5 Case study: The Amazon Basin

Background to the case study

Location

The Amazon Basin is a saucer-shaped depression that covers a large part of northern South America, as shown in Figure 5.1. The main river lies close to the equator and extends approximately 10° to its north and south.

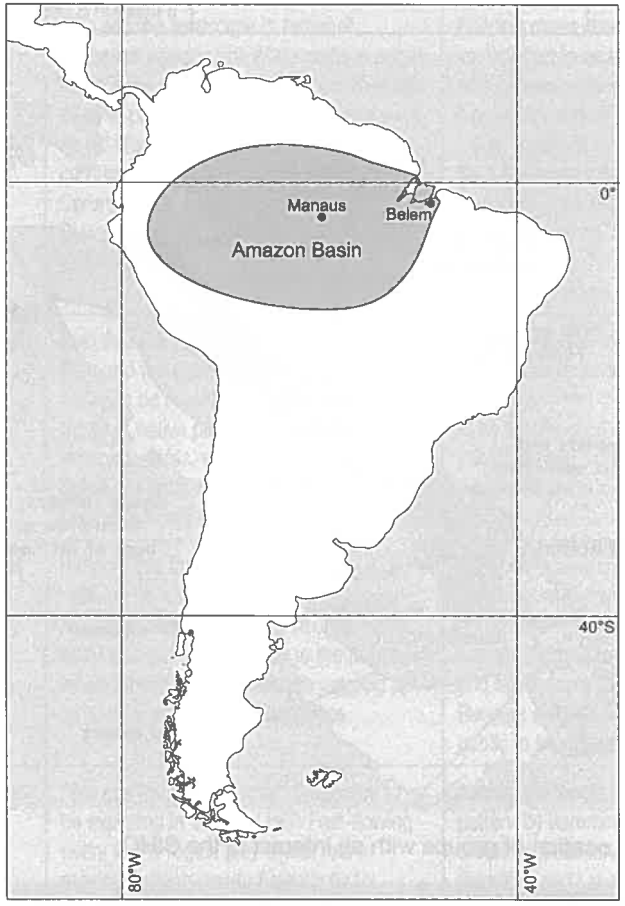


Figure 5.1 Location of the Amazon Basin

Size and extent

The Amazon Basin covers an area of approximately 7 million km². This huge river basin has its source high in the Andes mountains to the west, and it lies between two ancient mountain ranges – the Guyana Plateau to the north and the Brazilian Plateau to the south. The river empties into the Atlantic Ocean at its eastern boundary. Most of the basin lies in Brazil, although parts of it extend into eight other countries. The main features are shown in Figure 5.2.

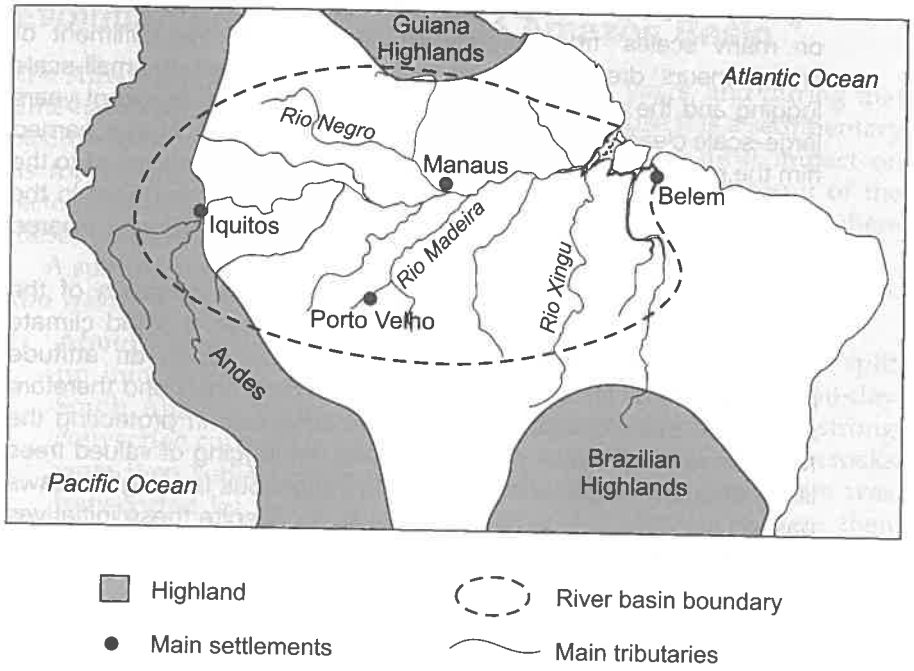


Figure 5.2 Main features of the Amazon Basin

Cultural history of the region

The Amazon Basin is often referred to as a 'green frontier'. This is because its vast size, its dense, often impenetrable rainforest, its humid climate and numerous bugs make it inhospitable for people. In spite of this there was a time in the Amazon Basin's history when many indigenous tribes lived there. However, following their harsh treatment by early European conquistadors, the number of indigenous Amerindians was significantly reduced, and those who were left were forced into small pockets within the rainforest to survive.

More than 300 different tribes are known, e.g. the Yanomani and Boro of Brazil, and the Quechua of Peru. These people have become much more westernised over time, and few now maintain traditional

lifestyles. Instead, most live in the region's few cities, such as Manaus and Belem.

For many years the Amazon Basin was viewed by the Brazilian government as 'too difficult', and ignored. However, it then became apparent that many valuable resources were to be found there. The government was therefore anxious to secure this region, and thus promoted resettlement schemes of people from overpopulated regions such as the northeast, and encouraged commercial ventures. The region was opened up in the 1970s by the construction of a major highway – the Trans-Amazonian Highway. This allowed development on many scales, from large-scale ranches and the fulfilment of entrepreneurs' dreams, such as Ludwig's Jari project, to small-scale logging and the clearing of land for market gardens. In recent years large-scale clearing of land by one entrepreneur, Blairo Maggi, earned him the nickname 'The Soya Bean King'. All these ventures led to the clearing of the native forest on a massive scale. At its height in the 1990s, it was said that the equivalent of a rugby field was cleared every minute!

Such massive deforestation quickly drew the attention of the rest of the world, who argued that this was altering world climate patterns and contributing to global warming. Such an attitude posed problems for a country trapped in a debt crisis and therefore anxious to see monetary return. Some advances in protecting the forest have been made, such as making the logging of valued trees like mahogany illegal, and recognising indigenous land rights. Laws passed are difficult to enforce, however, so despite these initiatives many problems remain and deforestation continues unabated.

❍ Useful statistics to learn

- *The Amazon is more than 7000 km long, and 300 km wide at its mouth.*
- *The Amazon Basin is 18 times the size of New Zealand.*
- *The Amazon holds 25% of all the world's fresh water.*
- *The region has 33% of the world's tropical rainforests.*
- *The river has more than 1100 tributaries.*
- *The gradient is so small that the river drops only 100 m from Iquitos to its mouth.*
- *The average temperature is 26°C, while the temperature range is only 2°C.*
- *The region receives more than 2000 mm of rain per year.*
- *Amazonia covers 59% of Brazil, but has only 5% of the population.*
- *Each hectare supports 200 trees.*
- *The region is home to more than 30 million species.*
- *The tallest trees reach up to 45 m.*
- *Destruction of the rainforest reached an all-time high in 1995.*
- *Around the world, seven species become extinct every day in tropical rainforests.*

Evolution and change in the Amazon Basin

The Amazon Basin has evolved over millions of years, and during that time has experienced many dramatic stages. Because it is a sedimentary basin, surface processes of deposition have had the most impact on its formation. However, these processes were an indirect result of the tectonic action which created the bordering mountain ranges where these sediments originated.

A summary of the main stages in the landscape's evolution follows. You will need to add details on these processes (see Chapter 2).

1 **About 500 million years ago** the continent of Gondwanaland split up into sections, one of which was the precursor to present-day South America and Africa. This break-up occurred due to strong convection currents in the mantle. These ancient pre-Cambrian rocks were then subject to erosion. The material eroded from them was transported by rivers, in which they accumulated and were then compressed under water into sandstone. A vast inland lake formed, which eventually drained into the Pacific.

2 **90 million years ago** South America and Africa separated from each other. As South America shifted westwards, it collided against the Nazca Plate, which was moving east. The collision pushed up the softer sedimentary sediments along the western boundary to form a range of fold mountains – the Andes. At the same time land in the north and east buckled, forming a trough-like basin.

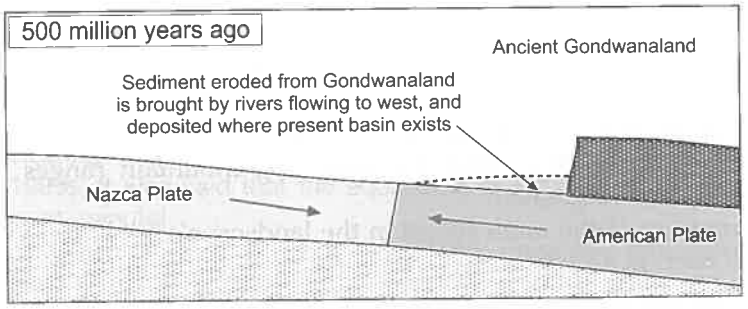
3 **10 million years ago** the Amazon River was forced to change direction and flow instead into the Atlantic Ocean. At the same time, intrusions of magma in the Andes aided earth building.

4 **2 million years ago**, during the quaternary period, the region experienced a cold spell, or ice age. This carved up the soft sedimentary rock of the Andes and caused much of it to be reduced to sediment.

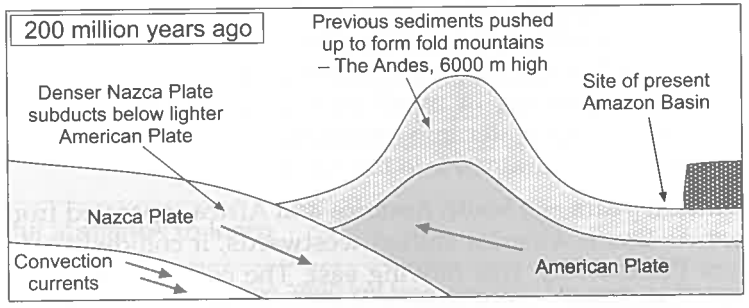
5 **Present**: this sediment was then transported by the many tributaries of the Amazon, such as the Rio Madeira. In the upper reaches of the Andes, steep gradients meant that river flow was fast and erosion

extensive, creating deep V-shaped valleys. As the sediment met the flat basin in the Andes foothills, river flow was reduced and instead the rivers began to deposit their loads.

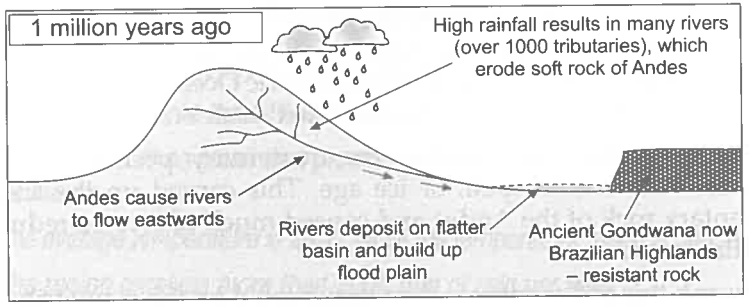
Over time the rivers have built up the basin, making it shallower and flatter. Today there is only a 100 m drop from the edge of the Andes foothills to the Amazon mouth. Because of this the basin is liable to flood seasonally, causing the build-up of extensive flood plains. Also, the river meanders due to the small relief, causing widespread deposition across the basin. Sediment tends to originate



Stage 1: Tectonic action begins with break-up of Gondwanaland



Stage 2: Continued tectonic action creates fold mountains



Stage 3: Erosion of fold mountains by rain builds up river basin

Figure 5.3 The main stages in the evolution of the Amazon Basin

from the Andes as the rock there is much softer than the hard ancient shields of the Guyana and Brazilian plateaus.

Figure 5.3 summarises these stages in the Amazon Basin's evolution.

Variations within the Amazon Basin

The Amazon Basin can be divided into four distinct zones, making it easier to then examine the variations that occur. These areas are shown in Figure 5.4. For each variation you need to describe the pattern and then explain it.

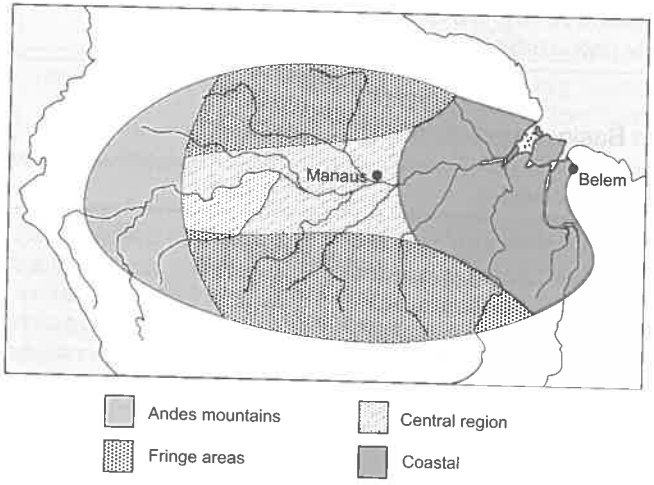


Figure 5.4 Main zones of the Amazon Basin

The Amazon Basin: Landform patterns

Zone	Landform pattern	Reason for pattern
Andes	Slopes of the Andes, where many rivers have their source. Region of V-shaped valleys (e.g. Napo) and scree slopes. Some volcanic cones, e.g. Sangay, and glaciers where permanent ice	Above the snow line, weathering and freeze-thaw action dominate. Volcanism occurs where crust is thin, though more active in past. Many rivers here due to high orographic rainfall, as winds blow east from main basin. Rivers flow fast due to steep slopes; energy used to erode and transport large amounts of sediment. Sediment is easily eroded as sedimentary rock is soft. Large amounts of sediment make the local rivers appear white.
Fringes	Guyana and Brazilian plateaus. Not as high – only up to 300 m. Region	Ancient shields have been eroded over long periods of time, so are not as high as recent Andes. Also hard rock, so little erosion happening today – no sediment

Zone	Landform pattern	Reason for pattern
	of clear rivers e.g. Xingu, and waterfalls and rapids	therefore rivers clear. Waterfalls occur as rivers run off hard plateau.
Centre	Very flat area with gradient of only 100 m from west to east. Region of flood plains and meanders	Region of deposition in basin. River flow reduced due to low gradient, so deposition occurs. Flat relief means flooding occurs in wet season, creating extensive floodplain or *Varzea*.
Coastal Plain	Flat area where rivers widen as they reach the sea, forming **delta**. Rivers towards the north tend to be black in colour, e.g. Jari	Rivers widen due to greater volume. More than 1100 tributaries merge here. Black water rivers in north, as they run over decayed swamp vegetation.

The Amazon Basin: Vegetation and soil patterns

Zone	Vegetation pattern	Reason for pattern
Andes	Vegetation zonation on slopes. Bare rock to mosses and lichens to tussock to shrubs to trees. Trees that exist are not as dense as on basin floor	Vegetation zonation is due to differences in soils and temperature, as snow line occurs. Towards the bottom of slopes temperature is 24°C, so trees are not as dense as on the basin floor where temperatures are higher. Less competition for light means trees are also not as tall, and don't show the same levels of stratification.
Fringes	Tops of plateaus have savannah grasslands measuring about 1 m high, with deep-reaching roots. Closer to the basin, this changes to deciduous forests (called the *Cerrado*)	Tops of plateaus do not have enough rainfall (less than 2000 mm) to support tree growth. Also, high temperatures mean high evapotranspiration levels. Extended dry season, so trees adapt by shedding leaves at this time. In areas which don't support trees, grasslands have deep roots to reach water table.
Centre	Area of dense rainforest with clear stratification. Trees are very tall, e.g. rosewood and kapok can measure up to 65 m tall	Strong competition between plants, as climatic conditions are ideal for plant growth (rainfall 2500 mm and average temperature 28°C). Rainfall is high due to convectional rain from ITCZ, which is overhead twice a year. Means that tallest plants (trees) survive. Other plants have to adapt, e.g. lianas and epiphytes. Trees keep leaves all year as rainfall evenly spread.
Coastal Plain	Area of mangroves	Swamp conditions due to delta. Wider rivers mean more light penetrates ground, so different types of plants exist.
Andes	Thin alpine soils	Steep slopes do not allow soils to develop to any great depth.

Zone	Vegetation pattern	Reason for pattern
Fringes	Podsols tend to occur here. These are iron-rich due to ancient sediments	Soils here tend to be affected by high evaporation rates that create a salt pan near the surface. This makes it difficult for rainwater to percolate, and adds to infertility.
Centre	Latosols exist under the main rainforest. These are deep but generally infertile. On the floodplains soils are more fertile and rich. These are the Varzea soils	Soils here are deep, as the high temperatures mean they are easily weathered. They do, however, suffer from leaching by rainfall, which makes them infertile as valued nutrients are often washed away. Plants have to rely on the thin surface layer where nutrients exist, creating long shallow roots. On Varzea, nutrients are naturally replaced by flooding of silts by rivers, therefore these soils are very fertile.
Coastal Plain	Latosols exist here too	Also subject to intense leaching. Rainfall here is even higher due to onshore winds from Atlantic.

These patterns are summarised in Figures 5.5 and 5.6 (see also Fig 1.3, p 13).

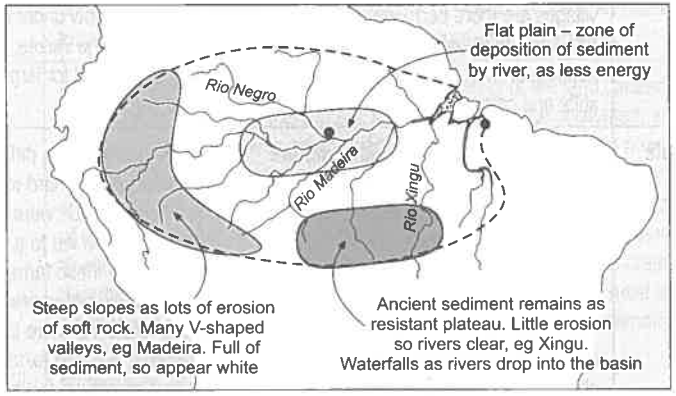


Figure 5.5 Variations of landforms in the Amazon Basin

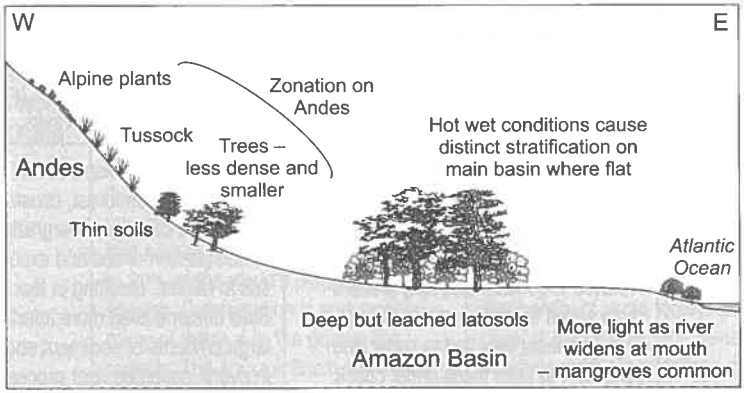


Figure 5.6 Cross-section of the Amazon Basin from west to east, showing main variations of vegetation and soils

Human use and perspectives

Group	Perspective/use	Effect on natural landscape
Amerindian indigenous people (e.g. Yanomani and Boro)	Have a strong *spiritual* attitude to the Amazon Basin, as rainforest provides them with the resources necessary to live. Because they live here, they also look on the Amazon in *social* terms. On Terra Firma, they practice shifting cultivation by clearing small plots or swidden by burning forest. They then sow seeds of manioc and bananas among the ashes, and tend crops for 3–5 years only. Plot is then abandoned and they move to another. Villages also tend to be moved, so are only temporary. On Varzea, soils are more fertile due to flood silt deposits, so villages are more permanent. However, they have to fit farming cycle around flooding of river. Houses have to be on stilts and cattle put on rafts.	Amerindians have very little effect on the landscape, as activities are on such a small scale. Because of spiritual connections they are also anxious to ensure that damage is minimal, so that rainforest is sustainable. The plots they use are small enough to easily rejuvenate when they are abandoned. The Amerindians have learnt to live within the acceptable boundaries of the environment, by not exploiting the resources and being able to read the signs when they are in danger of doing so. This lifestyle, however, depends on having large tracts of land available, and these are now under pressure for development. The Varzea, for example, is now being used for large-scale market gardening.
Small-scale settlers	As these people live here, attitudes are mainly *social*, although some also try to make a living from the land. Many were placed here under government resettlement schemes, especially from the overcrowded northeastern regions. Most were given land close to the new Trans-Amazonian Highway, which allowed such development. They were given 100 ha of land each, and told to use only 4 ha per year for farming and to rotate this in the same way as the Amerindians. The aim was that this land would last them 25 years, by which time the first land could be reused.	Farming proved more difficult than anticipated. It was hard to get crops to market, as roads were often impassable. This led to a sense of isolation. Also these farmers were greedy and did not appreciate the need to rotate. As more land was cultivated it became exhausted. Soils lost all natural fertility and became unusable, and land was often abandoned. The scale of use meant natural rejuvenation was not possible, so land turned into barren wasteland upsetting natural vegetation growth and soil formation processes.
Ranchers	Saw the region in *economic* terms as having large tracts of available land which could be used to make money. They burnt huge areas to clear them, and replaced vegetation with long grasses more suited to cattle. Large number of pests meant they had to spray land constantly to keep these under check. Also needed large amounts of fertiliser, which pushed up costs.	Sprays tended to disperse into neighbouring rainforest, causing permanent damage. Overgrazing led to compaction of soil and exposure of soil to rainfall, resulting in leaching. Soils became even more infertile. Also large amounts of sediment ended up in rivers, upsetting river processes.
Plantations	These also resulted from *economic* attitudes towards the Amazon. Many natural resources exist here, such as rubber trees, Brazil nuts and mahogany. It was felt that, rather than travelling long distances from tree to tree as indigenous peoples did, it would be more efficient to grow patches of the plant in one area as a plantation. Good examples of this were Henry Ford with his rubber trees, and, in 1967, Ludwig, who planted Gmelina trees close to the Jari river. In the latter case, the aim was to grow these trees to make paper and fill a gap in world demand. It was a huge project involving not only growing the trees, but also providing housing, food and amenities for 6000 workers, and a floating paper mill from Japan for processing.	In all cases plantations were not successful. The large machinery brought in for construction caused damage to larger tracts of rainforest than were cleared for access. These also compacted soils, causing run-off and erosion. The trees took a long time to mature, meaning the land was subjected to massive leaching and erosion by the elements. This meant lots of fertilizers had to be added. Being a one-crop culture, the trees, when finally mature, were vulnerable to pests and many were lost. Economically this was not a success and many projects were abandoned. Jari project was sold in 1982, leaving huge tracts of the rainforest permanently changed and ecosystems damaged.
Mining	Another economic use of the Amazon is mining for its valuable minerals, e.g. the Carajas project which was established in the 1980s to mine iron ore. The aim of this was not only to clear huge tracts of land for an open cast mine, but also to establish an HEP station at Turicuri by damming the river, and an aluminium smelter and refinery at Belem to use the iron ore. These were all connected by railways, resulting in the clearing of more land.	Clearing of the land caused permanent change to the ecosystem and the wildlife in it. As in the previous example, large machinery compacted the soil and toxic chemicals and sediment entered the waterways, upsetting fish life. The creation of the dam caused the most extensive changes by altering climate flows and decreasing rainfall.
Environmental bodies such as Greenpeace and the World Wildlife Fund	Interests are *environmental*. Many people look at the Amazon Rainforest as having great significance to the world. It influences world climate, both in producing large amounts of oxygen and as a sink for carbon dioxide. Cutting it down it adds to global warming and upsets the hydrological cycle, causing less rainfall. The Amazon is also home to 30% of the world's plant and animal species. Deforestation is endangering many of these, e.g. the golden lion tamarin. The Amazon Basin also holds many plants necessary for medicines.	Environmental groups are anxious that deforestation of the Amazon should be stopped, and campaign for this to happen. It is estimated that one fifth of the original forest has been removed, with deforestation now occurring at a level of 50 000 km^2 a year. Even in areas where secondary forest growth has occurred, unacceptable conditions exist. Such forests lack the biodiversity of virgin forests as the cover is inadequate. Unfortunately, however, such organisations do not have any power to institute change – they can only advise, monitor changes using aerial photography, and provide funding for specific projects.

Group	Perspective/use	Effect on natural landscape
Brazilian Government	Interests here are *political*. The government is aware of the opposition to deforestation by other countries. While anxious to retain a good image, it is also hampered by huge debts and few available resources.	Laws have been passed to try to limit deforestation, such as one in 1996 that allows landowners to cut down only 20% of the forest on their property. Logging of mahogany trees has been made illegal. However, due to a lack of resources, such laws are not able to be enforced, and little has been done to protect the rainforest. Only 4% of it is in protected reserves.

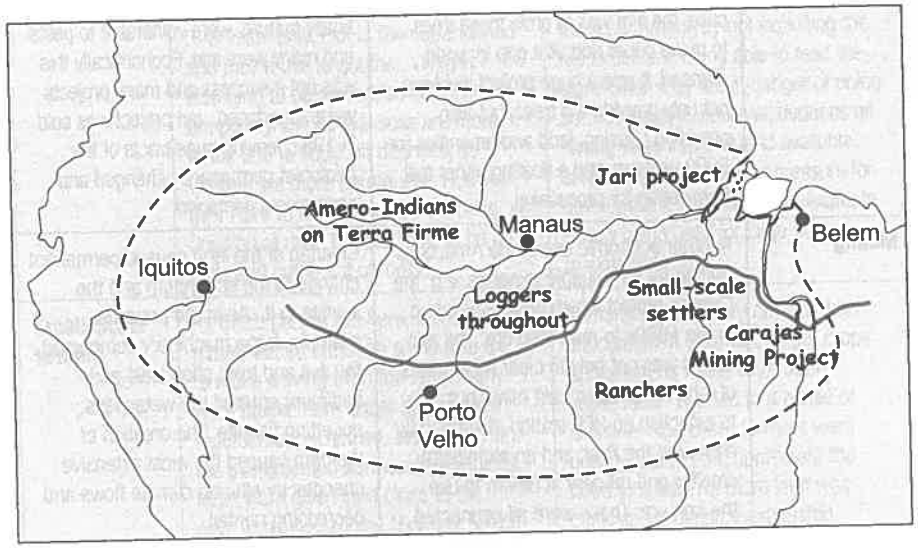


Figure 5.7 The location of groups with an interest in the Amazon Basin

The CD has activities to support this chapter.

Glossary of terms

Instruction words

Account for	Give a reason to explain this
Clarify	Make this clear by simplifying it
Compare	What are the similarities between
Comprehensive	Using depth (specific detail) and breadth (number of examples)
Describe	Say what it is like
Detail	Specific names and statistics
Examine	Say what, where, why and how – both describe and explain
Explain	Say why it is like this
Justify	Explain why, or give a reason why it is this one

Content words

Aeolian processes	Processes caused by the wind
Alluvium	Sediment carried and deposited by rivers
Arête	Sharp ridge caused by ice action
Aroha	Maori love of the environment
Braided river	River made of many small channels that interweave
Caldera	Very large crater created by a massive explosion that has blown most of the volcanic cone away
Cirque	Small basin in high mountains, where glaciers form
Climax vegetation	Final vegetation type to establish in an area over time
Composite cone	Large volcano with many vents
Convection currents	Movements in a liquid caused by heat. In the mantle these cause the continental plates to move
Convectional rainfall	Rain caused by rising moist air in tropical areas
Crater	Depression formed at the top of a volcano around the vent
Crevasse	Deep crack in a glacier formed as it moves
Cultural	Activities to do with people and their actions
Delta	Formed when a river divides into several channels near its mouth
Dynamic	Constantly changing
Ecosystem	A natural community and interactions
Element	A component that makes up a landscape
Finger lake	Long lake left in a glacial valley as ice melts
Fiord	Valley shaped by glaciation and then flooded by sea after glacier melts
Fissure	Weak spot in earth's crust where magma surfaces
Flood plain	Land beside river affected by seasonal flooding
Fluvial processes	Processes to do with rivers and running water
Fold mountains	Mountains caused when soft rock folds under pressure