Back on our Map

Goldilocks aster

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1. Introduction to BOOM

Back on Our Map (BOOM) aimed to engage communities in South Cumbria with their natural environment, by restoring the landscape and reintroducing and reinforcing locally threatened or extinct native species. National Lottery players supported the £2m project, alongside several other public, private and charitable sector organisations. Led by the University of Cumbria, BOOM worked closely in partnership with Morecambe Bay Partnership, and lead partners Cumbria Wildlife Trust, Natural England and Forestry England.

The project a network of protected areas including Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNRs) and Arnside and Silverdale Area of Outstanding Natural Beauty (AONB). It covered an area of 600km2, extending along the lowlands of Morecambe Bay from Barrow-in-Furness in the west to Arnside and Silverdale in the east and Ambleside in the north (Fig 1.1).

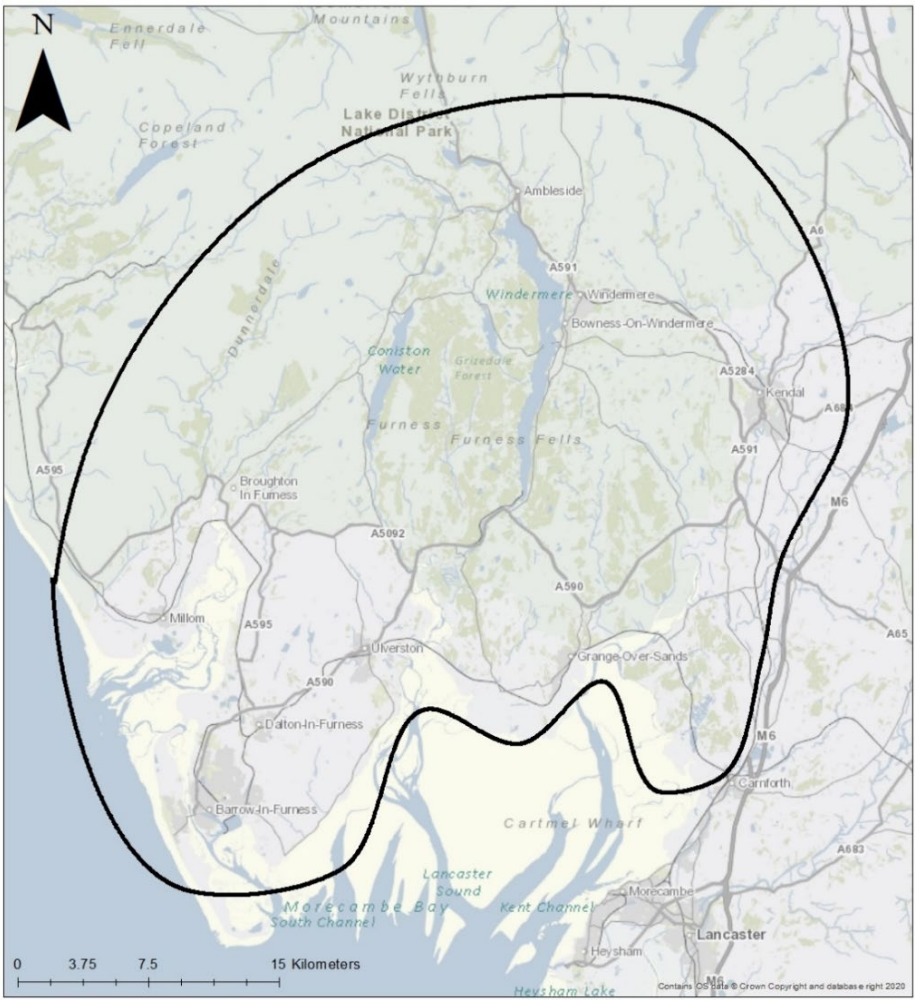


Figure 1.1: Map of the BOOM working area.

BOOM reintroduced and expanded the range of the hazel dormouse, small blue butterfly, goldilocks aster, great and oblong-leaved sundew, green-winged orchid, maidenhair fern, spiked speedwell, and aspen (table 1.1). A reinforcement of a Duke of Burgandy population was carried out on the Graythwaite Estate. The pine marten community-based feasibility study identified suitable locations for future reinforcement. For the Corncrake, public engagement sound walks raised awareness of the species.

Table 1.1: Species included in the BOOM project.

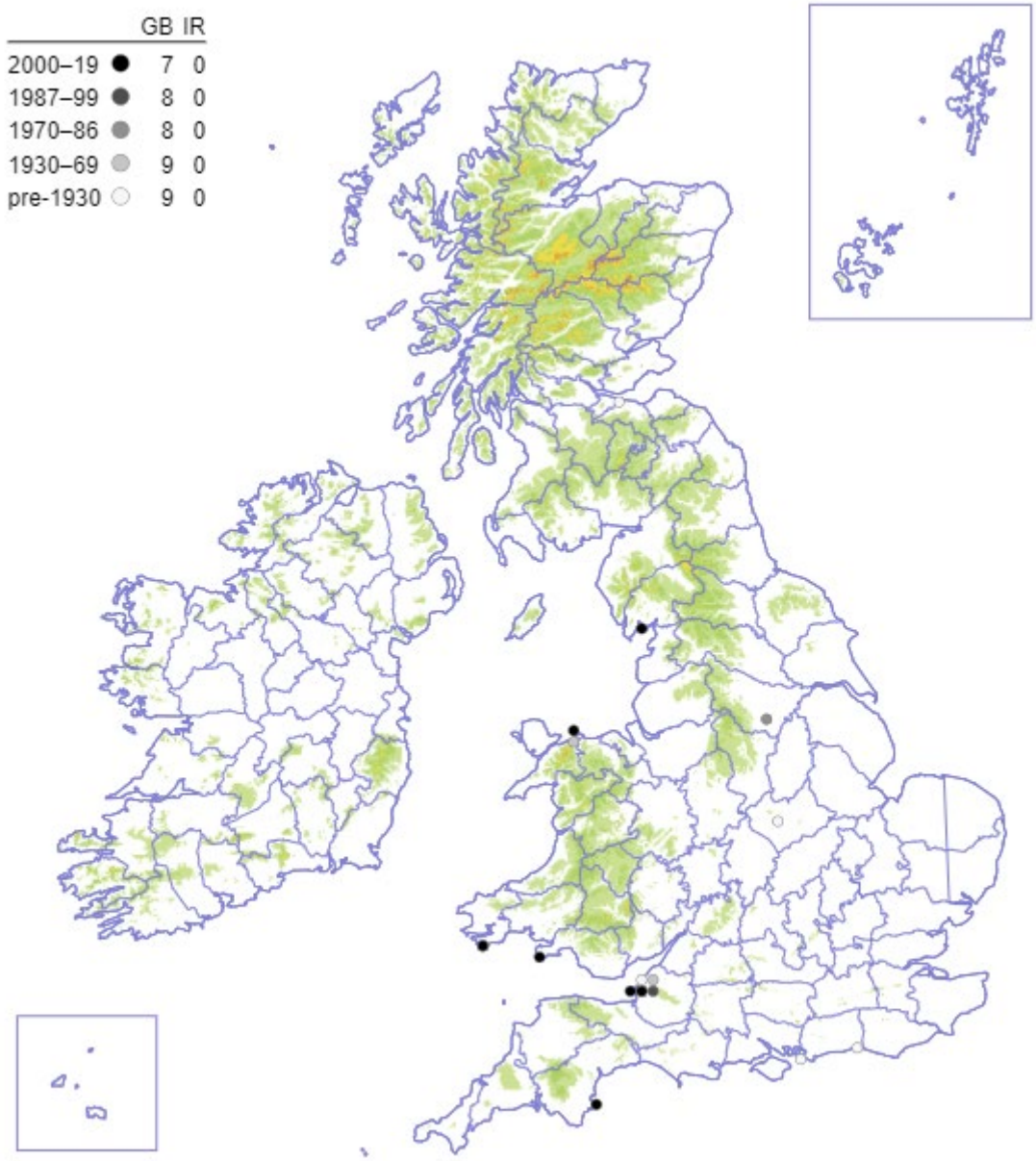
Common Names	Scientific Name	BOOM Objectives
Aspen	*Populus tremula*	Reintroduction
Corncrake	*Crex crex*	Public Engagement and Interpretation
Duke of Burgundy	*Hamearis lucina*	Reinforcement
Goldilocks Aster	*Galatella linosyris*	Reintroduction
Great Sundew	*Drosera anglica*	Reintroduction
Green-winged Orchid	*Anacamptis morio*	Reintroduction
Hazel Dormice	*Muscardinus avellanarius*	Reintroduction
Maidenhair Fern	*Adiantum capillus-veneris*	Reintroduction
Oblong-leaved Sundew	*Drosera intermedia*	Reintroduction
Pine Marten	*Martes martes*	Feasibility Study
Small Blue	*Cupido minimus*	Reintroduction
Spiked Speedwell	*Veronica spicata*	Reintroduction

Across south Cumbria, the project engaged a wide range of community groups, volunteers and members of the public. Social activities and training events helped communities get involved with the BOOM species reintroductions.

This document covers the work BOOM did on the Goldilocks aster (*G.linosyris)*, including the propagation techniques, reintroduction local community involvement and suggested next steps.

2. Species background

Goldilocks aster, *Galatella linosyris,* is a herbacious, long-lived perennial, restricted to a few coastal localities in western Britain where it occurs on limestone sea-cliffs, rocky slopes and cliff-top grassland (Stroh et al., 2023). It tends to be found in isolated clumps on shallow soil and many of its colonies are located on inaccessible cliff ledges (Heckford and Beavan, 2013). Now thought to be extinct in Cumbria, due to over-grazing and competition with scrub, *G.linosyris* has only eight remaining populations in the UK. In Pembrokeshire, it occurs in maritime heath and grassland on south facing clifftops, these areas are also being grazed by sheep. Although seed is freely produced, *G.linosyris* is self-incompatible and the production



Galatella linosyris (L.) Rchb.f. in *BSBI Online Plant Atlas 2020*, eds P.A. Stroh, T. A. Humphrey, R.J. Burkmar, O.L. Pescott, D.B. Roy, & K.J. Walker. https://plantatlas2020.org/atlas/2od4p9h.cft6xz [Accessed 22/09/2023]

of fertile seeds can often be absent in some isolated populations. In such cases populations can consist of just one clone that is sterile and reproducing vegetatively (Stroh et al., 2023).

G.linosyris can grow tall, up to 50cm, when not competing with other more vigorous plants and displays a disciform of yellow flower heads arranged in plumes (Wigginton and Committee, 1999). The leaves are lanceolate and abundant; it flowers between July and October.

3. Project rationale

In 1967 a single, small colony of *G.linosyris* was present on an inaccessible cliff ledge on the western cliffs of Humphrey Head, and remained so for 25 years. It is unclear what caused this resilient patch to finally disappear but many theories remain, including inbreeding from isolation and recreational activities from the nearby outdoor center. There is no way of knowing for certain, but we do know that as a obligate outbreeding species, *G.linosyris* is at risk of inbreeding depression which can ultimately lead to population extinction (Husband and Schemske, 1996). The last anecdotal sighting of the plant on Humphrey Head was in 2007 and this was also the last sighting of the plant in the county of Cumbria, where it is now thought to be extinct.

G.linosyris is classed as Endangered in the Vascular Plant Red List for England (Stroh et al., 2014) and is found in only eight localities across the UK (Devon, Somerset, Glamorgan, Pembrokeshire, and Caernarvonshire). It is imperative to acquire additional, suitable sites which can also support the species long-term, such as historic site Humphrey Head and coastal sites within its natural range.

Although all the sites in which *G.linosyris* currently inhabits are well protected, designated sites, the populations are small, isolated, vulnerable and constantly under threat from encroaching scrub habitat. In 2016 a large population of *G.linosyris* on the Gower Peninsula was burnt by a fire, which could have had serious impact on the population. The only management suitable to protect entire populations against stochastic loss is reintroductions and translocations. This will mitigate the risk at existing sites and prevent loss of the species nationally in its entirety.

4. Project objectives

The project aim is to reintroduce *G.linosyris* to south Cumbria and north Lancashire, the formerly northern-most population in the UK through plug planting. The outcome will consist of two new populations, one at Humphrey Head where the plant was last extant in Cumbria, the other at Jack Scout, within the natural geographic range of the species and with a similar habitat and south-west facing aspect. This will enhance the survival of the species nationally, protecting isolated populations against stochastic events. The project will also provide knowledge of successful propagation and translocation techniques of self-incompatible species to inform future sustainable plant conservation management.

5. Project location

5.1 Release site 1 – Humphrey Head

Humphrey Head (SD 388 746) is a striking limestone peninsula, jutting out into Morecambe bay at the southern tip of Cumbria, south of the village of Allithwaite. The western cliffs of the peninsula and the fields a top the cliff are part of a Nature Reserve leased and managed by Cumbria Wildlife Trust that form the Humphrey Head SSSI. The land is owned by Holker Estate and a local famer, Harry Wilson, grazes cattle in the fields. When the tide is low, it is possible to walk the base of the cliff perimeter and follow a path back across the fields on top.

The last remaining plant was said to be towards the southern tip of the peninsula, on a small ledge. The ledge is inaccessible to rabbits but is close to anchors used for climbing ropes, after speaking with the outdoor centre they assured us that these routes were no longer in use.

5.2 Release site 1 – Jack Scout

Jack Scout, SD459736, has many similarities with Humphrey Head, both occupy west-facing limestone cliffs that overlook the same sand flats. Also, both sites have small areas of calcareous grassland and similar associated plants such as blue moor grass and limestone bedstraw (*Sesleria caerulea* and *Galium sterneri*).

Jack Scout lies 6km from Humphrey Head, across Morecambe Bay. The land is owned and managed by the National Trust and a local farmer grazes the land with his cattle at specific times of year.

5.3 Donor stock

5.3.1 Pembrokeshire, Castlemartin

There are two locations in Castlemartin, Pembrokeshire, that host *Galatella linosyris.* Firstly at Castlemartin range, near Penyholt Bay, which is used by the Military of Defence for tank training and shell firing. It is bordered by dramatic limestone cliff coastline that Pembrokeshire is famous for and is a typical maritime grassland consisting of *Festuca rubra -Holcus lanatus* maritime grassland, *Festuca rubra - Plantago* spp. maritime grassland and *Festuca rubra - Daucus carota* ssp. Gummifer. The *G.linosyris* here grow in a large clump of over 200 plants, but are short and stocky compared to their northern cousins at the Great Orme. This cliff top is often grazed by sheep and the sward is generally short when the aster are in flower. Interestingly, *G.linosyris* were found growing in the scars of old shell impacts; the tank training providing the disturbed ground that the aster favoured in order to spread.

The second location in Pembrokeshire is to the East, just south of St Govans Chapel. Both of these sites are managed by Natural Resources Wales and protected as part of the Castlemartin Range SSSI.

5.3.2 The Great Orme / National Botanic Garden of Wales (NGBW)

The Great Orme is a limestone headland on the north Coast of Wales near the town of Llandudno. The site is occupied by calcareous grassland, dry dwarf shrub heath, maritime cliff and slope with an assemblage of rare vascular plants and striking moths and butterflies. It is a popular site with visitors and lovers of Natural History. It is protected by the Great Orme SSSI and SAC, and preserved and managed by the National Trust. As part of the Millenium seed bank initiative 8000 *G.linosyris* seeds were collected.

Figure 5.1 Above – picture of *G.linosyris* at the Great Orme. Photo credit Kevin McGinn. Right – picture of *G.linosyris* at Castlemartin, Pembrokeshire. Photo credit, Joanna Morgan.

5.3.3. The Gower Peninsula / National Botanic Garden of Wales (NBGW)

The Gower Peninsula is an Area of Outstanding Natural Beauty in South Wales. There are several areas with *G.linosyris* but these are constantly under threat from spreading scrub and wildfires. The Botanic Garden of Wales have a cultivated population of the plant, provenance from the Gower Peninsula.

Figure 5.2 *G.linosyris* at National Botanic Garden of Wales, Great Orme origin

5.3.4 Cambridge University Botanical Garden (CUBG)

The Cambridge Botanical Garden has had a cultivated population of *G.linosyris* for over half a century. Although this population is persisting and spreading well, they do not produce viable seed. The provenance of these plants is thought to consist of that from the original Humphrey Head plant but also Berry Head in Devon.

Figure 5.3 Searching for *G.linosyris* at the Gower Peninsula. Left, Sammy Haddock. Right, Kevin McGinn.

Figure 5.4 Analysing *G.linosyris* seed at Castlemartin, Pembrokeshire. Right, Kevin McGinn, Left, Ellie Kent.

6. Project Partners

The success of this project would not have been possible without the collaboration from a wide range of partners and stakeholders, listed below:

Partner	People	Role
The University of Cumbria	• Ian Convery, Professor of Environment and Society. • Dr. Dorthe Villadsen, Lecturer in Conservation.	• Lead organisation for BOOM and employer of BOOM officers and staff. • Key member of stakeholder group • Academic support for genetic experimentation work
Natural Resources Wales	• Paul Culyer, Senior Officer, Land Management	• Land management at the donor site, Castlemartin, Pembrokeshire • Gained access to the Range and acted as a guide onsite • Applied for SSSI consent to remove seed • Facilitated discussions with the National Botanic Garden of Wales
National Botanic Garden of Wales	• Kevin McGinn, Science Officer	• Allowed access and acted as a guide for the Great Orme • Acted as a guide for the Botanic gardens • Gave expert knowledge and advice on the viability of seed • Shared seed from the seed bank as well as their cultivated plants
Botanical Society of Britain and Ireland	• Peter Stroh, Scientific Officer and England Officer, • Lynne Farrell, President	• Correspondence with Peter Stroh and Lynne Farrell was invaluable when investigating the provenance of plants at Cambridge Botanical Garden • Shared adult plants from Cambridge botanical garden for reintroduction.
The National Trust	• Craig McCoy, Arnside and Silverdale Area Ranger	• Land managers for recipient site Jack Scout

	• John Hooson, Nature Conservation Advisor	• Practical, onsite support in reintroduction process • Committed to ongoing monitoring • Facilitated discussions with the Trust's Natural Environment Advisory Group.
Cumbria Wildlife Trust	• Peter Jones, Reserves Officer • Wendy Nelson, Volunteer Reserve Warden • Julia Sier, Head Gardener at Plumgarths	• Land managers for the donor site, Humphrey Head. • Practical, onsite support in reintroduction process • Committed to ongoing monitoring • Growing and propagating plants
Researchers	• Dr. Donald Piggott	• Historical account and documents of *G.linosyris* in the country. • Warm chats and lovely cups of tea.

6.1 Consents and Agreements

As part of any translocation process, there may need to be licenses, consents or agreements in place before any work takes place. It is advised that a thorough investigation be initiated with landowners and local statutory bodies concerning what processes need to be started before any translocation preparation. This will ensure the project is legally viable. Below is a list of licences, consents or agreements that were obtained by this project prior to translocation:

- SSSI consent to collect seed from Castlemartin, Pembrokeshire
- SSSI consent to plant *G.linosyris* at Humphrey Head and Jack Scout
- Landowner agreements - Written contracts with the landowners in question about the works to take place onsite presently and into the future.
- UK plant passport for *G.lionsyris*.

7. Pre – translocation research and work

7.1 Donor stock synopsis

G.linosyris is sparsely populated in the UK meaning donor site choice was limited. The current donor sites were chosen because, although not in close proximity to the recipient sites, they were known to have stable populations with similar habitat and management techniques as the recipient sites.

During the BOOM project it was discovered that Cambridge University Botanic Garden (CUBG) had a collection of *G.linosyris* and they sent us a sample of their collection to help with reintroduction. The plants at CUBG were thought the be originally from Humphrey Head and/or Berry Head in Devon with the accession stating collection was completed in 1963, by Professor Donald Pigott (Peter Stroh, personal communication, 2020). Although this was a fantastic addition to the project, it meant that the method of reintroduction needed careful consideration. Plants that have spent several generations in ex-situ cultivation may lose genetic variation from inbreeding or genetic drift, meaning they may no longer be able to adapt to abiotic conditions in the wild and cope with stress (Abeli et al. 2020; Maunder et al. 2001a). Plants in cultivation often occur in small groups with low numbers of individuals, the use of small groups of individuals as a donor in reintroductions does not correlate with success (Abeli et al., 2020; Bellis et al., 2019). This could also be true for plants grown at The National Botanic Garden of Wales from the Gower Peninsula.

G.linosyris are thought to be self-incompatible (Preston et al., 2002) and anecdotal observations of the plants at Cambridge suggest the seed is not viable and that the plants are only reproducing vegetatively (Peter Stroh, personal communication, 2020). The nature and quantity of collection in 1963 is unclear for now, however this anecdotal evidence suggests that either just one plant was collected from Humphrey Head in 1963 or the population was already isolated and lacking genetic diversity at the time of collection. In a scenario such as this it would be counterproductive to adopt the 'local is best' approach, as adaptive potential may be limited and compromised (Breed et al., 2013). It is strongly recommended throughout the literature that, to salvage an isolated population, genetically diverse donors, ideally from more than one population, are required (Breed et al., 2013; Godefroid et al., 2011; Kephart, 2004; Maschinski and Albrecht, 2017). Which reflects well with the initial objectives of this project.

However, an unpublished experiment conducted by Prof. Donald Pigott, during his time at Sheffield University, provides evidence of morphological differences in *G.linosyris* from varying localities across the UK that persisted when grown in identical conditions in cultivation. Unfortunately, Pigott's study was just shy of the era of molecular testing, his own experiment just succeeding Watson and Crick's discovery of the structure of DNA and therefore molecular testing on *G.linosyris* populations in the UK never occurred, and have not to this day (Watson

and Crick 1953). Nevertheless, Pigott's anecdotal evidence of morphological differences in the plants suggest there may be chromosomal differentiation in the donor populations. This is not surprising given their extensive distance of >100km; certainly no cross pollination would have taken place and it is unclear how long isolation and local adaption had been occurring. Therefore, cross pollinating the distant populations with the native but cultivated Humphrey Head plants may risk outbreeding depression, causing a reduction in fitness and potentially extinction of the native stock (Frankham et al. 2011; Storfer 1999; Forrest et al. 2011; Grindeland 2008), the native stock being who's reintroduction success would be most celebrated within the local community.

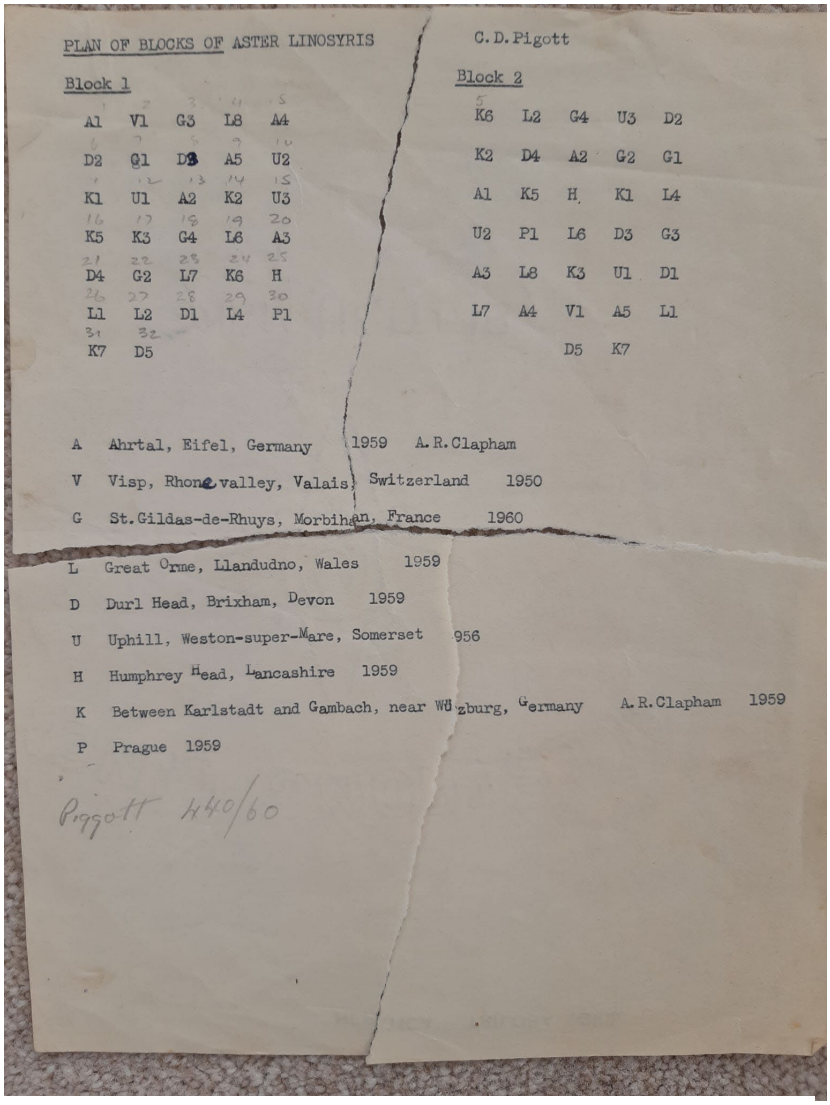


Figure 7.1. A photo of Donald Pigot's experimental set up of *G.linosyris* from his time at Sheffield University in the 1960's

Essentially, we had hit a conundrum and the only way to proceed was to understand our donor stock better; through experimentation (i.e. looking at morphological differences in the plants

when grown in similar environment) and propagation. However, many hurdles were met during the four years which is best described through a seed collection timeline.

7.2 A personal point of view

During the course of the project the BOOM team had the pleasure of meeting Professor Donald Pigott. Pigott raised concerns about plant translocations in general; his previous work had focussed on understanding rare species at their climatic limits and their natural responses to climate change, he therefore, saw reintroductions and translocations of rare plants a hindrance to understanding these longitudinal range shifts. This, of course, is a valid and not uncommon opposition to plant reintroduction and it seemed fair and respectful to include it here considering the wealth of contributions Prof. Pigott has given to botany over the decades.

The BOOM team had several meetings with Prof. Pigott to discuss future action of the project. Despite his initial concerns, Donald was accepting of the project and supported activities by shared a treasure of data and information with us about *G.linosyris* that was incredibly valuable.

7.3 Seed collection, experimentation and propagation timeline

When collecting seed the BOOM team strictly followed IUCN guidelines for translocation and only removed seeds from 10% of the known population at each donor site. Seeds were selected from ripe seed pods and, when possible, were not collected from plants previously used for collection. This was thought to reduce the likelihood of genetic bottlenecking. Below is a table timeline highlighting the seed collection of *G.linosyris* that took place throughout the project.

In summary, the seed from the seed bank which was initially from the Great Orme germinated well in the first year of the project (65% germination rate), but growth was slow and overall survival into adulthood was low (30% of seedlings that germinated). Unfortunately, this success was not repeated when the morphological difference experiments were attempted.

Table 7.1 Timeline of seed and material collection from 2020 to 2023 as part of the BOOM project.

Year	Date	Action	Via	Provenance	Seed viability	Outcome
2020	Mar-20	50 seed sent to BOOM	Kevin McGinn, Millenium seed bank at NBGW	Great Orme	65 % germination rate but slow growth	10 adult plants planted at Humphrey Head in 2023
	Sep-20	36 adult plants sent to BOOM	Peter Stroh, via. Cambridge Botanical Garden	Humphrey Head/Berry Head but in cultivation since 1960s	No viable seed but reproduced vegetatively	140 plants planted at Humphrey Head in 2023
	Oct-20	50 seed heads collected	Paul Culyer, Natural Resources Wales	Castlemartin, Pembokeshire	Seed stored over winter in cool dry conditions	
	Oct-20	50 seed sent to BOOM	Kevin McGinn, Millenium seed bank at NBGW	Great Orme	Seed stored over winter in cool dry conditions	
2021	Mar-21	Over-wintered seed sown in experimental conditions	BOOM	Great Orme and Castlemartin	0% germination rate from both sites	0 adult plants
	Oct-21	Seed and cuttings collected by BOOM	Paul Culyer, Natural Resources Wales	Castlemartin, Pembokeshire	Seed stored over winter in cool dry conditions	
	Oct-21	50 seed sent to BOOM	Kevin McGinn, Millenium seed bank at NBGW	Great Orme	Seed stored over winter in cool dry conditions	
2022	Mar-22	Seed sown in experimental conditions	BOOM volunteers	Great Orme and Castlemartin	0% germination rate from both sites	0 adult plants
	Oct-22	Cuttings collected	Paul Culyer, Natural Resources Wales and Kevin McGinn, NBGWs	Castlemartin, Pembokeshire	Cuttings did not take	0 adult plants
	Oct-22	Seed collected and seed analysis	Paul Culyer, Natural Resources Wales and Kevin McGinn, NBGWs	Castlemartin, Pembokeshire	Unviable seed	0 adult plants
	Oct-22	Survey of the Gower Peninsula	Kevin McGinn, NBGW	Gower Peninsula	Viable seed	Unable to take any from the wild because the population was not large enough

	Nov-22	100 + seed sent to BOOM	Kevin McGinn, NBGW	The Gower peninsula, but kept in cultivation at the botanical gardens	Viable seed, high germination rate	Many plants lost in the drought. 60 plants growing slowly ready to plant in spring 2024

The seed from Pembrokeshire, Casltemartin and Penyholt Bay, were unviable and showed no germination in any year of the project. Upon inspection of the seed at the National Botanic Garden Wales, it became clear that about 95% of the seed from Pembrokeshire, was empty. We therefore had no evidence from experiment results to aid our reintroduction decisions.

Experiment methodology can be found in the appendix.

During population monitoring at the Gower Peninsula it was decided that the population was too small to remove material from the wild. However, seed was obtained from the National Botanic Garden of Wales's cultivated collection. This seed had a high germination rate and will be planted into the wild in spring 2024.

During propagation BOOM used peat free organic compost when possible. Before sowing seeds, the compost was sterilised. This can be done with boiling water or by putting the compost into the microwave for 1minute. Sterilising the compost will prevent other species or plant and fungi growing in your trays and impacting the plants.

The compost was left over night in a sealed bag to cool. Once the soil cooled to the same temperature as the surrounding environment it was combined with horticultural grit and placed into standard seed trays with the ratio of 1 part grit, 2 part compost. Each tray was labelled with the seed provenance and the date of sowing. A cloche was placed over each seed tray, to keep the moisture level constant and reduce the impact of frost, and they were placed outside. If the seed germinated and subsequently produced at least 2 true leaves they were pricked out and potted into root trainers or individual pots using the same method for compost sterilisation and grit to compost ratio.

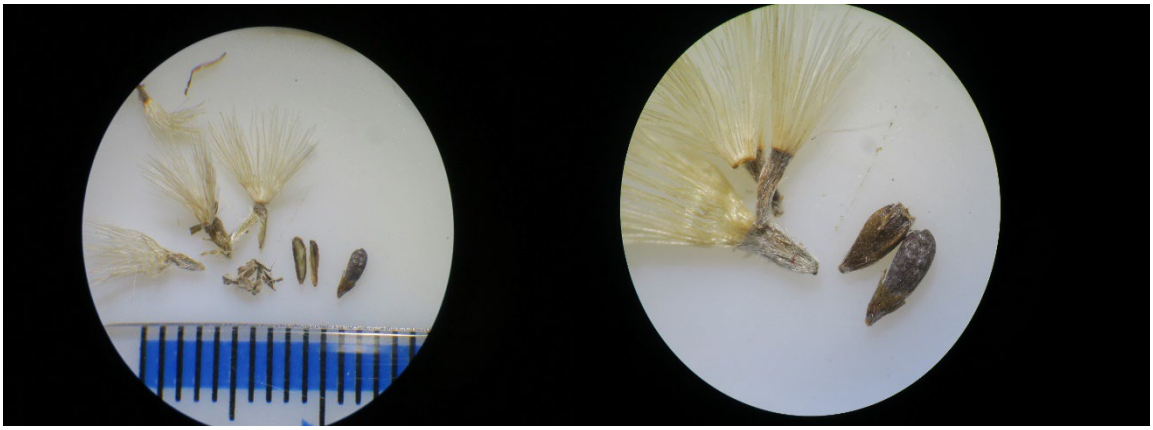


Figure 7.2 Seeds collected from Castlemartin in Pembrokeshire (on the left in both photos which still contain seed tufts) compared with seed from the seed bank at National Botanic Garden of Wales (NBGW), provenance Great Orme. These photos show the stark difference in seed appearance when looked at under a microscope. The seed from Castlemartin is small and hollow and unlikely to be viable. The seed from Great Orme is plump and full with endosperm, very much likely to be viable seed.

7.4 Experiment results

Unfortunately, due to difficult in establishing seed viability and unexpected droughts germination rates were very low or non-existent and a sufficient comparison was not possible. However, after three years of investigating and experimentation attempts we now have a greater understanding of the seed at each location and results were likely to be strong if the experiment were to be set up again. Which of course we strongly recommend.

7.5 Recommendations

- When working with plants of which there is unknown seed viability, working with experts at a local botanical gardens can be incredibly beneficial. They will have the knowledge and equipment to better understand seed viability before sowing.
- Although it is unclear why seed from the Great Orme did not germinate during experiment attempts, one theory concerns the winter storage. To reduce this risk it is advised to sow seeds immediately when collected in autumn.
- Viable seed is plump and contains green/white pith on the inside. Unviable seed will be shrunken and empty.

8. Translocation

In April 2023, 140 *G.linosyris* adult plants were planted into 3 plots on the cliff top of Humphrey Head. All plants originated from the 36 gifted by Cambridge University Botanical Garden and thought to be originally sourced from Humphrey Head and Berry Head, Devon. They were kept since September 2020 by the BOOM team, in which time they reproduced vegetatively and propagated by separating and repotting into separate pots. These plants do not produce viable seed but reproduce by spreading vegetativley. The site selected from reintroduction was about 650m north of the original location of *G.linosyris* before it became extinct. It was decided not to plant in the exact historical location due to inaccessibility for monitoring and the risk posed by rock climbers. In October 2023, a further 45 plants were planted in the same location. These plants were of Great Orme provenance, initially sourced from NBGW seed bank.

Plot	Provenance	Planting date	No. plants	No. flowers
1	CUBG (Humphrey Head and Berry Head)	25/04/2023	63	0

Figure 8.1. Table of translocated plant totals at Humphrey Head

2	CUBG (Humphrey Head and Berry Head)	25/04/2023	36	0
3	CUBG (Humphrey Head and Berry Head)	25/04/2023	41	0
4	NBGW (Great Orme)	03/10/2023	21	9
5	NBGW (Great Orme)	03/10/2023	24	0
		Total	185	9

8.1 Recommendations

- It is best to plant adult plants into the wild that have robust root systems
- If possible remove the top layer of vegetation that will surround the translocated plant to give it the best opportunity to establish without competition
- If you do remove the vegetation be sure to water your plants, especially in dry spells as removing the grass may remove some moisture from the soil.
- Cage your plants to protect from livestock and rabbits.
- Plant in well-draining soil, with very little shade and preferably on a slope/somewhere that soil is often disturbed.
- Plant at the beginning of autumn to avoid dry spring weather, but preferably well before any expected frost.
- Secure your cages well as the disturbed ground will attract badgers and they can easily dig up all that's been planted.

9. Monitoring

Ideally monitoring would take place every month after translocation, but this was not always possible. Below is a table highlighting the monitoring results:

Plot	Provenance	Count date	No. flowers	No. plants	% +/- since last check	% +/- from total planted
1	Cambridge	25/04/2023	0	63	NA	NA

2	Cambridge	25/04/2023	0	36	NA	NA
3	Cambridge	25/04/2023	0	41	NA	NA
1	Cambridge	09/06/2023	0	46	-27%	-27%
2	Cambridge	09/06/2023	0	25	-30%	-30%
3	Cambridge	09/06/2023	0	52	+27%	+27%
1	Cambridge	13/09/2023	3	45	-2%	-29%
2	Cambridge	13/09/2023	0	15	-40%	- 58%
3	Cambridge	13/09/2023	7	66	+27%	+61%
1	Great Orme	03/10/2023	9	21	NA	NA
2	Great Orme	03/10/2023	0	24	NA	NA
1	Cambridge	03/10/2023	2	36	-20%	-43%
2	Cambridge	03/10/2023	0	15	0%	-58%
3	Cambridge	03/10/2023	7	47	-29%	15%

G.linosyris was planted on two occasions, April and October, 2023. The plants planted in April were watered regularly after translocation because of the severe drought in June. Of the three plots planted in April, plot 3 is showing the most signs of success, with a 61% increase in July. Plot 2 has had the largest decrease in size of 58%.

In September plot 3 recorded seven flower heads and plot 1 had two flower heads. Pollinators were seen on the plants, despite being aware that the CUBG plants are self-incompatible and not producing viable seed, this is still promising. The flowers from the Great Orme are known to produce viable seed, therefore the cross pollination between the two provenances may increase the fitness of the CUBG plants. A small amount of seed will be collected from the CUBG plants and grown at home to see if this is the case. Not enough time has passed to collect monitoring data on the Great Orme plants.

10. Summary, Legacy and Conclusion.

Despite a few setbacks during the last four years, in terms of finding reliable donor stock across the nation in the midst of a pandemic. The BOOM team have taken a cautious approach to translocation, listened to the opinions and thoughts of local people and adapted the project when objectives became unrealistic and have still reintroduced an extinct plant back into south Cumbria. Below is a bullet pointed summary of activities and achievements outlined in this document:

- Completed a thorough investigation into the history of the donor stock, especially the provenance of plants at Cambridge University Botanical Gardens
- Planted 185 *G.linosyris* back into south Cumbria, where it had recently become extinct.
- Developed a strong partnership with organisations and stakeholders across England and Wales.
- Documented a 67% increase in plants planted for translocation and witnessed pollination.
- Secured a strong legacy with volunteer Julia Sier, Cumbria Wildlife Trust, the National Trust and the Arnside and Silverdale AONB.

10.1 Legacy

The future of this project centres on completing the initial aims of this project which includes planting *G.linosyris* at Jack Scout and monitoring success at Humphrey Head. More conclusive and robust research into crossing populations is needed and attempting another greenhouse experiment is strongly recommended. It has been agreed that monitoring at Humphrey Head will be continued by Cumbria Wildlife Trust and volunteer ranger, Wendy Nelson. Work at Jack Scout will be adopted by the National Trust alongside the Arnside and Silverdale AONB. This should include ongoing expert consultation from Prof. Pigott and maintaining relationships with Kevin McGinn and Paul Culyer in Wales for a strong across nation collaboration.

10.2 Conclusion

G.linosyris has been considered extinct in Cumbria since 2007 yet now 185 plants have been reintroduced to the cliffs of Humphrey Head where it was last seen alive in the county. After detailed investigation into the provenance of particular communities at certain botanical gardens and attempted experiments, it was decided to plant *G.linosyris* from Cambridge University Botanical Garden (CUBG) as this was thought to contain at least one plant from the original site at Humphrey Head. However, this population was known to not produce viable seed and is only thought to reproduce vegetatively, and there is already evidence of such occurring at the site. Forty-five *G.linosyris,* from the Great Orme were then planted adjacent to those from CUBG on Humphrey Head. This Great Orme population does produce viable seed, therefore, it will be incredibly interesting to see how this influences the plants from

CUBG. As an obligate outbreeder, outcrossing the two donor populations through pollination will potentially increase seed viability and enhance fitness (St. Clair et al., 2020).

Plants from the Gower Peninsula, which have been grown in cultivation at NBGW are being grown by our volunteer, Julia Sier, these plants should be used to populate Jack Scout and, if proven low risk of outbreeding depression through experimentation, should be used to enhance genetic diversity of the reintroduced population at Humphrey Head.

Not all objectives were completed in the project timescale, *G.linosyris* is yet to be planted at Jack Scout. However this is due to project officers following advice from the literature and concerned partners and members of the public to take a cautious and experimental approach to reintroduction, delaying planting activities onsite until decision had been reached. Although the experiments were unsuccessful, BOOM has cemented the starting block for future research into the species and solidified nationwide partner connections which are the foundations of the project going forward.

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Appendices

1. Protocol given to volunteers for experiment set up.

Set up:

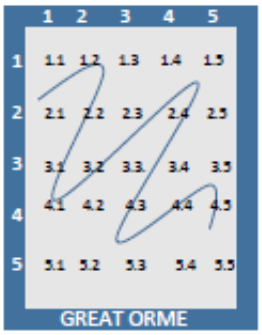
1. Using a ruler to guide you, label your seed trays with your permanent maker, 1-5 along the top and 1-5 down the side as if you were creating a 5x5 grid, like so:

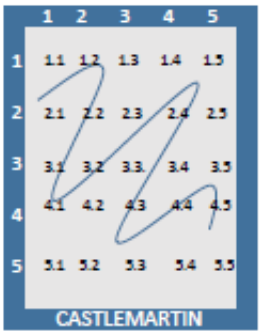
2. You may also want to label the tray with the location, if you don't have any plant labels, to avoid any mix up!

3. Fill your trays with slightly damp compost keeping the surface relatively flat. Be sure to add the same amount of grit and compost into each tray to keep the conditions as similar as possible. About 2/3 compost and 1/3 grit.

4. Using your ruler to guide you place a seed at each grid point 1-5 along row one. Repeat with row two and so on.

5. Each seed now has an individual code which corresponds to its location in the tray, like so:





This will help you when filling in the data sheets.

6. The only important thing to remember is to put the right location in the right seed tray and be sure that they are labelled correctly.

7. Place your seed trays outside in the open air or in a greenhouse / poly tunnel. If leaving them outside, make sure they are protected from birds and mice with a mini cloche or netting (we can reimburse you for these things if necessary, so keep your receipts!).

8. The best way to water the seeds would be with a spray bottle or place them in a tray and keep the soil moist from below. If you do need to use a watering can, be very careful not to move the seeds from their location, as they may get shifted by the water and bunched up in one corner.

Data collection

I have attached to this email some data collection sheets, which are hopefully fairly self-explanatory but please ask me if you have any questions. No question is a stupid question! I will hopefully have the answer and if not I will find out.

The key things to collect are – date you sowed the seed, date each seed germinated (just put the date you spotted it if you happen to miss a day or two, or give a little estimate) and the date they produce true leaves, i.e. not the initial seedling leaves (cotyledons) but the leaves that are produced after this.

It will be best to check your seeds at least every 2/3 days before germination occurs and then measurements of height and leaf size should take place once a week after this. Only measurements of true leaves are needed, there will be no need to measure the cotyledons.

It is important that the seeds are checked often before germination as many seedlings die in the early stages after germination and this can be easy to miss if not checked regularly.

If a seedling dies, please make a note of the date in the notes column.