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# Comment on: "Is 're-mobilisation' nature restoration or nature destruction? A commentary", by Delgado-Fernandez et al.

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## Introduction

Delgado-Fernandez et al. (2019) present a thorough commentary of the process of sand dune re-mobilisation and present some interesting ideas on this increasingly popular management strategy. However, we challenge their assertion that sand dune systems in north western Europe tend towards an immobile vegetated state in a natural system. In particular, we demonstrate that natural and highly mobile dune fields have become over-stabilised and immobile directly as a result of contemporary anthropogenic factors and that the failure to both consider a full systems approach to coastal dune environments and to correctly interpret the remobilisation process leads Delgado-Fernandez et al. (2019) to draw incorrect conclusions.

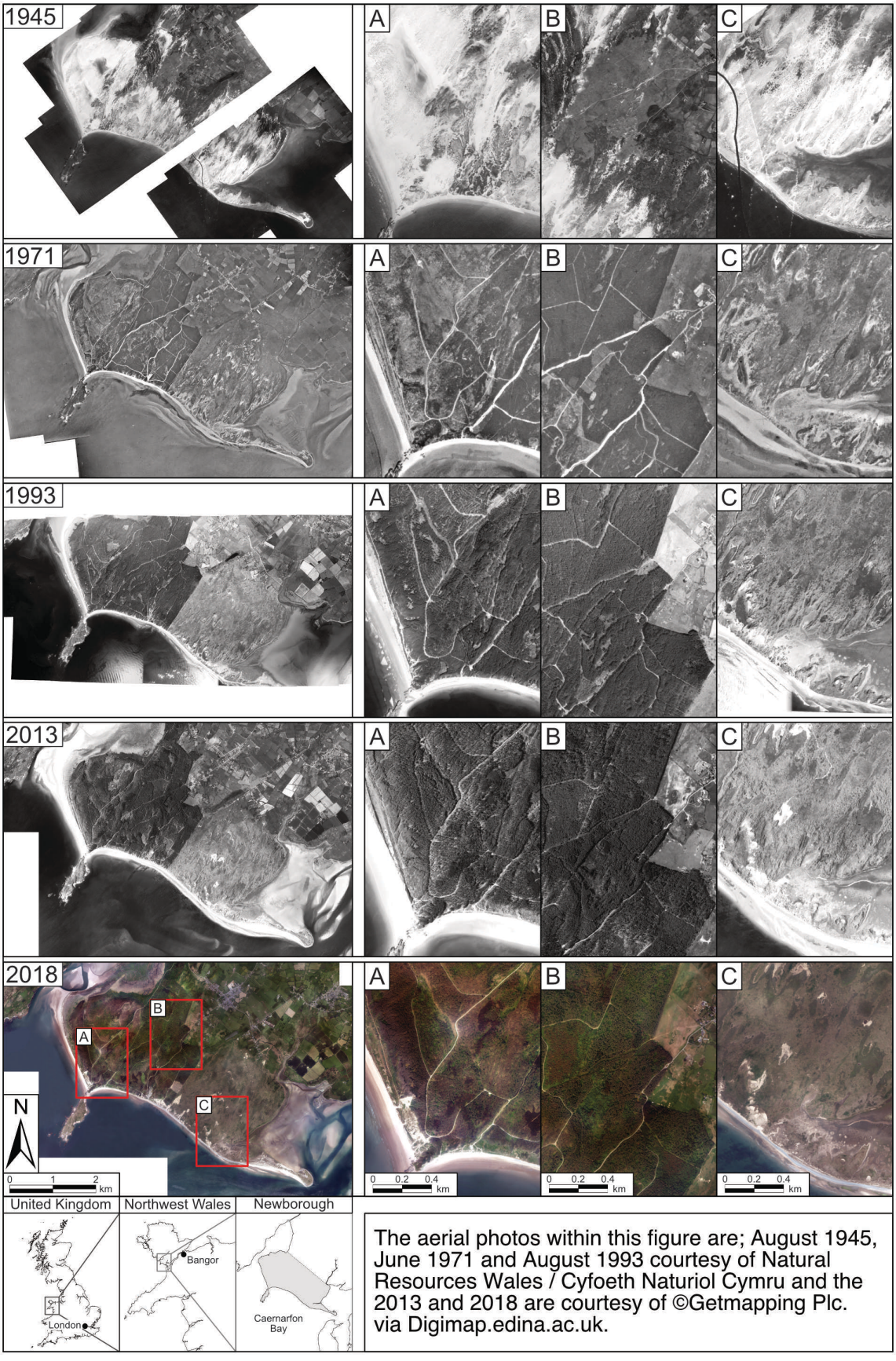
## What is the natural state of the dunes?

A fundamental premise of Delgado-Fernandez et al. (2019; hereafter DF19) is that the natural state of coastal dune systems in north western Europe and in particular the British Isles is one in which dunes are generally immobile, with minimal inland sand transport, because cool temperatures and high precipitation promote the growth of dense vegetation. They assume that a dune field tends towards a succession to higher-species – grasses to shrubs to trees – in other words the 'terrestrialisation' of a component of a marine system and further state that: "…there is little evidence suggesting that the trend towards vegetative colonization over the last few decades is also not natural" (DF19; p.1100), despite the observation that these over-stabilised dune fields exhibit very little of the wide cross-shore gradient of physical processes and resultant distinctive habitats expected of a naturally evolving coastal dune environment (Nordstrom, 2008). Instead, we believe that sufficient evidence exists to argue that the natural state of many of these north western European sites is one of an active dune field system.

Newborough, Anglesey, UK is one such site that has frequently been cited (including by DF19) as an example of a transgressive parabolic dune field that has become naturally immobile over the past 70 years. Greenly (1919; p 773) provides an early description of an unvegetated dune system "One may stand in some of the hollows between the bosses of Bryn Llwyd and see not so much as a blade of bent-grass" and Ranwell (1958) provides evidence that the dunes were highly active in the period 1952–1955 with approximately 75% of the total dune area classified as mobile over a similar period by Rhind et al. (2001); by 1991 the proportion of mobile dune had reduced to 6%. Initially these observations appear to support the premise of natural dune stabilisation by vegetation growth, however, a more detailed investigation of the available evidence indicates that these changes were almost entirely driven by anthropogenic interference during the 20$^{th}$ century.

Newborough can be divided into two zones separated by rock ridge. The north-western section known as Gwningaer fawr was occupied by the Forestry Commission and was planted from the late 1950's through to the 1970's initially with European Marram grass (*Ammophila arenaria*) and subsequently with Corsican pine (*Pinus nigra*); the foreshore was also withy fenced in 1950–51. To

the south-east of the ridge lies Newborough Warren, which was concurrently planted with Marram from the 1950's to 1970's by Nature Conservancy. In addition, grass cuttings from road verges and hedges throughout the Isle of Anglesey and waste cattle fodder and bedding from the port of Holyhead were spread over the forested area to increase the organic matter and bind the soil (J. Ratcliffe, personal communication), and which will have introduced non-native species to the dune field.




The aerial photos within this figure are; August 1945, June 1971 and August 1993 courtesy of Natural Resources Wales / Cyfoeth Naturiol Cymru and the 2013 and 2018 are courtesy of ©Getmapping Plc. via Digimap.edina.ac.uk.

*Figure 1: Aerial photograph montage depicting the evolution of Newborough, Anglesey, UK between 1945 (upper left panel) and 2018 (lower left panel). Three specific regions of interest (A – C) are highlighted in the 2018 image and these are expanded in the series of right-hand panels. The aerial photos within this figure are; August 1945, June 1971 and August 1993 courtesy of Natural Resources Wales / Cyfoeth Naturiol Cymru and the 2013 and 2018 are courtesy of ©Getmapping Plc. Via Digimap.edina.ac.uk.*

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Prior to the artificial stabilisation through planting, the dune system across Newborough remained highly mobile despite some historical anthropogenic interference. Marram grass provided an important resource for the local population and limited planting had occurred along the northern boundary of Newborough to protect the village from wind-blown sand (cf. Ranwell, 1958; Fig.2). There is certainly little evidence to indicate that the mobile state prior to the 1950's arose due to anthropogenic stripping of Marram grass. Instead, the harvesting of Marram in the northern region was through annual sustainable hand cutting in the month of July (Greenly, 1919), which left the roots fully intact.

The evolution of the Newborough dune system from 1945 to 2018 is detailed in Fig. 1. The 1945 image shows the pre-anthropogenically modified (natural) state of the dune system and highlights the vast expanse of bare, mobile sand. Moving forwards through time, the European Marram grass and Corsican pine, initially planted c.1960, were well established by 1971. As the decades progress the forestry thickens (shown by less distinct planting lines and roads) and is extended westwards towards Malltraeth. The area of bare sand rapidly decreases across Newborough as the unforested dunes become vegetated and largely stabilised, that is until the rejuvenation trial, c.2013 (see central bare sand in 2013 'C' image) and then followed by more extensive works between 2013 and 2015 (see further bare sand in 2018 image).

Focusing on the highlight boxes in Fig. 1, in 1945 'A' the northern rocky tip of Ynys Llanddwyn island continues northwards to form the ridge of rock that separates the Gwningaer fawr (Malltraeth) and Y Tywyn (Newborough Warren) sides of the dune system and clearly shows highly dynamic aeolian landforms. Progressing on from 1971, the staged planting and densification of the forestry are clear as is the westerly facing line of withy fencing enhanced fore dunes. The 1945 'B' image shows an earlier stage of sand dune stabilisation immediately adjacent to the Newborough village southern boundary and this region, known as pant y bwgan, is the likely initial area of Marram grass cultivation and harvesting referred to by Ranwell (1958, fig. 2). This historic region of marram grass cultivation is subsequently replanted in stages with Corsican Pine, an extension of agricultural use (up to 1993), a portion of forestry harvested (seen as immature trees in 2013) and on to a dense present-day forest. The 1945 'C' image illustrates that the dune dynamism was not restricted to the Malltraeth side and landforms consistent with active aeolian processes are seen throughout the Newborough Warren (un-forested) eastern side and continue along the coastline to Aber Menai point. Two large tidal breaches are visible in the 1945 'C' image at the proximal end of the Aber Menai spit (the westerly and easterly are c.300 m and c.150 m long, respectively), highlighting the dynamism of this region and that post-anthropogenic interference the dunes progressively accrete, infill and become stabilised, as shown in the successive era 'C' photos. Overall, the suite of aerial photographs provides significant evidence that it is contemporary anthropogenic interference that has led to the vegetative over-stabilisation of the Newborough dune system, and similar occurrences can be identified at numerous other north west European sites (e.g., Bloemendaal, the Netherlands; Aquitaine Coast, France).

## Dune fields as part of the coastal geomorphic system

Contrary to the argument of DF19 that there is "no geomorphological basis" (DF19; p.1098) for the sealing and stabilisation of dunes making dune systems more vulnerable, we would argue that artificially locking-up large volumes of sand in primary dune ridges reduces the natural ability of the system to respond to and to buffer further changes through morphodynamic feedback; the vegetative sealing is effectively increasing the relaxation time of the system far beyond natural timescales. Abiotic factors such as storminess and the available sediment supply are recognised by DF19 as fundamental factors in controlling dune evolution, however, we believe that their failure to fully consider coastal dune environments within the context of the wider coastal system also leads to incorrect conclusions.

DF19 describe the interaction of the beach and foredune system as acting (generally over the short-term) purely to mobilise and transport sand inland. Following Nickling and Davidson-Arnott (1990), storm waves are considered to erode sand from the foredune or toe of the primary dune leading to scarping and the transfer of the eroded sand to the beachface; subsequent landward-directed aeolian transport rebuilds a high foredune ridge. This fails to recognise that under storm conditions energetic run-up will erode sand from the dune face and transport this material seawards towards the surf zone (e.g., Sallenger, 2000). In the inner surf zone, strong undertow during storm conditions results in net seawards-directed sediment transport (e.g., Aagaard et al., 2004) and sandbar development and, given even a small oblique angle of wave approach, alongshore sediment transport gradients. The net result of these factors is that sediments eroded from the dunes are not deposited directly back onto the beach, widening the beachface and facilitating enhanced onshore-directed aeolian transport. Instead, we argue that the sub-, inter- and supra-tidal beach, including foredune ridges, act as a dynamic large-scale sediment system functioning over much longer (decadal) timescales.

We believe that the natural state of north west European coastal dune systems is therefore one of dynamic dunes as part of the larger coastal system with significant areas of exposed sand and episodic periods of sand dune accumulation (cf. Bristow, 2003). It appears clear from the Newborough case, that a significant proportion of sand eroded from the foredunes is transported alongshore in a south-easterly direction by wave-driven nearshore currents. This has resulted in extensive spit formation with a distal termination at Aber Menai point, where it meets the Menai Strait, with saltmarsh formation to the rear (Figure 1 'C').

## Sustainability of re-mobilisation works

DF19 argue that sand dune rejuvenation can be short-lived and unsustainable, again using Newborough Warren as a case study. They cite Rodgers et al. (2019) who state that after an initial increase in the area of mobile sand following remobilisation works (notching) at Newborough, vegetation quickly re-established. However, the interpretation of Rodgers et al. (2019) is fundamentally flawed by: (1) a complete misunderstanding of how the notching processes was performed; and (2) the use of areal rather than volumetric measures of mobile sand.

The sand and vegetation that was removed to form the notches through the primary dune wall was mechanically spread on top of the adjacent dune crests and landward dune limbs, vegetation first then sand, burying the existing vegetation and providing large areas of sand for deflation (essentially creating artificial deflation basins). Once deflation occurred over the proceeding time (c.1-year), the buried vegetation re-emerged. Rodgers et al. (2019) incorrectly interpret this sequence as the removal of vegetation to bare sand followed by a natural re-establishment of vegetation and hence evidence that rejuvenation works are not self-sustaining in northern latitude dune systems.

Furthermore, Rodgers et al. (2019) only consider areal rather than volumetric metrics of mobile sand. We believe that the volume of mobile sand has significantly increased following the notching works, since the vertical accretion (and thus volumetric metric) of sand associated with the notches is immense, but un-quantifiable using the Rodgers et al. (2019) photographic data.

## Conclusion

It is our interpretation that extensive stabilisation works, particularly those carried out in north west Europe during the 20th century, have unbalanced natural coastal dune systems, and that re-mobilisation seeks simply to restore this equilibrium. Natural coastal dune systems are part of the larger coastal marine system and cannot be considered in isolation; sediments are exchanged between the entire system from the sub- to the supra-tidal by a wide gradient of cross-shore (and perhaps alongshore) processes. The over stabilisation and unbalancing of the natural system, whilst perhaps aiming to prevent coastal erosion and the inundation of properties, have resulted in dune systems becoming an entity that is inflexible and incapable of naturally adjusting to contemporary rises in sea level and increasing storminess.

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