

MAPPING DIVERSITY IN PEMBROKESHIRE: A BIOLOGICAL APPLICATION OF ARCGIS

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One of the most common teaching days at FSC Pembrokeshire is ecological “succession”. Over the past year we have been using ArcGIS online to map our sample sites and to analyse the trends and patterns that we find in our biotic data. Currently within FSC, the focus has been to incorporate geographical information systems (GIS) in to geography courses as there is a natural specification link. However, GIS is central to many aspects of ecological research, which tend to have a spatial component to the data. This can range from the distribution of sampling sites and habitat types to capturing locations and movements of individual animals (MacLeod, 2013). Just as in geography, allowing our biology students to engage with this technology will help them experience contemporary techniques as used by professional ecologists. This short article discusses two approaches to developing our use of GIS in ecology fieldwork and data analysis as well as highlighting some of the lessons we learnt along the way.

THE FIELD SITE

At Orielton Field Centre we use Broomhill Burrows sand dune system at Freshwater West (SM890004) as our field site to investigate the process of succession (Figure 1). Broomhill Burrows is a SSSI within the Pembrokeshire Coast National Park. As well as being one of Pembrokeshire’s largest dune systems, it also has the most extensive and diverse dune slack vegetation, with a mixture of short dune turf, gorse scrubland and moss-dominated grey dunes (CCW, 1987).



FIGURE 1. Students sampling a fore dune at Broomhill Burrows, Pembrokeshire.

METHODS OF DATA COLLECTION

The data has collected since March 2015, mainly by A Level Biology and Geography students during fieldwork with occasional opportunistic sampling by FSC staff and university groups. As a result, a variety of sampling strategies have been used: from transects of the entire sand dune system to stratified random samples with age of sand dune. All samples were taken using a point frame quadrat, with the latitude and longitude of each quadrat being recorded using the ‘GPS log’ app. The frequency of each species was subsequently recorded in an Excel spreadsheet. Simpson’s diversity index for each quadrat was calculated.

Once data are collated into a spreadsheet with latitude and longitude coordinates, the file is saved as comma-separated value format (.csv). Back in the classroom this file can then be dragged and dropped on to the ArcGIS online

map. The main drawback of this particular method is that GPS data have to be recorded separately, and so requires students to record all 6 decimal places of their latitude and longitude correctly.

An alternative method of collecting data would be to use the 'ArcGIS collector' app which allows you to directly map points offline which are synchronised to ArcGIS online when the device is next connected to the internet. This method is used at Dale Fort Field Centre when sampling the Gann Saltmarsh as a study of succession. We felt that the large variety of species present at Broomhill Burrows, both across the sand dune system and within a small sample area, would make the collector app difficult to use during sampling. However, it is well suited to the smaller number of species present on a saltmarsh. The main benefit of this method is that the latitude and longitude are recorded electronically.

USE OF ARCGIS ONLINE

The first thing that students explore is how the distribution of key species change with distance through the sand dune system. They map this distribution by changing the displayed attribute to a key species such as marram grass (*Ammophila arenaria*). The display can then be changed to proportional symbols or to counts and amounts to show the varying abundance of the species. By adding a copy of the data layer and changing the attribute to show a second key species such as red fescue grass (*Festuca rubra*), students can begin to see at what point on the dune system the community changes from pioneer dominant to true grasses and herbaceous plants (Fig. 2).

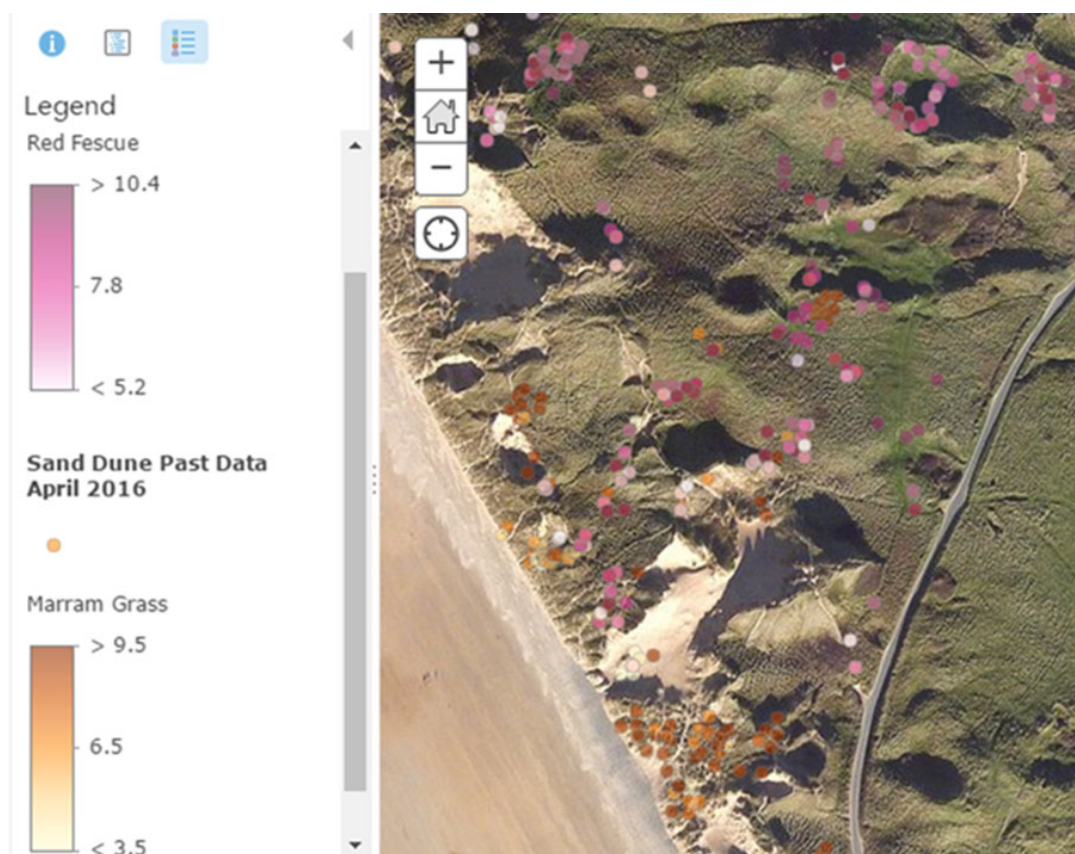


FIGURE 2. Abundance of marram grass (*Ammophila arenaria*,) and red fescue (*Festuca rubra*) at Broomhill Burrows, Pembrokeshire. (Marram grass is shown in orange, red fescue in pink).

A relatively new feature of ArcGIS online is the ability to display multiple attributes on the same point at the same time. This allows for exploration of the relationships between attributes, such as species diversity and the abundance of a particular species, and can answer questions such as: "Does a high abundance of marram grass have an effect on species diversity?"

Once students are familiar with these data presentation techniques we introduce the analysis functions of ArcGIS online. The most useful one in terms of the data we collect is the 'Interpolate Points' function. This feature works by predicting the values in between points, approximating the gaps in the areas where we have not recorded

data. In order to get the best prediction, we apply the interpolation function to a past data layer which is regularly updated. This prompts discussion with students about the value of building up large past data sets to track possible changes to a habitat over time.

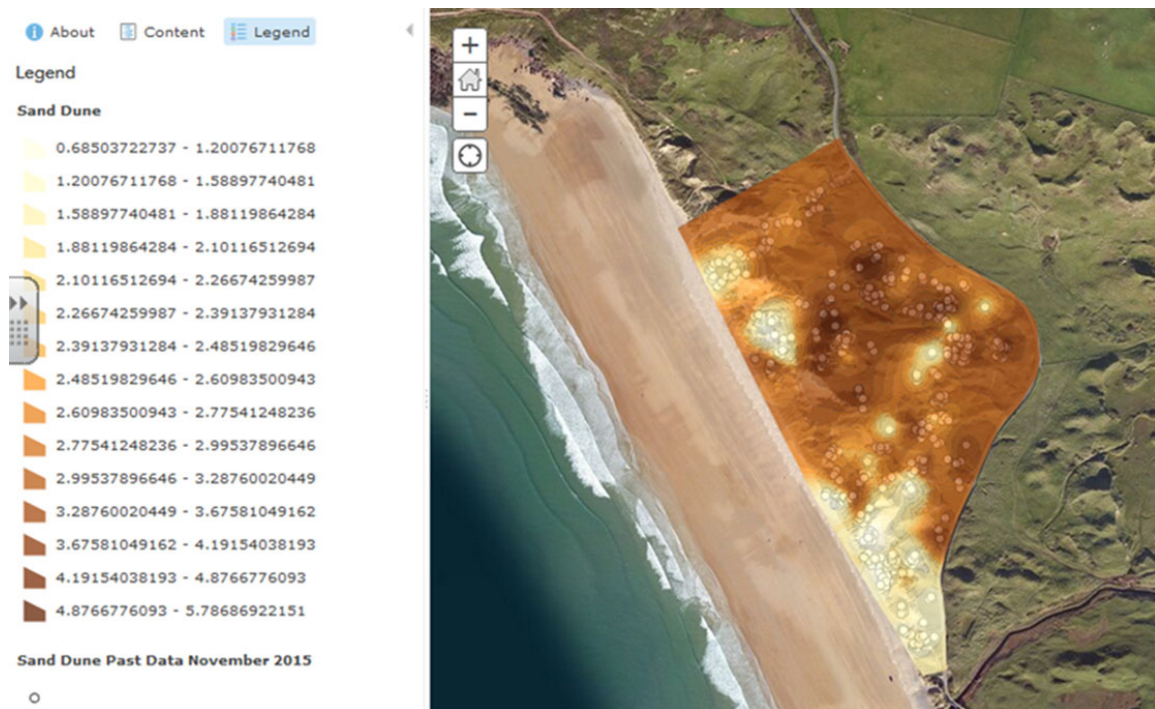


FIGURE 3. Interpolation map of species diversity at Broomhill Burrows, Pembrokeshire. (Pale yellow shows low species diversity, darker orange-brown show high species diversity).

The most common attribute that we interpolate is species diversity, as it relates to the hypothesis that species diversity increases with increasing age of dune. As demonstrated in Figure 3, there is a general pattern of lower species diversity at the front of the sand dunes, with a higher diversity as we move inland.

An image such as Figure 3 is also useful for highlighting patterns which are less obvious to the students during field sampling and from individual data sets. Throughout the system there are patches with higher or lower species diversity than the surrounding areas. These correlate with the tops of sand dunes (low diversity) and dune slacks (high diversity). This allows students to consider how microhabitats created by height of dune, aspect of dune and level of grazing could potentially affect their results and the general pattern of diversity found throughout the dune system. The sand dunes at the front centre of the system show an unexpectedly high diversity. This reflects a general pattern seen across many Welsh sand dune systems of increased stability with far fewer mobile and embryonic dunes, with potential for accelerated levels of ecological succession. Major concerns for Broomhill Burrows include increased stability, net erosion of sediment, optimising water supply and establishing appropriate grazing levels (Wales Biodiversity Partnership, 2011). Again this observation is a prompt for discussion with students into wider ecosystem connections, climate change and management of dynamic habitats.

CHALLENGES AND FUTURE AIMS

As the data set grows we hope to be able to fill both spatial and temporal gaps in sampling sites. Some parts of Broomhill Burrows have a dense cover of bramble and so are not suitable for sampling with most student groups. These areas will need to be sampled by FSC staff when the opportunity arises. At Dale Fort, conservation and access arrangements limit sampling to certain areas of the salt marsh. We hope that over time the data set will allow exploration of the seasonal differences in both sand dune and salt marsh vegetation. As most of our sampling effort is concentrated in the summer months, staff may have to go out during winter and collect samples to ensure that there are data for comparison.

Another challenge faced is the possibility for misidentification of species by student groups. This is especially a problem when plants are not in flower as they are harder to spot, and for grasses where we only identify three or four of the most common species. We hope that by amassing a large data set we will be able to spot major trends and patterns and reduce the impact of individual misidentification events on the data set as a whole.

Our next step is to start mapping disturbance on the sand dunes. This will be undertaken with the 'ArcGIS collector' app. Students will record the presence of fire pits, the location of blow-outs and map the type and extent of paths throughout the dunes. As we continue to collect more data, we hope that we can link these disturbances to local changes in diversity and show students how collecting data can help to inform conservation and management decisions.

As part of FSC's effort to collect 'Big Data' by keeping and collating data from all of our centres, it would be interesting to compare trends and patterns found at Broomhill Burrows to other sand dune systems sampled by other centres, or to other successional habitats such as salt marshes and shingle ridges. Sampling other sand dune systems in Pembrokeshire could also add a new element to data analysis, especially to compare the effects of different conservation threats and management strategies.

In conclusion, by using ArcGIS online as a tool to analyse our data we are helping our students make the connection between the data they collect from four small sites and the wider temporal and spatial trends we see across the whole sand dune system. It has helped to promote discussion about sample site location and engage students as they recognise the importance of collecting data for long-term species monitoring and management of habitats.

REFERENCES

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More information on ArcGIS can be found at: www.arcgis.com

More formation on ArcGIS online for schools can be found at: <http://www.esriuk.com/industries/schools>

