A Preliminary Botanical Survey of the Sand Dunes at Baltray, Co. Louth

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All photos by Ciarán Flynn.

About the Author

Ciarán Flynn is a freelance ecologist with extensive botanical experience. Having attended Trinity College Dublin (TCD), he attained a first-class honours degree in Zoology. As part of these studies, he was awarded a Gold Medal for his exceptional degree results and elected Scholar by the Board of TCD. His thesis examined the potential natural vegetation of Black Mountain, Cooley using fossil pollen analyses to reconstruct previous plant communities. To further pursue his interest in the Irish flora, he has drafted a PhD proposal focussing on Atlantic bryophyte ecology in Irish temperate rainforests.

The development of his botanical field skills has been achieved through regular participation with the Botanical Society of Britain and Ireland (BSBI) and Dublin Naturalists' Field Club (DNFC). As a BSBI county recorder for Louth, he possesses detailed knowledge of important botanical sites and species within the county. Notable finds include *Trichomanes speciosum* (Killarney Fern) (gametophyte) on Slieve Foy and *Trifolium ornithopodioides* (Bird's-foot clover) on Clogherhead, the latter comprising the first county record since 1837. Moreover, he is currently engaged in a study of bryologically significant sites in Slieve Gullion, Co. Armagh, supported by an Irish Naturalists' Journal Grant (2024). His avid bryophyte recording efforts in Cooley have yielded new county records for the moss *Orthotrichum pulchellum* and the thallose liverwort *Metzgeria conjugata*.

Previous professional experience includes habitat classification (UK BAP) and vegetation surveys undertaken for the Northern Ireland Countryside Survey, as well as habitat and plant surveys of Rathcor and Baltray for the Louth Nature Trust. Desk-based projects include a 'County Meath Biodiversity Audit' conducted with FitzGerald Ecology. This involved a synthesis of records and data relating to many habitats and taxonomic groups, data cleaning in R and production of shapefiles in QGIS. Furthermore, he drafted much of the accompanying report which, *inter alia*, identifies important sites for biodiversity and highlights knowledge gaps.

Finally, Ciarán is a member of both the BSBI's Committee for Ireland and DNFC's Board and Research and Publications Subcommittee. He has written several articles on his botanical discoveries in Co. Louth and has been editor of the BSBI's *Irish Botanical News* since 2024.

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1. Introduction

Monitoring of botanically important sites is critical for effective conservation. These sites often act as a refugium for species extirpated from other locations and which are now rare in the wider landscape. Moreover, they harbour specialised ecological conditions where both rare habitats and plant species can be found. Given the continued anthropogenic pressure on such habitats and species, it is crucial that important sites are regularly monitored. This requires surveys to ascertain their presence and to detect any changes over time.

Louth Nature Trust commissioned Flynn Ecology to conduct a botanical survey of a section of the dunes at Baltray, Co. Louth (see section 2.1.). The ecological value of this site has been recognised by its inclusion in the Boyne Coast and Estuary Special Area of Conservation (SAC). The aims of the study are as follows:

- To generate a comprehensive list of vascular plants found in the study site.
- To record a selection of bryophytes (mosses and liverworts).
- To classify and record the habitats present according to Fossitt (2000).
- To describe the physical and floristic composition of habitats, with an emphasis on species indicative of particular habitats.

2. Methodology

2.1. Site description

The site comprises a 280m x 580m area amongst the Baltray sand dunes within the Boyne Coast and Estuary SAC (Figure 2.1, Figure 2.2). Several Annex I habitats (EU Habitats Directive) are found within the SAC and those relevant to the current study are provided in Table 2.1. The site is located east of the reservoir and is bisected by a path leading towards the coast. Specific information is unavailable for this small area. Furthermore, as it is representative of the wider area, the whole sand dune system is described here. Situated in the south-eastern corner of Co. Louth, these sand dunes extend south from Termonfeckin to the River Boyne. The system continues south of the estuary with extensive dunes at Mornington, Co. Meath. No age estimates for dune initiation at Baltray could be found in the literature. The sand dunes 60km north at Murlough, Co. Down began development at various times between 6 and 2ka BP (thousand years before present) (Orford, 2005). However, extrapolating dune chronology from one nearby site to another is ill-advised. Local factors such as anthropogenic disturbance can influence the timing of dune development (Wilson and Braley, 1997).

The classic pattern of dune succession can be encountered at Baltray – from embryonic dunes to marram dunes and, finally, fixed dunes. Alterations in soil properties and vegetation over time drive these habitat changes. The initial soils are composed entirely of raw sand and are frequently calcareous due to the carbonate content in the sediment. Over time, leaching promotes the acidification of the soil. Indeed, podzolic soils have developed on some dunes such as at Murlough (Wilson, 1992) which support heathland. Although podzols with heath are not present at Baltray, the effect of soil acidification on vegetation is still evident. *Pteridium aquilinum* (Bracken) is abundant on parts of the fixed dunes. Conversely, changes in soil pH and structure are influenced by the vegetation. Small accumulations of wind-blown sand are colonised by the grass *Elymus junceiformis*. As the roots

promote the binding of the sand, further accumulation may take place. Over time, this habitat transitions into one dominated by marram, *Ammophila arenaria*. This grass is more robust than *E. junceiformis* and marram outcompetes it where the soil has become sufficiently deep. These dunes still exhibit much sediment mobility. Marram responds to sand accumulation via rapid growth of stems and rhizomes. The latter further stabilises the substrate (Huiskes, 1979). Stabilisation of the sediment coupled with organic matter accumulation and acidification produces fixed dunes, typically hosting various grassland species. Marram is much less abundant here. Areas for the three dune habitats at Baltray (Annex I habitats, EU Habitats Directive) were estimated by Delaney *et al.* (2013) (Table 2.2). Fixed dunes comprised the majority (86%) of the habitat with embryonic (8%) and marram dunes (6%) consisting of smaller proportions. This is a general representation of sand dune habitats and succession, the details of which may vary on site-by-site basis. For instance, differences in the flora and vegetation are linked to land use.

Table 2.1. Qualifying Interests of Boyne Coast and Estuary SAC relevant to the current survey. * denotes a priority habitat under the EU Habitats Directive.

Habitat code	Habitat name
1210	Annual vegetation of drift lines
2110	Embryonic shifting dunes
2120	Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)
*2130	Fixed coastal dunes with herbaceous vegetation (grey dunes)

Table 2.2. Area and proportion of three sand dune habitats in Baltray. Estimates are derived from the Sand Dunes Monitoring Project (Delaney *et al.*, 2013).

	Area (ha)	Proportion of dune habitat (%)
Embryonic dunes	3.37	8
Marram dunes	2.73	6
Fixed dunes	38.80	86

Table 2.3. A selection of notable species recorded from Baltray. None of these appear to be widespread within the dune system here. Other significant species are mentioned in the text. Recorder initials: BSBI = Botanical Society of Britain and Ireland (record collected during a field meeting); CF = Ciarán Flynn; DTH = David T. Holyoak; SF = Shane Farrell. Distribution data were taken from the BSBI Distribution Database (BSBI, 2024). Threat status follows Wyse Jackson *et al*. (2016).

Species	Grid reference and year	Recorder	Significance
Cuscuta epithymum	O 148 773 (2023) O 1527 7780 (2019) O 1486 7754 (2019)	CF SF SF	One of three extant sites on the east coast of Ireland.
Salvia verbeneca	O 1494 7720 (2021)	BSBI	Northernmost site in Ireland.

	O 153 781 (2019)	SF	
Didymodon acutus (D. icmadophilus)	O 1481 7758 (2007)	DTH	Flora (Protection) Order 2022 Endangered
X Festulpia hubbardii	O 1494 7732 (2006)	PG	One of five Irish sites.

Various forms of land use can be encountered at Baltray. Recreational activities by visitors appears to be mostly restricted to walking. The consequent disturbance along paths maintains an open sward locally. Non-intensive cattle grazing also takes place in the winter in western parts of the site. Some areas here have restricted access during the breeding season to avoid disturbance to ground-nesting birds such as Meadow Pipits and Skylarks. Similarly, a predator-exclusion fence is erected along the shoreline annually to protect the Little Tern colony here.

Several notable plant species have been recorded at Baltray (Table 2.3). Given the small size of the study area within a larger dune system, it proved difficult to conclusively localise plant records to it. Hence, I will describe records from the wider dune system as the habitats are spatially contiguous and there is a chance that the species mentioned here may have occurred/do occur within the study site. The obligate parasite *Cuscuta epithymum* (Dodder) occurs in at least three areas, two of which are outside the SAC with a third perhaps marginally within it (BSBI, 2024; C. Flynn, pers. obs.). Records within the Botanical Society of Britain and Ireland's (BSBI) Distribution Database (DDb) suggest that Baltray is one of only three localities for dodder on the east coast. The other two sites with recent (post-2000) records are Killard Point, Co. Down and the Lady's Island Lake area, Co. Wexford (BSBI, 2024). Moreover, dodder has declined within Co. Louth. It has probably been lost from Lurgangreen, Castlebellingham (Praeger, 1901) and Ballymakellett, Cooley (Synnott, undated) with Baltray being the final remaining site. Occasionally, it was a contaminant of imported seeds although this is rarely the case now due to improved seed cleaning techniques. Only populations on sand dunes are deemed to be native in Ireland (Praeger, 1934; Scannell and Synnott, 1987). *Salvia verbeneca* also forms a biogeographically important population here. Baltray constitutes its northernmost locality in Ireland (BSBI, 2024). It has most recently been observed east of the reservoir outside of the SAC (2021). Another population was recorded further north and possibly within the SAC (2019). Strong declines in its Irish distribution since 1987 have been noted (Stroh *et al.*, 2021). Typical habitats encompass those with well-drained, infertile soil including sand dunes (Stroh *et al.*, 2021). Other notable vascular plant species recorded from Baltray include *Cynoglossum officinale* (Near Threatened) (Wyse Jackson *et al*., 2016), *Echium vulgare* and the annuals *Cerastium semidecandrum* and *C. diffusum*. The little-known hybrid between the grasses *Festuca rubra* and *Vulpia fasciculata*, *X Festulpia hubbardii* has also been found (Green, 2007). This taxon is, however, probably more widespread than current records indicate. Whilst all of these species persist here today, some losses seem to have occurred. A dune slack was host to the horsetail *Equisetum variegatum* and moonwort *Botrychium lunaria* (Synnott, 1970). It is unclear where this slack occurred exactly although the habitat may now have disappeared. In addition to these vascular plants, the rare moss *Didymodon acutus* was recorded in 2007 at the edge of the golf course. However, a targeted search in 2015 failed to re-find this taxon (NPWS, 2017). Listed as Endangered on the Irish Red List (Lockhart *et al*., 2012) and scheduled on the Flora (Protection) Order (FPO) 2022, this species has only been found in four Irish vice-counties (Pilkington and Hodgetts, 2023). Moreover, all recent records have been from sand dunes (Lockhart *et al*., 2012). The identity of *D. acutus* populations in Britain and Ireland has been subject to some

confusion (Blockeel and Kučera, 2019). Currently, all previous Irish *D. acutus* records have been transferred to *D. icmadophilus sensu* Kučera (Pilkington and Hodgetts, 2023). This taxonomic position has either not been accepted or fully implemented as it continues to be listed as *D. acutus* on the FPO 2022.

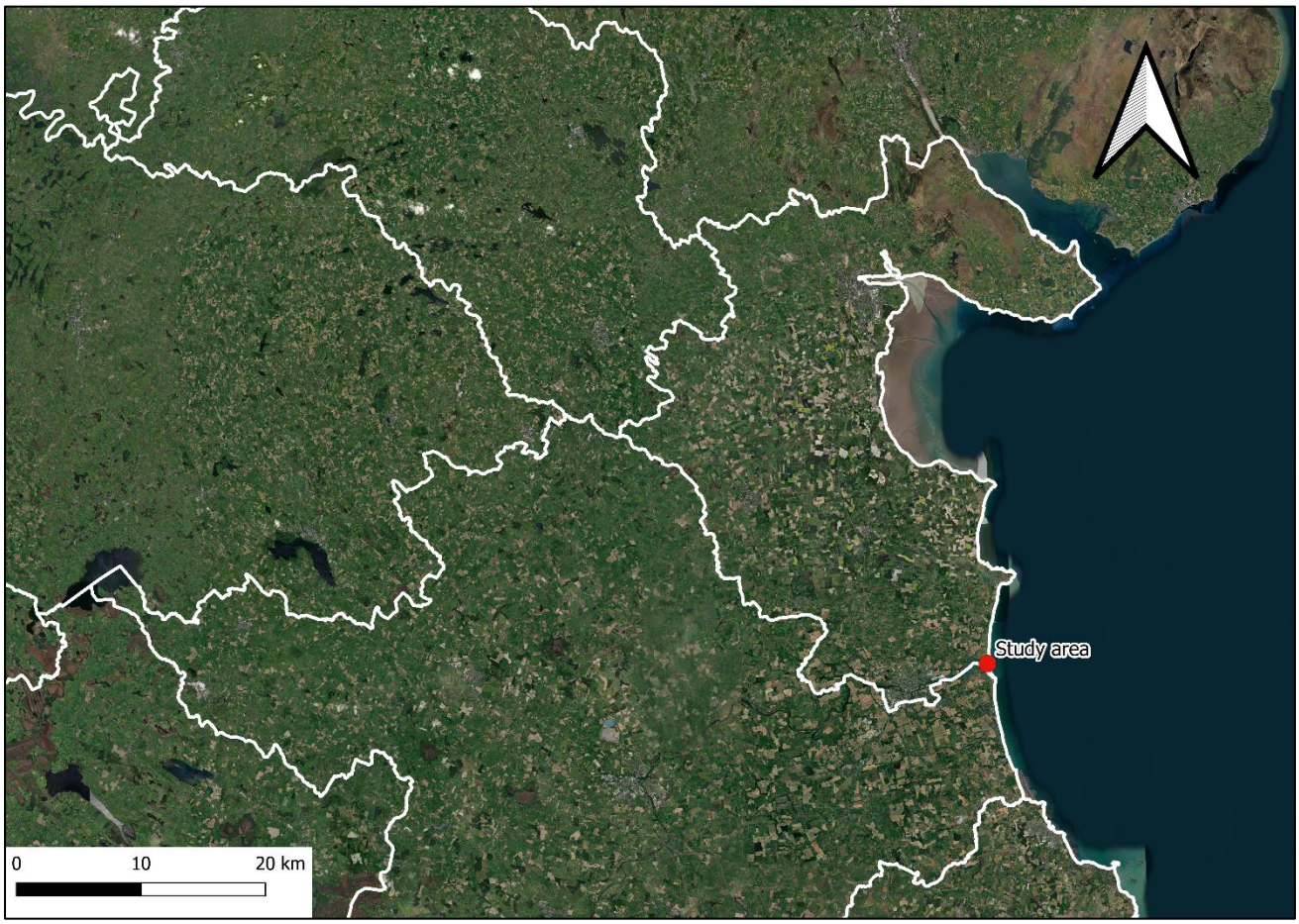

Figure 2.1. Location of the study area in relation to the east of Ireland. Baltray is situated in the south-east of Co. Louth adjacent to Co. Meath.

Figure 2.2. Study area at Baltray in relation to Boyne Coast and Estuary SAC.

2.2. Fieldwork

Site visits were conducted on the 12th July and 11th-12th September 2024. All vascular plant species were recorded and later compiled into a comprehensive species list. A small number of bryophytes were also recorded where these appeared to be of interest. Samples were collected for microscopic examination to confirm identifications. The keys and descriptions in Smith (2004) and the British Bryological Society website (British Bryological Society, 2024) were consulted. Stace (2019) was consulted for vascular plant identification. Habitats were classified according to Fossitt (2000). Details of the physical and floristic structure of each habitat were gathered in the field. Some sections in the northern part of the site could not be accessed due to the presence of ground-nesting birds.

Vascular plant nomenclature follows Stace (2019). Bryophyte nomenclature follows Blockeel *et al.* (2021).

3. Results

3.1. Overview of results

Eighty-six vascular plant and four bryophyte species were found in the study area. Four habitats were recorded, all of which were sandy. Accounts of each habitat and their associated species are described below.

3.2. Sand shores (LS2) and embryonic dunes (CD1)

Sand shores and embryonic dunes occur in a mosaic at Baltray. They are therefore described together. Small accumulations of sand were colonised by the grass *Elymus junceiformis* (Figure 3.1). This grass reduces sediment mobility in these embryonic dunes. In association with such nascent dunes and sand shores were *Leymus arenarius*, *Honckenya peploides*, *Atriplex laciniata* (Figure 3.2) and *Salsola kali* (Figure 3.3). These formed an incomplete vegetation cover along the upper shoreline and are typical inhabitants of the foreshore. *Beta maritima* subsp. *maritima* was also occasionally encountered. Two members of the Asteraceae (Compositae) family, *Jacobaea vulgaris* and *Sonchus oleraceus* grew very sparingly here. These ruderal taxa grow in many different habitats with low competition including embryonic dunes. The dunes became larger moving landward. One area was quite extensively vegetated with *E. junceiformis* in contrast to the adjacent marram-dominated dunes.

Figure 3.1. Embryonic dunes (CD1) colonised by the grass *Elymus junceiformis*.

Figure 3.2. *Atriplex laciniata* growing on embryonic dunes (CD1).

Figure 3.3. *Salsola kali* growing on embryonic dunes (CD1)

3.3. Marram dunes (CD2) and fixed dunes (CD3)

Marram dunes and fixed dunes grade into each other and so are treated together here. These two habitats are distinguished by vegetation cover and the abundance of marram *Ammophila arenaria* (Fossitt, 2000). However, the fixed dunes contain a high amount of marram in many parts of the site (Figure 3.4). Amongst the abundant marram grew *Arrhenatherum elatius*, *Jacobaea vulgaris*, *Ervilia hirsuta* and *Centranthus ruber*. The grass *Dactylis glomerata* was occasionally encountered. Higher richness was recorded along the lightly trampled paths. These yielded *Anthyllis vulneraria*, *Galium verum*, *Festuca rubra* agg., *Aira caryophyllea*, *Poa pratensis* s.l., *Ononis repens*, *Anacamptis*

pyramidalis, *Trifolium arvense* (Figure 3.5) and *Daucus carota*. Low levels of disturbance enable the growth of taller vegetation which can outcompete many herbs found in more open swards. Indeed, assessments of Annex I fixed dune habitat in Baltray highlight the low abundance of positive indicator species and high vegetation height (Delaney *et al.*, 2013). Such areas likely suffer from under-grazing. The plant communities here contrast with the grazed sections of the site such as in the south-west (O 152 771) (Figure 3.6). *Ammophila arenaria* is much less frequent here. Typical members of well-drained, neutral grassland can be found – *Anthoxanthum odoratum*, *Rhinanthus minor*, *Daucus carota*, *Plantago lanceolata*, *Centaurea nigra*, *Lotus corniculatus*, *Knautia arvensis*, *Ononis repens*, *Galium verum* and *Linum catharticum*. Scattered hawthorn trees (*Crataegus monogyna*) also occur. Similarly, a grazed area north of here (ground-nesting bird area) shares a lower sward and various herbs of dry, neutral grassland such as abundant *Rhinanthus minor*, *Lotus corniculatus*, *Galium verum* and *Euphrasia* sp. Closer to the shore and near pathways, the marram dunes have an incomplete vegetation cover. The margins of one such path yielded *Trifolium arvense*, *Galium verum*, *Daucus carota*, *Anthyllis vulneraria* and *Aira caryophyllea*. Closer to the shore, *Phleum arenarium*, *Euphorbia paralias*, *Leontodon* sp. and *Carex arenaria* were encountered.

Figure 3.4. The tall sward within the fixed dunes (CD3) with abundant *Ammophila arenaria*.

Figure 3.5. *Trifolium arvense*, with its distinctive hairy inflorescences, growing on the margin of a path within fixed dunes (CD3).

Figure 3.6. A grazed area of fixed dune in the south-west of the site. The rayless form of Common Ragwort (*Jacobaea vulgaris*) can be seen in the foreground.

3.4. Alien species

Three alien species of concern were found during the present survey. The woody climber *Clematis vitalba* grew in at least ten distinct sites (Figure 3.7). Outside the study area, *Hippophae rhamnoides* (Sea-buckthorn) (Figure 3.8) and *Rosa rugosa* occur on the dunes slightly north of the estuary at O

1564 7645. Only small populations of the latter two species were seen here. On North Bull Island, *H. rhamnoides* is considered the most damaging invasive species present in the dune system with *C. vitalba* also deemed a high priority for removal. *Rosa rugosa* does not appear to be as damaging here (Lyons, 2020) although it is a foremost threat alongside *H. rhamnoides* on the Sefton Coast, England (Smith, 2020).

Figure 3.7. *Clematis vitalba* forms dominant patches locally in the fixed dunes.

Figure 3.8. The invasive Sea-buckthorn *Hippophae rhamnoides* growing near the Boyne estuary (O 1564 7645).

4. Discussion

4.1. Review of findings

The typical habitats of sand dunes in Ireland were found at Baltray. Embryonic dunes on the shore transitioned to marram and fixed dunes inland with the latter hosting grassland vegetation. These habitats are shared by other sand dune systems on the east coast. However, some of these systems contain habitats absent from the current study site. North Bull Island, for example, contains dune slacks. These areas are seasonally inundated, and the water table lies close to the surface year-round. On North Bull Island, they are host to a range of ecologically specialised species including the orchid *Epipactis palustris*, Adder's-tongue *Ophioglossum vulgatum* and the rare thallose liverwort, *Petalophyllum ralfsii*. Dune slacks with *Botrychium lunaria* and *Equisetum variegatum* have previously been reported from Baltray (Synnott, 1970). Slacks do not appear to have been formally recorded from Baltray recently although remnants may persist between Baltray and Termonfeckin (B. Martin, pers. comm., 2024). The relocation and detailed survey of any surviving areas is a priority. Groundwater abstraction has likely driven the lowering of the water table and, hence, the drying out of slack habitat. North of Baltray at Murlough, Co. Down, the dunes support heathland. Leaching of soil nutrients coupled with the initial low calcium carbonate input from the sand here has promoted development of podzols (Wilson, 1992) and heathland. However, dune heathland is a rare habitat in Ireland and local factors (sediment characteristics) may preclude its development at Baltray. Direct comparisons should not be made, however, between sand dune systems due to differences in area. Larger systems will likely contain more habitats.

Many species typical of sand dunes were encountered although the most significant taxa were not found. Various environmental conditions exist on sand dunes. Generally, well-drained, infertile, acidic to calcareous soils are to be found in an open, unshaded environment. Many species can be found both in the dunes in Baltray and in other inland habitats where similar conditions prevail. These include components of dry, neutral grassland vegetation such as *Galium verum* and *Knautia arvensis*. Others, however, are mostly restricted to sand dunes in Ireland currently. This distribution may reflect a requirement for specialised ecological conditions which are not found inland. Their absence from inland areas may result from the destruction of suitable habitats and/or because the necessary conditions are limited to the coast (milder coastal climate, for instance). Two examples are *Salvia verbeneca* and *Cynoglossum officinale*, both of which occur in Baltray but were not found within the study area. The south-western corner of the northern grazed field contains *C. officinale*, and *S. verbeneca* has been seen slightly west of this corner. Therefore, either species may occur elsewhere in this field. Given the importance of the Baltray populations, future surveys should be extended to include these and facilitate their monitoring over time. Away from the grazed areas, the predominantly tall, dense sward is inimical to their survival. This underscores the importance of grazing in the maintenance of these populations and species diversity in the dune system.

The impact of disturbance on plant communities and diversity can be seen across the dunes. Areas of fixed dunes with cattle grazing displayed higher richness and a different species assemblage than ungrazed parts. More herbs indicative of dry, neutral grassland were encountered including *Rhinanthus minor* and *Euphrasia* sp. Ungrazed sections contained an assemblage more akin to dry

meadows with such species as *Arrhenatherum elatius* and *Dactylis glomerata* although other herbs were present here in smaller quantities too. In the absence of baseline data, it is not possible to definitively assess the changes brought about by the introduction of grazing within the study area. Yet comparisons with ungrazed areas of the dunes provide an indication of the effects. The abundance of marram in parts of the fixed dunes likely results from under-grazing. Indeed, the fixed dune habitat at Baltray was assessed as 'Unfavourable – Inadequate' due to the low amount of positive indicator species and tall vegetation (Delaney *et al.*, 2013). Low disturbance levels have probably contributed to both of these. Under-grazing appears to be a widespread issue as 21% of fixed dune habitat sampled nationally was affected by it (Delaney *et al.*, 2013). Similarly, excessive disturbance can be detrimental although this does not appear to be of concern at Baltray. Cattle grazing is not the only type of disturbance. Trampling by walkers along paths creates an open substrate colonised by several species incapable of tolerating the competitive environment where the sward is taller. Rabbit grazing has a beneficial effect on several dune systems including North Bull Island (Lyons, 2020). There may also be some rabbit activity west of the study area close to the last sighting of *Salvia verbeneca*. It is important to stress that an appropriate level of disturbance is desirable. Both excessive and insufficient disturbance can have deleterious effects on the site's flora.

The presence of certain invasive species merits further action. Of these, *Clematis vitalba* is the most widespread and was found in at least ten locations. Having a high number of distinct sites within a small study area is concerning. Without data on its previous abundance at the site, it is unclear whether this species is spreading. Populations of *C. vitalba* can be identified on satellite imagery as bright green patches (Figure 4.1). Changes in abundance could possibly be measured by comparison with historical aerial/satellite images. Its potential to become invasive on sand dunes (Smith *et al.*, 2024) means that removal should be considered. Similarly, the population of *Hippophae rhamnoides* (outside the study area at O 1564 7645) should be removed immediately, especially as the population is currently small. On North Bull Island, the necessary removal of this species has severely damaged adjacent habitat where large thickets had become established (Lyons, 2020). Therefore, it is an opportune time to remove the plants here at Baltray before they become problematic. Follow-up visits may also be required to remove any new growth. Monitoring of the *C. vitalba* populations should be conducted to establish whether these are continuing to spread.

The timing of site visits in 2024 hindered the detection of some early-flowering species. Several *Cerastium* species, mostly restricted to coastal areas, have been recorded from Baltray including *C. arvense*, *C. diffusum* and *C. semidecandrum*. These flower in the spring and then either die back or become inconspicuous for the rest of the summer.

Figure 4.1. Three patches of *Clematis vitalba* visible on satellite imagery of the study site. A smaller fourth patch may be present although it is quite indistinct in this image.

4.2. Recommendations

Some modifications for future surveys as well as management actions are recommended. The priority for future work is the monitoring and conservation of the rare and important species found in Baltray.

- Extend the survey area. Inclusion of an area west of the current study site where several significant species grow would be desirable.
- Establish a series of plots to monitor vegetation over time. These should encompass populations of important species such as *Salvia verbenaca*, *Cynoglossum officinale*, *Cuscuta epithymum* and *Echium vulgare*. These plots would capture changes in abundance and species assemblages which would otherwise be difficult to detect.
- Search for dune slacks in the wider Baltray area. If present in a favourable condition, these are likely to host rare and specialised species, and the habitat would be vulnerable to desiccation.
- Manage invasive species in the area. Removal of *Hippophae rhamnoides* is a priority. Populations of *Clematis vitalba* should be monitored for future spread and removed if necessary.

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Appendix A: Vascular plant species list

Eighty-six vascular plant species were recorded. Nomenclature follows Stace (2019) with commonly used synonyms also provided.

Acer pseudoplatanus
Agrostis capillaris
Aira caryophyllea
Ammophila arenaria
Anacamptis pyramidalis
Anthyllis vulneraria
Arenaria serpyllifolia s.l.
Arrhenathrum elatius
Artemisia vulgaris
Atriplex laciniata
Atriplex prostrata agg.
Avenula pubescens
Beta vulagris subsp. maritima
Briza media
Bromus hordeaceus
Capsella bursa-pastoris
Carex arenaria
Centaurea erythraea
Centranthus ruber
Cerastium fontanum
Chamaenerion angustifolium
Cirsium arvense
Clematis vitalba
Crataegus monogyna
Crepis capillaris
Dactylis glomerata
Daucus carota
Elymus junceiformis
Elymus repens
Ervilia hirsuta (Vicia hirsuta)
Eryngium maritimum
Euphorbia paralias
Euphrasia agg.
Festuca rubra agg.
Galium verum
Geranium robertianum
Hedera helix agg.
Heracleum sphondylium
Holcus lanatus

Honckenya peploides
Hypericum perforatum
Hypochaeris radicata
Jacobaea vulgaris (Senecio vulgaris)
Knautia arvensis
Leontodon saxatilis
Linum catharticum
Lolium perenne
Lotus corniculatus
Lysimachia arvensis (Anagallis arvensis)
Matricaria discoidea
Medicago lupulina
Odontites vernus
Ononis repens
Orobanche sp.
Phleum arenarium
Plantago coronopus
Plantago lanceolata
Plantago major
Poa annua
Poa pratensis s.l.
Polygonum sp.
Ranunculus acris
Raphanus raphanistrum subsp. *maritimus*
Rhinanthus minor
Rubus fruticosus agg.
Rumex acetosa
Rumex crispus
Salsola kali
Sambucus nigra
Sonchus arvensis
Sonchus asper
Sonchus oleraceus
Taraxacum agg.
Thymus polytrichus
Tragopogon pratensis
Trifolium campestre
Trifolium dubium
Trifolium pratense
Trifolium repens
Trisetum flavescens
Valeriana officinalis
Veronica chamaedrys
Veronica persica

Vicia sepium
Viola tricolor s.l.
Vulpia bromoides

Appendix B: Bryophyte species list

Four bryophyte species were recorded in the study area. Nomenclature follows Blockeel *et al.* (2021) with commonly used synonyms also provided.

Bryum sp.
Ceratodon purpureus
Pseudoscleropodium purum
Syntrichia ruraliformis (Syntrichia ruralis var. *ruraliformis)*