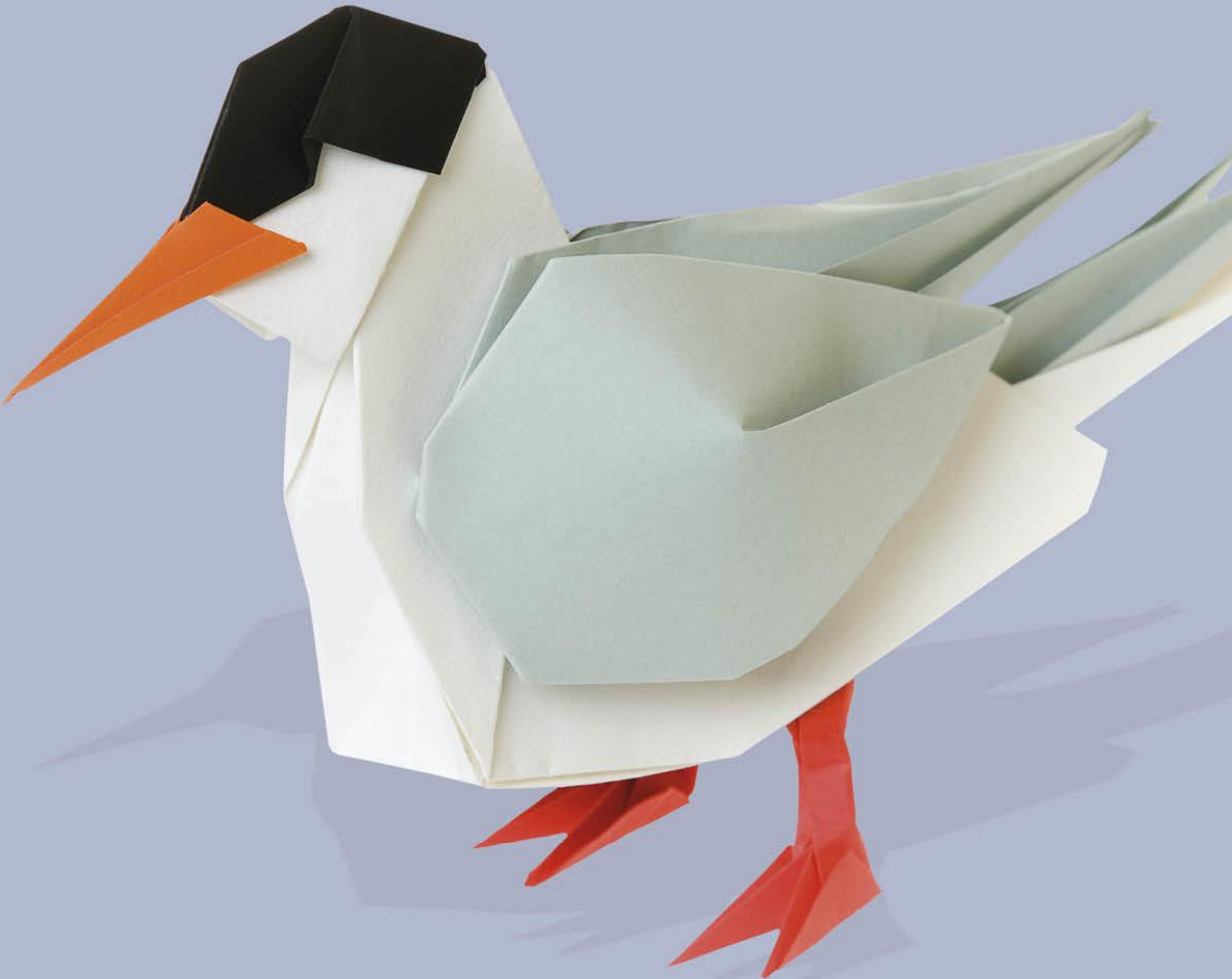
edexcel

NEA Exemplar 3: An investigation into the processes of primary vegetation succession in a coastal sand dune belt - candidate write up



A Level Geography

Pearson Edexcel Level 3 Advanced GCE in Geography (9GE0)

ALWAYS LEARNING

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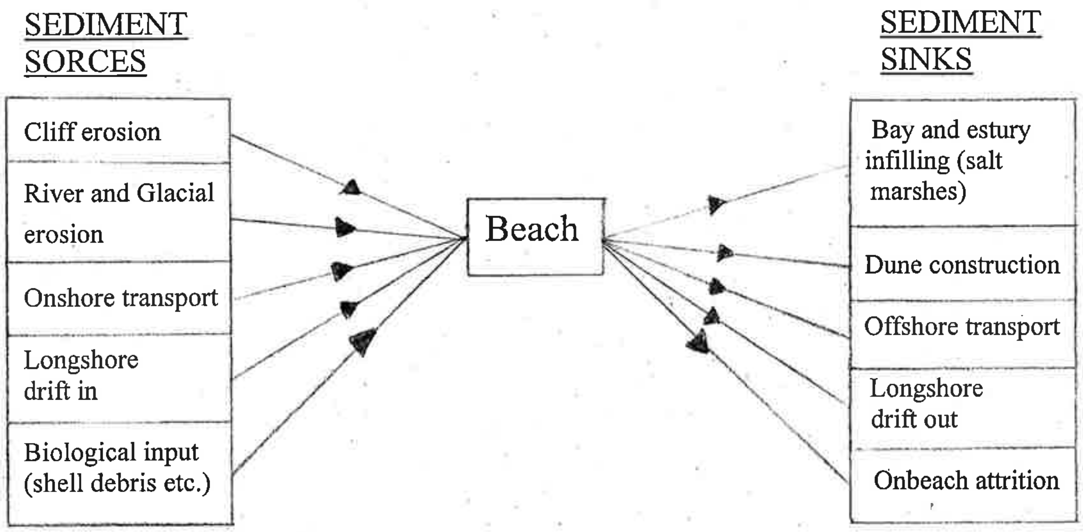
Contents

Chapter 1 - Introduction:

A beach is a temporary store of sediment between the lowest level of the tide and the highest level of storm waves. The sediment on the beach comes from a variety of sediment sources (such as cliff erosion) and passes the beach en-route to sediment sinks, of which sand dunes are one. Sediment can spend long periods of time on the beach, and is therefore often broken up into smaller, more rounded particles before it is transported to a sediment sink, which can in turn be re-eroded and the material moved towards another sink via another beach. However, it is more usual for a sediment sink to be colonized by vegetation, thus preventing any further erosion.

A beach as a sediment store between sources and sinks

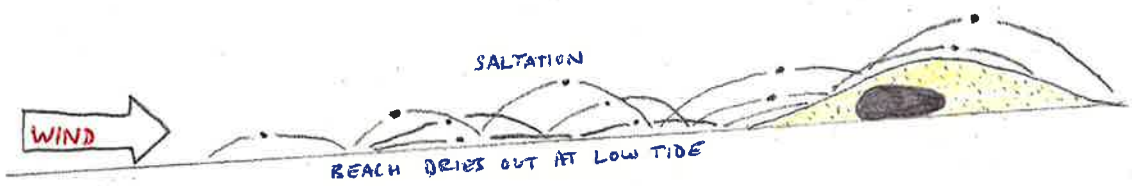


Dune belts are major sediment sinks. In areas with large supplies of fine sediment, strong onshore winds and beaches that dry out at low tide (allowing for the abundant sand to be blown inland), dunes are very common at the top end of beaches. As the beach dries out at low tide the wind picks up the fine particles of sediment and carries them up the beach and beyond the reach of the tide.

This movement occurs due to saltation and creep. Approximately 1mm from the sandy surface there is an area of zero velocity; most sand particles project through this and are picked up by the wind and transported. The wind blowing over a surface exerts a force known as *shear stress*. Most particles of sand have inertia due their weight and larger particles can, therefore, only move when this shear stress overcomes the inertia and saltation results. One sand particle will disturb another until more and more sand is being blown across the beach at low level by the wind.

Vegetation then starts to colonise the windblown sand. The sand forms drifts around the vegetation, which grows up through the drifting sand, trapping more and more of it. As the vegetation colonises it, the dune belt expands and grows towards the sea.

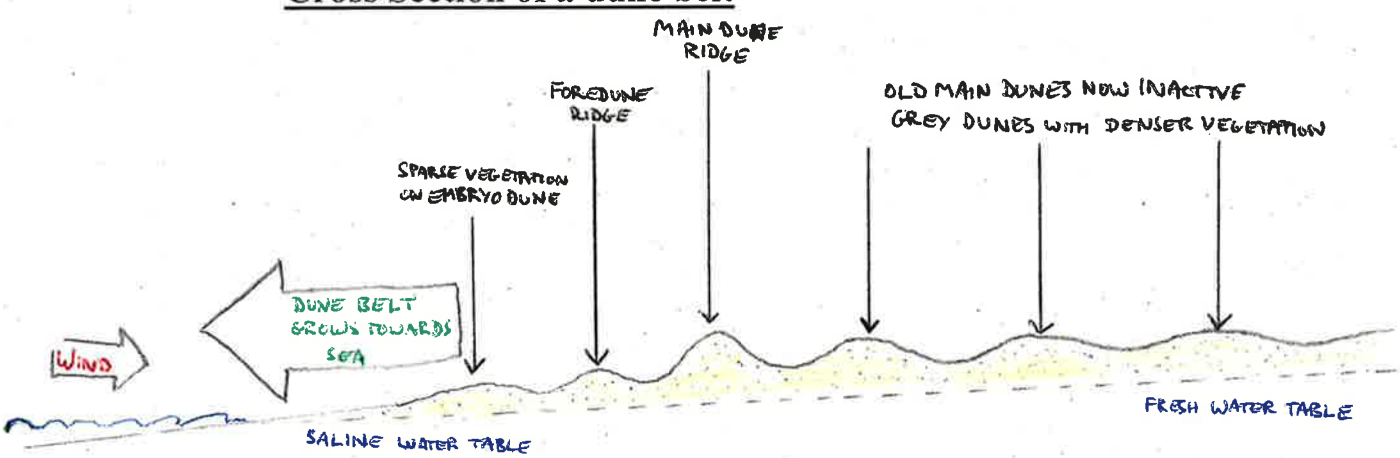
Diagram showing movement of sand across a beach and the resulting formation of a drift.



The vegetation that starts to colonise the dunes is very different from ordinary grasses and shrubs. Vegetation such as Sea Couch Grass (a pioneer species) which is present at Camber is adapted to the hostile conditions present at the top of the beach. It is an environment of high alkalinity, drought, salt and wind, resulting in the constant sand-bla

sting of such vegetation. Only specialised pioneer species such as Sea Couch Grass and Sea Rocket are therefore able to start growing.

Cross Section of a dune belt



This project sets out to investigate into the process of primary vegetation succession in a coastal sand dune belt by testing three hypotheses:

1) <u>That the density of the vegetation cover increases with distance inland from the beach.</u>

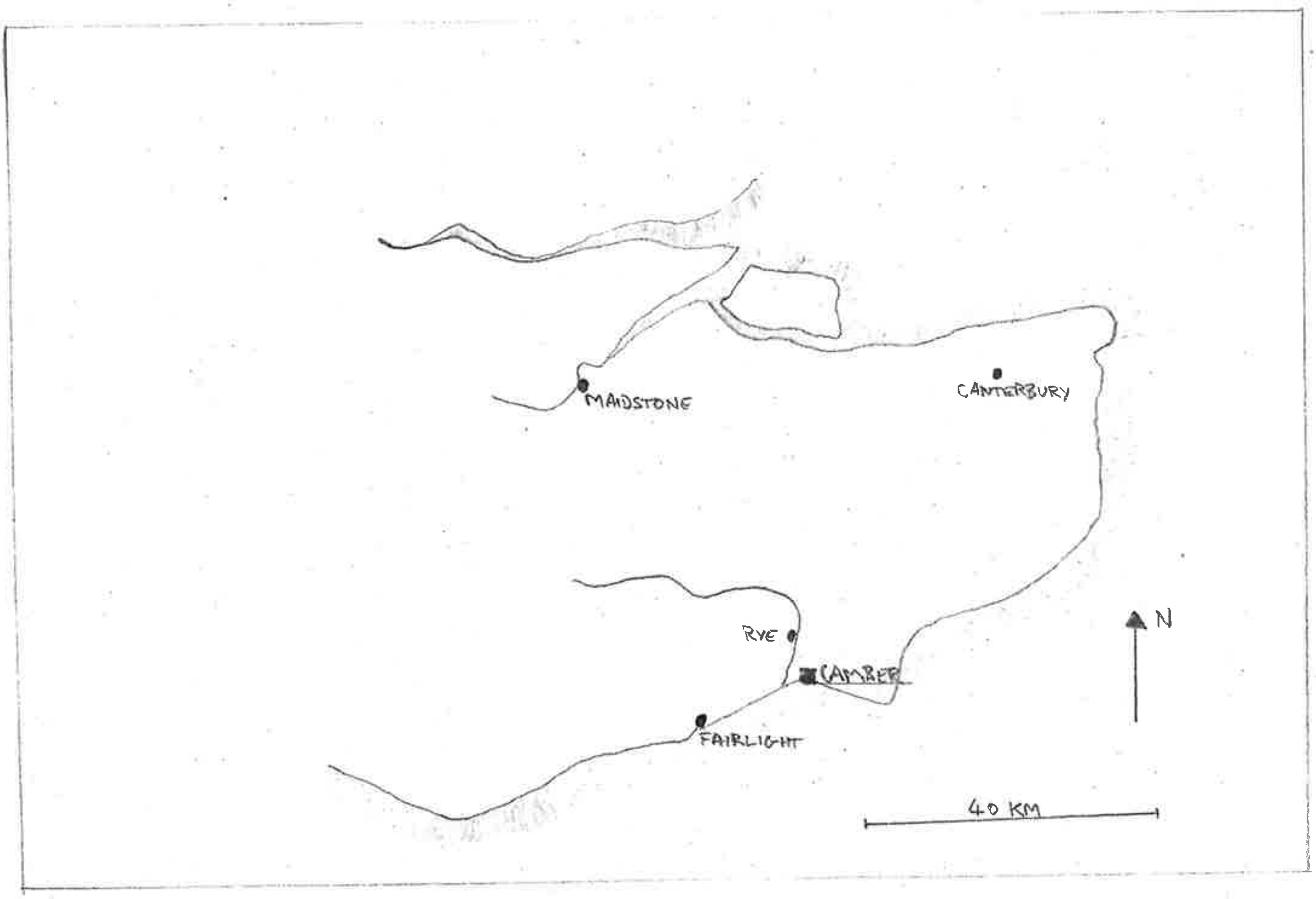
2) <u>That species diversity (the number of species) increases with distance from the beach.</u>

3) <u>That soil p.H decreases with distance inland from the beach.</u>

Chapter 2 - The Study Area:

It was decided to test the three hypotheses at Camber Sands, on the east bank of the River Rother, on the border between Kent and East Sussex on the English Channel. Four km long and up to one km wide stretching across Rye Bay, Camber Sands is an extensive area of mud and sand flats, with a dune belt at the top of the beach. Behind this dune belt lies farmland and Rye Golf course.

Map showing the location of Camber Sands in S.E England



Camber Sands was the perfect local area to test the hypotheses for three main reasons:

i) The erosion of the cliffs at Fairlight to the west of Camber, in East Sussex, and the constant transportation of sediment downstream from the River Rother provides a copious supply of sediment to Camber Sands. Extensive sand/mud flats are consequently formed, which dry out during low tide. The prevailing wind, blowing from the southwest, picks up this sediment and carries it ashore, adding it to the well-vegetated dune belt. In addition, the location of a number of WWII block houses (presumably built to a command a clear field of fire across the beach) now separated from the beach by two distinct dune ridges indicates that the dunes have advanced in recent years. These factors meant that it was likely that the hypotheses could be rigorously tested at Camber.

ii) The dune belt is relatively untouched by man, so is more or less in its natural state. Human activities at Camber do not interfere in any way with the pattern of vegetation growth - there is no intense dune use (although there are paths used by tourists and dog-walkers) so the hypotheses should operate without any external factors influencing them.

iii) Camber Sands is readily accessible from the town of Rye where I live and close enough to Tonbridge School to allow time for several visits. The area is also small enough to allow it to be surveyed in great detail and a high level of understanding to be gained about the way in which the dune belt has evolved. Therefore, Camber sands provided a practical proposition from which to test my hypotheses.

A GENERAL VIEW OF THE DUNE BELT AT CAMBER LOOKING WEST FROM THE CREST OF THE DUNE RIDGE ACROSS TO THE ROTHER ESTUARY (INCIPIENT BLOWOUT FORMATION CAN BE SEEN IN THE MIDDLE DISTANCE).

THE WIDE FORESHORE AT CAMBER – A MASSIVE SUPPLY OF SEDIMENT FOR THE DUNE BELT IN THE PREVAILING SOUTH WESTERLY WINDS.

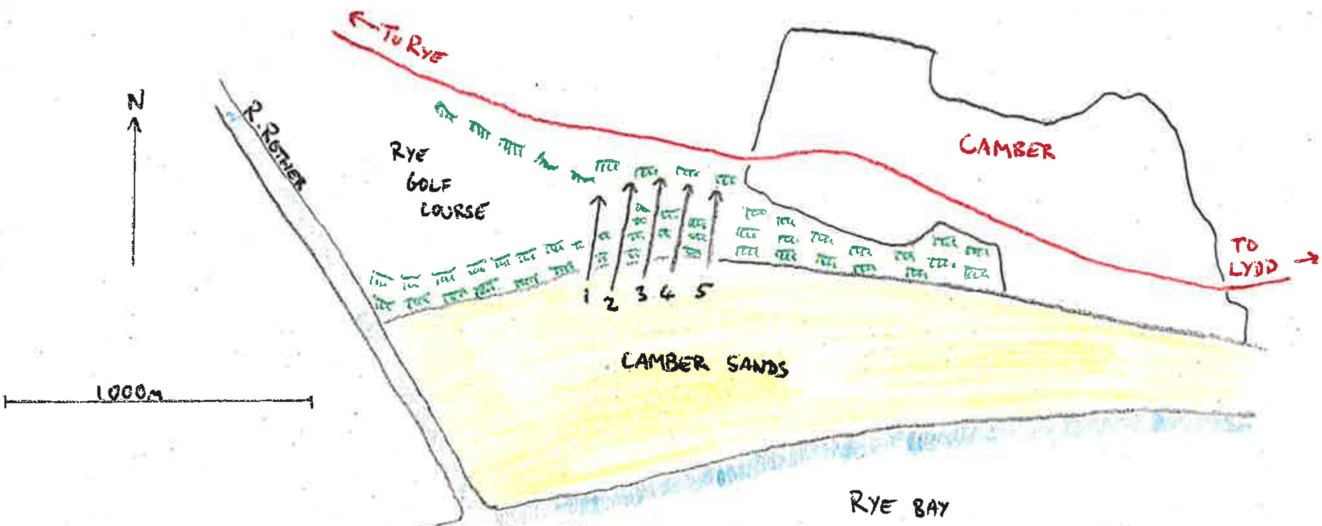
Chapter 3 - Data Collection:

In order to test the hypotheses on the process of primary vegetation succession in a dune belt, a number of transects were set up through the dune belt at Camber.

a) The Measurement Transects

Five transects were chosen at approximately 40m intervals along the dune belt. Each transect ran approximately 100 metres into the dune belt.

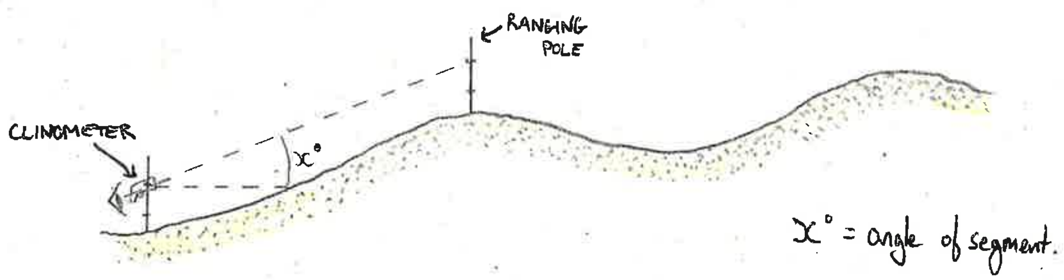
Map of showing the location of the five transects



b) Measurement of Dune Profiles

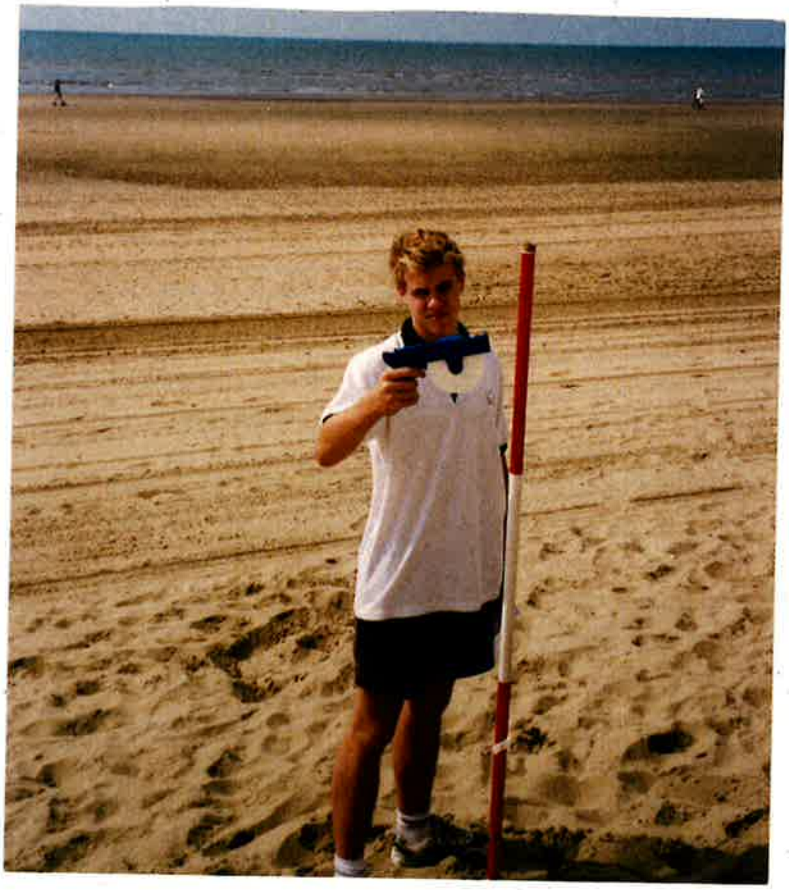
In order to measure the dune profiles, ranging poles were used to mark every break of slope along the transects and a tape measure used to record the length of each slope segment. A clinometer was used to measure the gradient of the segments of dune when lined up with the ranging poles.

Diagram showing how dune profiles were measured



PHOTOGRAPH OF THE LINE OF ONE OF THE TRANSECTS WITH BARE SAND IN THE FOREGROUND, SOME MARRAM ON THE TRANSECT AND SEA BUCKTHORNE BEHIND.

A GRADIENT MEASUREMENT BEING RECORDED USING THE CLINOMETER.



c) Measurement of Changes in Vegetation

A 0.5 x 0.5 metre quadrat was placed on the tape at 10m intervals along each transect. The quadrat was divided into 100 squares, so it was relatively easy to estimate the percentage species cover under each quadrat. However, species identification proved to be more difficult with, for example, lyme grass, couch grass and marram grass all being similar. Using a field guide, however, they were eventually identified.

d)Measurement of soil pH

Soil pH was measured using a soil acidity kit. A hole was dug in the sand at alternate quadrat locations, 5cms deep, and a sample collected. The sample (of approximately $5cm^3$) was then added to a test tube with $1cm^3$ of barium sulphate, some distilled water and a few drops of universal indicator fluid. The tube was then shaken and the colour of the solution was compared with a pH chart to discover the acidity or alkalinity of the sample.

A systematic sample of five transects across the breadth and width of the dune system provided ample data from which it was possible to draw meaningful conclusions.

IT PROVED IMPOSSIBLE TO TAKE SYSTEMATIC WIND VELOCITY MEASUREMENTS BECAUSE OF GUSTY CONDITIONS THROUGHOUT THE SURVEY. HOWEVER, WIND VELOCITIES WERE MEASURED AND RECORDED AT DIFFERENT POINTS ALONG SEVERAL OF THE TRANSECTS.

Chapter 4 – Results:

The field data is summarized on the next six pages in diagrammatic form. The dune cross sectional profile along each transect has been drawn to scale, the vegetation species and the proportion of the sample plot which they cover has been represented by pie charts and the soil pH is shown by simple bars placed at the appropriate position along each transect.

Each pie chart shows the percentage of ground covered by each species at 10m intervals for each transect.

Key To Pie Charts

Lyme Grass

Sea Rocket

Couch Grass

Marram Grass

Thistle

Sedge

Sea Buckthorne

Moss

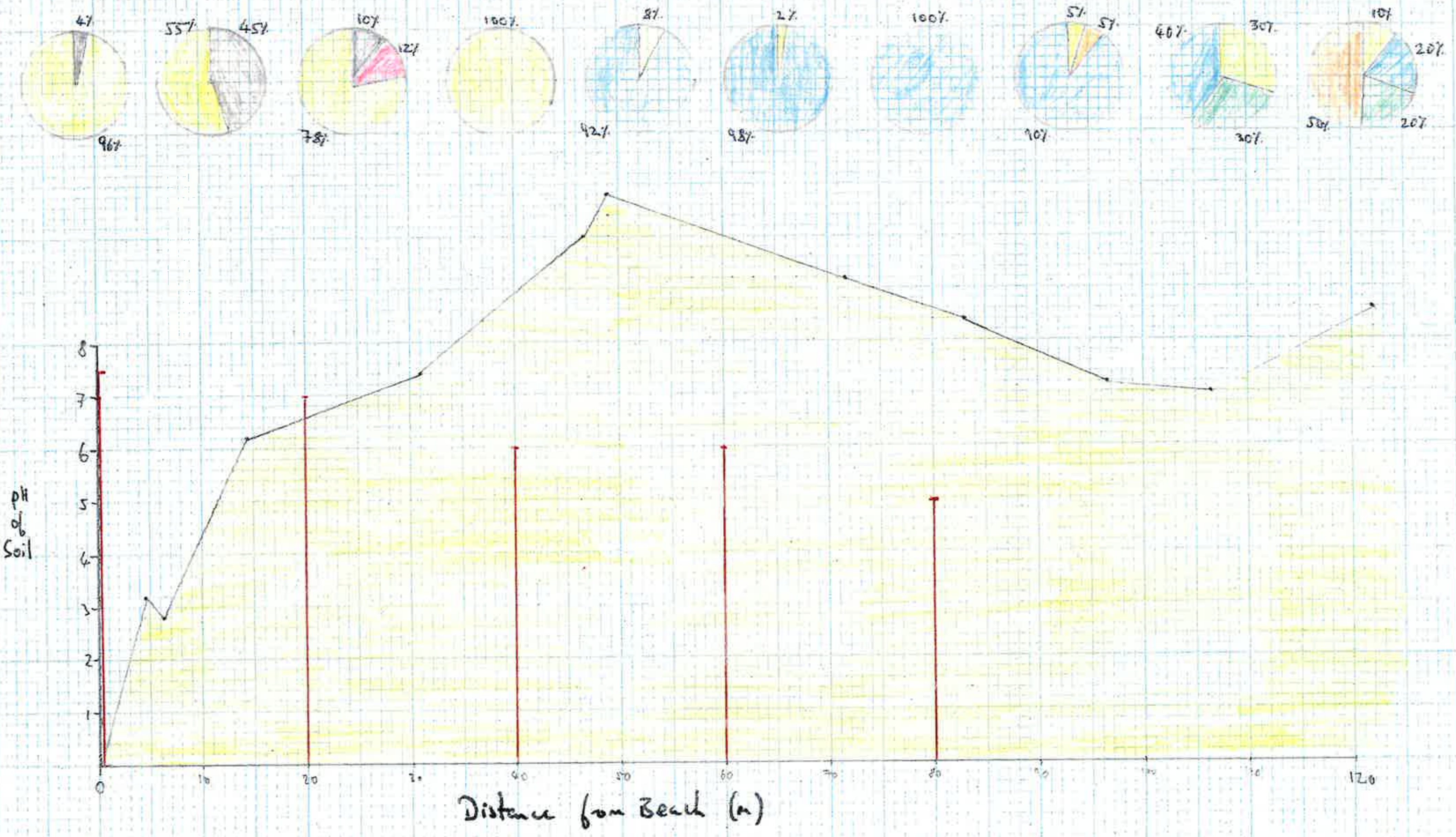
Gorse

Bramble

Elder

Other Grasses

Transect 1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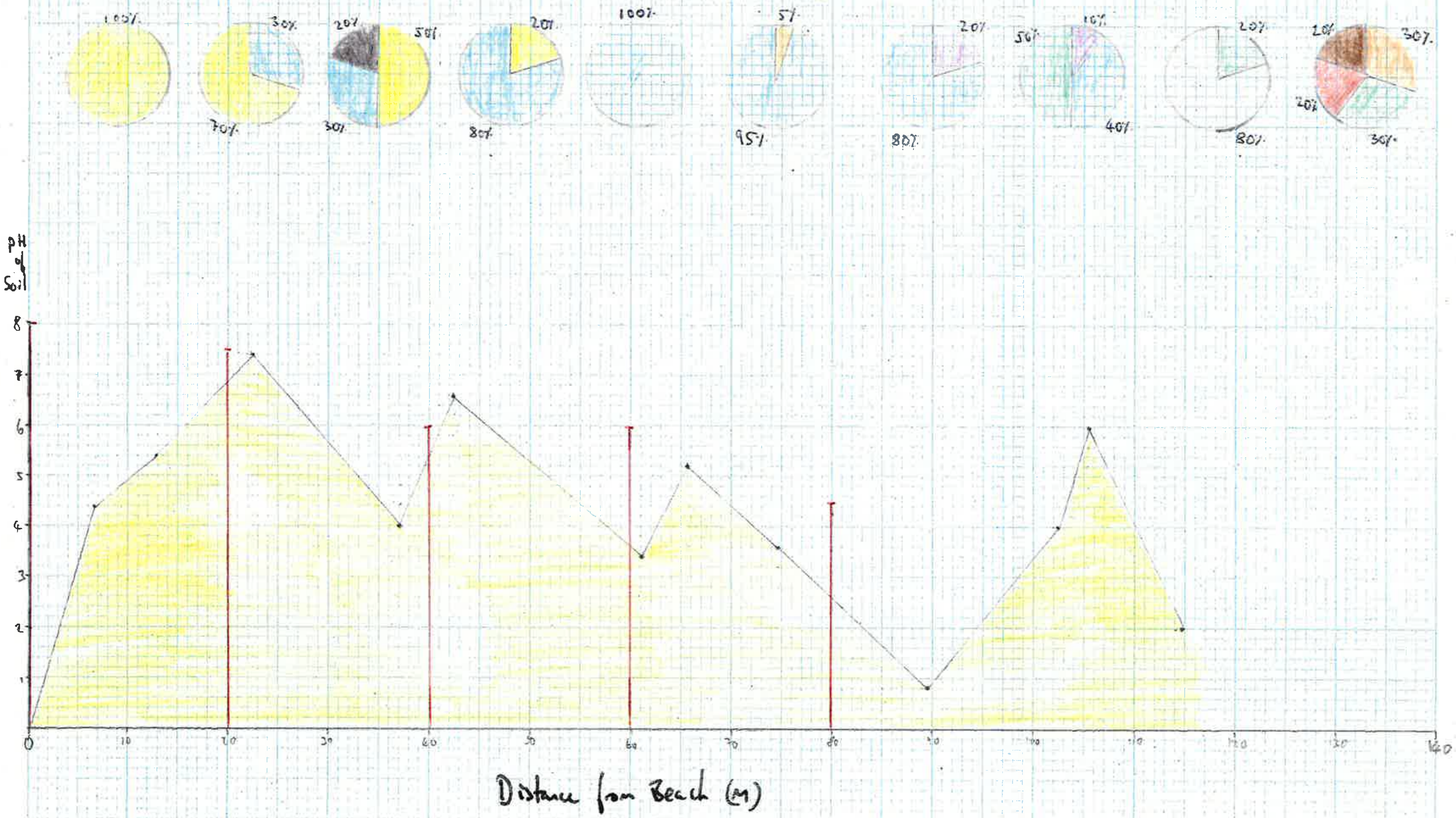
Distance from Beach (m)

Transect 2



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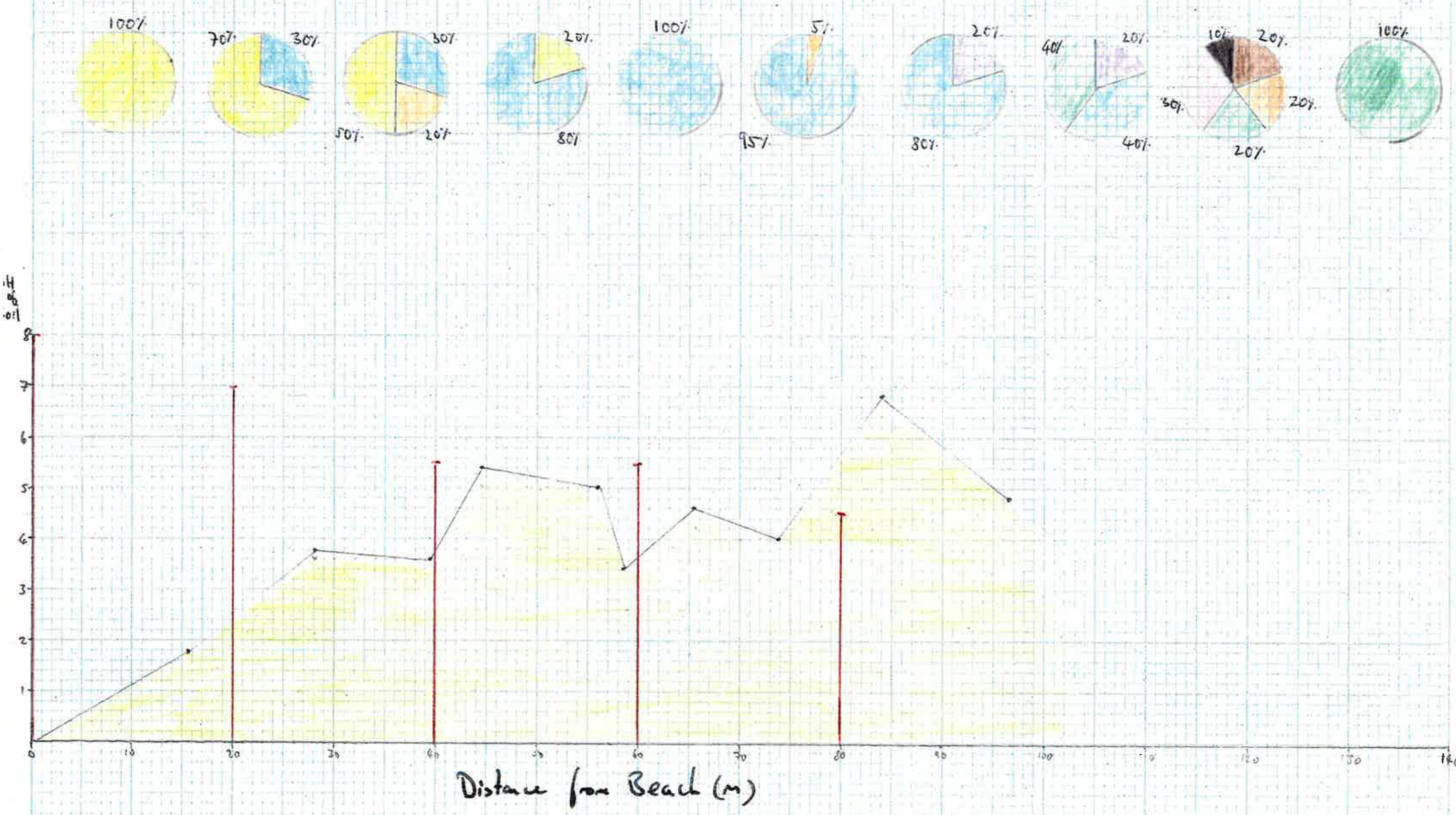
pH of Soil
Distance from Beach (m)

Transect 3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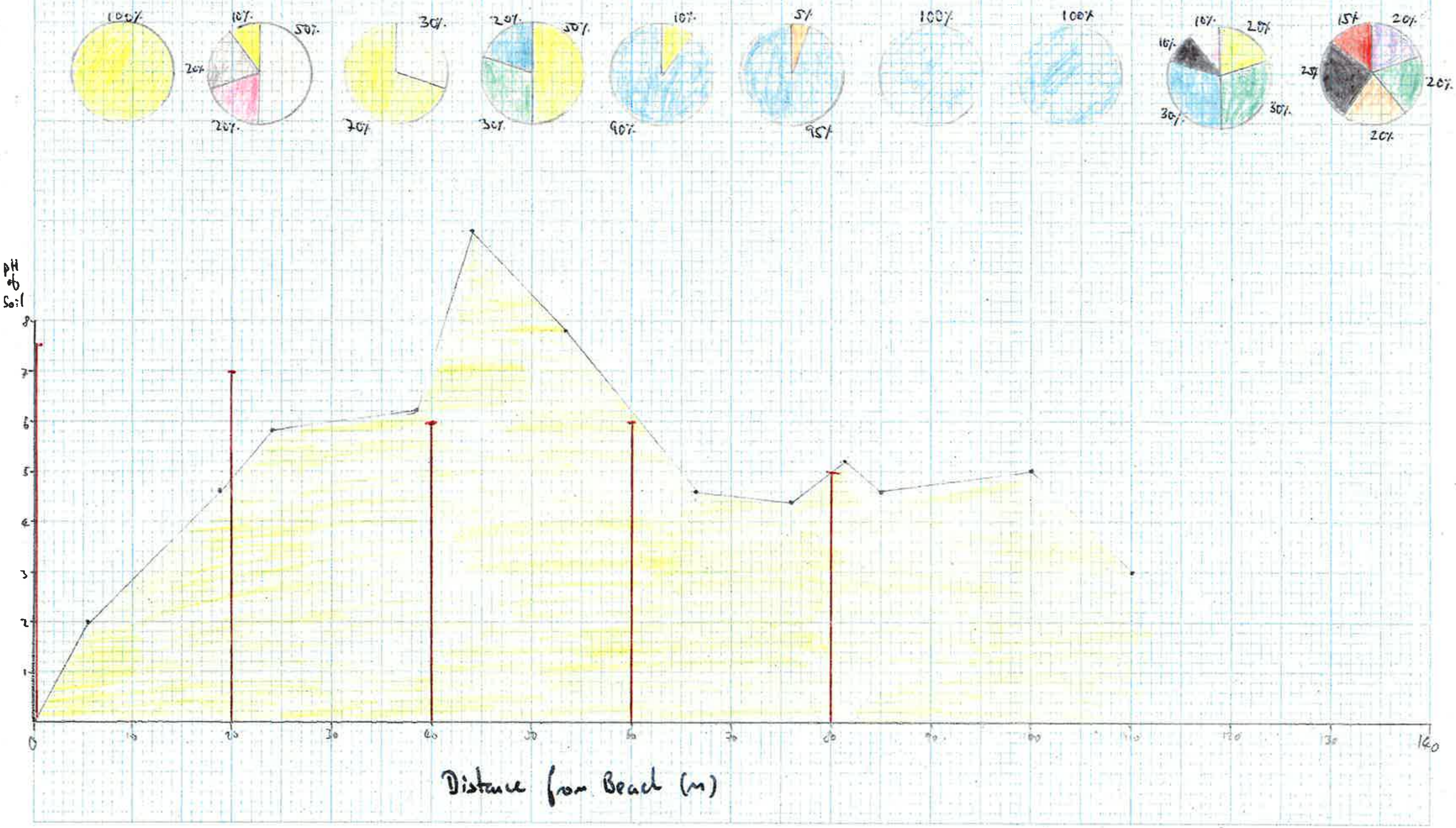
Distance from Beach (m)

Transect 4.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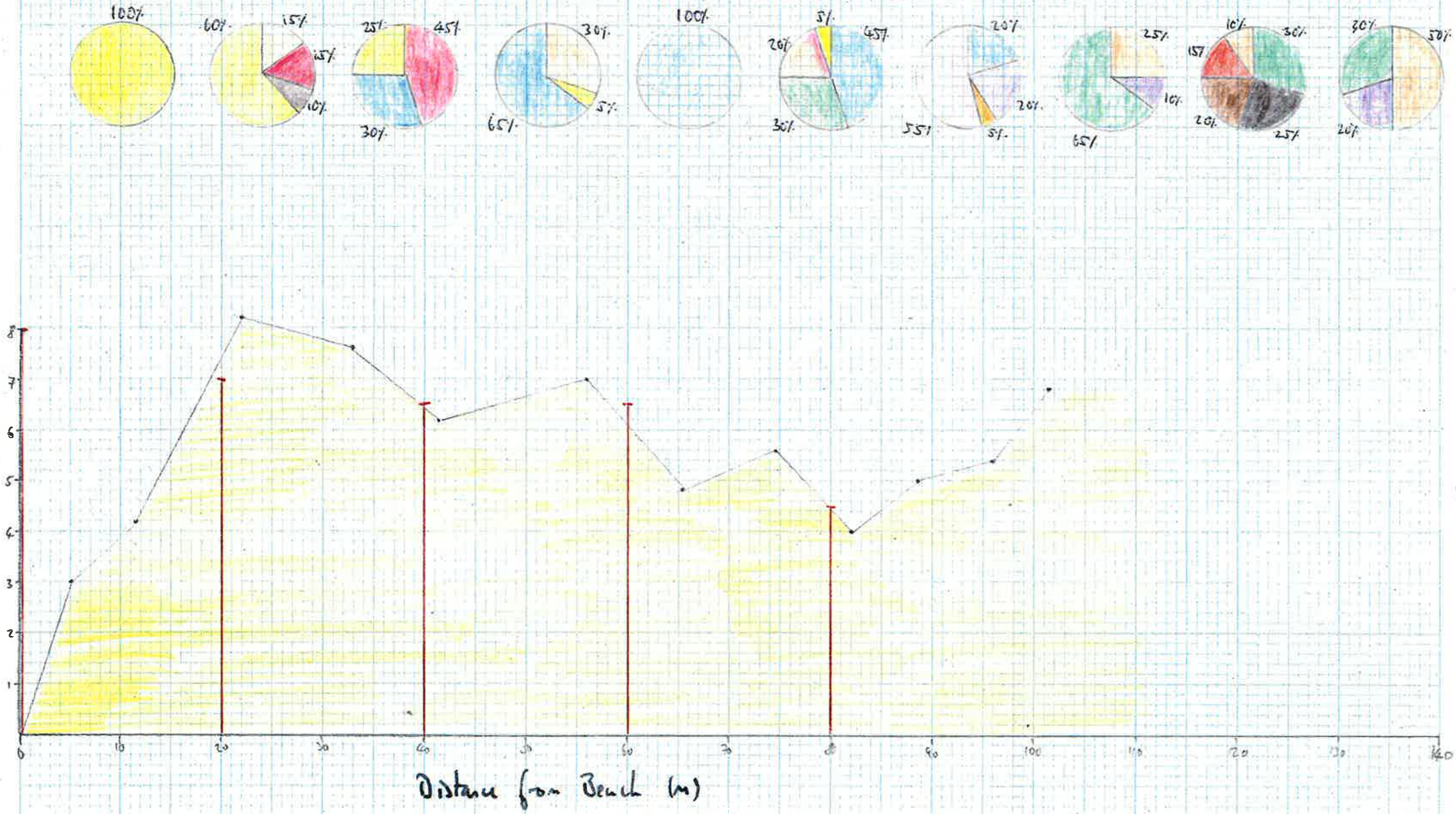
Distance from Beach (m)

Transect 5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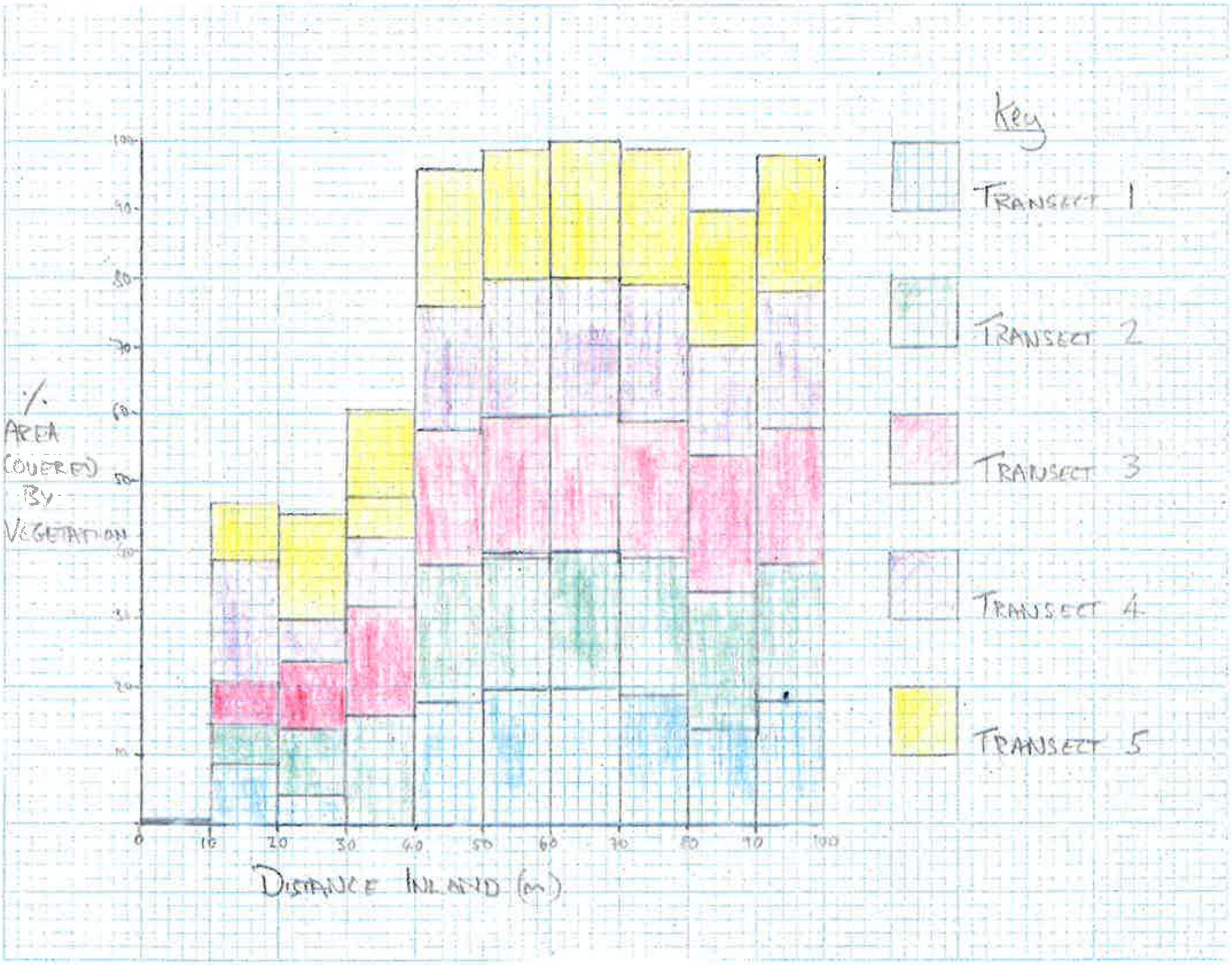
Distance from Beach (m)

Chapter 5: Analysis of Results
a) Interpretation of Results

To see if the first hypothesis (that the density of the vegetation cover would increase with distance inland from the beach) was confirmed by the results across all five transects, a divided bar graph of distance inland against the percentage of bare sand covered by vegetation was plotted across all the five transects. (The percentage area vegetated for each transect has been scaled down so that each transect can only make up one fifth of the total on the vertical scale.)

DIVIDED BAR GRAPH OF DISTANCE INLAND AGAINST PERCENTAGE AREA COVERED BY VEGETATION FOR ALL FIVE TRANSECTS



The pattern on this divided bar graph partially confirms the hypothesis that the vegetation density increases with distance inland from the beach. The average area covered by vegetation is only 0.8% at the top of the (0 metres on the divided bar graph.) However, this rises to 100% for all five transects by 60-70 metres.

The change to dense vegetation is very fast with nearly 50% coverage at 10-20 metres from the beach.

There is also an obvious anomaly at 70-80 metres inland where there is an unexpected decrease in the density of the vegetation from 100% at 60-70 metres to 99% at 70-80 metres and a further decrease to 90% 80-90 metres inland. After this the density of vegetation again starts to increase to 98% at 90-100 metres.

Overall, however, the divided bar graph shows an increase in vegetation density, yet the increase is not as regular or uniform as expected with two obvious anomalies where there was infact a slight decrease in the vegetation density.

To see whether the second hypothesis, that the number of species increases with distance inland from the beach, was true, a line graph of distance inland against the total number of species recorded was plotted across all five transects. The line graph can be seen on the following page.

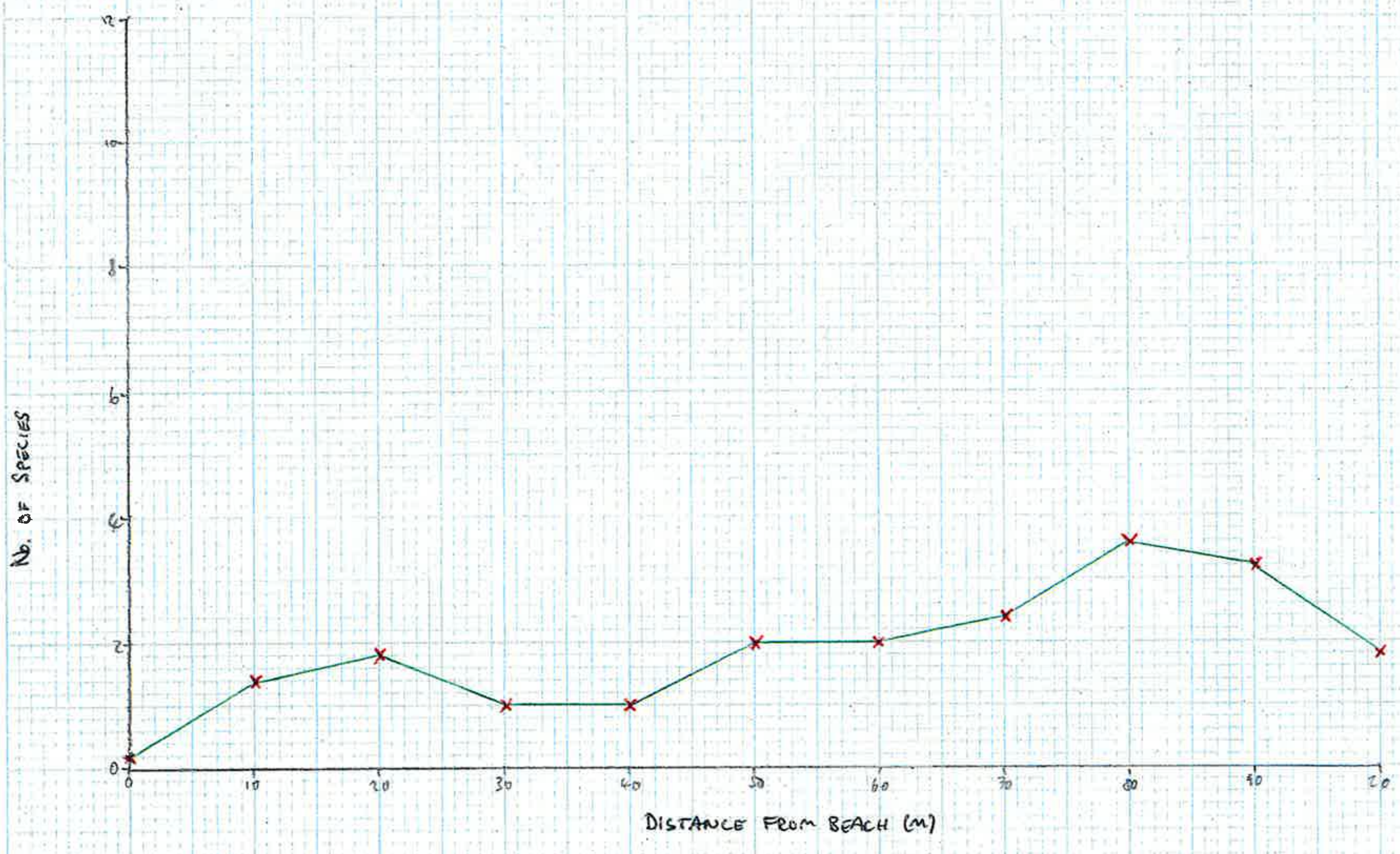
The pattern on the line graph confirms the hypothesis - the number of species did increase with distance inland from the beach.

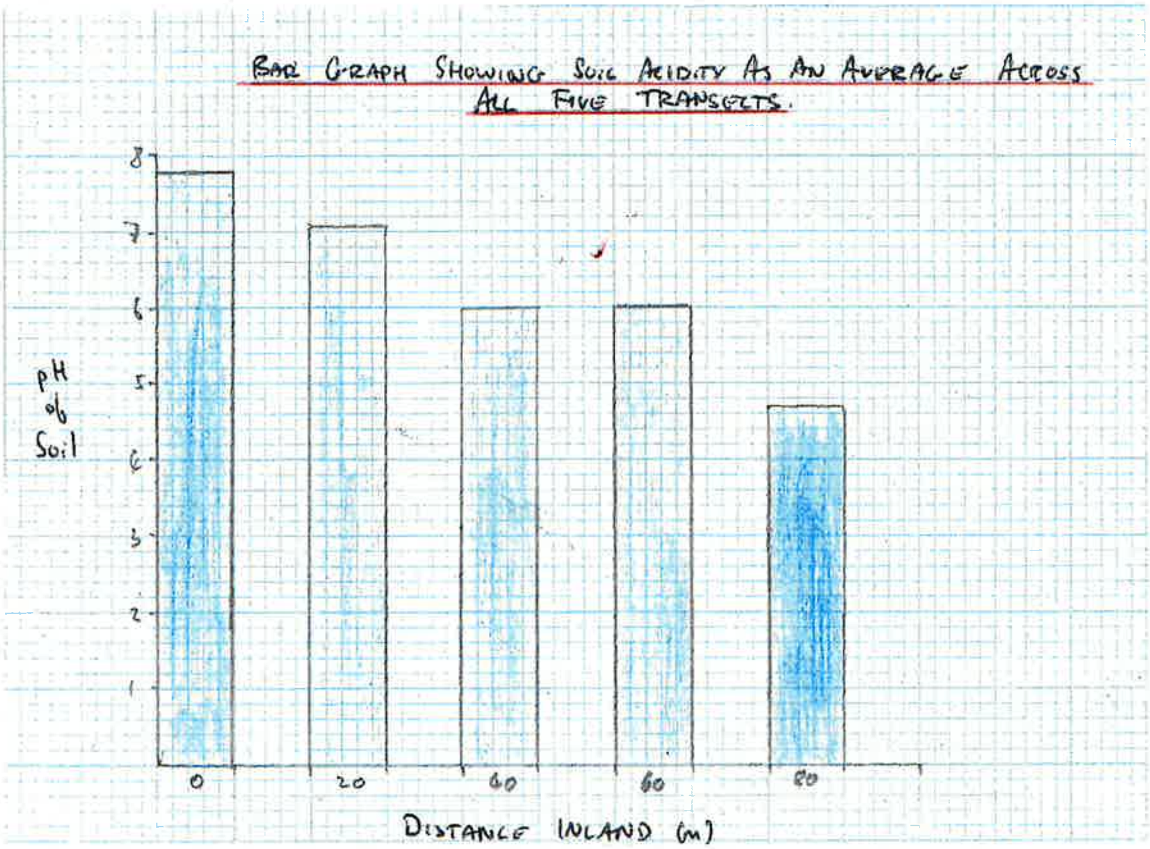
The line graph lines clearly show that the total number of species increases. For transect five, for example, there is an increase from 0 species at 0 metres to 5 species at 80 metres inland. However, although the trend is fairly clear, the detail shows a very irregular change. For example, after a steady increase to 4 species by 60 metres inland for transect 5, there is a sudden drop to only 3 species at 70 metres, before increasing again to 5 species at 80 metres inland. This pattern of increase with obvious anomalies as the number of species suddenly drops is common across all five transects. Each transect, for example, sees a sharp drop in the number of species at 100 metres inland. This is most obvious on transect 4, where 5 species at 90 metres drops to only a single species by 100 metres. Such detail can be more closely observed by studying the raw data, yet the average across all five transects clearly shows the trends.

Overall, the line graph shows an increase in the number of species with increase in distance inland from the beach, but the increase is much less steady than expected.

To see whether or not the third hypothesis was confirmed by the results, the mean pH for each distance inland was plotted on a bar graph.

LINE GRAPH TO SHOW HOW SPECIES DIVERSITY INCREASES WITH DISTANCE FROM THE BEACH AS A MEAN ACROSS FIVE TRANSECTS.





These figures clearly confirm the hypothesis with mean pH falling from 8 at the dune base to 5 at 80 metres inland from the beach.

However, as the individual bars drawn on the dune profiles in chapter four show, the decrease in pH was not uniform. Between 40 and 70 metres, when two pH readings were taken, the two readings were the same within each transect. For transects 1,2 and 4 these readings were all pH 6. For transect 3 they were pH 5.5 and for transect 5 they were pH 6.5. Despite this slight anomaly in all five transects, the general pattern was that soil pH decreased with distance inland from the beach, thus proving my hypothesis correct.

b) Explanation of Results

The first hypothesis was confirmed by the results - the density of vegetation did increase with distance inland from the beach along all five transects. This is due to the way in which vegetation colonizes the sand blown up the beach.

As explained in chapter one, sand blasting onshore will have initially accumulated around patches of vegetation adapted to the harsh environmental conditions of the shoreline area. These pioneer species could clearly be seen in the form of couch grass and sea rocket. Because of the conditions, vegetation cover is, however, sparse in this zone of embryo dunes and the foredune ridge.

With the increased stability of the foredune ridge at 10 metres inland, marram is well adapted to the conditions of rapid sand accumulation (as seen by it's presence on the pie charts) because it is fast growing and resists exposed locations well. This first stage of species succession then accounts for an increase in vegetation density as marram becomes the dominant species over sea rocket and couch grass.

By 20 metres inland, the main dune ridge was accounting for the major increase in vegetation density in this area. The main dune ridge is the environment to which marram is best adapted, with high winds and rapidly moving sand requiring fast growth. As marram thrives in these conditions, it grows abundantly on the main dune ridge, increasing the vegetation density dramatically.

This increase in vegetation density may have been accentuated by the embryo and foredune areas being poorly defined due to winter storm damage. Wave inundation of the zones colonized by pioneer species during winter storms seemed to have heavily eroded the embryo and foredunes, perhaps contributing to a decrease in species cover by the pioneer plants.

Inland of the dune sequence, the occurrence of marram along the length of the transect remains at a high level, even on the increasingly stable grey dunes, contributing to high vegetation densities throughout the transects inland. For example, even at 50 metres inland, marram is dominating the ground cover on some transects. Across the dune system, the pie charts of percentage species cover demonstrate a vegetation succession from pioneer species like couch grass on the embryo dunes to marram as the main colonist on the main dune ridge, followed by small quantities of flowering plants succeeding on the grey dunes. Finally, on the oldest grey dunes, small shrubs and bushes begin to succeed like bramble and sea buckthorne, becoming dominant by 80 metres.

On the inland side of the main dune ridge, wind velocities decrease markedly and the amount of moving sand decreases rapidly, increasing dune stability. This allows species better adapted to more stable soil conditions to colonize. In these more stable conditions, a greater number of species are able to survive as stability has increased and salinity is declining with distance inland. The soil also contains more organic matter and nutrients, allowing a greater biomass to be supported, explaining the increase in vegetation density. As succession continues with distance from the sea, vegetation density is allowed to develop further because as taller species, especially shrubs, begin to colonize, the vegetation can be stratified by height - a sparse ground layer of vegetation surviving beneath the shrub layer - increasing the vegetation density.

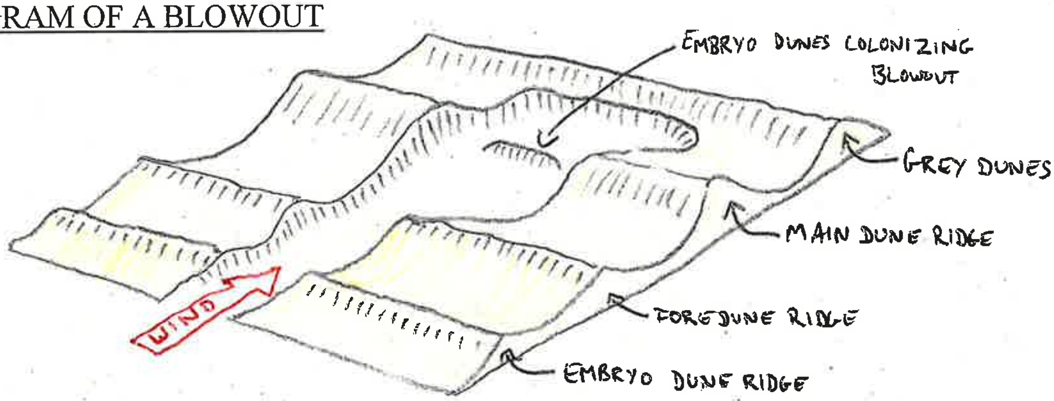
The increase in vegetation density to virtually 100% at 40 metres marks the positioning of the first grey dune, reflecting the increased stability of the area.

However, the increase in the density of vegetation was not as smooth as expected. In transect 4, for example, there were areas of bare sand and sparse vegetation where it might be expected that the sand would be densely vegetated. 30 and 40 metres inland from the beach there was a high percentage of bare sand in comparison to the other four transects.

This uneven increase in vegetation cover is also the result of erosion of the dunes. Where human use of the dunes is particularly concentrated, the constant erosion caused by trampling feet enables the wind to scoop out a blowout stretching back into the dunebelt. As the vegetation is destroyed, the once stabilised sand between the root systems is blown away, causing the blowout.

Even though new embryo dunes were recolonizing some of the blowouts at Camber, they seriously disrupted the regular pattern of the increase in vegetation cover with distance inland by creating areas of bare sand well inland from the beach.

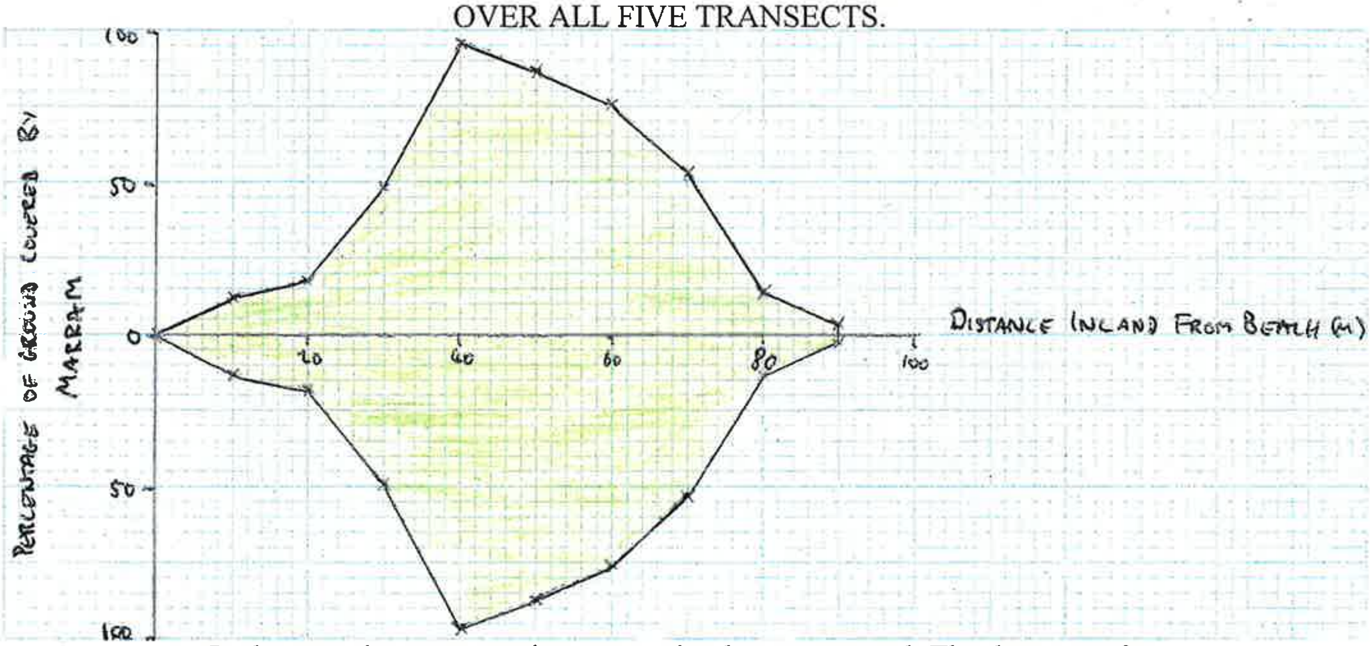
DIAGRAM OF A BLOWOUT



INCIPIENT BLOWOUT FORMATION ALONG A FOOTPATH

The results for the number of species with distance inland from the beach ties closely with those for vegetation cover. From 0-20 metres inland, very few species are able to colonize due to the harsh conditions. Therefore, the number of pioneer species is small, only couch grass and sea rocket being found in this zone. On the first dune ridge, between 10 and 30 metres, the number of species is very variable between transects. Environmental conditions are less harsh than in the pioneer zone - salinity will have decreased but wind speeds and sand movements remain high. On the windward side of the first dune ridge, conditions are harsher and only marram survives in large quantities, although traces of Lyme grass and sea buckthorne are found. With increased shelter from the wind and less sand movement on the lee side of the first dune ridge, the percentage cover of marram increases dramatically and the number of species present increases sharply in the more stable conditions with traces of sedge and thistle in addition to marram. The dominance of marram grass in the early sections of the transects is partially responsible for the number of species recorded between 10 and 40 metres on all the transects. As the kite diagram below indicates, marram was so dominant here that it tended to exclude other species. Marram is a major colonizer with the capacity to grow up through drifting sand but it depends on fresh supplies of calcareous sand to stay alive. It therefore played a major role in the stabilisation of drifting sand on fore and main dunes but tended to become less important with distance inland.

KITE DIAGRAM SHOWING THE PERCENTAGE COVER OF MARRAM GRASS OVER ALL FIVE TRANSECTS.



In the grey dunes vegetation succession has progressed. The dunes are far more stable and vegetation density has increased markedly allowing an increased organic content in the soil and a larger number of species to colonize which are better adapted to the gentler environmental conditions, particularly of decreased salinity, increased soil moisture and lower wind speeds. Towards the end of the transects, therefore, substantial small trees, especially elder, were found.

In areas where there are slacks, there are often a greater number of species to be found here. In the slacks the conditions are more sheltered and closer to the water table than the ridges, allowing for increased soil moisture.

The first grey dune crest at around 40-50 metres shows a marked decline in the number of species. Here wind velocities will be much higher in the more exposed conditions and greater aridity will persist as the ridge is much further above the water table than the slacks. In these harsher conditions fewer species can survive successfully and notably marram increases in dominance in this area.

Clearly, therefore, the general trend of increase in the number of species inland from the beach is not simple and the variation in the pattern between transects shows how complicated vegetation colonization and succession is, even over small areas. Species presence is very much affected by the localised environmental conditions.

PHOTOGRAPH SHOWING THE DOMINANCE OF MARRAM GRASS ON THE MAIN DUNE RIDGE

The third hypothesis was also confirmed by the results. The pH value of the soil did decrease with distance inland. However, the decrease was not regular because soil is more acidic in the slacks than on the ridges and because blowouts were responsible for moving fresh calcareous sand into the dune belt.

The ridges are steeper than the trough-like slacks. The steeper the slope, the more free draining the soil. This inability to hold water repels large scale colonization of plant species. The density of vegetation directly affects the acidity of the soil. Inland, as the environment becomes more suitable (less sand blasting, more moisture, less wind, less salinity), the pioneer species become replaced by the mid-seral stages of vegetation succession. The greater density of vegetation creates an increased amount of dead organic matter in the soil. This humus is full of humic acid which acidifies as well as nourishes the soil, providing a rich compost which encourages further vegetation growth, which in turn produces more humus. The result is more acidic soil in the slacks.

The acidity increases inland partly due to the decreasing influence of shells. Shells, commonly found along the beach at Camber are encountered as far inland as the foredunes. As they are made out of calcium carbonate, the sand is naturally alkaline. As the dune system ages, and humus replaces the sandy soils of the foredunes, the soil will naturally become more acidic.

The increasing acidity of the soil, in turn, helps to explain why the number of species of vegetation and its density increases inland. The greater amount of humus in the soil and the lower pH levels create more ideal growing conditions for plant species than where the humus-free and alkaline soils of the foredunes, dominates.

Vegetation in its mid-seral stage (in the grey dunes) therefore owes its existence to the main colonizers and pioneer species that colonize the dunes first, before they die and create more ideal conditions for other species - having created shelter, humus-rich soil, moisture in the soil and a more acidic soil that can be exploited by these more aggressive, dominant species.

Overall, the results of the field survey show (with certain exceptions and anomalies) a classic pattern of vegetation succession being generated as sand has accumulated to form a dune belt that has grown seaward, forming new dune ridges over time. In fact, a number of observations made in the field support this interpretation of the results.

The WWII block houses (see Chapter 2) indicate, as mentioned, that two distinct dune ridges (including the present main dune ridge) have reached their current size only over the last fifty years. This is supported indirectly by some observations made where groundsmen from Rye Golf Club had been doing some clearance work on the second dune ridge next to the fairway of one of the holes. In an effort probably to make it easier to retrieve wayward golf balls, they had cut a patch of sea buckthorne, exposing the stumps. Straightforward counting of annual growth rings indicated that the oldest species here were about 37 years old – confirming that this dune ridge has only been in existence for perhaps around 50 – 60 years. Rye Golf Club itself was founded in 1895 and extends no further than the third main ridge inland from the sea, indicating that this third ridge (covered mainly with mature sea buckthorne, gorse, brambles and elder) is at least 105 years old, probably rather more. Unfortunately, however, analysis of old Ordnance Survey maps proved inconclusive in dating the seaward expansion of the dune belt.

PHOTOGRAPH OF THE WWII BLOCK HOUSES FROM THE CLEARED DUNES ON THE GOLF COURSE MENTIONED IN THE TEXT. THE CUT STUMPS OF SEA BUCKTHORNE CAN BE SEEN IN THE FOREGROUND. IT IS ENVISAGED THAT 50 YEARS AGO THIS AREA FORMED THE TOP OF THE BEACH WHERE, PERHAPS, FOREDUNES WERE GROWING AND BEING CONVERTED INTO MAIN DUNES WHILE THE MAIN GREY DUNE RIDGE IN THE BACKGROUND WAS ACTUALLY STILL AN ACTIVE YELLOW DUNE.

Chapter 6 - Conclusions and Limitations

The results obtained show that both the density of the vegetation and the number of species do increase with distance inland, thereby confirming the hypotheses. However, these changes were not as straightforward as expected. Winter storm damage frequently cuts back the dunes, resulting in a much swifter transition to dense vegetation than expected. Neither was the increase in vegetation density smooth. An uneven increase in vegetation cover was the result of several blowouts within the dune belt - large areas of bare sand where, under normal conditions, there would be dense vegetation.

Although the number of species increased inland, the uniform pattern was disturbed by the domination of the main coloniser species, marram, which squeezed out other floral competitors.

The acidity of the soil also increased inland, although it was not steady, due to blowouts and the nature of the dunes, with exposed ridges less habitable climates for vegetation than the more sheltered and humid slacks. These conditions determine the density of vegetation, which in turn determines the acidity of the soil.

There was the practical problem of the difficulty in identification of non-flowering vegetation species that limited the accuracy of the results. It was not easy, for example, to differentiate marram from couch grass. The problem was compounded by the fact that textbooks only showed the plants when in flower.

The explanations of the results were limited also. Five transects were measured, a small number considering the 1.5 kilometres that are Camber Sands. However, the transects were taken from an area typical of the dune belt as a whole and more transects than five would have made the task of obtaining and drawing up results unnecessarily time consuming for no corresponding increase in either accuracy or usefulness.

The conclusions reached at Camber might not be applicable to other dune systems. Although the project might explain the system at Camber, it is unlikely that the hypotheses would work in different locations. The dunes at Camber are formed from sediment taken eastwards along the English Channel from sources such as Fairlight Cliffs in Sussex and the conditions and climate are peculiar to Camber. These dunes will be dissimilar from those in Cornwall, for example, where many dune systems are comprised of quartz sand from broken down granite and wind conditions are different too. These different factors affect patterns of vegetation across the dune belts and therefore will result in dissimilar results and conclusions.

In order to obtain a more thorough picture of dune systems, the project might have been extended so that measurements were taken in different areas, such as Cornwall, and the results compared and contrasted with those from Camber. This comparison of different dune systems would result in the gaining of a more complete picture of dune belts in general, not simply five transects taken across one such belt in East Sussex.

Other, more practical, limitations were that a great number of soil samples needed to be taken to confirm the pH trend. The vegetation succession could have been studied in more depth also. For example, factors affecting the succession, such as the micro-climate could have been sampled and temperature and wind speed recordings taken, as could readings showing the salinity and organic content of the soil to give a complete overview of conditions in the slacks and on the ridges.

Bibliography

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APENDIX

TRANSECT No: ONE

DUNE PROFILES:

Segment no.	Gradient (°)	Distance (m)
1	+16	4·60
2	−2	1·80
3	+17	7·50
4	+6	16·50
5	+13	15·80
6	+4	2·30
7	−8	22·80
8	−4	11·30
9	+6	13·70
10	−1	9·60
11	+8	15·60
12	−25	19·80

VEGETATION SURVEY

Distance from Beach (m)	% Bare Ground	SPECIES												
		A	B	C	D	E	F	G	H	I	J	K	L	M
0	96	4												
10	55	45												
20	78	10	12											
30	100													
40	8				92									
50	2				98									
60					100									
70	5				90	5								
80	30				40				30					
90	10				20				20			50		
100	5				10					40		45		

Key:

A = LYME GRASS
B = SEA ROCKET
C = COUCH GRASS
D = MARRAM GRASS
E = THISTLE
F = SEDGE
G = OTHER GRASSES
H = SEA BUCKTHORNE
I = MOSS
J = GORSE
K = BRAMBLE
L = ELDER
M = OTHER.

TRANSECT NO: TWO

DUNE PROFILES:

Segment no.	Gradient (°)	Distance (m)
1	+22	6.70
2	+5	6.10
3	+10	9.40
4	−17	14.30
5	+13	5.60
6	−16	18.60
7	+9	4.90
8	−8	8.70
9	−14	14.60
10	+16	12.80
11	+10	3.20
12	−20	8.70

VEGETATION SURVEY:

Distance from beach (m)	% Bare Ground	SPECIES												
		A	B	C	D	E	F	G	H	I	J	K	L	M
0	100													
10	70													
20	50				30			20						
30	20				80									
40					100									
50					95	5								
60					80		20							
70					40		10		50					
80									20	80				
90									30		20	30	20	
100	50								50					

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- M = OTHER

TRANSECT No: THREE

DUNE PROFILES:

Segment no.	Gradient (°)	Distance (m)
1	+9	15·60
2	+10	12·30
3	−1	11·40
4	+9	6·90
5	−2	11·20
6	−8	2·60
7	+6	6·80
8	−3	8·10
9	+16	10·20
10	−10	12·30
11		
12		

VEGETATION SURVEY:

Distance from Beach (m)	% Bare ground	SPECIES A	B	C	D	E	F	G	H	I	J	K	L	M
0	100													
10	70													
20	50				30	20								
30	20				80									
40					100									
50					95	5								
60					80		20							
70					40		20		40					
80								10	20	30		20	20	
90									100					
100	50								30			20		

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TRANSECT No: FOUR

DUNE PROFILES:

Segment no.	Gradient (°)	Distance (M)
1	+10	5.50
2	+13	13.20
3	+6	4.90
4	+2	14.60
5	+18	5.20
6	−10	9.20
7	−16	13.00
8	−1	9.30
9	+4	5.20
10	−3	3.30
11	+2	15.00
12	−10	10.00

VEGETATION SURVEY

Distance from beach (M)	% Bare ground	SPECIES A	B	C	D	E	F	G	H	I	J	K	L	M
0	100													
10	10	20	20	50										
20	70			30										
30	50				20				30					
40	10				90									
50					95	5								
60					100									
70					100									
80	20				50			10	30	10				
90							20	25	20		15	20		
100						5		5	90					

Key

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J = GORSE
K = BRAMBLE
L = ELDER
M = OTHER

TRANSECT No: FIVE

DUNE PROFILES:

Segment (no.)	Gradient (°)	Distance (m)
1	+15	5.00
2	+6	6.50
3	+20	10.50
4	−3	11.00
5	−7	8.40
6	+4	14.50
7	−11	9.20
8	+4	9.20
9	−8	7.60
10	+5	6.80
11	+2	7.20
12	+7	5.30

VEGETATION SURVEY:

Distance from Beach (m)	% Bare Ground	SPECIES												
		A	B	C	D	E	F	G	H	I	J	K	L	M
0	100													
10	60	10	15	15										
20	25		65		30									
30	5			30	65									
40					100									
50	5			20	65				30					
60					20	5	20			55				
70							10		65			25		
80								25	30		15	10	20	
90							20		30			50		
100							10		70			20		

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K = BRAMBLE
L = ELDER
M = OTHER.

Distance Inland (m)	Soil pH for each transect				
	1	2	3	4	5
0	7.5	8	8	7.5	8
20	7	7.5	7	7	7
40	6	6	5.5	6	6.5
60	6	6	5.5	6	6.5
80	5	4.5	4.5	5	4.5