

### Key Terms

Tropical rainforest  
Equatorial climate  
Abiotic  
Ecosystem  
Biotic  
Nutrients  
Nutrient cycle  
Soil  
Litter  
Biomass  
Leaching  
Biodiversity  
Emergents  
Canopy  
Prehensile

## The structure, functioning and adaptations of the tropical rainforest reflect the equatorial climate (biotic and abiotic components, biotic adaptations, nutrient cycles)

Most tropical rainforests are located between 20° north and south of the Equator. This zone has an equatorial climate. This means it is hot all year round with average temperatures of 27-29°C and never falls below 20°C. There is precipitation all year round with annual precipitation rates of 2000-3000mm a year. These conditions are ideal for plant growth.

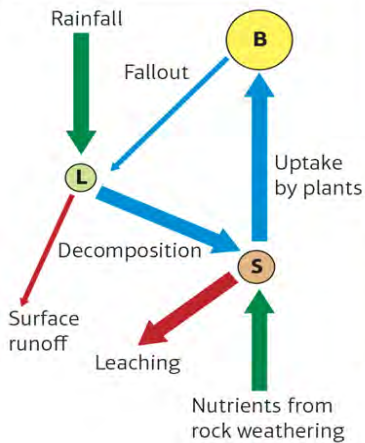
The non-living components of the tropical rainforest ecosystem such as soil, climate and rocks are the abiotic components. The living things such as plants and animals are the biotic components.

The nutrient cycle describes how nutrients are transferred around an ecosystem. It has 3 stores: litter, soil and biomass. Nutrients are transferred between these stores. The biggest store is the biomass which is made up of all the biotic components. When the leaves fall and enter the litter store they decompose quickly so the nutrients are transferred into the soil. The plants then absorb these nutrients.

Due to the constant precipitation a lot of water travels through the soils, as it does this it takes nutrients and minerals with it. This is called leaching. This makes the soils low in nutrients.

The tropical rainforest has a very high biodiversity. This is because the conditions for plant growth are so good allowing the ecosystem to support thousands of species. As well as this, the ecosystems have developed and evolved over thousands of years.

An example of a nutrient cycle diagram



### Key

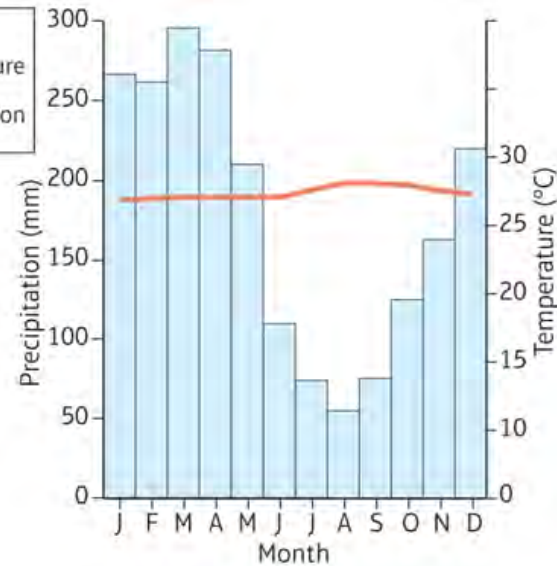
The size of the arrow indicates the amount of flow



As plants and animals die, their tissues fall into the litter store.  
As living tissue decomposes, nutrients are transferred to the soil store.  
Some nutrients are lost from litter by surface runoff. Plants take nutrients from the soil. This is very rapid in the TRF.  
Soil loses nutrients by leaching

### Key

— Temperature  
■ Precipitation

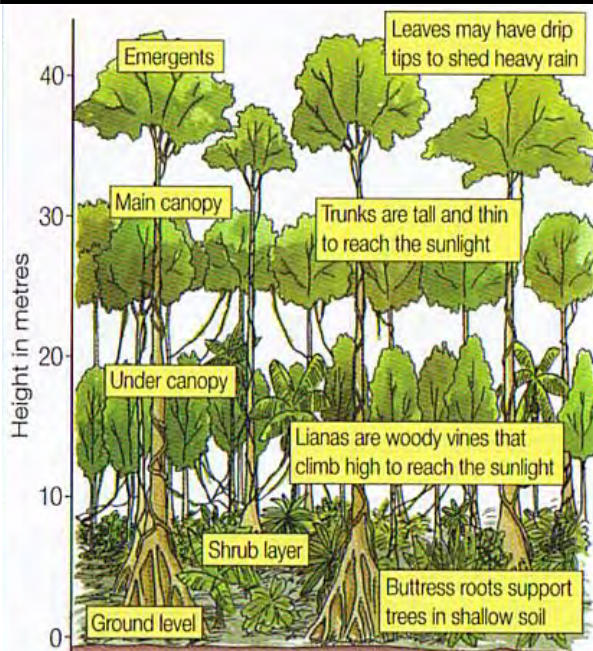


### Questions

1. Explain one way how plants are adapted to the equatorial climate. (2)
2. Identify two ways in which the chameleon is adapted to the challenges of the tropical rainforest environment. (2)
3. Explain why Madagascar's rainforests have high levels of biodiversity. (4)

### Plant adaptations

The main challenge for plants in the rainforest is competing for light. Some trees have adapted to grow extremely tall (50m+) called emergents. Trees below this form the canopy layer and are between 30-40m high. If a tree falls and dies, a light patch will appear and tree saplings will race upwards to the light and the gap is filled by the winner which spreads its branches and leaves out to collect as much sunlight as possible. A second adaptation is drip-tip leaves which means water can run off them quickly. If this did not happen moss and algae would grow quickly over the leaf surface blocking its ability to absorb sunlight. Another adaptation is buttress roots. As the soil in rainforests is very thin and the nutrients are concentrated at the top of the soil, the roots of the trees have evolved to be tall, slender and shallow to collect what they need to grow.



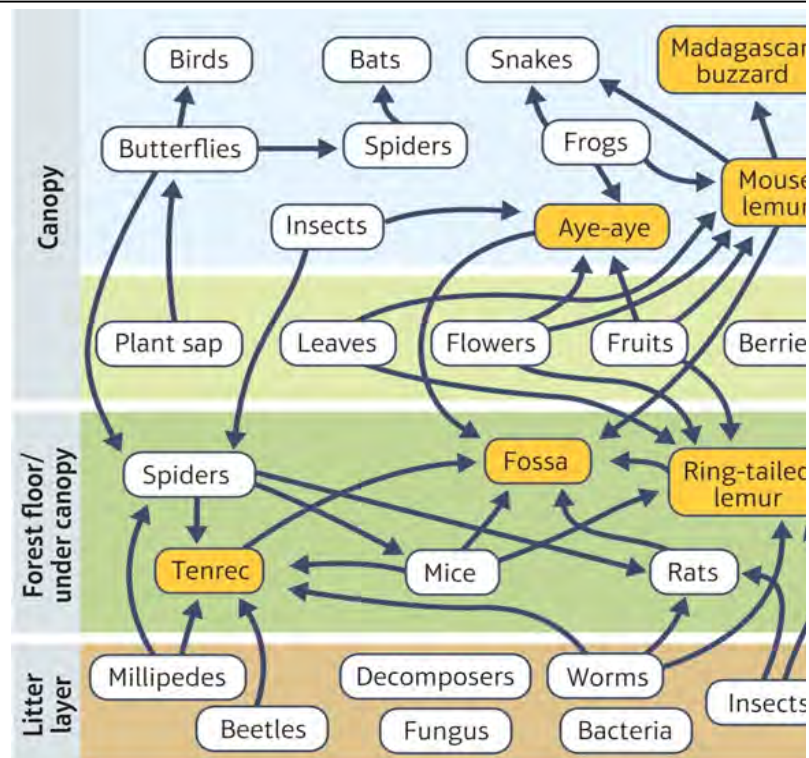
Food webs are a type of diagram used to show who eats what in an ecosystem. These are highly complex in tropical rainforests due to high biodiversity and due to the different layers in the rainforests there are mini-ecosystems with their own food webs.



### Animal adaptations

Due to the abundance of plant life in rainforests, animal life thrives. In the Madagascar rainforest it is estimated that 14,000 plant species support 250,000 known animal species, of which 75% are not found anywhere else in the world. The animals have adapted in many ways:

- As plants flower and produce fruits at different times of year, animals (specifically monkeys) have adapted to travel through the canopy. They have gripping hands and feet, long prehensile tails for balance and coloured vision to identify if fruits are ripe.
- Birds have also evolved such as eagles, these have powerful legs and clawed talons that can grab monkeys from the canopy.
- Some animals like chameleons' camouflage to avoid being eaten.



**Tropical rainforests are threatened directly by deforestation and indirectly by climate change**  
(Causes, Effects, Climate change)

Deforestation happens as the forest is converted into farmland. Trees are cut down either to sell as timber, provide space for open-cast mining and HEP schemes. Deforestation, logging and mining are direct threats to the rainforest.

Deforestation causes

- Commercial agriculture—this is when crops are grown to sell at a profit. This is the main cause of deforestation in the tropical rainforest (75% deforestation in Brazil is for cattle farming). In recent years the rainforest has been cleared to grow sugarcane to export. Deforestation in the South East Asian countries is mainly to clear land for palm oil plantations. These crops are in high demand as they are biofuels.
- Subsistence agriculture—this is when people farm to feed their families. A small plot of trees is felled and burnt so crops can be planted. Leaching is a big problem because of this as the nutrients in the soils are washed away during any precipitation. Poorer farmers resort to 'slash and burn' as no money is needed to clear the land which creates a lot of pollution. In the past land would be left barren for a long period of time after being used for crops. However as the population is growing more and more land is being cleared for families and plots are having to be used straight away.
- Commercial hardwood logging—many countries are participating in commercial logging to earn money to pay off interest on international debts. A lot of countries have strict controls on logging however it still occurs illegally on a large scale due to demand. Chinese buyers will pay high prices for hardwood timber such as rosewood. Poverty is another reason why logging is high in tropical rainforests. Logging companies pay very well so locals take the jobs even though it is illegal. The police and government are generally aware of illegal logging but allow it due to corruption
- Mining—valuable minerals can be found underneath the tropical rainforest so open-cast mines are created to extract the minerals. This means huge areas of forests are lost for the mines and roads created. The roads encourage farmers to settle in the rainforest and clear the land for crops (approx. 15% deforestation is linked to mining and road building).
- Fuelwood—The indigenous people of the rainforest use the trees as fuelwood.

Climate change

Climate change is an indirect threat to the rainforest meaning there is no direct cause between one thing and another. The Earth's atmospheric temperature is increasing which is affecting the atmospheric circulation systems that bring wet seasons to the equatorial climate. The warmer temperatures mean that the rain belt moves polewards and the rainforest receives less rainfall. This means the rainforest may suffer with drought conditions and many areas will become seasonal tropical forests. Temperatures in the tropical rainforest are similar all year round and many species will not be able to adapt to any change in temperature or lack of rainfall. The flying fox bats have been dying due to heatwaves as their bodies cannot cope with the change in temperature. There is a higher risk of forest fires as plants and trees dry out in the heat. As large areas dry out, drought tolerant species would out-compete the rainforest species. This would lead to ecosystem stress in which the plants and animals would have a lower tolerance to pests and diseases.

**Key Terms**

Commercial agriculture  
Subsistence agriculture  
Logging  
Deforestation  
Mining  
Fuelwood  
Direct threats  
Indirect threats  
Ecosystem stress

**Questions**

Explain why rates of tropical rainforest deforestation are rising in some areas but falling in others. (4)  
Explain the difference between a direct threat and an indirect threat. (2)  
Assess the severity of threats to the tropical rainforest (8)  
Identify 3 ways the TR is being deforested (3)



## Conservation & sustainable management of tropical rainforests is vital if goods & services are not to be lost for future generations

(Advantages/disadvantages of CITES, REDD, sustainable forestry, ecotourism)

### Key Terms

CITES  
REDD  
Remote sensing  
Sustainable rainforest management  
Ecotourism

### Questions

1. Select the conservation strategy that you think would be best for the tropical rainforest biome. Justify your choice. (8)
2. Why do people in Japan, China, USA and the UK have a role in reducing deforestation? (3)
3. Several options exist for conserving the tropical rainforest in a sustainable way. Three possibilities are:
  - a.) Create a national park area
  - b.) Use remote sensing to monitor human activity
  - c.) Use CITES and REDD
 Select the best option you think would be best to manage the tropical rainforest (12+4)

### Global Actions

CITES (Convention on International Trade in Endangered Species of wild fauna and flora) and REDD (Reducing Emissions from Deforestation and forest Degradation) are international organisations that have made agreements to protect the tropical rainforest. Countries sign up to these agreements and receive aid and assistance.

- CITES - The main aim is to prevent the trade of endangered animal and plant species across the world. Especially if it threatens the rainforests biodiversity. There are currently 35,000 species listed under CITES protection. There are different levels of protection. Countries have to agree to monitor trade across their borders and punish people importing or exporting products from endangered species if they sign up to CITES.
- REDD—The is a UN (United Nations) scheme that advises governments on how they can reduce deforestation and promote afforestation. Remote sensing is used to monitor deforestation rates. It receives funds from sources such as

Organisation	Advantages	Disadvantages
CITES	181 countries have signed up to it It is targeting the issue	Illegal trade is increasing as demand is high. It cannot manage all 181 countries.
REDD	International expertise is on hand to help tackle deforestation. Funding is attractive to governments	Deforestation is still happening at a rapid scale in South Asia. It is vague about what afforestation means and allows crop plants to be grown instead of native plants.

### Local Actions

Amazon, Brazil—There are several reasons why deforestation rates reduced in Brazil between 1994 and 2013. Pre 2005 deforestation rates were high due to the demand for soya beans so land was cleared to create crops. However, the international price of soya beans dropped in 2005 and so the demand fell. Also, environmental groups used this time to push TNCs to only buy sustainably-grown soya beans. At the same time the Brazilian government increased its commitment to REDD. This was helped by a billion-dollar fund from Norway. The protected areas in the rainforest were expanded and laws against deforestation were enforced by the government and police.

### Challenge of Sustainable forest management

An alternative method to protect the rainforest is sustainable rainforest management. This aims to prevent damage to the rainforest so that it benefits local people. This combined with ecotourism can create jobs for locals as guides and in hospitality. The tourists are encouraged to buy handcrafted products from locals. This means locals do not illegally log or trade in animal or plant species. The scheme also educates locals on how to live more sustainably such as higher yielding crop use so less land needs to be used. The issue is most of the sustainable management methods require funding to survive, as well as this the schemes only really work in areas that are already protected such as National parks.

**The taiga shows different characteristics, reflecting a more extreme and seasonal climate.**

(biotic and abiotic components, biotic adaptations, nutrient cycles)

**Key Terms**

- Biome
- Subarctic climate
- Productivity
- Migrating
- Food webs

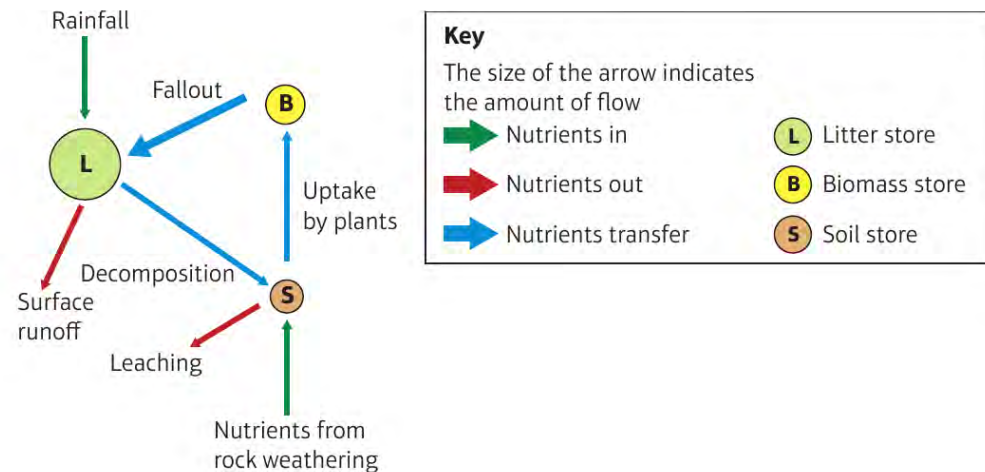
The largest biome on the Earth's surface is the taiga biome. It stretches from 50°N to 70°N across North America and Asia. The climate of this region is known as the subarctic climate. This is dominated by very cold, dry and long winters with average temperatures of -40°C. Summer months have mild temperatures and are short, the average temperature is 16°C. There is normally snow on the ground for the whole year, the annual precipitation rate is low with less than 500mm a year.

In comparison to the tropical rainforest the taiga has a lower productivity in terms of nutrients and a lower biodiversity. The taiga growth period is short due to a short summer this makes the biomass small, decomposition is slow due to the low temperatures and can even stop during the winter months. Because of these conditions only a few species are adapted to survive leading to low biodiversity.

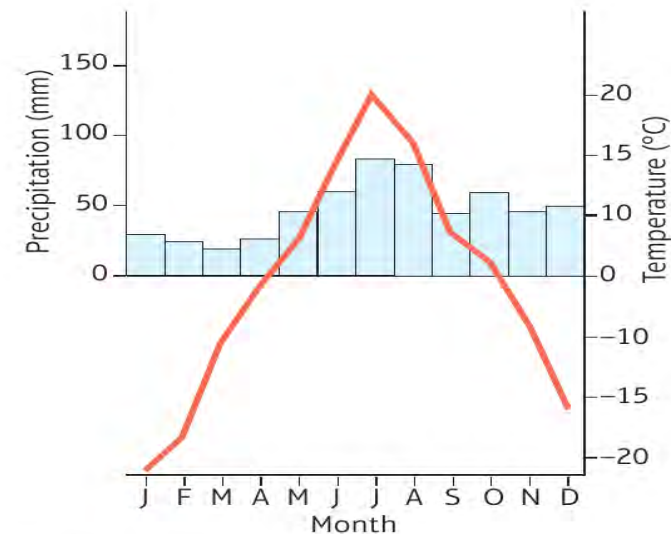
Nutrient cycle—The biomass and soil stores are small and transfers of nutrients between the stores is low. The biggest store is the litter store, this is mostly made up of pine needles which are tough and decompose slowly. Due to the slow decomposition it takes a long time for nutrients to enter the soil. This means the soil cannot support a large amount of biomass. The pine needles that become litter are acidic therefore the soil becomes acidic which again limits the species that are able to thrive in the taiga environment. Generally, only coniferous species can survive along with mosses, lichens and fungi. With fewer plant species there is also fewer animal species. Most of the animals that live in the taiga environment have migration routes. Birds are very common due to lots of insects available.

**Questions**

1. Identify the largest store in the taiga nutrient cycle (1)
2. Explain how the process of leaching removes nutrients from the taiga ecosystem (2)
3. Explain (using the nutrient cycle) why the taiga forest is considered to be a fragile ecosystem (4)
4. Explain how plants are adapted to the taiga ecosystem (4)
5. Explain how animals are adapted to the taiga ecosystem (4)



**Figure 3** The nutrient cycle of the taiga

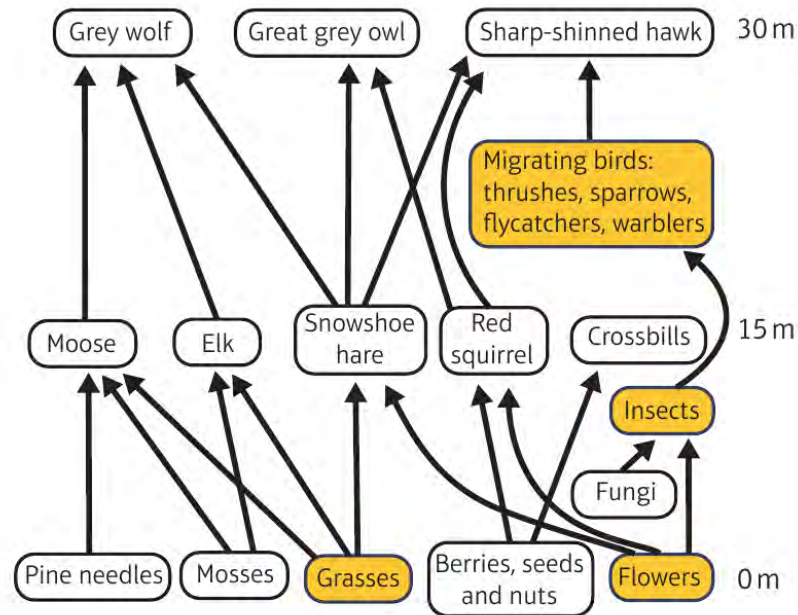


### Plant adaptations

Taiga forests are usually full of conifer trees. These trees remain green all year round as they do not drop their leaves as they do not have the energy to regrow leaves each year. As well as this the trees need to be ready for photosynthesis to occur in spring. Conifer trees have specially adapted leaves which are needle shaped called pine needles. They are this shape so they have a small surface area so they lose less water from evaporation. They also have a waxy coating to help reduce water loss. The needles are a dark green colour so they can absorb as much sunlight as possible so they can photosynthesise. The needles contain only a little amount of sap so they do not freeze easily and can operate in cold conditions. There are only a few conifer species in the taiga ecosystem and they grow close together to gain protection from wind damage. Most are conical shaped with downward facing branches, this is so heavy snow falls off quickly.

### Animal adaptations

Due to seasonality in terms of the climate there is also seasonality with animal life. During the summer months the taiga has a large amount of animal populations, this drops dramatically in winter. The Canadian taiga has over 300 bird species in the summer however, only 30 stay during the winter as many migrate south. They migrate to the taiga in winter due to a lot of insects. The animals that stay in the taiga all year round are specially adapted to live there. They generally have thick fur coats for insulation, smaller ears, noses and short tails to reduce the chance of frost bite. Many animals also hibernate during the winter months; they build up a large layer of fat during the summer months so they can go into a sleep-like state. Some animals develop a white coat during winter months to camouflage better.



**Figure 8** A food web for a Canadian taiga ecosystem

### Food webs

The food webs in this ecosystem are much simpler in comparison to the rainforest as there is a lower biodiversity due to the climate. There is a limited amount of plant species, the trees are roughly the same height and only have one layer. The forest floors have little undergrowth and the soils are generally shallow with few nutrients. It is very dark due to conifers growing very close together. There are few reptiles and amphibians as they are cold blooded and they struggle to find heat in this environment. The few large mammals in the taiga have large territories and spend most of the summer building up their fat reserves.

## The taiga is increasingly threatened by commercial development

(Direct threats and indirect threats, acid precipitation, forest fires and biodiversity loss)

Commercial development is a direct threat to the taiga environment. This happens when an area has valuable resources that can be sold to make money. The threats to the taiga can be classed as direct or indirect. Direct threats include logging as it removes trees that are a key biotic component of the ecosystem. An indirect threat is mining, HEP and oil and gas extraction as they damage the taiga due to their side effects such as flooding, pollution and oil spills.

Deforestation is high in the taiga environment due to the softwood available. They use a clear cutting method to collect the timber, this is where all the trees in an area are cut down and transported to sawmills to be cut into useable timber for construction and trees are turned into a pulp. Russia has a huge deforestation issue as huge amounts of forests are being cleared (average 12 million hectares a year in 2014). As much as half of the logging is illegal. This is a huge threat to the taiga as the plants that are logged are not replanted. In Canada the government controls logging and ensures that any trees felled are replanted.

Oil and gas extraction is another threat to the taiga in Russia as 20% of the world's oil and gas reserves are found here. Greenpeace an NGO (Non-governmental organisation) that campaigns environmental issues states that Russia's oil industry spills 5 million barrels (795 million litres) of oil each year through accidents and leaks. This affects the animals and people that live in the area. In contrast Canada which also has oil and gas reserves controls the extraction still has the occasional oil spill e.g. in 2011, 5 million barrels' bitumen (oil) mixed with water spilled due to a broken pipeline in Alberta. Due to the poor drainage systems in the taiga environment the oil is not easily washed away and as well as this decomposition occurs very slowly therefore the oil remains in the ecosystem for a long time this can kill the roots of the trees.

Acid precipitation—This occurs when fossil fuels are burnt in industries, chemicals such as sulphur dioxide are created and are released into the atmosphere (Volcanoes also do this). When this reacts with water and oxygen it forms an acid which can form acid precipitation. The most damage that is caused is when the acid gets into the soils, lakes and ponds. Acidic water kills insects and their eggs, this means there is less food available for migrating birds. Microbes in the soil are killed therefore nutrients cannot enter the soil. As a result of this the plants become weaker and they become less resistant to changes in temperature, forest fires and pests and diseases.

Forest Fires— Natural causes of forest fires are lightning strikes. Most fires are caused by humans such as hunters lighting camp fires and gas flares in oil fields. The taiga is adapted to forest fires as the ash left after a fire is nutrient rich which plant species benefit from. The problem is naturally the forest is adapted to fires every 80-100 years, however they have become much more frequent as global temperatures have increased and saplings are burnt before they can replace the old trees.

Pests and diseases— The taiga has mould and fungus species that damage the needles, trunks and roots of conifer trees. Insects also eat the pine cones, young leaves and the saplings. As well as this other pests and diseases have migrated into the taiga biome as the temperatures have increased. The damage is happening on a large scale for, example the silkworm which spread into eastern Siberia from Mongolia in the early 2000s killed many plants it didn't help that the area was also suffering from forest fires and droughts.

Plagues of spruce-bark beetles have killed large numbers of taiga trees in North America. In Alaska's forests over 6 million acres have showed signs of spruce-bark beetle activity.

### Key Terms

Direct threat  
Indirect threat  
Acid precipitation  
Forest fires  
Pests  
Diseases

### Questions

1. Describe one direct threat and one indirect threat to the taiga caused by commercial development (2)
2. Assess the severity of the threats to the taiga biome (8).
3. Explain the process by which pollutants can produce acid precipitation downwind of their source. (2)
4. Explain one way in which acid precipitation is a threat to the taiga forest. (2)
5. Explain why climate change could intensify the threats to the taiga forest (4)

## The taiga wilderness areas need to be protected from over-exploitation

(National parks, Sustainable forestry, conflicting views)

The taiga is a fragile ecosystem and takes a long time to recover from damage. Due to the long cold winters and lack of nutrients vegetation grows slowly. As well as this, decomposition is slower so any pollution remains in the ecosystem for a long time. Species diversity is low in the taiga environment therefore if a disease affects one species it has a big impact on the whole ecosystem. The flora and fauna in the taiga would struggle to adapt to any changes, especially climate.

Protected wilderness areas and National Parks can be created to prevent commercial development of the taiga within their boundaries. The aim of a National Park is to preserve the taiga environment and its biodiversity. Researchers find out as much as they can about the biotic and abiotic components of the ecosystem to inform the public and local government about its importance. In contrast protecting 'wilderness' areas is more proactive as it is active ecosystem management, rather than just leaving the area wild. One example of active management is culling elk as there is not enough predators to keep their numbers down, so rangers will kill a small percentage of the population. If there are too many elk in an ecosystem it prevents saplings growing into trees as they are eaten. There are not enough predators in the taiga ecosystem as they need large territories to survive and the National Parks and wilderness areas are generally not big enough. Any predators that range outside the National Park areas are not protected and are therefore at risk of being poached or trapped by farmers who see them as a threat. Licenced hunting keeps many predator populations down. National parks also want to attract tourists to educate about the environment, however tourists want to see big predators and the predators want to seek more remote areas away from humans. National parks are popular tourist destinations as well as conservation areas. E.g. Canada's busiest National park Banff has 3-4 million tourists visiting each year. Some are winter tourists that go to ski and sledge. All the tourists that visit the taiga ecosystem damage the ecosystem they come to enjoy through footpath erosion etc. Human-wildlife conflict occurrences can also happen such as grizzly bear attacks.

**Sustainable Forestry**—This is when trees are cut down and are replanted with native taiga species. The whole forest area is carefully managed so that the biodiversity is not lost. Forest corridors are created to allow species migration and the areas are preserved. Sustainable management is expensive and requires long-term planning. This is usually only possible for large companies or when international organisations provide funding.

**Conflicting views**—Many different groups of people have an interest in how the taiga is used.

**Forestry** — Countries like Canada have strict controls on logging and timber can only be used sustainably. However in some countries like Russia are unsustainable when it comes to forestry.

**Mining and Energy production**— Without mining and energy production Russia and Canada would be very poor, for example 380,000 Canadians work in the mining industry.

**Indigenous peoples**—They want to maintain aspects of their traditional uses of taiga resources, such as hunting.

**Recreation and tourism**—In North America and in Russia they go to the taiga environment to relax as well as this international tourism also brings visitors and money to the local economies.

### Key Terms

Over-exploitation  
Commercial development  
Territories  
Sustainable forestry  
Indigenous people  
Recreation and tourism

### Questions

1. Explain two reasons for conflicting views on protecting or exploiting the taiga (4)
2. Evaluate the obstacles that limit the effectiveness of global strategies aimed at conserving forest biomes
3. Why might people living in forested areas of the world be against establishing national parks? (4)
4. Which do you think is in need of protection the rainforest or taiga forest? Give reasons (6)

Other challenges include:

1. Migration
2. Money
3. Pollution