

Introduction

Is your class prepared to embark on a thrilling adventure: a secret mission deep into the rainforest to expose environmental threats?

'The game is very gripping. I look forward to playing it because it has that sense of adventure and I like that.' Year 7 pupil

'You do maths without realising what you are doing.' Year 8 pupil

'I like the sense of adventure. It's more exciting than a normal maths lesson!' Year 9 pupil

Overview

Deep in a tropical rainforest, a small team of undercover environmentalists are on a mission to investigate and expose the illegal activities being carried out by a multinational logging organisation, Log Inc, and the deforestation that is destroying the planet. It will be a dangerous mission requiring the environmentalists to use all their cunning and intelligence to monitor the damage whilst evading detection and collecting evidence for UN international inspectors.

Rainforest involves four 50- to 60-minute lessons, each with optional homework:

- 1 Establishing base camp
- 2 Logging activity
- 3 Sustainability
- 4 Escape

The mathematical learning emerges from the action. Each lesson involves a separate mission leading to non-routine problems for pupils to solve by working in small groups. The problems, some of which are open-ended, are designed to promote discussion, reasoning and thinking skills. Some parts of the lessons are optional so that you can tailor them to the time that you have available. Each lesson ends with a 'cliff hanger' intended to maintain pupils' interest and to lead into the optional homework.

The case study includes this introduction, four lesson plans, video and audio clips, slides, resource sheets presenting the challenges, and some possible solutions to the problems.

Mathematical content

The National Curriculum states: 'Mathematical thinking is important for all members of a modern society as a habit of mind for its use in the workplace, business and finance; and for personal decision-making. Mathematics is fundamental to national prosperity in providing tools for understanding science, engineering, technology and economics. It is essential in public decision-making and for participation in the

knowledge economy... Mathematics equips pupils with uniquely powerful ways to describe, analyse and change the world. It can stimulate moments of pleasure and wonder for all pupils when they solve a problem for the first time, discover a more elegant solution, or notice hidden connections. Pupils who are functional in mathematics and financially capable are able to think independently in applied and abstract ways, and can reason, solve problems and assess risk.'

Mission: Rainforest gives pupils many of these opportunities. As they solve the problems, pupils will need to use a range of process skills: planning and organising, exploring and discovering relationships, analysing and reasoning, representing and interpreting, and reflecting and communicating.

The mathematical content in Rainforest is suitable for pupils who are confident with level 5 of the National Curriculum, and some of the content at level 6. **It should suit pupils of above average attainment in Year 7, and average or above average attainment in Years 8 and 9.** In particular, pupils will need to be able to calculate with decimals and percentages; find perimeters, areas and volumes and convert between units of measurement; use coordinates, find the midpoint of a line segment, make and interpret scale drawings and draw simple plans and elevations.

The teacher's role

Rainforest is an opportunity for pupils to apply and use skills that they have previously been taught and to see connections between mathematical topics. The lessons are best used consecutively to maintain momentum but you will need to **prepare pupils in advance by teaching or refreshing any mathematical skills that will be new or that they have not used for some time.**

After introducing the case study, organise the class in groups of about four pupils, who could stay together throughout the lessons. Your role as the teacher is **to lead the development of the story and introduce the challenges, then encourage the groups to decide for themselves how to resolve them. At the end of each lesson, lead a whole-class discussion, helping the groups to share their problem-solving strategies and to evaluate their progress.**

If your pupils are not accustomed to solving unfamiliar problems, you may need to forewarn them that they could be challenged by the case study, because the problems are not 'five-minutes-or-less' activities. They may well get stuck at some point. They need to know that this is a normal part of problem solving and that working out how to make a start is an important skill. Clarify in advance how much help you will offer as the story unfolds, and when. **Feed in hints only when and if pupils get stuck without telling them exactly what to do so that they merely follow the steps you have outlined.** Advise the groups to brainstorm to generate ideas, to explain and consider each proposal carefully so that everyone in the group can verify whether or not it works, and to try a variety of approaches. You can also pose suitable questions or prompts to stimulate their thinking, pair groups to learn from each other and take whole-class feedback at any point.

In the final problem of the case study try to make sure that all pupils in the class succeed so that they end the case study feeling a real sense of achievement.

Resources needed

The Rainforest materials include:

- these introductory notes
- four lesson plans, with slides and resource sheets presenting the problems, including optional homework tasks
- video and audio clips
- where applicable, solutions to the problems.

The resource is easy to operate and is designed for use in a normal maths classroom. The only technical equipment required is an interactive whiteboard (IWB) or whiteboard, one laptop (for you to use to load and navigate around the resource), a data projector and speakers. Pupils will also need calculators, rulers, squared paper and interlocking cubes.

The launch page features links to the introduction, the lessons and solutions. Clicking on the 'Lessons' button leads to a sub-menu for Lessons 1 to 4. Click on an individual lesson to access the lesson notes, resource sheets and audio and video clips for that lesson. These are numbered in the order needed in the lesson. All the print resources can be either viewed on screen or printed out.

Each lesson plan starts with a narrative explaining the storyline, followed by a description of the problems, the skills linked to the mathematical content, and a list of the video, audio and print resources for the lesson. These notes are on a shaded background. The rest of the lesson plan is a guide to the possible flow of the lesson, questions to ask and ways of adapting activities for pupils of differing abilities.

For the lessons and homework a maximum of **13** resource sheets need to be printed, either one copy per pair or one per pupil.

Pupils will also need calculators, rulers, squared paper and interlocking cubes.

Adapting the lessons

Mission: Rainforest is designed to be adaptable, giving you the freedom to modify lessons to match pupils' ages and abilities and the school timetable.

All the lesson plans make suggestions for differentiation, with ideas for simplifying or extending the main problems or providing alternatives.

Since lessons vary in duration from one school to another, in all the lessons some activities are optional. These can be omitted if lessons are less than 50 minutes, or if pupils take longer than you expect to solve the problems.

The resource sheets for each lesson include a selection of shorter and longer tasks or problems, all related to the storyline. You can choose from these as you wish.

For example, they can be used as:

- supplementary problems for any groups that solve the main problem quickly, or for schools where the lesson is longer than an hour
- alternative problems to provide further differentiation in lessons
- introductory or follow-up work
- optional homework.

Alternatively, if you want the class to tackle all the activities in a lesson, you could split a lesson over two teaching periods. For example, the second lesson of the case study explores issues of deforestation and carbon off-sets by helping pupils to relate the use of rainforest timber to their everyday lives, such as eating burgers, reading newspapers and being driven in a car. There are probably enough supplementary multi-step problems for this lesson to sustain work over two lesson periods, provided that pupils are left to make their own decisions about approaches. This lesson is also a particularly good opportunity for persuasive writing in cross-curricular work with the English department.

Cross-curricular opportunities

Subject	Topic
Geography	Map work; interactions between people and their environments, including causes and consequences of these interactions, and how to plan for and manage their future impact
English	Imaginative and persuasive writing to develop ideas, themes, imagery, settings and/or characters when writing to imagine, explore and entertain; debate on deforestation issues; report writing, e.g. for a radio news broadcast
ICT	Use of spreadsheets; taking and editing close-up digital photographs of tropical plants; using email to send a report; Internet research into illegal logging
PE	Gymnastics; navigating an obstacle course, including a 'bridge'
Science	Variation and classification of rainforest plants and animals
CDT	Designing and making a bridge structure to carry a maximum load
Art	Painting and drawing impenetrable forest

Assessment

Bowland Maths provides useful assessment materials and also two CPD modules specifically on assessment on the Bowland Maths website

(<http://www.bowlandmaths.org.uk>).

You can use the Mission: Rainforest lessons to build a picture of your pupils' understanding and skills, choosing suitable criteria at levels 5 and 6. For example, assess whether pupils are able to:

Level 5

- show understanding of situations by describing them mathematically using symbols, words and diagrams
- draw simple conclusions of their own and give an explanation of their reasoning

- recognise and use number patterns and relationships
- use known facts, place value, knowledge of operations and brackets to calculate, including using all four operations with decimals to two places
- solve problems involving the conversion of units and make sensible estimates of a range of measures in everyday situations
- use and interpret coordinates

Level 6

- interpret, discuss and synthesise information presented in a variety of mathematical forms
- break a problem into smaller parts and structure problems that need several steps
- use logical argument to establish the truth of a situation
- visualise and use 2D representations of 3D objects
- calculate volumes and surface areas of cuboids.

Useful websites

Tropical rainforests, including deforestation statistics

rainforests.mongabay.com/defor_index.htm

Illegal logging

www.greenpeace.org/international/campaigns/forests/threats/illegal-logging
www.illegal-logging.info/uploads/cserge.pdf

Sustainable logging

rainforests.mongabay.com/1011.htm

River crossing puzzles

www.mathfair.com/rvrcrossing.html

Professional development

Bowland Maths also includes Professional Development materials to help teachers develop the skills needed for the case studies and for the new Programme of Study. There are seven modules which cover the main pedagogical challenges for this type of investigative problem solving. Each module is activity based; it is built around problems similar to the case studies, but short enough to fit into a single lesson. For an outline of the Professional Development modules, go to:

<http://www.bowlandmaths.org.uk/pdmodule.htm>

Pupils' reactions

'I want to do more of these because they were fun and got our brain working.'

'My favourite bit was having to work out calculations because it helps us learn more about maths.'

'More fun than doing sums off a board.'

'It was challenging and different to a normal maths lesson.'

Lesson 1: Establishing base camp

Narrative

A team of 12 environmentalists is on a secret mission to investigate illegal logging. A small advance group has just landed in a clearing in the middle of a dense rainforest. They have glimpsed from the air the headquarters of Log Inc and its outbuildings, the terrain they are now in and some of its main features. The area is remote and not well charted so their map is only an outline. The group now needs to work out the best place for base camp taking account of what they know about the terrain.

Problems

Main problem

The group works out what they can tell about their surroundings from the map and what they will need to do first. They decide where the team will set up their base camp and the factors that they need to consider. After overhearing a walkie-talkie conversation between some of Log Inc's workers, they glean extra information about the area and review their decisions about the best place for base camp.

Supplementary or homework problems (optional)

- 1 When the whole team arrives they must decide how to stack their crates of provisions to ensure that they are kept dry and that the exposure of the sides and top of the stack to the warm damp forest air is minimised.
- 2 The team considers their likely use of energy in the rainforest for their daily living and work and how to provide it.

Skills required

In this lesson or the homework pupils will:

- solve problems involving the conversion of units and make sensible estimates of measures, including compound units, in everyday situations
- use coordinates and find the midpoint of a line segment, given the coordinates of its end-points
- calculate volumes and surface areas of cuboids.

Rainforest resources

- 1.1 Video clip: (2 minutes) Opening film – a team of environmentalists is about to arrive in the rainforest on a mission to gather evidence for a report to the UN. The advance group must determine where the team will set up base camp.
- 1.2 A4 resource sheet: a map of the forest area marked in squares (print one per pupil)
- 1.3 A slide: a map of the forest area with additional information added
- 1.4 Audio clip: (90 seconds) Walkie-talkie conversation between Log Inc workers revealing important features of the terrain not shown on the team's map
- 1.5 Optional slides: clues from the walkie-talkie conversation, with a table of distances on the map in actual miles and kilometres

Review

- 1.6 Optional A4 resource sheet of supplementary or homework problems (if you are using one of the problems for homework, print one copy per pupil, otherwise print several copies to use as needed in the lesson)
- 1.7 A slide: the map of the forest area, including the extra information revealed in the walkie-talkie conversation
- 1.8 Video clip: (45 seconds) The team sets off through the dense forest but, before too long, they realise they are being followed! But by whom?

Other resources

For pupils: rulers, compasses, calculators. For Supplementary or homework problem 1 (optional), computers and spreadsheet software. For Supplementary or homework problem 2 (optional), interlocking cubes to represent crates.

Main activity

You might like to use the website references in the introduction to these notes, in particular rainforests.mongabay.com/defor_index.htm, to help you to set the scene.

Show **Resource 1.1**, a two-minute video clip of the advance group arriving.

Give out **Resource 1.2**, an A4 copy of the map, one per pupil, then show **Resource 1.3**, a slide of the map of the forest with hot spots of extra information to be added to their maps. Point out the scale (1 cm represents 80 m) and the direction of north (the bottom of the map). You may need to remind the class that 5 miles is about 8 km. Check that pupils can use the grid system and compass points by asking them for the positions and directions of a few features, then ask:

- What can we tell about the land from the map? What do we need to do first?

Establish that their first job is to set up base camp. Split the class into groups of about four. Tell them that they will work in the same groups throughout the case study, often as two pairs who then join forces. Ask the groups to decide where they are going to set up base camp and to think about the factors that they will need to consider. Listen in on the subsequent group discussions, drawing the attention of the class to pertinent, interesting or well-considered ideas.

Once the groups have come to a preliminary decision, play **Resource 1.4**, a 90-second audio clip of a walkie-talkie conversation between the Log Inc HQ and their guards, mentioning points about the terrain not marked on the map: a kennel for guard dogs, a guard checkpoint, a spring, a waterfall, a cave and crocodiles. You may need to play the clip a second time, pausing at intervals so that the groups can mark the extra information on their maps, or if pupils need to see the clues, show the first slide of **Resource 1.5**. They will then need to review their decisions about the best place for base camp. You could if you wish move one person from each group into a different group at this point to justify their decision.

Differentiation

If pupils need help in identifying and using the map scale of 1 cm to 80 m, discuss and complete the table of information on the remaining slides of **Resource 1.5**.

If time allows, or if any groups quickly reach a sensible decision on where to position the base camp, ask them to do one of the supplementary problems on **Resource 1.6**.

Bring the whole class together to discuss and justify their decisions. Use **Resource 1.7**, a slide of the map including all the new features, to support the discussion. There is no single 'right place' for base camp but some decisions are likely to be better justified than others. Some factors to take into account are, for example, the distance to fresh water, communication opportunities, flat ground for erecting tents, suitable places for energy generators and for storing crates of provisions, safety, distance from the Log Inc's HQ and keeping undetected.

To round off, play **Resource 1.8**, a 45-second video clip. The advance group sets off through the dense forest to find Log Inc's HQ. Soon they realise they are being followed. But who is it?

Optional homework

Ask pupils either to complete work started in class or to do a remaining problem from **Resource 1.6**.

Solutions: Lesson 1

Main problem

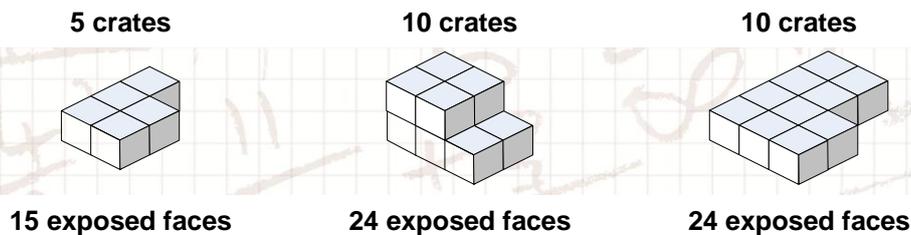
There is no 'right answer' for the location of base camp but it is important that pupils can justify their decision in terms of the factors that affected it (for example, the distance to fresh water, communication opportunities, flat ground for erecting tents, a suitable place for energy generators and storage of crates of provisions, safety, distance from the Log Inc's headquarters and remaining undetected). They should record their final decision on the map as they will need this for the supplementary problem.

Supplementary or homework problems on Resource 1.6

1 It helps if pupils have some interlocking cubes to work with. They will probably find that, if they discount the surface area in contact with the ground, keeping shapes flat but compact produces the smallest surface area and making tall thin towers produces the largest. Challenge them to explain why this is the case. Other questions to ask are:

- Does the number of exposed square faces increase or decrease when you move one 'crate'?
- What is the best way to count the exposed faces? (e.g. systematically round the sides in turn and then the faces on top)

The smallest surface area for 5 crates is 15 m^2 and for 10 crates is 24 m^2 .



2 a A spreadsheet would be useful to model figures for energy consumption.

This could result in a table as below. (This assumes that washing is done in the springs or river and that cooking is done over fires.)

Appliance	Watts)	Hours per day	kWh	No. of items	Total (kWh)
lamp	100	2	0.2	4	0.8
mobile phone charger	20	0.5	0.01	12	0.12
camera charger	40	0.5	0.02	4	0.08
laptop charger	60	1.5	0.09	12	1.08
TOTAL					2.08

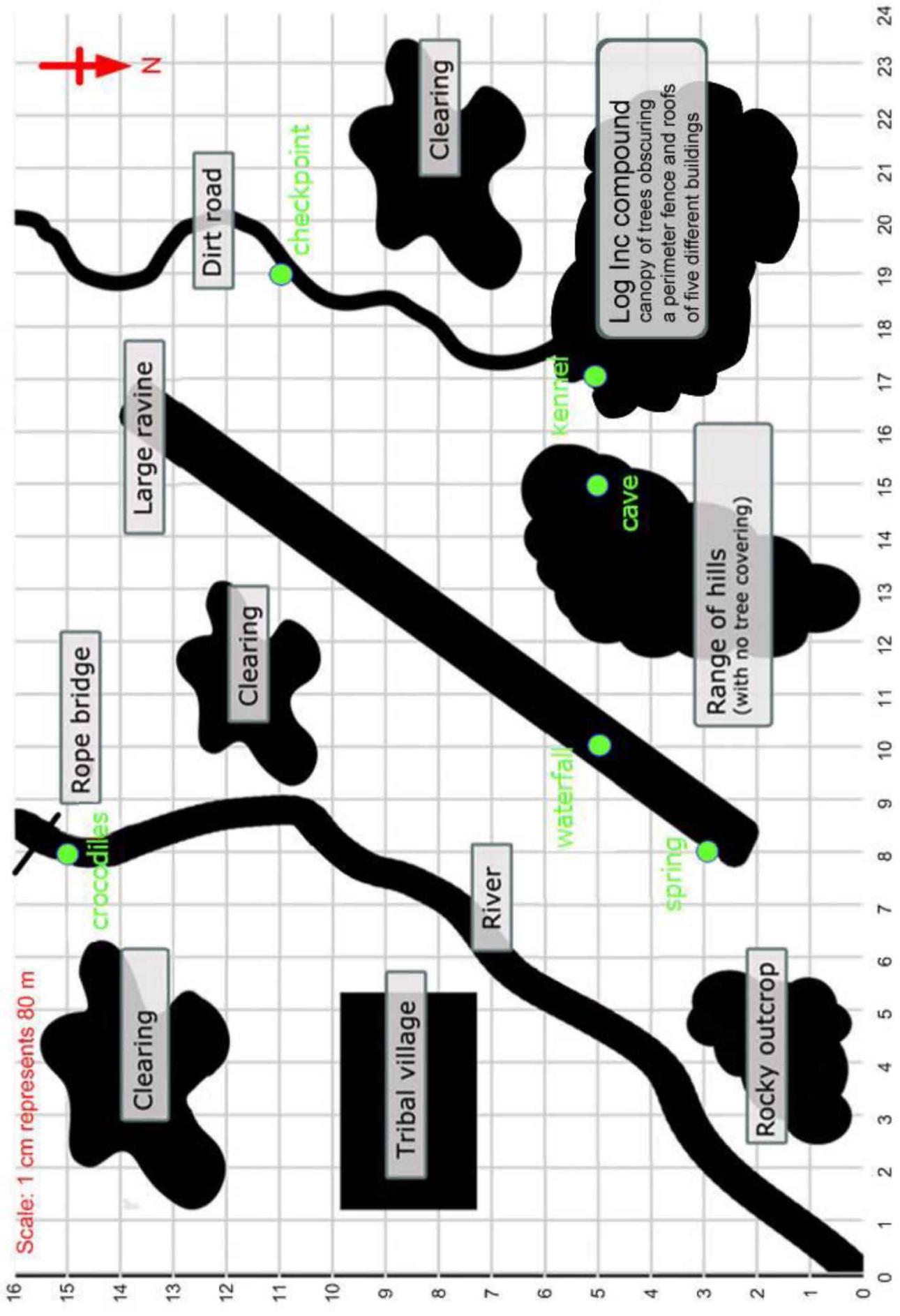
b The energy produced by the generators is :

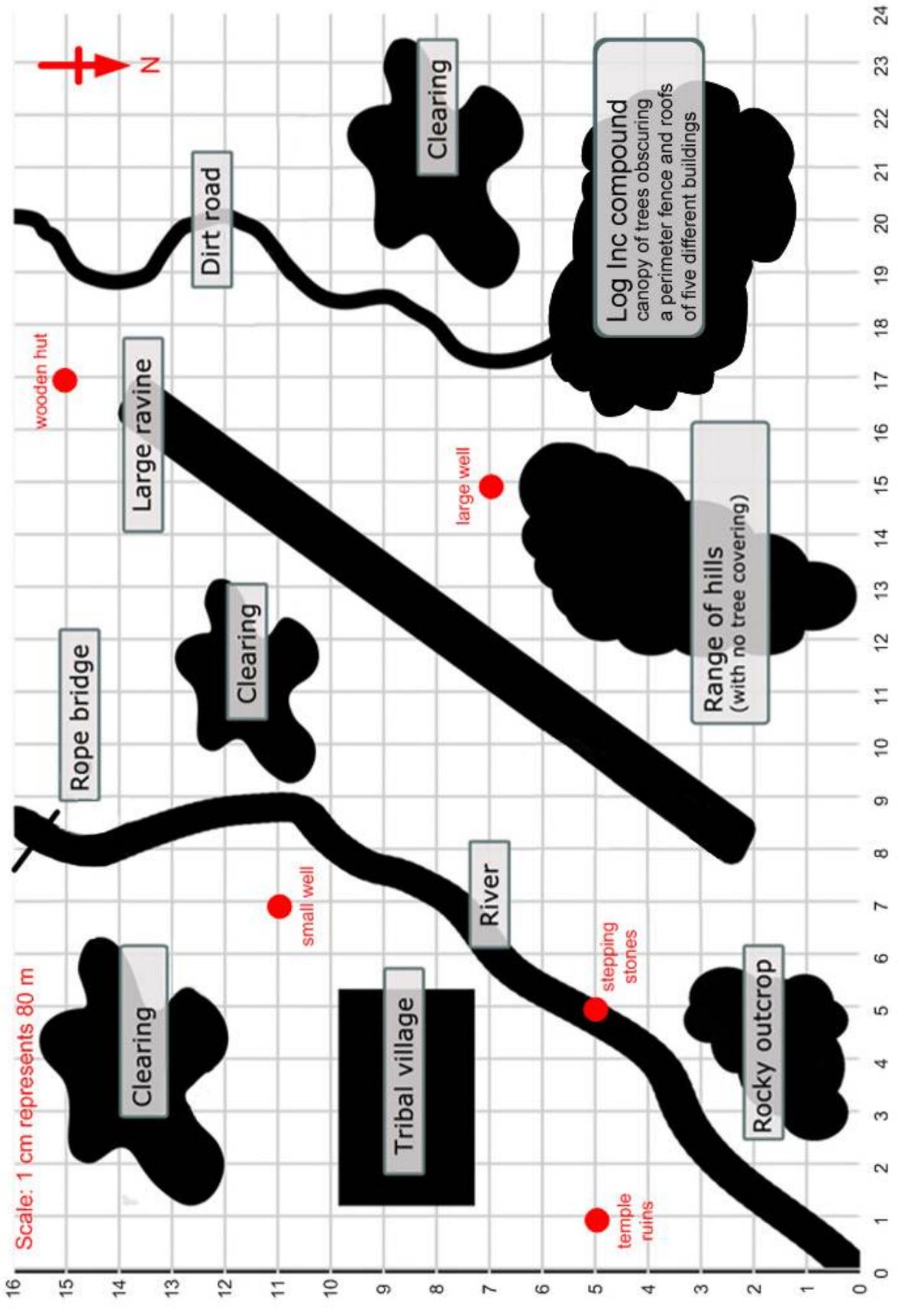
Solar panel: $1500/365 = 4.1 \text{ kWh per day}$

Wind turbine: $500/365 = 1.4 \text{ kWh per day}$

The team could manage with 2 wind turbines.

c After consideration the groups may decide, for example, to bring candles for lighting and fewer laptops to reduce their energy consumption to 1.4 kWh per day .





Clues

- The new kennel for the guard dogs is due north of the wooden hut and north-west of the large well.
- The guards have a new checkpoint south-west of the large well on the east side of the dirt track.
- There is a spring 240 metres due north of the midpoint between the temple ruins and the large well.
- The waterfall into the ravine is a quarter of a mile from the stepping stones.
- There is a cave due west of the temple ruins and exactly half a mile from the small well.
- Two large crocodiles have been seen near the rope bridge.

Resource 1.5

The map scale

map	metres
1 cm	80 m
..... cm	160 m
..... cm	400 m = 0.4 km
..... cm	800 m = 0.8 km
..... cm	1.6 km

Resource 1.5

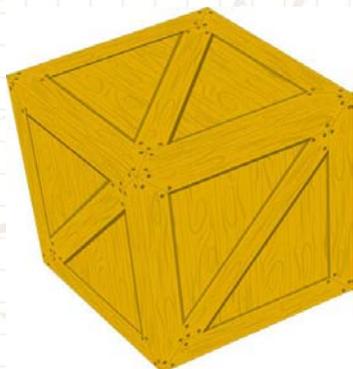
The map scale

map	metres	miles
1 cm	80 m mile
..... cm	160 m mile
..... cm	400 m = 0.4 km mile
..... cm	800 m = 0.8 km mile
..... cm	1.6 km	1 mile

Resource 1.5

Supplementary or homework problems

- 1 The team has several crates of provisions containing computer and surveillance equipment and food supplies.



We need keep them as dry as possible. They need to be stacked so that the exposed sides and top of the stack have minimum contact with the warm damp air.

There are 5 crates to stack. Each crate is a 1 m by 1 m by 1 m cube.

- How can we stack them?
- How many of the 1 m by 1 m square faces will be exposed to the air?
- What if there are 10 crates?
- We are scheduled for a supply drop in a week that will double the crates. How can we stack them?
- If we need to move the camp and set up somewhere else, is there another way to stack them whilst keeping the exposed surface area to a minimum?

- 2 **Energy consumption** over h hours by an appliance of w watts is $\frac{wh}{1000}$ kilowatt hours (kWh).

So a 280 watt laptop used for 3 hours uses $\frac{300 \times 4}{1000} = \frac{1200}{1000} = 1.2$ kWh of electricity.

The energy use of a number of household appliances is given in the table

<http://www.carbonfootprint.com/energyconsumption.html>

A Think of a normal day in your home – about how much energy do you think you use?

B What do you think would be the same about your use of energy at the base camp?

What would be different about your use of energy usage at the base camp?

C A typical 10m^2 solar panel produces around 1500kWh electricity per year.

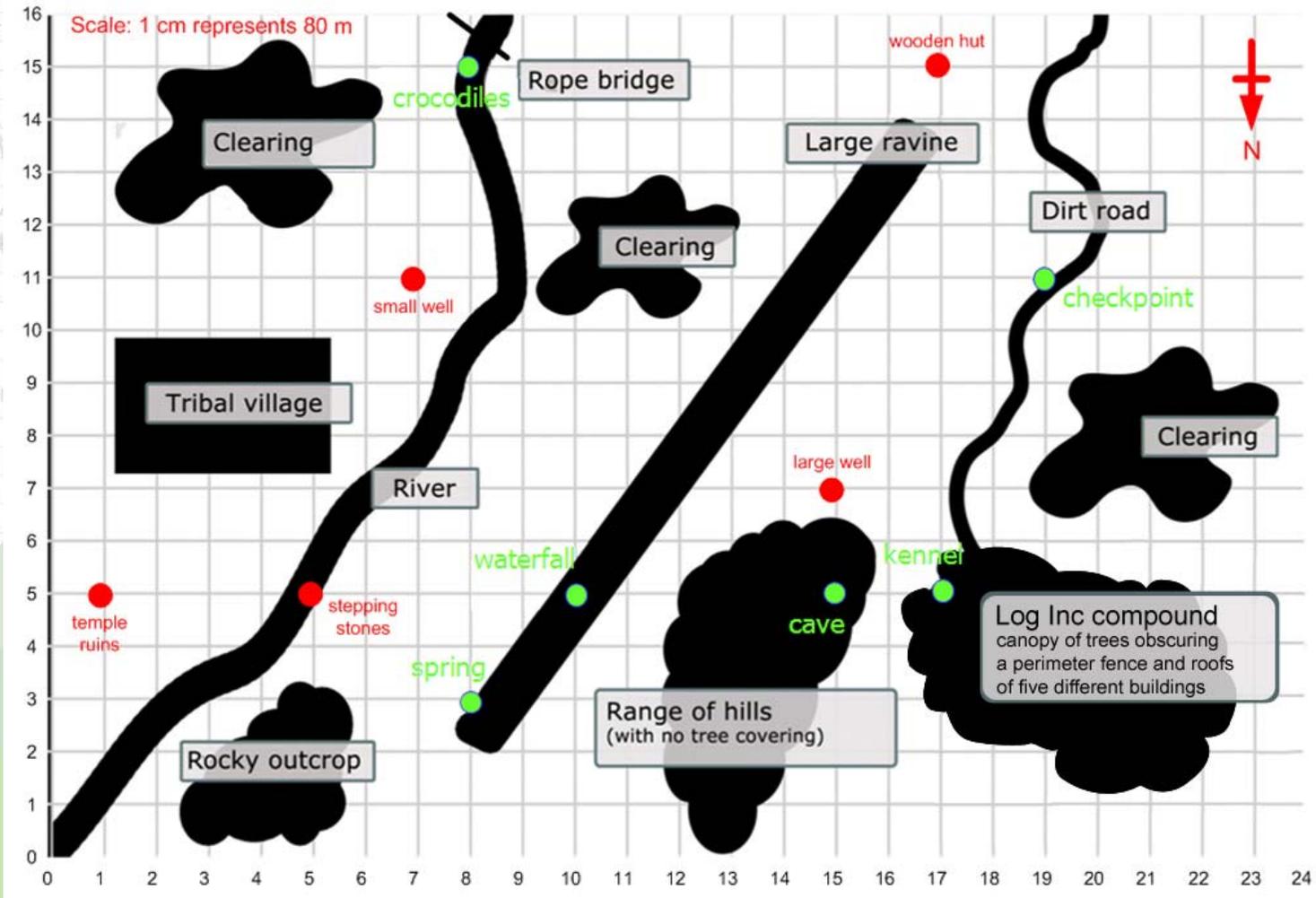
A typical 2 m diameter wind turbine produces about 500kWh electricity per year.



Assuming that these figures would also apply at your base camp, what appliances would you use there? Which would you not use there?

D How would you balance your electricity usage through the day?

Slide of the map with information revealed



Resource 1.7

Lesson 2: Logging activity

Narrative

After a few days of camping in the forest and carrying out surveillance, the team has gathered some valuable evidence for their report on illegal logging activities to the UN. The information has come from snatched conversations between guards, picking up the frequencies of the Log Inc walkie-talkies, a logging lorry invoice and the loads of a sample of lorries over a period of time. An intercepted walkie-talkie conversation suggests that the logs are destined for pulping to make newsprint and that the area, once cleared, will become a cattle ranch.

Problems

Introductory short problem

The team is putting together evidence for their report for the UN. The loggers have been working 7 days a week. The team has recorded the number of lorries each day and estimated their load and the area of forest cleared. The groups estimate the number of trees being felled by Log Inc per year and the annual area of deforestation.

Supplementary or homework problems (optional)

- 1 To help them assess the scale of the problem, the groups estimate the requirements of a national newspaper, *The Daily Grapevine*, for newsprint and works out approximately how many large rainforest trees are being felled each year just to keep this newspaper supplied.
- 2 Deforestation in rainforests is partly due to clearing space for cattle ranches. Log Inc's annual area of deforestation is destined to become a cattle ranch which supplies a fast food chain, and all the beef will end up as burgers. The groups estimate how many burgers per year the cleared area will provide.

Skills required

In this lesson or the homework pupils will:

- round whole numbers to any given power of 10 and decimals to the nearest whole number or to one or two decimal places
- make estimates and approximations of calculations
- calculate percentages of quantities
- use the order of operations, including brackets, with more complex calculations
- use a calculator efficiently to carry out calculations with more than one step
- enter numbers and interpret the display in different contexts
- check results by considering whether they are of the right order of magnitude and by working problems backwards.

Rainforest resources

- 2.1 Video clip: (2 minutes) The advance party makes another video log entry and demonstrates some of the evidence they have found
- 2.2 (Optional) A4 resource sheet of a short introductory problem (if you are using this, print one per pair)
- 2.3 A4 resource sheet of further problems or homework (print as many copies as needed, depending on your plans)
- 2.4 Mobile phone photos of number plates, close-ups of names and addresses on invoices, including a wood pulping company, and a letter to a developer suggesting that the cleared area will become a cattle ranch
- 2.5 Video clip: (1 minute) A few of the team gains access to Log Inc's CCTV cameras and find out what they are up against. They are nearly discovered by security guards – it's a narrow escape!
- 2.6 Optional homework about the format and contents of the UN report.

Other resources

For pupils: calculators.

Main activity

Introduce the next stage of the mission. Play **Resource 2.1**, a two-minute video clip of the evidence gathered by the advance party.

Give out **Resource 2.2**, a short problem, one per pair. Its main purpose is to find estimates of the number of trees felled by Log Inc each year and the annual area of deforestation to use in subsequent calculations. The problem is intentionally structured so that it does not take too long.

Ask the groups to work on the problem, using calculators as appropriate. You may need to remind them how to calculate a mean and that there are 365 days in a year. They may not be familiar with the hectare ($10\,000\text{ m}^2$). Help them to visualise it by comparing it with the size of a standard football pitch (7140 m^2).

Give out **Resource 2.3**, one per pair, and select problems for the groups to work on collaboratively. You could if you wish allocate different problems to different groups, or the groups could select for themselves the problem that they will tackle. They will need to write at the top of the sheet their estimates of the number of trees felled by Log Inc each year and the annual area of deforestation, carrying forward the information from **Resource 2.2**. If you would prefer the teams to spend longer on these problems, omit **Resource 2.2** and simply give the groups suitable approximations to write on their sheets (e.g. $55\,000$ trees, 2.75 km^2 deforestation).

In the beefburger problem, encourage the groups to think through for themselves how to solve the problem by breaking it down into steps. If it becomes necessary prompt them with hints such as:

- About how many cattle could Log Inc's cleared area support? How much beef would these cattle yield? How many burgers could be made from the beef?
- How much beef does the fast food chain need each day? How many cattle would that be in a year? How much grazing land would these cattle need?

In the newspaper problem, allow the groups to devise how to work out their estimate of the area of deforestation required for the annual sales of the newspaper. If they get really stuck prompt them with a suggestion to work out the mass of new wood pulp required for the weekly circulation of *The Daily Grapevine*. If necessary, as a second hint, ask:

- Approximately how many mature trees need to be felled each year to provide new wood pulp for *The Daily Grapevine*?

Differentiation

Key Stage 3 pupils may not be accustomed to calculating with realistic large numbers. Encourage those who struggle with the calculations to use approximations that will make their calculations easier. If they are not sure which operation to use, ask them to think about the question with easier numbers substituted. More able pupils can be asked to consider how they could make their estimates more accurate and how they could check their working.

The introductory problem could be extended by asking pupils to suggest a likely range for the number of mature trees felled each year.

The newspaper problem could be extended by asking the groups to estimate the area of deforestation each year needed to keep the UK supplied with its national newspapers.

Review

Bring the class together to discuss solutions. Pupils' answers will depend on what approximations they have made. In feedback, compare these answers and whether they are realistic. Discuss the approximations and when they should be made.

Now show **Resource 2.4**, mobile phone photos taken by the team as part of their evidence. Tell the teams that they are now closer to being ready to present their findings to the UN. Ask the class:

- Which data do you think would be more important to present to the UN, and why? In what format would you present it, and why? (e.g. charts, tables, numerically, text, photos) Will you also inform the general public about your findings? If so, how will you do it? (e.g. poster, presentation, TV programme, magazine article)

Finish by playing **Resource 2.5**, a one-minute video clip showing a few of the team gaining access to Log Inc's CCTV cameras. But they are nearly discovered by security guards, so it's a narrow escape!

Optional homework

Ask pupils either to do a remaining problem from **Resource 2.3**, for which they may need a calculator. If they have not already done so, they will need to write at the top of Resource 2.3 their estimates of the area cleared each year, carrying forward the information from Resource 2.2.

Alternatively, they could write up their individual conclusions about the questions for the report to the UN posed at the end of the lesson. To remind them of the questions, use **Resource 2.6**.

Footnote

This lesson offers a particularly good opportunity for pupils to do some persuasive writing in cross-curricular work with the English department. Each group of four could be split into two pairs. One pair could use their data to persuade people not to buy a daily paper in order to save the planet from deforestation. The other pair could take the point of view of the newspaper company and use the same data to persuade people of the benefits of buying a daily paper.

Solutions: Lesson 2

Introductory problem on Resource 2.2

a

	Estimated total number of logs	Estimated number of large trees felled
Sunday	280	140
Monday	400	200
Tuesday	380	190
Wednesday	200	100
Thursday	240	120
Friday	300	150
Saturday	320	160
Total	2120	1060
Mean (per day)	302.9	151.4

- b A rough estimate for the total number of large trees being felled each year is $151.4 \times 365 = 55\,261 \approx 55\,000$, with an estimated range of $73\,000 - 36\,500 = 36\,500$.

Though these rough annual estimates are the best that can be made using the only evidence available to the team, it would be worth discussing their reliability. First, the figures are based on a very small sample of what themselves were estimates. You could ask the teams to think about the degree of error that there could have been when they were estimating the numbers of logs each day, and the effect this would have when the figures are projected across the year. You could also ask them to consider whether it would be likely that logging would continue at the same rate throughout each week of the year. For example, Log Inc, may suspend logging in the two wettest months of the year when the tropical rain is at its heaviest. If this were the case, how would it affect the annual estimates?

Pupils may be familiar with the way that high diving scores are calculated. The highest and lowest marks awarded by the team of judges are discounted and the mean is calculated from the remaining marks. Pupils could think about why this system was introduced. If a similar system were adopted for the logs, how would this affect the mean and the range?

- c The estimated area being cleared by Log Inc each year is $151.4 \times 365 \div 200 \approx 275$ hectares per year ($2\,750\,000 \text{ m}^2$ or 2.75 km^2), with a range of $(73\,000 \div 200) - (36\,500 \div 200) = 365$ hectares per year.
- d About 150 large trees are felled each day.
Each team deals with 10 trees per day, so there are $150 \div 5 = 15$ teams.
Each team has 4 loggers, so $15 \times 4 = 60$ loggers are working for Log Inc.

Further problems on Resource 2.3

Answers will vary depending on pupils' estimates.

2 Beefburgers

- a Assume that Log Inc clears about $2\,750\,000 \text{ m}^2$ of rainforest per year.
This area, if turned into a cattle ranch, would support $2\,750\,000 \div 1000 = 2750$ cattle.

 2750 cattle would yield about $2750 \times 800 = 2\,220\,000 \text{ kg}$ beef.
This beef would make about $2\,220\,000 \div 100 = 22\,200$ burgers.

- b** 75 burgers per second is

$75 \times 60 \times 60 \times 24 = 6\,480\,000$ burgers per day.

If these burgers are each 0.1 kg,
the chain needs 648 000 kg beef each day for their burgers.

The number of cattle needed to supply the beef for one day is about
 $648\,000 \div 800 = 810$ cattle.

The number of cattle needed to supply the beef for one year is about
 $810 \times 365 = 295\,650 \approx 300\,000$ cattle.

These cattle require $300\,000 \times 1000 = 300$ million m^2 of grazing land, or 300 square kilometres,
about twice the size of England and Wales combined.

2 Newspaper production

- a** The newspaper's weekly circulation requires about
 $800\,000 \times 6 \times 0.3 \times 0.6 = 864\,000$ kg new wood pulp.

About $2500 \times 0.9 = 2250$ kg of each tree trunk is used to make new wood pulp.

The weekly circulation requires about $864\,000 \div 2250 = 384$ trees.

The annual circulation requires about $384 \times 52 = 19\,968 \approx 20\,000$ trees.

To produce 20 000 trees, the area of forest that must be cleared is
 $20\,000 \div 200 \approx 100$ hectares ($1\,000\,000 \text{ m}^2$ or 1 km^2)

The problem could be extended by estimating the area of deforestation each year to keep the UK supplied with its national newspapers.

The UK has a population of about 60 million.

The USA has a population of just over 300 million, so (assuming that newspapers are bought at a similar rate per head of population) pupils could estimate the area of deforestation needed to keep the USA supplied annually with national newspapers.

In developed countries, the problem could be tackled, for example, by making national newspapers only available online.

- b** Pupils' suggestions, e.g.

How does the area of newspaper pages used for photographs vary from one type of UK national newspaper to another? (tabloid/broadsheet, weekday/Saturday/Sunday)

If there were no photographs in national newspapers, about how many rainforest trees could be saved each year?

Pupils would need to use measurements, approximations and suitable calculations to answer the questions. They would also need to do Internet research to find out daily circulation figures of national newspapers.

Optional homework on Resource 2.6

Pupils' suggestions and justifications.

The purpose of the homework is to help pupils to see how different reports are suitable for different audiences. Their justifications should address this point.

Introductory problem

1 The team is ready to start analysing their data ready for their report to the UN.

The loggers have been working for 7 days a week. The branches of the felled trees have been sawn off and burned on the spot and **each trunk has been sawn in half to make two large logs.** The team has been taking substantial risks but the members have managed to record the number of lorries and their loads as they take the logs away each day.

a Help in the fight against Log Inc by completing the table.

	Estimated total number of logs on all lorries	Estimated number of mature trees felled
Sunday	280	
Monday	400	
Tuesday	380	
Wednesday	200	
Thursday	240	
Friday	300	
Saturday	320	
Total		
Mean (per day)		

b Give an estimated range for the total number of mature trees felled by Log Inc **per year.**

..... trees

c Each night the team has counted the number of tree stumps left in a measured area. They have worked out that on average each hectare (10 000 m²) of rainforest has produced about 200 mature trees, which have now been felled.

Give an estimated range for the total area of deforestation (the cleared area) created by Log Inc each year.

..... m²

d On a typical day, the loggers work in teams of 4 people. Each team of loggers has dealt with about 10 large trees each day. Estimate how many loggers are working for Log Inc.

..... loggers

Further problems

1 These questions will really help the team prove their case against Log Inc.

One of the main reasons for logging is to provide wood for the paper industry.

Newspaper paper is called newsprint; it is generally made from 60% new wood pulp and 40% recycled newsprint.

One of the UK newspapers sells about 800 000 copies every day from Monday to Saturday.

On average the paper weighs about 300 g each day.

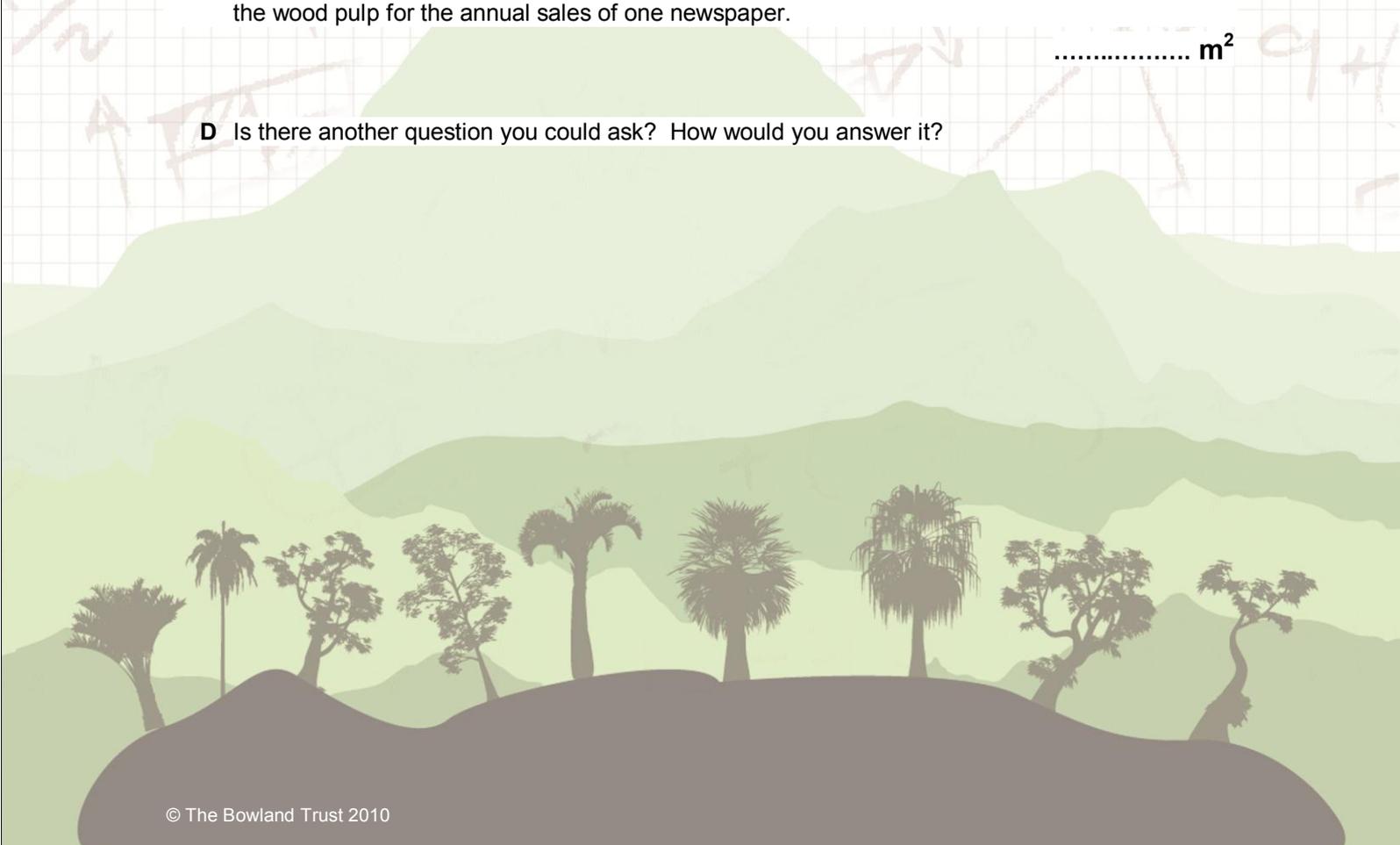
A The newspaper's **weekly** circulation requires about **kg new wood pulp**

B The average mass of the trunk of a mature rainforest tree is about 2500 kg.
10% of it is bark.

Assuming that the rest is all turned into new wood pulp - approximately how many mature trees need to be felled **each year** to provide new wood pulp for the newspaper?
..... **trees**

C Each hectare (10 000 m²) of rainforest produces about 200 mature trees.
Can you estimate the total area of deforestation (the cleared area) created each year to provide the wood pulp for the annual sales of one newspaper.
..... **m²**

D Is there another question you could ask? How would you answer it?



Write your estimates of:

- The number of mature trees felled by Log Inc each year: **trees**
- The area of rainforest cleared by Log Inc each year: **m²**

Additional homework

Deforestation in rainforests is partly due to space being cleared for cattle ranches. One cow needs about 1000 m² of grazing land and yields about 800 kg of beef.

- A** Use your estimate of the area of rainforest cleared by Log Inc each year. Assume that this area is going to be turned into a cattle ranch. All the beef is used to make 100 g burgers.

Complete this sentence:

If **m²** of rainforest cleared by Log Inc became a cattle ranch, the ranch would support enough cattle to make about **burgers** every year.

- B** One fast food chain claims that they make more than 75 burgers per second. How many burgers is this per day?

..... **burgers**

- C** How many cattle are needed to provide beef for burgers for one day for the fast food chain?

..... **cattle**

- D** Cattle are slaughtered for beef when they are 1 year old. How many cattle are needed to provide beef for one year for the fast food chain?

..... **cattle**

- E** How many square metres of grazing land (possibly cleared rainforest) do these cattle need?

..... **m²**

Lesson 3: Sustainability

Narrative

During the team's time in the rainforest, they have been able to meet some of the people in the local villages and are starting to understand some of the issues that the locals face. As the team has spent time compiling data about Log Inc, the local people are starting to trust them. The environmentalists are therefore not surprised when the elders of a local village come to ask for their help. The elders want the team to explain and present some alternatives to logging which would also bring wealth into their village.

Problems

Main problem

Together, a number of villages occupy about 300 000 hectares of rainforest land. Some of the villagers are keen to sell their land to loggers as this generates a large profit for them. The team must present a case that convinces them to preserve as much rainforest as possible. The presentation will need to include some options with details of how each option would affect the villagers' finances in the short, medium and long term.

Supplementary or homework problems (optional)

The team needs a better idea what Log Inc's building and compound look like, ready for their UN report, and surveillance needs to increase.

- 1 Sketches of the building have been emailed through by the advance party. The team at base camp must now draw the building's plan, side and front views.
- 2 Two of the team have paced the perimeter and have texted the information that it is L-shaped and 1 kilometre long. The team at base camp must draw a possible scale plan of the compound.
- 3 Nine of the team will observe the gates of the compound for 3 days. Everyone in the group will do one shift with each other person, so that each pairing is different and skills are shared. All the shifts will be of equal length. The team must work out the length of a shift.

Skills required

In this lesson or in the homework pupils will:

- identify the necessary information to solve a mathematical problem
- break a problem into smaller parts and structure problems that need several steps
- try out and compare mathematical representations
- develop a reasoned case or argument and present or communicate it
- draw conclusions of their own and give an explanation of their reasoning
- check results, considering whether they are reasonable
- draw simple plans and elevations and make scale drawings
- solve problems involving the perimeter and area of 2D shapes
- structure problems that need several steps.

Rainforest resources

- 3.1 Video clip: (40 seconds) The team has been approached by local villagers who have asked for their help, so they have arrived at the village ready to offer their expertise
- 3.2 A4 resource sheet of the main problem (print one per pair or group)
- 3.3 Slide showing success criteria
- 3.4 Optional A4 resource sheet of supplementary or homework problems (print as many copies as needed, depending on your plans for using the problems)
- 3.5 A4 peer review sheet (print one per pair or group)
- 3.6 Video clip: (50 seconds) The Log Inc alarm sounds – the team has been detected! They must escape before they get caught!
- 3.7 Slides reminding pupils how to draw front, side and plan views of 3D objects (optional)

Other resources

Squared and plain paper for the optional supplementary or homework problems.

Main activity

Introduce the next stage of the mission. Play **Resource 3.1**, a 40-second video clip of the team at a local village, ready to help the indigenous people.

Give out **Resource 3.2**, the main problem, one per pair or group. Read it through together to make sure that everyone understands the information. Explain that the task is to prepare a short report for the villagers explaining what you advise them to do and why, and then to present the key ideas, either on a poster that can be displayed in the centre of the village, or in a presentation that you can show to the villagers.

Show **Resource 3.3**, a slide of the success criteria for the task.

Ask the groups to spend 5 minutes thinking about how they are going to tackle the problem and to make a plan. Then take some feedback, asking questions like:

- ▶ How are you going to present your findings?
- ▶ How are you going to organise your report?
- ▶ What do you think will be important to include?
- ▶ Would it be useful to include a spreadsheet or a graph?
- ▶ Would it be useful to put some results in a table?

Allocate time for groups to complete the task, stressing that it is important to present a *mathematical* case to the villagers.

If pupils have considered the report to the UN for homework after lesson 2, include a discussion of comparisons between the two reports (to the villagers and the UN), drawing out points about tailoring the report to the needs of the audience.

Differentiation

To make the main problem easier it would be possible to limit the options available to pupils. For example, you could ask them to consider only the **logging** and **sustainable** options.

You could also add an optional extension that more able pupils could explore, e.g. farming **soy** on deforested land produces a profit of around \$300–\$600 per hectare each year. For reference, you may wish to make use of more complex data from the Internet, e.g. on assets.panda.org/downloads/wnf_amazonerapport_def.pdf

Groups that finish ahead of time could assist another group or, if time allows, you could ask them to try one of the supplementary problems on **Resource 3.4**. The supplementary problems vary in difficulty. The second is the easiest and the third is the hardest. Squared paper is needed for the first two supplementary problems.

Review

Bring the whole class together to present their findings to each other.

This activity would lend itself to peer review. As an option, pupils could use the **Resource 3.5**, a peer review sheet, to record their assessments. Any notes could be made on an extra sheet of plain paper.

To round off, show **Resource 3.6**, a 50-second video clip. The alarm sounds – the team has been detected and must escape before they get caught!

Optional homework

Ask pupils to do a remaining problem from **Resource 3.4**. They will need a ruler and squared paper. If they need a reminder on how to draw front, side and plan views of simple 3D objects, use one or more slides from **Resource 3.7**.

Solutions: Lesson 3

Main problem

This problem is not really about the numbers but more about how pupils justify their choice of figures and the decisions that they make.

Here are some figures that teams might use in their argument:

Logging

300 000 hectares at \$1000 per hectare gives a one-off figure of \$300 million (\$300 000 000)

Cattle ranching

300 000 hectares at \$51 gives a figure of \$15.3 million per year which rises to \$44.4 million if the highest figure of \$148 per hectare is included. Teams might opt for a middle value of around \$100 per hectare which would raise \$30 million per year.

Harvesting

300 000 hectares of rainforest at \$426 per hectare will raise \$127.8 million per year.

Eco-tourism

Assuming that the figure provided is accurate then \$75 000 might be raised per year by eco-tourism.

General

An argument might be that the one-off profit from selling to Log Inc for logging and cattle ranching is attractive. For example, Log Inc's potential income from these two activities would be \$300 million from the initial logging and an additional \$300 million from the ranching, giving a total income of \$600 million over the ten years at an average of \$60 million per year. Log Inc would be prepared to pay half of this to the villages for the sale of the land.

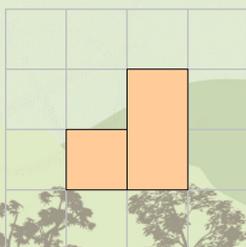
However, it is clear to see from this that the sustainable option of harvesting is more than twice as profitable over a ten-year period and has the additional benefit that the income will continue into the future. Even when the loss of income from the current arrangement of leasing the land is taken into account, this would be a better option.

Using these figures, the income generated by ecotourism is almost negligible although teams might argue that calculating a figure per hectare is inaccurate.

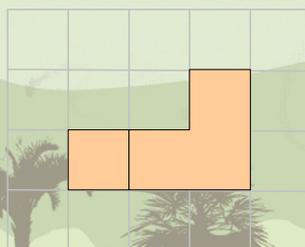
Supplementary or homework problems on Resource 3.4

1 Views of Log Inc's headquarters

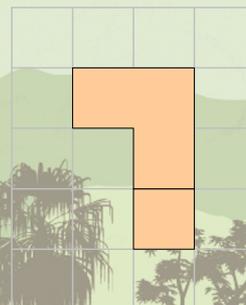
Front view



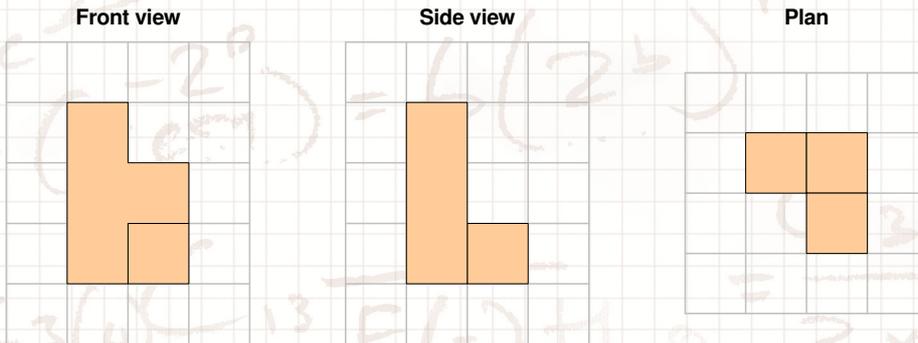
Side view



Plan

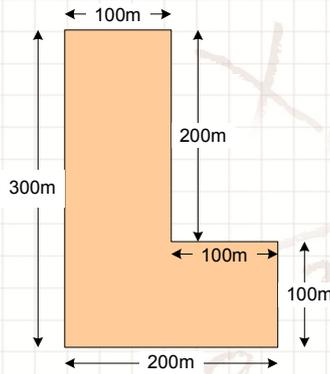


Views of the sleeping block



2 Pupils' own solutions

Different solutions are possible but one possibility is:



3 Pupils may find it helpful to draw diagrams such as:

	A	B	C	D	E
A	×	AB	AC	AD	AE
B	BA	×	BC	BD	BE
C	CA	CB	×	CD	CE
D	DA	DB	DC	×	DE
E	EA	EB	EC	ED	×

In general, n people can pair up with $n - 1$ other people, but since A observing with B is the same pair as B observing with A, and so on, each pair is counted twice. So the total number of pairs is $\frac{1}{2}n(n-1)$.

For 9 people, the number of pairs (and hence the maximum number of shifts) is $9 \times 4 = 36$, and the length of a shift is 2 hours.

Main problem

The sums of money mentioned on the fact cards below are in US dollars (\$).

Logging a single hectare of rainforest generates logs that can be sold for around \$1000 cash. It will take at least 50 years for the rainforest to grow back again. Land that has been logged can be used for grazing cattle.

The **sustainable** annual value of a rainforest is around \$426 per hectare. This profit comes from a variety of sources, such as harvesting and selling non-timber products, and from carbon storage.

One section of rainforest in Ecuador reported revenues of \$148 235 per year for five **eco tourism** sites at Cuyabeno. These sites cover an area of 603 380 hectares. On average, the profit is \$0.25 per hectare per year.

The profit from **cattle ranching** on deforested land is from \$51 – \$148 per hectare. Depending on how the land was cleared for ranching, it will become barren and unusable for grazing after anything from 3 to 20 years.

A number of villages around Log Inc's headquarters make up about 300 000 hectares of rainforest in total.

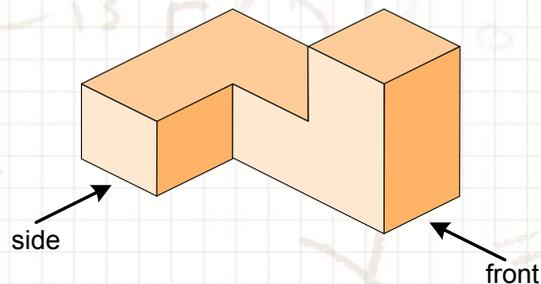
The loggers have been trying to convince the villages to sell the land to Long Inc. They have been very persuasive and some villagers are keen to sell their land to loggers as this would generate the greatest profit for them. You must stop this happening but the only way to do this is to let the villagers know that they do have other options that will not harm the environment. You must present a case that convinces the villagers to preserve as much rainforest as possible.

You will need to show some of the different ways that the villagers could use their land to make profits and how this would affect their finances over the short, medium and long term.

You can find a more detailed breakdown of the costs at assets.panda.org/downloads/wnf_amazonerapport_def.pdf

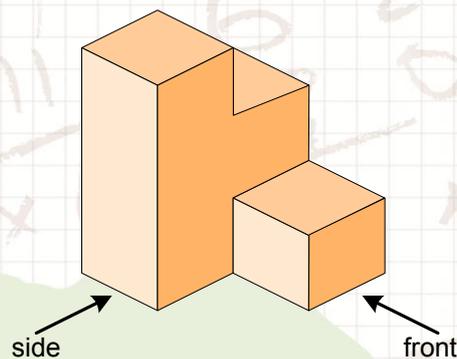
- 1 **A** You need some squared paper.

You can tell from your photos that Log Inc's headquarter building, a pre-fabricated structure, is based on cubes and is shaped like this.



Help with the surveillance operation by drawing a plan, front view and side view for the building.

- B** If you have time, repeat for the sleeping block.



- 2 You need some squared paper.

Some of the advance group have paced round the perimeter of Log Inc's compound. They have found that it is L-shaped and 1 kilometre long.

Choose a suitable scale and draw a possible scale plan of the compound.

Write the scale you have chosen next to your drawing.

Label each side of the L-shape with its actual length in metres.

Work out the actual area of the compound you have drawn.

- 3 Pairs from a group of nine will observe the gates of the compound for 3 days.

Everyone in the group will do one shift with each other person, so that each pairing is different and skills are shared. All the shifts will be of equal length.

How long will each shift be?

<p>Success criteria: Please give a mark out of 5 for each criterion</p>	Names					
	<p>1 Is the presentation/poster clear and easy to understand?</p>					
		<p>2 Is the presentation/poster accurate?</p>				
			<p>3 Does the presentation/poster give you, as a villager, enough information to make a decision?</p>			
				<p>4 Does the presentation/poster convince you that you don't need to sell all your land for logging ?</p>		
					<p>Total marks(out of 20)</p>	

Lesson 4: Escape

Narrative

Four of the team were nearly caught by the guards but they have escaped into the forest. They are close to a point where a dilapidated rope bridge is suspended across a muddy river infested with crocodiles. In the confusion, they have lost all but one of their torches. They are suffering from various degrees of exhaustion and are hiding in the dense undergrowth waiting for first light. One member of the group uses his camera to film the other three as more evidence for the UN. A radio message from another group informs them that they must get across the bridge to the clearing where a helicopter can evacuate them – but they must hurry, the guards are only 15 minutes behind them! The group cannot leave it any longer. They must cross the river in the dark, using the bridge.

Problems

Main problem

The rope bridge can hold only two people. It is dark and dangerous, so the torch must be used by whoever is crossing. The group leader can cross in 1 minute, but the other three will take 2 minutes, 5 minutes, and 8 minutes respectively. When two people cross together, they must move at the slower person's pace. Can all four of them get across the bridge in 15 minutes or less? And how can the group use their mobile phones to send their plan to the other environmentalists who are following?

Supplementary or homework problems (optional)

- 1 Another group of four has reached the river. They come across an old canoe with a paddle but the canoe cannot carry more than 100 kg. The leader weighs 90 kg and the others weigh 80kg, 55kg and 45 kg. They have a single 20 kg pack of equipment which contains their gear and their UN report. How can they get across as quickly as possible?
- 2 Having escaped from the rainforest and out of the clutches of Log Inc, the team must now return to UK. How will they get home? Which method of transport will they use to minimise their carbon footprint?

Skills required

In this lesson pupils will:

- identify the necessary information to solve a mathematical problem
- try out and compare mathematical representations
- use logical argument to establish the truth of a situation
- draw simple conclusions of their own and give an explanation of their reasoning
- check results, considering whether they are reasonable.

Rainforest resources

- 4.1 Video clip: (1 minute): It is dark. The group pauses to gather breath – the fourth member of the group valiantly continues to film. A walkie-talkie message comes through – the guards are close behind and the group needs to get over the rope bridge and to safety.

- 4.2 A4 resource sheet of the main problem and a supplementary one about getting across the river (print one copy per pair, and one copy per pupil if needed for homework)
- 4.3 Final video clip: (1 minute 20 seconds): A helicopter is circling around and the team is running through forest. 'Heavies' appear on the horizon. The team runs into a clearing and escapes in the nick of time!
- 4.4 A4 resource sheet of an additional problem (print one copy per pair, and one copy per pupil if also needed for homework)
- 4.5 Slide with an outline map of the world showing the relative locations of Venezuela and the UK HQ

Other resources

For pupils: pencils and erasers, and scraps of paper which can be labelled **A**, **B**, **C** and **D** with the times taken to cross the river.

Main activity 1

Begin the final stage of the mission. Play **Resource 4.1**, a 1-minute video clip.

Give out copies of **Resource 4.2** for groups to work on the first main problem. If they get stuck, feed them at intervals with prompts such as:

- ▶ Would it help to draw a diagram showing the two river banks and use scraps of paper to represent the people?
- ▶ Which member of the group should make the most crossings?
- ▶ Which two people should cross together so that the crossing time of the faster one is discounted and is not included in the total time?

Differentiation

Any groups that may need a simpler problem, or groups that finish the first problem quickly, could try the supplementary problem on **Resource 4.2**.

Main activity 2

Take brief feedback on the river crossing problems, then play **Resource 4.3**, the final video clip (80 seconds) showing the success of the mission: the helicopter lands, picks up the team and takes off again, all just in time.

If time allows, or as an alternative to the river crossing problems, give out **Resource 4.4**, the additional problem. Data is provided to allow pupils to plan their journey home from Caracas, Venezuela to the UK. The sources of information used for this resource are:

http://www.carbonfund.org/site/pages/carbon_calculators/category/assumptions

http://www.epa.gov/chp/documents/hotel_casino_analysis.pdf

http://docs.wri.org/wri_co2comm_2002_commuting_protected.xls

Use **Resource 4.5**, a slide showing an outline map of the world, to check that pupils know the location of Venezuela and understand the options that are available. Also point out that for every 1200 km of road travel, they will need an overnight hotel stop.

Give the groups an opportunity to talk through some of the issues and understand the problem. Emphasise that you will be asking them to present a reasoned and costed method to travel home, based on the data given.

This task could be time-consuming task if pupils considered every possibility. One approach would be to ask the groups to discuss travel possibilities, then to share their ideas in a plenary. The class could then discuss which possibilities to pursue and one or two groups could calculate the CO₂ footprint for each selected possibility. Teams could present their findings and together select the preferred method of travel. This approach would minimise duplication of calculations while engaging all pupils in the possibilities. It would also allow all pupils to 'end the case study feeling a real sense of achievement'.

Review

Take feedback on the progress the groups have made in planning their journey home.

Finish the case study by explaining that in real life people are often required to work in teams on problems that involve mathematics, just as would happen if there really were an undercover mission to find out more about illegal logging activities.

Optional homework

Pupils could either do the supplementary problem if they have not done it in class, or they could continue to refine their planning of their journey home.

Solutions: Lesson 4

Main problem on Resource 4.2

- 1 Assume that the team leader is **A** (1 min) and the others are **B** (2 min), **C** (5 min) and **D** (8 min).

An obvious first idea is that the time to return the torch to the people waiting to cross should be minimised. This strategy makes A the torch bearer, shuttling each person across the bridge in turn.

Elapsed time	Start side	Action	Other side
0 minutes	ABCD		
2 minutes	CD	A and B cross, taking 2 minutes	AB
3 minutes	ACD	A returns, taking 1 minute	B
8 minutes	D	A and C cross, taking 5 minutes	ABC
9 minutes	AD	A returns, taking 1 minute	BC
17 minutes		A and D cross, taking 8 minutes	ABCD

This strategy takes 17 minutes, which is too long.

If the two slowest people cross individually, this wastes time. To solve the problem, they need to cross together. For example:

Elapsed time	Start side	Action	Other side
0 minutes	ABCD		
2 minutes	CD	A and B cross, taking 2 minutes	AB
3 minutes	ACD	A returns, taking 1 minute	B
11 minutes	A	C and D cross, taking 8 minutes	BCD
13 minutes	AB	B returns, taking 2 minutes	CD
15 minutes		A and B cross, taking 2 minutes	ABCD

This strategy takes exactly 15 minutes.

The return crossings made by A and B could be interchanged.

Supplementary or homework problem on Resource 4.2

Assume the team are:

A (90 kg), B (80 kg), C (55 kg) and D (45 kg) and the rucksack is R (20 kg).

Variations on the solution on the right are possible but they all result in 9 crossings, five across and four back.

Start side	Action	Weight	Finish side
ABCD + R	Start		
AB + R	C and D cross	100 kg	CD
ABD + R	D returns	45 kg	C
BD + R	A crosses	90 kg	AC
BCD + R	C returns	55 kg	A
B + R	C and D cross	100 kg	ACD
BD + R	D returns	45 kg	AC
D	B crosses with R	100 kg	ABC + R
CD	C returns	55 kg	AB + R
	C and D cross	100 kg	ABCD + R

Additional problems 4.4

Assuming that 'UK HQ' is in London ..., here are two possible options that pupils could use in their arguments.

- **Option A:**

By air direct from Caracas to London:

Caracas to London \approx 4690 miles

0.18 kg of CO₂ per mile \rightarrow 844.2 kg of CO₂

for 4 people \rightarrow 3376.8 kg of CO₂

- **Option B:**

By air from Caracas to Miami

By sea from Miami to Southampton

By bus from Southampton to London

By air Caracas to Miami \approx 1371 miles

0.18 kg of CO₂ per mile \rightarrow 246.78 kg of CO₂

for 4 people \rightarrow 987.12 kg of CO₂

By sea Miami to Southampton = 3882 sea miles

0.43 kg of CO₂ per sea mile \rightarrow 1669 kg of CO₂

for 4 people \rightarrow 6676 kg of CO₂

By bus Southampton to London = 111 miles

0.08 kg CO₂ per km \rightarrow 8.88 kg

for 4 people \rightarrow 35.52 kg

Total for the journey = 987.12 + 6676 + 35.52

= 7698.64 kg of CO₂

These are not the only possibilities.

Pupils might think that air travel gives a larger carbon footprint. Certainly figures would suggest that where it is possible rail travel has a lower carbon footprint than short haul air travel but where rail or road travel is not possible (e.g. for long distances across oceans), air travel is a better alternative than sea travel.

Main problem 1



Four of the team have escaped. They have one torch left between them.

They have reached a dilapidated rope bridge across the river.

They estimate that the guards and their dogs are about 15 minutes behind them.

It is obvious that the rope bridge can hold at most two people at a time.

It is dark and dangerous, so the torch has to be used by whoever is going across.

The group leader can cross the bridge in 1 minute, as he is skilled in rainforest survival - the second in command will take 2 minutes - it will take 5 minutes for the third team member as he is scared of heights and the fourth team member will take 8 minutes because she has twisted her ankle badly during the escape.

When two people cross the bridge together, they must move at the slower person's pace.

Can all four of them get across the bridge in 15 minutes or less?

How will you communicate the plan to the rest of the team?

Talking will alert the guards but you can text on your mobile phone.

You need to be as brief as possible - time is of the essence!

Supplementary or homework problem

Another group of four has reached a different part of the river.

They have found an abandoned canoe with a paddle and are keen to use it to cross the water but the canoe is old and battered and can't carry much weight.

The group agree that if they try to put more than 100kg in the canoe it is likely to sink.

The group leader, with his rucksack, weighs 90 kg and the other three weigh 80kg, 60kg and 40 kg.

They have an extra single 20 kg pack of equipment which contains their computers and cameras and their report for the UN, which they must not leave behind.

They need to get across the river as quickly as possible.

How are they going to do it? How many crossings will it take?

Additional problem

The end is in sight. You are close to completing your mission successfully. There is just one more challenge in your way – you must get home.

You need to plan your journey back to the UK HQ in London from Caracas, Venezuela. There are four people in your group and you will all travel together if possible.

You can break your journey at any point or use different types of transport at different stages if you wish.

The speed and cost of your journey are not important. Your main aim is to keep your 'carbon footprint' as low as possible to limit damage to the environment. Your 'carbon footprint' is the total amount of carbon dioxide (CO₂) you produce on the journey. It depends on the type of transport you use and the distance you travel.

Here are some facts to help you to plan your journey.

Sea travel

For each passenger, the liner Queen Catherine gives out 0.43 kg of CO₂ per sea mile.

Air travel

For each passenger, an aeroplane typically produces from 0.24 kg CO₂ per mile for short flights to 0.18 kg CO₂ per mile for long-haul flights.

Rail travel

For each passenger, commuter rail and subway trains on average give out 0.16 kg of CO₂ per mile, and long distance trains give out 0.19 kg of CO₂ per mile.

Bus travel

For each passenger, inner city commuting buses give out 0.3 kg of CO₂ per mile, and long distance bus trips emit 0.08 kg of CO₂ per mile.

For every 750 miles of travel by bus, you will need an overnight hotel stop.

Hotel rooms

A one-night stay in a room at an average hotel produces 29.53 kg CO₂ whereas an upmarket hotel room produces 33.38 kg CO₂.

Approximate distances

By air	Caracas	Miami	New York
Miami	1371 miles		
New York	2136 miles	2000 miles	
London	4690 miles	4463 miles	3487 miles

By sea	Puerto la Cruz	Miami	New York
Southampton	4020 sea miles	3882 sea miles	3156 sea miles

By road or rail	Caracas	Miami	Southampton
Puerto la Cruz	155 miles	-	-
New York	-	1330 miles	-
London	-	-	111 miles

Puerto la Cruz, on the Venezuelan coast, is the nearest port to Caracas.