Candidate 2

Title: Abiotic factors and primary succession across a sand dune

Aim: to investigate how abiotic factors (wind speed and infiltration rate) associated with succession zones change across a relatively recently formed sand dune system.

Underlying environmental science:

1. Primary plant succession is the process by which a plant community changes from composed of a few pioneering plants that have colonised bare ground to a stable climax community composed of woodland species.
2. Succession occurs over several stages with different plants modifying the habitat at each stage, making it more suitable for the species that replace them (succession).
3. Only a few plant species are present at the initial stage of succession, but species number increases as succession continues.
4. Sand dune systems are excellent systems for studying plant succession (see figure below).

Sand dune succession

Various zones can be recognised in a set of sand dunes which may represent different stages of succession (Fig 2)

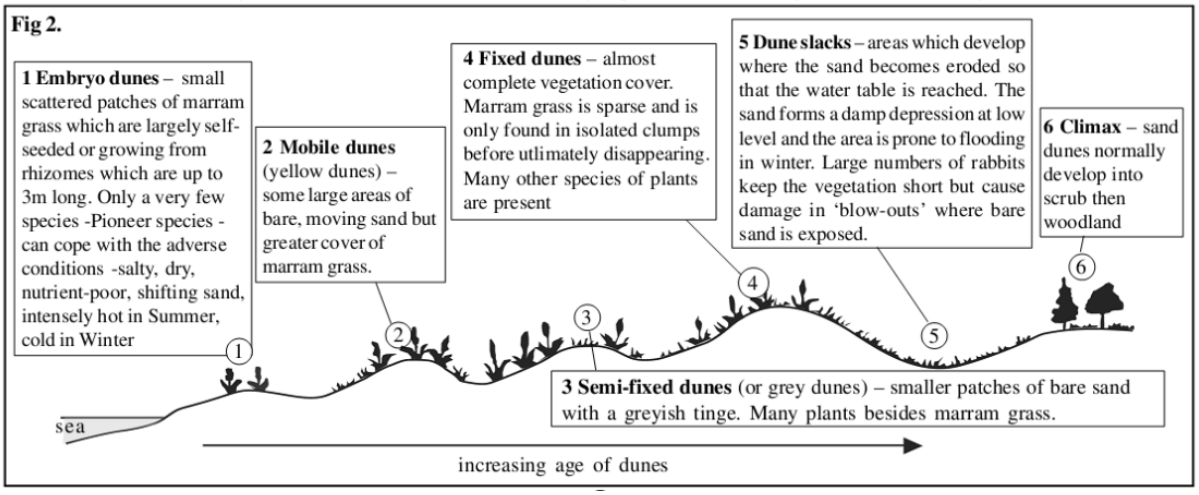


Figure from https://jagssouthwales2013.wordpress.com/about/

5. At the strandline, moving bare sand is colonised by pioneer species, particularly Lyme and Marram grass, which are highly salt and draught tolerant and produce rhizomes which stabilise the sand. This causes embryo dunes to form, which develop into higher yellow dunes, then semi-fixed grey dunes and later fixed dunes.
6. As the strandline advances outwards due to continued sand accretion, plants adapted for growing on the dunes behind come in. These, in turn, modify the habitat e.g. by reducing wind speed and increasing soil organic matter and therefore moisture retention. This creates conditions for other plants to replace them that are better adapted to the new conditions than they are.

7. Further back, behind the foredunes, hollows can form due to sand blow outs and the water table may reach the surface allowing marsh plants to grow in what are called dune slacks.
8. As ground level increases further inland, a dune scrub and heathland forms that will eventually be replaced by the climax woodland community.
9. The sand dune system being studied is the largest area of windblown vegetated sand in Britain (Dargie 2001). Strong easterly winds cause sand deposition at the strandline, resulting in continued growth of the sand dune system eastwards (Crawford 1989). This makes the sand dune system ideal for studying plant succession and the factors involved in the process.
10. My study investigated how soil water infiltration and wind speed changes across a belt transect running from the strandline to the dune heath/woodland zone and how such changes are associated with plant succession.

Fieldwork methods:

Soil water infiltration and wind speed were recorded at points selected using stratified random sampling along a 265m belt transect.

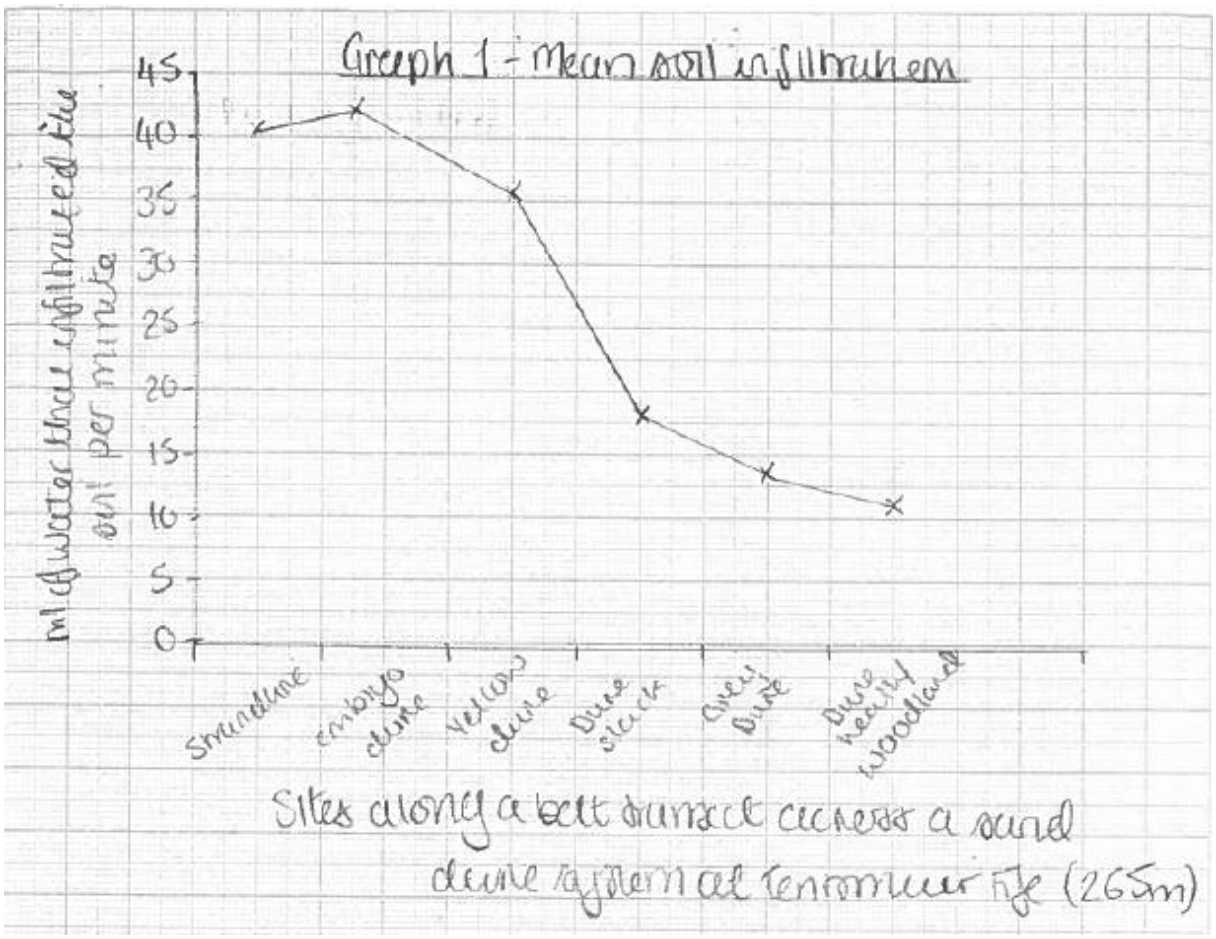
Infiltration was recorded at the sampling points by adding 50ml of water to a 10.5cm diameter graduated tube inserted into the ground and measuring how much water infiltrated into the soil per minute using a stopwatch.

Wind speed was recorded using an anemometer.

Raw data:

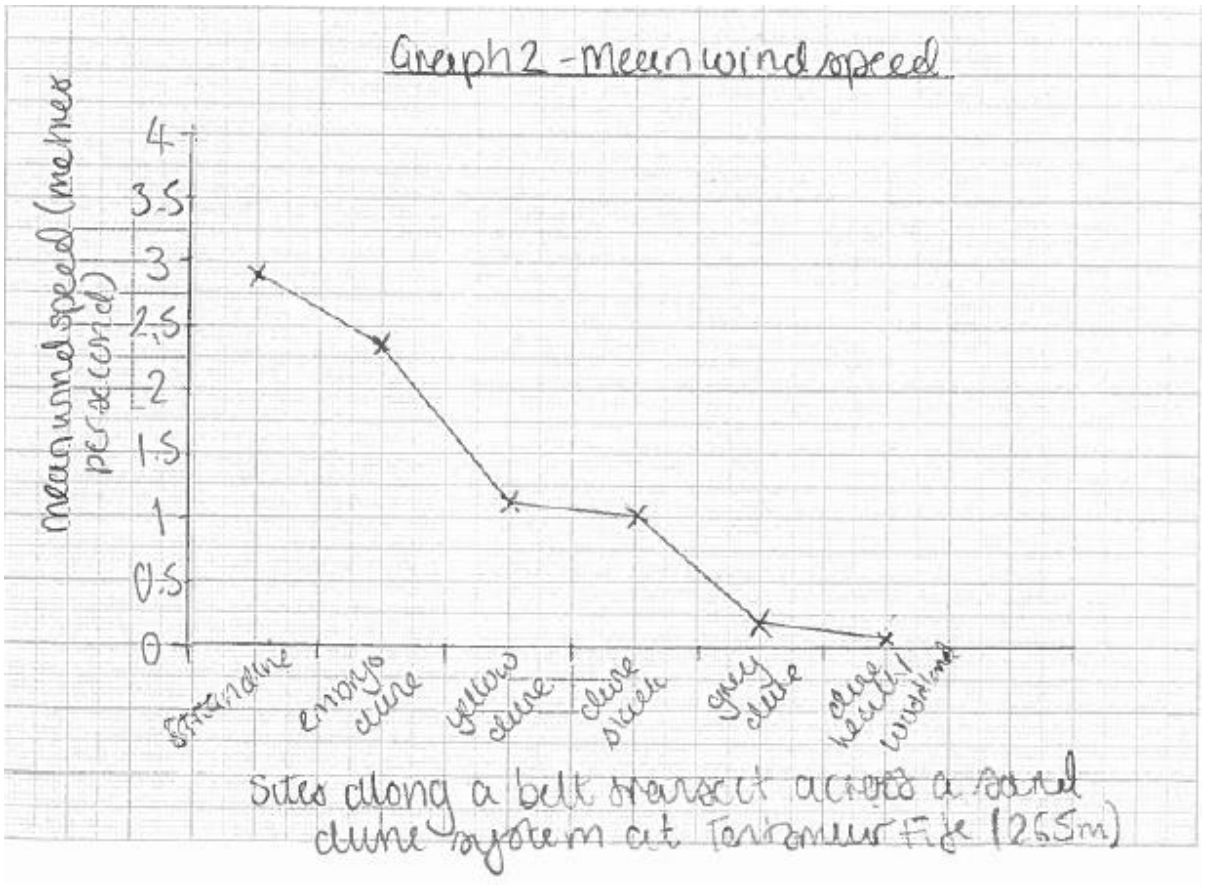
(i) Raw data for infiltration (ml of water that infiltrated soil per minute) collected at sample points along a 265m belt transect across the sand dune system

Sites within succession zones	**1**			**Mean**	**2**			**Mean**	**3**			**Mean**	**Overall mean**
Samples within sites	1	2	3		1	2	3		1	2	3		
Strandline (0 - 21m)	31	28	31	**30**	41	52	42	**45**	46	44	48	**46**	**40.3**
Embryo dune (21 – 44.5m)	45	39	23	**35.7**	48	25	35	**36**	51	59	55	**55**	**42.2**
Yellow dune (44.5 – 88m)	21				50				36				**35.7**
Dune slack (88 – 149m)	50				3.40				1.11				**18.2**
Grey dune (149 – 215m)	8				17				15				**13.3**
Dune heath/ woodland (215 – 265m)	11												**11**



(ii) Raw data for wind speed (metres per second) collected along a belt transect across the sand dune system

Sites within succession zones	**1**			**Mean**	**2**			**Mean**	**3**			**Mean**	**Overall mean**
Samples within sites	1	2	3		1	2	3		1	2	3		
Strandline (0 - 21m)	3.8	3.4	0.9	**2.7**	2.2	2.5	3.0	**2.6**	2.9	3.1	3.2	**3.1**	**2.8**
Embryo dune (21 – 44.5m)	2.6	2.5	2.6	**2.6**	2.5	2.7	2.7	**2.6**	1.2	2.1	1.4	**1.6**	**2.3**
Yellow dune (44.5 – 88m)	1.1	1.5	0.7	**1.1**	0.6	1.2	1.5	**1.1**	1.4	1.7	1.5	**1.5**	**1.2**
Dune slack (88 – 149m)	3.1	2.0	1.2	**2.1**	0.7	0.9	1.1	**0.9**	0	0	0	**0**	**1**
Grey dune (149 – 215m)	0.5	0.3	0.4	**0.4**	0	0.2	0	**0.07**	0	0	0	**0**	**0.157**
Dune heath/ woodland (215 – 265m)	0.2	0	0	**0.07**									**0.07**



Data relevant to the fieldwork investigation obtained from a literature source

Table 1. Comparison of community development in lichens and vascular plants in relation to distance from the strand line.

Sampling station	1	2	3	4	5	6	7	8	9	10	11	12
Distance from the strand line (m)	11	21	31	41	51	61	71	81	91	101	111	131
pH	7.2	7.0	7.0	7.5	7.0	7.0	6.5	7.0	7.0	6.5	6.5	5.0
% Cover	6.0	25.0	57.5	29.5	26.0	26.0	86.5	75.0	33.0	99.0	97.0	96.0
Lichens												
Number of species per station	0	0	2	6	6	8	9	14	8	10	12	11
Cumulative number of species	0	0	2	6	8	10	12	16	17	18	20	24
Mean number of species per quadrat	0	0	1.4	2.0	2.9	3.1	3.3	5.0	1.8	5.5	5.4	3.6
Vascular Plants												
Number of species per station	3	3	8	4	7	6	11	12	10	9	13	14
Cumulative number of species	3	3	8	8	11	11	13	17	19	19	20	26
Mean number of species per quadrat	1.6	1.4	2.3	2.4	3.3	2.5	4.4	4.7	3.3	4.0	4.7	7.0

Reference: Topham P.B. & Hitch H.B. (1985) A study of lichens in relation to dune succession at Tentsmuir Point National Nature Reserve, Fife. *Transactions of the Botanical Society of Edinburgh 44: 347-355.*

Formula for extended statistical calculation

% change in abiotic factors between Strandline and Dune heath/Woodland succession zones =

[(Strandline mean – Dune heath/Woodland mean) ÷ Strandline mean] × 100

1. % decrease in soil infiltration between Strandline and Dune heath/Woodland
   40.3 – 11 = 29.3
   29.3 ÷ 40.3 = 0.727
   0.727 × 100 = 72.7%

2. % decrease in wind speed between Strandline and Dune heath/Woodland
   2.8 – 0.07 = 2.73
   2.73 ÷ 2.8 = 0.975
   0.975 × 100 = 97.5%

Analysis:
Water infiltration and wind speed both decreased markedly moving along the belt transect from the strandline to the dune heath/woodland zone. The decrease in infiltration rate reflects an increase in existing soil moisture content moving inland from the strandline, while the decrease in wind speed reflects an increase in shelter. Conditions for plant growth and survival therefore improve moving inland from the strandline allowing succession to take place.

The data from the literature source suggest that % plant cover and mean number of lichens and vascular plant species per quadrat tend to increase with distance from the strandline. The

literature source further shows that a third abiotic factor, soil pH, also decreases markedly from the strandline moving inland, from alkaline to acidic soil conditions. This will also affect the types of species found across the transect, moving inland from the strandline.

Conclusion:
Fieldwork and a literature source showed that three abiotic factors – soil infiltration, wind speed and soil pH – decrease markedly moving inland from the strandline across the sand dune system at the investigation site. These changes are associated with plant succession in terms of increases in % plant cover and number of plant species per quadrat as shown in the literature source (Topham and Hitch 1985).

Evaluation

1. Because of shortage of time it was not possible to take three replicate samples of soil infiltration at each site within each succession zone. Greater accuracy would have been achieved if more replicate samples of infiltration had been taken in the yellow dune, dune slack, grey dune and dune heath/woodland zones of succession.
2. Records were taken on a single day and are only representative of that day. Values for particular abiotic factors are likely to vary from one day to the next. This would be especially true for wind speed. Ideally, records should be taken on different days throughout the year, to obtain a deeper understanding of how abiotic factors change across the transect.
3. It would have been of value to take three replicate soil samples at each site and determine the soil moisture content and % organic matter.
   % organic matter can be estimated by the on ignition (change in weight when the sample is placed in a muffle furnace to burn off organic matter).
   % moisture content can be determined by drying at 105 degrees Celsius.
   Thus a relationship could be investigated between the infiltration rate and the amount of organic matter and moisture in the soil.

References

1. Sand dune succession figure accessed March 2019 from https://jagssouthwales2013.wordpress.com/about/

2. Dargie, T.C.D. (2000) *Sand Dune Vegetation of Scotland*, Scottish Natural Heritage Commissioned Report No. F97AA401, SNH, Edinburgh. Accessed March 2019

3. Crawford, R.M.M. (1989) *Studies in Plant Survival.* Blackwell Scientific Publications, Oxford. Accessed March 2019.

4. Topham P.B. & Hitch H.B. (1985) A study of lichens in relation to dune succession at Tentsmuir Point National Nature Reserve, Fife. *Transactions of the Botanical Society of Edinburgh 44: 347-355.* Accessed March 2019.