

Hilltop – an agricultural problem

Contents: A data analysis problem-solving exercise concerning a trace element disease among farm animals.

Time: 2 periods.

Intended use: GCSE Biology, Chemistry and Integrated Science. Links with work on trace elements, plant nutrition and soil analysis.

Aims:

- To develop understanding of the importance of trace elements in plant and animal nutrition.
- To develop an awareness of the problems of animal disease and the economic use of land, the effect of the environment on farming and the role of scientists in helping farmers achieve better production.
- To develop skills in data handling and data analysis.

Requirements: Students' worksheets No. 110.

This material has been developed from a project initially designed for the Science in Society Project. The exercise is best carried out by students working in groups of two or three.

The unit is concerned with the effect of trace elements on the health of farm animals and a scientific study of the problems encountered. Students are asked to compare the concentration of metal ions in sick and healthy cattle and to select elements with significantly high or low concentrations in the unhealthy animals. Elements with particularly low concentrations in the unhealthy animals include copper, iron and manganese. Molybdenum stands out with a relatively high concentration in the unhealthy cattle.

Manganese is not known to have a specific function in animals. Copper and iron act as coenzymes, enabling specific enzymes to function properly. Iron is also present in haemoglobin.

Later in the unit, pupils study data concerning stream sediments. They should find that affected farms have high values for molybdenum concentrations. They should also notice that the affected farms have no particular deficiencies in iron, copper and manganese even though the unhealthy animals are deficient in these three elements.

This leads to molybdenum as the cause of the sickness and this is confirmed when shales are found to be the source rock for the molybdenum in the stream sediments and soils. Students will probably not appreciate the finer points of the sickness which teachers may wish to discuss as follows.

The symptoms displayed by the cattle are caused by copper deficiency. This suggests that molybdenum in the diet is preventing the uptake of copper. Further studies have suggested that molybdenum forms associations with proteins in the same fashion as copper though it is unable to act as an effective coenzyme. Thus copper is 'blocked' and the proteins cannot catalyse reactions which are essential for metabolism in the cattle.

Acknowledgement Photo on page 1 from Milk Marketing Board.

HILLTOP – AN AGRICULTURAL PROBLEM



Introduction – the problem at Hilltop

The Hilltop area is an imaginary part of the United Kingdom, though the information is based on real-life investigations. This unit involves studying data about the Hilltop area in order to understand why some farms in the area are losing money.

Map 1 on page 2 shows the nine farms in the Hilltop area and its four streams. The farms are similar in size and use similar farming methods. Five of the farms are successful in rearing cattle but four of the farms are unsuccessful and are losing money. These unsuccessful farms are:

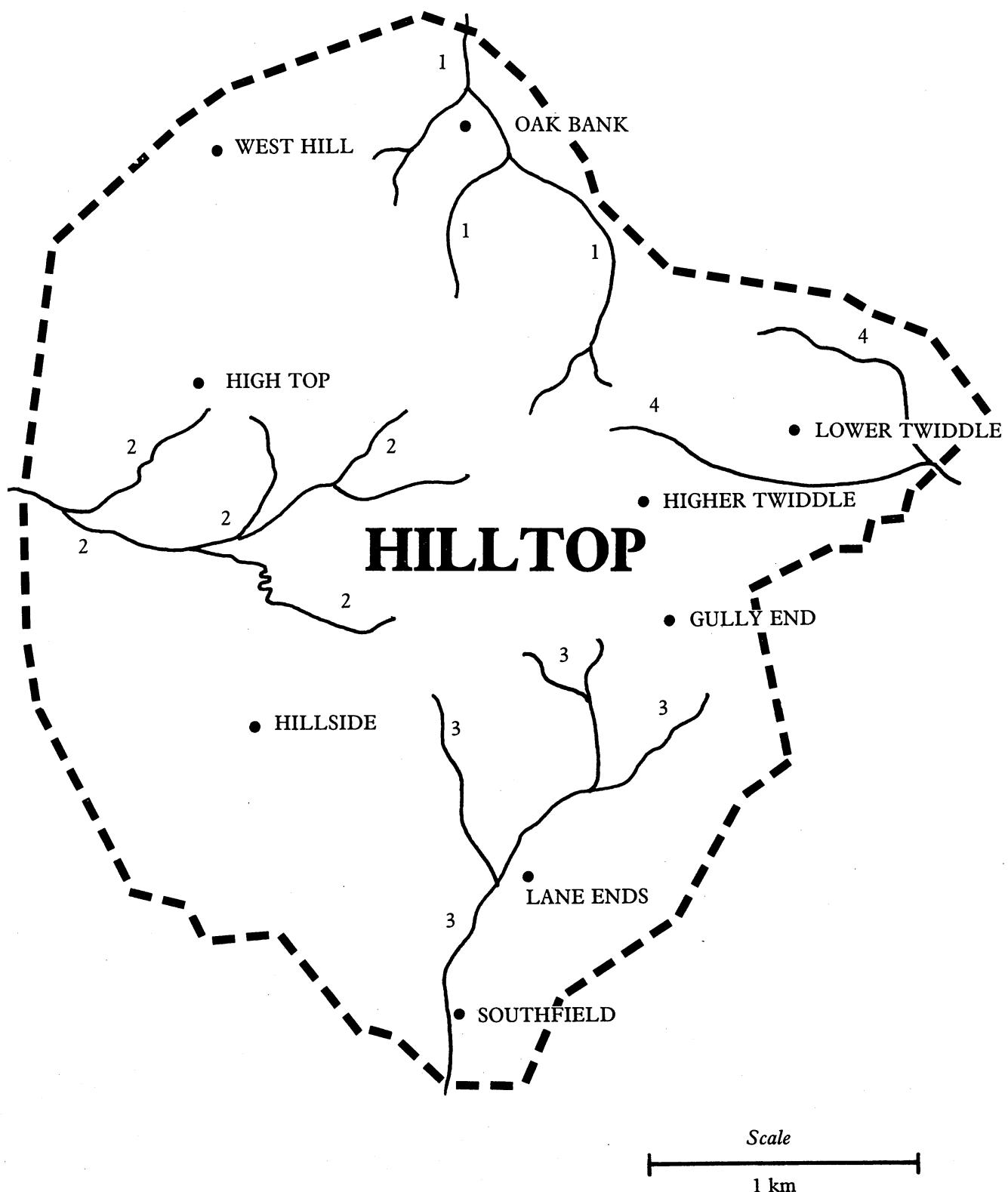
Lane Ends, Oak Bank, Southfield and West Hill.

Animals on these farms are underweight and do not grow healthily. The cows produce small, sickly calves and they give much less milk than they should. The unhealthy cattle have a dull coat and their hair tends to fall out. They develop a strange walk which farmers call 'staggers'.

The object of this study is to discover why the animals on some farms are affected in this way.

Question

- 1 *Describe in your own words the problem you will be trying to solve in this unit.*



Map 1 *The natural drainage of the Hilltop farms*

The streams are numbered 1 to 4.

Trace elements

All animals need traces of certain elements in their diet. Each element has a particular job to do in the body and may be vital for an animal's health. For example, in the human diet, iodine is an important trace element which helps the thyroid gland work properly. Some trace elements can be poisonous if their concentration is too high.

The sickness in the animals is due to either

- (i) deficiency (too little) of certain trace elements, or
- (ii) excess (too much) of a poisonous trace element.

Many trace elements build up in the liver, which acts as a kind of filter and a store for certain elements. Analysis of the livers of healthy animals provides a standard for comparing with other animals.

Table 1 shows the concentrations of various trace elements in the livers of healthy and unhealthy animals from the Hilltop area.

Table 1 The average concentrations (in p.p.m.) of various trace elements in the livers of healthy and unhealthy animals from the Hilltop area

Element	Symbol	Concentration in parts per million (p.p.m.)	
		Healthy animals	Unhealthy animals
chromium	Cr	2.0	1.1
copper	Cu	70.0	16.0
iron	Fe	180.0	44.0
lead	Pb	0.05	0.05
manganese	Mn	40.0	12.0
mercury	Hg	0.01	0.01
molybdenum	Mo	3.5	24.0
nickel	Ni	4.0	1.3
zinc	Zn	4.0	3.0

From studies in other areas, the sickness was known to be caused by a deficiency of one of the trace elements in Table 1. This deficiency *might* be because there is too little of this element in the soil. But it could also be the result of another element blocking the uptake of a vital element.

The normal method of correcting deficiency of a trace element is to provide additional amounts of the deficient element. This is done either in fertilizers added to the soil or as chemicals in the animal's food.

Both methods of treatment were tried in the Hilltop area. Neither method improved the health of the animals. The next step was to carry out a geological examination of the area. Scientists examined the local rocks, soil and streams to find which elements were deficient or in excess in the soil. Deficiency or excess in the soil would be passed on to the grass eaten by the cattle.

Questions

- 2 Compare the figures for healthy and unhealthy animals in Table 1. Which element(s) may be greatly deficient (at least 3 times too low) in the diets of the unhealthy animals?
- 3 Which element(s) may be present in excess in the diets of the unhealthy animals?

Geology of the Hilltop area

Several years ago a thorough geological survey had been made of the Hilltop area.

Extracts from the geological survey of the Hilltop area

Extract 1 – Stream sediments

Analysis of stream sediments can be used to compare the elements present in different drainage areas. Elements that are found in the sediments of rivers and streams are also likely to be found in the grass. Samples were dug from the stream beds, dried and analysed. The samples were labelled according to the streams on Map 1. The results are shown in Table 2.

Table 2 Concentrations of elements present in the sediments of the different streams, in parts per million (p.p.m.)

Stream	Cr	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Zn
1	2	40	280	30	180	0.5	34	3	60
2	1	32	170	4	140	—	4	1	16
3	1	94	420	44	310	—	60	4	81
4	2	54	340	28	220	0.5	5	2	74

Questions

- 4 Which four farms are unsuccessful and losing money because of unhealthy animals?
- 5 Look carefully at Map 1. Which streams drain towards the unsuccessful farms?
- 6 Look carefully at Table 2. Are the streams draining towards the unsuccessful farms deficient in the element or elements listed in your answer to question 2?
- 7 Do the streams draining towards the unsuccessful farms have an excess of the element or elements listed in your answer to question 3?
- 8 What do you think is the cause of the problem?

Extract 2 — The underlying rocks

Map 2 shows a geological map of the Hilltop area. Samples were taken from the different rock types in the area. The analysis of these samples is given in Table 3.

Table 3 Analysis of rock samples. (Values show the elements present as parts per million (p.p.m.))

Rock type	Cr	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Zn
Limestone	0.75	4.2	120	3.5	160	0.03	1.25	0.65	4.5
Grit	1.10	3.7	65	40	145	0.03	1.80	1.3	3
Mudstones	1.20	5.6	165	5	125	0.04	3.5	1.45	2
Shales	1.45	7.7	175	4	137	0.03	62	1.5	2.5
Sandstones	1.50	11.5	200	5	157	0.04	5	1.8	6.2

Questions

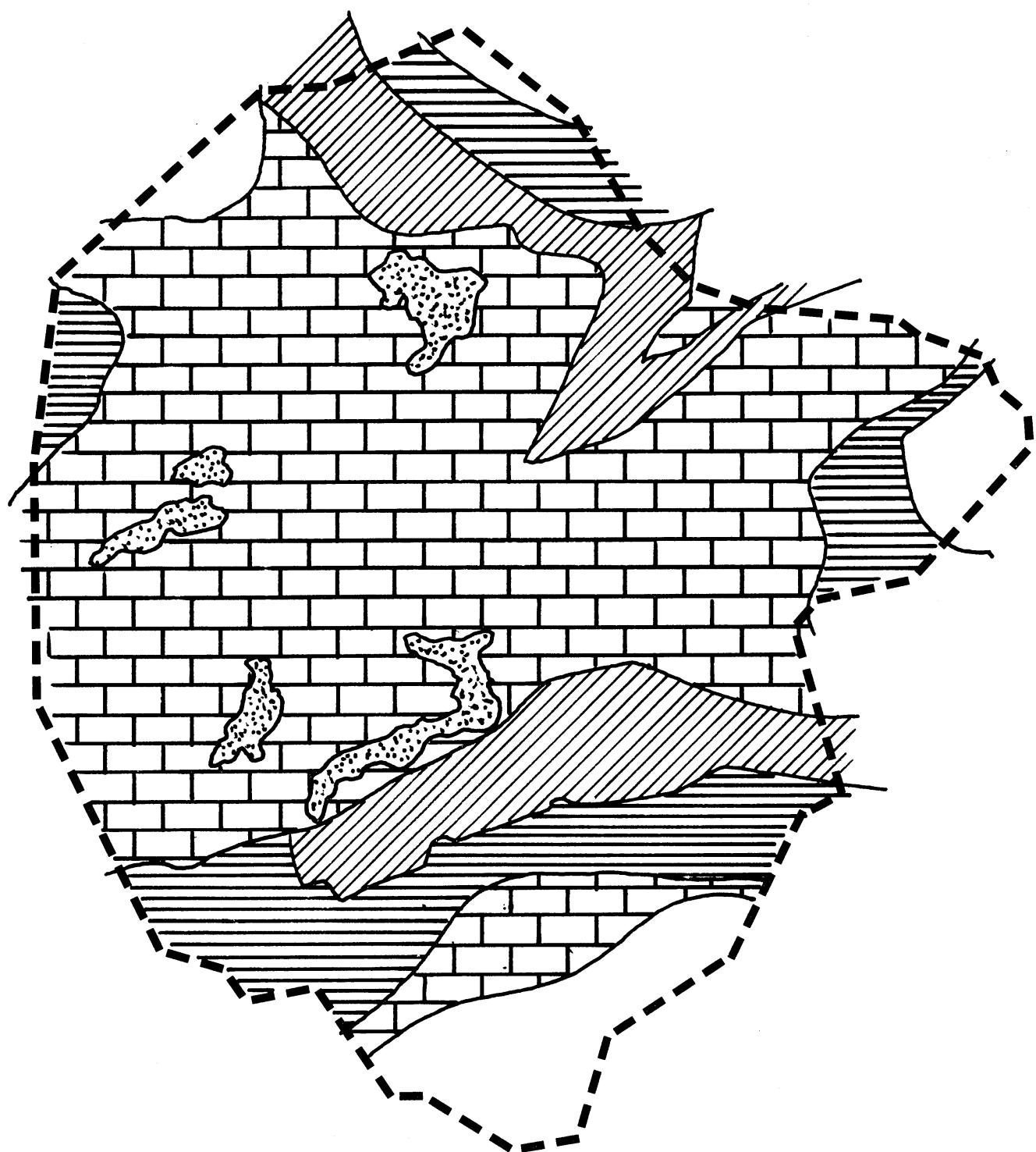
- 9 Consult Maps 1 and 2. (They can be viewed at the same time by holding them up to the light together, one on top of the other.) Which rock types may affect the streams draining towards the unsuccessful farms?
- 10 Now consult Table 3 and your answer to question 9. Which rock seems the most likely source of the element you suspect?
- 11 State the basic cause of the sickness in the animals and explain how the rocks in the area are causing the problem.

Easing the problem

Having found the element that was making the animals unhealthy, the scientists were unable to find a complete cure. However, they were able to help the farmers cut down the sickness in their animals.

Question

- 12 What advice would you give to the farmers of the unsuccessful farms?



[Brick pattern]	Limestone
[Stippled pattern]	Grit
[Horizontal lines pattern]	Mudstones
[Diagonal hatching pattern]	Shales
[Blank pattern]	Sandstone

Map 2 Geological map of the Hilltop area

SATIS 1

List of units in this book

101 SULPHURCRETE

Reading, questions and experimental work on the use of sulphur as a building material.

102 FOOD FROM FUNGUS

Information, questions and decision-making exercise concerning the production and marketing of a novel food.

103 CONTROLLING RUST

Information, questions and decision-making exercises concerning rusting and its prevention, in particular its economic aspects.

104 WHAT'S IN OUR FOOD? – A LOOK AT FOOD LABELS

Survey, analysis and discussion concerning food labelling and food additives.

105 THE BIGGER THE BETTER?

Data analysis and discussion concerning economies of scale, with particular reference to ethene manufacture.

106 THE DESIGN GAME

Designing an energy-efficient home.

107 ASHTON ISLAND – A PROBLEM IN RENEWABLE ENERGY

Information and problem-solving exercise on the use of renewable energy sources.

108 FIBRE IN YOUR DIET

Information, questions and data analysis on the link between dietary fibre and disease.

109 NUCLEAR POWER

A structured discussion concerning the principles and issues behind the use of nuclear power.

110 HILL TOP – AN AGRICULTURAL PROBLEM

A data analysis problem-solving exercise concerning a trace element disease among farm animals.