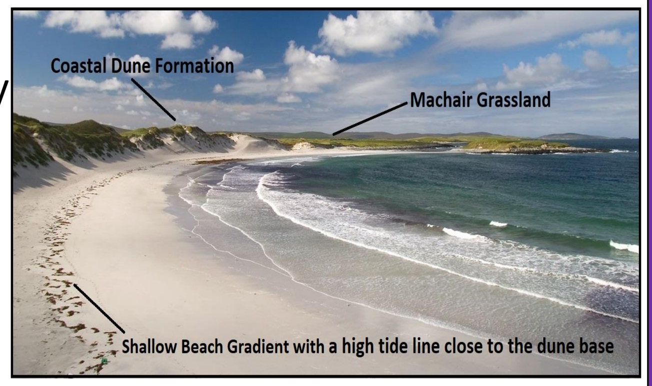
An Investigation into the History and Morphology of the Outer Hebrides Machair Grassland Environment

Jon-Francis Forward, Erin Collins & Thomas O'Brien

Department of Geography, Durham University, Science Laboratories, South Road, Durham, DH1 3LE, UK

Introduction

The Outer Hebrides are one of only two locations globally where machair, a form of calcareous grassland, can be found (Doody, 2012). The Holocene Marine Transgression (HMT) saw a large relative rise in sea level, which, combined with the powerful Atlantic coastal processes, led to the major incursion of sand and glacial outwash in c 7600 BP, creating the low-lying, sediment rich machair landscapes (Ritchie et al., 2001).

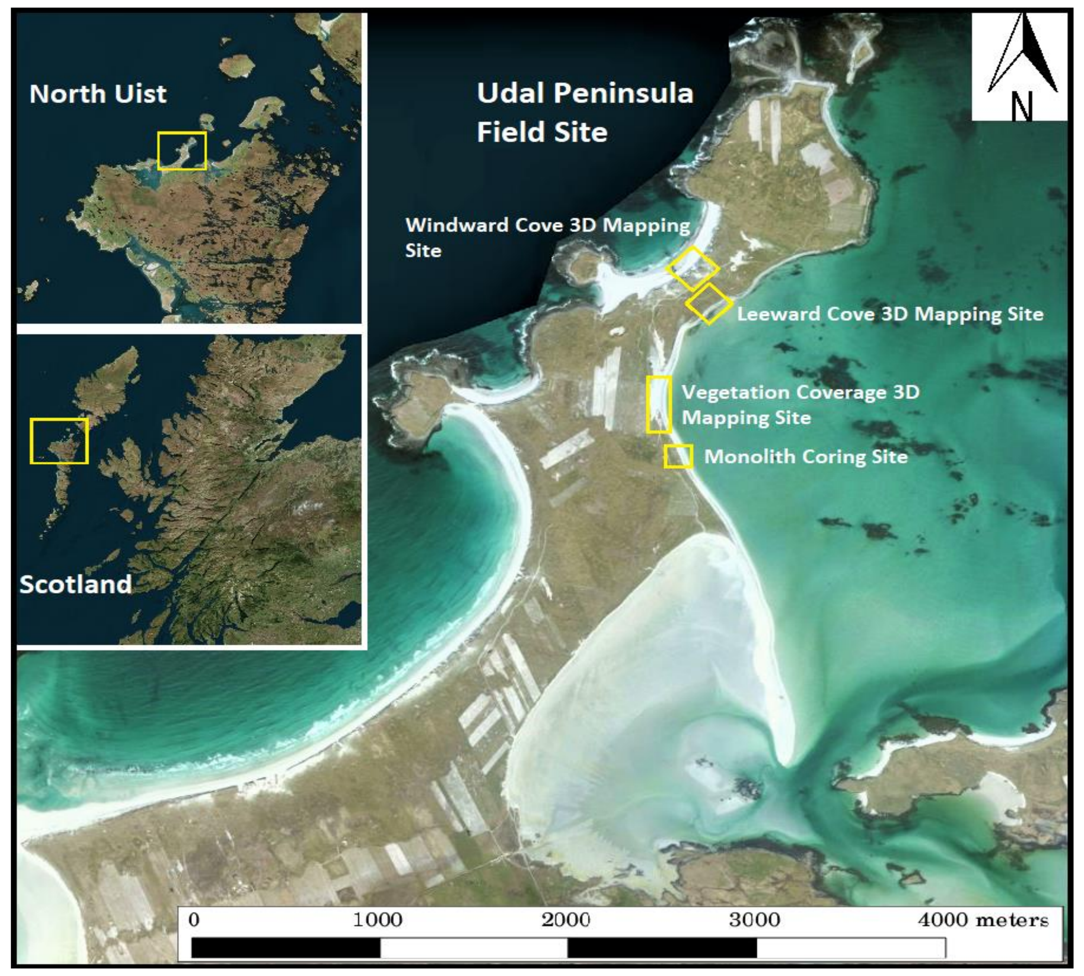


Today, "machair is arguably considered as much a cultural product as a geomorphological one" (Hansom & Angus, 2001, p.68), however the interactions between the physical, meteorological and agricultural processes that shape this ecosystem are complex and largely unknown. This research aims to investigate:

- **Part A.** What are the current land uses and area of machair on the Udal Peninsula and how has this changed over time.
- **Part B.** Do different kinds of land-use affect the type and rate of erosion?
- **Part C.** Does the lithostratigraphy of the Udal peninsula in North Uist record past storm activity in its sediments?

This project aims to build a picture of the ecosystem's resilience upon which future management can be based and the impacts of Climate Change mitigated.

Field Locations



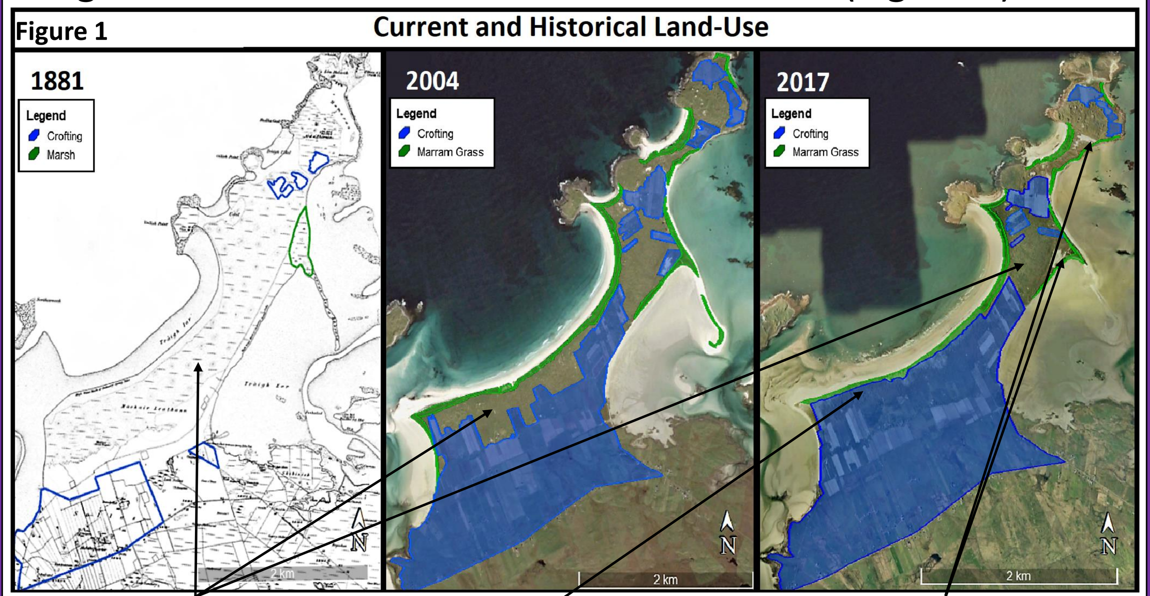
Methods

- **Part A:** Sourced aerial imagery from Google Earth, maps from DigiMap and field photos to analyse current and historical land use.
- **Part B:** Photographed exposed sand profiles topped with different vegetation types using a Phantom 4 drone.
- Created 3D models using the image stitching photogrammetry software DroneDeploy.
- **Part C:** Collected a 105cm monolith sediment profile.
- Analysed changes in organic matter (OM) with depth.

Part A: Current and Historical Land-Use

- Throughout the 20th Century and particularly during the early 2000s, a huge increase in the area of crofting agriculture on the Udal Peninsula is evident (Figure 1).

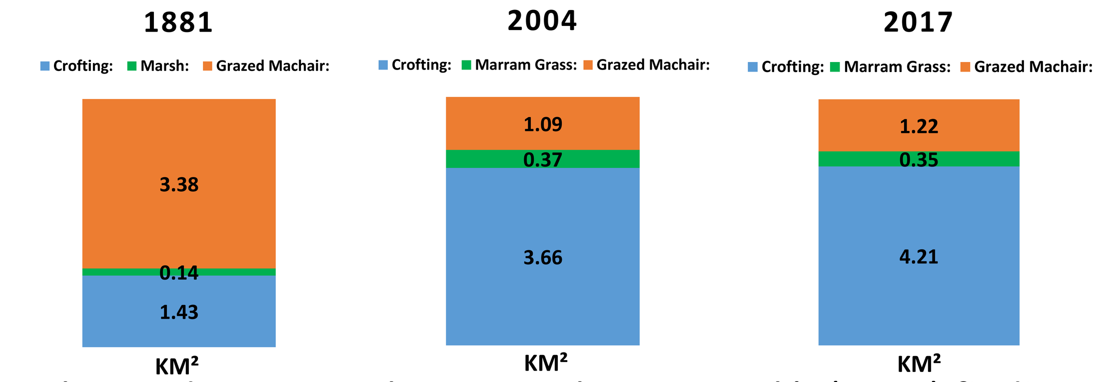
Figure 1 Current and Historical Land-Use



Shrinking areas of machair left for livestock grazing

Expansion of crofting plots right up to the coastline

Crofting plots abandoned due to rate of coastal erosion



- This evidence corroborates Pakeman et al.'s (2011) findings that improvements to agricultural machinery are leading to the expansion of crofting plots.
- This results in livestock grazing on the small remaining areas of machair, which increases erosion (Sloss et al., 2012).

Part B: Effect of Land-use on Erosion

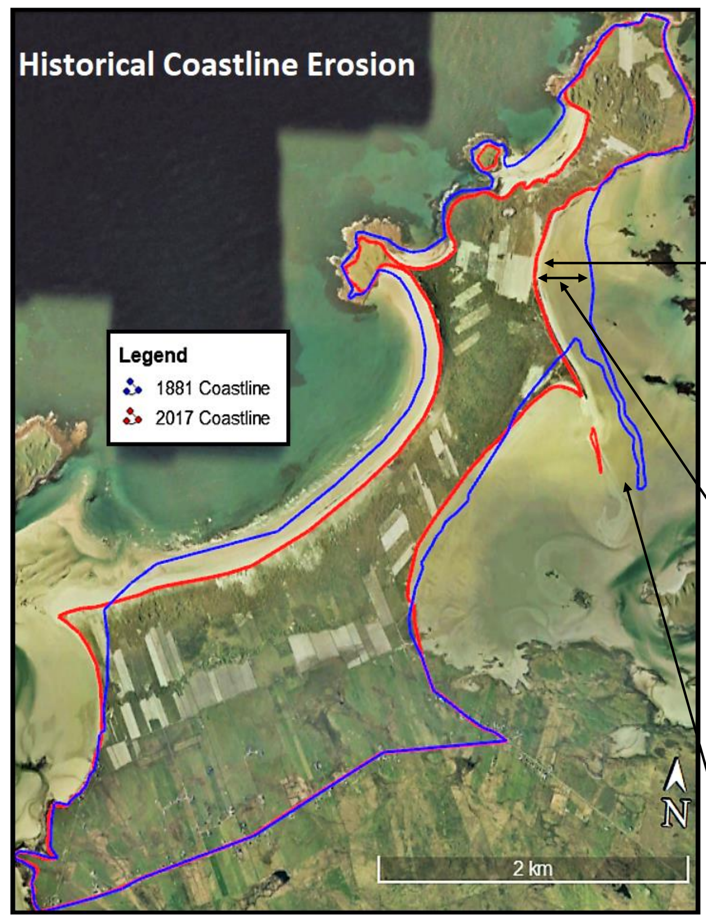


Figure 2

Between 1881 - 2017 the Udal Peninsula has lost 950,000m2

Largest erosion occurred in the absence of marram covered dunes where the fields adjoined the beach (Figure 1)

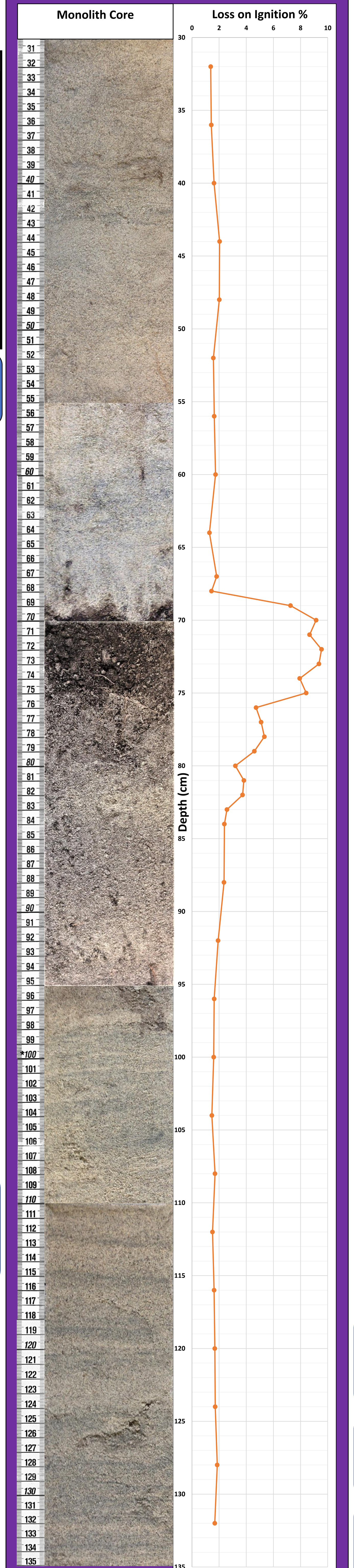
Coastline retreat in some areas of up to 366m

Spit formations, rate and scale of erosion are indicative of Longshore Drift (LSD)

- At the peninsula scale there largely appears to be no correlation between land-use and marine erosional processes.
- However, at the smaller scale there is much more evidence suggesting that land-uses, such as livestock grazing, has a big impact on dune morphology and coastal erosion rates.
- Overgrazing and animal tracks are causing trough blowouts along the Windward Cove, greatly reducing the ability of the foredunes to resist marine and aeolian erosion (Fig. 4)

Udal Monolith

Figure 3



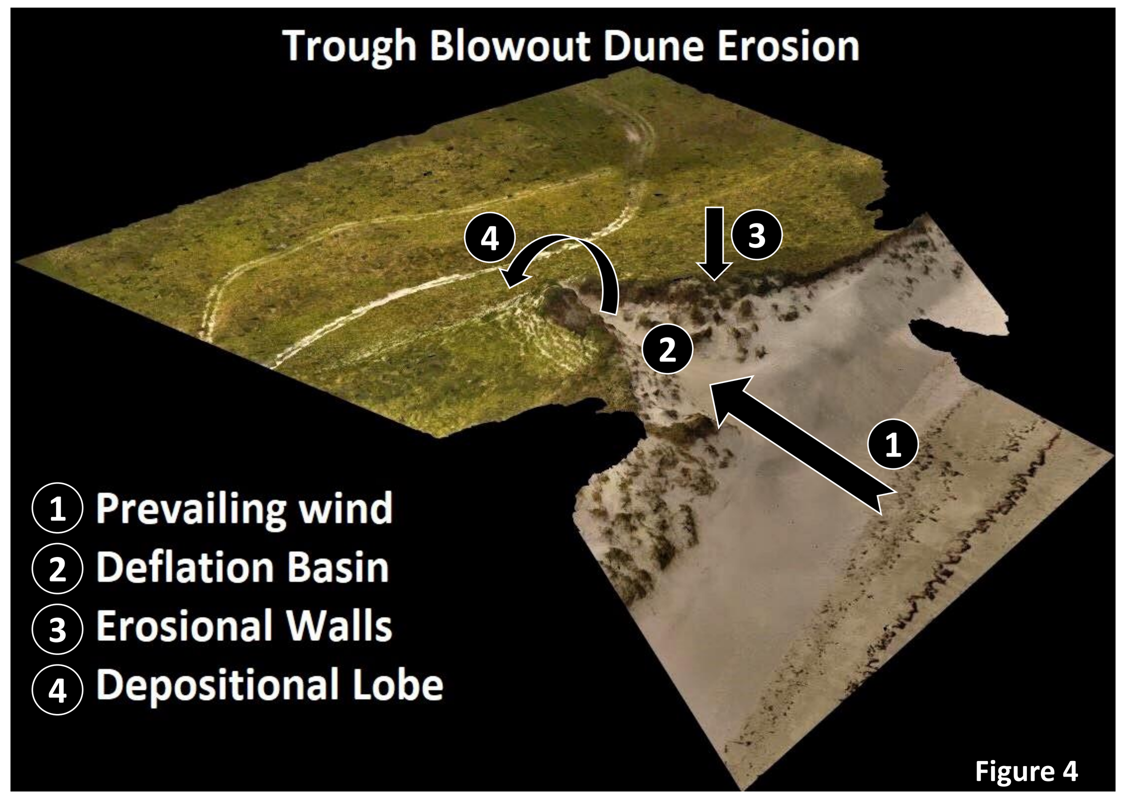


Figure 4

- During high tides and storms, trough blowouts channel sea water and high winds onto the machair fields behind.

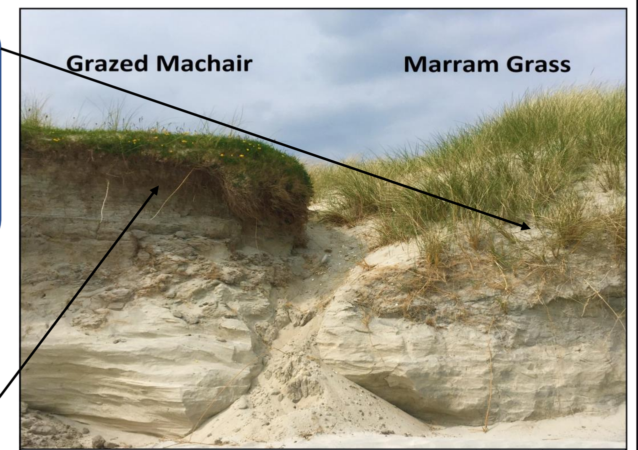
Effects of Vegetation on Erosion:

- Observations of the exposed sand profile on the leeward side suggest that the overlying vegetation greatly effects erosion rates:

While the long roots of marram grass stabilise the sand to great depths, the surface is vulnerable to trampling and erosion.

In contrast, Machair appears to effectively hold the ground surface together due to its short, dense roots.

However, the exposed sediment beneath is prone to undercutting mainly by aeolian abrasion, resulting in slumping.



- Historical evidence of large geomorphological events such as storms can be found in the layers of these exposed sediment profiles.

Part C: Lithostratigraphic evidence of Historical Storms

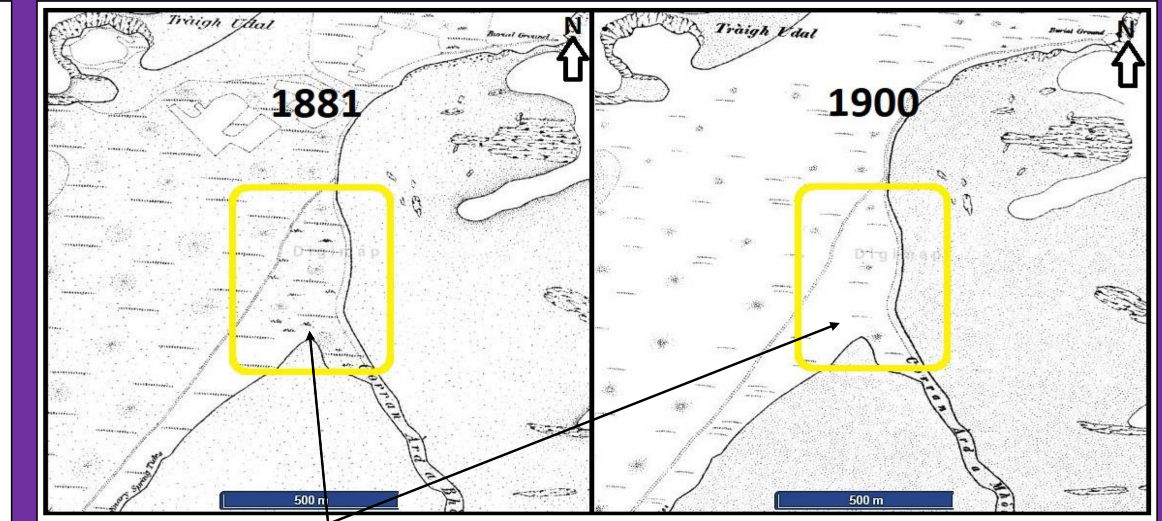
- The monolith core's organic matter content is low and fairly even from 30-68 and 92-132cm.
- Between 68-72cm there is an abrupt 8.1% increase in OM levels, gradually reducing back down to 1.9% at 92cm (Fig. 3).

Monolith Coring Site

The OM spike perfectly matches the dark layer in the monolith, suggesting that this layer was once a vegetated marsh or wetland.

This hypothesis is corroborated by the numerous freshwater snail shells that were found just below the dark layer between 78-85cm.

The abrupt transition between the dark layer and the overlying sand, between 68-69cm, implies a sudden, singular event.



In 1881 there was a marsh where the monolith was taken, however, by 1900 it isn't evident.

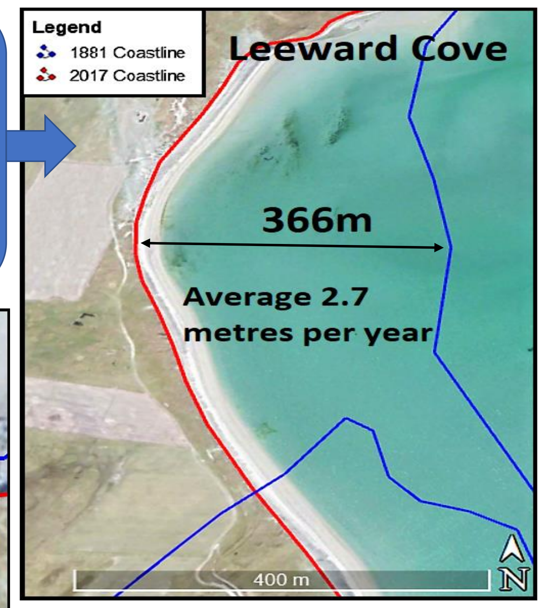
This suggests that a large storm occurred between 1881 and 1900, inundating the marsh with sand

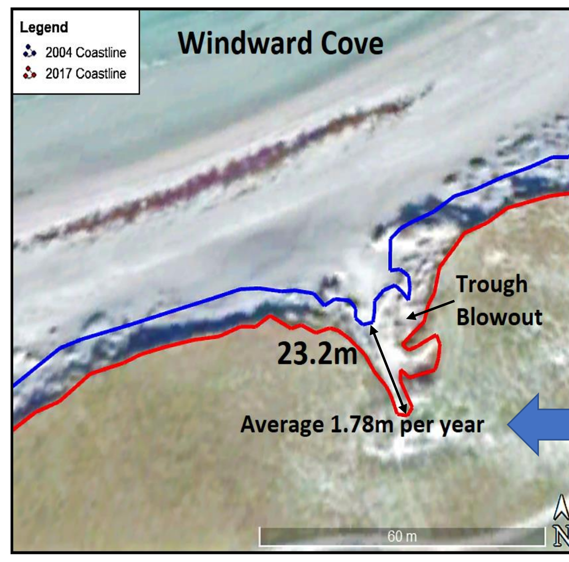
- Historical weather records show that on November 23rd 1881, a massive storm coinciding with a high tide, resulted in "huge waves sweeping over the entire peninsula" (Dawson et al. 2011), causing major flooding.

Summary:

- **A:** There are three main types of land use on the Udal peninsula, crofting, livestock grazing on machair, and marram grass.
- The last century has seen large increases in crofting and a resulting decrease in both marram and machair grassland

B: Coastal processes such as LSD have the largest effect, and are responsible for the majority of the erosion on the Peninsula.





Smaller scale aeolian erosion and sediment transportation also play a significant role and are much more strongly correlated to land use.

- On much of the peninsula dunes are the only barrier preventing inundation during storms.
- Managing land use to protect the marram covered dunes and minimise blowouts is therefore vital.
- **C:** Lithostratigraphic and historical evidence indicate that if large storms breach the dunes they can change the physiography.
- The vulnerability of the Udal Peninsula to geomorphic change makes it imperative that measures are taken to slow erosion rates and preserve dune integrity.

References:

- Dawson, A., Warren, J., and Ritchie, W. (2011). Weather and Coastal Flooding History: The Uists and Benbecula. *South Ford Hydrodynamics Study*, pp.31-33.
- Doody, J. (2012). Sand Dune Conservation, Management and Restoration.
- Hansom, J. and Angus, S. (2001) Natural Heritage of Scotland, Edinburgh, p.68.
- Pakeman, R., Huband, S., Kriel, A. and Lewis, R. (2011). Changes in the Management of Scottish Machair Communities. *Scottish Geographical Journal*, 127(4), pp.267-287.
- Ritchie, W., Whittington, G. and Edwards, K. (2001). Holocene changes in the physiography and vegetation of the Atlantic littoral of the Uists, Outer Hebrides, Scotland. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, 92(02), pp.121-136.
- Sloss, C., Shepherd, M. & Hesp, P. (2012) Coastal Dunes. *Nature Education Knowledge* 3(10):2.