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Floristic diversity of the Langeyri peninsula: a comprehensive inventory and the distribution of nootka lupine

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Abstract

This study provides a comprehensive floristic inventory of the Langeyri peninsula in Súðavík, in the Westfjords of Iceland, documenting 97 plant species across 34 families within a 110,400 m² area. The survey, conducted from August 12th to 19th, 2023, aimed to characterise the plant communities supporting local bird populations, including key nesting species such as Arctic terns and common eiders. Special attention was given to mapping the distribution of the invasive Nootka lupine *Lupinus nootkatensis*, which poses a potential threat to native vegetation and bird habitats. The findings highlight the rich biodiversity of the peninsula and the presence of diverse ecological niches, while also pointing to the need for ongoing monitoring of invasive species. Recommendations for future management focus on preventing further spread of lupine and minimising human impact on sensitive habitats.

Keywords: Botany, floristic inventory, Iceland, coastal vegetation, bird habitat, invasive species, *Lupinus nootkatensis*

Résumé

Cette étude fournit un inventaire floristique complet de la péninsule de Langeyri à Súðavík, dans les Westfjords d'Islande, documentant 97 espèces végétales réparties en 34 familles sur une superficie de 111 400 m². L'inventaire, mené du 12 au 19 août 2023, visait à caractériser les communautés végétales soutenant l'avifaune locale, incluant des espèces clés telles que les sternes arctiques et les eiders à duvet. Une attention particulière a été portée à la cartographie de la répartition du lupin d'Alaska *Lupinus nootkatensis*, qui constitue une menace potentielle pour la végétation indigène et les habitats des oiseaux. Les résultats mettent en évidence la richesse de la biodiversité de la péninsule et la présence de niches écologiques variées, tout en soulignant la nécessité d'un suivi continu des espèces invasives. Les recommandations pour la gestion future portent sur la prévention de l'expansion du lupin et la réduction de l'impact humain sur les habitats sensibles.

Mots-clés : Botanique, Inventaire floristique, Islande, végétation côtière, habitat des oiseaux, espèces invasives, *Lupinus nootkatensis*.

1. Introduction

Flora plays a fundamental role in the functioning of ecosystems, providing the foundation upon which a multitude of species rely. Plant communities contribute to habitat structure, soil stability, and nutrient cycling, which in turn support both biodiversity and ecosystem services (Ayyam *et al.* 2019). In coastal environments, vegetation is especially critical, serving as a buffer against erosion, regulating microclimates, and providing essential nesting, foraging, and sheltering opportunities for a variety of species (Graells *et al.* 2022). When it comes to bird conservation, the relationship between flora and avifauna becomes particularly important. The diversity and health of plant communities affect the availability of nesting sites and the abundance of food resources, particularly for migratory and ground-nesting birds. Vegetation cover directly correlates with species richness, providing essential protection from predators and suitable conditions for breeding (Graells *et al.* 2022). In coastal habitats, such as the Langeyri peninsula (Island) native vegetation is instrumental in sustaining bird populations, ensuring that habitats remain suitable for bird species (Ayyam *et al.* 2019; Graells *et al.* 2022).

Located in the north-western part of the Westfjords of Iceland (**Fig. 1**), Langeyri lies within a landscape shaped by Miocene to Lower Pliocene basaltic formations and

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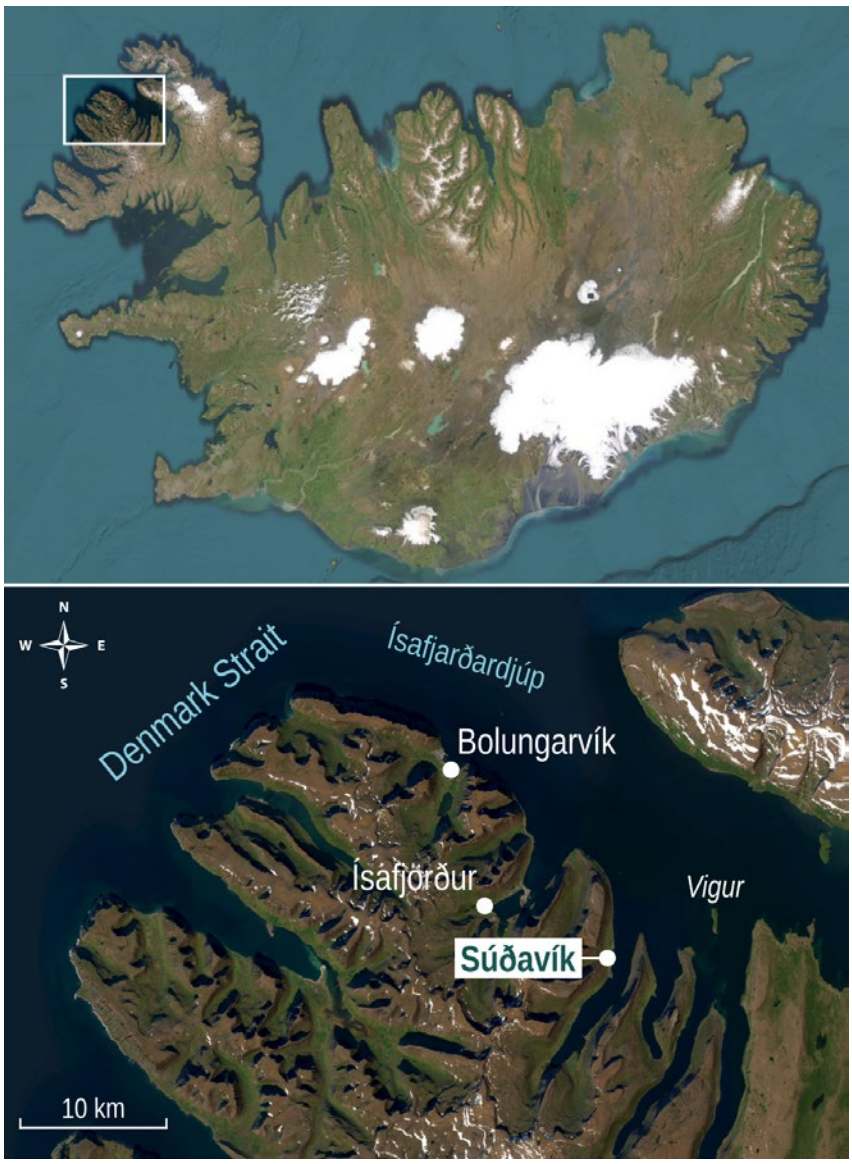

Fig. 1 - Location of the Langeyri peninsula in Súðavík, Westfjords, Iceland.

glacial modelling (Ellero *et al.* 2023). This geodiverse setting, marked by lava flows, sedimentary interbeds, and prominent coastal landforms, offers a mosaic of ecological conditions that influence vegetation patterns.

This geological setting is further influenced by climate. The region is characterised by a subpolar oceanic climate, relatively mild given its high latitude, yet marked by frequent precipitation and strong winds. In 2007, mean annual temperatures for areas below 400 m in Iceland ranged from −2 to +9 °C, with July as the warmest month and January the coldest. In recent decades, the Westfjords have undergone significant climatic shifts: the 2001–2020 period was notably warmer than 1961–1990, particularly during winter, and annual precipitation has increased since 1991 (Bannan *et al.* 2022).

Coastal ecosystems of Iceland are shaped by a combination of subarctic climate, volcanic substrates, and strong marine influences. Vegetation is generally low and patchy, shaped by wind exposure, poor soils, and short growing seasons. In many coastal habitats, seabirds play a central ecological role: their nesting activity enriches the soil with nutrients, influencing plant composition and supporting local biodiversity. These bird-mediated processes also contribute to key ecosystem services, including cultural values and nature-based tourism. The Langeyri peninsula presents a unique case study where both flora and avifauna coexist in a dynamic interplay. Despite ongoing human activities, the area remains an important breeding and nesting ground for various migratory bird species, such as Arctic terns *Sterna paradisaea*, black-headed gull *Chroicocephalus ridibundus*, or common eider *Somateria mollissima*. Understanding the composition and distribution of the peninsula's plant life is crucial for appreciating the ecological balance that supports these bird populations, as well as for identifying potential shifts in Iceland's fauna that changes in plant cover may cause (Jónsson *et al.* 2006). Icelandic ecosystems exhibit heightened vulnerability to the introduction of novel species, such

as the Nootka lupin (*Lupinus nootkatensis*) into the pre-existing biological communities, particularly when such introduced species possess invasive characteristics (Arnalds 2015).

The Nootka lupin is a nitrogen-fixing species that was initially introduced to Iceland with the goal of facilitating the revegetation of nutrient-poor, eroded soils. While it proved cost-effective and successful in promoting vegetation in the short term, its long-term ecological impact is more problematic. This species has been shown to hinder the natural succession of native plant communities, ultimately affecting broader ecosystem restoration efforts. Icelandic ecosystems are particularly vulnerable to the introduction of non-native species, especially when those species exhibit invasive traits like lupin (Arnalds 2015). Despite various eradication efforts, controlling the spread of lupin has met with only limited success (Benediktsson 2015), and its impact on indigenous biodiversity remains a pressing conservation issue (Arnalds 2015).

In this study, I conducted a comprehensive flora inventory of the Langeyri peninsula through direct observation and fieldwork, documenting the plant species that contribute to the ecological structure of this coastal habitat. Special attention was given to the invasive Nootka lupin, which poses a significant threat to the local flora (Benediktsson 2015 ; Arnalds 2015). This invasive species alters habitat conditions, potentially diminishing the suitability of nesting grounds for bird species that depend on native vegetation (Jónsson *et al.* 2006). By examining both the current plant composition and the potential impact of invasive species, this inventory provides key insights into the conservation needs of the Langeyri peninsula's ecosystem.

2. Material and methods

2.1. Study area

Súðavík, located within the Álftafjörður fjord in the Westfjords of Iceland (**Fig. 1**), is a village with a strong fishing tradition, situated approximately 20 kilometres from Ísafjörður. It serves as a key transit route to Hólmavík and Reykjavik, with both ecological and tourism interests at its core. Notable attractions include the Arctic Fox Centre (Melrakkasetur Íslands 2023) and sea angling opportunities provided by Iceland Sea Angling (2023). Among its natural highlights are the Valagil ravine (Visit Westfjords 2023) and the Langeyri peninsula, a region that, despite its commercial activity, is significant for bird breeding and nesting.

The Langeyri peninsula features several facilities, such as storage areas and boats associated with the local Iceland Sea Angling company, as well as the base of the local rescue team. Recent developments have underlined Langeyri's importance within Súðavík's growth. Though human activities occupy 39,600 square metres, representing 26% of the peninsula's 150,000-square-metre total area, the majority of the land remains in a natural state, with only a modest pathway interrupting its landscape (**Fig. 2**).

Ecologically, the Langeyri peninsula is diverse, encompassing rocky shores, barren coastal fields, a cultivated area, shrublands, and a freshwater pond. This distinct environment attracts numerous migratory

Fig. 2 - Landscape of Langeyri. A ditch is visible in the foreground, with the path and pond in the middle ground. The buildings are in the background.

Fig 3 - Representation of the sampled area for the plant inventory of the Langeyri peninsula, in Súðavík, Iceland (Basemap: Loftmyndir ehf).

bird species that choose the area for nesting. These species include for example the Arctic tern, black-headed gull, common eider, but also common redshank *Tringa totanus*, or Eurasian oystercatcher *Haematopus ostralegus* (Milesi-Gaches 2024).

2.2. Data collection

Between the 12th and 19th of August 2023, the region delineated in **Fig. 3** underwent a systematic botanical survey. Plant species were identified primarily with the help of the field guide *Flowering Plants and Ferns of Iceland* (Kristinsson 2010). For challenging identification cases, the application Flora Incognita was employed as an auxiliary tool (Mäder *et al.* 2021). Species names and taxonomic classifications were standardised according to the *Annotated Checklist of Vascular Plants of Iceland* (Wąsowicz 2020), which provides the accepted nomenclature and authorship for the Icelandic flora.

Photographic documentation of plant species was undertaken, with special emphasis on capturing various stages of their life cycle, when possible. This was done to facilitate post-fieldwork identification and potential corrections. The gathered data were subsequently cross-referenced and adjusted in line with the *Annotated Checklist of Vascular Plants of Iceland* (Wąsowicz 2020).

GPS coordinates for individual plants and clusters of Nootka lupine *Lupinus nootkatensis* were documented using the application GPS Point (Grečnár 2023). The presence of Nootka lupine was noted both within the surveyed region and in adjacent areas upon observation.

3. Results

In a comprehensive survey conducted on the Langeyri peninsula from August 12th to 19th, 2023, a total of 97 plant species spanning 34 distinct families were identified (**Fig. 4**). The *Poaceae* family stands out, accounting for 13.5% of the overall species richness with 13 unique species. Furthermore, 15 of the families are represented by a single species each.

The inventory of the plant species in Langeyri allows a better characterisation of the represented habitats. The western part of the peninsula (from the road to the pond) is dominated by rich heathlands and common associated plant species, such as *Betula nana*, *Vaccinium uliginosum*, *Empetrum nigrum*, *Calluna vulgaris* or willow species (*Salix spp.*) (Arnalds 2015). The northwestern part of the peninsula is more characterised by shrublands with a clear dominance of *Betula pubescens*. The presence of *Solanum tuberosum* can be explained by the presence of a small garden close to the path, within the Arctic tern colony (**Fig. 5**).

Papaver somniferum (opium poppy) was identified in the survey at the beginning of the path, in the immediate vicinity of the commercial buildings. This constitutes an unexpected finding for the Langeyri peninsula. This species is typically cultivated for ornamental or medicinal purposes and is not native to Iceland. Its presence in the area suggests a possible introduction through human activity, such as garden escape or accidental seeding. Although only one individual was observed (**Fig. 6**), its occurrence in this natural environment stands out due to its association with cultivated landscapes rather than wild habitats.

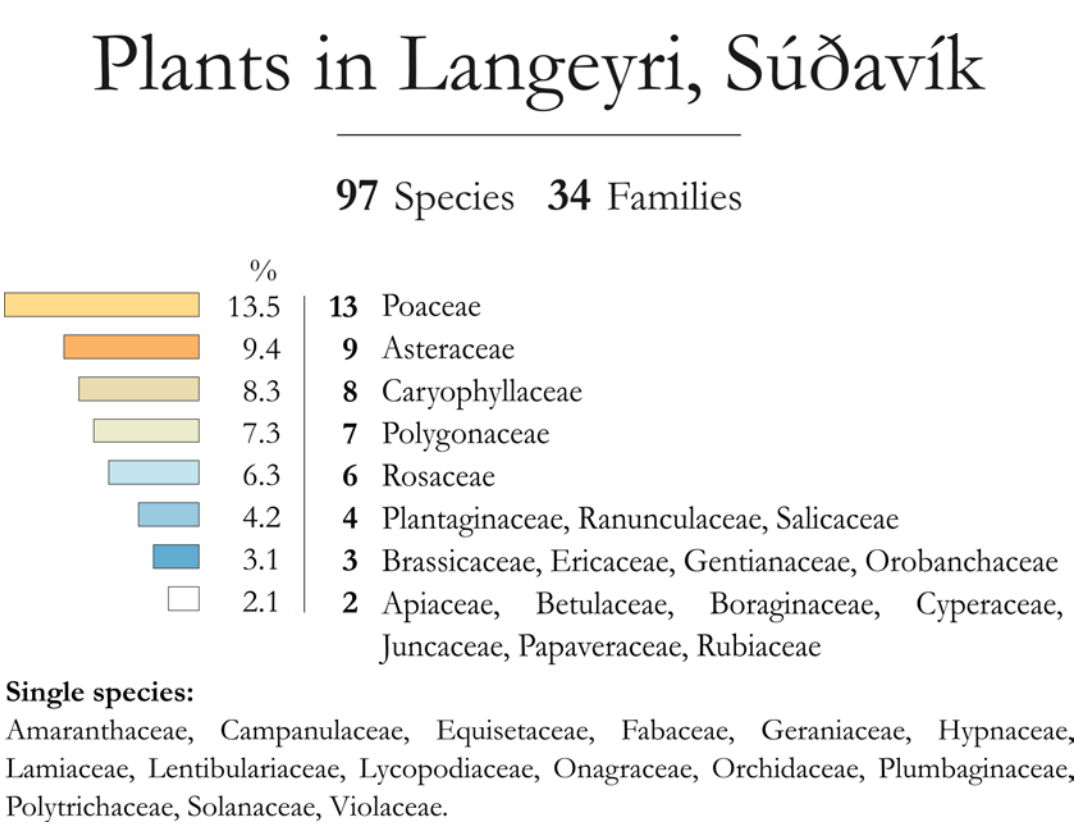

Fig. 4 - Number of species and plant families identified in Langeyri, Súðavík, along with the percentage contribution of each family to the total inventory.

Nookta lupine

Lupine was predominantly located on the north of the peninsula, near the boundary of the bird nesting area (**Fig. 7**, area 1). This patch is especially likely to affect the nesting habitat of Arctic terns, and to a lesser extent, the habitat of Common redshanks *Tringa totanus*. Single plants were also discovered near the road (**Fig. 7**, area 4) and the dirt road (Figure 7, area 3). Area 2 in **Fig. 7** is of particular concern as it is directly adjacent to or within the bird habitat.

Potential threats

In addition to the presence of lupine as a potential environmental hazard, multiple other threats were identified through fieldwork and concurrent studies in the same geographic region. The Act No. 64/1994 on the protection, conservation and hunting of birds and wild mammals allows the collection of Arctic terns' eggs until the 15th of June. In 2023, individuals were observed collecting eggs, thus traversing habitats out of the existing pathways. Although access via the dirt road is officially restricted during the breeding season commencing on the 10th of April, to the 7th of July, individuals who appear to be unaware of these regulations frequently venture onto the peninsula. Moreover, annual observations in early September indicate that berry collection activities are common, suggesting another potential source of human impact on the local flora.

4. Discussion

The discovery of 97 plant species within a relatively small natural area of 110,400 m² on the Langeyri peninsula, in Súðavík, highlights the biodiversity present in this subarctic coastal environment. The average of 8.8 species per hectare is notable, especially considering the challenging conditions of the Westfjords, where harsh weather and limited growing seasons pose significant constraints on plant life. This species richness points to the adaptability of the flora and the existence of diverse ecological niches that support a variety of plant communities. While no national benchmark exists for vascular plant density in Iceland, long-term monitoring on Surtsey, a recently formed volcanic island offers an imperfect, yet useful, point of comparison. There, species richness per hectare ranged from 4.8 to 10.4 between 1996 and 2015, depending on habitat development and seabird influence (Magnússon *et al.* 2022). The values observed at Langeyri thus fall within this documented range, suggesting that the site's floristic diversity is consistent with natural patterns found in Icelandic coastal ecosystems. This site was also selected for its importance as a seabird nesting area, and long-term studies on Surtsey suggest that seabird colonies can significantly shape plant communities through nutrient enrichment. Although no direct measurements were made at Langeyri, a decline in seabird presence could plausibly alter soil conditions and, consequently, affect vascular plant diversity over time.

List of species

Amaranthaceae (1)
Atriplex prostrata

Apiaceae (2)
Angelica archangelica
Angelica sylvestris

Asteraceae (9)
Achillea millefolium
Erigeron uniflorus
Lepidotheca suaveolens
Pilosella spp.
Scorzoneroides autumnalis
Senecio vulgaris
Taraxacum spp.
Tripleurospermum maritimum
Tussilago farfara

Betulaceae (2)
Betula nana
Betula pubescens

Boraginaceae (2)
Mertensia maritima
Myosotis spp.

Brassicaceae (3)
Cakile maritima
Capsella bursa-pastoris
Cardamine pratensis

Campanulaceae (1)
Campanula glomerata

Caryophyllaceae (8)
Cerastium fontanum
Honckenya peploides
Sagina nodosa
Silene acaulis
Silene dioica
Silene latifolia
Stellaria graminea
Viscaria alpina

Cyperaceae (2)
Carex nigra
Eriophorum angustifolium

Equisetaceae (1)
Equisetum arvense

Ericaceae (3)
Calluna vulgaris
Empetrum nigrum
Vaccinium uliginosum

Fabaceae (1)
Lupinus nootkatensis

Gentianaceae (3)
Gentiana nivalis
Gentianella amarella
Gentianella campestris

Geraniaceae (1)
Geranium pratense

Hypnaceae (1)
Hypnum cupressiforme

Juncaceae (2)
Luzula multiflora
Luzula spicata

Lamiaceae (1)
Thymus praecox

Lentibulariaceae (1)
Pinguicula vulgaris

Lycopodiaceae (1)
Selaginella selaginoides

Onagraceae (1)
Chamerion angustifolium

Orchidaceae (1)
Platanthera hyperborea

Orobanchaceae (3)
Bartsia alpina
Euphrasia sp.
Rhinanthus minor

Papaveraceae (2)
Papaver radicatum
Papaver somniferum

Plantaginaceae (4)
Hippuris vulgaris
Plantago maritima
Veronica chamaedrys
Veronica scutellata

Plumbaginaceae (1)
Armeria maritima

Poaceae (13)
Agrostis capillaris
Agrostis stolonifera
Alchemilla alpina
Avenella flexuosa
Dactylis glomerata
Deschampsia cespitosa
Elymus repens
Festuca rubra
Festuca vivipara
Leymus arenarius
Molinia caerulea
Nardus stricta
Phleum pratense

Polygonaceae (7)
Bistorta vivipara
Oxyria digyna
Polygonum aviculare
Rumex acetosa
Rumex acetosella
Rumex crispus
Rumex obtusifolius

Polytrichaceae (1)
Polytrichum spp.

Ranunculaceae (4)
Ranunculus acris
Ranunculus repens
Ranunculus reptans
Thalictrum alpinum

Rosaceae (6)
Alchemilla alpina
Alchemilla vulgaris
Comarum palustre
Dryas octopetala
Geum rivale
Potentilla anserina

Rubiaceae (2)
Galium saxatile
Galium verum

Salicaceae (4)
Salix glauca
Salix lanata
Salix phylicifolia
Salix viminalis

Solanaceae (1)
Solanum tuberosum

Violaceae (1)
Viola tricolor

Fig. 5 - Birds do not nest directly within the potato patch, but they use the enclosure as a roosting area.

Fig. 6 - A: Photograph of *Papaver somniferum* flower ; **B**: Close-up of the distinctive leaves of *Papaver somniferum*.

Fig. 7 - Areas where Nookta lupine *Lupinus nootkatensis* was found (Basemap: Loftmyndir ehf).

While looking into details, the survey results align with the expected vegetation types for the area, given the elevation and landscape features of the Langeyri peninsula (Arnalds 2015). For example, the western portion, dominated by heathlands, supports species typical of lowland habitats, while the northwestern shrublands are characterised by a dominance of *Betula pubescens*. These variations in habitat types provide critical resources for nesting and foraging bird species, reinforcing the importance of maintaining diverse vegetation for avifauna conservation.

The diversity of plant species observed on the Langeyri peninsula reflects the presence of several distinct plant communities. The heathlands in the western part, dominated by *Betula nana*, *Empetrum nigrum*, *Calluna vulgaris*, and *Vaccinium uliginosum*, are characteristic of acidophilous dwarf shrub communities within the class *Loiseleurio-Vaccinietea*. Shrublands with *Betula pubescens* in the northwestern sector suggest transition zones toward *Betulo-Salicetum* formations. Pioneer species such as *Leymus arenarius*, *Honckenya peploides*, and *Mertensia maritima* near the coastline indicate the presence of halophilic dune communities that can be related to the *Juncetea maritimi* class. The floristic assemblages observed thus correspond to a mosaic of coastal vegetation types structured along gradients of salinity, substrate stability, and seabird activity.

The presence of *Papaver somniferum* on the Langeyri peninsula is notable, as it is typically associated with cultivation rather than wild habitats. Its appearance near commercial buildings suggests a human-mediated introduction, either through garden escape or accidental seeding. While only a single individual was observed, the occurrence of this non-native species raises questions about potential impacts on local plant communities. Although *Papaver somniferum* is unlikely to become invasive, its presence underscores the influence of human activity on the peninsula's flora, highlighting the need for ongoing monitoring of introduced species.

Another significant concern identified in this study is the distribution of *Lupinus nootkatensis* (Nootka lupine), which poses a more substantial threat to the local ecosystem. On the Langeyri peninsula, lupine was found primarily near the northern boundary of the bird nesting area, where it poses a threat to species such as Arctic terns and common redshanks. Its presence near key habitats could degrade the quality of nesting grounds by outcompeting native vegetation that these bird species depend on (Jónsson *et al*. 2006).

The scattered distribution of lupine, with isolated plants found near roads and dirt tracks, suggests that human activities may contribute to its spread. Seed dispersal may be facilitated by vehicles, footwear, or other equipment, highlighting the need for preventive measures to control further expansion. This reinforces the importance of ongoing monitoring to detect early signs of lupine spread, allowing for timely intervention to protect the ecological integrity of the peninsula.

In addition to the threat posed by invasive species, human activities such as egg collection and berry picking present further risks to the local flora. Although regulations restrict access during the breeding season, observations indicate that visitors may still inadvertently damage plant communities by venturing off designated pathways. Such activities not only disturb bird nesting areas but also contribute to the trampling of vegetation, potentially hindering the growth of sensitive species.

Overall, the findings of this inventory highlight

the need for a comprehensive management strategy that addresses both invasive species control and the regulation of human activities on the Langeyri peninsula, particularly in the context of climate change in the region (Bannan *et al.* 2022). Efforts to prevent the spread of Nootka lupine should be prioritised, alongside raising awareness about the ecological importance of the area and promoting responsible behaviour among visitors. By integrating invasive species management with habitat conservation, the ecological balance of this biodiverse peninsula can be preserved, ensuring that it continues to support a rich diversity of plant and bird species.

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