The Higher Education Academy Subject Centre for History, Classics and Archaeology

INTRODUCTION

In Britain, Environmental History is a dynamic new and emerging sub-discipline that demands close inter-disciplinary cooperation and understanding. It is popular at all levels, but undergraduate students intending to study the subject are faced with an immediate dilemma, mainly because they are products of a highly stratified education system. While they will usually be studying for a degree that is broadly classified as either Humanities or one of the Sciences, Environmental History utilises sets of data from both academic disciplines. As a consequence, students are required to step outside their individual disciplinary 'comfort-zones' and engage with, and use, evidence from an area of study that is usually largely alien to them. In order to enjoy the full benefits of this interdisciplinary subject, students should be prepared to be both patient when they are on familiar territory and open-minded and diligent when they are not.

In general, Environmental History should consist of team-taught courses using lecturers from both History and the Environmental Sciences so that undergraduates are encouraged from the beginning to engage with different kinds of evidence from each set of disciplines. While such a pedagogical approach clearly works and seems to be popular with students, it can be an interesting exercise while marking essays, field reports, and exams to try and guess which discipline a particular student belongs to. In this respect, at least at first, it is usually easy to tell whether you are marking the work of either a Humanities or a Science undergraduate from the way they present their submissions, their (un)familiarity with different data sets, the ways in which they interrogate data, and the way they structure their essay or report.

In general, Science students are more comfortable and familiar with the different ways of presenting quantitative data, making and recording their own observations in the field, and interrogating graphic data, even though they are not entirely aware of the processes by which a historian would tackle primary evidence. In worst-case scenarios, some students from the Sciences will use historical evidence unquestioningly as though it was data derived from experimentation because they have no frame of reference to inform them that different biases could have affected that evidence. History students can be just as naive in tackling and evaluating quantitative evidence and they usually are not sure how this type of data could be best packaged and presented to support their arguments. They also seem to be at a distinct disadvantage when it comes to interpreting scientific data, like pollen diagrams, in graphic form. This can be partially overcome by undertaking field trips where students are provided with some pertinent historical information together with scientific equipment that enables them to make their own quantitative observations. In such an environment, away from the formalities of the lecture, tutorial, or seminar, students from different disciplines can observe, and learn, from watching their peers in action.

Such benefits, however, can often be short-term. Therefore, this exemplar is intended to provide students of environmental history with a guide to planning, researching, writing, and presenting essays and reports that require the use of evidence from more than one academic discipline. The point of this exemplar is to try to genuinely amalgamate the two approaches by explaining how they each work at a basic level for students of both disciplines, and how we can best utilise two apparently different data-sets to plan and write essays and reports.

ESSAYS AND REPORTS

AIMS, OBJECTIVES, AND LEARNING OUTCOMES

Aims

- The ability to read selectively and carefully, and demonstrate a balanced understanding of different, sometimes conflicting, views into clear written and spoken expositions of a coherent argument.
- The ability to present an argument effectively in written form.
- The capacity to react, adapt to and learn from contrary ideas and arguments put forward in texts.
- The ability to promote and develop individual skills.
- An understanding of historical and scientific methods of analysis and enquiry.
- The handling of simple data-sets in generating and testing hypotheses.
- Ways of bridging the intellectual gap between humanities and the sciences.

Objectives

- To introduce an historical perspective into explaining contemporary environmental problems.
- To pursue the scientific method of enquiry into issues which were formerly the preserve only of the historian.

Learning Outcomes

- Promote the development of critical argument.
- Allow the analysis and synthesis of complex data-sets from different disciplines in both essays and reports.
- Develop communication skills.
- Develop presentational skills in relation to data-sets.
- Accentuate different but complementary writing skills in essays and practical reports.
- Encourage observation skills in practicals and fieldwork.

Assessment criteria

This is done according to standard university assessment criteria, details of which can be found at either http://www.history.stir.ac.uk/links/documents/index.php or http://www.sbes.stir.ac.uk/information/undergrad/documents/handbook2007.pdf

Before we begin planning strategies, it is necessary to define the different sources available to students of Environmental History.

BASIC SKILLS: EVALUATING DIFFERENT SOURCES OF DATA

HISTORICAL SOURCES

Historical evidence is essentially categorised into two areas commonly referred to as primary and secondary sources. There are distinct differences in how these types of evidence should be treated and used.

1) Primary sources

Primary sources are generally available in either manuscript or in printed form. They can consist of materials like charters, books, private letters, estate accounts or reports, and chronicles, but also include other types of primary sources like maps, photographs, and paintings. These all have one common feature: they generally form material either written or created during the period that is being studied. They can also be written in different languages. For example, primary sources from Scotland can be written in Gaelic, Latin, Scots and English. Whenever primary source material has been translated into modern English, the original language extract as well as the translation should always be incorporated into the commentary since translation is not an exact science.

Historians always treat primary sources in the same way, no matter in what form they appear, and there are standard questions that they apply to every piece of evidence. Such an approach usually leads to a greater understanding both of the material and of the person who created it. To make the best out of this kind of evidence about the past, the student should first either read quickly through, or look at, the primary source, bearing in mind questions such as:

- What kind of primary evidence is it? What is its general nature and purpose: a treaty, a charter, a private letter, a public letter, an estate map or plan, or a painting? Whether it was private, open, or confidential may be important. When was the source produced – for example, was it contemporary with the events it describes.
- What does the source say or portray?
- Is its timing significant?
- Is the source authentic or is it a forgery? Is it accurate and trustworthy? Was it designed to deceive? Does it represent a reality or an aspiration?
- Why might it be important: because of its creator's standing; because of the information or the views it contains; or because it had a direct or indirect effect on events?

These questions can be broken down further through investigation of the background.

- Who was (were) the creator(s)? What is the source's provenance? What is known about the creator? What bits of this information are particularly important for understanding and assessing the importance of the source?
- Does the creator have first hand knowledge of what he/she is writing about? Is he/she writing, drawing, or painting from hearsay or with hindsight? If so, does this add to or subtract from the value of the source?
- Why is the creator, for example, writing: to give an order, convey information, or influence others? Does the source material make significant omissions or assumptions?
- Who was meant to see/hear the primary source and who did see/hear it?
- What effects, if any, did the source have on events? If it was designed to bring change, did it do so and in the way expected? Was it designed to stave off developments and did it succeed in doing so? Did it influence a person's or group's attitudes and actions, either by design or unintentionally?

In some courses the student may be asked to write a commentary on an excerpt from a larger primary source of any kind and such a commentary should contain two or three major points. In writing this commentary, the student should focus on the excerpt itself, referring to the whole source document only when it helps understanding or influences assessment of the significance of the excerpt itself. It is important to remember, however, that different sources need to be investigated and assessed in different ways, so use the guidelines flexibly.

In writing about a primary source the student will necessarily have to be selective but generally aim to comment on **who** wrote or drew it, to/for **whom**, and **why**, **what** the source either says or shows, and **why** the source is important for the student in throwing light on the particular development or issue.

At first this may seem like a lot to remember but it does become easier with repeated practice.

2) Secondary sources

Historians define secondary sources as material that has been written or created by a person removed in time and space from the event or landscape being described, drawn, or painted. For example, all historical monographs, collections of essays, and articles are defined as secondary sources because they are interpretative writings that contain theories and argument based upon primary sources. Like primary sources, secondary source material is subject to a wide range of potential biases: the solutions to most of these are covered in the previous section. Even so, students using secondary sources should also be aware, for example, that the author(s) could have skewed the primary source evidence if they were writing according to a particular historiographic theory, like Nationalist or Marxist theory. It should also be remembered that we are all to some extent affected by our personal circumstances and life experiences, so it is difficult not to let individual biases creep into writing. The trick is for the student to remain detached from their writing.

BASIC SKILLS: ENVIRONMENTAL SCIENCE SOURCES

The scientific method

The working principles of the sciences have become enshrined in what is called the ‘scientific method’. This is a systematic process which places great emphasis on the defining and testing of hypotheses. Typically, the method will follow the following patterns:

- **Observation** – this is usually a qualitative observation or even a simple question like, ‘Why do plants and animals look different?’
- **Hypothesis** – this is when the scientist defines the hypothesis to explain the observation. The wording of the hypothesis is critical. It **must** lead to testing and it **must** define the test to be applied. The answer, ‘Plants and animals look different because God made them so’, is not an hypothesis because there is no test indicated which could prove God. In contrast, the statement, ‘Plants and animals look different because environmental stresses lead to adaptations which change their appearance’, is an hypothesis because it can be tested whether environmental stresses lead to changes in the appearances of plants or animals that once looked similar. We then infer that adaptation either has or has not taken place.

1) Testing the hypothesis

A test, or several tests, or even better still several tests which are independent of each other, are made which, if successful, will show the hypothesis to be reasonable. So in testing the Darwinian hypothesis above, some scientists will turn to tracing changing appearances of particular plants or animals through time through fossils (palaeontology). Others will study an animal which is under stress to see whether the animal changes appearance (e.g. moths changing colour to hide on soot-covered tree trunks is melanism). Others will take an animal and systematically change its environment in the laboratory through experimentation.

2) Acceptance or rejection of the hypothesis

The results of the tests must be able to answer the question. Results should be clear enough to be shown to be correct: this is why scientists are drawn to mathematics and seek to provide quantitative rather than qualitative answers. Numbers and statistics can be used together to make a hypothesis probable. Many people assume that rejection of an hypothesis is somehow a slur or a mark of failure in the scientist. This is not true. Often it helps clarify the thought process to hypothesise something you do not think will be right.

3) Assessment of the hypothesis

If the hypothesis turns out to be wrong, but the observation you initially made was sound, and the question you asked was sensible and interesting, then you can think of a different hypothesis (a different way to explain what you wanted to know). But if the hypothesis is found to offer a likely explanation, then it is equally important to test the hypothesis further, by repeating experiments and testing it in other ways and in different settings. Scientists are just as sceptical as historians. For example, there is a popular myth that climate-change scientists want to prove each other right in order to receive more funding for their work. This is a fallacy: if scientists accept an hypothesis that is later disproved their own work is falsified.

Two different approaches to thinking

Some scientists do not follow the method defined above. It is possible to simply collect lots of information (data) and then sift and sort them so that they make sense. This is sometimes called the **Baconian approach**, after a famous Elizabethan scientist, Roger Bacon. Darwin admitted that this was what he began to do as he sailed on *The Beagle*. Unfortunately, the Baconian approach takes time even though it might seem more likely to achieve the right result, in the same way that an infinite number of monkeys might eventually write *King Lear*. In a world where time is money, formal hypothesis testing, where you only test the mechanism that you thought of, is preferred because it is quicker. However, testing the hypothesis by collecting data on only one mechanism can lead to failure and thence the need to start again. This is why defining the hypothesis is such a critical part of the scientific method. Almost every scientist now employs formal hypothesis-testing, though in some published scientific papers the hypothesis is often not formally stated. Some scientists prefer to introduce their work by describing their initial observations.

Facts and Probabilities

There are very few facts or 'absolute truths' in science. Hypotheses do not establish facts: they only establish that one explanation is better than another. One influential view by the philosopher Karl Popper is that science cannot prove anything but can only disprove something. Some explanations are clearly wrong while others might be right. Thus science is open-ended and by its nature will never reach its goal of explaining the world. Physicists in the nineteenth century thought that Newton had explained everything until Einstein came along. Scientists will not know when they have found the right answer. We live in a world where things are more or less likely to happen – a world of probabilities rather than certainties. Qualitative data, those involving no measurement of numbers, are usually weak because tests of probability are not possible. One person's idea of a significant result is not the same as another's. With quantification it is possible, if enough measurements are made, to define objectively what you accept as significant. Scientists measure probability on a scale from 0.0 (entirely random with no pattern) to 1.0 (no variation in the pattern). If a scientist defines the significant probability of a series of measurements to be 0.95, he/she is saying that they expect what they are measuring to happen 95 times out of 100 to be significant. This is possible in experiments where every factor or variable other than the one being studied can be fixed or held constant, but in the natural world where this is not possible, significant results are usually accepted at much lower probabilities, say around 0.60 or 60%.

Experiments and the Historical Sciences

Most scientists use experiments to test an hypothesis: experiments that are very well explained can then be repeated by other scientists in other laboratories. In the 1980s two American scientists claimed to have discovered an atomic process called 'cold fusion', immeasurably more efficient than present techniques, but no-one has ever been able to repeat or replicate their findings even though they follow precisely the original experiments.

However, scientists who work in establishing changes through time, the historical sciences, cannot experiment. A palaeontologist cannot replicate the mass extinction of the dinosaurs 65 million years ago because it only happened once. This presents a fundamental problem for historical scientists and historians, a problem called 'contingency', in which it is argued that events in the past were all unique, and so studying them will not explain anything in general. Since the purpose of science and history is to draw out general theories to explain the world, contingency is a problem. Replication of a sort is possible for historical scientists if the observation you make happened more than once. For example, there have been six mass extinctions in geological time (five natural and the last by us), so you can test the hypothesis that the same cause happened in all previous events: did a meteor hit the Earth in every mass extinction? This might be a way out of the contingency problem if you can assume that all past events were similar in all respects – **but assumptions are dangerous!**

Environmental history is a 50:50 collaboration between historical sciences and history: one is not subservient to the other. Some scientists have assumed that history is more important because things are written down but this usually belies an ignorance of the errors and misconceptions that come in reading primary sources. Historians cannot write environmental history without documents, or paintings or some other clue left by people in the past. They also cannot write about prehistory but an historical scientist can: historians cannot write about how woodlands work, only when they are manipulated or destroyed by people. A famous historical ecologist, Oliver Rackham, was once asked whether it was possible to write an environmental history of Mars. An historian would say no; an historical scientist would say yes!

How to read the historical sciences

Processes and change

Most historical sciences are those engaged in explaining the environment, because the environment demonstrably changes. For example, to build urban flood defences on predictions of the amounts of rainfall made fifty years ago would not be wise. Many of the historical sciences are sub-disciplines: in physical geography or geomorphology there are scientists who only study processes happening at the moment, just as there are historical geomorphologists who recognise that processes may change through time. Historical scientists can be geologists, archaeologists, historical geomorphologists and climatologists, ecologists, biologists, botanists, and soil scientists (pedology) all linked by the prefix palaeo- (meaning past). The diversity of methods involved cannot possibly be summarised here but to see how diverse and bewildering these methods are, look at:

J.J. Lowe & M.J.C. Walker, *Reconstructing Quaternary Environments* (Harlow, 1997).

The **Quaternary Period** is the most recent part of geological time. Environmental history largely deals with environmental change in the last part of the Quaternary, called the **Holocene Epoch**, which has lasted so far *c*.11,500 years. A scientist often finds ingenious ways of measuring events that happened in the past by using proxy measures. A scientist cannot, for example, describe temperature directly before the date that thermometers were invented, but by measuring something that responds to temperature, like the growth of tree rings, temperature can be estimated back thousands of years. A lot of the arguments in the historical sciences literature revolve around just how well a proxy measure reflects or represents the thing you want to measure. The measure of probability when comparing tree-ring growth and temperature at the present day is often only around 0.5 to 0.6, which is accepted as significant, but a probability of 0.5 means that temperature can only explain 50% of the variation in tree-ring growth.

Time and its implications

All historical scientists have to measure time somehow to understand when things changed and how fast the changes took. This is called 'the rate of change'. Rates of change are important because most historical scientists are observing and measuring past changes in order to more confidently predict what will happen next: this is the goal of palaeo-climatology. The first issue in reading published work in the historical sciences is to come to grips with chronology and in this regard the historical sciences are just like history. It is critical to be able to understand time. Without this understanding it is not possible to know the difference between **cause and effect**. Rain turns to snow **after** temperature falls. Time is measured by scientists in different ways and time is measured with different accuracies. With time and skill, you begin to understand how successful the scientist has been at measuring time – accurate to the year, to the decade or maybe only to the century. This determines how well the rate of change can be measured.

In the historical sciences there can be much discussion of time-lags, which are delays between cause and effect. However, if the delay is very long there is time for what is assumed to be the effect of one cause to actually be the effect of a cause that has not been measured. For example, was Gutenberg's invention of the printing press in the fifteenth century the cause of WWII? The answer is yes if you think that the ability of a lot of people to read influenced what politicians thought in the late 1930s. The answer is no if you seek the cause of WWII in various events that happened in Germany in the 1930s. Historical scientists need to assess causes as being primary or secondary; distant or immediate so it is needed to decide whether the time-lag is reasonable.

SIs

SI stands for *Système International D'Unités* which is the internationally ratified form of the metre-kilogram-second system of measurement, representing accepted scientific convention for measurements of physical quantities. There are a total of seven base SI units and two supplementary units, each of which has a specific abbreviation or symbol, and the student will frequently encounter these abbreviations or symbols in scientific reports.

Base Units	**Measured quantity**	**Name of SI unit**	**Symbol**
	Length	Metre	m
	Mass	Kilogram	kg
	Amount of Substance	Mole	mol
	Time	Second	s
	Luminous intensity	Candela	cd
	Temperature	Kelvin	K
	Electric current	Ampere	A
Supplementary Units			
	Plane Angle	Radian	rad

	Solid Angle	Steradian	sr

ESSAY PLANNING

Essays in Environmental History are no different from other essays in planning and structure. Any essay is made easier by good planning. First of all, the student must read the question carefully and make sure they understand what is being asked of them since the setter may ask the student to tackle a ‘compare and contrast’ question. Then, on a single sheet, the student should put the points from the ideas sheet in an order that answers the question. Often, this may take the form of a spider diagram. The first, and perhaps even the second, attempt may need to be drastically revised, but eventually a framework for the overall argument should emerge. The student should then go through the main set of notes taken from the reading for the essay, incorporating whatever fits into the framework. This outline will probably need to be revised, but eventually a skeleton of the essay should emerge. Ensure that every paragraph has a clear thrust that contributes to the conclusion. Then, but only then, the student can clothe the skeleton in the flesh of words which should always be written in the **Past Tense**. The result should be a well argued piece of work where a series of points contribute to logically building up the case, just like a lawyer in court pleading on behalf of a client.

As such, an essay is essentially an argued case, showing that a particular point of view is to be preferred to any alternative. Usually it entails weighing up the merits of the standpoints of different historians. Therefore, it is not a body of information, nor a bloc of description, nor a chronological story of events. The best way for a student to escape the last of these traps, which is probably the hardest to avoid, is to ensure that the essay is not structured in date order but written thematically. How an essay question is answered is also usually defined by certain key words within the essay title.

1) Key words in essay questions.

Account for
Give reasons for/explain why something happens.
Analyse
Break up into sections and investigate.
Comment on
Identify and write about the main issues, where the student provides arguments based on what they have read. Avoid personal opinion.
Compare
Either look for the similarities or differences between two things. Show the relevance or consequences of these similarities or differences. Come to a decision which, if any, is preferable.
Contrast
Bring out the differences between two or more items or arguments. Demonstrate how the differences are significant.
Critically evaluate

Weigh arguments for and against something, assessing the strength of the evidence on both sides. The student should use criteria to guide their assessment of which opinions, theories, models or items are preferable.

Define

Provide the precise meaning of something. Where relevant, the student should show they understand how the definition may be problematic.

Describe

Give the main characteristics or features of something, or outline the main events.

Discuss

Investigate or examine by argument and debate. Provide reasons for and against before examining the implications.

Distinguish between

Bring out the differences between the subjects of the assignment.

Evaluate

Assess and judge the merit, importance, or usefulness of something. The student should back their judgement with relevant evidence.

Examine

Look closely into a topic, usually within defined dates.

Explain

Make clear why something happens or how it came about.

Explore

Examine a topic in detail from one or more viewpoints.

Illustrate

Make something explicit using plenty of evidence.

Interpret

Show the meaning and relevance of either data or of other material presented.

Justify

Both give evidence which supports an argument or idea and answer the main objections which might be made.

Narrate

Outline what happened.

Outline

Provide the main points, features, and general principles of a given topic. Demonstrate the main structure and interrelations but omit details and examples.

Relate

Narrate, showing similarities and connections.

State

Give the main features of a given topic briefly and clearly.

Summarise

Draw out the main points, omitting details and examples.

To what extent

Consider how far something is true, or contributes to a final outcome.

Trace

Follow the development or history of an event or process. Such an approach often demands a strict internal structure.

2) Points.

The argument assembled by the student should consist of a series of points that contribute to building up the case. Every point made should play its part. If a point, however interesting, does not have a logical place in the articulation of the argument, it should be dropped. It should, in principle, be possible to state how every sentence of an essay stands in relation to the thrust of the whole piece of writing.

3) Evidence.

Every point in an essay needs to be supported from concrete evidence, which will normally fall into one of three categories. The most common is an instance of a generalisation. Thus if it is claimed that during the 'Age of Improvement' in Scotland some landlords conducted social and scientific experiments upon their estates, the name of Lord Kames can be mentioned. A second type of evidence, more frequent in some essays than in others, consists of statistics. Figures, especially when compared with each other, can be specially convincing. Thus, claims that the British steel industry expanded in the late nineteenth century can be vindicated by the evidence that whereas steel output in 1871 was 329,000 tons, in 1900 it was 4,900,000 tons. Statistics are often best presented as percentages. A third type of evidence is a quotation, which has to come from a primary source, not a secondary one. More is explained about the use of quotations in section 6. Some form of evidence is required to back up every assertion.

Students of Environmental History must also be very careful when they introduce scientific evidence to back up and strengthen a case largely constructed from historical data, and *vice versa*. A case in point might typically involve a large-scale forest clearance, for which there was good evidence in the historical record relating to the numbers of trees felled but not the types. In such a case the student could turn to the pollen record for help. However, depending on the site chosen the pollen could represent local (could be as low as tens to hundreds of metres), intermediate, or regional patterns of vegetation. It is important to first work out the spatial scale and any dating issues associated with the pollen data.

Students should also be prepared to face the fact that in Environmental History the scientific and the historical evidence could directly contradict each other. In such a case, the student will be faced with a stark choice: are they prepared to accept the findings of one discipline over another? If so, they must justify their choice and this is where an assessment of the different biases present in each body of evidence becomes crucial. For example, the person who produced the historical evidence may have been lying for a particular reason or the scientist who took the readings may have been hung-over and forgotten to calibrate an instrument properly. Which of these sources is the student prepared to trust most, or are they both untrustworthy?

4) Paragraphs.

Every paragraph should consider only one factor contributing to the argument. For example, some of the reasons for the creation of planned villages in the Highlands of Scotland post-1750 include the continuing fear of Jacobitism and the introduction of new industries to provide gainful employment and education: these topics (and all the other factors) need to be given separate paragraphs. The first sentence of a paragraph should introduce its topic, helping the reader to know what to expect. Other sentences will explain the points being made and provide supporting evidence (with the implication that the paragraph will contain several sentences, not just one or two).The last sentence should normally convey the paragraph's thrust, that is its contribution to the argument of the whole essay. It might, in the instance just given, say that 'civilising' the Highlanders was a British governmental priority post-1750.

5) Blocs of paragraphs.

Although there is more scope for variation in the arrangement of paragraphs, it is usually better to put those that have a similar thrust together. Thus in an essay considering whether the ecological writings of Frank Fraser Darling were the chief factor in influencing official attitudes towards the uplands of Scotland for much of the twentieth century, paragraphs containing reasons in favour of Darling being the most important explanation should form one bloc and reasons against should form another. Normally reasons for and against should not alternate because when all the paragraphs supporting a particular viewpoint are assembled in one section, it is easier to weigh up their collective significance. In an essay where there is a single issue to discuss, for and against a proposition, it is usually best to place the bloc whose case will eventually be rejected before the bloc that will eventually be endorsed. Then the stronger case comes immediately before the conclusion to which it naturally leads.

6) Quotations.

If under two lines long, quotations should be contained within inverted commas and be integrated into the text of an essay. If longer, they should have no inverted commas and should be presented separately by starting a fresh line a short way in from the margin (see below). In the latter case, the essay text should resume at the margin after the quotation on a new line:

> Roots are very different in different Plants: But 'tis not necessary here to take notice of all the nice Distinctions of them; therefore I shall only divide them in general into Two Sorts *viz*. *Horizontal Roots*, and *Tap Roots*, which may include them all.[1]

Quotations are welcome as supporting evidence when they are drawn from primary sources and are as brief as possible. The primary sources will

[1] Jethro Tull, *Horse-Hoeing Husbandry: or, An Essay on the Principles of Vegetation and Tillage* (3rd ed. London, 1751), 1.

commonly have been found in a secondary work, in which case the reference should cite both. Quotations consisting of the words of secondary works themselves should be used sparingly and only when the aim is to challenge or evaluate their validity or to illustrate historiographic opinion. Secondary works, however, should not be quoted to assert points of fact or as though they constituted evidence for an argument. **Remember**, secondary works do not constitute 'fact' since they are another person's theories.

7) Footnoting.

Both History and Environmental Sciences have their own regularised methods of footnoting. Generally, historians prefer to use either MLA or Chicago Style (see footnote in Section 6) while scientists use the Harvard style. As yet, there is no fixed style for Environmental History so students are not penalised for using one system to the exclusion of the other.

8) Introduction/Conclusion.

The purpose of the introduction is to explain the question for consideration, **not** to give the answer. If the answer is provided or even hinted towards at the start of your essay, the advantage of keeping the reader in suspense for the solution is lost. Also, it looks like the author has made up their mind before they have assembled the evidence. This is a way in which a history essay is like a good murder mystery: there will be a scattering of clues about the likely solution, but it is not spelled out until the conclusion. The introduction needs to be sufficiently long to explain what subordinate issues are raised by the question, perhaps justifying the order in which the material is to be addressed. The conclusion also has to be of reasonable length. It is where the writer states the answer to the question, briefly recapitulating the reasons for taking that point of view, evaluating the relative importance of those reasons and finally, in the last sentence, giving a direct response to the title of the essay. At all costs avoid sitting on the fence.

7) Bibliography.

This should list all references cited in an appropriate format that provides sufficient information for any reader to find any of your references in a library. This information normally consists of author, book or journal title, place of publication, and date of publication.

REPORT PLANNING

A report should be very different in style to an essay. It will probably be more factual, drawing almost entirely on your own laboratory or field work and interpretations, though it should be no less imaginative than the essay. Scientific reports can vary greatly in length but they all have the same structure.

Practical reports.

Essentially, practical reports are basic exercises that have been designed to make the student reflect more deeply on their experiment(s), and to hone the skills required for writing up research work. In general, the introduction should be short and outline the aim(s) of the experiment(s). It is good practice to keep a lab workbook, even though the materials and methods of the experiment have been supplied by a session-supervisor. During the assessment process, a great deal of attention will be paid to how different students have analysed and presented their data and findings. In the latter case, all of these must be justified by the evidence.

Structure.

1) Title.

This should explain what the experiment was about.

2) Abstract or Summary.

It is good practice to include an abstract which briefly describes the methodologies employed, the results obtained, and any conclusions. It thus allows a reader to quickly grasp the essentials of the report.

3) Introduction.

This should be used to orientate the reader and explain why the experiment was undertaken. It should also be used to explain methodologies and the hypothesis that underpins the experiment.

4) Materials and methods.

This should clearly explain how the work was done and contain sufficient detail for a third party to repeat the experiment.

5) Results.

This section of the report should display and describe the data obtained from the experiment. This usually takes written form but it should be complemented by a presentation of your data in graphic form. The effective presentation of data in an important element in this type of exercise.

6) Discussion and conclusions.

This section should first discuss the results of the experiment, what they mean, and their importance. it might also usefully include any suggestions for further experimentation or research.

7) Bibliography.

This should list all references cited in an appropriate format that provides sufficient information for any reader to find any of your references in a library. Like an essay bibliography, this information normally consists of author, book or journal title, place of publication, and date of publication.

MANIPULATING, TRANSFORMING AND DISPLAYING DATA EFFECTIVELY.

There are two main parts to the process of discovering any meaning within data.

- Initial data manipulation to evaluate the nature of the results. This may lead to the discovery of patterns and relationships within the data and so can generate new hypotheses for further testing.
- Confirmatory analysis: this is generally used to test any hypotheses that may have been generated during the experiment.

At this point it should be realised that spreadsheets can be superb tools for aiding the manipulation and transformation of data. Packages like EXCEL or the free CALC of openoffice.org also allow the immediate visualization of data sets by utilising inbuilt graphic functions.

- It is usually best to try and simplify data as much as possible. Some packages can do this automatically for the student and numerical values can be adjusted by either rounding up or down, or by taking the mean values.
- It can be fun to try and arrange data in as many different ways as possible, always remembering to back-up the original data set. Playing with figures and the different ways of graphing them can sometimes lead to unexpected hypotheses. Graphing data also means that the student can provide a visual summary that is easy to interpret. Play with different types of graphs (see section 2 below) as some will be easier for a reader to interpret than others. Always bear an audience in mind when presenting data.
- Playing with data in different ways also allows the student to look for different patterns in that data, as well as highlighting the exceptions (called outliers). Are these outliers a result of a mistake that has been made in the recording or experimental stages or do they represent something significant?

Graphing data

Graphs are really just a way of displaying the maximum amount of information in a minimum amount of space. They are created to provide a visual impression of results and are different to a table, which is used give an accurate numerical record of the respective values of different data. It is up to the student to decide which method will be the more effective in any given circumstance; sometimes both methods are used in conjunction with each other.

1) Basics.

Graphs have a Y- and an X- axis, The X-axis runs horizontally across the page; the Y-axis is vertical and positioned at right-angles to the X-axis.

- Each axis should have an appropriate label and reference marks to show the location of any numbers used.

- Each graph should possess a legend to provide explanatory detail.
- Take care over the scale and layout of the different axes.
- It is important to remember that the graph is there to impart information so it must not be too small. Usually, half a page of A4 size is adequate for a graph.

As well as measuring or estimating something like time, historical scientists will also either measure or estimate by proxy something changing in the environment. In such cases the X-axis should always be the **independent variable** and the Y-axis the **dependent variable**. For instance, if a scientist plots the rate of soil erosion changing with time, time is the X-axis. This is because time is not affected by soil erosion but the rate of soil erosion is affected by time. In other instances the X-axis need not represent time. Suppose you want to find out whether flowers open when it gets warm. In such an instance the X-axis would be the number of flowers opening and the Y-axis temperature, because it would be mistaken to think that flowers can affect temperature. However, when the questions you ask get more complicated the relation between independent and dependent variables can get very hard to disentangle.

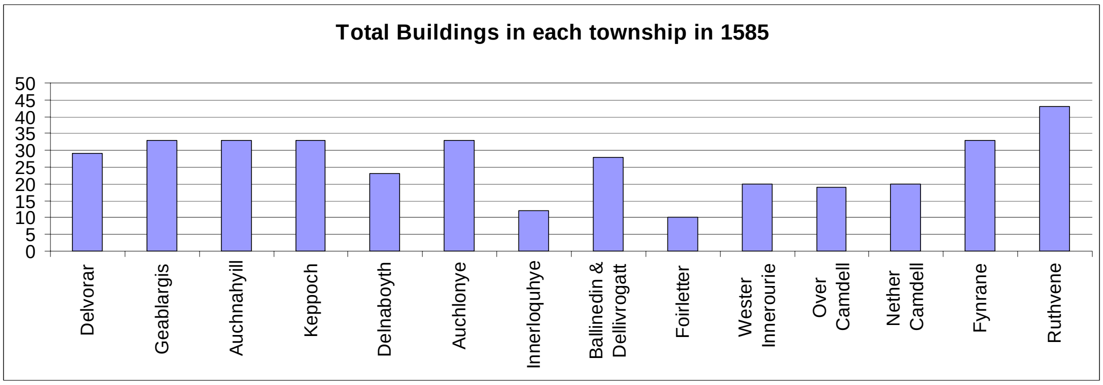
Either or both of the axes can be plotted as a linear series, in which the values either increase regularly (2, 4, 6, 8), or sometimes can be plotted on other scales (e.g. logarithmic: 1, 10, 100, 1000). Take care you understand the scales presented and be wary of any graph where the scale is not shown. This is often used in newspapers to fool or frighten you. Make sure that you fully understand what was being measured, and thus what the X-Y graph means. This sounds obvious but lots of arguments develop in science because one scientist thinks that another scientist was not measuring what they thought they were. This is particularly common when scientists use proxy measures because they are never quite certain what the proxy measure relates to. Does a flower open because the sun comes out or because the temperature has risen? Sunshine and temperature are different.

2) Types of Graph.

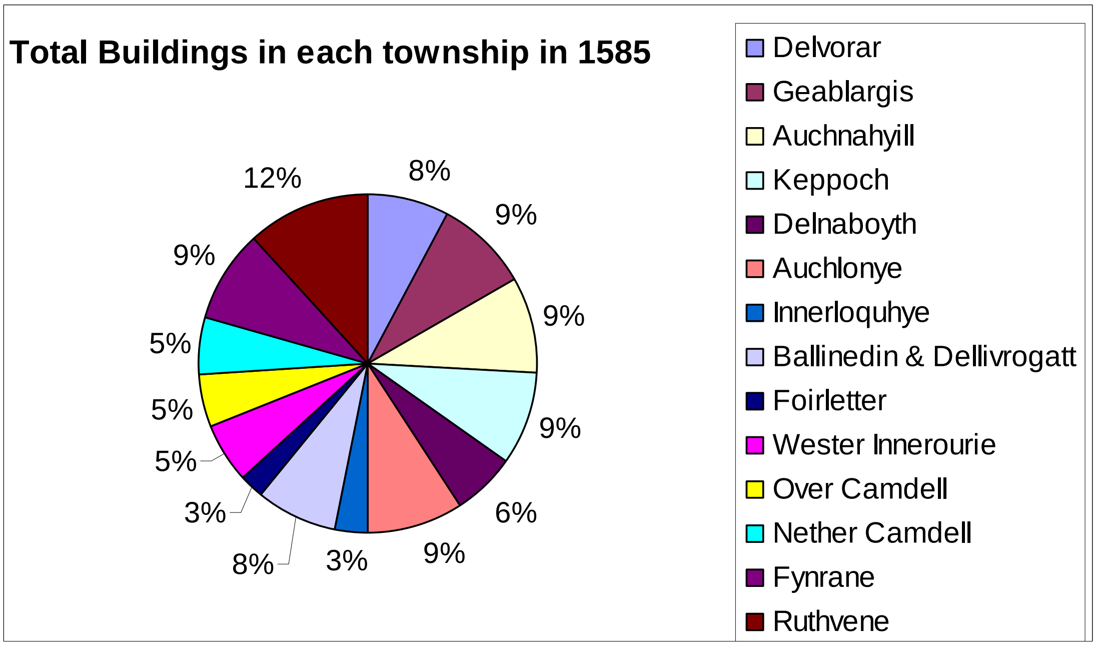
There are many different types of graph, all of which can be used for different purposes. These include:

- Pie Charts: these illustrate portions of a whole, usually expressed as a percentage
- Histograms: these show frequency distributions.
- Plotted Curves: always used for data sets where the relationship between two variables can be represented as a continuum.
- 3-D Graphs: these show the interrelationships of three variables.
- Scatter Diagrams: these are commonly used to demonstrate the relationship between individual data values for two interdependent variables.
- Bar Charts: these represent frequency distributions.

Below is a simple Bar Chart crated from historical data to show the number of structures in fourteen Scottish Highland townships in 1585. Is this the most effective way of conveying this type of information or do you consider that another option might be more effective? If so, return to the data and look at other graphic options.



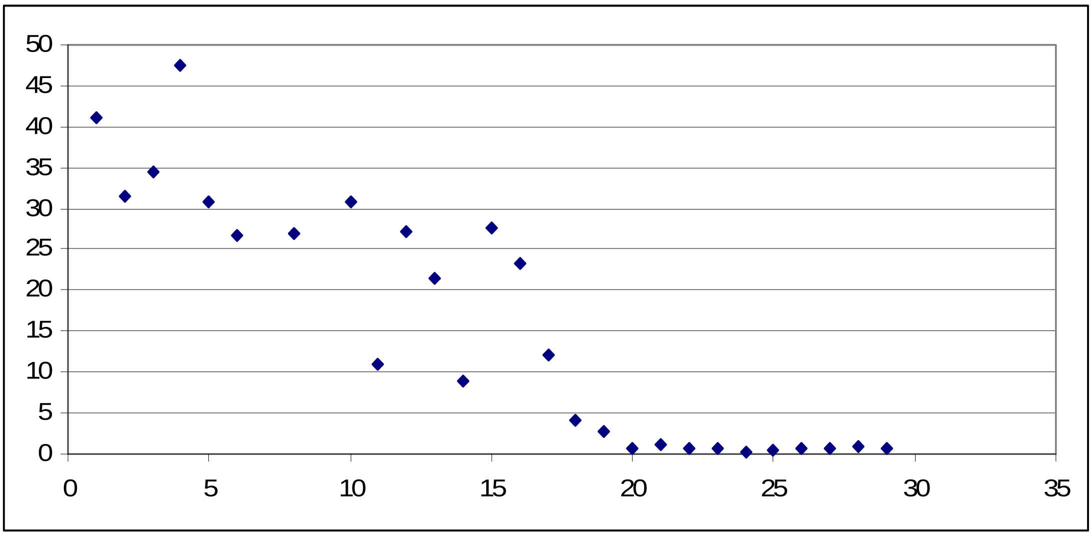
Underneath is the same data represented as a Pie Chart. Is this graph more or less effective that the previous example? Is it displaying the same information to the reader or does it complicate matters? Do more colours make a difference to the visual impact?



Above all, when using graphs created by a third party, the student must make sure that they understand the axes before they consider the relationship between them. it is all too easy to be influenced by the shape of a graph before understanding the scale of the axes, which is why graphs are often used to misrepresent information.

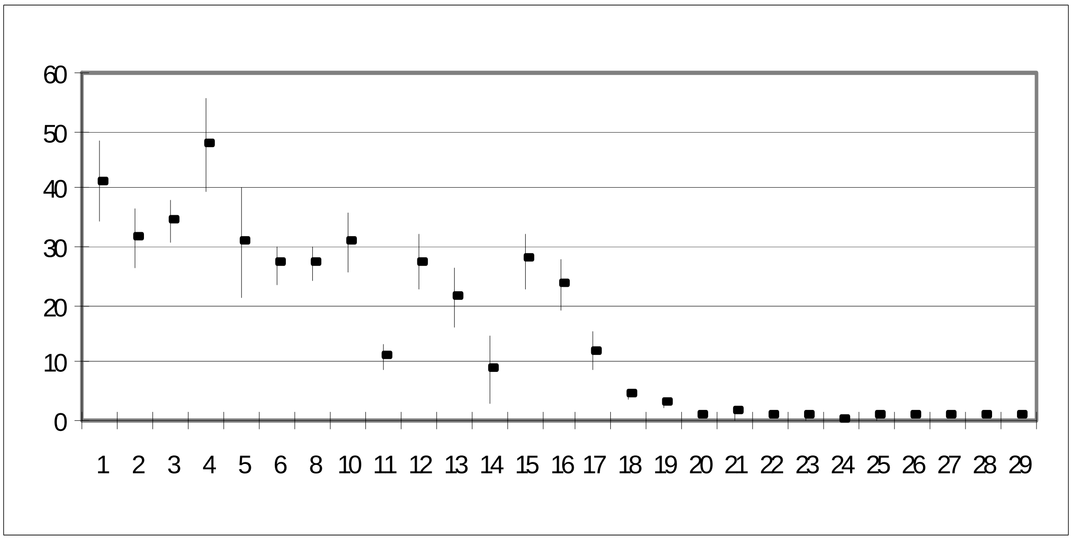
Scientists, on the other hand, like to measure variables many times to make sure the numbers are right. When they do this, they automatically generate averages (which are an expression of the most common number in a series) and a measure of the range of the numbers in the series. There are lots of ways to measure the average (mean, median or mode). The range can simply be from the smallest to the largest number but is most commonly expressed as the standard deviation around the average. For example, Graph 1 measures the amount of vegetation colonising a salt marsh out to the sea from only one measurement: the X-axis is distance and the Y-axis is vegetation cover because the cover is controlled by how close the sea is, not the other way round.

Graph 1



In contrast, Graph 2 measures vegetation cover five times, and so each central value (the mean) also has a bar expressing the variation in the five measurements.

Graph 2



Graph 1 looks better because the points have only one value, but actually Graph 2 is more accurate because it reflects the precision of the measurement more honestly. Precision is a measure of how carefully and how often the numbers are measured. Precision increases with the number of times something is measured, which the scientist should note. Accuracy is different to precision and relates the value to the number it should be.

RECOMMENDED READING

As an aid for helping students from History understand Environmental Science and *vice versa*, the following texts are recommended:

J. Black and D.M. MacRaild, *Studying History* (2nd ed. China, 2000).
Allan Jones, Robert Duck, Rob Reed and Jonathan Weyers, *Practical Skills in Environmental Science* (Singapore, 2000).
J.J. Lowe & M.J.C. Walker, *Reconstructing Quaternary Environments* (Harlow, 1997).
Open University, *Environmental science: air and earth* (Milton Keynes, 2002).
Open University, *Environmental science: landforms and cycles* (Milton Keynes, 2002).
Open University, *Environmental science: water and life* (Milton Keynes, 2002).
John Tosh with Sean Laing, *The Pursuit of History* (4th ed. Malaysia, 2006).
R.J. Evans, *In Defence of History* (Chatham, 2000).