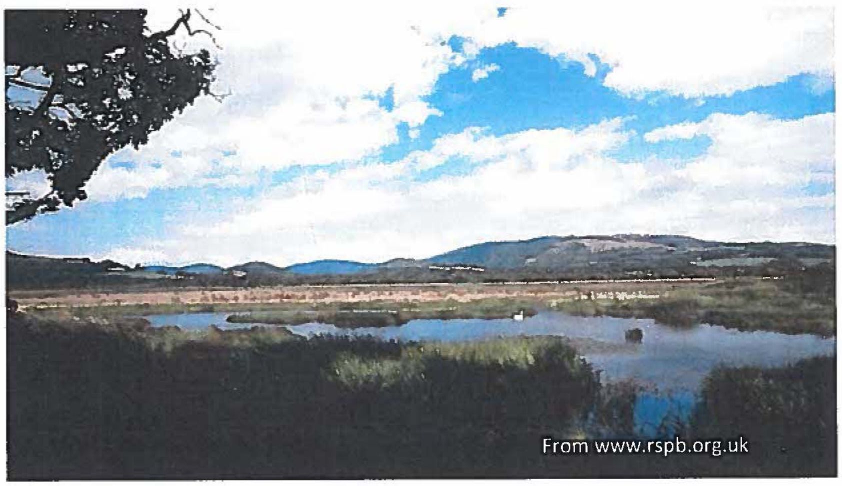
Candidate 2 evidence

Factors Affecting Biodiversity on the RSPB Mersehead Reserve

Advanced Higher Geography Study



Word count: 2722 (excluding list of contents, annotations to any illustrations, references, bibliography, appendices)

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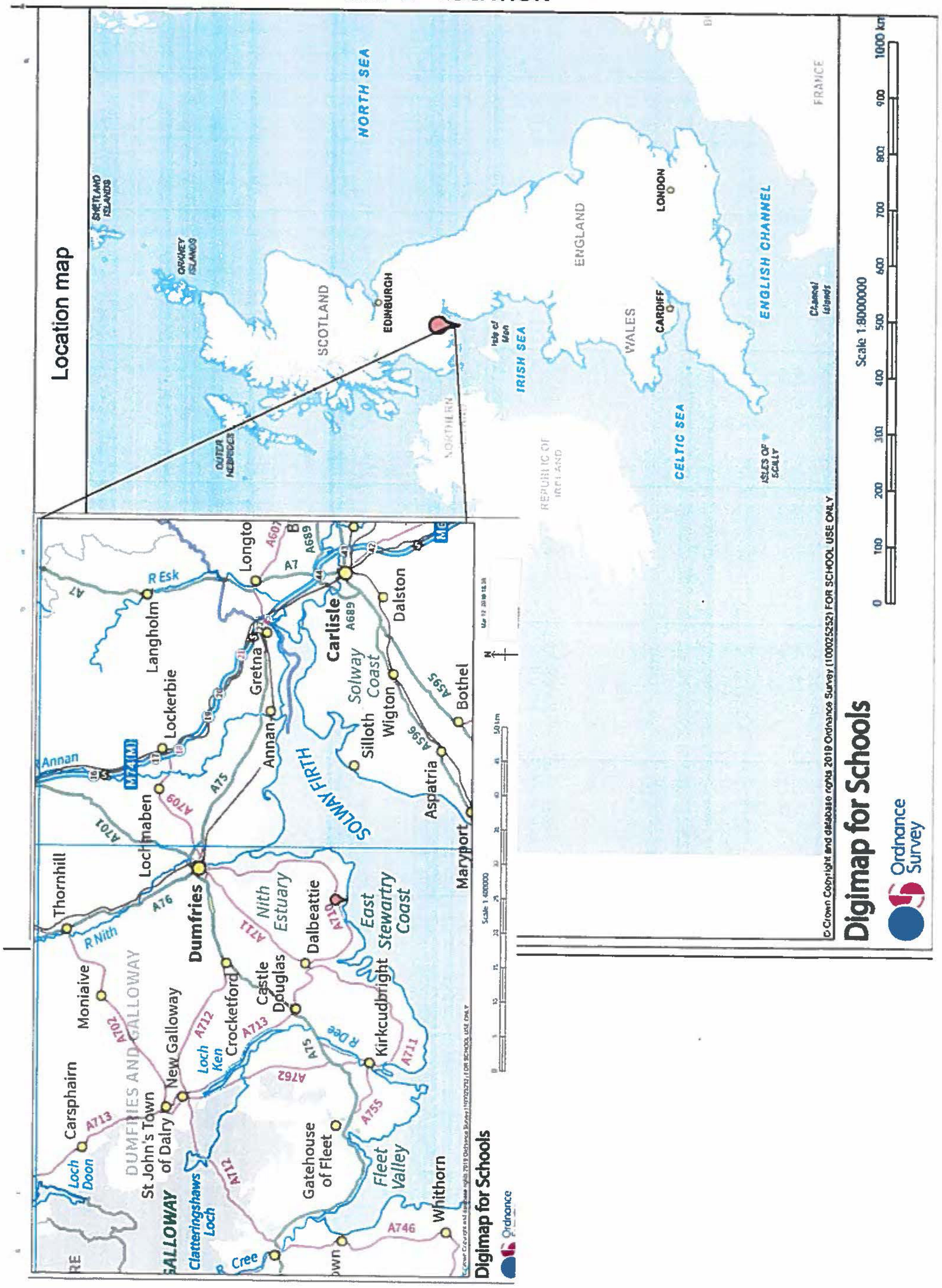
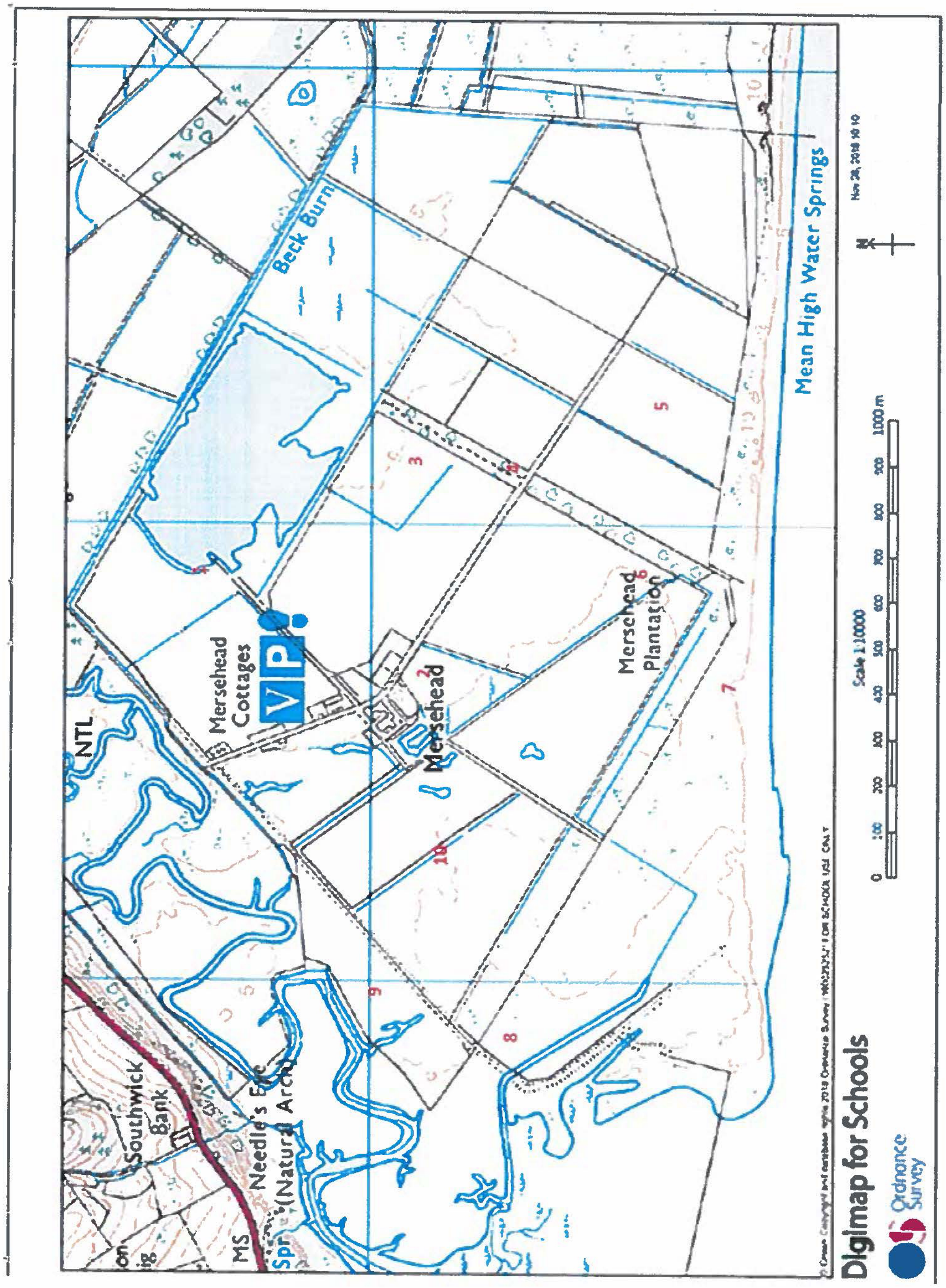
MAP 1 – LOCATION



MAP 2 – SITES ON MERSEHEAD RESERVE



Justification of Study

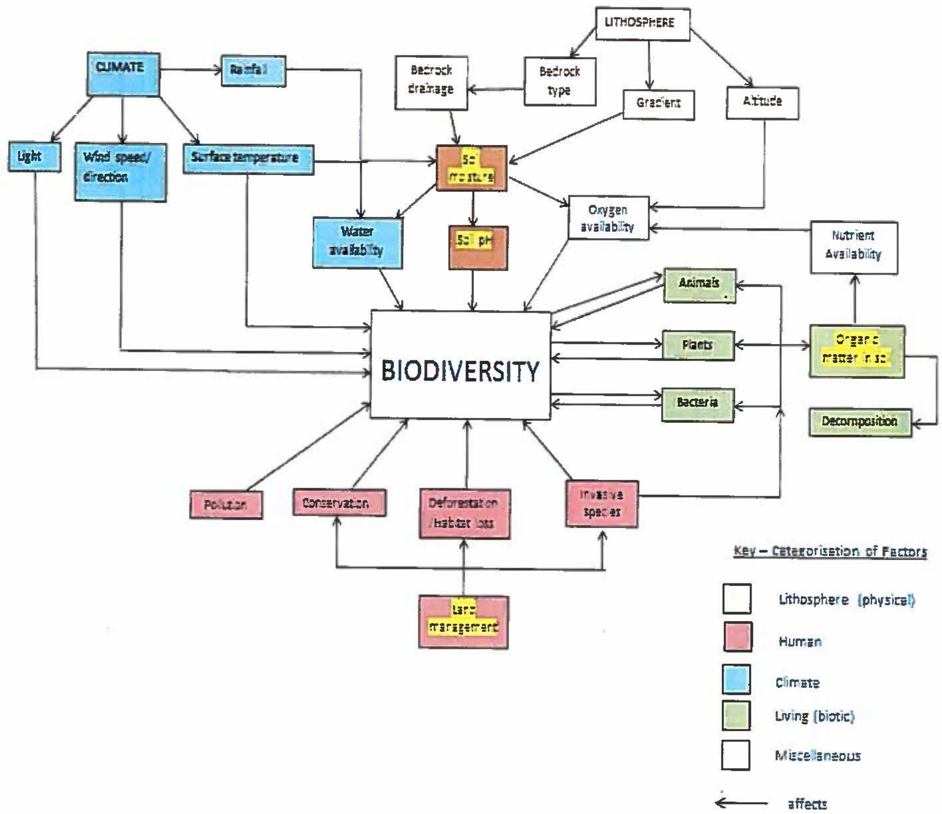
There is justification in studying biodiversity at the Mersehead Reserve, firstly because biodiversity is fundamental to the planet's ecology and natural systems (nutrient cycles, evolution, and decomposition amongst others) rely on it. There is reason to study further because biodiversity is reducing; vertebrate species populations have decreased by over 52% over the last 40 years [WWF Living Planet Report]. Thus, to sustain biodiversity we must understand the affecting factors so these can be utilised for biodiversity promotion. Conservation will be most successful when the understanding of these factors is considered, and how they interact to impact biodiversity. Human society is dependent on the environment, and the damaging repercussions of reducing biodiversity are already affecting societies globally.

A nature reserve was chosen because it provided a location with variability in habitats and theoretically factors affecting biodiversity. Land management is carried out by the RSPB here, allowing for the impact of this factor to be accounted for.

Theory: Factors affecting Biodiversity:

I attempted to create a diagram to represent the factors that theoretically affect biodiversity:

Diagram 1:



The factors highlighted in yellow were investigated and following research questions were chosen:

RQ1: Analysis of the relationship between soil moisture content and biodiversity

RQ2: Analysis of the relationship between soil pH and biodiversity

RQ3: Analysis of the relationship between organic matter content of soil and biodiversity

RQ4: Analysis of the relationship between land management strategies and biodiversity

APPROACH TO DATA COLLECTION:

Allocation of sites

Mersehead has a variety of established habitats, which are the result of both natural processes and land management strategies by the RSPB. To ensure the investigation was representative of the reserve a stratified sampling was used for the allocation of sites. The number of sites allocated to each distinct habitat was chosen based on percentage land cover. Habitat categorisation and data was taken from this table from *RSPB Mersehead Reserve Management Plan 2016-2021*, Figure 1:

Habitat		Code	Status	Area (ha)	Comments
Woodland and Scrub	Broadleaved, semi-natural, high forest	A.1.1.1.1		4.0	
	Scrub, scattered, neutral	A.2.2.2		10.1	
Grassland	Neutral, lowland	B.2.0.2		33.76	
	Improved/reseeded, lowland	B.4.2		51.86	
	Marshy, lowland	B.5.2	UKBAP	114.63	
Swamp and Fen	Wet reedswamp	F.1.1	UKBAP	4.0	
Open water	Open water, standing	G.1		2.0	
Coastland	Intertidal, mud/sand	H.1.1	UKBAP, SSSI	712.0	
	Intertidal, shingle	H.1.2		5.0	
	Saltmarsh	H.2.1	UKBAP, SSSI	66.25	
	Sand dune, inc. dune grassland	H.6	UKBAP, SAC, SSSI	30.25	
Cultivated/ disturbed land	Arable	J.1.1	UKBAP (field margins)	37.65	Spring cereals, wild bird cover crops and field margins
Boundary	Intact hedges	J.2.1	UKBAP	2.0	Species rich
	Ditches	J.2.6		3.0	
Built up	Agricultural buildings	J.3.1		0.9	
	Domestic buildings	J.3.2		0.6	
Other	Tracks/paths	J.5		4.0	
Total				1082	

PERCENTAGE LAND COVER CALCULATIONS:

(Intertidal zones were irrelevant so subtracted to give a total land area of 365ha)

Woodland/shrub: (14.1/365) x 100 = 4%
Grassland: (200.25/365) x 100 = 55%
Swamp: (4/365) x 100 = 1%
Open water: (2/365) x 100 = 0.5%
Saltmarsh: (66.25/365) x 100 = 18%
Sand dune, inc dune grassland: (30.25/365) x 100 = 8%
Arable: (37.65/365) x 100 = 10%
Boundary: (2/365) x 100 = 0.5%
Buildings: (1.5/365) x 100 = 0.4%
Tracks and paths: (4/365) x 100 = 1%

Figure 2A

LAND COVER PERCENAGE TO NUMBER OF SITES:

Woodland/shrub: 4% - 1 site
Grassland: 55% - 5 sites
Swamp: 1% - 0 sites
Open water: 0.5% - 0 sites
Saltmarsh: 18% - 2 sites
Sand dune: 8% - 1 site
Arable: 10% - 1 site
Boundary: 0.5% - 0 sites
Buildings: 0.4% - 0 sites
Tracks and paths: 1% - 0 sites

Figure 2B

The sites were allocated randomly within the habitats (see Map 2) prior to sampling through pencil pin-pointing, which is a relatively unscientific method. Because some inaccessible sites had to be changed so sampling could be carried out, the data is only representative of areas accessible. This increases the likelihood of these sites being impacted by human/animal presence e.g. trampling which is likely to affect primary producer growth.

This stratified sampling system is more effective than systematic transect sampling because a line that incorporated all habitats could not be plotted, so a transect method would be less representative of the reserve as a whole.

Sampling methods

(1) **Quadrat biodiversity sampling:** Primary producer (vegetation) biodiversity was measured using a $60cm^2$ quadrat. The quadrat was randomly placed on the ground and the number of different vegetation species within was recorded, three times for each site. This made the data more representative because an average was calculated.
A drawback of this method is the results are only a biodiversity indicator because vegetation is not equivalent to overall biodiversity. Sampling happened in October, so distinguishing between different species without flowers/shoots was difficult. Also, plants larger than $60cm^2$ could not be accounted for. However, this was consistent across all sites.

(2) **Soil sampling:** At each of the chosen sites soil was collected using an auger, which was wiped clean between uses to prevent cross-contamination. It was drilled to a consistent depth (marked line on auger). The soils were kept in separate zip-lock bags to prevent loss of moisture between collection and testing.

(3) **Testing soil pH:** To separate test tubes a spatula full of each soil sample was mixed with 10ml of deionised water. After stirring, a calibrated pH meter was used to record the pH.
An advantage is this method gave relatively reliable pH readings, by using a pH meter which is less subjective than universal indicator (comparing colour chart to solutions).
An inaccuracy of this method is that the heavier soil samples settled at the bottom of the test tubes. The precipitate did not dissolve sufficiently through the water giving a possibly more diluted and unrepresentative pH reading.

(4) **Testing soil moisture:** The crucible mass was record. The soil sample and crucible for each site were weighed together. The crucibles were placed into an electric drier and the re-weighed every hour until the mass no longer decreased.
This is an appropriate method because percentage moisture content can be calculated from results. To increase reliability of results the crucibles were placed in the electric drier at the same time and for the same duration until the mass no longer decreased by more than 0.05g.
A drawback of this method is that moisture may have been lost from the soil samples prior to testing, despite zip-lock bags being used. The drier may not have reached a high enough temperature to remove all wetness from the samples. Moisture content of soil would be directly affected by precipitation intensity prior to sampling; however sites were sampled on the same day to ensure this was consistent across all sites.

(5) **Testing organic matter content (OMC) of soil:** The mass of soil was weighed, then consecutively burned and re-weighed until the mass did not decrease by more than 0.003g.

See initial raw data from these sampling methods in Appendixes.

Interview

An interview with RSPB Warden, Rowena Flavelle, gave primary information about the RSPB's land management strategies. The Warden shared a copy of the management plan and answered these questions:

1. What land management strategies do the RSPB implant to create different environments on the RSPB Mersehead Reserve?
2. What challenges does the RSPB face when creating these environments?
3. What species do you expect to see at each of these environments; wetland, woodland, sand dunes and arable land?
4. Why do you encourage biodiversity in these different habitats?

Figure 3

Interviews are advantageous because information gathered is from an expert on the subject. The questions relate to the RSPB's actions/motivations, so hearing from a representative of this organisation is most appropriate way of extracting this information, specific to Mersehead.
A weakness of this method is that the interviewee may be inclined to present the RSPB positively, and gives subjective, qualitative data so cannot be statistical analysed. Thus it is difficult to definitively to state a significant relationship.

OVERALL RESULTS (TABLE 1):

Site	Habitat Type (based Figure 1)	Soil pH	Moisture content (%)	Organic matter (%)	Biodiversity reading	Biodiversity reading averages for selected habitats
1	Grassland	7.17	30.12	34.19	3	2.72
2	Grassland	7.13	14.64	15.44	1	
3	Grassland	6.99	29.26	33.50	4.3	
4	Woodland	5.30	31.48	46.54	3.3	3.3
5	Grassland	7.37	16.50	17.20	2	2.72
6	Arable	7.31	12.43	13.52	2	2
7	Sand dunes	7.46	0.37	1.51	1.3	1.3
8	Saltmarsh	7.28	31.34	36.48	2.3	1.65
9	Saltmarsh	7.29	40.43	45.25	1	
10	Grassland	7.12	33.07	62.86	3.3	2.72

RQ1 – Analysis of the relationship between soil moisture content and biodiversity

Theory

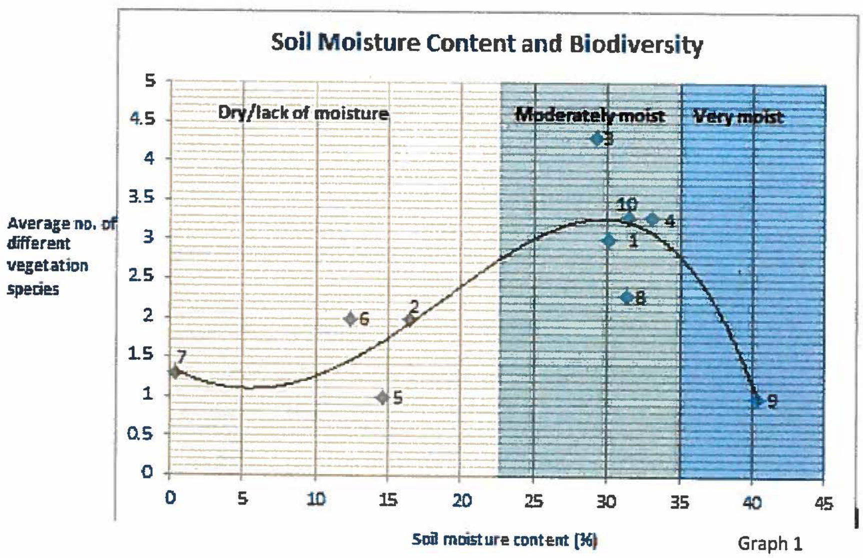
Soil moisture content is a primary water source for plants, so affects soil productivity. This is because plants require water; as a reactant of photosynthesis and because water it is a major component of their physiology – studies have suggest plants are ~90% water [scienceline.ucsb.edu]. Various studies have shown that reduction in soil moisture corresponds to a reduction in plant growth/productivity (see Appendixes, *Item 1*). A high biodiversity reading is only possible with high productivity.

Analysis

From table 1, it is clear that soil moisture does vary across the reserve, with a range of 40.06. Reasons for this variation include the sandy soil at site 7, where large void spaces increase infiltration rate, thus upper horizons lack moisture. Site 8 and 9 are close to the Beck Burn, site 1 is close to the freshwater pond and site 10's proximity to the ditch could possibly elevate soil moisture readings (see Map 2).

Based on the understanding that there is an optimum range for plant growth within the moderately moist interval, the results were graphed to see if an inverted 'U' relationship existed.

In moist soils voids are filled with water and anaerobic conditions discourage growth, whereas in dry soils there is not enough water to sustain plant-life. Graph 1 does suggest a non-linear relationship:



Graph 1

This parabolic relationship is supported by other studies (Appendixes, *Item 2*).

From table 1, site 7 has the lowest soil moisture reading of 0.37%, biodiversity is correspondingly reduced to 1.3. The limited number of plants here are generally grasses, e.g. Marram grass. Marram grass has unique adaptations for the dryness (see Diagram 2).

Diagram 2:

The leaves are rolled inward with a reduced number of stomata and thick waxy cuticle that reduce water loss through transpiration.

Marram grass is considered a pioneer species in psammosere succession. This grass is the early colonisers of the dunes due to their unique adaptations.

The sclerenchyma (thick layer of cells providing strength and mechanical structure) of marram grass is abundant so prevents damage by the coarse sand granules. Sclerenchyma is plant tissue that provides a stiff and strong outer layer.

The grasses have large root networks which extend both horizontally across the upper soil and with tributary roots stretching into deeper soils, to create a lager surface area for the absorption of water from the soil. In turn this helps stabilise and cement the sand dune.

Information from www.talkinggrass.co.uk and Journal of Material and Environmental Sciences

Site 9 has the highest soil moisture reading at 40.43% and lowest biodiversity reading of 1. Prolonged saturation causes anaerobic conditions, without oxygen plants cannot respire and germinate. Therefore only a limited variety of plants are present at site 9 because they have acquired unique reproductive (and other) adaptations, this can be said for plants surviving in other wet soils.

Conclusion

Specific adaptations are unique to relatively small variety of plants, so moist soils have a lower biodiversity index. At both extremes of soil moisture biodiversity is reduced, due to the increased limitations on plants. In turn, this would explain why the sites with the highest biodiversity readings, (3, 4 and 10) have soil moisture readings within the moderately most interval (from Graph 1).

RQ2 – Analysis of the relationship between soil pH and biodiversity

Theory

The soil pH is determined by the acidifying hydrogen (H^+) and alkaline hydroxyl (OH^-) ions concentrations. Theoretically, nutrient availability, microbe activity and toxicity are all determined by soil pH. Essentially, proteins make up all organisms and cannot function in extreme pHs (become denatured).

pH in soil is not consistent at different depths because nutrients are leached (accumulation of dissolved salts) into lower soils through a process called illuviation [www.britannica.com].

The optimum range for plant growth is generally taken to be between pH6.5 and pH7.5 [www.nutrientstewardship.com]. For this investigation the values in Figure 2 (USDA Natural Resource Conservation Service; 1998) will be referred to:

CATEGORISATION OF SOIL PH
The most common classes of soil pH are:
Extremely acid 3.5 – 4.4
Very strongly acid 4.5 – 5.0
Strongly acid 5.1 – 5.5
Moderately acid 5.6 – 6.0
Slightly acid 6.1 – 6.5
Neutral 6.6 – 7.3
Slightly alkaline 7.4 – 7.8
Moderately alkaline 7.9 – 8.4
Strongly alkaline 8.5 – 9.0

Figure 4

Analysis

The consistency of slightly alkaline readings is possibly because the RPSB lime acidic fields and/or the raised beach geomorphology of the reserve. Sandy soil is alkaline because the calcium carbonate (from shells) reacts with water to produce calcium hydroxide (alkali). Site 7 is closest to the sea; there is more calcium carbonate in the soil, explaining the higher pH reading. Site 4 (pH 5.3) is a deciduous woodland site so is likely to be supported by a brown earth soil. A common pH range for this soil is slightly acidic, between pH5.0 and pH6.5 [AS Level Geography; 2000].

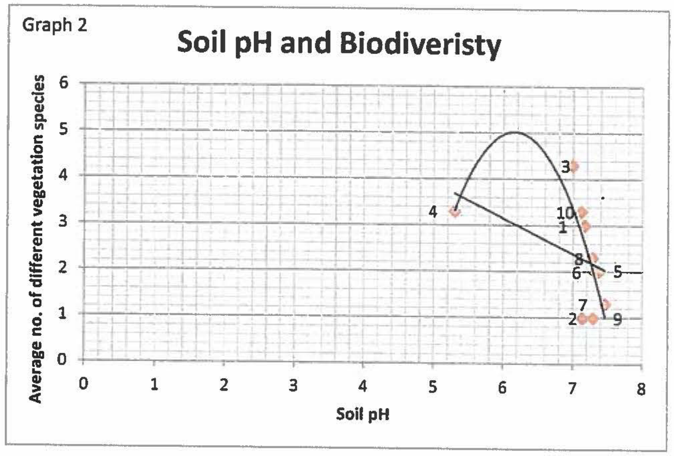
To test for the null hypothesis that no relationship exists between soil pH and biodiversity readings at the ten sites, both Spearman's rank and Pearson's coefficient correlations was carried out (see appendixes *Calculations 3*). The null hypothesis could be rejected by the Spearman's; a linear negative correlation between soil pH and biodiversity was proven to exist. The disadvantages and advantages of these methods are (see Figure 5):

	Spearman's rank correlation	Pearson's product moment correlation
Advantages	Establishes whether there is a linear relationship between two sets of data. Simple to calculate.	Establishes whether there is a linear relationship between two sets of data. Uses the actual values from the data, as a result is considered more powerful, because it takes into account extremes of data and the variation in size of intervals between values.
Disadvantages Both – not appropriate for non-linear relationships.	Uses a ranking system, not the actual values, so does not take into account the extremes of data and the variation in size of intervals between values. Does not establish direction of causation.	Does not establish direction of causation. Not as mathematically simple to calculate.

Figure 5

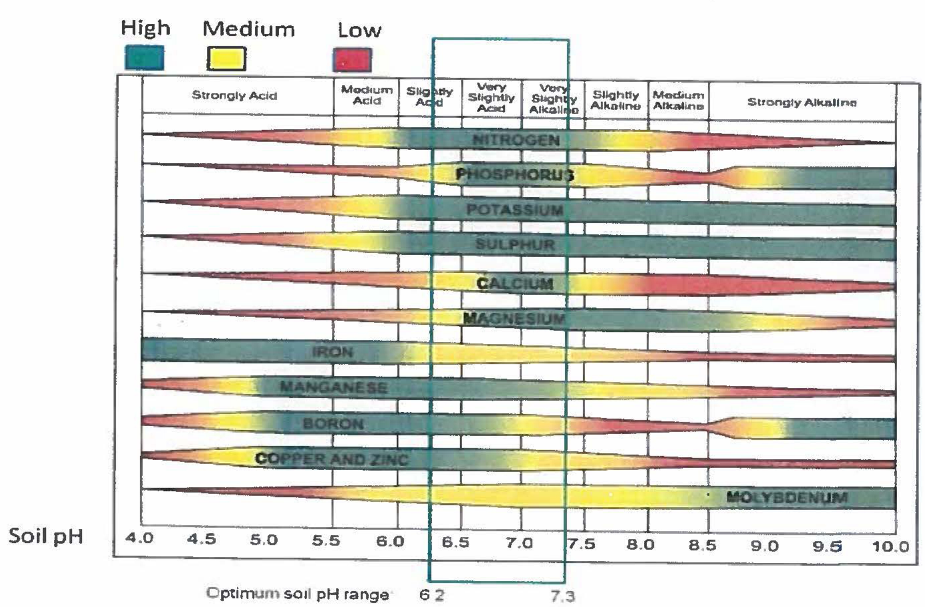
It could be suggested that a non-linear relationship exists because plant growth has an optimum pH range exceeding this plant growth (and biodiversity) would reduce. Some studies indicate this suggested non-linear relationship (see Appendixes, *Item 3*).

In Graph 2, a curved parabolic trend line does indicate this. However, this relationship cannot be proven to exist because the samples had a narrow range of pH readings. To investigate this further a greater variety of pHs would have to be sampled, though this does not occur across the Mersehead reserve.



The relationship between soil pH and biodiversity is closely linked to nutrient availability. Diagram 3 [www.planetpermaculutre.wordpress.com] shows that at between pH6.2 and 7.3 nutrient availability is maximised, this is approximately in line with the optimum range of biodiversity. This explains why site 7 has the highest pH and second lowest biodiversity reading; plant growth is stunted by a lack of nutrients. Nutrient availability is affected by pH because of the ionic interactions within the soil making ions insoluble so they cannot be absorbed by plants.

Diagram 3:



From www.planetpermaculutre.wordpress.com

My results suggest the optimum range should be expanding to include pH 5.3 based on site 4 in Graph 2.
Possibly soil does not always act as the nutrient reservoir; at site 4 the rapid decomposition of material and extraction by plants could result in biomass being the major nutrient reservoir. Therefore, the reduced pH would not inhibit nutrient accessibility so would affect biodiversity to a lesser extent.

Conclusion

The Spearman's value was within 0.02 of the significance table value so is a weak correlation, thus the potential for a parabolic relationship is not eliminated. Sites which have a greater biodiversity, sites 3 and 10, have a pH reading within the optimum range, because of nutrients are available. The close connection between nutrient availability and pH suggests that the abiotic factors which affect biodiversity are interrelated.

RQ3 – Analysis of the relationship between organic matter content of soil and biodiversity

Theory
To illustrate the theoretical relationship between plant growth and OMC I created Diagram 4:

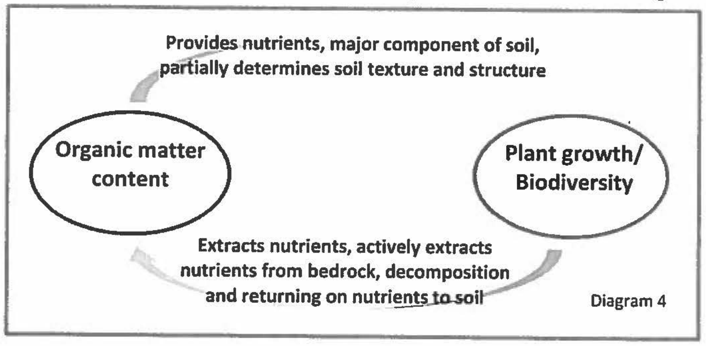
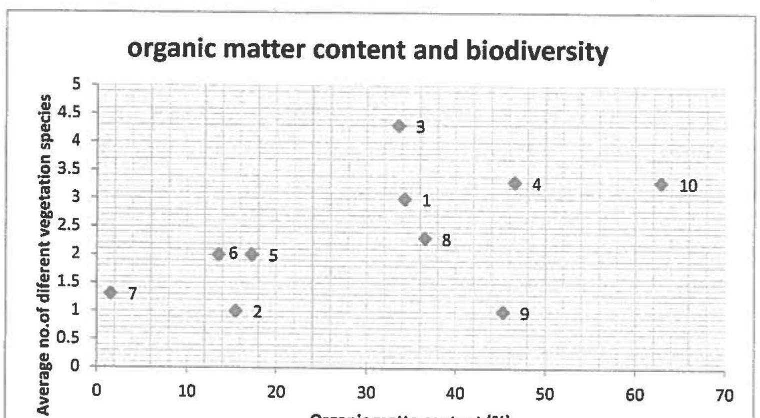


Diagram 4

Many studies (see Appendixes, *Item 4*) have shown that nutrient concentration affects plant growth. Nutrients are derived from organic matter in soil and for high biodiversity there must be nutrients available, thus there is reason to test this relationship.

Analysis
From table 1, OMC varies greatly across the ten sampled sites with a range of 61.35%.
The results were generally as expected, most notable site 7 has a low OMC (1.51%) due to the sandiness and site 9 has a high OMC (45.25%) possibly due the accumulation of alluvial deposits from the river. However, from Map 2 there is evidence to suggest that this deposition is not a significant given that site 8 is in closer proximity to the river, yet has a lower OMC reading.



Graph 3

Visually Graph 3 shows a loose relationship, as OMC increases, biodiversity increases (positive correlation). However due to anomalies like sites 2, 3 and 9, amongst others, this relationship cannot be proven. The null hypothesis was accepted from Spearman's rank or Pearson's coefficient correlations.

Conclusion

The OMC results show great variation but this factor is least closely linked to biodiversity across the ten sites. Possibly this is because although OMC may be present in soils it is not accessibly but plants due to the soil pH and/or the anaerobic conditions due to soil saturation (explaining site 8 and 9). The direction of causation in this relationship is difficult to decipher given that organic matter is derived from biotic material. From my analysis, this factor is not the most significant in affecting biodiversity.

RQ4 – Analysis of the relationship between land management strategies and biodiversity

Theory

The RSPB Mersehead reserve is managed '*to protect threatened birds and wildlife so that our towns, coast and countryside will once again teem with life*' [RSPB page on birdlife.org]. Thus it is clear that the RSPB does intend to intervene with the biodiversity of reserves and surrounding areas.

Analysis

From the interview, it was clear that the RSPB have two land management practices that significantly affect biodiversity.

Firstly, the RSPB have hydrological control of habitats through tile drains, flap values and 7.5km of ditches – water from the Beck Burn is used. Most notably at the grassland sites were a monoculture of grass is promoted by maintaining moderately moist conditions, because this area is a feeding ground for migratory Barnacle Geese; a key species for Mersehead. The grassland sites have a relatively high biodiversity readings (average of 2.72) possibly because soil moisture is moderated thus plant growth increases.

Secondly, the RSPB introduced a Natterjack toad community to the sand dunes, after the population diminished in a nearby location. This and the measures put in place to support the population - reducing 75% of grass sward length to less than 10cm and 25% to between 10 and 20cm, along with the removal of soft rush coverage to 20-30% [*RSPB Mersehead Management Reserve Plan 2016-2021*] – will affect the ecosystem at the sand dunes. Although the initial removal of rushes would reduce biodiversity if new vegetation does not colonize the available space this could promote biodiversity. These measures could help explain the relatively low biodiversity of sites 8 and 9.

Final Conclusion

Through the analysis of each factor it is clear that the biodiversity reading at each site is affected by a variety of different factors to differing degrees depending on the location. The convergence of factors – where one factor is extreme generally the other factors are also - presents the idea that factors must be interlinked and interdependent.

Referring back to Diagram 1, this is a somewhat adequate description of the relationships between factors and biodiversity. Fundamental all factors are interconnected, even from basic weathering process caused my climatic factors on the lithosphere.

Land management can be considered a very significant factor that affects biodiversity because it is how many affecting factors are controlled on the Mersehead reserve. In several cases the RSPB's practices could be the primary cause for reduced biodiversity readings, however the RSPB's priority is not to increase biodiversity index of each individual site but to increase biodiversity on the reserve as a whole. Also by maintaining conditions to sustain populations of rare or otherwise unsupported species, the RSPB may decrease the biodiversity on a small scale but over a greater area may significantly influence the biodiversity index nationally or even globally.

APPENDIX

Table 1: Raw data for soil pH

Site	pH meter test
1	7.17
2	7.13
3	6.99
4	5.30
5	7.37
6	7.31
7	7.46
8	7.28
9	7.29
10	7.12

Table 2: Raw data for soil moisture content

Site	1	2	3	4	5	6	7	8	9	10
Mass of empty crucible (g)	44.302	43.137	43.950	48.365	45.502	38.634	44.043	45.686	46.438	42.130
Initial mass of soil and crucible (g)	74.134	60.780	81.794	58.853	81.734	59.237	56.955	78.059	60.157	62.103
Initial mass of soil (g)	29.832	17.643	37.844	10.488	36.232	20.603	12.912	32.373	13.719	19.973
Mass of soil and crucible completely dried (g)	65.152	58.197	70.721	55.551	75.757	56.646	56.907	67.914	54.610	55.497
Mass of dried soil (g)	20.850	15.060	26.771	7.186	30.255	18.012	12.864	22.228	8.172	13.367
Mass lost through drying (g)	8.982	2.583	11.073	3.302	5.977	2.591	0.048	10.145	5.547	6.606
Moisture content	30.12%	14.64%	29.26%	31.48%	16.50%	12.43%	0.37%	31.34%	40.43%	33.07%

Table 3: Raw data for organic matter content

Site	1	2	3	4	5	6	7	8	9	10
Original mass of crucible	24.82	24.12	24.80	24.12	24.83	23.95	23.96	24.81	24.13	24.83
Original mass of soil and crucible	31.81	31.76	36.83	29.04	38.38	34.82	30.60	35.83	29.39	32.80
Mass of soil and crucible after burning	29.42	30.58	32.80	26.75	36.05	33.35	30.50	31.81	27.01	29.84
% organic matter	34.2	15.4	33.5	46.5	17.2	13.5	1.5	36.5	45.3	62.9

Biodiversity and Moisture

Calculation 1:

Spearman's rank correlation:

Null hypothesis –No relationship exists between moisture content of soil and the average number of vegetation species (biodiversity reading) at the sites.

Alternative hypothesis – There is a relationship between moisture content of soil and the average number of vegetation species (biodiversity reading) at the sites.

Site	Moisture content of soil (%)	Rank	Biodiversity reading (Av. No. of different veg species)	Rank	d	d^2
1	30.12	6	3	7	-1	1
2	14.64	3	1	1.5	1.5	2.25
3	29.26	5	4.3	10	-5	25
4	31.48	8	3.3	8.5	-0.5	0.25
5	16.50	4	2	4.5	-0.5	0.25
6	12.43	2	2	4.5	-2.5	6.25
7	0.37	1	1.3	3	-2	4
8	31.34	7	2.3	6	1	1
9	40.43	10	1	1.5	8.5	72.25
10	33.07	9	3.3	8.5	0.5	0.25
						$\sum d^2 = 112.5$

$r_s = 1 - \frac{(6\sum d^2)}{n(n^2-1)}$ $r_s = 1 - \frac{(6 \times 122.5)}{10(10^2-1)}$ $r_s = 1 - \frac{675}{990}$ $r_s = 0.3181818...$

$r_s = 0.32$

In the critical values table a degree of freedom of 10 has a significance level of 0.648 (for 95% certainty) and 0.794 (for 99% certainty). Therefore the null hypothesis must be accepted because r_s

equals 0.32 which is less than 0.648. So it can be stated that there is no relationship between moisture content and biodiversity.

Calculation 2:

Pearson's Product Moment Correlation Coefficient:

Null hypothesis –No relationship exists between moisture content of soil and the average number of vegetation species (biodiversity reading) at the sites.

Alternative hypothesis – There is a relationship between moisture content of soil and the average number of vegetation species (biodiversity reading) at the sites.

Site	Moisture content (%) (x)	Biodiversity reading (Av. No. of different veg species) (y)	$(x-\bar{x})$	$(y-\bar{y})$	$(x-\bar{x})^2$	$(y-\bar{y})^2$	$(x-\bar{x})(y-\bar{y})$
1	30.12	**3**	6.165	0.65	38.007225	0.4225	4.00725
2	14.64	**1**	-9.315	-1.35	86.769225	1.8225	12.57525
3	29.26	**4.3**	5.305	1.95	28.143025	3.8025	10.34475
4	31.48	**3.3**	7.525	0.95	56.625625	0.9025	7.14875
5	16.50	**2**	-7.455	-0.35	55.577025	0.1225	2.60925
6	12.43	**2**	-11.525	-0.35	132.825625	0.1225	4.03375
7	0.37	**1.3**	-23.585	-1.05	556.252225	1.1025	24.76425
8	31.34	**2.3**	7.385	-0.05	54.538225	0.0025	-0.36925
9	40.34	**1**	16.385	-1.35	268.468225	1.8225	-22.11975
10	33.07	**3.3**	9.115	0.95	83.083225	0.9025	8.65925

$\sum x=239.55$ $\sum y=23.5$

$\bar{x}=23.955$ $\bar{y}=2.35$

$\sum(x-\bar{x})^2=1360.28965$

$\sum(y-\bar{y})^2=11.025$

$\sum(x-\bar{x})(y-\bar{y})=51.6535$

$$r=\frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2\times\sum(y-\bar{y})^2}}$$

$$r=\frac{51.6535}{\sqrt{1360.28965\times 11.025}}$$

$$r=\frac{51.6535}{122.4630287}$$

$$r=0.421788\ldots..$$

$$r=0.422$$

Degrees of freedom= n-2 = 10-2 = 8

In the critical values table a degree of freedom of 8 has a significance level of 0.632(for 95% certainty) and 0.765 (for 99% certainty). Since the Pearson's Product moment correlation of 0.422 is less than these values the null hypothesis can be accepted. Therefore it can be stated that there is no relationship between soil moisture content and biodiversity.

Biodiversity and pH

Calculation 3:

Spearman's rank correlation:

Null hypothesis - No relationship exists between the pH of soil and the biodiversity reading at the sites.

Alternative hypothesis -There is a relationship between the pH of soil and the biodiversity reading at the sites.

Site	pH of soil	Rank	Biodiversity reading (Av. No. of different veg species)	Rank	d	d^2
1	7.17	5	3	7	-2	4
2	7.13	4	1	1.5	2.5	6.25
3	6.99	2	4.3	10	-8	64
4	5.30	1	3.3	8.5	-7.5	56.25
5	7.37	9	2	4.5	4.5	20.25
6	7.31	8	2	4.5	3.5	12.25
7	7.46	10	1.3	3	7	49
8	7.28	6	2.3	6	0	0
9	7.29	7	1	1.5	5.5	30.25
10	7.12	3	3.3	8.5	-5.5	30.25

$\sum d^2 = 272.5$

$r_s = 1 - \frac{(6\sum d^2)}{n(n^2-1)}$ $r_s = 1 - \frac{(6 \times 272.5)}{10(10^2-1)}$ $r_s = 1 - \frac{1635}{990}$ $r_s = -0.65151....$

$r_s = -0.65$

In the critical values table a degree of freedom of 10 has a significance level of 0.648 (for 95% certainty) and 0.794 (for 99% certainty). Therefore the null hypothesis can rejected with 95% certainty because 0.65 is greater than 0.648 although is less than 0.794 so it can be stated at a relationship exists between pH of soil and average number of different vegetation species.

The r_s is below zero so therefore the relationship is a negative correlation, as pH decreases the biodiversity reading increases thus creating a negative correlation. This can be seen when the two variables are graphed.

Biodiversity and Organic Matter

Calculation 5:

Spearman's rank correlation:

Null hypothesis - No relationship exists between the organic matter content of soil and the biodiversity reading at the sites.

Alternative hypothesis -There is a relationship between the organic matter content of soil and the biodiversity reading at the sites.

Site	Organic matter (%) (x)	Rank	Biodiversity reading (Av. No. of different veg species)	Rank	d	d^2
1	34.19	6	3	7	-1	1
2	15.44	3	1	1.5	1.5	2.25
3	33.50	5	4.3	10	-5	25
4	46.54	9	3.3	8.5	0.5	0.25
5	17.20	4	2	4.5	-0.5	0.25
6	13.52	2	2	4.5	-2.5	6.25
7	1.51	1	1.3	3	-2	4
8	36.48	7	2.3	6	1	1
9	45.25	8	1	1.5	6.5	42.25
10	62.86	10	3.3	8.5	1.5	2.25
						$\sum d^2 = 84.5$

$r_s = 1 - \frac{(6\sum d^2)}{n(n^2-1)}$ $r_s = 1 - \frac{(6 \times 84.5)}{10(10^2-1)}$ $r_s = 1 - \frac{507}{990}$ $r_s = 0.5121212...$ $r_s = 0.51$

In the critical values table a degree of freedom of 10 has a significance level of 0.648 (for 95% certainty) and 0.794 (for 99% certainty). Therefore the null hypothesis must be accepted because r_s equals 0.51 which is less than 0.648. So it can be stated that there is no relationship between moisture content and biodiversity.

Calculation 6:

Pearson's Product Moment Correlation Coefficient:

Null hypothesis - No relationship exists between the organic matter content of soil and the biodiversity reading at the sites.

Alternative hypothesis -There is a relationship between the organic matter content of soil and the biodiversity reading at the sites.

Site	Organic matter (%) (x)	Biodiversity reading (Av. No. of different veg species) (y)	$(x-\bar{x})$	$(y-\bar{y})$	$(x-\bar{x})^2$	$(y-\bar{y})^2$	$(x-\bar{x})(y-\bar{y})$
1	34.19	3	3.541	0.65	12.538681	0.4225	2.30165
2	15.44	1	-15.209	-1.35	231.313681	1.8225	20.53215
3	33.50	4.3	2.851	1.95	8.128201	3.8025	5.55945
4	46.54	3.3	15.891	0.95	252.523881	0.9025	15.09645
5	17.20	2	-13.449	-0.35	180.875601	0.1225	4.70715
6	13.52	2	-17.129	-0.35	293.402641	0.1225	5.99515
7	1.51	1.3	-29.139	-1.05	849.081321	1.1025	30.59595
8	36.48	2.3	5.831	-0.05	34.000561	0.0025	-0.29155
9	45.25	1	14.601	-1.35	213.189201	1.8225	-19.71135
10	62.86	3.3	32.211	0.95	1037.548521	0.9025	30.60045

$\sum x = 306.49$ $\sum y = 23.5$

$\bar{x} = 30.649$ $\bar{y} = 2.35$

$\sum(x-\bar{x})^2 = 3112.60229$ $\sum(y-\bar{y})^2 = 11.025$

$\sum(x-\bar{x})(y-\bar{y}) = 95.3855$

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \times \sum(y-\bar{y})^2}}$$

$$r = \frac{95.3855}{\sqrt{(3112.60229 \times 11.025)}}$$

$$r = \frac{95.3855}{185.246971}$$

r=0.5149099.....

r= 0.51

Degrees of freedom = n-2

In the critical values table a degree of freedom of 8 has a significance level of 0.632 (for 95% certainty) and 0.765 (for 99% certainty). Therefore the null hypothesis must be accepted because r equals 0.51 which is less than 0.632. So it can be stated that there is no relationship between organic matter content of soil and biodiversity.

Appendixes – Items

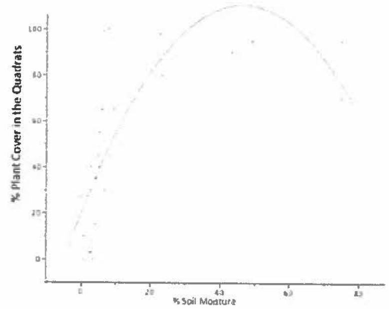
Item 1:

"*The Effect of Soil Moisture on the Growth and Yield of Vegetable Crops*" by J.F Bierhuizen and N. M. Devos from the Institute of Land and Water Management research in the Netherlands, stated that "*moderate soil moisture stress already causes a considerable decrease in vegetative growth*". From their study they found a relationship between soil moisture and plant growth.

Item 2:

This study taken from Palto Alto Baylands nature preserve, among others, indicates there is an optimum range of plant growth which occurs in the moderate soil moisture values. The data presented is shown in graphical form, although the y axis labelled "% plant cover in quadrat" and not biodiversity (average no. of different vegetation species), as previous noted, this productivity or plant cover will give an overall indication of plant growth. Increased variety in vegetation growth (biodiversity) is unlikely to occur without an equally high percentage of plant cover – productivity. Largely the two measures are very much connected, so it is justifiable to presume that if this inverted U shape relationship occurs with percentage plant cover and soil moisture then it is likely to also occur between biodiversity and soil moisture. Diagram from http://virtualmarsh.org/marsh-field-guide/palo-alto-baylands/.

% Plant cover as a function of Soil Moisture
(All unrestored & restored samples were used to increase the sample size which increases our confidence when testing this relationship)

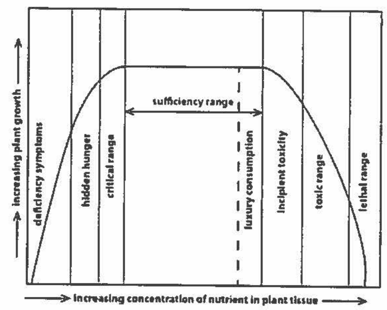


Item 3:

A study issued by the United States Department of Agriculture written by W.H. Allaway, "*pH, Soil Acidity and Plant Growth*",(1957), concluded that "the plants grew well except at extremely acid or extremely alkaline pH values".
From: Page 70, Yearbook of Agriculture 1957 from https://naldc.nal.usda.gov/download/IND43894850/PDF

Item 4:

One study, in the context of agricultural soil management, investigated the relationship between nutrient in plant tissue and plant growth. This is relevant to the relationship between organic matter and biodiversity because nutrient concentration within the plant is an indicator of nutrient concentration in the soil, because this is where nutrients are extracted from to become part of plants' composition. The following diagram shows this relationship, it was created by M. Raviv and J. H. Lieth, and was first published in their book *Soilless Culture: Theory and Practice* (2008).



Appendixes – Table

Table 1: Raw data for soil pH

Site	pH meter test
1	7.17
2	7.13
3	6.99
4	5.30
5	7.37
6	7.31
7	7.46
8	7.28
9	7.29
10	7.12

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