Status of the Tree Mallow Seedbank on Craigleith in 2021

Report prepared for Scottish Seabird Centre

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Contents

Summary

This purpose of this report is to detail the state of the seedbank of tree mallow on Craigleith in 2021 and compare the number of seeds found with that found in a previous study conducted in 2011. A substantial seedbank of tree mallow was still present on Craigleith in 2021, although in total this was approximately half that recorded a decade previously. The more northerly parts of the island had very low accumulations of tree mallow seeds in the soil, with greater numbers of seeds in the more southerly areas. Greater numbers of seeds were found in areas where rabbits were present. It is likely that disturbance of the soil by rabbit digging creates bare patches and brings tree mallow seeds to the soil surface, where they then germinate and outcompete native vegetation.

Introduction

This project was initiated to determine the abundance of tree mallow (*Lavatera arborea*) seeds (the seedbank) present in the soil on Craigleith in 2021. Tree mallow is native to coastal areas of the Mediterranean and the south-west coast of the UK, but when introduced beyond these locations it often becomes invasive, causing significant changes to vegetation communities (Van der Wal 2006). On Craigleith, invasive tree mallow covered over 80% of the island in 2006, blocking the entrances to puffin (*Fratercula arctica*) burrows, with a resultant decline in the number of breeding birds using the island. A successful campaign of cutting and removing tree mallow from Craigleith (Scottish Seabird Centre's SOS Puffin initiative) has reduced the coverage of this plant to only 6%, with most plants remaining now growing in difficult to access areas on the south and south-west cliff faces of the island (Anderson 2021). A concurrent increase in the number of apparently occupied puffin burrows has occurred as tree mallow coverage declined, indicating a successful outcome for the Scottish Seabird Centre's SOS Puffin initiative.

With much of Craigleith cleared of extensive adult tree mallow plants for over a decade, this study was undertaken to:

a) assess the abundance of tree mallow seeds still present in soil samples taken from across the island;
b) determine if any environmental factors (soil moisture, dominant vegetation, soil depth, presence of tree mallow plants and presence of rabbits [*Oryctolagus cuniculus*]) are related to tree mallow seed abundance, and;
c) compare the number of seeds found in 2021 with that found during previous seedbank studies in 2011.

The Site

Craigleith is a small (7.4 ha) island 1000 m north of North Berwick. Along with Fidra and the Lamb, it forms part of the Forth Islands SSSI and is also an SPA. It is home to breeding populations of many seabirds, including cormorants (*Phalacrocaorax carbo*), herring (*Larus argentatus*) and greater black-backed (*Larus marinus*) gulls and puffins. Tree mallow has been controlled on the island since 2007, with the slopes now dominated by grass swards of red fescue (*Festuca rubra*) and Yorkshire fog (*Holcus lanatus*), and common nettle (*Urtica dioica*), docken (*Rumex* spp.) and Yorkshire fog occupying large areas of the glen (Anderson 2021).

Sampling Protocol

Soil sampling was undertaken on Craigleith on 19 August 2021 (L Parfitt, L Ross, H Anderson) and on 6 September 2021 (L Parfitt, E Burton). In total, 28 soil samples were collected from around the island (Fig 1). To allow direct comparisons with sampling that occurred in 2011, the same locations as the 2011 study were used. Sampling locations were identified using GPS points (accuracy ±3 m). At each location a soil corer (5.5 cm Ø) was used to extract a soil sample, which was then placed in a sealed, labelled plastic bag. In addition, at each location the dominant plant was recorded, soil moisture was measured in %vol using a HH2 soil moisture meter (Delta-T Devices), total soil depth was measured in cm, the presence or absence of rabbits (indicated by droppings, digging or scrapes) and the presence or absence of adult tree mallow plants were also noted. To preserve any seeds present, soil samples were stored in a refrigerator prior being sieved and extracted.

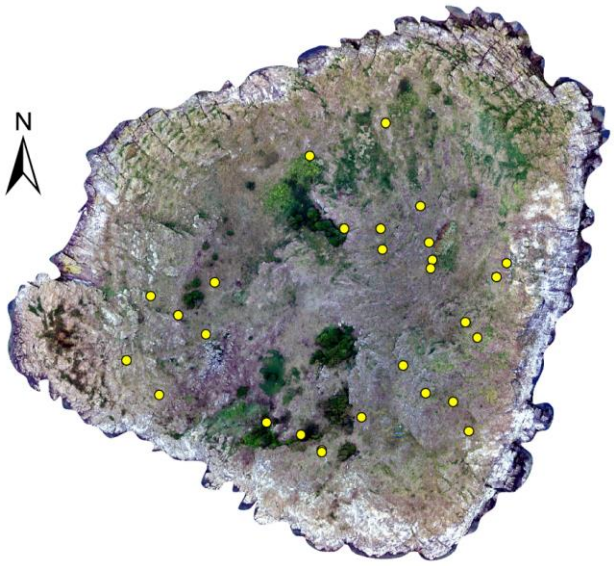

Figure 1 Sampling locations for tree mallow seeds on Craigleith. Underlying image was captured by drone on 6 September 2021

In early October 2021 in the soil lab at the University of Aberdeen, the soil samples were individually sieved in a 3.35 mm soil sieve with a collection tray to remove plant litter and stones. Each sample was then sieved through a 1.0 mm sieve, with any tree mallow seeds present then counted and placed in a paper envelope to prevent rot. Sieves were brushed

out after each sample to prevent contamination and ensure all seeds had been collected. The soil from each sample was dried in an oven until a stable weight was achieved, allowing the abundance of tree mallow seeds to be expressed as number of seeds per g dry soil.

For each sample, the number of intact seeds (firm and whole) and the number of damaged seeds were recorded. For viability analysis, a standard procedure was followed to break seed dormancy, where a quarter to a third of each intact seed was cut away using a scalpel to break the endocarp and encourage germination (Davies et al. 2015). Seeds were then placed on damp filter paper and left to germinate for 24 hours in a temperate glasshouse. Those that showed no sign of germination after 24 hours were discarded.

Results

The total number of tree mallow seeds found on Craigleith in 2021 was almost half that found in 2011 (0.38 per g soil and 0.74 per g soil, respectively; Fig 2).

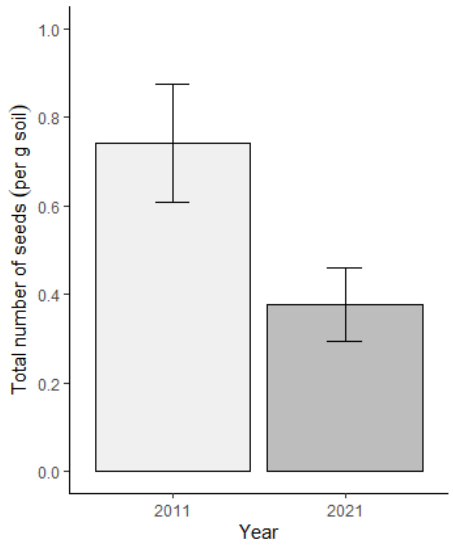

Figure 2 Total number of tree mallow seeds found in soil samples taken from 28 sampling locations on Craigleith in 2011 and 2021. Error bars indicate standard error of the mean. For sampling locations, see Fig 1.

Spatial analysis of seed densities found that higher densities of seeds were found towards the south and east of the island in 2021, with hotspots occurring in four particular locations (Fig 3).

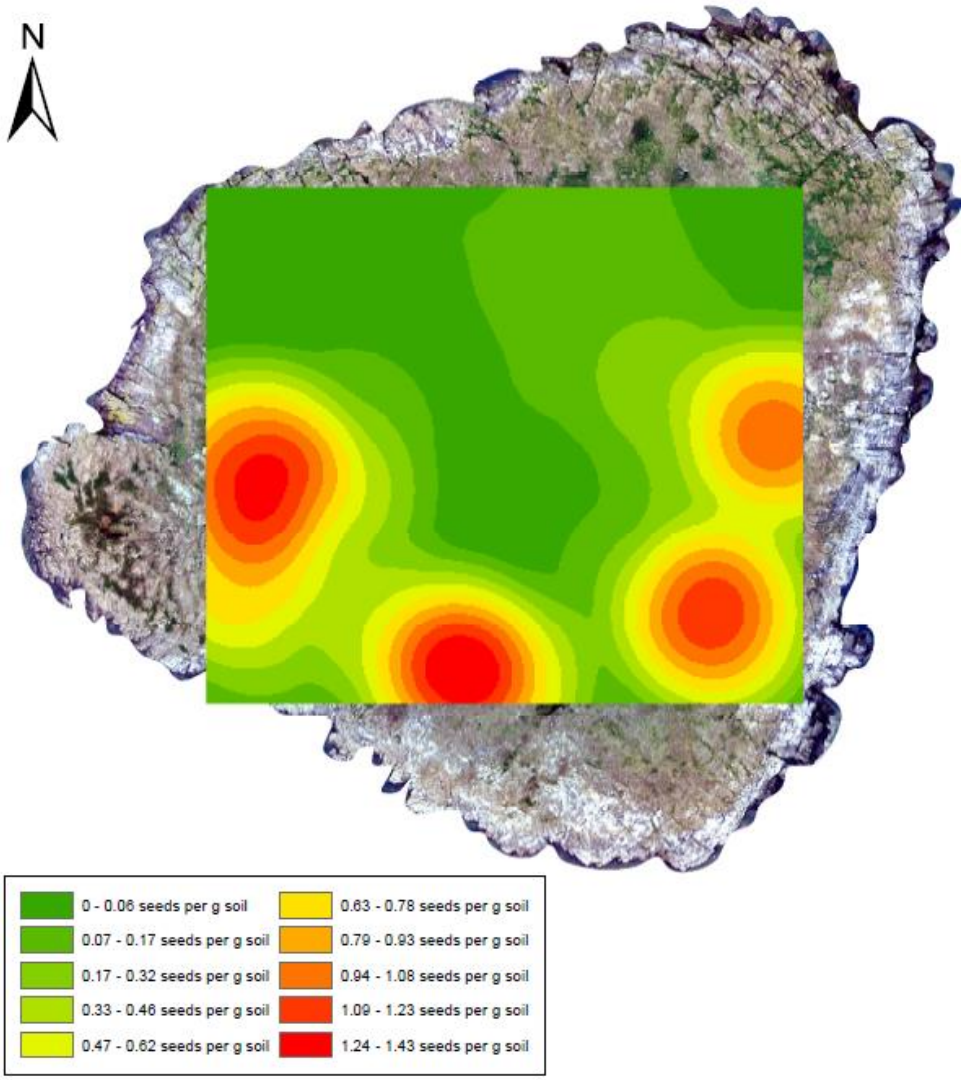

Figure 3 Tree mallow seed density heatmap of Craigleith for 2021. Green colours indicate low seed densities, red colours high seed densities. Note: it is not possible to calculate densities beyond the minimum boundary geometry of sampling locations.

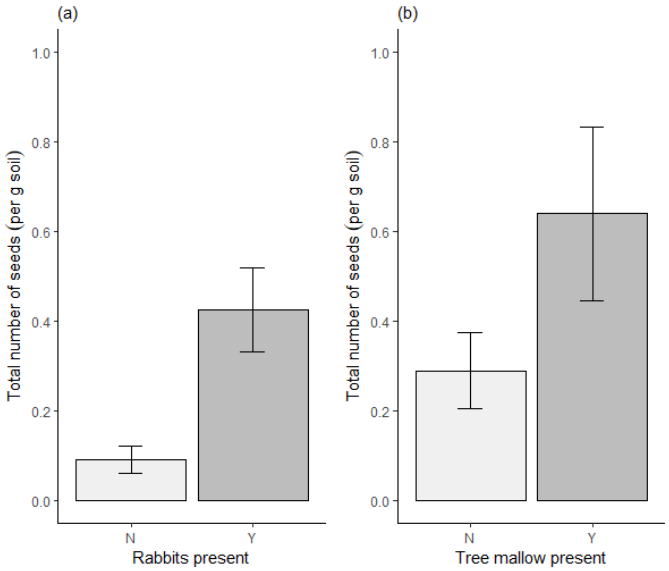

Figure 4 Total number of tree mallow seeds on Craigleith in 2021. Total number of tree mallow seeds per g of soil when, (a) rabbits were present or absent, and (b) tree mallow plants were present or absent. Bars indicate standard error of the mean. Rabbit presence was indicated when signs of digging or scraping, or where droppings were seen within 0.5 m of the sampling location. Tree mallow presence was indicated when live plants were seen within 0.5 m of the sampling location.

Nearly eight times as many tree mallow seeds were found in areas where rabbits were present (signs of digging, scraping or where droppings were evident), compared to where rabbits were absent (Fig 4a). There were just over twice as many tree mallow seeds found at locations where tree mallow plants were already present compared to where they were absent (Fig 4b). There were no obvious relationships between the number of tree mallow seeds and soil moisture, soil depth or the dominant vegetation present at the sampling location.

Almost all seeds (90%) collected were viable and germinated after 24 hours. There was no spatial pattern to seed germination, with seeds from each sampling location being viable.

Discussion

The Scottish Seabird Centre's SOS Puffin initiative, which has cut and removed mature invasive tree mallow plants from Craigleith, has been very successful, with a reduction in cover of the plant from over 80% to less than 10% of the island in a decade (Anderson 2021). However, tree mallow seeds will have been shed from flowering plants present on the island before the large-scale clearance of mature plants from the island (pre-2008). Under the right conditions, accumulations of tree mallow seeds in the soil (the seedbank) have the potential to germinate, which could result in the return of dense stands of plants if not controlled. Therefore, understanding the status of the tree mallow seedbank is important for the future ecological management of Craigleith and control of tree mallow growth on the island.

Cutting mature plants is a recognised method of controlling the seedbank of invasive plant species (Richardson and Kluge 2008) and this approach has reduced the total seedbank of tree mallow on Craigleith. However, viable tree mallow seeds were still found across the island during this survey, over a decade since clearance of flowering plants has occurred.

This is not unexpected as invasive plants have the ability to produce many seeds (6-8 seeds per fruit in the case of tree mallow) and seeds from invasive plants can remain dormant in the soil for many years (Pyšek et al. 2015). It is likely that the vast majority of tree mallow seeds counted during this survey came from flowering plants that were cleared from the island over a decade ago, rather than wind-blown seeds from the small numbers of mature plants growing on the inaccessible cliffs in the south-east and south-west of Craigleith.

The greatest accumulations of tree mallow seeds were found in the more southerly areas of the island. This may be due to seeds being carried downhill from the higher northerly parts of the island by soil slippage and being blown downhill. However, it is encouraging that seed numbers are particularly low in the northern areas of Craigleith, indicating a substantial depletion in the tree mallow seedbank here. This part of the island has extensive coverage of grass swards, particularly red fescue (*Festuca rubra*) and Yorkshire fog (*Holcus lanatus*), which are effective in reducing tree mallow seed germination. Since the northerly parts of the island have been free of mature tree mallow plants for quite some time (Anderson 2021), it is likely that these areas would experience minimal tree mallow regrowth if germination and continued growth without management intervention were to occur. However, any regrowth left unchecked would lead to the production and accumulations of more tree mallow seeds, with the result that the island would become over-run by this invasive species again.

The main cause of tree mallow seed accumulation would appear to be soil disturbance, with substantially more tree mallow seeds found in areas of the island where rabbits were present and where tree mallow seedlings were already germinating. Disturbed habitats generally possess larger seedbanks (Brown & Warr 1992) and promote seed germination, with digging and burrowing creating gaps in the vegetation that allow seedlings to grow (Crawley et al. 1999). Under these conditions, the seeds of invasive species such as tree mallow would be expected to dominate any primary vegetation due to their greater competitive ability, as observed by these areas having larger numbers of tree mallow seedlings present. Over the last few years, both rabbit numbers and the number and size of bare soil patches on Craigleith have been increasing (Anderson 2021). Therefore, it is highly likely that the soil disturbance activities of rabbits have promoted the accumulation and germination of tree mallow seeds in the more southerly parts of Craigleith. However, any young tree mallow seedlings are unlikely to escape herbivory by rabbits late in the year, so providing the numbers of rabbits remains high, some tree mallow control will occur via herbivory. Although, if rabbit numbers fall then this situation could easily be reversed, with substantial tree mallow growth occurring due to the large numbers of seeds in the soil and their ability to

grow quickly and outcompete native vegetation. This would also be the case if manual tree mallow cutting and control procedures were stopped.

Conclusions

Over a decade since large-scale clearance of tree mallow occurred on Craigleith there is still a substantial seedbank present on the island. Much of this occurs in the more southerly parts of the island and the accumulation of seeds and their germination are favoured by the high numbers of rabbits on the island and the disturbance they cause to the soil. It is recommended that counting of annual rabbit numbers and vegetation monitoring continues, along with periodic inspections of the island for tree mallow growth. Manual tree mallow cutting and control will continue to be required to keep this invasive plant under control. Further seedbank studies in the future could add to our knowledge of how to control this invasive plant and to the longevity of its seedbank, which is currently unknown.

Acknowledgements

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