AQA
Realising potential

A-LEVEL

A-LEVEL GEOGRAPHY (7037)

EXAMPLE NEA INVESTIGATION

Marked investigation with commentary

An example investigation folder with completed proposal form and examiner commentary

To what extent do carbon stores vary between trees in William Farr woods and Hill Holt wood, Lincolnshire?

Version 1.0 November 2017

Contents

AQA Realising potential

2018 candidate record form

A-level Geography
NEA Independent fieldwork investigation (7037/C)

Please attach the form to your candidate's work and keep it at the centre or send it to the moderator as required. The declarations should be completed by the candidate and teacher as indicated.

Centre number	**Centre name**
Click here to enter.	Click here to enter text.
Candidate number	**Candidate's full name**
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Work submitted for assessment **must** be the candidate's own. If candidates copy work, allow candidates to copy from them, or cheat in any other way, they may be disqualified.

Candidate declaration

Have you received help/information from anyone **other than** subject teacher(s) to produce this work?

☒ No ☐ Yes *(give details below or on a separate sheet if necessary).*

Click here to enter text.

Please list below any books, leaflets or other materials (eg DVDs, software packages, internet information) used to complete this work **not** acknowledged in the work itself. Presenting materials copied from other sources **without acknowledgement** is regarded as deliberate deception.

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I have read and understood the above. I confirm I produced the attached work without assistance other than that which is acceptable under the scheme of assessment.

Candidate signature.

Date Click here to enter a date.

Teacher declaration

I confirm the candidate's work was conducted under the conditions laid out by the specification. I have authenticated the candidate's work and am satisfied (to the best of my knowledge) that the work produced is solely that of the candidate.

Teacher signature.

Date Click here to enter a date.

Candidate number Click here to enter.

Candidate's full name Click here to enter text.

NEA proposal

To be completed by the candidate

Investigation title	To what extent do carbon stores vary between trees in William Farr Woods and Hill Holt Wood, Lincolnshire?

How the title links to the specification content

3.1.1.3: The carbon cycle. Major stores of carbon-biosphere. 3.1.1.4: Water, carbon, climate and life on Earth. Human intervention in the carbon cycle designed to influence carbon transfers and mitigate the impacts of climate change.

Planned investigation hypothesis or question/sub-questions

I will investigate carbon stored in sample sites within the two woodlands in order to test the following hypotheses; 1: Carbon stores will be higher in a managed woodland and 2: Deciduous trees will have a greater carbon store than coniferous trees.

Investigation focus – indication of how the enquiry will enable the candidate to address the investigation title and explore the theme in relation to the chosen geographical area

William Farr woodland is a relatively small area close to where I live, which is a fully established wood yet completely unmanaged and contains both deciduous and coniferous vegetation. Hill Holt Wood also has mixed woodland and is sustainably managed through coppicing to promote increased biomass. Therefore these locations will be ideal to investigate my proposed hypotheses. I will expect to find higher carbon content at Hill Holt due to the management practices. Theory indicates deciduous trees have a higher carbon content so I expect to find differences between these two types of tree across the two woodlands.

Planned methodology – indication of qualitative and/or quantitative techniques including primary and, if relevant, secondary data collection techniques. Indication of the planned sampling strategy or strategies

Primary data collection will be based on sampling a 100m2 area in each woodland through random sampling and measuring tree circumferences and heights – using a tape measure, clinometer and tree species identification card. To calculate the biomass in each tree, I will use the data to then calculate the tree volume and then average the findings in the sample area. I will then scale this up to calculate the average carbon content in a hectare of woodland in that area. Data will also be calculated by tree type, deciduous vs coniferous. Data will be collected individually but I will ensure I have a parent or friend with me for safety reasons. Secondary information will be important to help with the calculations as well as the use of maps and tree species ID cards.

Data collection: ☒ Individual ☐ Group

To be completed by the teacher

Teacher approval for the investigation or details of any necessary amendments that need to be made before approval can be given

You have a clear direction for your proposed study with two testable hypotheses, which you have adapted from your recent fieldwork at the FSC centre. Ensure you are very clear exactly how to conduct your calculations for carbon content in the trees as these can be complex. You will need to seek permissions to conduct these studies in each woodland and consider ethical issues too.

☒ Approved ☐ Approved subject to the implementation of amendments above ☐ Resubmission required

Full name Click here to enter text.

Teacher signature.

Date Click here to enter a date.

To be completed by the teacher

Marks must be awarded in accordance with the instructions and criteria in the specification.

Area	Level	Overall level	Mark	Comment
Area 1. Introduction and preliminary research **10 marks** (a) To define the research questions which underpin field investigations (AO3)	4	3	8	Research question, securely identified and is explicitly referenced to the specification. Supported by use of relevant literature sources. Theoretical and comparative context are understood and stated.
(b) To research relevant literature sources and understand and write up the theoretical or comparative context for a research question (AO3)	3			
Area 2. Methods of field investigation **15 marks** (a) To observe and record phenomena in the field and devise and justify practical approaches taken in the field including frequency/timing of observation, sampling, and data collection approaches (AO3)	3	3	10	Clear use of appropriate data collection approaches and sampling. Explicit justification of data collection approaches. Clear demonstration of practical knowledge and understanding of appropriate field methodologies. Clear implementation of chosen methodologies with good quality, relevant data.
(b) To demonstrate practical knowledge and understanding of field methodologies appropriate to the investigation of human and physical processes (AO3)	3			
(c) To implement chosen methodologies to collect data/information of good quality and relevant to the topic under investigation (AO3)	3			

<table>
<tr><th>Area</th><th>Level</th><th>Overall level</th><th>Mark</th><th>Comment</th></tr>
<tr><td>Area 3. Methods of critical analysis
20 marks

(a) To demonstrate knowledge and understanding of the techniques appropriate for analysing field data and information and for representing results, and show ability to select suitable quantitative or qualitative approaches and to apply them (AO3)</td><td>3</td><td rowspan="3">3</td><td rowspan="3">10</td><td rowspan="3">Precise demonstration of appropriate techniques for analysing and representing results. Clear ability to select and apply suitable approaches. Partial ability to interrogate and critically examine data to comment on accuracy and the extent to which it is representative. Focused application of knowledge to order and understand observations.</td></tr>
<tr><td>(b) To demonstrate the ability to interrogate and critically examine field data in order to comment on its accuracy and/or the extent to which it is representative, and use the experience to extend geographical understanding (AO3)</td><td>2</td></tr>
<tr><td>(c) To apply existing knowledge, theory and concepts to order and understand field observations (AO2)</td><td>3</td></tr>
<tr><td>Area 4. Conclusions, evaluation and presentation
15 marks

(a) To show the ability to write up field results clearly and logically, using a range of presentation methods. (AO3)</td><td>3</td><td rowspan="3">3</td><td rowspan="3">9</td><td rowspan="3">Clear ability to write up results clearly and logically, using a range of presentation methods. Secure evaluation. Precise explanation of how results relate to the wider context(s). Clear understanding of the ethical dimensions. Partial ability to write a structured analysis of fieldwork findings in order to answer a specific geographical question. Draws inconsistently on evidence and theory to make a reasoned case.</td></tr>
<tr><td>(b) To evaluate and reflect on fieldwork investigations, explain how the results relate to the wider context and show an understanding of the ethical dimensions of field research. (AO3)</td><td>3</td></tr>
<tr><td>(c) To demonstrate the ability to write a coherent analysis of fieldwork findings in order to answer a specific geographical question and to do this drawing effectively on evidence and theory to make a well-argued case. (AO3)</td><td>2</td></tr>
<tr><td></td><td colspan="2">Total
(60 marks)</td><td>37</td><td></td></tr>
</table>

Details of additional assistance given

Record here details of any assistance given to this candidate which is beyond that given to the class as a whole and beyond that described in the specification (*continue on a separate sheet if necessary*).

No additional assistance given.

Concluding comments

Overall a sound hypothesis-led investigation conducted well. Preliminary research and methods are stronger than the analysis and conclusions. Nonetheless, the investigation is focused throughout and shows understanding of geographical context, with some good links.

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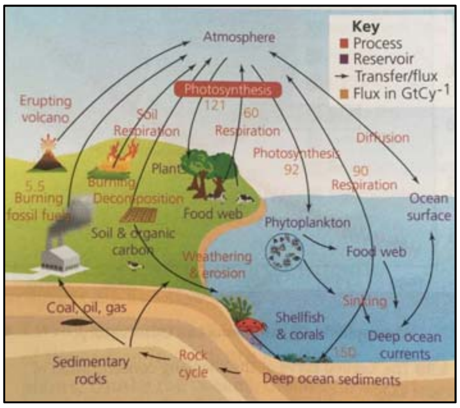
Introduction and preliminary research

Carbon: an introduction

Carbon is one of the most abundant elements on Earth. It originated from the Earth's interior when it was first being formed and escaped onto the surface through volcanic processes- which still continue today. It is stored throughout the planet; in the lithosphere, hydrosphere, atmosphere and biosphere and moves from one store to another through a closed system known as the carbon cycle. As seen in figure 1, the movement between the stores are known as transfers or fluxes and include processes such as photosynthesis and respiration. During the carbon cycle, the element transforms from organic carbon into inorganic carbon and back again.

Figure 1: The Carbon Cycle (Skinner et al, 2016)



Scientists predict there are more than ten million different carbon compounds in existence on Earth (Skinner et al 2016) but we study carbon dioxide (CO_2) in most detail due to the effect it has on our climate and the role humans have in this.

Carbon in the atmosphere

Carbon dioxide is a variable gas found within the atmosphere and although accounts for only 0.03% of atmospheric composition by volume (Waugh, 2009), it is nonetheless significant. Atmospheric levels of CO_2 have been relatively consistent for centuries until the Industrial Revolution where anthropogenic CO_2 levels began to increase, largely due to the burning of fossil fuels. Worldwide emissions of CO_2 are increasing today at more than 1% per year (Henson, 2006) which is fundamentally due to increases in global populations and subsequent growth in industry and agriculture. Between 2005 and 2014, this equates to 9Gt (billion tonnes) of carbon being released into the atmosphere each year from several geographical sources (Moriarty, 2017). Carbon dioxide is known as a greenhouse gas as it traps outgoing radiation from leaving the atmosphere, thus increasing global temperatures. Without such greenhouse gases the planet would have a global temperature 33°C lower than it is today (Waugh, 2009), however, there has been a significant rise in greenhouse gas concentrations in the past 150 years which is widely accepted as being a contributing factor to global climate change.

Area 1.1 a generalised introduction, not clearly linked to the investigation focus.

Carbon in the biosphere: a focus on plants

It is thought that 50% of the carbon entering the atmosphere stays there, 25% gets absorbed by the oceans and the remaining 25% enters land-based ecosystems (Henson, 2006). Through the process of photosynthesis, CO2 is captured to form carbohydrates thus enabling plants to increase biomass whilst releasing oxygen into the atmosphere. It could even be argued the increase in anthropogenic CO2 entering the atmosphere is stimulating plant growth and through photosynthesis it is being removed anyway so we don't need to worry about this increase in emissions. However, there are other factors which affect plant growth so this could be seen as an overly simplistic viewpoint.

Area 1.2 good use of literature sources. Well referenced. This section is more focused on the theme of investigation.

Introduction and preliminary research. Theoretical context well understood.

19% of all carbon found in the biosphere is stored in plants (Skinner et al 2016) which includes not only the visible part of the plant but also the below-ground biomass. It is widely accepted that the amount of carbon in the plant ranges from between 35% and 65% of the dry weight (Skinner et al 2016) but this figure is affected by the type of vegetation and location. Long-lived trees such as oak and beech are slow to mature therefore maximise carbon storage compared to fast growing species although willow for example is an effective carbon store (Adams, 2017). Jenkins et al (2001) shows broadleaved trees have a higher biomass than coniferous species which in turn will affect the amount of carbon stored. However, it is important to note there is also a seasonal variation in the amount of carbon taken up by plants; during the growing season, more carbon will be utilised during photosynthesis whereas the autumn will see carbon released as leaves fall from deciduous trees. (Moriarty, 2017). A similar variation will also be evident when comparing tree growth in the high latitudes to forests in the tropics due to the differences in incoming solar radiation.

Human intervention

Introduction and preliminary research. Theoretical context well understood.

It is well documented that forests can reduce the impact of CO2 emissions into the atmosphere by storing carbon within their biomass. People often intervene with sustainable forestry practices such as coppicing and maintaining early growth to maximise biomass (Adams, 2017) as well as to protect woodlands for current and future use. Hill Holt Wood in Lincolnshire is an example of a managed woodland and social enterprise who have an aim to run sustainably and 'off grid' (Hill Holt Wood [www]). They undertake coppicing regularly as part of their sustainable practices and actively manage the species within the woodland. Although people actively manage such woodlands, are they actually being successful in increasing biomass and therefore increasing carbon storage? Do broadleaved (deciduous) trees always have a higher biomass?

Hypotheses

Area 1.1 introduction and preliminary research.
The research question is effectively identified here and there is a clear reference to the specification 3.1.1.3 and 3.1.1.4.

These questions have led to the following focus for this investigation:

Hypothesis 1: Carbon stores will be higher in a managed woodland.

Hypothesis 2: Deciduous trees will have a greater carbon store than coniferous trees.

Area 1.2 introduction and preliminary research. Location is very clearly defined and justified. Good use of maps and some GIS in this section, although key for shading missing from aerial photographs.

Location of the investigation

Hill Holt Wood in Lincolnshire (figure 3 and 5) is a good location to study an established managed woodland due to the careful practices in place for sustainability as mentioned above. It is easy to access to collect the data needed and it a mixed forest. It is 13.7 hectares in area. In contrast, William Farr Woods in Welton, Lincolnshire is an unmanaged woodland but again is a mixed woodland and easy to access (figure 3 and 4). It is the site of an old RAF base but the woodland is very established and is 3.4 hectares in area.

Figure 2: Study areas in the wider context of the UK.

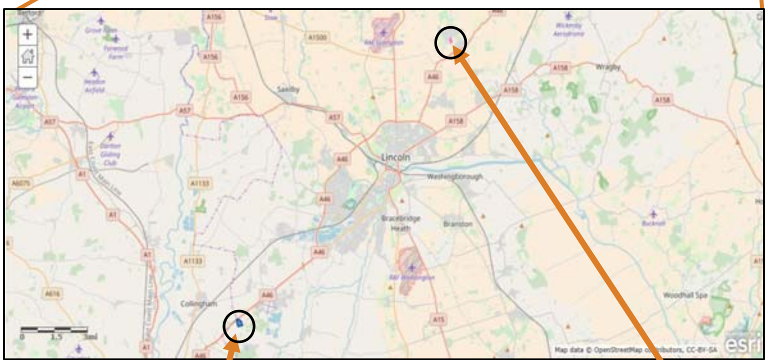


Figure 3: Study locations in the context of Lincoln

Location 2: Hill Holt Woods

Location 1: William Farr Woods

Figure 4: Location 1 – William Farr Woods

Figure 4: Location 2 – Hill Holt Woods

Area 2.1/2.2 methods of investigation: no evidence for overlay, however, a sound and justified method for identifying sample sites.

Area 2.1 methods of investigation. Well-reasoned justification of data collection approach.

Area 2.1/2.1 methods of investigation. Appropriate data collection approach, well justified. Detailed demonstration of knowledge of appropriate field methodology.

Area 2.1/2.2 methods of investigation. Well-reasoned justification of data collection approach. Detailed demonstration of knowledge of appropriate field methodology.

Area 2.2 methods of investigation. Detailed demonstration of knowledge of appropriate field methodology.

Methods of field investigation

Data collected	Method	Justification
Carbon storage	An overlay grid was created and each square in the grid was numbered. The overlay was attached over the maps for both sets of woods – William Farr Woods and Hill Holt Wood. A random number table was used to then pick out an area to study in each woodland. Once in that area of woodland a 10x10m² area was measured with tape measures and set out on the ground. In each area, all trees with a stem circumference greater than 7cm were recorded – anything less than this is classed as a sampling rather than a tree. The following measurements were needed to enable carbon storage calculations to be undertaken (see appendix). Height of the tree: • the angle to the top of the tree using a clinometer (Q) • distance stood from the base of the tree using a tape measure (Y) • distance from the ground to eye height using a tape measure (X) • the height of the tree (h) can then be calculated with the formula Y(tanQ)+X Stem volume: • the stem circumference was measured (in m) at breast height from the ground using a tape measure • the radius was then calculated by dividing the circumference by 2π • volume can then be calculated with the formula πr2 (h÷3). The stem volume can then used to calculate biomass of the tree truck. This is added to figures for the crown and root biomass (calculated with formula) to reach a total biomass figure which is needed for analysis later. This is using	An overlay and random number table was used to generate a randomly selected site and to eliminate any chance of bias. This sampling technique ensured that all areas in both woodlands were at equal chance of being selected for data collection. The clinometer used was essential in collecting the angle from eye level to the top of the tree – this data is an important data set to calculate carbon storage. The measuring tape were also an integral piece of equipment for collecting data for carbon storage. Due to it being made from flexible plastic it was appropriate for measuring tree stem circumference.

Area 4.2 evaluation. Some understanding of the ethical dimension for the research.

Area 3.2 evaluation. Some understanding of the ethical dimension for the research.

	guidance from the Field Studies Council [www] as well as Jenkins et al (2011). The tree species was identified using a tree species identification sheet. Data was recorded on a pre-designed recording sheet. **Ethical issues:** Care was taken to ensure no seedlings were trampled on. Measurements were taken quickly and quietly so wildlife wasn't disturbed too much. **Safety:** Measurements were not taken alone- a partner helped in the collection. Care was taken near brambles.	
Annotated photographs	Whilst in each woodland photographs were taken to annotate the differences between a managed and an unmanaged environment. **Ethical issues:** Care was taken to ensure no images were taken with people in them.	Photographs display clear evidence and for this study provides a clear and effective comparison. If field sketches had been completed, instead of photographs being taken, there is more room for human error and so photographs eliminate this.

Area 4.2 evaluation. Evaluation and reflection on the fieldwork investigation.

Issues

In the managed woodland the hazel trees had been coppiced so the base of the tree was split into many different stems. This may affect the carbon data and therefore, affect my conclusions.

The unmanaged woodland used to be an old RAF base and on the ground there was evidence of foundations to buildings. This may have affected the growth rate of trees and therefore the data we collected may not be fully representative for all unmanaged woodlands.

The photographs taken were of only the part of the wood where measurements were taken from. Therefore it may not be truly representative of the whole woodlands. Personal perspective could have also influenced the image taken.

Area 2.3 shows appropriate data collection, evidence in appendix with well-designed recording sheet for the task.

Detailed selection of the chosen methodology to collect good quality data which is relevant.

Area 3.1 presents data as table of results.

Results

(Full results tables can be found in the appendix.)

Figure 5: Results summary for Location 1: William Farr Woods

Average carbon mass per tree in the woodland (chosen area) in tonnes	0.002534833
Number of trees per 100m^2	15
Carbon stored in 100m^2 of the woodland in tonnes	0.0380225
Carbon mass per hectare (ha) of woodland in tonnes	3.80224999

Figure 6: Results summary for Location 2: Hill Holt Woods

Average carbon mass per tree in the woodland (chosen area) in tonnes	0.064173653
Number of trees per 100m^2	10
Carbon stored in 100m^2 of the woodland in tonnes	0.641736526
Carbon mass per hectare (ha) of woodland in tonnes	64.17365256

Figure 7: Average carbon content by tree type across both woodlands

	Tonnes of carbon (average)
Deciduous trees	0.14800
Coniferous trees	0.00021

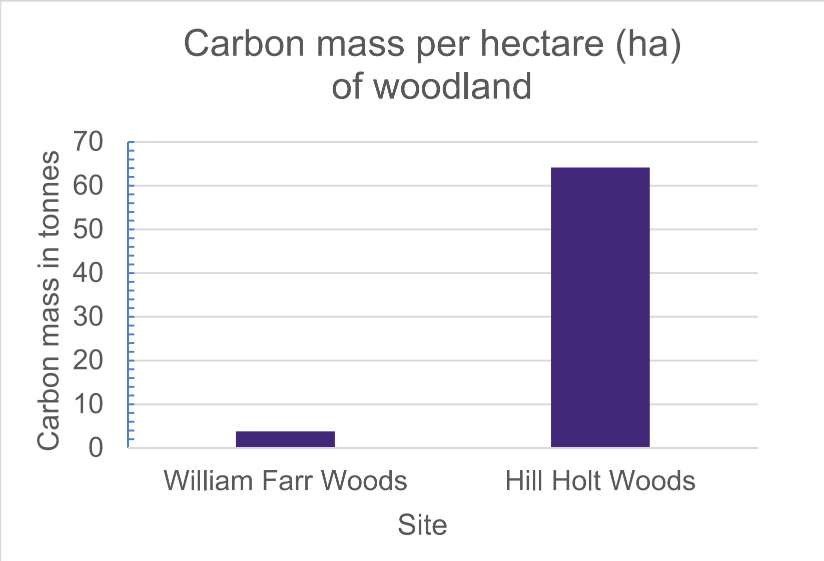
Area 3.1 methods of critical analysis. Simple demonstration of appropriate technique to present the data.

Methods of critical analysis

Hypothesis 1

Carbon stores will be higher in a managed woodland.

Figure 8: Carbon mass per hectare (ha) of woodland.



Area 3.1 methods of critical analysis. Starts to analyse results.

As shown in figure 8, there is a difference between the carbon mass per hectare found in William Farr Woods and Hill Holt Woods. The difference is 60.37 tonnes which shows support that carbon stores are higher overall in a managed woodland.

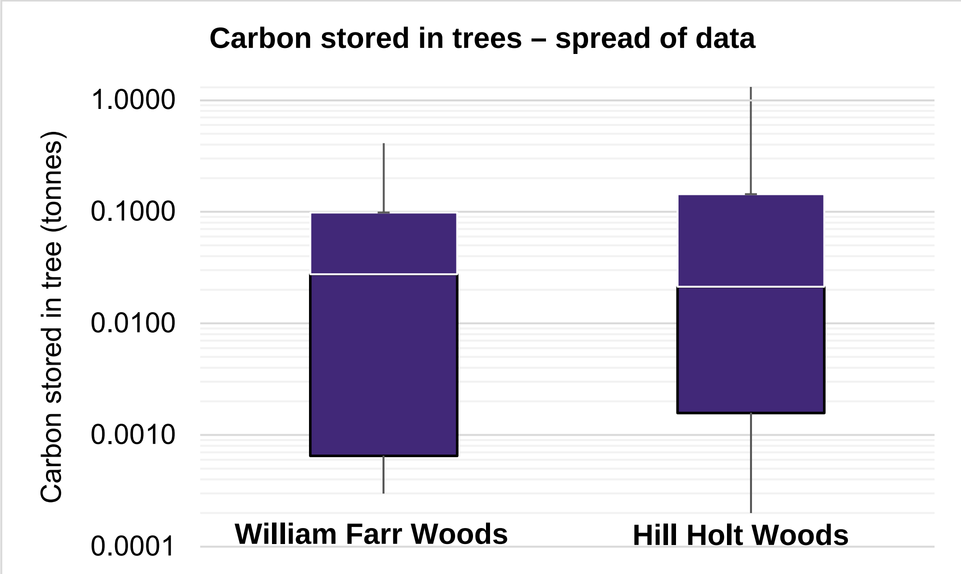
Area 3.2 evaluates reliability of fieldwork data.

Area 3.2 methods of critical analysis. Comments on accuracy of data and extent to which it is representation.

The mean averages shown in figure 5 & 6 are quite different (0.0025 in location 1 and 0.0642 in location 2), a difference of 0.0617 tonnes although the mean is more greatly affected by extreme values in the data set so may not be wholly reliable.

Area 3.1 methods of critical analysis. Demonstration of appropriate technique to present the data, with use of a logarithmic scale.

Figure 9: Spread of data found in each location



Area 3.2 methods of critical analysis. Starts to interrogate data.

Figure 9 shows there is a greater spread of data found in location 2 (Hill Holt Woods) than found in location 1 (William Farr woods). However, the medians were quite close 0.0275 in location 1 and 0.0213 in location 2 suggesting there isn't much of a difference in the carbon content in the two woodlands, far different from the data shown in figure 8 above.

Area 3.1 methods of critical analysis. Appropriate analysis – demonstrating knowledge and understanding of appropriate techniques for analysis.

In order to further analyse the results, a Mann–Whitney U test was carried out on the data to see if the difference seen in figure 8 was statistically significant.

The null hypothesis for the test was:

"There is no difference between the carbon content found in William Farr woods and Hill Holt woods".

Value of U = 75.5

Critical value = 39

Degrees of freedom = 0.05

Area 3.2 methods of critical analysis. Clear ability to interrogate and critically examine field data.

Having carried out the calculations, it was found that the U value (75.5) was higher than the critical value (39). This means with 95% certainty the null hypothesis can be accepted and although the raw data and figure 8 show a marked difference in the findings, this difference is not statistically significant. Therefore indicating hypothesis 1 for this investigation (Carbon stores will be higher in a managed woodland) needs to be rejected.

Graph not referred to in reference to either hypothesis.

Hypothesis 2

Deciduous trees will have a greater carbon store than coniferous trees.

Figure 10: Tree species found in location 1, William Farr woods.

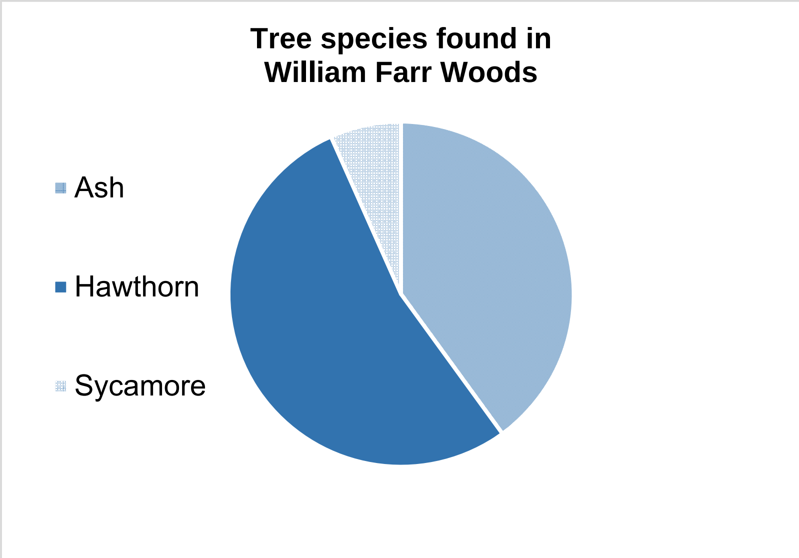


Figure 10 shows that there were only three types of tree found in the study area at William Farr woods all of which were deciduous.

Figure 11: Tree species found in location 2, Hill Holt Woods.

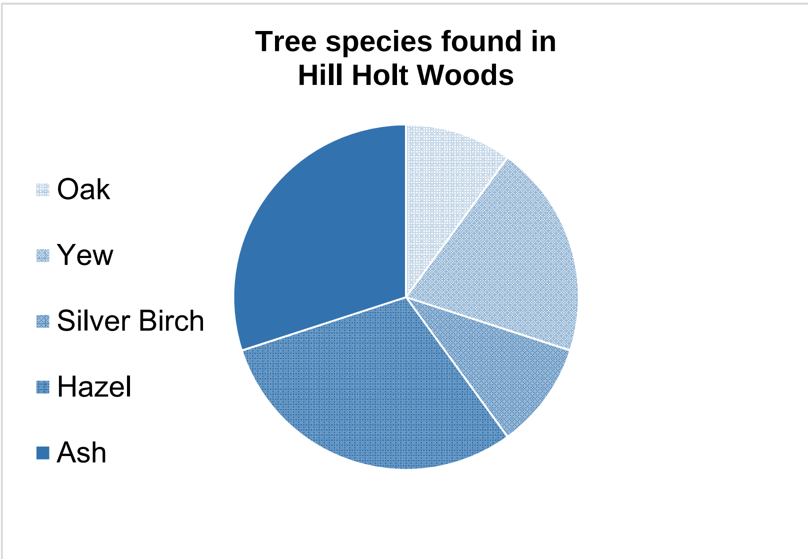
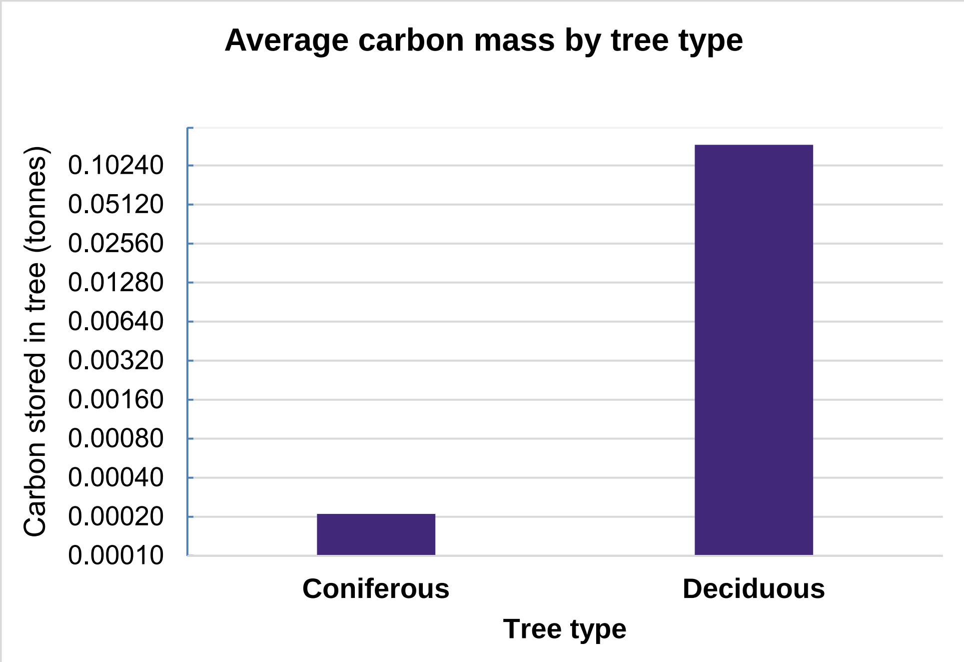


Figure 11 shows that there was more variety of tree species found at Hill Holt woods and some coniferous as well as deciduous.

Area 3.1 methods of critical analysis. Appropriate graph to represent the results, again simple.

Figure 12: Average carbon mass (tonnes) by tree type.



Area 3.2 evaluation and reflection on the fieldwork investigation.

Methods of critical analysis. Awareness of limitations of technique, based on small size of sample.

Figure 12 shows there appears to be a large difference between the average carbon mass of coniferous and deciduous trees. Coniferous trees showed an average of 0.00021 tonnes compared to deciduous trees showing 0.14800 tonnes on average- a difference of 0.14779 tonnes. However, there were only two coniferous trees sampled, both at location 2 (Hill Holt wood). Both these trees were small in size (2.8m and 2.75m in height) with narrow stems 0.09m and 0.01m. As the sample was small, conclusions cannot be drawn from this investigation. The sample is also too small to run a statistical test to establish differences between coniferous and deciduous trees.

Area 3.1/3.2 methods of critical analysis. Effective demonstration of knowledge and understanding for representing the results of field data collection. Qualitative approach effectively applied and existing knowledge of theory well applied.

Photographs – Location 1 (William Farr Woods)

Varying tree stem widths, with many stems covered with ivy. The ivy could be preventing the growth of the trees and therefore limiting the amount of carbon storage overall.

In the unmanaged woodland trees have fallen down and have not been removed. This overall is good for the ecosystem as it decomposes and carbon and nutrients return into the soil – providing a good environment for growth.

This woodland is unmanaged, yet it is clearly used regularly by the public as paths have been created from trampling. This damages the samplings which will therefore have a knock-on effect on the carbon storage potential versus the reality.

The woods had a lot of ferns and low level shrubs growing. These could limit the growth of trees for the futures if they prevent tree saplings to grow because of low light levels.

Area 3.1/3.2 appropriate technique used to show the data. Some analytical comments.

Area 3.1/3.2 methods of critical analysis. Qualitative approach effectively applied and existing knowledge of theory well applied.

Photographs – Location 2 (Hill Holt Woods)

Hazel trees in the woodland are clearly managed by being coppiced. Measuring the stems of the tree for calculating carbon storage is made more difficult and so data collected from this location may be less accurate due to this.

Due to the woodland being managed it has created a lot of space in the woodland for hazel trees to grow and develop. The space allows more light to to travel and therefore the tree's growth rate can increase. Thus, suggesting there will be a greater carbon storage.

There are very little invasive plants around the coniferous trees on the ground, allowing the trees to grow, yet as they are still small in height the carbon content may be low.

In the managed woodland it is clear to see the planting of coniferous trees. In the photograph a line of coniferous trees were growing in the same area suggesting that in this specific area the soil and light levels are ideal for growth, but are not necessarily found here.

Area 3.1/3.2 methods of critical analysis. Qualitative approach effectively applied and existing knowledge of theory well applied.

This deciduous tree is a good example of how successful a managed woodland can be. The tree's carbon storage is likely to high as its width and height are large when compared to similar trees in the unmanaged woodland.

In the managed woodland it is clear to see the active planting of trees and the clearing of space to allow for trees to grow. This, later on, impacts on the quantity of carbon storage as the trees have the chance to grow tall and wide as they are not having to compete for nutrients and sunlight.

The ground is cleared to allow for trees growth rate to be quicker (especially when compared to an unmanaged woodland). The lack of creeping and invasive plant/shrubs allows for deciduous and coniferous trees to develop.

Conclusion

Hypothesis 1

Carbon stores will be higher in a managed woodland.

Woodlands are managed for sustainability as well as to increase biomass (Adams, 2017). The investigation showed a difference between the mean carbon mass per hectare in the two woodlands with Hill Holt wood having a much higher figure than William Farr wood (0.0025 tonnes compared 0.0642 tonnes). This suggests the hypothesis can be accepted because there was a higher store of carbon found in the managed woodland.

However, the medians are more similar and the statistical test showed the difference is not significant enough to accept the hypothesis. Therefore the hypothesis of 'carbon stores will be higher in a managed woodland' will in fact be rejected. These findings were a surprise when compared to the literature. Coppicing is the preferred method for sustainable management at Hill Holt (see figure 14) and as such it was expected the figures for stem biomass and therefore carbon content would be much higher than that found at William Farr woods.

Hypothesis 2

Deciduous trees will have a greater carbon store than coniferous trees.

Jenkins et al (2001) shows broadleaved trees have a higher biomass than coniferous species which in turn will affect the amount of carbon stored. This was supported by the findings in William Farr and Hill Holt woods. Coniferous trees showed an average of 0.00021 tonnes compared to deciduous trees showing 0.14800 tonnes on average- a difference of 0.14779 tonnes as shown in figure 12. Slower growing deciduous trees will often have a greater stem circumference therefore root biomass will be larger to support the weight. This will increase the overall biomass which again was supported by the findings of the investigation. The findings of the investigation supported the literature because deciduous trees were found to have a higher carbon content in these woodlands. However, sample size was not representative so these results could simply be anomalies.

From this fieldwork, it is clear there are a number of future investigations that could take place to research this subject further. The findings from these two chosen woodlands were inconclusive due to the reasons shown in the evaluation. Therefore by extending the study within these woodlands to ensure a fairer representation of the woodland (i.e. with more sites within each) could result in different findings. Alternatively, different woodlands maybe a better option as William Farr woods had a past use which could have affected these and potential future results. On a larger scale, carbon storage in trees could be investigated by comparing woodlands at differing latitudes or altitudes to see if there are differences due to climatic reasons.

Area 4.2 evaluation. Effective evaluation and reflection on the fieldwork investigation seen throughout this section.

Area 4.3 conclusions drawn on both hypotheses, with attempt to provide summative statement. Clear link to literature review/theoretical context.

Area 3.2 methods of critical analysis. Comments on accuracy and the extent to which the data is representative.

Evaluation

	Problem	Possible solution	Links to results and conclusions
Hypothesis 1: Carbon stores will be higher in a managed woodland	The unmanaged woodland (William Farr Woods) previously used to be on a RAF base and so underneath the woodland there is some evidence of former foundations for buildings. This could affect the location of where trees are able to grow within the woodland and, as a random number table was used to establish where to collect data from, I could have ended up in a sparse area which may not be fully representative of an unmanaged woodland.	To choose an unmanaged woodland which has had no former use in the past. This may mean the accessibility may not be as good but the results are more likely to be reliable because there would not be previous human activity to affect the results. Perhaps more than one $10x10m^2$ area could be sampled if the study were to be repeated- again to eliminate such issues.	Any data collected from an area of the William Farr Woods which has been affected by its former use may have affected the findings. The carbon storage calculated may not be as high as a different area of the woodland as foundations or previous clearing will affect the growth rate of the tree and subsequently the amount of carbon stored. It could be for this reason my findings suggest the hypothesis should be rejected due to the site chosen not being fully representative of an unmanaged woodland.
Hypothesis 2: Deciduous trees will have a greater carbon store than coniferous trees	Despite being an area of mixed woodland, there were no coniferous trees in the unmanaged woodland sample site and there were several small trees intentionally planted in groups in the managed woodland. Again this could have been due to the use of a random	To take a greater number of samples (three 10x10m squares) will ensure a fairer representation of each woodland and types of trees included in both woodlands. Alternatively, choose a more stratified sampling technique to decide locations within the	Due to being a mix of coniferous and deciduous trees, but less coniferous overall in both woodlands, the data we collected could have been overall inaccurate and not truly representative of each of the woodlands. Therefore, my conclusion made for my hypotheses 'deciduous trees will have a greater carbon store than

	number generator with overlay to determine the chosen sites for the study.	woodlands to ensure a more even sample of each tree type.	coniferous trees' again may well be due to the lack of data rather than due to actual findings.

Area 1.2 introduction and preliminary research. Clear use of relevant literature sources. Well-referenced.

References

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Appendices

1. Data collection table

Tree number	Lay out a 10x10 grid in the woodland. **Total number of trees in 100m^2 =**	Stand away from the base of the tree (on the same level as it) and measure the angle to the top of the tree **(Q)** =	Measure the distance/ m from your feet to the base **(Y)**=	**Distance (X) /m from the ground to your eye** =	**Stem circumference (C)/m** at breast height from ground =
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					

2. Raw data table

William Farr Woods	Lat	0.000017*(	Long
Location 1: Co-ordinates…	53.302445		-0.47794

	Ash	Ash	Hawthorn	Ash	Hawthorn	Ash	Hawthorn	Hawthorn	Hawthorn	Hawthorn	Ash	Ash	Hawthorn	Sycamore	Hawthorn
Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Lay out a 10x10 grid in the woodland. **Total number of trees in 100m2 =**	15														
Stand away from the base of the tree (on the same level as it) and measure the angle to the top of the tree **(Q) =**	65	68	47	70	48	60	68	67	68	68	82	69	60	43	68
Measure the distance /m from your feet to the base **(Y)=**	2.5	2.7	2.9	2.3	2.9	3.4	1.4	1.4	1.4	1.4	2.1	2.5	2.8	2.8	2.2
Distance (X) /m from the ground to your eye =	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Height (h) /m = Y(tan Q) + X =	6.96127	8.2827	4.7099	7.9192	4.8208	7.489	5.0651	4.8982	5.0651	5.0651	16.542	8.1127	6.4497	4.211042241	7.0452
Stem circumference (C)/m at breast height from	0.65	1.9	0.6	1	0.9	1.1	0.13	0.1	0.09	0.12	1.35	0.57	0.42	0.09	0.46

ground =															
Stem circumference (C)/cm at breast height from ground =	65	190	60	100	90	110	13	10	9	12	135	57	42	9	46
Stem Radius (r)/m = Circumference/2π =	0.10345	0.3024	0.0955	0.1592	0.1432	0.1751	0.0207	0.0159	0.0143	0.0191	0.2149	0.0907	0.0668	0.014323945	0.0732
Stem volume (as a cone) /m^3= πr^2 (h÷3) =	0.07802	0.7931	0.045	0.2101	0.1036	0.2404	0.0023	0.0013	0.0011	0.0019	0.7997	0.0699	0.0302	0.000904781	0.0395
in cm	0.00078	0.0079	0.0004	0.0021	0.001	0.0024	2E-05	1E-05	1E-05	2E-05	0.008	0.0007	0.0003	9.04781E-06	0.0004
To calculate the crown and root biomass you need to know the diameter (DBH). **Diameter /m=** 2r =	0.2069	0.6048	0.191	0.3183	0.2865	0.3501	0.0414	0.0318	0.0286	0.0382	0.4297	0.1814	0.1337	0.02864789	0.1464
DBH cm	20.6901	60.479	19.099	31.831	28.648	35.014	4.138	3.1831	2.8648	3.8197	42.972	18.144	13.369	2.864788976	14.642
Nominal Specific Gravity	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.49	0.53
Calculated crown biomass	0.03085	0.4152	0.0253	0.0897	0.0691	0.1135	0.0006	0.0003	0.0002	0.0005	0.1885	0.0223	0.0105	0.000230425	0.0131
Calculated root biomass	0.04479	0.4032	0.0367	0.1315	0.101	0.1669	0.0008	0.0004	0.0003	0.0007	0.2784	0.0323	0.015	0.000319492	0.0189
Total biomass /tonnes = **stem biomass + crown biomass +root biomass =**	0.07604	0.8226	0.0622	0.2222	0.1706	0.2816	0.0014	0.0007	0.0006	0.0011	0.4712	0.0549	0.0256	0.00055435	0.0322

Carbon stored in the tree /tonnes = biomass ÷ 2 =	0.03802	0.4113	0.0311	0.1111	0.0853	0.1408	0.0007	0.0004	0.0003	0.0006	0.2356	0.0275	0.0128	0.000277175	0.0161
Average carbon mass per tree in the woodland (chosen area)=	0.002534833														
Number of trees per 100m2 =	15														
Carbon stored in 100m2 of the woodland/tonnes **= average carbon per tree x number of trees in 100m2**	0.0380225														
Carbon mass per hectare (ha) of woodland /tonnes = carbon mass in 100m2 x 100 =	3.80224999														

Hill Holt Woods Lat Long
Location 1: Co-ordinates… 53.133335 -0.71324

	Oak	Yew	Yew	Silver Birch	Ash	Hazel	Hazel	Ash	Hazel	Ash
Tree number	1	2	3	4	5	6	7	8	9	10
Lay out a 10x10 grid in the woodland. **Total number of trees in 100m2 =**	10									
Stand away from the base of the tree (on the same level as it) and measure the angle to the top of the tree **(Q)** =	73	31	30	39	61	59	83	75	78	56
Measure the distance /m from your feet to the base **(Y)**=	1.65	2	2	1.96	2	4.9	2.15	2.3	2.7	2.35
Distance (X) /m from the ground to your eye =	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Height (h) /m = Y(tan Q) + X =	6.99691	2.8017	2.7547	3.1872	5.2081	9.755	19.11	10.184	14.303	5.084
Stem circumference (C)/m at breast height from ground =	2.05	0.09	0.1	0.1	0.29	4	1.19	0.77	0.6	0.4
Stem Radius (r)/m = Circumference/2π =	0.32627	0.0143	0.0159	0.0159	0.0462	0.6366	0.1894	0.1225	0.0955	0.0637

Stem volume (as a cone) /m^3= πr^2 (h÷3) =	0.779 98	0.000 6	0.000 7	0.000 8	0.011 6	4.140 1	0.717 8	0.160 2	0.136 6	0.021 6
in cm	0.007 8	6E-06	7E-06	8E-06	0.000 1	0.041 4	0.007 2	0.001 6	0.001 4	0.000 2
To calculate the crown and root biomass you need to know the diameter (DBH). **Diameter /m=** 2r =	0.652 54	0.028 6	0.031 8	0.031 8	0.092 3	1.273 2	0.378 8	0.245 1	0.191	0.127 3
DBH cm	65.25 35	2.864 8	3.183 1	3.183 1	9.231	127.3 2	37.87 9	24.51	19.09 9	12.73 2
Nominal Specific Gravity	0.56	0.39	0.39	0.53	0.53	0.53	0.53	0.53	0.53	0.53
Calculated crown biomass	0.480 46	0.000 2	0.000 3	0.000 3	0.004 2	1.329	0.137 9	0.046 9	0.025 3	0.009 3
Calculated root biomass	0.798 64	0.000 2	0.000 2	0.000 4	0.006	1.392	0.203 1	0.068 4	0.036 7	0.013 3
Total biomass/tonnes = **stem biomass + crown biomass +root biomass =**	1.283 47	0.000 4	0.000 5	0.000 7	0.010 2	2.742 9	0.344 8	0.116 2	0.062 7	0.022 7
Carbon stored in the tree/ tonnes = biomass ÷ 2 =	0.641 74	0.000 2	0.000 2	0.000 4	0.005 1	1.371 4	0.172 4	0.058 1	0.031 3	0.011 3

Averages by tree type

	Average in tonnes
Carbon Content – Deciduous	0.14800
Carbon Content – Coniferous	0.00021

William Farr Tree	Carbon content – Deciduous	Carbon content – Coniferous
1	0.03802	
2	0.41132	
3	0.03110	
4	0.11112	
5	0.08532	
6	0.14082	
7	0.00069	
8	0.00036	
9	0.00028	
10	0.00057	
11	0.23558	
12	0.02745	
13	0.01282	
14	0.00028	
15	0.01609	

Hill Holt Tree	Carbon content – Deciduous	Carbon content – Coniferous
1	0.64174	
2		0.00019
3		0.00024
4	0.00036	
5	0.00510	
6	1.37144	
7	0.17242	
8	0.05809	
9	0.03134	
10	0.01134	

Mann-Whitney U test

Site 1	Rank	Site 2	Rank
0.00028	3	0.00020	1.5
0.00030	4	0.00020	1.5
0.00040	5.5	0.00040	5.5
0.00060	7	0.00510	9
0.00070	8	0.01130	10
0.01280	11	0.03130	15
0.01610	12	0.05810	17
0.02750	13	0.17240	21
0.03110	14	0.64174	24
0.03802	16	1.37140	25
0.08530	18		
0.11110	19		
0.14080	20		
0.23560	22		
0.41130	23		
	195.5		**129.5**

Deciduous	Rank	Coniferous	Rank
0.00028	3	0.00020	1.5
0.00030	4	0.00020	1.5
0.00040	5.5		
0.00040	5.5		
0.00060	7		
0.00070	8		
0.00510	9		
0.01130	10		
0.01280	11		
0.01610	12		
0.02750	13		
0.03110	14		
0.03130	15		
0.03802	16		
0.05810	17		
0.08530	**18**		
0.11110	19		
0.14080	20		
0.17240	21		
0.23560	22		
0.41130	23		
0.64174	24		
1.37140	25		
	322		3

Commentary

To what extent do carbon stores vary between trees in William Farr Woods and Hill Holt Wood, Lincolnshire?

Area 1: Introduction and preliminary research (10 marks)

To define the research questions which underpin field investigations. (AO3)

The aim of the investigation is effectively identified, ie investigating carbon storage in the two woodlands; William Farr woods and Hill Holt woods. A hypothesis-led approach has been taken from the aim and these two hypotheses are stated. These are clearly testable in the field and link to the overall aim.

Links to the specification are:

- **The carbon cycle**

Major stores of carbon – biosphere.

- **Water, carbon, climate and life on Earth**

Human intervention in the carbon cycle designed to influence carbon transfers and mitigate the impacts of climate change.

These are completely referenced on the proposal form.

Level 4 (lower): a research question that is effectively identified and is completely referenced to the specification.

To research relevant literature sources and understand and write up the theoretical or comparative context for a research question. (AO3)

The theoretical context to the area of study is well understood, although the first part is not directly linked to the investigation and is too generalised. Use of geographical literature demonstrates a good range of sources and is well referenced using the Harvard referencing style. The use of sub headings strengthens the section and enables the context of the investigation to be clear leading into the two hypotheses. Figure 1 (the carbon cycle diagram) is embedded in the text and relevant to the section ‘Carbon: An introduction’. The use of maps at various scales gives a sound geographical context to the investigation.

Level 3: supported by focused use of relevant literature sources. Theoretical and comparative contexts are consistently understood and stated.

Level 3

8 marks

Area 2: Methods of field investigation (15 marks)

To observe and record phenomena in the field and devise and justify practical approaches taken in the field including frequency/ timing of observation, sampling, and data collection approaches. (AO3)

Appropriate methods are clearly identified and linked to the hypotheses along with explicit justification. Limited range of approaches (tree height, circumference and species along with photographic evidence) although these are appropriate to the investigation. The use of an appropriate sampling strategy has been clearly identified along with explanation of how this was undertaken (through a grid system and random number table), although reasons for rejecting other sampling methods have not been stated.

Level 3 (higher): clear use of appropriate observational, recording and other data collection approaches including sampling. Explicit justification of data collection approaches.

To demonstrate practical knowledge and understanding of field methodologies appropriate to the investigation of human and physical processes. (AO3)

There is a clear demonstration of practical knowledge and understanding of the field methodologies appropriate for this investigation into carbon storage. It is clear how the field data is needed to calculate the stem volume using a given formula and how/why this is needed in order to subsequently calculate biomass. There is a clear understanding of the mathematics behind such an investigation. The use of each item of equipment is clearly understood with good links to the underlying geography.

Level 3: clear demonstration of practical knowledge and understanding of field methodologies appropriate to the investigation of human and physical processes.

To implement chosen methodologies to collect data/ information of good quality and relevant to the topic under investigation. (AO3)

There is clear evidence of relevant data collection based on the methods outlined as shown in the appendix and data summary tables. The sample size was relatively small but 'scaled up' to enable comparisons to be made (into carbon per hectare). The sample size of the coniferous trees was particularly small (2 trees) but this was identified within the investigation. All intended methods were carried out and results used.

Level 3: clear implementation of chosen methodologies to collect data/information of good quality and relevant to the topic under investigation.

Level 3

10 marks

Area 3: Methods of critical analysis (20 marks)

To demonstrate knowledge and understanding of the techniques appropriate for analysing field data and information and for representing results and show ability to select suitable quantitative or qualitative approaches and to apply them. (AO3)

The investigation demonstrates precise knowledge and understanding of appropriate analytical techniques. Statistical analysis of difference using a Mann-Whitney U test has been undertaken and the significance of the results has been stated. The data has been presented in appropriate, albeit limited, methods of bar charts and box whisker diagrams. Good use of logarithmic scale to present a wide range of data. Annotated photographs are effectively used and link well to the investigation.

Level 3: precise demonstration of knowledge and understanding of the techniques appropriate for analysing field data and information and for representing results.

Clear ability to select suitable quantitative or qualitative approaches and to apply them.

To demonstrate the ability to interrogate and critically examine field data in order to comment on its accuracy and/or the extent to which it is representative, and use the experience to extend geographical understanding. (AO3)

Data is interpreted and analysed for each of the two hypotheses with links to wider geographical understanding albeit limited. The extent to which the data collected is reliable is commented upon where the extent to which the data is representative is also questioned.

Level 2 (higher): partial ability to interrogate and critically examine field data in order to comment on its accuracy and/or the extent to which it is representative.

To apply existing knowledge, theory and concepts to order and understand field observations. (AO2)

Knowledge and understanding of theory and concepts is consistently applied to the field data to recognise and apply links to the wider geographical context of carbon storage – although this is somewhat limited in places. More effective through the photograph annotations over the graphical analysis.

Level 3 (lower): focused application of existing knowledge, theory and concepts to order and understand field observations.

Level 3 (lower)

10 marks

Area 4: Conclusions, evaluation and presentation (15 marks)

To show the ability to write up field results clearly and logically, using a range of presentation methods. (AO3 strand 3)

The investigation is written in a clear and logical manner clearly led by the hypotheses. A limited range of techniques have been used to present the field results with no inconsistency – these are fully embedded throughout the text.

Level 3: clear ability to write up field results clearly and logically, using a range of presentation methods.

To evaluate and reflect on fieldwork investigations, explain how the results relate to the wider context and show an understanding of the ethical dimensions of field research. (AO3 strand 2)

The evaluation is effective and demonstrates sound reflection on the investigation – identifying issues as well as possible solutions. Some evaluative comments can also be seen earlier in the investigation. Although consistently linked to the hypotheses, there is limited explanation of how the results relate to the wider context and the implication of the findings. Ethical dimensions of this particular field research have been clearly identified. The student has also suggested further field research opportunities surrounding this geographical question.

Level 3 (lower): secure evaluation and reflection on the fieldwork investigation. Precise explanation of how the results relate to the wider context(s). Clear understanding of the ethical dimensions of field research.

To demonstrate the ability to write a coherent analysis of fieldwork findings in order to answer a specific geographical question and to do this by drawing effectively on evidence and theory to make a well-argued case. (AO3 strand 3)

Valid conclusions are reached based on the field data collected with clear links back to the original hypotheses. The fieldwork analysis is structured, however, lacks the depth needed to fully answer the geographical question. The student draws upon some theory to make an argued case, albeit limited.

Level 2 (higher): partial ability to write a structured analysis of fieldwork findings in order to answer a specific geographical question. Draws inconsistently on evidence and theory to make a reasoned case.

Level 3 (lower)

9 marks

Overall

Area 1: 8
Area 2: 10
Area 3: 10
Area 4: 9

Total: 37

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