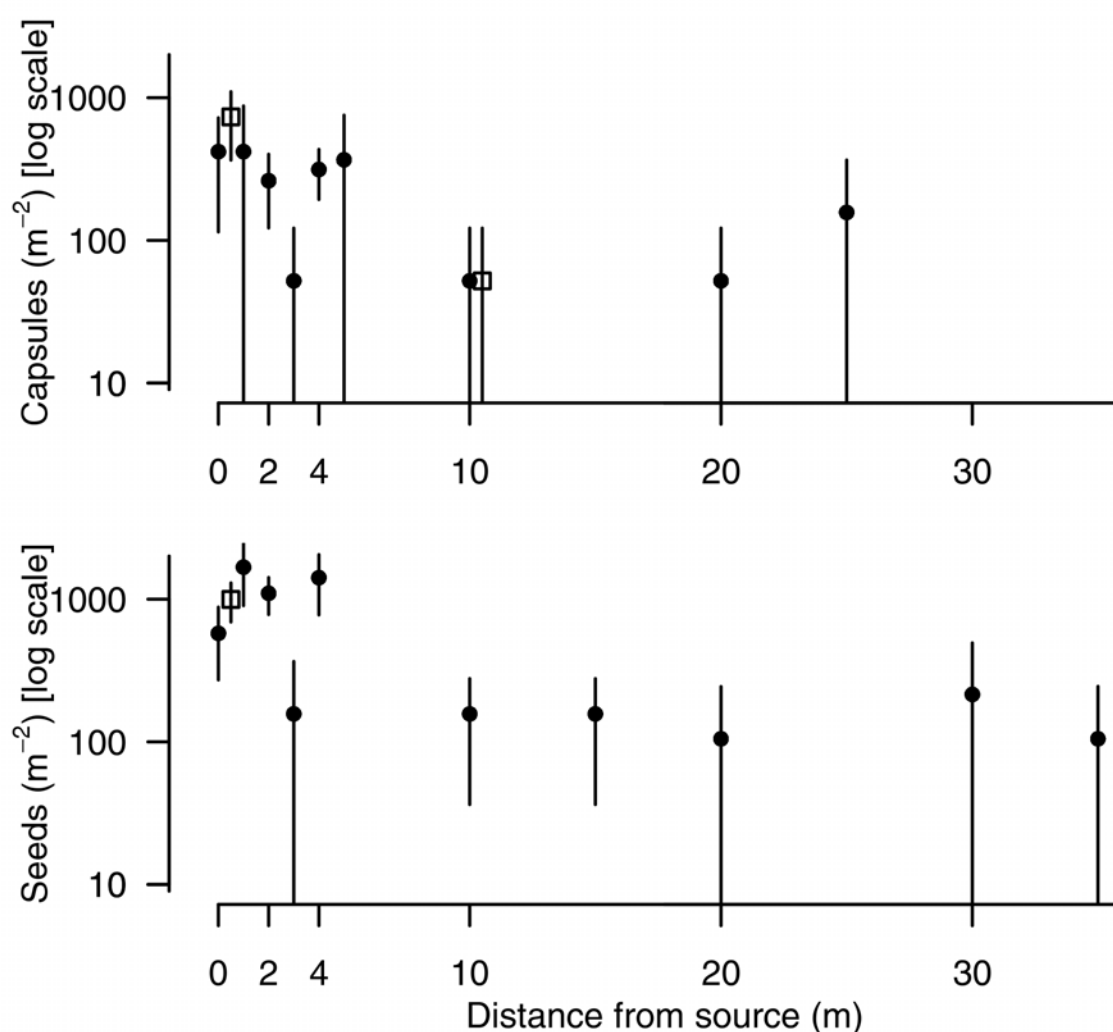


Figure 3. Mean density of seeds (lower) and capsules (upper) of *Calluna vulgaris* on bare ground at various distances for three parallel pairs of transects between two parallel banks of *C. vulgaris* plants 90 m apart. Filled circles for distance from one vegetated edge; unfilled squares for distance from the other edge. Bars are 95% confidence intervals (asymmetric because of the log scale).

Table 1. Density (m^{-2}) of *C. vulgaris* seeds (and capsules, below in *italic*) for each trapping site in the experiment with an isolated patch of translocated plants. Traps that caught nothing are shown by '-'. A single propagule in a 9 cm diameter trap appears as 157 m^{-2} ; at greater distances, where there were more replicate traps, it appears as 39 m^{-2} . The R^2 values are for the fit to a model in which log density is linearly proportional to the distance from the seed source.

	N	E	S	W	NE	SE	SW	NW
Length of transect (m)	50	50	50	50	10	10	10	10
Distance from seed source (m)	Number of <i>C. vulgaris</i> seeds and capsules (m^{-2})							
0	472 <i>1100</i>	314 <i>1415</i>	94 <i>3472</i>	314 -	472 <i>1100</i>	472 <i>1572</i>	472 <i>786</i>	629 <i>845</i>
0.5	472 -	- -	- <i>157</i>	- <i>157</i>	157 <i>157</i>	472 <i>157</i>	157 -	629 -
1	- -	- -	- -	- -	-	314 -	- -	- -
2	314 -	- -	- -	157 -	314 -	- -	- -	157 -
3	157 -	- -	- -	- -	- <i>157</i>	- -	- -	- -
4	- -	- -	- -	- -	- -	- -	- -	472 -
5	314 -	- -	- -	- -	- -	- -	- -	- -
10	- -	- -	- -	- -	- -	- -	- -	- -
20	- -	- -	- -	- -				
30	79 -	- -	- -	- -				
40	39 -	- -	- -	- -				
50	- -	- -	- -	- -				
R^2 seeds	0.196	0.063	0.063	0.046	0.445	0.209	0.022	0.279

Statistical analysis

The fit to the simple decay hypothesis was very poor (natural experiment 0–45 m from seed source $R^2 = 0.32$; translocated experiment see Table 1).

DISCUSSION

Results obtained were similar to, and followed the same trend as, those observed by Bullock & Clarke (2000); although differences were also recorded. Bullock & Clarke (2000) trapped 91% of

C. vulgaris seeds at less than 0.8 m compared with 57% and 73% in the first 1 m for, respectively, the natural and translocated experiments in this study. A few capsules were trapped at 40 m here compared with only 4 m by Bullock & Clarke (2000). The habitats examined may account for these differences as Bullock & Clarke (2000) worked in a grassland where the grasses can act as seed traps, as shown by Nathan & Muller-Landau (2000) and Bullock & Moy (2004). In the current study, *C. vulgaris* seeds and capsules may have been blown farther from the seed source, and possibly beyond the research site,

because there was no vegetation to disrupt wind action in the upland environment. Small elliptical seeds such as those of *C. vulgaris* are carried easily by wind and/or water (Fagundez & Izco 2004). Trapped seeds may have originated from another seed source. As there were no *C. vulgaris* plants or seeds within the experimental area, however, the seeds must have travelled at least the measured distance.

Variability in the results obscured the attempt to test a simple decay process in the distribution of density with distance from source.

Quantity of seed source will almost certainly influence the numbers of seeds trapped, as illustrated in these two experiments, with more seed trapped in the natural experiment from larger established sources. However, numbers of seeds trapped were much smaller than those reported by other authors (Barclay-Estrup & Gimingham 1994, Bullock & Clarke 2000). Again this may represent dispersal of *C. vulgaris* seeds in an open upland environment, as compared with those observed in lowland grassland. This also illustrates important factors associated with using grasses as nurse species in post-wildfire management, to stabilise the site, provide protection and to act as seed traps.

The implication of these results is, as suggested by Radley (1965) and Maltby *et al.* (1990), that natural vegetation regeneration will be slow on an upland moor post-wildfire. Although *C. vulgaris* seeds can be dispersed 40 m into a bare site, the number of seeds is significantly lower than reported in other studies (Barclay-Estrup & Gimingham 1994, Bullock & Clarke 2000). Despite *C. vulgaris* being generally classified as an r-strategist, producing large numbers of seeds and having high recolonisation potential, these results suggest this may not always apply on upland moorland post-wildfire. In addition, the potential for seed to germinate and give rise to recolonisation of burnt peat has not been examined here, but is another vital consideration of moorland restoration schemes, and also currently under investigation (Gilbert 2008).

REFERENCES

- Barclay-Estrup, P. & Gimingham, C.H. (1994) Seed-shedding in a Scottish heath community. *Journal of Vegetation Science*, 5, 197–204.
- Bullock, J.M. & Clarke, R.T. (2000) Long distance seed dispersal by wind: measuring and modelling the tail of the curve. *Oecologia*, 124, 506–521.
- Bullock, J.M. & Moy, I.L. (2004) Plants as seed traps: inter-specific interference with dispersal. *Acta Oecologica*, 25, 35–41.
- Chabrierie, O. & Alard, D. (2005) Comparison of three seed trap types in a chalk grassland: towards a standardised protocol. *Plant Ecology*, 176, 101–112.
- Fagundez, J. & Izco, J. (2004) Seed morphology of *Calluna* Salisb. (*Ericaceae*). *Acta Botanica Malacitana*, 29, 215–220.
- Gilbert, J.A. (2008) *Calluna vulgaris* regeneration on upland moorland post-wildfire. PhD thesis, University of Central Lancashire, Preston, UK.
- Gilchrist, P., Gilbert, J.A. & Butt, K.R. (2004) Burning issues: lessons from natural regeneration after wildfire. In: Anderson, P. (ed.) *Upland Ecology, Tourism and Access, 18th Conference of the IEEM, Buxton, 25–27 Nov. 2003*, Institute of Ecology and Environmental Management, Winchester, 79–91.
- Legg, C.J., Maltby, E. & Proctor, M.C.F. (1992) The ecology of severe moorland fire on the North York Moors: seed distribution and seedling establishment of *Calluna vulgaris*. *Journal of Ecology*, 80, 737–752.
- Maltby, E., Legg, C.J. & Proctor, M.C.F. (1990) The ecology of severe moorland fire on the North York Moors: effects of the 1976 fires and subsequent surface and vegetation development. *Journal of Ecology*, 78, 490–518.
- Nathan, R. & Muller-Landau, H.C. (2000) Spatial patterns of seed dispersal, their determinants and consequences for recruitment. *TREE*, 15(7), 278–285.
- Nordhagen, R. (1937) Studien über die monotypische Gattung *Calluna* Salisb. (Studies of the monotypical kind of *Calluna* Salisb.). I Bergens Museum Arbog, Naturvi-denskabelig Rekke, 4, 1–55. Cited in: Gimingham, C.H. (1972) *Ecology of Heathlands*, Chapman and Hall, London.
- Radley, J. (1965) Significance of major moorland fires. *Nature*, 205, 1254–1259.

Submitted 17 Dec 2009, final revision 09 Jly 2010
Editor: R.S. Clymo

Author for correspondence:

Dr Jackie Gilbert, School of Built and Natural Environment, Kirkham Building, University of Central Lancashire, Preston PR1 2HE, UK. Tel: +44 (0)1772 893490; E-mail: jagilbert1@uclan.ac.uk