Alderney Wildlife Trust

Alderney Dune Extent Analysis

VERSION: 1

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Contents

Summary

- Sand dunes are important ecosystems ecologically, economically and socially
- This work aims to assess changes in the extent of the sand dune ecosystem on Alderney, the Channel Islands over the last ~25 years
- Supervised image classification of aerial photographs of the island dating between 1996 and 2022 were used to quantify changes in the position of the dune edge over time
- Whilst there were spatial and temporal variations in dune extent, linear modelling shows that most of the coastal dunes on Alderney have remained stable
- The furthest west section of Platte Saline is the only part of Alderney's dune system which is actively growing
- There has been a loss in dune extent on part of the dunes, specifically the eastern half of Longis, and a section of Platte Saline in the central eastern part of the beach – it may be that these areas should be prioritised for any future work which aims to improve the condition of the sand dunes

Introduction

Alderney has four dune systems with embryo and mobile dunes at Saye, Braye, Longis, and Platte Saline, as well as additional dune grasslands. Currently, little information is available on the condition of these dune habitats. In the UK, there has been a general loss of sand dune ecosystems over time; it is thought that the UK has lost 30% of its dune habitat since 1900 (1). Changes in the extent of the sand dunes on Alderney have not previously been assessed, and so it is unknown whether sand dunes have also been lost on the island. The aim of this report, therefore, is to assess changes in the extent of sand dunes on Alderney using historic aerial imagery, which date from 1996 to 2022. This work should help to understand the current trends in the extent of Alderney's sand dunes, helping to predict future patterns, and aid decision-making on priority areas for any future work to improve the condition of the island's sand dunes.

Understanding the condition of the sand dunes is important, due to the ecological, economic and social benefits that healthy sand dune ecosystems provide. These include, but are not limited to, being important for biodiversity, providing natural flood defences, improving water quality through filtration and aesthetic value, particularly their attractiveness to tourists (1). Sand dunes also play a role in carbon sequestration, sequestering an estimated 0.58 to 0.73 tonnes of carbon/hectare/year (t C/ha/yr) from analysis of sand dunes on the west coast of the UK (2). The role of sand dunes in carbon sequestration has economic, as well as environmental consequences; a study at the UK level concluded that, assuming no further losses of coastal dunes, the value of the carbon dioxide sequestration and storage from dunes in the period 2000-2060 is worth ~£1 billion, with this economic value declining if dunes are lost (3).

Sand dunes are dynamic ecosystems, which naturally vary in extent and characteristics, as they are shaped by naturally varying processes like wind, storms and rainfall (1). This means that fluctuations in the extent of the dune habitats are expected, however, a consistent decline in extent or quality of the dunes would have negative consequences for the island. This may be increasingly pertinent with current and future climate change, as changes such as sea level rise and the increased frequency of storms can increase erosion of the dunes and alter sediment supply (1).

The following assessment of changes in dune extent forms part of a wider project to conduct condition assessments of key habitats on Alderney. This work assesses the extent of dune habitat, and additional field surveys will be carried out to assess the quality of the habitat going forwards.

Methods

Aerial photos taken of Alderney in 1996, 2001, 2004, 2009, 2012, 2019 and 2022 were analysed to assess changes in dune extent over time on the island. Analysis was carried out using ArcGIS Pro version 3.4.0. These aerial images were clipped to the extent of the dunes and classified using supervised classification with random trees. The images were classified as dune vegetation (predominantly marram grass), non-dune vegetation (predominately other grass species e.g. the grassland on Braye common) and sand or rocks. Several iterations of training pixels and classification groups were tested to maximise the accuracy of this classification.

From these classified rasters, lines were drawn to represent the dune edge where the dune vegetation transitions to sand or rocks, marking the seawards edge of the sand dunes. The decision to look at only changes in the seawards edge of the dune, rather than overall area, was based on the lower accuracy of classification of non-dune vegetation often found on the landwards boundary of the dune. A series of transects perpendicular to dunes on each beach were used to extract points at which changes in the position of the dune edge between years could be measured.

With the points created for the position of the edge of the dune at fixed intervals along the beach, changes in dune extent were measured by measuring the distance between the point at the dune edge in 1996, and the dune edge in the target year. This was repeated for all years, and for each of the transect points along each beach. The coordinates of these points and the distances between them were then exported into RStudio using R 4.5.0 for analysis.

Linear models were used to assess the significance of changes in dune extent, with separate models run for each of the four beaches. The longitude of the transect which the dune extent points were taken from was used to divide the points into the groups “furthest east”, “east”, “west” and “furthest west” on each beach; this was done to split the beach spatially into sections, as changes in dune extent may not occur consistently along the length of the beach. To assess changes in dune extent over time, a linear model of change in dune extent (measured for each year against 1996 as a baseline) dependent on the interaction between year and the spatial longitudinal grouping was used. The data was also plotted to allow visualisation of the results.

Results

Supervised image classification was successfully carried out on all available aerial photographs from between 1996 and 2022, for the dune areas at Braye, Longis, Platte Saline and Saye on Alderney. An example of the classification imagery produced is shown in Figure 1 below, as an example from the section of Longis assessed (only the area between the anti-tank walls on Longis was considered, as the wall creates a barrier to natural dune shaping processes elsewhere on the beach). The same imagery and points were also created for all the other beaches.

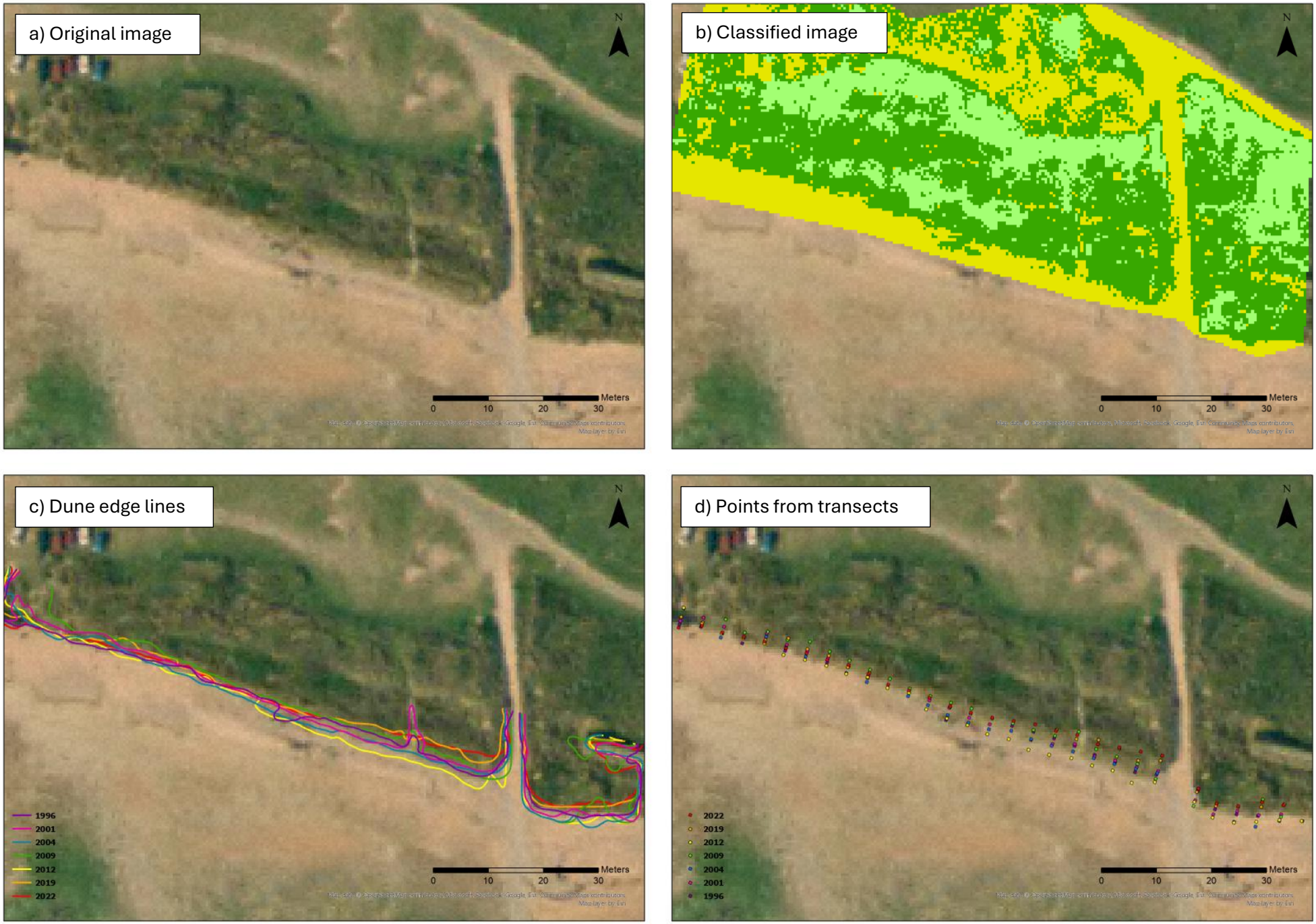

Figure 1 Images from Longis as an example of the classification process, with a) showing the original aerial photo at Longis, b) showing the classified image, c) showing the lines for the seawards edge of the dune for the different years, and d) showing the final points along the transects that were used to measure change in dune extent. The background photo is from 1996.

Classification Accuracy

The overall accuracy of the classification varied between years, with the lowest accuracy being 88% in 2012, and the highest being 96% in 2022 (Figure 2). These accuracy values were from classification run using training polygons from across all four of the beaches, as this yielded more accurate classification results than using training pixels from individual beaches.

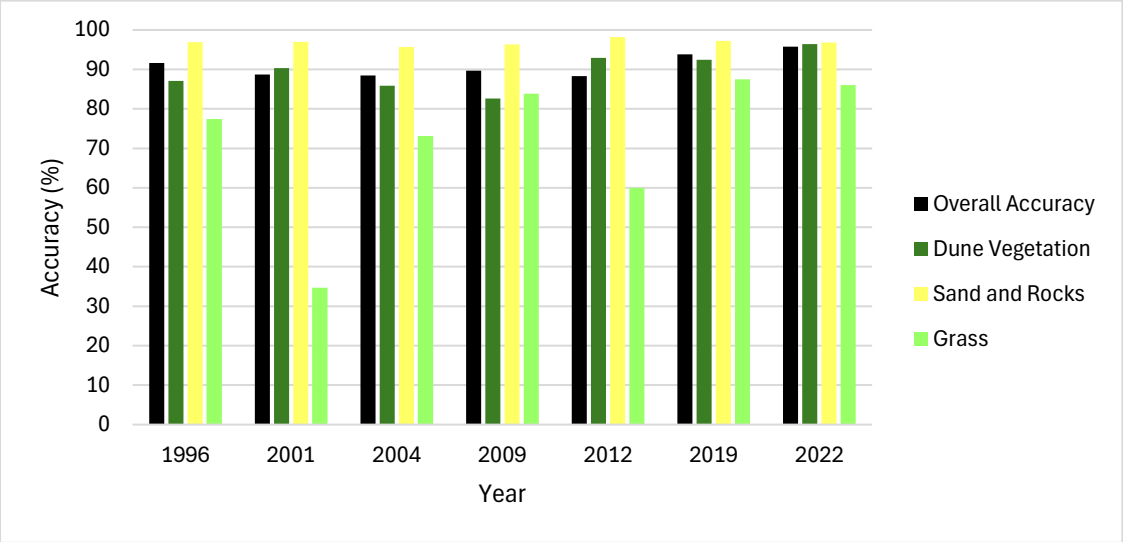

Figure 2 The U-accuracy values from the image classification of aerial photos across all dunes.

The greatest inaccuracies arose due to misclassification of grass and non-dune vegetation as dune vegetation. This was especially problematic in 2001 and 2012; in these years, it seems that the time of year when the photographs were taken was later, resulting in drier non-dune vegetation. For example, on Braye common 2001 (Figure 3), the grass on the common is dry and therefore a similar colour to the marram and dune vegetation. This may explain the low accuracy of the grassland classification in this year (only 35%) compared to other years, as the grassland on the common was misclassified as dune vegetation as the classifier works on RGB values.

Figure 3 The aerial photograph of Braye from 2001. The colour of the grass on Braye common is similar to that of the dune vegetation, due to the time of year when the photograph was taken.

The classification accuracy for the dune vegetation and sand and rocks was much higher and varied less between years (between 83% and 96% for the dune vegetation, and between 96% and 98% for the sand and rocks). It was therefore decided that only the seaward edge of the dune

would be used for assessing change over time in dune extent, as this edge consists of the transition from sand/rocks to dune vegetation, which are both more accurately classified. Changes in the landwards edge of the dune were not assessed, due to the inaccuracy of the classification of grassland vegetation. At the landward edge of the dune, the dune vegetation in most cases transitions into roads (e.g. at Saye) which is a fixed man-made structure anyway, or often into managed grassland (e.g. Braye Common or Saye campsite) and so changes in the position of the dune edge in these may be more influenced by human intervention than natural processes.

Georeferencing error

The aerial photos have been georeferenced, which introduces error as images can become distorted and georeferenced using different points. To quantify this error, points were marked at obvious fixed features on the aerial images (e.g. the corners of the concrete wall, the day mark on the harbour wall etc.), and the distance between these marked points between the points from 1996 and the other years of aerial photographs was measured. At least 15 fixed points were used for each beach. The error differed between beaches and between years, with the greatest error arising from georeferencing at Saye beach in 2001 with an average error of 4.7m, and the smallest average error arising from georeferencing at Longis beach in 2022 with an average error of 1.18m. The average georeferencing errors are shown below in Table 1.

Table 1 The georeferencing error at each beach for each year's aerial photographs. The value for georeferencing is the average distance between fixed points on the 1996 and the target year aerial photos, measured in metres.

Georeferencing error (m)	**Year**					
Beach	**2001**	**2004**	**2009**	**2012**	**2019**	**2022**
Platte Saline	2.39	2.72	3.24	2.98	3.51	3.14
Braye	1.96	1.82	1.90	1.73	1.57	1.89
Saye	4.70	3.75	3.03	3.19	2.98	3.09
Longis	2.02	1.40	1.70	1.45	1.30	1.18

Attempts to correct the georeferencing were made, but changes made only applied to the small spatial area where the georeferencing points were. This, in combination with the lack of fixed features within the dune, meant that attempts to improve the georeferencing of the dunes were unsuccessful. The errors with the georeferencing were inconsistent across the beaches and between beaches, and varied not only in extent but also direction, and so no attempts were made to correct the GPS of the dune extent points. Instead, the quantification of the georeferencing error was purely used as a frame of reference, to see if the measured changes in dune extent exceeded the potential error arising from georeferencing.

Change in dune extent

Violin plots of changes in dune extent (

Figure ***4***) showed that the change in dune extent varied between the multiple measured points on each beach. This can be interesting as, for example, results that indicate that the dunes are stable could be due to either a lack of change consistently across the beach, or alternatively a loss of dune extent in some parts of the beach, and a gain in others causing an overall lack of change at the level of the beach as a whole.

Visual interpretation of the violin plots does suggest that how consistently across the beach the dune changed in extent did vary between years. The violin plots suggest that there may be spatial patterns along each beach as to where the dune extent is changing. For example, the plot for Saye seems as if the points where dune extent has increased are mostly in the eastern sections of the beach. To further visualise whether the same points along the beach are consistently changing, line graphs were produced, linking the same points on the beach over the multiple years (Figure 5). These graphs show that mostly all the points follow the same patterns as each other between years, with some exceptions.

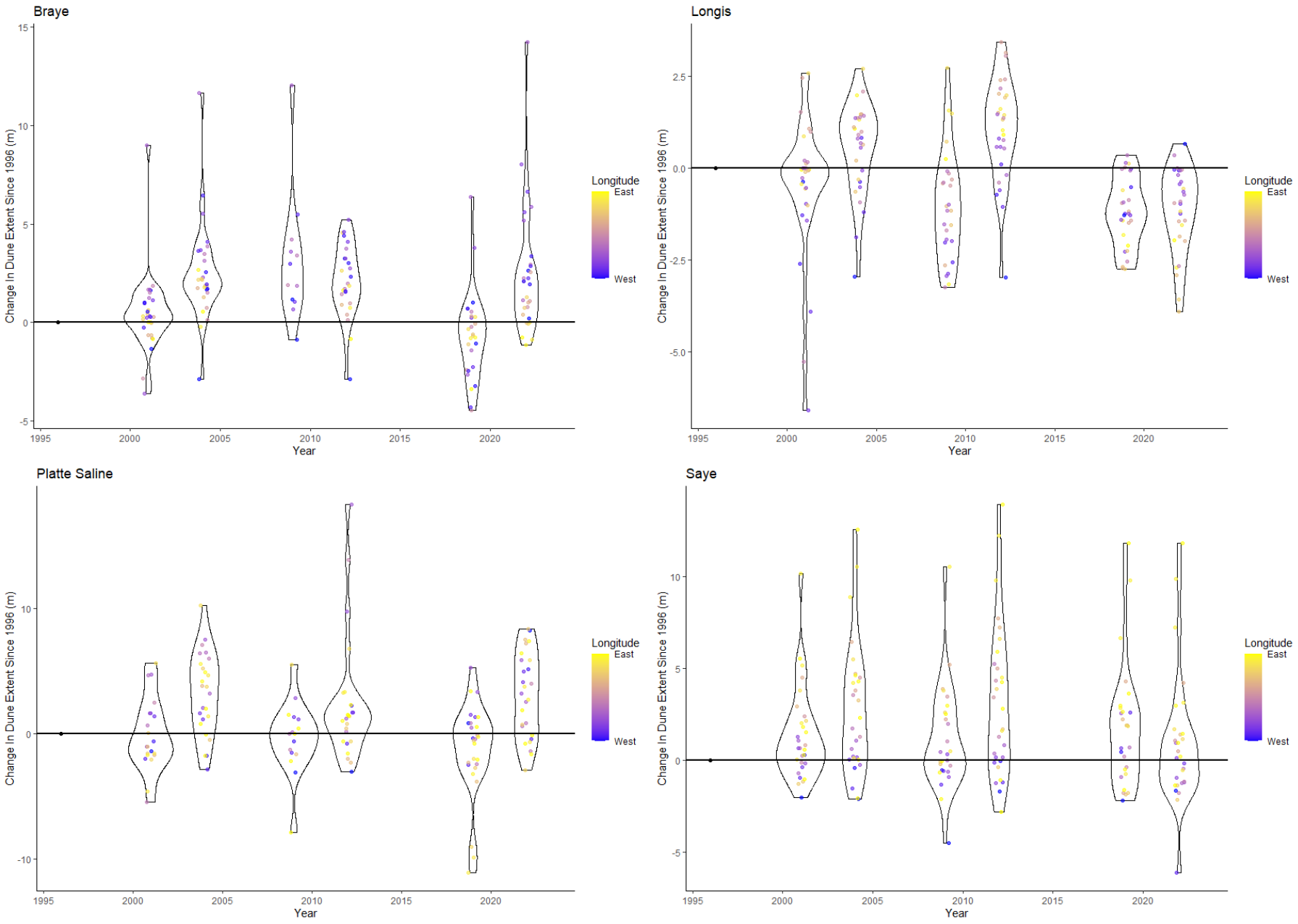

Figure 4 Violin plots of changes in dune extent on a) Braye, b) Longis, c) Platte Saline and d) Saye beaches. A value of zero shows no change in the position of the dune since 1996. Each point represents a different transect on the same beach, and the colour of the point is representative of the position along the beach, with points further east in yellow and further west in blue. Each point is measured as distance from 1996 as the baseline. The violin plots show density, with the widest parts reflecting the change in dune extent at the majority of positions on the beach.

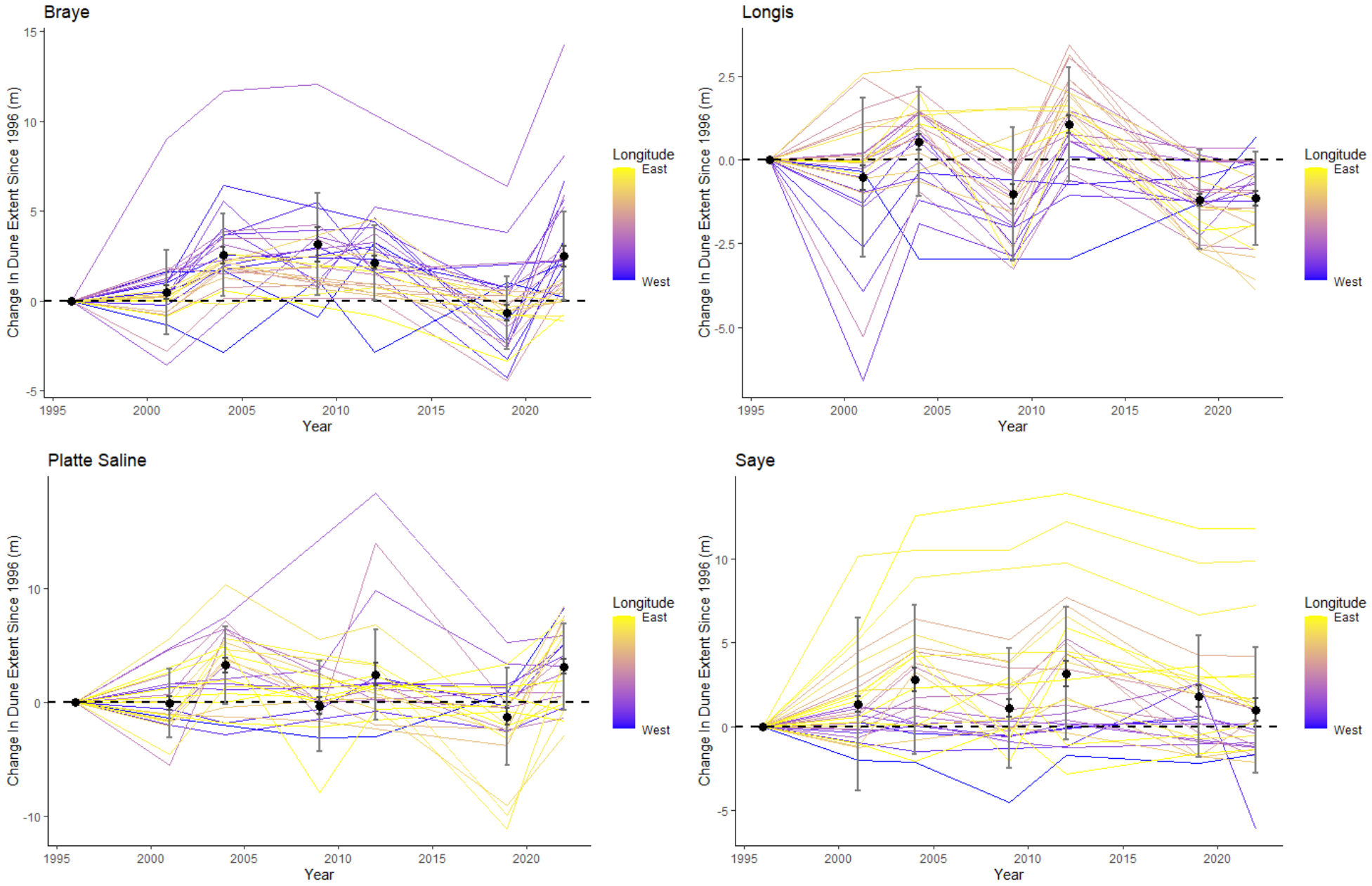

Figure 5 Change in dune extent over time on a) Braye, b) Longis, c) Platte Saline and d) Saye beaches. The colour of the lines is representative of their position on the beach, with more easterly transects in yellow and more westerly in blue. The dotted black line at 0 shows the values for 1996, against which all the changes in dune extent are measured. The solid-coloured lines join the points from the same transects. Error bars show standard error from the different between the different transect points in dark grey, and additional potential error arising from georeferencing in light grey.

Visual outliers on the graph were sense checked by examining the points on the aerial photos, which lead the removal of some transect points e.g. one transect on Saye crossed with the concrete bunker and the classifier inconsistently marked the edge of the dune as one edge of this bunker or the other, and so the changes observed were not representative of genuine change in dune extent. Other apparent outliers instead seem to reflect genuine changes in dune extent, for example on Braye beach, the outlying points on the top line of the graph in represents a point on the beach where in 1996 there was a patch of bare sand which became vegetated in subsequent years (***Figure 6***).

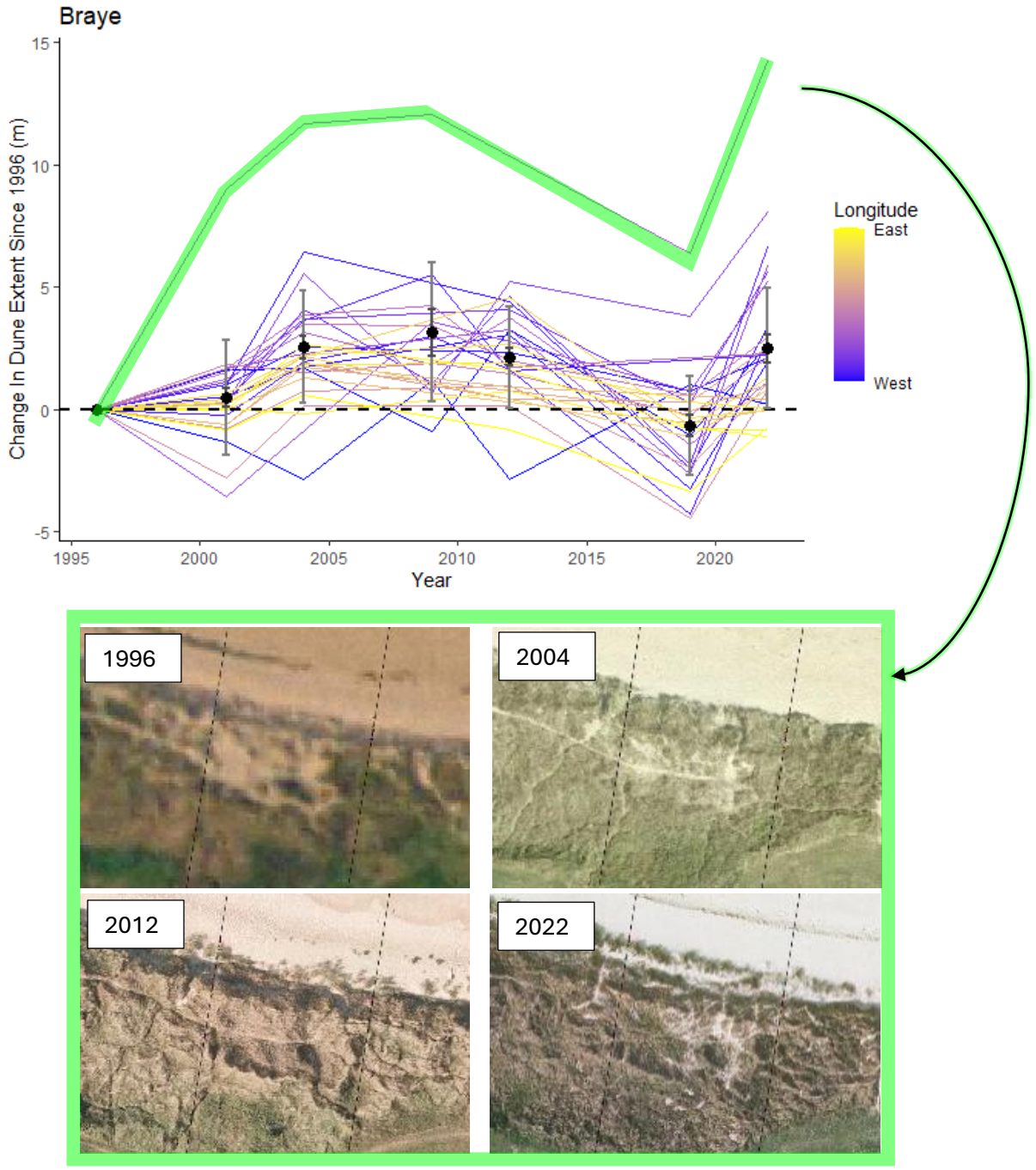

Figure 6 All outlying points were sense checked by examining the aerial photographs. The apparent outlier at Braye beach occurs due to a patch of bare sand becoming vegetated, as shown by the aerial images of this section of the beach from 1996, 2004, 2012 and 2022.

Linear modelling results

The results of the linear modelling showed that for both Braye and Saye beaches, there was no significant effect of neither year nor longitudinal position on dune extent, suggesting that these dune systems have remained stable over time.

For Platte Saline, there was a significant change over time in dune extent, differing between sections of the beach (Figure 7).

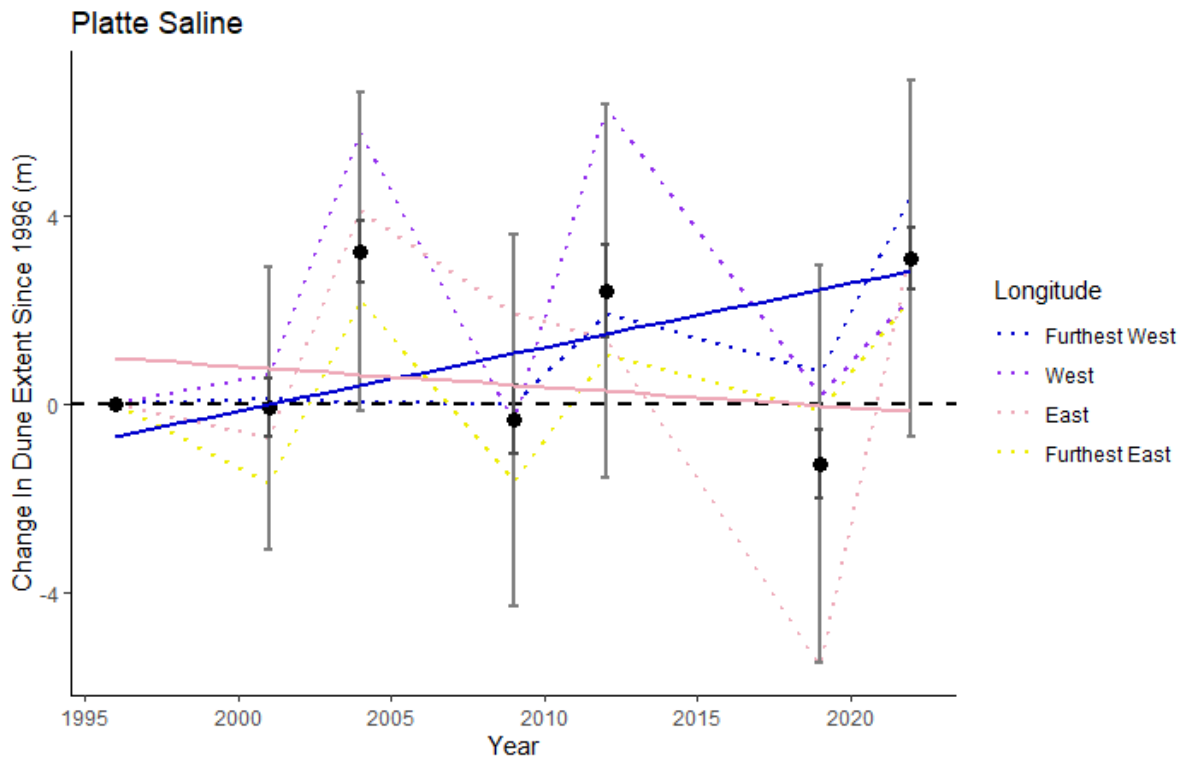

Figure 7 Change in dune extent over time at Platte Saline. Different sections of the beach, divided by longitude, are shown in different colours. The dotted lines join the average value of all the transect points for each year in each beach section. The solid lines show the significant results from the linear model of the effect of year and longitude group on change in dune extent. Error bars show standard error from the different between the different transect points in dark grey, and additional potential error arising from georeferencing in light grey. In the furthest west section of the beach, there has been an increase in dune extent over time, whereas in the central eastern section, there has been a loss of dune exent over time.

There was a significant negative change in dune extent over time in the central eastern section of the dune (p=0.045). The greatest change in the dune extent in this eastern section since 1996 was in the 2019 image, with an average loss of dune extent of 5.56 metres. In this section of the beach, examination of the aerial photographs suggests that the loss of dune extent arises from a loss of density of the dune vegetation (Figure 8).

Figure 8 The same area of Platte Saline (central eastern) in 2004 (left) and 2019 (right)

There was also a significant change over time in the furthest west section of Platte Saline (p = 0.035), with a significant increase in dune extent. The greatest change in the dune extent in this far western section since 1996 was in the 2022 image, with an average increase of dune extent of 4.46 metres. In this section of the beach, examination of aerial photographs again suggests that the change in dune extent arises from a change in the density of the dune vegetation (Figure 9). For the other sections of the beach, there was no significant change in dune extent over time.

Figure 9 The same section of Platte Saline (far west) in 1996 (left) and 2012 (right)

For the Longis dunes, there was a significant negative change in dune extent over time, in both the eastern and far eastern sections of the dune (p=0.007 for the eastern section, and p=0.002 for the furthest east section; Figure 10). The greatest change since 1996 was in the 2022 image, with an average loss of dune in the furthest eastern section of 2.21 metres. Comparison of the aerial images does look like there has been a genuine loss of dunes in this eastern half of the gap between the anti-tank walls on the beach at Longis (Figure 11).

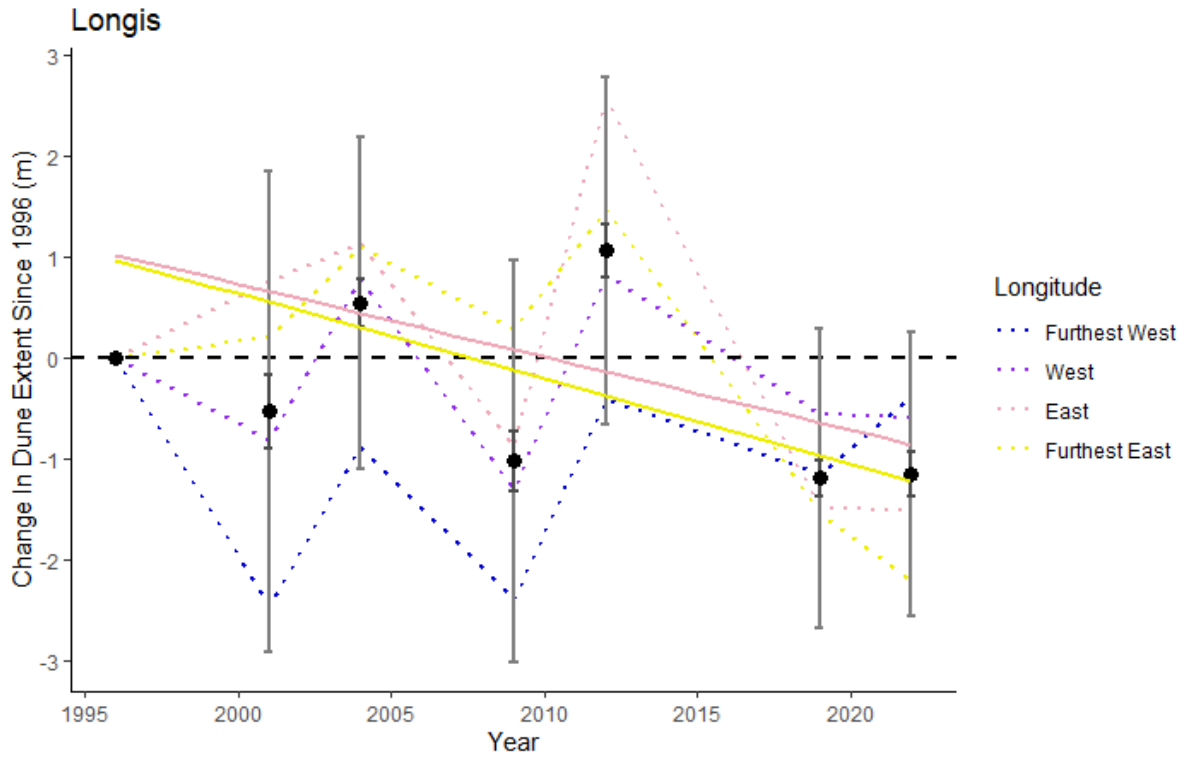

Figure 10 Change in dune extent over time at Longis. Different sections of the beach, divided by longitude, are shown in different colours. The dotted lines join the average value of all the transect points for each year in each beach section. The solid lines show the significant results from the linear model of the effect of year and longitude group on change in dune extent. Error bars show standard error from the different between the different transect points in dark grey, and additional potential error arising from georeferencing in light grey. In both the central eastern and furthest eastern sections of the beach, there has been a loss of dune exent over time

Figure 11 The same area to the east of Longis in 2012 (left) and 2022 (right)

Discussion/conclusions

Overall, the results of the analysis of aerial photography show that for most of the sand dunes in Alderney, particularly on Braye and Saye beaches, the extent of the dunes has remained stable over the last ~25 years. There have been fluctuations in dune extent between years, but in most sections, this has not resulted in an overall change in extent. Where there has been a significant change in dune extent, more sections of the beach have lost dune extent than have gained. There has been a loss of dune extent in the eastern half of the Longis dunes, and the central eastern section of Platte Saline. The far western section of Platte Saline is the only section of dunes in Alderney which have increased in extent. The observed change in dune extent exceed the error associated with georeferencing, suggesting this may be a genuine change. This is corroborated by visual comparison of the aerial photos, which do show changes in dune extent between the images.

These results suggest that sand dunes are generally stable on Alderney, and the variation that can be observed between years may reflect that natural dune shaping processes, such as the blowing of sand, may be occurring. This would be a positive indicator of the condition of the dunes, as overstabilisation can be a major concern for sand dune ecosystems (1). Further work to assess the quality of the sand dunes however is required to fully understand the condition of the dunes on Alderney, for example vegetation composition surveys.

Whilst the dunes on Alderney are mostly stable, there have been losses on parts of Longis and Platte Saline beaches. If future work focusses on improving the condition or area of dunes on the island, these may be good areas to specifically target.

References

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3. *The value of carbon sequestration and storage in coastal habitats.* **N.J. Beaumont, L. Jones, A. Garbutt, J.D. Hansom, M. Toberman,.** s.l. : Estuarine, Coastal and Shelf Science, 2014, Vol. 137, pp. 32-40. doi.org/10.1016/j.ecss.2013.11.022..

Links

Sand-Dunes-Managers-Handbook_WEB.pdf

The value of carbon sequestration and storage in coastal habitats - ScienceDirect

Ch11CoastalMargins.pdf