Unit 3 Study Guide

Geography - Year 12 ATAR

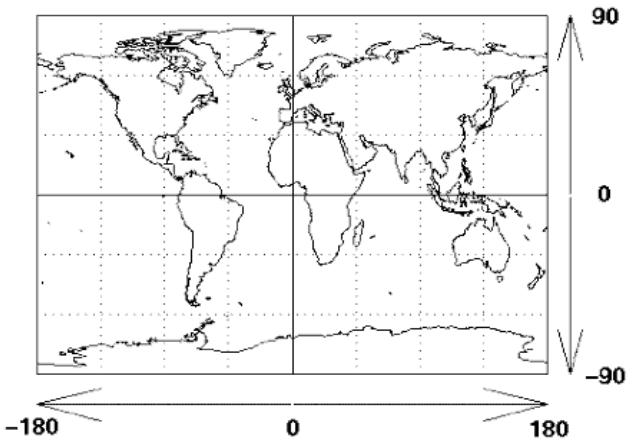
Land Cover Change & Climate Change

Contents Page

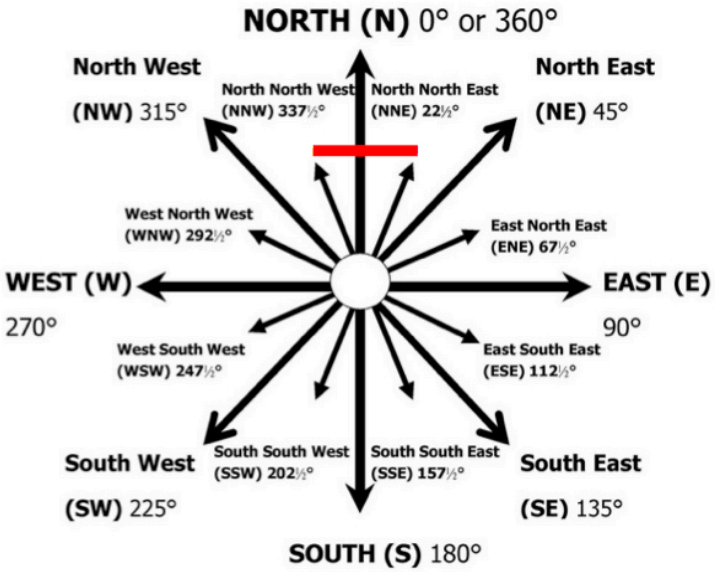
Mapping Skills

Latitude and Longitude:

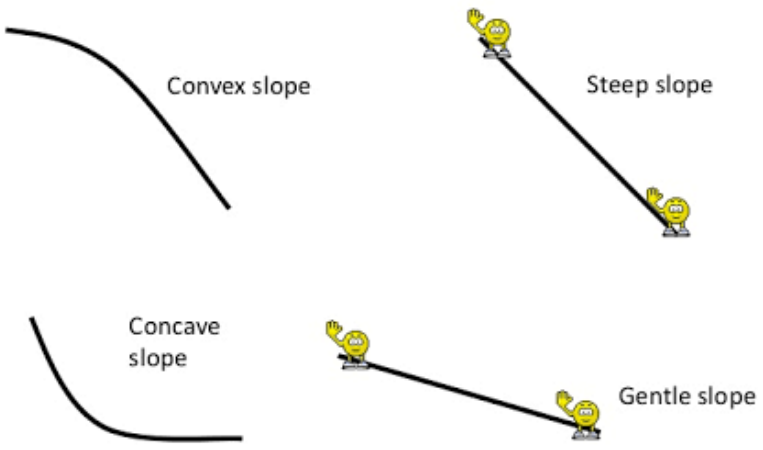
When giving geographical locations: Latitude first (N/S), Longitude second (E/W)



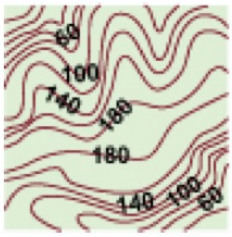
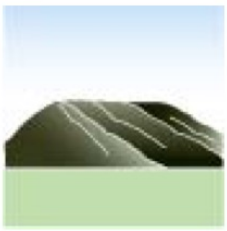
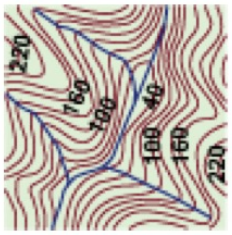
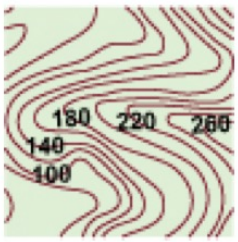
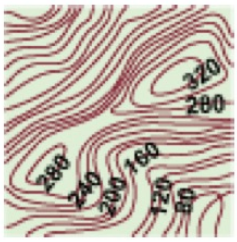
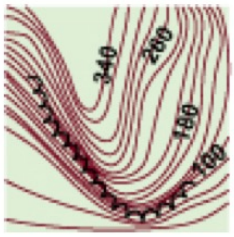
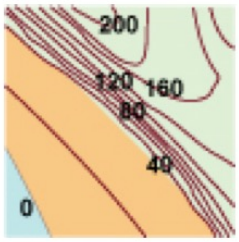
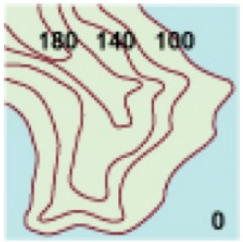
16 Point Compass:

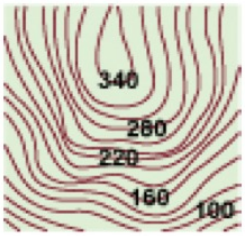
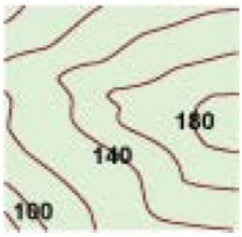
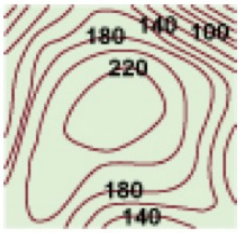
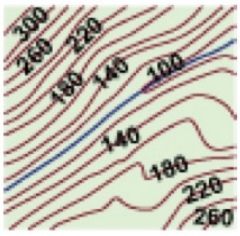


Types of Slopes:

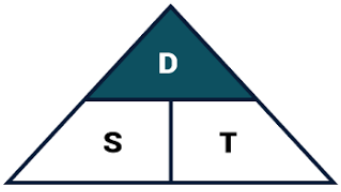


Identifying Landform Features:

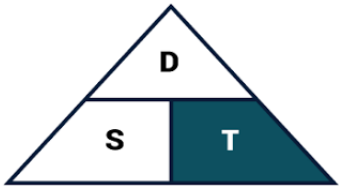
Ridge		Long narrow continuous elevation	
Creek		Marked by blue line, contours indicate direction of flow	
Spur		Subsidiary summit of a mountain, lower than the summit of the mountain but connected by a ridge	
Saddle		Two hills with a dip in between	
Cliff		Rock face exposes a clear vertical drop in height	
Shoreline		Fringe of land at edge of large water body eg: ocean, sea, lake	
Headland		Large area surrounded by water on 3 sides, rocky due to exposure and weathering	

Steep slope		Contour lines close together	
Gentle slope		Contour lines far apart	
Hill		Rounded area projected above surrounding land	
Valley		V shaped in Australia, caused by water erosion	

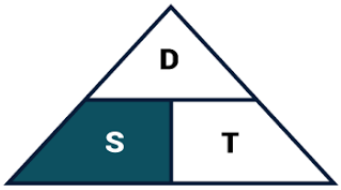
Working out Speed, Distance, Time:



Distance = Speed x Time



$$\text{Time} = \frac{\text{Speed}}{\text{Distance}}$$



$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Site and Situation:

Site:
The location of somewhere with respect to the physical features it is located on/directly next to:
- It's height above sea level/altitude
- Nearby physical features
- Nearby water bodies
- Local/Surrounding vegetation

Site refers to **physical** (natural features e.g. rivers, topography) **features** of landscape upon which a settlement is built. Only describe features in the immediate vicinity of the settlement.

A good way to describe **SITE** is to REMEMBER **SAGA**...

Slope (gentle or steep)
Aspect (north, east, south or west facing)
Ground conditions (for example coastal plain)
Altitude (height above sea level.

Situation:
Location in relation to other areas
- Position in state/territory
- Latitude and Longitude
- Nearby cities
- Nearby transport routes

Situation of a location takes into account **where a place is with respect to other places**.
The following features are elements of a settlement's situation:

1. **Latitude and longitude**
2. **Distance and direction to other settlements** of similar and greater size
3. **Distance and direction to other key cultural features** e.g. major HWY, junction, railway line

Example: Dunsborough is 20 kilometres WNW of Busselton located on the Caves Road
Dunsborough is located at Latitude 33° 36' S and Longitude 115° 06' E

Cultural and Natural Features Examples:

Cultural:
- Streets
- Ports
- Buildings
- Farmland/Rangelands
- Orchards
- Mines

Natural:
- Volcano
- River
- Mountain
- Ocean

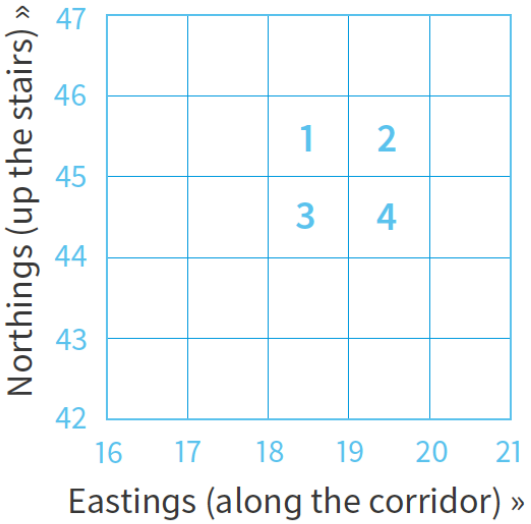
Grid References:

- *Eastings are always listed first*

<u>There are two main types of grid reference:</u>

- 4-figure – Area Reference, this identifies a single square on a map, i.e AR4567
- 6-figure – Grid Reference, this identifies a specific location within a square on a map, i.e GR456679

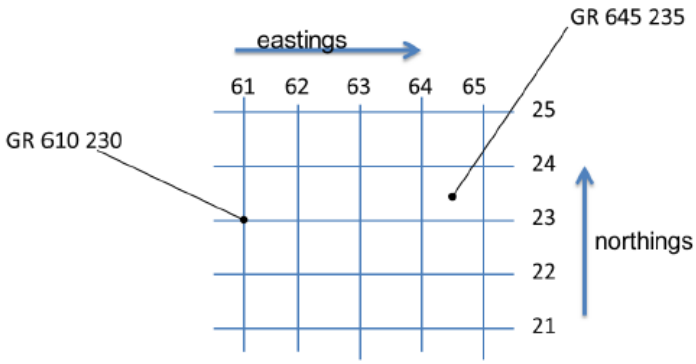
When asked to give map evidence, give grid references



<u>GRID REFERENCES (GR)</u> – 6 digits:

Lines of EASTINGS and NORTHINGS together form a grid.

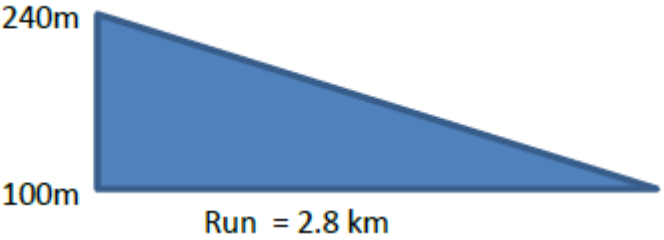
A grid reference is a six figure number, made up of a three-figure eastings reading and a three-figure northings reading.



WHEN ASKED TO GIVE MAP EVIDENCE YOU MUST GIVE <u>GRID REFERENCES</u> AND REFER TO <u>SPECIFIC NAMES</u> ON THE MAP WHERE POSSIBLE

Gradient:

Rise =
240 – 100 = 140 m



Rise : Run

140 m : 2.8 km

140 : 2800

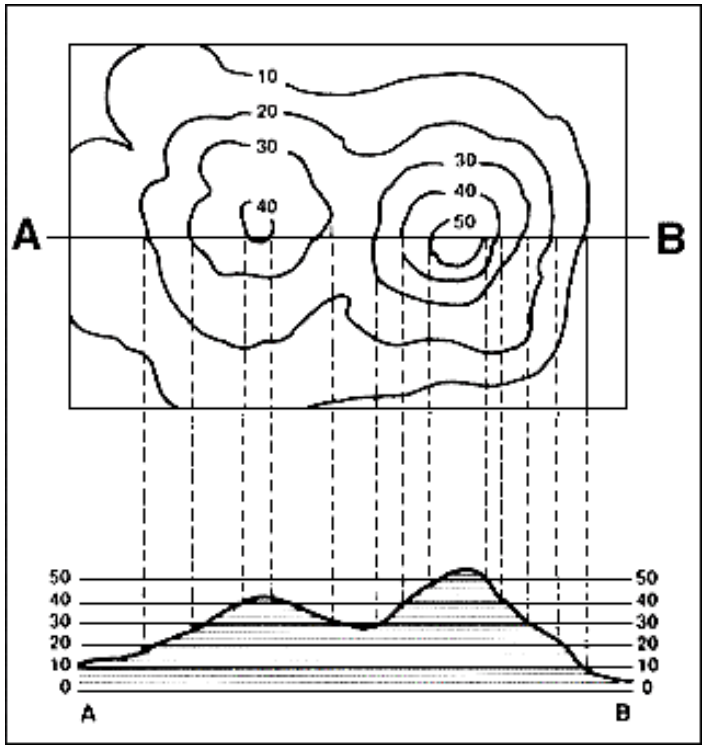
$\frac{140}{140} : \frac{2800}{140}$

Answer → 1 : 20

Cross Sections:

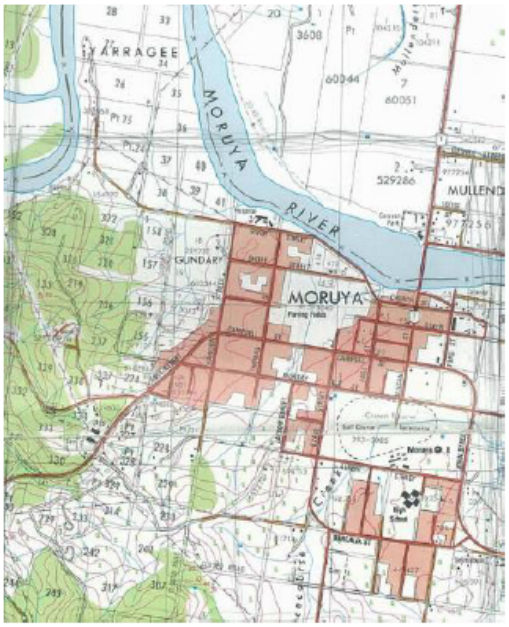
Drawing a cross section

Step 1: place the straight edge of a piece of paper along a line joining points A and B.
Step 2: starting from Point A, mark the position where the edge of your sheet of paper cuts each contour line. Write the value of each contour on your sheet of paper
Step 3: Draw the horizontal and photo axis of your cross section. The length of the horizontal axis should equal the length of line A – B
Step 4: Place your sheet of paper along the horizontal axis and then plot the contour points and heights as if you were drawing a line graph
Step 5: Join the dots with a single smooth curved line.

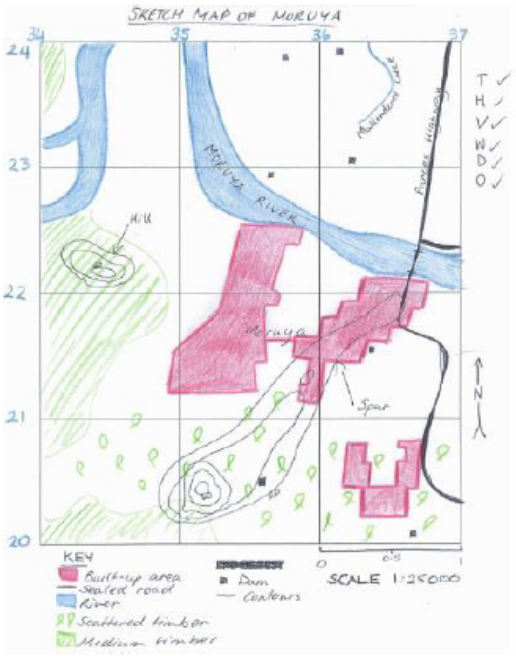


Sketch Maps:

From topographic map to...

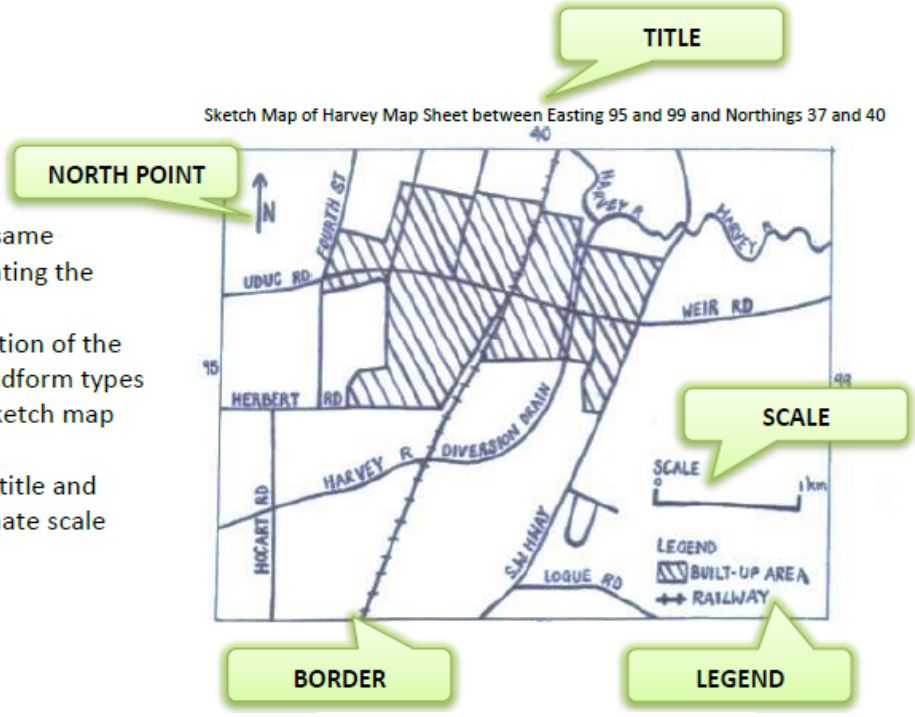


sketch map



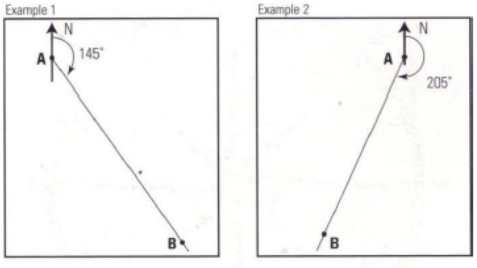
To draw a sketch map:

1. Draw a border frame in the same proportion of the map indicating the relevant grid lines
2. Sketch and label the distribution of the relevant phenomena e.g. landform types
3. If symbols are used on the sketch map include a legend
4. Label the sketch map with a title and north point and an approximate scale

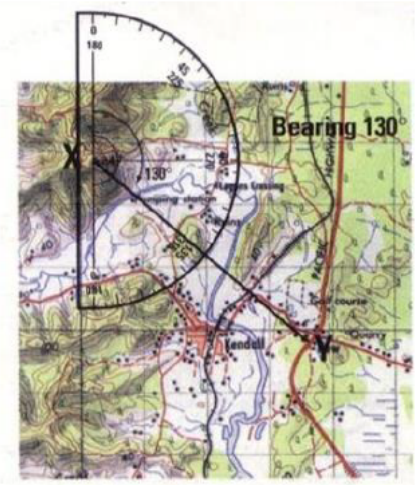


Bearings:

A bearing is a measurement of direction between two points. Geographers use bearings to give an accurate indication of the direction of one point from another. A bearing is an angle, measured clockwise, that a line makes with a fixed zero line. Unless stated otherwise, the zero line is always taken to be north.



Use a protractor to determine the angle.



Scale:

Map scale represents the relationship between distance on the map and the corresponding distance on the ground. The scale on the topographic map is usually found at the bottom centre of the map. Scale is represented in different ways on a topographical map.

LINEAR OR DRAWN SCALE

RATIO Scale: 1:250 000

REPRESENTATIVE FRACTION Scale: $\frac{1}{250\,000}$

STATEMENT

Not equals

One centimetre on the map represents one kilometre on the earth's surface

TYPES OF RATIO SCALES:

Large Scales	Medium Scales	Small Scales
1:100 1: 10 000 1: 20 000	1:25 000 1: 50 000 1: 100 000	1:500 000 1: 5 000 000 1: 70 000 000
House plans Orienteering maps Road directory maps	Topographic maps	Regional touring road maps State and National maps Atlas and world maps
		

Note:

Large number

Small Scale maps have LARGE numbers (i.e. 1: 70 000 000). They show a large area of land but provide less detail of the features found in the area e.g. 1:250,000, world maps

Medium Scale maps show a medium area of land but provides more detail of the features found in the area than small scales e.g. 1:25,000, topographic maps

Small number

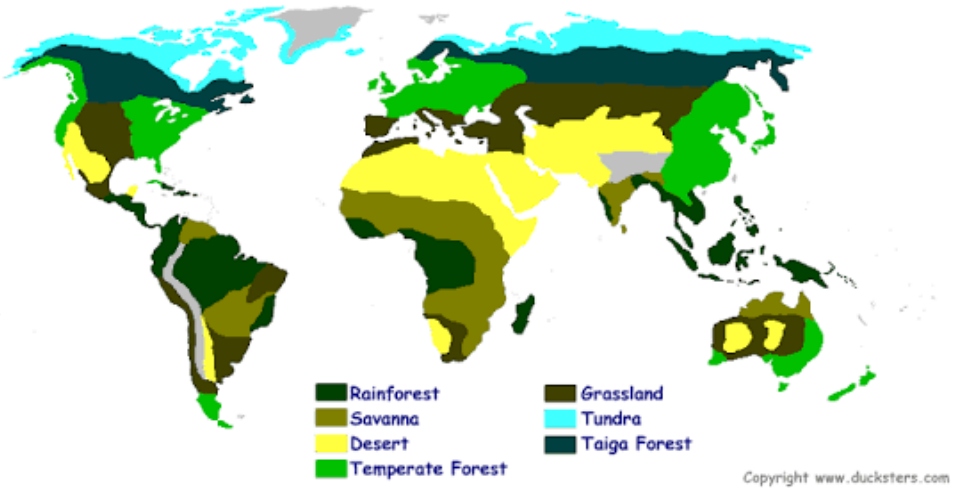
Large Scale maps have SMALL numbers (i.e. 1:100). These maps show very close detail of that area e.g. 1:10 is a suitable scale for a house plan

Syllabus Points

- **Define the concepts of environment, natural and anthropogenic biomes, land cover change, ecosystem structure and dynamics, biodiversity loss, climate change and sustainability.**

Concept	Defintion
Environment	The living and non living elements of the Earth's surface and atmosphere. It includes human changes to the Earth's surface, for example, croplands, planted forests, buildings and roads.
Biodiversity Loss	The reduction in the variety of plant and animal species in the natural environment, as a result of various factors like climate change and land cover change.
Ecosystem Structure & Dynamics	A biological community of interacting organisms and their physical environment (abiotic). The composition of biological communities and their physical and chemical processes.
Climate Change	Refers to the change in temperatures and precipitation of a region over an extended period of time. This time period can range anywhere from millions of years to decades. Climate change can occur through both natural and anthropogenic means. Natural factors include volcanic activity and anthropogenic factors include deforestation, increase of urban settlement. Refers to a period of global warming (interglacials) and global cooling (i.e ice age).
Sustainability	Sustainability is the concept of development that considers the impacts on the natural environment, society, economy and future generations. It involves the protection of the environment while maintaining the economic development necessary to satisfy the needs go the people, while ensuring that the social development of people is not impaired so that they can continue to lead healthy and productive lives.
Anthrome (Anthropogenic Biome)	An anthropogenic biome is an Anthrome, which is a biome that is dominated by humans and has undergone anthropogenic changes. Refers to part of the earth's surface through sustained direct interaction between humans and ecosystems.
Natural Biome	A geographical area of distinct plants and animals, which have adapted to that environment.
Land Cover Change	Refers to the process in which the earth's physical surface is altered due to natural and/or anthropogenic means.

Biomes



Forests

Rainforest

- Highest biodiversity of any biome
- More than 2000mm rain per year
- Temperatures between 20-25 degrees
- Year long growing season

Broadleaf/Temperate

- Distinctive seasons
- Significant variations in temperature between winter and summer
- Year round rainfall
- Temperatures between -5 to 20

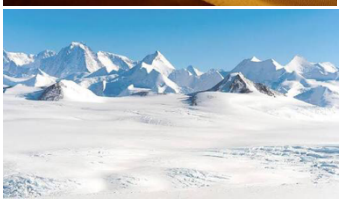
Boreal

- Short summers, long winters
- Cold climate
- Pines are a typical tree
- Short growing season

Savanna/Grassland

- 600-1500mm rainfall
- -5 to 20 degrees
- Winters are warm and dry
- Scattered trees and lots of spinifex
- Much of subsaharan Africa and northern Australia is savanna/grassland

Desert



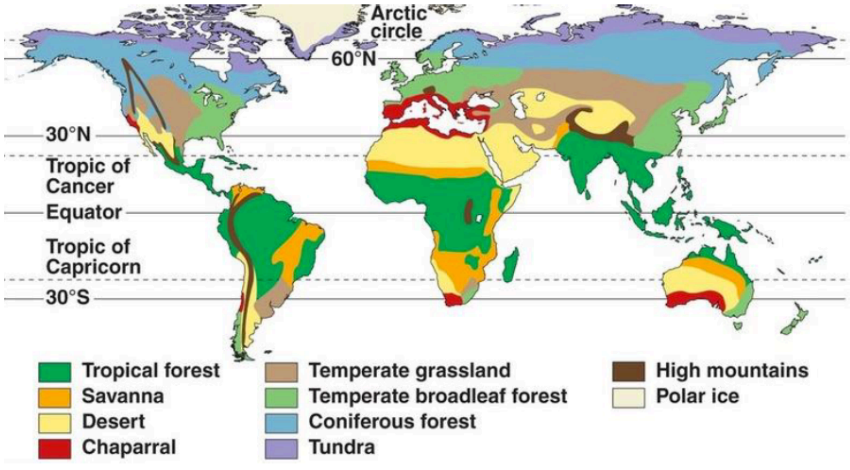
- Hot and cold deserts
- Makes up 40% of the earths land biomes
- Low rainfall (less than 250ml)
- Low biomass
- Affected by pressure belts, mountains, and distance from the ocean
- High pressure cells over deserts cause stable conditions
- Rainfall decreases inland
- Temperature greatly varies from day to night

Tundra

- Long winters
- -34 degrees average temperature
- 150-250mm rainfall
- Permafrost means only short rooted plants can grow

Aquatic Biomes

- Covers 70% of the earths surface
- Less than 1% is fresh water
- High biomass, eg coral reefs



Natural Biomes:

A specific geographical area of the earth where similar conditions prevail, resulting in communities of distinctive similar living organisms (flora & fauna). These similar conditions can include temperature, rainfall, soil, topography and the amount of light available. A natural biome is often identified by the distinctive species living there and are often named after the dominant vegetation type found in the area. E.g. tropical rainforest biome. The flora and fauna tend to possess similar characteristics in response to the complex environmental conditions that prevail as they have adapted to each particular environment (e.g. desert). This has resulted in a delicate balance that is often maintained by being dependent on each other. Climate is the main influence of a natural biomes location.

Anthromes:

A global ecosystem unit defined by global patterns of sustained direct human interactions with ecosystems, creating a description of the terrestrial in its contemporary, human altered form. Also know as anthropogenic biomes or human biomes.

Only 22% of Earth's ice free land surface is not affected by anthropogenic activity.

Examples of anthropogenic biomes are urban areas, villages, and croplands are examples of anthromes.



Difference between Natural Biomes and Anthromes:

A biome is the largest of the biophysical units found on the Earth. They can be mainly identified by major global vegetation types and their associated climates. There are eight major biomes that are spread throughout the world, due to climate factors. These include; rainforests, tundra, taiga, chaparral, temperate deciduous, tropical savanna, deserts and grasslands. Due to human activity especially since the beginning of the Industrial Revolution (1780), biomes have been significantly altered. When a biome is altered it becomes an anthrome. This term refers to changes resulting from direct impacts of human activities on natural biomes or environments. An example of a biome that has undergone major land cover change would be temperate deciduous regions of the world.

Before industrial activity began in full, these biomes were characterised by moderate climate, with temperatures ranging from -20 to 30 degrees Celsius, an average of 750mm to 1500mm of rain annually, vegetation that consisted of well-developed understory and trees that lost their leaves in winter. Due to human/anthropogenic activity, parts of this biome can now be classified as a 'densely populated anthrome', this can be seen in parts of Germany, France and the North-Eastern seaboard of the United States of America. Dense Settlements are the second most densely populated regions of the world. Dense settlements are highly heterogeneous with regards to population density and tree cover. No consistent pattern of climate amongst areas designated as dense settlements can be determined. The total lack of variety in land use within dense settlements points towards their use as strictly residential districts. Population density never falls below 100 persons/km even in the non-urban parts of the dense settlements anthrome which suggests that these areas consist of both the sprawling edges of major cities in underdeveloped nations.

Anthropocene:
The word Anthropocene combines the root "anthropo", meaning "human" with the root "cene", the standard suffix for "epoch" in geologic time. The Anthropocene defines Earth's most recent geologic time period as being human-influenced, or anthropogenic, based on overwhelming global evidence that atmospheric, geologic, hydrologic, biospheric and other earth system processes are now altered by humans. Evidence includes climate change, habitat loss and species extinction, which have all changed the Earth's biodiversity. The Anthropocene is distinguished as a new period either after or within the Holocene, the current epoch, which began approximately 10,000 years ago (about 8000 BC) with the end of the last glacial period.

Land Cover Change:

The change in the biophysical and built environment, brought about by human activity. Land cover refers to the natural physical and biological elements on the earth's surface such as water, soil vegetation. Humans have been modifying natural land for thousands of years, to obtain food and other resources. Current rates of land cover change, however, are greater than any time in history. The factors driving land cover change include world population growth, urbanisation, industrialisation and rising living standards. Natural causes of land cover change include cyclones, bushfires, tsunamis.
The specific types of LCC include:
• Deforestation
• Urban and industrial expansion
• Mining
• Agriculture

Climate change & biodiversity loss are the two major consequences of LCC.

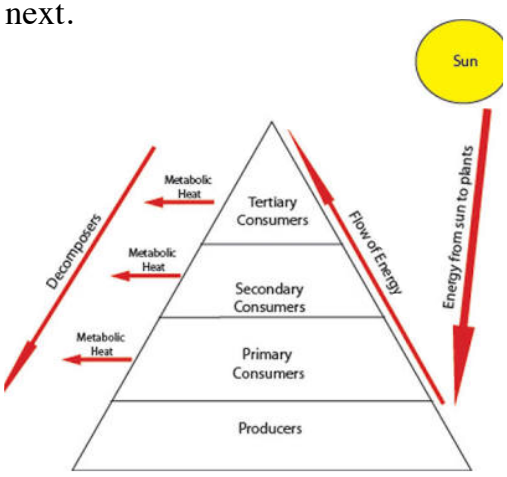
Ecosystems

Ecosystem structure - The abiotic and biotic features of the ecosystem, their interactions and a source of energy make up the structure of an ecosystem.
Ecosystem dynamics - The network of interactions within the ecosystem community, these could include nutrient cycles and energy flows.

1. Systems through which **incoming solar energy** is captured and moved through a **hierarchy** of life forms.

2. Characterised by the complex interactions between the **abiotic** and **biological** environments. It involves four major spheres- the **biosphere** *(all the living organisms)* **lithosphere***(the rigid outermost shell – the crust and upper mantle)*, **hydrosphere** *(all the water on or near the earth)* and the **atmosphere** *(body of air which surrounds earth)*

Energy Flows – All animals and plants in an ecosystem occupy levels of the trophic pyramid. Food chains/webs pass nutrients and energy flows from one trophic level to the next.



- 95% of energy lost at each trophic level
- Energy is lost through respiration, excretion etc.
- Energy is consumed at each level for growth, body heat, energy for movement.
- Autotrophs (Producers) have the ability to produce growth undergoing photosynthesis.

The Four Main Components of an Ecosystem Are:

1. Abiotic: Non-living components which consist of climatic features such as sunlight and humidity, inorganic substances such as water and organic substances such as proteins.
2. Producers: Known as autotrophic organisms, can convert solar energy into chemical energy and can store energy for later use.
3. Consumer: Known as heterotrophic organisms are reliant on other organisms for nutrients and can be categorised into herbivores and carnivores.
4. Decomposers: Heterotrophic organisms which breakdown dead organic matter and waste matter e.g. fungi.

Structure

• Ecosystems are distinctive communities of plants and animals interacting with each other and with the non-living or abiotic environment

• These ecosystems vary in size (spatial structure)

• Ecosystems form part of biological hierarchy where the largest unit is the biome

• Within the biotic components there are energy flows, nutrient cycles and biological processes such as, reproduction and evolution. In abiotic components there is tectonic activity, erosion and deposition, as well as variations in atmospheric composition, weather and climate

• Abiotic elements include atmospheric conditions – weather and climate, inorganic nutrients and minerals, water, rocks, landforms and solar energy

• Many ecosystems are characterised by being at different stages of progression development.

• An undistributed ecosystem may reach a final stage where organisms form a climax community and the ecosystem has reached a level of stability and remain there unless an extreme weather event occurs such as fire, earthquakes, volcanic eruptions or landslides

Dynamics

• Ecosystem interactions and dynamics can be studied by looking at trophic level interactions. Includes study of ecological succession, energy flows and biochemical process

• Ecological succession: - Are biomes and the biological communities that exist within them

- These changes are a result of new organisms that enter the ecosystem, the gradual evolution of existing organisms and the changes that occur within the abiotic environment
- Two different types *PRIMARY* that occurs where a biological community establishes itself in what was essentially a lifeless location and *SECONDARY*, which occurs where a community that previously existed was removed by some event.
- At every stage of an ecosystems development, certain types of plants & animals have characteristics that allow them to flourish in the current conditions

Energy Flows

- Trophic pyramid was the bottom of the pyramid is made of autotrophs which are the plants & are the largest part of an ecosystems biomass
- Animals make up the primary, secondary and tertiary level consumers
- Food chains and food webs pass nutrients and energy from one trophic level to the next in an ecosystem

Biochemical Process

• Involve the cycling and transfer of substances through the biotic and the abiotic components of an ecosystem

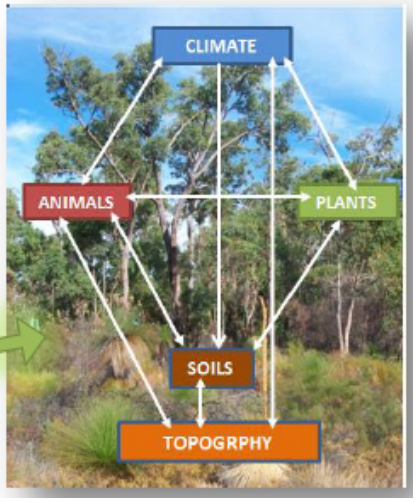
• Includes the cycling of water, oxygen, carbon dioxide, nitrogen and phosphorous

• Water is essential as it regulates temperatures, sustains life and transports nutrients

- Carbon dioxide is an essential part of photosynthesis

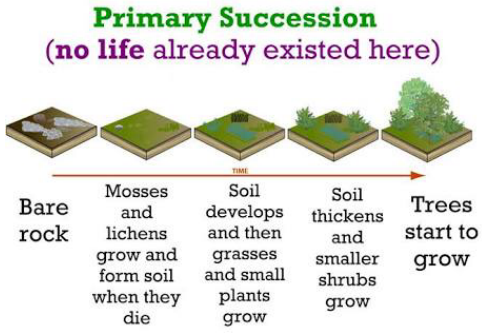
ECOSYSTEM INTRACTIONS

1. No organism exists in isolation. Individual organisms live together in an ecosystem and depend on one another. In fact, they have many different types of interactions with each other, and many of these interactions are critical for their survival.
2. All living and non-living elements within an ecosystem interact and play a part in maintaining ecosystem balance.
3. These interactions can be localised, such as the inter-relationships between the plants, animals, soils, topography and climate within the area.

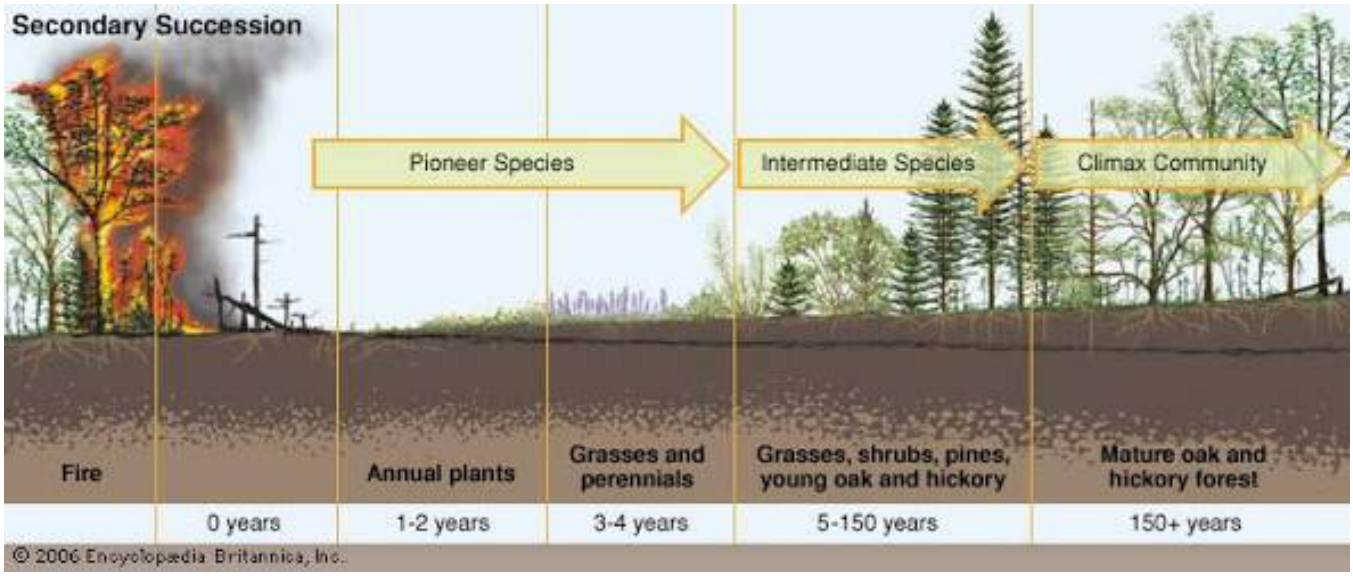


Ecological Succession – The evolution of organisms in an ecosystem.

- Primary: A biological community is established in what used to be a lifeless location e.g lava fields.



- Secondary: Where a community/ecosystem has been altered/removed and there is a chance for new organisms to invade. These invading organisms may take over if they are better adapted to the new conditions.



SPATIAL SCALE (BIGGEST TO SMALLEST)

ENVIRONMENT → BIOME → ECOSYSTEM

Biodiversity:

Refers to the number, type and variety of biotic living organisms found within an ecosystem or environment. They interact and depend on each other in a biome. The fully developed natural ecosystems within biomes have a high degree of biodiversity. It is an important characteristic while the loss is a way of assessing the extent of land cover change.

- **'Biological diversity'** - The **type**, **number** and **variety** of **living organisms** within a **given environment**.
- Often considered at three levels:
  - **Genetic diversity** - the variety of genetic information contained in all the **plants, animals** and **micro-organisms** on earth;
  - **Species diversity** - the variety of **living organisms** on earth;
  - **Ecosystems diversity** - the variety of habitats, communities and ecological processes on earth.

Biodiversity Loss:

-A decrease in species, genetic and/or ecosystem diversity.

Any change to the earth's land cover has the potential to impact on the biodiversity of natural environments and ecosystems. Biodiversity refers to the number, type and variety of living organisms found within an environment or ecosystem. Any negative changes are called loss. The United Nations considers that land cover change and the development of anthropogenic biomes are posing a serious threat to the world's biodiversity. It is estimated that the loss of biodiversity has already exceeded the upper limits of rehabilitation, with current extinction rates being 100-1,000 times higher than pre-industrial levels.

Biomass:

The amount of organisms within a biome or an individual ecosystem. Measurement & observation assists in identifying & classifying different biomes. (Flora and Fauna) Rainforest biomes have high biomass, desert biomes have low biomass.

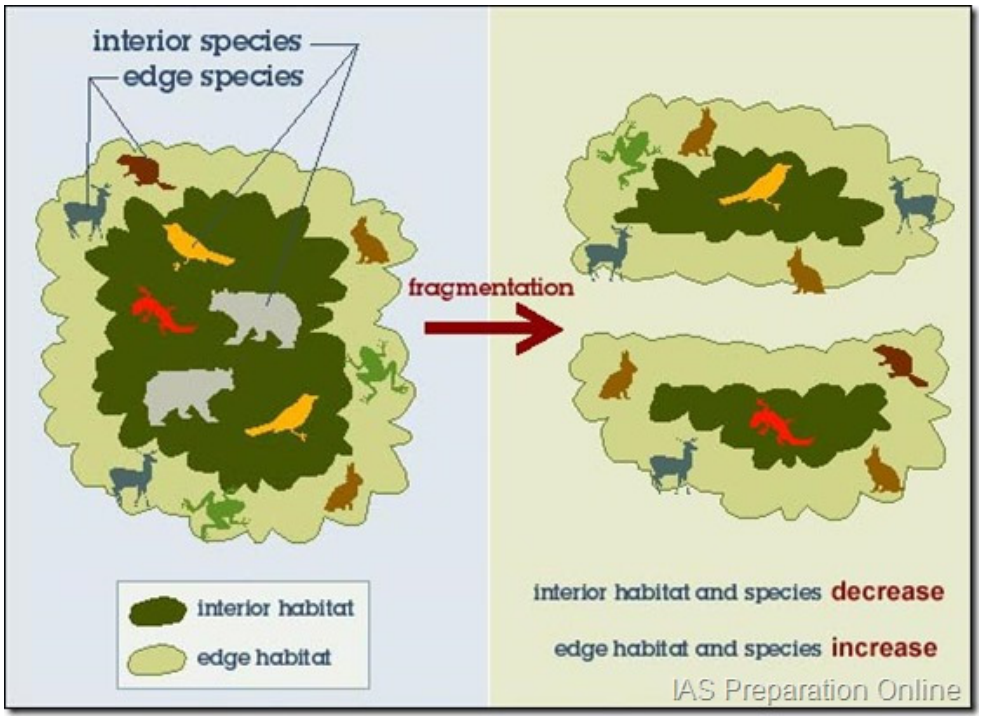
Fragmentation:

Interest in **Biodiversity** has grown rapidly in recent decades, in parallel with the growing concern about **nature conservation**, largely as a consequence of accelerating rates of:

- **Natural habitat** loss
- **Habitat/Ecosystem fragmentation** and **degradation**
- **Extinctions** of **species**.

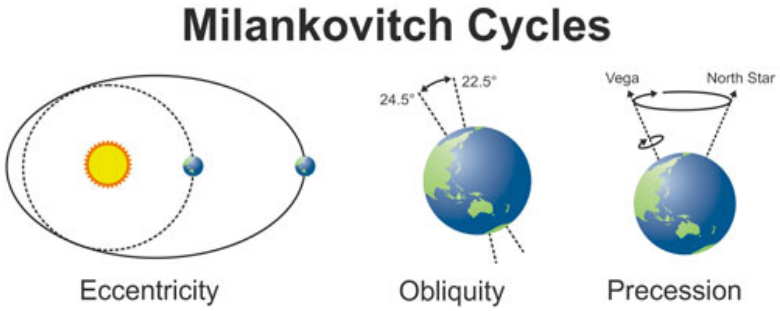
Habitat fragmentation is the process by which habitat loss results in the division of large, continuous habitats into smaller, more isolated remnants.

Destruction of habitats and **fragmentation** has occurred through human settlement including the construction of harbours, dams, reservoirs, roads, railways etc.



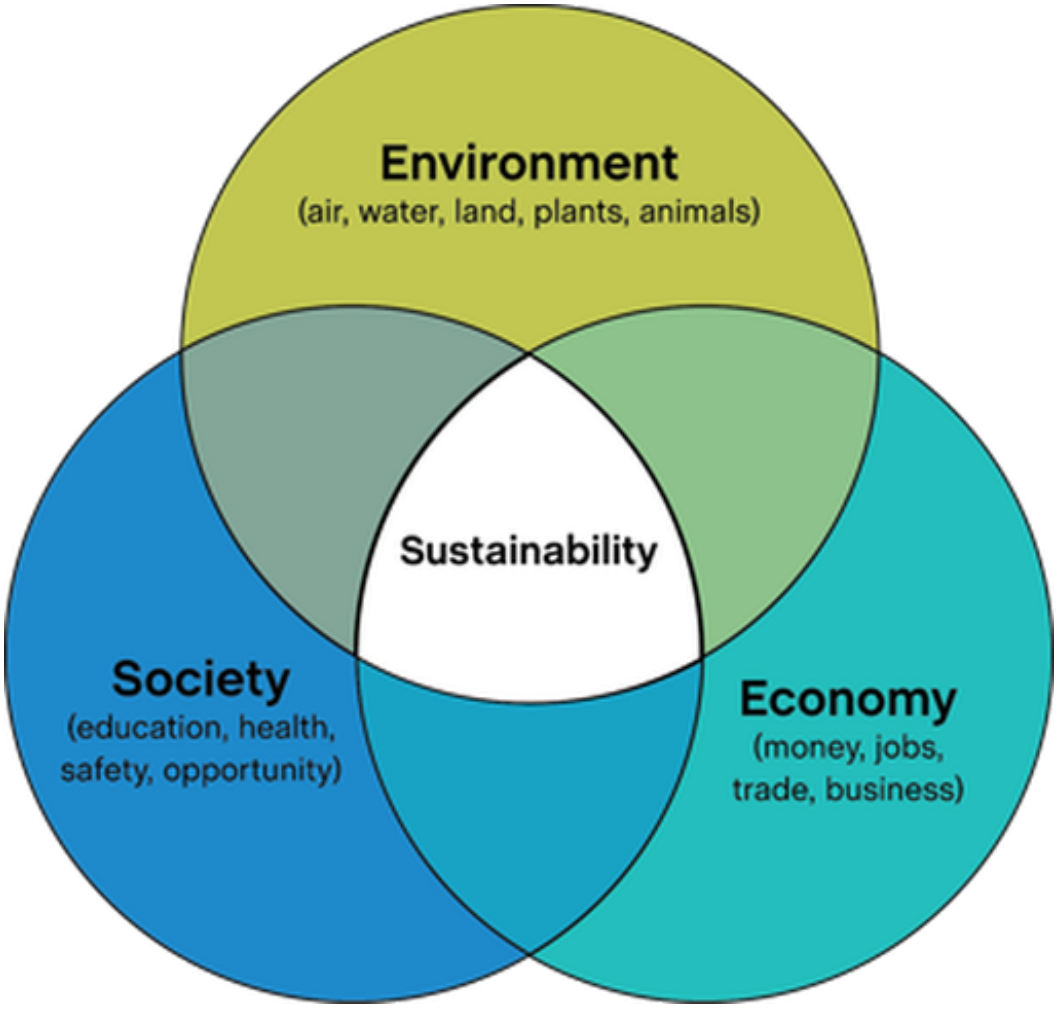
Climate Change:

- Up until the last 200 years, the world's climatic patterns and weather systems have been largely the result of natural systems and their interactions (the heat budget, the hydrological cycle, atmospheric circulation and the carbon cycle). In recent years, land cover change, biodiversity loss, and the development of anthropogenic biomes have had a significant impact on the earth's natural climate system.
- Climates have changed naturally over time due to changes in the Earth's axis, distance from the sun and orbit (i.e Milankovitch cycles), and volcanic events. However, world population growth and large scale industrialisation has seen the creation of anthropogenic climate change, with evidence in the form of rising global temperatures, changing precipitation patterns and rising sea levels. Atmospheric carbon dioxide levels have increased from 280ppm to over 380ppm.
- The increase in agriculture (cattle and sheep), along with widespread clearing of forests (deforestation), industrial development and increased rates of fossil fuel use have added GHG emissions into the atmosphere. These land cover change activities by human activities are significant anthropogenic drivers of climate change.



Sustainability:

- Meeting the needs of current and future generations through simultaneous environmental, social and economic adaptation and improvement.
- Anthropogenic biomes must be sustainable to survive. This means meeting the needs of current generations without compromising the needs of future generations using the three pillars of sustainability (environmental, economic and social considerations).
- A report by the United Nations estimates that humans have affected about 85% of the world's terrestrial environments, with 60% of natural biomes being degraded in the past 50 years. Land degradation by overgrazing and intensive agriculture is a major driver of land loss.
- Sustainable development is an objective where all land use decisions are based on the need to prevent biodiversity loss and manage resources to meet the needs to future generations.
- "We are failing in our responsibility to future generations and even the present ones"
  - Kofi Annan

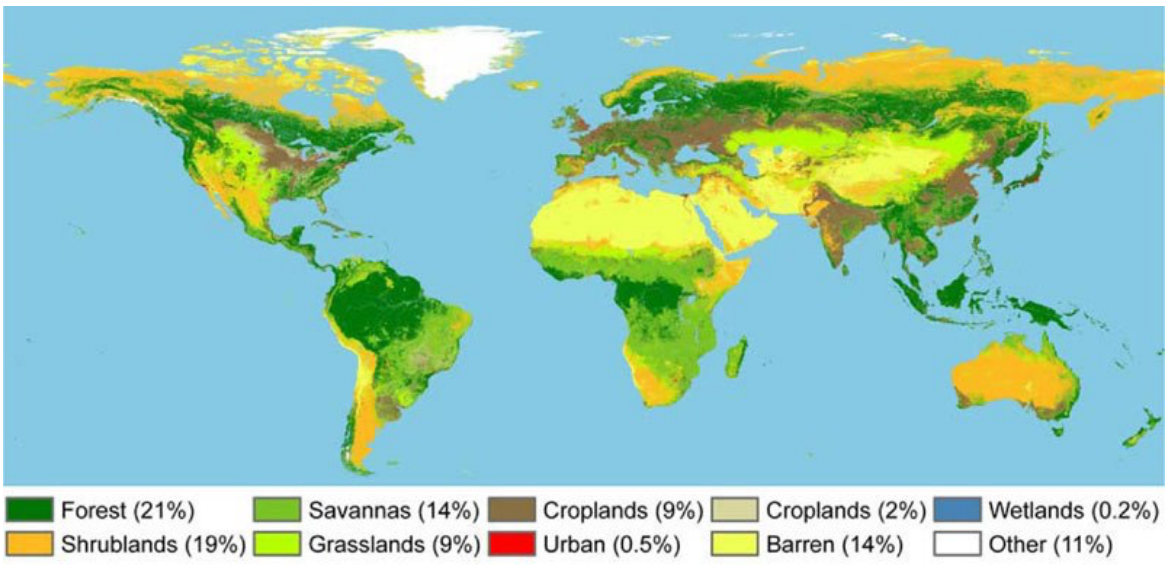


- **Identify and classify examples of land cover changes with reference to global forests, agriculture and urban land cover**

Anthropogenic biomes or **anthromes** are created as a result of land cover change. The impact is measured through % of vegetation clearing, genetic and species diversity, ecological fragmentation and soil and water quality.
Land Cover Definition: Is the physical material at the surface of the earth. Land covers include grass, asphalt, trees, bare ground, water etc.

Land Cover	Characteristics	Examples
Forest	- Either tropical, temperate, boreal, grass, or non-existent depending on climate. - Anthropogenic through recreational parks, national parks. - Change occurs through mining of trees for economic gain and creation of industry.	- Sclerophyllous forest of south-west Australia. - Spinifex grass across semi-arid Australia. - Amazonian rainforest.
Agriculture	- Either croplands or rangelands depending on climate. - Change occurs through clearing of land for grazing, feeding of cattle and increased demand for food sources and crops.	- Intensive beef and dairy farming on rural-urban fringe. - Rice plantations of south-east Asia.
Urban	- Dense settlements that fragment existing natural vegetation. - Change occurs through increased population growth, changes in the climate of a specific region and expanding secondary and tertiary industries.	- Perth metropolitan area

Humans can impact biomes ranging from slight environmental modifications through to complete LCC. The world is more urbanised today than ever before. E.g. China used to be agriculturally based but now more than 25 million living in Shanghai alone.



Forest and Woodland Biomes:

Global Forest areas include:
• Amazonian region (South America)
• Boreal forests (North America and Russia)
• Rainforests (South East Asia; Papua New Guinea)
• Jarrah, Carrie forests in South West Australia

Populated Forests:
• Near agricultural lands and urban settlements
• These may include reserves where structures such as roads, picnic areas, & tourist accommodation are found
• Evidence of logging
• Introduced to fauna and flora
• E.g. Rainforests of Indonesia
• Boreal forests of North America & Russia
• Dieback is an introduced disease which kills species (due to humans)

Remote Forests:
• Canada, Russia, Amazonian core (Brazil, Columbia, Ecuador)
• Located far away from large populations
• Largely untouched
• High biodiversity
• High resource potential
• Can be exploited through mining, timber industry (E.g. Manaus and Belen)

Wild Forests:
• Characterised by vast tree cover
• Total lack of civilisation and human interaction
• E.g. Equatorial and boreal forests of northern hemisphere, tundra
• Papua New Guinea forests are so high up and hard to get to, there is a complete lack of resources and 6 months of complete darkness, followed by 6 months of complete sunlight due to angle of inclination

Australian Forests:
• Native vegetation covered most of nation prior to European settlement
• Currently since colonisation 85% of Australia is vegetated by native species (in arid and semi-arid biomes)
• Forest and woodland coverage has been changed from 55% to 42%
• This corresponds to intensively used rural and urban land use zones
• Large areas of forests and woodlands are now protected as national parks & reserves
• E.g. Banana plantation on the North coast of Queensland (fresh water source)

Agriculture:

• Can be intensive or extensive
• LCC produce a variety of rural landscapes
• This is caused by different structures, crops, farm animals etc.
• Deforestation, clearing of native flora and fauna
• Irrigation (water stress)
• High levels of salinity
• Soil erosion
• CO2 and GHG emissions from machines, methane from cows
• European farms are smaller in size and more green
• Australian farms are large with a higher yield
• E.g. of intensive farming is egg farming, wine, hobby farms, rice paddy farming.

Croplands:
Crops don't move
• Include irrigated and rain-fed farming systems, intensive populated cropping systems, remote extensive cropping systems
• E.g. south east Asia rice farming
• Village based, poor, intensive food production, is for local consumption, for large rural populations
• E.g. European, Australian and North American moderately intensive cropping found near large population centres
• Intensive dairying (Harvey), vineyards (Margaret River/Swan Valley) and orchards
• E.g. extensive cropping further away from urban centres
• Wheat belt in WA

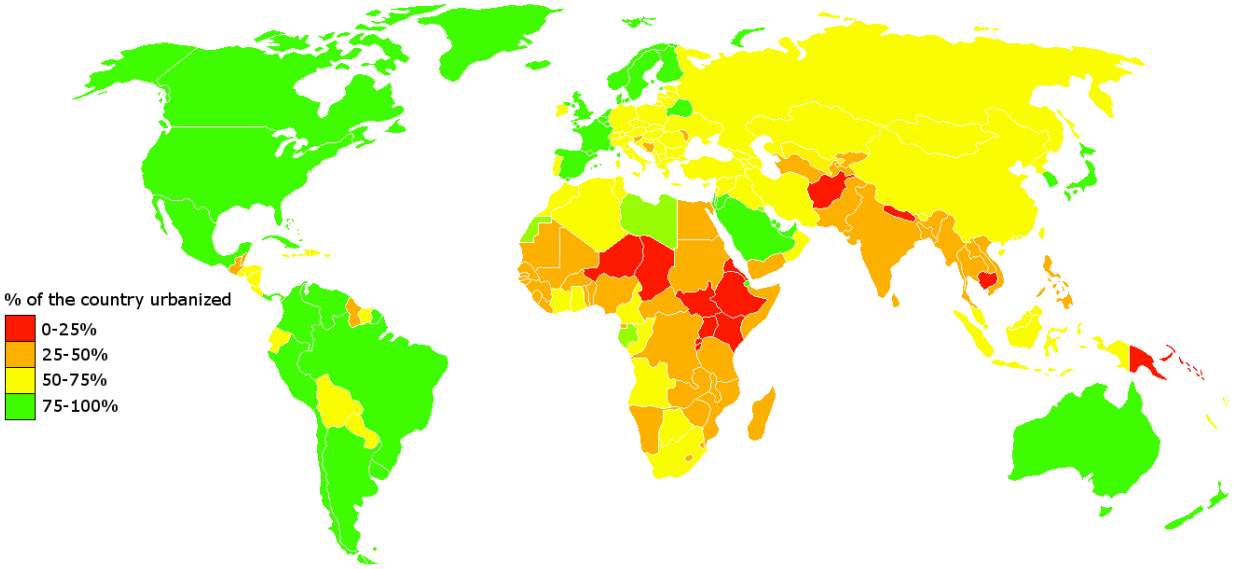
Rangelands:
Crops move (livestock)
• Extensive
• Populated or remote system rely on natural pastures to support cattle
• Zulu people in Africa
• Semi-arid regions
• Grazing sheep for wool in Australia
• Little biodiversity, requires management to maintain
• Qatar and China have bought farms in NW of Australia to ensure food for their country (beef)

Urban Regions:
• Major cities, regional towns, urban villages
• Densest anthropogenic biomes
• Covered by human structures/built land cover
• 50% of world's population lives in urban settlement, which covers only 7% of the earth
• Location depends on resources, accessibility, defence, government, cultural values
• Australia's urban land pattern reflects European occupation
• E.g. sea travel exploration of coasts
• Capital cities are coastal
• Timber, stone (building) and water (population) are all urban land uses that have altered natural environment
• Humans; residents, industries of built environment consume natural resources (water, energy, land)
• Waste generated by humans also has impacts as well as introduced animals & plants
• Landfill
• Sweden has no waste – turns it all into energy
• Population growth, economic growth, climate change are also impacts

- **Use remote sensing images, other spatial technologies, and fieldwork to identify and measure the location, nature, rate, extent and consequences of land cover change**

Geographic Information Systems (GIS) are ways of presenting spatial information.

Satellite imagery and other forms of **remote sensing** allow us to see the change in land over space and time (e.g. intensity).
Fieldwork enables a first hand perspective on ongoing land cover change. For example, the City of Mandurah's Marlee Reserve is an example of a protected biodiversity hotspot under the Ramsar Convention.



- **The implications of anthropogenic biomes to the functioning of the world's ecosystems**
- **The impact of world population growth, growing affluence, advances in technology on the nature, rate and extent of land cover change and biodiversity loss**

Anthropogenic biomes impact on ecosystems in various ways including;
> Ecosystem fragmentation (e.g. City of Mandurah's Marlee Reserve);
> Loss of ecosystem services (as a result of land cover change);
> Loss of biodiversity and associated species extinction or invasive species.

These ultimately affect the **structure and dynamics** of ecosystems through interruptions in biogeochemical processes, food chains and energy flows.

A growing world population, more specifically a growing urbanised population and associated need for more areas for sustenance, leads to the reduction in the natural environment, and thus ecosystems become degraded and either have to adapt or die off.

Growing **affluence** leaves more people able to afford resources. As a result, demand for products and services, like sustenance or wood products, leads to increases in **deforestation and land degradation** practices.

Advances in technology leads to the exacerbation in the rate and size of land cover change (e.g. bigger machinery is able to clear more land than previously, and is done so cheaper and faster than previously).

Anthropogenic biomes impact the ecological balances that existed in the original ecosystems prior to human alteration. The flow of energy through foods chains/webs and ecosystems will be greatly altered as habitats are changed/removed. This results in the changing of individual species numbers. This will affect the species above and below in the food chain/web. Those most at risk are those "at the pinnacle", such as tigers in SE Asia and cheetahs in Africa. They rely on low order producers and consumers for food and energy. Along with habitat destruction and illegal hunting, their numbers have been greatly reduced. Pandas have also experienced a decrease in numbers due to bamboo habitat destruction. Polar bears have also been affected through the Anthropocene due to climate change. Ecosystem services are the benefits people obtain from ecosystems. These include services such as:

- Food and water
- Food and disease control
- Cultural services such as spiritual, recreational, and cultural benefits
- Supporting services such as nutrient cycling that maintain the conditions for life on Earth.

Ecosystem services	Anthropogenic issues
• Food and water	• Quality and yield/overexploitation, invasive species.
• Flood and disease control	• Deforestation/building infrastructure on flood plains etc.
• Cultural services	• Particularly important to indigenous peoples • Increasing population
• Nutrient cycling	• Deforestation can lead to changes in the water, carbon, nitrogen, oxygen, phosphorous and Sulphur cycles.

How Anthromes Have Impacted The World's Ecosystems:

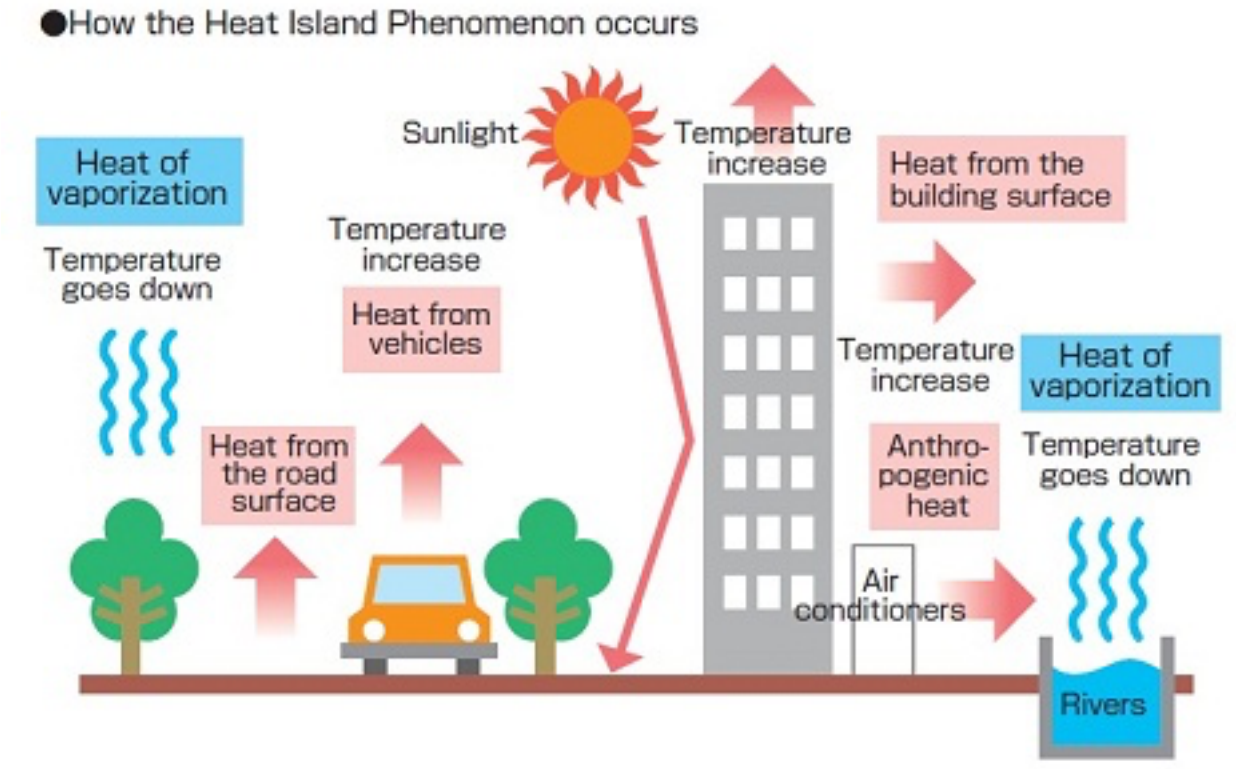
Ecosystem services are the benefits people obtain from ecosystems such as; water and food, flood and disease control, cultural services like spiritual, recreational and cultural benefits, supporting services like nutrient cycling that maintains the conditions for life on earth. Anthropogenic biomes impact ecological balances that existed in the original ecosystem prior to human alteration. The flow of energy through food chain/webs and ecosystems will be greatly altered as habitats are changed and removed (or fragmented). This results in the changing of species numbers. For example habitat destruction occurring in China such as the removal of bamboo and the illegal hunting of endangered species have caused the numbers of pandas to decrease rapidly. Polar bears have also been affected due to climate change melting their ice cap habitats, thus reducing places for them to live.

Ecosystems are impacted by anthropogenic biomes as they provide 'ecosystem services'. Once a biome has been fully partly integrated by humans then ecosystems begin to suffer as the anthropogenic environment begins to dominate. There becomes an issue with yield quality and quantity in agriculture as there is an overexploitation of key crops and the outbreak of invasive flora and fauna species. Deforestation begins to occur to make way for an increase in agricultural land or urban building infrastructure, particularly close to fresh water resources. This deforestation can lead to changes in the water, carbon, nitrogen, oxygen, phosphorus and Sulphur cycles.

Implications of Anthropogenic Biomes to the Functioning of the World's Ecosystems:
Ecosystem services are the benefits people obtain from ecosystems such as; water and food, flood and disease control, cultural services like spiritual, recreational and cultural benefits, supporting services like nutrient cycling that maintains the conditions for life on earth. Anthropogenic are when natural biomes have been altered by human activity. This has occurred at a rapid rate since the industrial revolution in the 1750's. An example is France which used to be a Moderate climate with vegetation that had a thick understory and trees which lost leaves in winter. It is now a temperate deciduous region with dense settlement. Urbanisation causes deforestation and land clearing. A loss of biodiversity occurs due to habitat destruction of plant & animal species where extinction rate are now 1000 times higher than pre 1750. Loss of energy can occur if too many trees are cut down and there is no wood left for energy. This could occur in LEDC's such as Tanzania who relies on wood for 80% of their energy.

Anthropogenic biomes offer a new way forward in global ecosystems integrating human and ecological systems. Humans affect the climate through changes in land use such as industrial, agricultural and residential uses which produce GHG's as well as altering land cover through deforestation for these uses. Cities are now warmer due to the removal of trees and green vegetation which has been replaced with black concrete. This has causes how water, energy and heat are exchanged between land and atmosphere. This make humans more susceptible to extreme heat events.

How Urban Development Has Resulted in the Loss of Biodiversity and the Urban Heat Island Effect:



Urban development will see more of the world's population living in cities and metropolitan areas surrounding cities. Although urban areas only cover 0.47% of the world's land area they contain more than 50% of the world's population. Urban areas can affect the climate because they change the reflectivity of a surface thus affecting the heat budget and water cycle through changes in the transmission of heat, water, albedo and radiation as well as vegetation cover. The clearing of land for urban and residential purposes has depleted the environment and the biodiversity through deforestation as both flora and are being depleted as their homes are being destroyed for other purposes such as agriculture or land reclamation.

- **The impact of world population growth, growing affluence, advances in technology on the nature, rate and extent of land cover change and biodiversity loss**

From 1900 to 2000, the world's population increased three times faster than in all of human history. It is currently growing at around 140 people per minute and is expected to reach a population of 9 billion by 2050. In 2007 the global urban population became larger than the rural population, this is due to growth and expansion of urban areas, the reclassification of area and migration from rural to urban areas. The rate of growth is decreasing since its peak in the 1960's, but the population is still increasing.

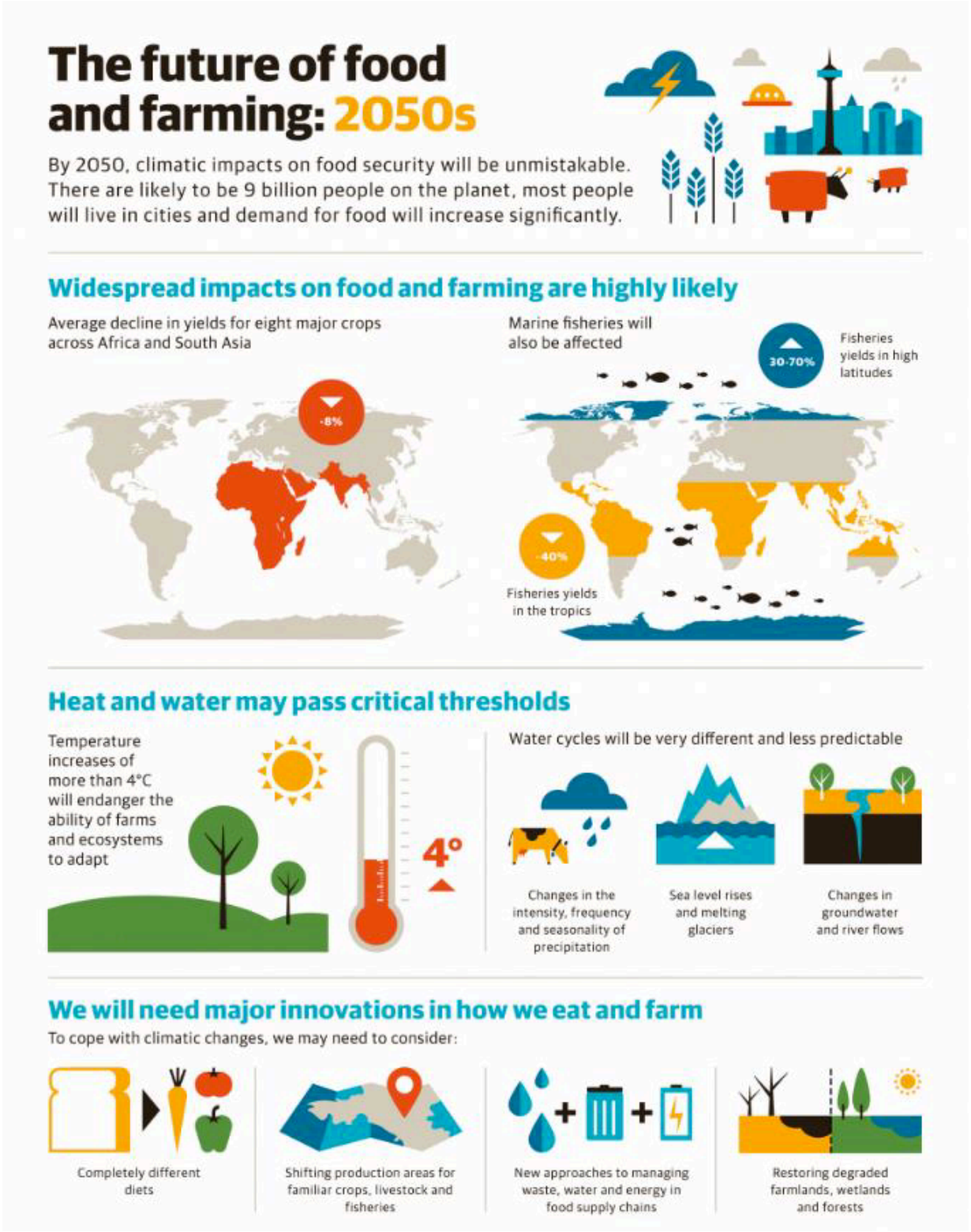
3 factors influence the human population and its growth:
• Humans are living longer
• Majority of population growth will occur in urban areas in developing countries
• Fertility rates are declining

Fertility Rate:
The average measure of the number of children will be born per woman in a country.
The dominant rate is 1.2-1.8 children per woman, but the 'replacement' rate should be 2.1 (for the population to not decrease).
Fertility rate decreases due to:
• Improved health care system (decreased rate of infant mortality, therefore the idea that you need to have more children because others might die is not needed)
• Increased cost of raising children
• Increased cost of education for children
• More women in workforce

Wealth:
• 1% of the world's population holds 50% of the world's wealth
• Diets of people in affluent countries consist of more meat and dairy which requires agricultural expansion and intensification
• Also demand more technology and resources
• Currently 20% of the world consumes 80% of the resources
• Caused global displacement of land use (wealthier nations rely on developing countries for development of goods even though they can afford to and have the resources to do it independently)

Industrial Revolution:

- 18th century
- Introduction of technology and machine development
- Allowed for large scale production
- With a higher population growth, more urban expansion in MEDC's, and industrialisation saw a pattern of technology hungry countries worsened the environmental quality
- This saw new technology for "clean up" and more sustainable practices
- E.g. "ocean bin"

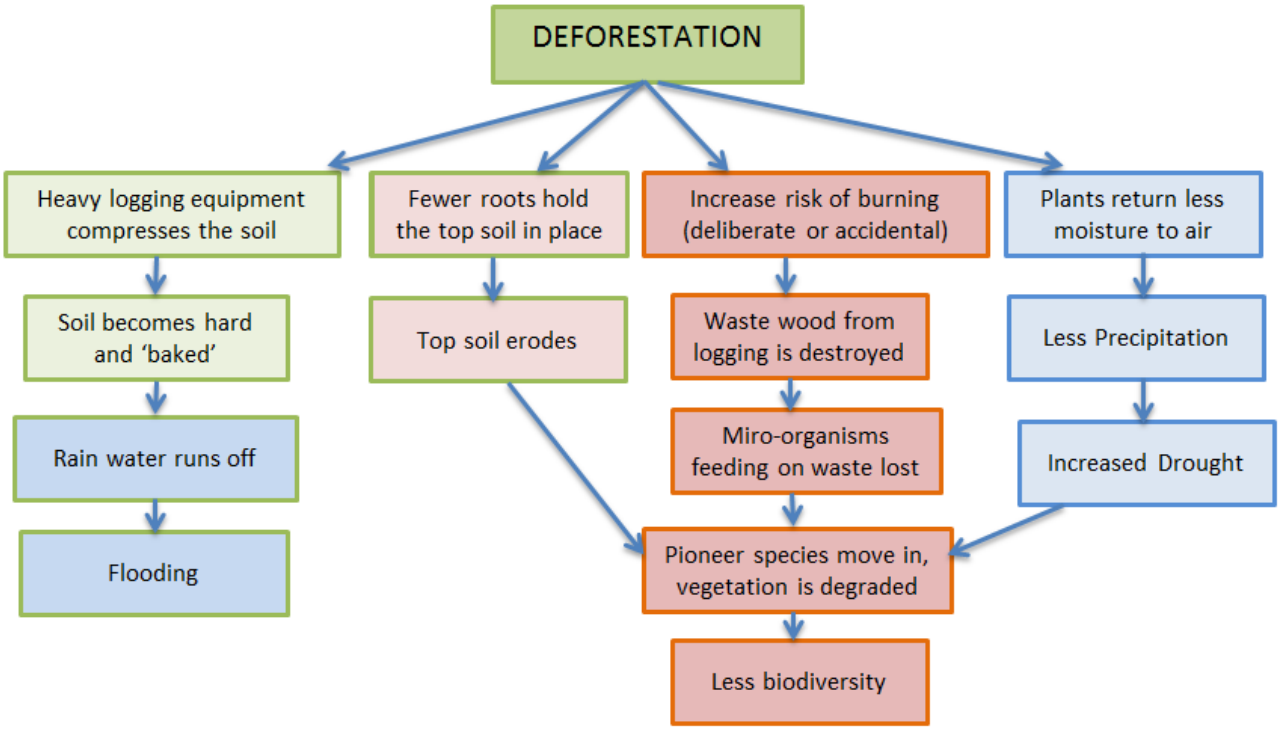


How World Population Growth Influenced the Rate and Extend of Land Cover Change:
Land cover change refers to the process in which the earth's physical surface is altered due to natural and/or anthropogenic causes. World population is estimated to be growing at 140 people per minute and by 2050 the world's population is expected to reach above 9 billion. The increase in world population leads to an increase in anthropogenic land cover change.

How World Population Growth Influenced the Rate and Extend of Biodiversity Loss:
World population growth increases the rate of biodiversity loss as with the expansion of urban settlement and intensification and expansion of agriculture. As a result of this habitats are destroyed or fragmented which often results in native fauna having to relocate. This can lead to extinction of species. Over 18'000 species are threatened.

- **The processes of land cover change (deforestation, the expansion and intensification of agriculture, rangeland modification, land and soil degradation, irrigation, land drainage and reclamation, and the growth of urban settlement, industry and mining)**

Deforestation:
Deforestation is a process of land cover change that involves the permanent removal of trees and often their associated vegetation. Rates of deforestation are high in parts of the developing world such as Brazil and Indonesia, where drivers of land cover change include logging for timber, the clearing of land for broad-scale agriculture or urban development. Forests cover approximately 30% of the Earth's surface but deforestation is reducing their area at the rate of 13 million hectares per year. The effects of deforestation can include an increase in the rate of biodiversity loss and reduces the greenhouse gas absorbing capacity of the Earth's forests.



- The Food and Agriculture Organisation (FAO) define deforestation as the **long-term reduction** of the tree canopy to below 10% - 30%.
- It is estimated that over the last 5,000 years, humans have been responsible for approximately 1.8 billion hectares of **deforestation**. In recent years, the rate of deforestation has reached an annual loss of 13 million hectares worldwide. While the rate of deforestation has slowed overall and the regrowth in certain areas has offset some of the loss, many forests are still experiencing rapid rates of decline. **Management strategies** for dealing with deforestation are being developed using the information received from the application of **remote sensing** and **spatial technologies**.
- Reasons for deforestation include: **population** growth, **economic** growth (a means of alleviating poverty), **international demand** for timber & forest products, **insecurity** of rights of local people, **incomplete valuation** of forest ecosystems, **wars** and **civil disruption**, **infrastructure projects** (mines, transport, dams, rural settlement).
- 4. Tropical forest losses
    i. Highest rates occurred in **South America** and **Africa**
    ii. Rapidly developing countries with rapid deforestation in 1990s (Brazil, Indonesia) have reduced rates of tropical forest losses
    iii. Less developed countries continue to have high rates of loss (Latin America, Africa)
- Deforestation in the Brazilian Amazon is responsible for as much as 10% of current GHG's
- **Fragmentation**: A type of deforestation that occurs when there is some clearing of forested land (mostly for road construction), which leaves fragments of intact forest (over time, the edges of each fragmented remnant vegetation becomes degraded). The remnants may become too small and too isolated to support forest ecosystems. This leads to eventual deforestation.
- Forest degradation alters **local** or **regional hydrology** and initiates changes in the **local climate**, causing it to dry as there is increased water runoff & decrease in net evapotranspiration (Tropical rainforests protect low albedo against radiative-forcing effects by keeping lower evapotranspiration rate)

Location:

Deforestation occurs on a global scale, tropical rainforests are particularly targeted. If current deforestation levels proceed, the world's rainforests may be completely destroyed in as little as 100 years. Countries with significant deforestation include Brazil, Indonesia, Thailand, the Democratic Republic of Congo and other parts of Africa, and parts of Eastern Europe. The country with the most deforestation is Indonesia. Since the last century, Indonesia has lost at least 15.79 million hectares of forest land.

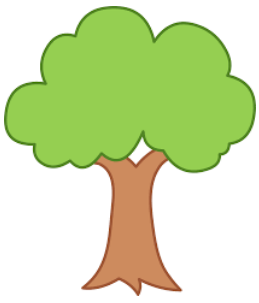
Causes:

There are many causes of deforestation. The WWF reports that half of the trees illegally removed from forests are used as fuel.

- Some other common reasons are:
- To make more land available for housing and urbanisation
- To harvest timber to create commercial items such as paper, furniture and homes
- To create ingredients that are highly prized consumer items, such as the oil from palm trees
- To create room for cattle ranching
- Common methods of deforestation are burning trees and clear cutting. These tactics leave the land completely barren and are controversial practices.
- Clear cutting is when large swaths of land are cut down all at once.
- Burning can be done quickly, in vast swaths of land, or more slowly with the slash-and-burn technique. Slash and burn agriculture entails cutting down a patch of trees, burning them and growing crops on the land. The ash from the burned trees provides some nourishment for the plants and the land is weed-free from the burning. When the soil becomes less nourishing and weeds begin to reappear over years of use, the farmers move on to a new patch of land and begin the process again.

Effects:

- **Climate Change**: Deforestation is considered to be one of the contributing factors to global climate change. The number 1 problem caused by deforestation is the impact on the global carbon cycle. Gas molecules that absorb thermal infrared radiation are called greenhouse gases. If greenhouse gases are in large enough quantity, they can force climate change. While oxygen (O_2) is the second most abundant gas in our atmosphere, it does not absorb thermal infrared radiation, as greenhouse gases do. Carbon dioxide (CO_2) is the most prevalent greenhouse gas. In 2012, CO_2 accounted for about 82 % of all U.S. greenhouse. Trees can help, though. 300 billion tons of carbon, 40 times the annual greenhouse gas emissions from fossil fuels, is stored in trees.
- **Loss of Species**: 70% of the world's plants and animals live in forests and are losing their habitats to deforestation. Loss of habitat can lead to species extinction. It also has negative consequences for medicinal research and local populations who rely on the animals and plants in the forests for hunting and medicine.
- **Water Cycle**: Trees are important to the water cycle. They absorb rain fall and produce water vapour that is released into the atmosphere. Trees also lessen the pollution in water by stopping polluted runoff. In the Amazon, more than half the water in the ecosystem is held within the plants.
- **Soil Erosion**: Tree roots anchor the soil. Without trees, the soil is free to wash or blow away, which can lead to vegetation growth problems. A third of the world's arable land has been lost to deforestation since 1960. After a clear cutting, cash crops like coffee, soy and palm oil are planted. Planting these types of trees can cause further soil erosion because their roots cannot hold onto the soil.
- **Life Quality**: Soil erosion can also lead to silt entering the lakes, streams and other water sources. This can decrease local water quality and contribute to poor health in populations in the area.



The Expansion and Intensification of Agriculture:

The expansion of agriculture that refers to increasing/expanding the land used for agricultural land use. Deforestation is often associated with this. The intensification of agriculture refers to increasing the productivity of agricultural land, this can be done by maximising outflow through increased, labour, capital and technology.

- Examples of countries continuing to expand are Indonesia (palm oil production) & Argentina (soy production)
- Intensification can involve the increase in productivity of resources used by agriculture to get a greater yield from the same amount of area
- This can occur through maximising output by adjusting:
    - Labour
    - Fertilisers
    - Pesticides
    - Water
    - Technology
- The land for agriculture to expand is diminishing with the expansion of urban areas into prime agriculture land, we can only turn to intensifying agriculture which has an increased pressure on the environment & natural resources
- Intensification causes soil degradation

Agricultural intensification is likely to remain an important concept during the 21st century due to:

- The challenge of meeting future global food demands
- Farming policies for more sustainable food production and land use systems
- Arable faming in Australia covers about 19 million ha. There is little possibility of expanding Australia's agricultural area due to unsuitable land forms, climate, relatively infertile soils.
- To establish Aus's arable industries it was necessary to clear the land of it's native vegetation, this had a severe impact on natural ecosystems due to:
    *Large quantities of fertiliser
    *Development of highly mechanised capital intensive farming operations

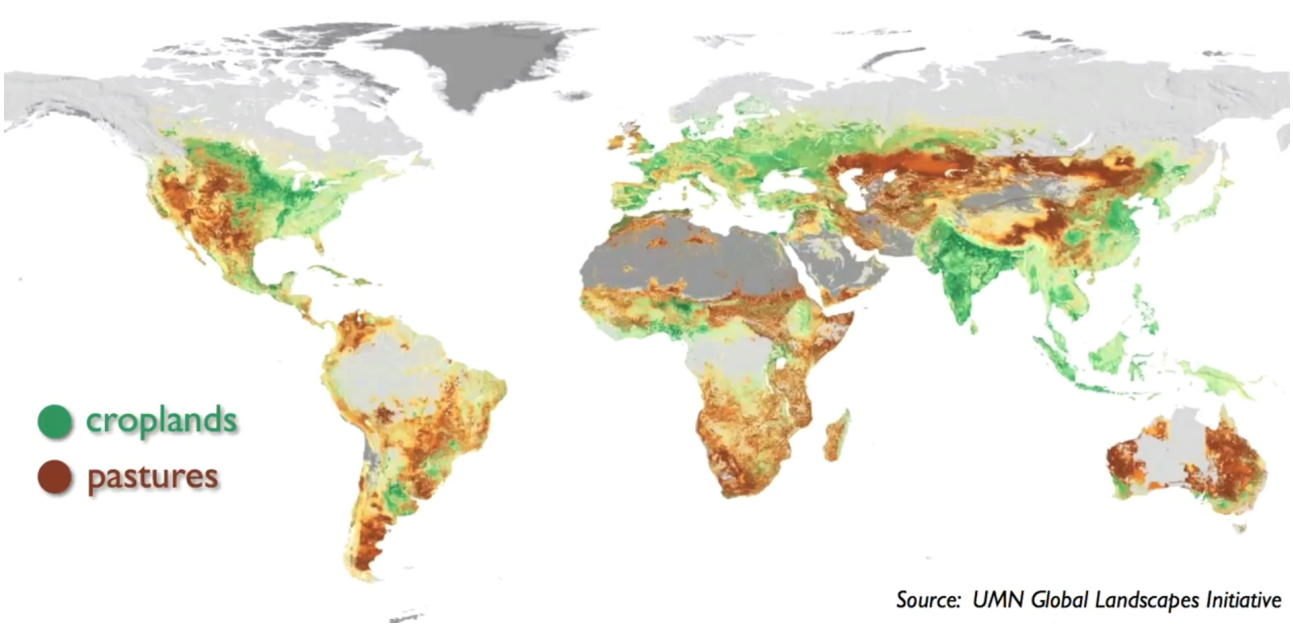
Rangeland Modification:

Rangelands are areas where vegetation such as grasses and shrubs used for grazing animals are found. They are extensive, relatively dry, open grasslands and suitable as permanent pastures for grazing livestock.

•81% of Australia is defined as rangeland

• These ecosystems have been under threat due to expanding agricultural use as well as the introduction to weeds & exotic species

- This impacts the ability for rangelands to provide ecosystem services to the population
- Rangelands should represent permanently renewable resources if managed properly like arable lands, however most rangelands have been poorly managed.
- Significant areas of rangelands have been converted to some of the world's most productive cultivated croplands.
- Clearing of rangelands can often lead to soil erosion and desertification problems
- Rangelands throughout the world are in a serious state of decline, and land degradation due to urban sprawl, land pollution, soil salivation, soil erosion after land clearance, or water clogging through changes in the water table.



Land and Soil Degradation:

Soil degradation is the decline in soil quality caused by it's improper use of agricultural, pastoral, industrial or urban purposes. Soil degradation is a serious global environmental problem and may be exacerbated by climate change. Land degradation is a process in which the value of the biophysical environment is affected by a combination of human-induced processes acting upon the land.

The decline in the quality and health of natural land resources, occurs due to:

- Overgrazing
- Excessive tillage
- Erosion
- Sediment deposition
- Mining
- Urbanisation
- Disposal of industrial wastes
- Road construction
- Decline of plant communities
- Effects of noxious plants & animals
- Soil compaction

Desertification occurs if there is a continual degradation in a dryland ecosystem (caused by unsustainable land-resource use, or changes in climate/ avoided through land management)
E.g. Murray Darling Basin draining through irrigation out of the rivers bringing salt to the surface increasing salinity. On a global scale, soil degradation is caused primarily by overgrazing (35%), agricultural activities (28%), deforestation (30%), overexploitation of land to produce fuelwood (7%) and industrialisation (4%). Soil compaction, low organic matter, loss of soil structure, poor internal drainage and soil acidity problems are other serious soil degradation conditions that that can accelerate the soil erosion process. The results of land degradation from irresponsible arable farming and pastoralism have been serious soil erosion, increased wind erosion which can lead to dust bowl conditions, and water erosion which can extend form rill formation to gully erosion. Serious land degradation has occurred in Australia through trying to bring about pasture improvement; as land was cleared of its scrub and deep rooted trees to plant pasture grasses, the water table which was once kept at depth by the roots of trees and shrubs has risen towards the surface, brining into topsoil and creating another form of desertification. The rising water dissolves the salts into subsoil. Then the water evaporates and leaves the salts behind rendering the land unproductive.

Irrigation:

Irrigation is the artificial application of water to land and/or soil. It is the artificial method of watering plants for agriculture. It involves diverting water from streams, flooding areas (rice paddies) or using pumps & sprinklers from ground water. Irrigation causes about 2 to 3 million ha to go out of production worldwide each year due to salinity problems.

Places that have sparse or seasonal rainfall could not sustain agriculture without irrigation. In areas that have irregular precipitation, irrigation improves crop growth and quality. By allowing farmers to grow crops on a consistent schedule, irrigation also creates more reliable food supplies.

Ancient civilisations in many parts of the world practiced irrigation. In fact, civilisation would probably not be possible without some form of irrigation. The earliest form of irrigation probably involved people carrying buckets of water from wells or rivers to pour on their crops. As better techniques developed, societies in Egypt and China built irrigation canals, dams, dikes, and water storage facilities. Ancient Rome built structures called aqueducts to carry water from snowmelt in the Alps to cities and towns in the valleys below. This water was used for drinking, washing, and irrigation.

Modern irrigation systems use reservoirs, tanks, and wells to supply water for crops. Reservoirs include aquifers, basins that collect snowmelt, lakes, and basins created by dams. Canals or pipelines carry the water from reservoirs to fields. Canals and pipelines, just like the ancient Roman aqueducts, often rely on the force of gravity. Pumps may also move water from reservoirs to fields.

Crops are irrigated by several methods: flooding an entire field, channeling water between rows of plants, spraying water through large sprinklers, or letting water drop onto plants through holes in pipes.

Letting water drop onto plants through holes in pipes, known as drip irrigation, is considered one of the most efficient methods of irrigation. Drip irrigation focuses the water onto the plant itself. Other methods can waste water by letting it absorb into the ground where there are no plants. Water can also evaporate into the air when sprayed through sprinklers.

Land Reclamation:
The process of creating new land from ocean, river beds or lake beds. The land reclaimed is known as reclamation ground or land fill. Land reclamation has a big impact on aquatic ecosystems. The most common method is the filling of an area with large amounts of heavy rock and/or cement, then filling with clay and dirt until the desired height is reached this is known as infilling. Infilling is regularly done in coastal areas. Sometimes rivers and lakes are also filled naturally with sand or dirt, developing some new land in the process.

- The Flevopolder in the Netherlands is the largest artificial island in the world (area of 970km2) & is mainly used for agricultural production
- Tokyo drained the bay & created islands for people to live & is now landfill

Urban Settlement:
Increased inhabitants in metropolitan areas or in the city.
• Urban areas cover 3% of earth's land, they contain 50% of the world's population
• Affects climate due to colouring changing heat budget and water cycle through changes in albedo, heat, water, radiation and vegetation cover as well as wind flow, air quality, temperature & cloud distribution (monitored by spatial technologies)

Growth of Industry and Mining:
Mining companies are expected to prepare environmental impact statements prior to mining and land reclamation to rehabilitate land destroyed by mining. These impact statements are often not adequately addressed in mining ventures worldwide.

- In 2014, Australia's exports of minerals and energy was valued at $195 billion and is an essential element to the Australian economy.
- The Kalgoorlie Super Pit is the largest open cut gold mine in Australia, but it changed the land cover of the area & greatly impacted the local environment

- Australia regulates their mining processes, but for example Venezuela has illegal gold mining occurring, which threatens the river systems due to erosion and mercury (used to separate gold) is washed downstream
- Lack of rehabilitation of land when finished
- Alcoa is a world leader in mine site rehabilitation

Impacts of Urbanisation on Local Environments:

Urbanisation impacts local environments through the clearing of land for urban areas, which can cause soil erosion and degradation. There is a peak in the amount of soil and sediment erosion after the construction phase of urbanisation. Sediment can either be blown or washed away with rain and movement (i.e wind). Soil can also be scraped off and lost inducing desertification. Once sensitive soil is disturbed, they may lower strengths when they are altered (soil compaction). This loss of strength increases the potential for landslides. This is especially true in areas of high densities of people and supporting structures such as roads, homes, and buildings. Urbanisation disturbs soil and sediment which leads to erosion. The lack of trees and vegetation in urban areas also decreases carbon dioxide uptake. In the past 260 years, carbon dioxide has increased in the atmosphere from 280ppm to 398ppm. This causes the GHG effect to be enhanced. Temperatures can also increase due to the change in albedo. For example, more roads (black) increases absorption of solar radiation. In Perth, suburbs are 6 degrees hotter than surrounding areas. The increase in temperature and carbon dioxide levels can also change aquatic and marine environments. For example, ocean acidification can occur making it difficult for shellfish to survive because their shells can fall apart. Cleared vegetation on the side of rivers can additionally allow fertilisers to enter the water causing algal bloom subsequently causing fish to suffocate (eutrophication) .

Impacts of Deforestation on Local Environments:

Deforestation is the removal or clearing of forests generally for uses such as agriculture and urban development through fires, clear-cutting for agriculture, logging for timber. Approximately 7 million ha's of forests are removed every year, with the highest rates being in Brazil with 17% of the Amazon rainforest already deforested in the last 50 years for cattle grazing & mining. This impacts the local environment as it reduces habitats for the native animals in that area. Deforestation also affects nearby rivers, streams, and other water sources as nutrients from the soil are removed through leaching, which happens when water (e.g., from rain) removes soluble nutrients from the soil and carries them elsewhere. Water sources in deforested areas were shown to have higher nitrate levels, lower dissolved oxygen levels, and higher temperatures (from 20-23 degrees Celsius) than in forested areas. Water temperatures increase because the trees that provide cover from sunlight are cut down. These factors disrupt a river ecosystem because the species that live in the stream have adapted to conditions before the deforestation and may be negatively impacted by the sudden changes. Deforestation affects not only forests and immediate surroundings but also the atmosphere, which in turn spreads across the biosphere all the planet's ecosystems and everything in them. According to a 2010 study, 17% of all GHG emissions come from deforestation, from both burning trees and the resulting loss of photosynthesis, which removes carbon dioxide (a GHG) from the atmosphere. As trees are cut down and burnt, the carbon they contain is released into the atmosphere. Although the increased levels of carbon dioxide may stimulate forest growth, more data is needed to measure the long-term impact. The soil that provides nutrients for vegetation in ecosystems is also affected by deforestation. Soil in deforested areas is exposed to more sunlight, which increases the soil temperature and oxidises the carbon in the soil to carbon dioxide. Some of the carbon dioxide released into the atmosphere comes from dead vegetation that decomposes in the ground. In heavily deforested areas, soil erosion and nutrient runoff are common after a rainfall. Soil erosion tends to be greater in drier, more mountainous areas, where there is less vegetation to prevent the movement of soil and to absorb the nutrients.

- **The differences in the process of land cover change between countries due to factors such as government policy, institutional arrangements, land ownership, type of economy, ideology and culture**

How Do Countries Act/Behave Differently in Regards to Land Cover Change:

Government Policy:

- Developed countries vs. developing countries have different rules/laws.
- Funding requirements and availability differ between various countries.
- Not recognising indigenous lands which results in unsustainable land cover change.

Institutional Arrangement:

- Government departments, private companies, religious groups, DFES, environmental groups, "friends of" groups, non-for-profit groups and volunteers. Depends all on funding + structure.

Land Ownership:

- Rights for indigenous owners – some countries ignore and some respect.
- Government-owned land vs. private ownership.
- Restrictions on what you can do on the land differ.

Type of Economy:

- More money should make you more sustainable but also gives you the ability to want/create more that may have negative impacts.
- Imports and exports are influenced.
- Type of economy (eg: farming or mining).

Ideology and Culture:

Indigenous rights, religious beliefs, political beliefs, change of parties, scientific understanding, what the community believes, education and awareness.

Difference in Land Cover Change Due to Government Policy in El Salvador and Papua New Guinea:

Government policy in El Salvador has seen the prohibiting of all mining for gold and other metals within the country since March 2017. El Salvador is the second most environmentally degraded country in the Americas and mining has been responsible for significant amounts of land cover change and environmental damage. There has been governmental consideration of the diminishing amount of clean water available in the country and after evaluation of the costs and benefits of metallic mining it was legislated to officially become the first country o the world to impose a nationwide ban on metal mining.

Government policy in Papua New Guinea is completely different with mineral extraction dominating their national economy. Most of their mining has been associated with gold, although large mines have been with copper, silver, nickel and cobalt. The OK Tedi Mine of PNG is majority owned by the PNG Sustainable Development Program Limited that was controversially nationalised by the PNG government in 2013. This open-cut mine has had a history of causing widespread environmental harm through loss of vegetation, discharge of contaminated tailings, increased flooding events and poisoning of ecosystems.

Nevertheless the PNG government continues to encourage mining and it's subsequent land cover change, due to it's importance within their economy. In contrast the Salvadoran government has minimised future land cover change through identifying that their fragile environment could not support any further metal mining and imposed a nationwide ban.

Australia	China
• Two cities containing over 4 million people • 24 million • 6th largest country • 88.9% of Australia's population in urbanised	• 1.4 billion (19.24% of the world's population) • In China, in 1985 there were 324 cities which has jumped to 662 in 2016 • 25% of the world's 500 largest urban areas are in China. Approximately 57% of China's population lives in urban areas.
• 12th largest economy • USD$67,458.36 GDP • Relies on agriculture and mining exports for income	• 2nd largest economy • Falls below other countries for GDP per capita (USD$6,807 in 2013), ranked 85th • Chinese property boom has increased individual wealth
• Land can be privately bought, sold, owned in Australia but is recorded by the government authorities • 1999 – Environment Protection and biodiversity Conservation Act protects native areas • Legislative restriction restricting land use change (Aboriginal and Torres Strait Islander Heritage Protection Act) • Freehold title = rights over land for all time (must comply with environment regulations) • Leasehold title = lease land from government for an agreed number of years (must comply with environmental regulations) • Traditional Land Rights = restricted process and LCC allowed requiring agreements from Indigenous Australians • Protected areas = nature conservation e.g. Shark Bay World Heritage Area due to unique biodiversity • Government policies have increasing influence on rate and location of LCC	• Owned and controlled by government • 1978 – reform and shift of ideology resulting in private housing ownership being recognised as a personal commodity • Increased personal wealth • Properties owned by individuals, land owned by government • Bribery and corruption is common in rural areas where farmland is owned by farming collectives with a communist party appointed to make decisions • Less control on rapid LCC because the government supports the need to expand economically & in terms of population • 2015- new laws to protect natural areas & prevent pollution through prosecution
• Mixed market economy • Mix of capitalism (personal economic freedom including private ownership of land and enterprises) and socialism (government can operate institutions which provide goods and services)	• Largely state owned due to communist ideology • Largely manufacturer • 2nd largest importer • Largest exporter of goods • Open market economy • Socialist market economy
• Local, state, federal government • Democratically elected • Varying responsibilities regarding LCC	• Centralised, single party; Communist party • Communist government has control over the economy and people for the 'good of the people' • Appoints members of the National People's Congress, the president, the premier, the governors of china's provinces and local mayors
• Capitalism • Vocalised opinions of stakeholders • Save the Beeliar Wetlands (local) • Authorities govern comment on LCC through legislation • Rehabilitation areas – degradation from mining • Department of Environment & Conservation Volunteers Australia (state) • Environmental impact studies are conducted & must be handed to correct level of government to study risks • Greenpeace, World Wildlife Fund (national) • Values natural environment & outdoor lifestyle	• Socialism • Mixed opinions • Cultural beliefs & wealth • Environment is sacrificed for economy • Human beings as greater than natural being • 500, 000 die per year from pollution-related illnesses • Outside pressure & awareness-raising worldwide organisations (Greenpeace, WWF) attitudes are changing • Younger generations protest • 2001-2005, the Chinese environmental authorities received more than 2.53 million letters, 430, 000 visits, 597, 000 petitioners seeking changes • Now they are leading the way

Difference in Processes of LCC Between Australia and China:

In the last 40 years, China has developed from a predominantly village country to rapidly urbanised (mainly in the east of the country around Shanghai). Australia has a population of 24.5 million, whilst more than this number live in Shanghai alone. Australia has been slowly urbanising for hundreds of years. Process of LCC have also been affected by ideology and cultural views. In Australia, we value the environment for a strong economy while China believes the environment can be sacrificed for economic gains. China reflects this as their increased population demands more power, which has seen a 74% increase in coal consumption since 2004. Whereas Australia hundreds of organisations such as Greenpeace, World Wildlife Fund and Planet Ark in addition to government departments like the department of Environment and Conservation Volunteers Australia which all have a huge influence on the rate and scale of LCC in Australia.

An Australian stakeholder and Their View in Response to a Strategy That Aims to Minimise the Effects of Climate Change:

Australia's federal government's Department of Climate Change and Energy Efficiency is a stakeholder who has a vested interest on strategies that aim to minimise the effects of climate change. They argue that the Australian government is committed to action so that they will protect the environment, sustain our society while helping to support the economy. This viewpoint led to the passing of a federal bill whereby the largest polluters now pay a $23 tax per tonne of carbon they release. This fee is scheduled to rise by 2.5% per year. The federal government's Department of Climate Change and Energy Efficiency agree that even though Australia produces only about 1.5% of global emission it still needs to be a global effort if anything is to done on tackling climate change

The Water Corporation is a stakeholder that has put plans in place to deliver sustainable water and wastewater services to Perth and its environment for the next 50 years in light of declining rainfall. It aims to reduce water use per person by 22 kilo litres per year by 2030. The 'Water Forever: Towards Climate Resilience' is an important document that addresses the key issues of sustainability. It aims to increase wastewater recycling to 605 by 2060, develop up to 100 gigalitres of water from new sources as well as increase the usage of desalination plants. The Water Corporation has also introduced various strategies to reduce water consumption. These include sprinkler rosters, encouraging the purchase of water efficient household appliances, promoting the choice of low water use lawns, water wise plants and encouraging the application of mulches to gardens, four minute showers, water efficient water heads, catching grey water to water garden.

- **Projecting changes in land cover using existing spatial models, incorporating both environmental and socioeconomic variables**

Urban Land Cover:
Although global urban land cover varies from 1% to 3%, this relatively small area requires a great amount of land to be transformed to support this area. This is what has the greatest effect on the global environmental change. As the global population grows, it is projected that urban land cover could triple by 2030 with the majority of expansion occurring in India and China. For example, Shenzhen in China which has grown from 3,148 (1950) to a projected 12 million (2025).

Agricultural Land Cover:
Agriculture involves the growing of crops and raising of livestock. 38% of the world's land is for agricultural, and 54% of Australia's land is used for this purpose. It is estimated by 2050 the global percentage is expected to reach 56%, predominantly from clearing one third of the world's remaining forests, savannahs and grasslands in predominantly North-East Africa and South-East Asia. For example, in Indonesia have increased from 2.024 million hectares in 1995 to 8.99 million hectares by 2050, which is expected to increase up to 20 million hectares (2050).

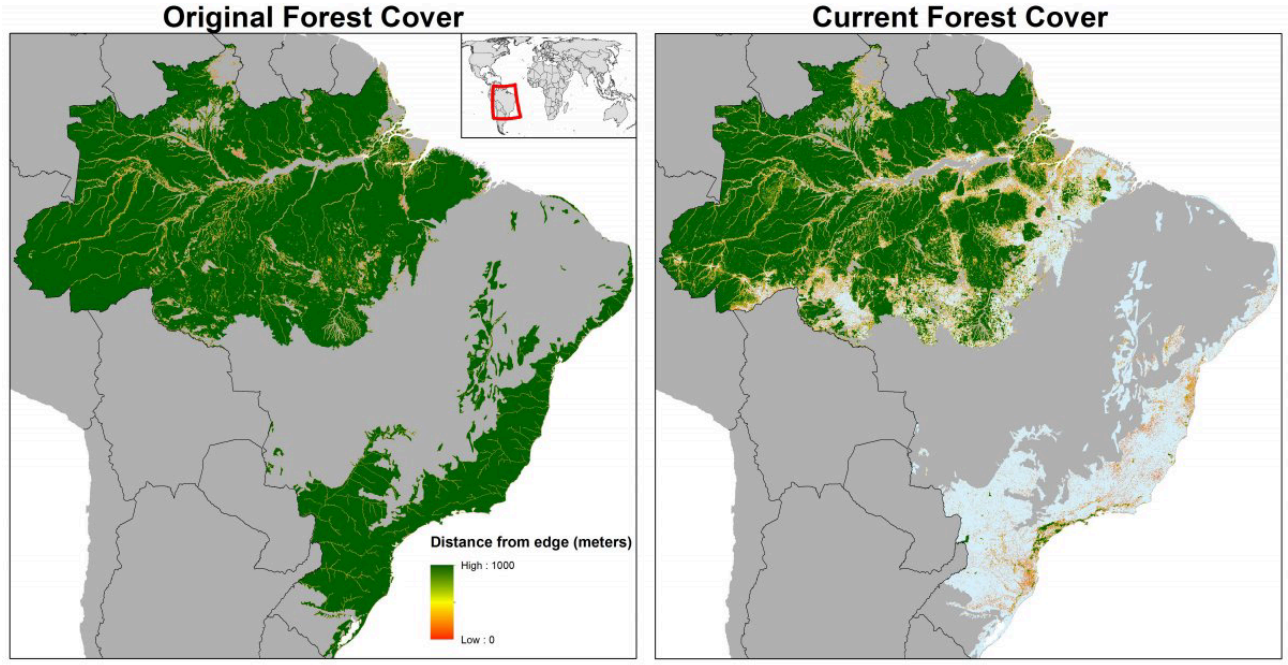
Global Forests:
Forests cover approximately 30% of the Earth's surface. Global forests are continually being deforested at rapid rate with an. Over half the world's tropical rainforests have already been clear and rainforests are decreasing at and estimated size of 20 football ovals per minute. While the Amazon has lost 17% of rainforest cover in the last 50 years. It is projected that this current rate of LCC will decrease the size of the Amazon by almost 50% by 2030 and by 2060 no forest is expected to remain.

Spatial Modelling:
LCC has great environmental effects on systems and processes. Spatial modelling is a methodology or set of analytical procedures used to derive information about present and future spatial relationships between geographic phenomena. Future predictions based on trends in LCC are essential to understand the potential impacts on ecological processes and subsequently human activities. Once these potential impacts are identified, mitigation and adaption strategies can be developed and implemented. Spatial modelling uses both environmental and socioeconomic variables. Environmental variables take into account the natural ecological processes occurring within biomes at the local scale, together with the wider earth systems and cycles such as the carbon cycle, heat budget, hydrological cycle and climate systems at the global scale. Socioeconomic variables take into account factors such as population growth and density, methods of energy production and demand plus economic activity and growth at the local scale and the influences of globalisation and economic interdependence at the global scale. A variety of methodologies in order to make sustainable planning for LCC. For example, scenario-based projections which take into account many processes and factors driving LCC to produce a number of outcomes or scenarios based on the variables considered. These predicted scenarios may then be assigned a value, indicating the likelihood or certainty of each occurring over time, referred to as a quantitative. Remote sensing and Geographical Information Systems use snapshots of past and present land uses plus vegetation cover age and change can be combined with other environmental and socioeconomic factors.

Land use and land cover change is still projected to intensify in rate and extent in the future, although many variables cause land cover change practices to fluctuate depending on location. These include:

- Countries and people becoming more economically developed
- The shift in economy from manufacturing to service-based
- A more sustainably aware society through renewable energy use
- The ongoing effects from natural and anthropogenic climate change

We can use remote sensing data to visualise current trends as well as ascertain future trends of land cover change (e.g. reduction in the Amazonian rainforest).



- **Indigenous peoples' land management practices and their impact on land cover over time, including those of Aboriginal and Torres Strait Islander Peoples.**

Indigenous people were the first instigators of the concept of sustainability. They lived semi-nomadic lives as hunters and gatherers of different forms of food. They possess great knowledge of the structure and dynamics of the land, as well as knowledge on seasons and sustainable land management practices. Examples of their sustainable practices include:

- Fire-stick farming to create a diverse array of fauna species and encourage new growth
- Hunting and gathering for as much as they needed and not being consumed by greed

Caring For Country:

Caring for Country directly relates to Indigenous Australians and can be defined as having the cultural awareness, the feeling of obligation and the right that has been inherited from generation to generation to manage traditional lands. Aboriginal Australians are the oldest surviving culture in the world. Certain practices date back to up to 80, 000 years ago. They lived, and some Aboriginals continue to live, as hunter-gatherers with a strong relationship and dependence on the land, sea and agriculture for survival, without destroying it. Therefore, current Aboriginal Australians have grown up with their attitudes and beliefs already based on caring for the sustainability of the land, sea and the environment.

Caring for Country is predominantly a regional scale program due to the inability to live on the land sustainably in a built up urban area such as Perth. A regional scale example of a Caring for Country program is the Ngaanyatjarra Lands. 98,000 out of a total 250,000 square kilometres are considered Indigenous Protected Area (IPA). Traditional land management practices have directly resulted in biological diversity is at an extremely high level on the land. The Ngaanyatjarra Lands Indigenous Protected Area emphasises the relationship that indigenous communities have with their land, as well as the aim to strengthen and maintain the practice of traditions of traditional land owners. 4 teams of Aboriginal rangers, employed by the Ngaanyatjarra Aboriginal Council Corporation, use strategies within the Caring for Country program to meet the challenges associated with sustainably living off of the land and the environment. Caring for Country is the environmental, natural resource and cultural heritage management activities brought about by Aboriginal and Torres Strait Islander communities and organisations. The motivation for these groups to care for the land comes from the responsibility passed on from the current generation's ancestors.

'Caring for Country' is where the indigenous practice sustainable land and water management to protect the environment. They do this because they have a spiritual, social and cultural relationship with the land and sea. Aboriginals set fire to already lived on land, allow it to burn and then regenerate for three years, they then return. This 'mosaic' or 'patchwork' pattern allows ecosystems to regenerate flora and fauna which in turn attracts animals for hunting. Indigenous people also map and track their water sources and change them often so that they do not overuse or runout of water. They live sustainably to decrease their impact on the environment.

Firestick Farming:

Firestick farming is a land management practise followed by indigenous people that has significantly impacted land cover change over time. The indigenous people would use firestick farming to clear land they needed to encourage fresh vegetation growth. However some parts of the forest were burnt so regularly that they grew into open woodlands and grasslands. The indigenous people encouraged the growth of woodlands and grasslands as it bought more flora and fauna tot he area which led to a greater food supply and an increase in the burning of forests, thus resulting in land cover change.

- **The impacts of land cover change on local and regional environments, including changes to the water cycle, soil erosion and degradation, loss of habitat and biodiversity, the degradation of aquatic and marine environments, loss of ecosystem services, changes to regional climates, and urban heat islands.**

Ecosystem Services :

The benefits people obtain from ecosystems; water and food, flood and disease control, cultural services like spiritual, recreational and cultural benefits, supporting services like nutrient cycling that maintains the conditions for life on earth.

• Loss of invasion resistance meaning non-native species can invade native areas and reduce the biodiversity of the area

• Lack of pollination in plants as bees are driven away

• A lack of marine diversity may impact on photosynthesis levels and thus carbon and nitrogen cycles

Particularly catastrophic for biodiversity hotspots such as the Busselton-Augusta region, where pollination is required for many fruits and vegetables. Marine ecosystem services, humans are depleting the fish stock through industrial waste and thus fish won't be able to be a part of our main diet.

Water Cycle:

Damming:

Increases amount of evaporation and infiltration in area by increasing the amount of water susceptible to erosion and the volume of water in contact with the lithosphere.

Land Cover Change:

Changes the surface and vegetation of the watershed area will likely increase the run-off and decrease infiltration which in turn increases soil erosion of cleared areas and sediment deposition in dams and natural waterways.

Irrigation:

Can completely deplete rivers & water tables as well as potentially increase the nutrient run-off from agricultural areas due to the use of fertilisers. Causes eutrophication of waterways where plant species & algae bloom at increased rates depriving the water & other marine organisms of oxygen.

Deforestation:

Reduces evapotranspiration by plants which can lead to rises in water tables as plants no longer use the water. This leads to decrease in rainfall by as much as 50%.

Air Borne Pollutants:

Cause change in nature of precipitation. E.g. acid rain caused by high levels of sulphuric acid occurs in china.

Overuse of Ground Water:

For drinking, irrigation, industrial use significantly lowers water table.

Soil Erosion and Degradation:

Soil is the part of the ecosystem that supports biodiversity. Increased demand for agricultural products such as palm oil, coffee and cotton there is also an increased demand for LCC.

• Grasslands and forests become croplands

This causes soil erosion, compaction, loss of soil structure, nutrient degradation and soil salinity. This results in an overall less fertile and an increased level of soil acidity due to continual application of fertilisers. This further results in clogged waterways from sediment, while soil becomes more prone to flooding because they have lost their water retention qualities. E.g. Darling Downs in Queensland has soil erosion that is threatening the productivity of agricultural land, resulting from poor farming techniques in the 1850's when farmers didn't understand the impacts. On the 3 million hectares that Queensland has crops on, 80% is vulnerable to soil erosion, This results in soil loss & loss of crop.

Loss of Habitat and Biodiversity:

Refers mainly to deforestation and degradation of forests at local and regional levels. This occurs due to the expansion of agricultural land, increased demand for timber and other forest products, as well as overgrazing. Loss of habitat is intrinsically linked to loss of biodiversity. In the past 500 years, human activity has decimated 869 species and placed large numbers on the brink of extinction.

• 1 in 8 birds
• 1 in 4 mammals
• 1 in 5 invertebrates
• 1 in 3 amphibians
• 1 in 2 turtles

Tropical rainforests are most at risk of exploitation e.g. Amazon and Indonesian rainforests. These contain over 50% of the world's biodiversity. Local examples include Yanchep Mallee Forest South West Ecoregion (includes Busselton-Augusta ecosystem).

Busselton-Augusta Ecosystem:

• A biodiversity hotspot
• High in number, type and variety of living organisms
• Contains endemic species (found nowhere else)
• The area is made up of heathlands and shrub-lands along the coastal plain which supports hundreds of plants species per square km
• Half of WA's native forests have been cleared for agriculture, urban areas (roads, power lines) & dams
• Of the remaining half, 40% is continually subjected to logging and clearing which impacts habitat loss & therefore loss of biodiversity
• Overgrazing pressure, fire regimes creates further effects
• Loss of habitat creates endangered and threatened species e.g. Baudin's Black Cockatoo
• Changes in groundwater movement from the use of groundwater in urban & agricultural activities could potentially threaten cave communities
• Non-native weeds, feral rabbits further disrupt ecosystems
• Phytophthora Dieback is a deadly disease caused by microscopic soil-borne pathogens that feed on the roots of plants causing root-rot in susceptible species
• Plant death occurs when they can't take up nutrients and water for survival
• 40% of plants are susceptible in WA

• Spread through human interaction e.g. LCC, road construction, earth moving of earth that is already infected, driving infested vehicles, walks with shoes infested. Spreads 1m naturally every year
• 20% of Jarrah forest is infected by dieback.

Degradation of Aquatic and Marine Environments:

• People living near water sources have impacted the quality and flow of water
• The quality of water-shed areas and runoff into oceans has impacted the flora and fauna of aquatic and marine environments
• Pollution; chemicals and effluent causes damage habitats and therefore animals
• Eutrophication can occur when excess nutrients e.g. fertilisers enter water courses and cause algal bloom which reduces oxygen in water causing fish and other animals to die e.g. Swan River eutrophication occurred and caused algal bloom in the Cockburn Sound area in December 2015 which resulted in over 2000 fish deaths due to a lack of oxygen in the water
- Fertiliser runoff; caused coral bleaching and algal blooms in the Great Barrier Reef in Queensland.
- A marine dead zone has been created at the mouth of the Mississippi river from run off of pesticides.

• Ocean acidification; can occur as a result of dramatic rises in CO2 levels in the atmosphere from LCC
• When the ocean absorbs this, pH levels decrease and the water becomes more acidic which in turn affects marine biology
• Since 1751, ocean acidification has lowered pH by 0.11 units from 8.179 to 8.069 in 2009 (30% increase in acidity)
• Corals, clams, mussels, shelled marine species have greater difficulty building calcium-based shells due to increased acidity
• Acidosis causes fish cells to try to balance oceans pH by changing the pH of the fish's blood which alters chemical reactions that occur in its body which are essential for survival. This causes an overdrive in attempt to get back the normal pH levels which impacts digestion, swimming, reproduction and growth (Great barrier reef)

E.g. Damming changes water temperature and level of nutrients which can have extensive effects such as sediment, nutrients from the Congo River can provide a carbon sink for atmospheric gases in the Atlantic Ocean. They replace fast moving water with slow moving water so that mosquito borne disease can proliferate and in China three dam object requires people to resettle, further requiring LCC.

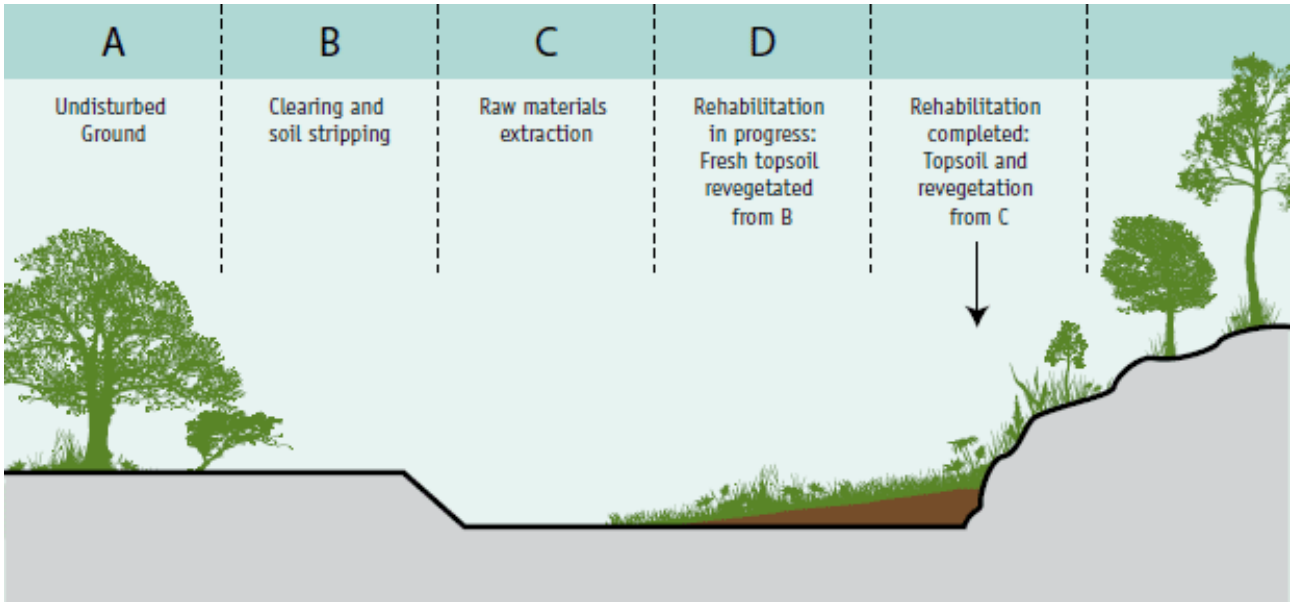
Regional Climates and Urban Heat Islands:

Urban heat island effect – the warming of temperatures in an urban area due to man-made environment
• Caused by removal of natural surfaces which absorb and use a greater level of heat
• Built environments use materials that are non-reflective and water resistant therefore radiate more heat
• Deaths from heat will double by 2050 due to climate change and urban heat island effect.
• Perth suburbs can be 6 degrees hotter than surrounding areas
• Suburbs have been cleared of natural vegetation and have little space for trees which help to reduce heat

Depth Study One: Alcoa LCC

- **approaches to land cover restoration and rehabilitation, and the mitigation of future land cover changes, including preservation strategies.**
- **the current and proposed strategies, at local to global levels, implemented to mitigate the adverse effects of either global climate change or loss of biodiversity**
- **how human activity has adapted, or may be required to adapt, to either global climate change or loss of biodiversity**
- **a program designed to address the impacts of land cover change on local and regional environments**
- **an evaluation of the program, giving consideration to environmental, economic and social benefit and costs**
- **an evaluation of at least one alternative approach to the management of land cover change in the area being studied, using the concept of sustainability to determine the extent to which the approach has the potential to address the issue into the future**

Mine Site Restoration and Rehabilitation: When mining companies move into an area to explore and extract mineral resources, land cover is removed. The extent of land cover transformation depends on the minion techniques used. Open cut mining removes topsoil and rock layers or overburden from above the deposit. This causes large areas to be stripped of vegetation. Mine site restoration and rehabilitation projects should involve restoring land cover to it's original productivity.



Social/Environmental/Economic Costs and Benefits of Alcoa Mining:

Mining companies are a significant part of the economy in Western Australia, making up almost half of WA's exports. A key contributor to this is Alcoa which operates in several locations including Huntly, Kwinana and Willowdale in the South West of WA. Mining brings many environmental, economic and social costs and benefits.

Alcoa is a recognised world leader in mine site rehabilitation and restoration and was the first mining company to achieve 100% plant richness 2001, plus other achievements including 60-70% species return in the rehabilitated mine site areas. Each year 600 hectares of mined land is rehabilitated helping restore mediterranean forests, woodlands and scrub in the Darling Scarp. This has greatly benefitted the local environment as threatened and endangered species including the Baudin's black cockatoo are able to return to rehabilitated area within the mining lease area. Mining is also causing the removal of established and mature ecosystems and despite being restored through rehabilitation the natural ecosystem has been fragmented and can take hundreds of years to be fully restored. An example of this includes native grass trees that take up to two hundred years to grow to maturity.

Alcoa has provided a significant economic benefit to Western Australia. In 2016, the mine injected approximately AU$78 million into the local community through salaries, wages and benefits, and more than AU$110 million in local WA supply contracts. Alcoa has over 200 individual contractors on the Huntly site alone in the Myara mining region. As well as having high employment rates Alcoa also sells any Jarrah waste wood from cleared forests to surrounding towns and areas, this helps prevent unnecessary land clearing. Alcoa had a significant economic input in 2015, paying $715.5m in wages and benefits to Alcoa's employees. However the opportunity cost of mining is significant, with almost $9.5 billion of state funds going into mining subsidies every year, opposed to other services such as education, healthcare and environmental protection groups. This sum of money would fund forty new schools, three major hospitals, ninety fire and rescue vehicles and pay for salaries of two thousand nurses, doctors and teachers for six years. The allocation of government funding is not sustainable as the government should allocate their funds into more sustainable practises such as education.

The Alcoa foundation allocates approximately 50% of their annual grant making budget to Alcoa's operating locations around the world to be used for local initiatives in the areas of education, environment, governance and community enhancement. This greatly benefits surrounding local communities as it allows them the opportunity to grow and expand their economy as well as implement environmental plans to maintain sustainable environmental practises. to not damage the local environment. WA Mining operations are transient and as a result can be located near to residential areas, a cost of mining in WA is the noise pollution that constantly impacts the local community. Noise is continuously monitored to assess potential impacts on neighbours. Ongoing assessment is required to confirm the operations remain within the Environmental Protection (Noise) Regulations 1997. Primary sources of noise pollution within Alcoa mines include; blasting of the hard cap rock ore layer, mobile equipment such as dozers, scrapers and trucks and conveyer belts, transfer stations and crushers. These all contribute to the growing issue of noise pollution within residential areas as a result of Alcoa's mining activity. Alcoa attempts to manage this problem by only conducting mining activity during the day and not on weekends or public holidays.

In regards to the subsequent land cover change due to Alcoa mining, there has been a loss of natural habitats as the original vegetation has been altered significantly. This has had negative impacts of the biodiversity of the local ecosystems which are now fragmented, as despite rehabilitation efforts the flora and fauna will take hundreds of years to be fully restored.

All photos listed below are from 2018 LSHS Year 12 ATAR Geography Alcoa Huntly Excursion.

This is a hauling mining truck used on the Huntly mine site to transport bauxite between locations. These trucks are usually built at a height higher then 3 metres and are approximately 3 and half metres in width. They are around 10 metres long. The roads built around the Huntly mine site are around 7 metres in width allowing for a truck to be on either side of the ride at all times. There target gross machine operating weight is 623690.0kg

All visitors on the mine set are required to stay in enclosed vehicles unless given permission to do so. If given permission to exit the bus, all visitors are required to wear hard hats, fluorescent vests and safety glasses.

Visitors must also wear long sleeved clothing and enclosed shoes. This is all to keep visitors safe.

Alcoa's Huntly mine is well known for giving tours, giving 5588 visitors in 2015 a chance to tour the Huntly mine site. The tours around the site are given by bus to keep visitors safe and prevent injury, this is done by having a smaller vehicle lead the bus around the site, this smaller vehicle is equipped with a siren and flashing to light to alert workers on site of their presence and to drivers in a higher level machinery able to see them clearer.

If any busses are going to enter non dieback areas after being in dieback areas, the bus has to complete washed down as well as any visitors present on the bus. This is to prevent non dieback areas from being infected by dieback.

Alcoa employs specific dust controls to minimise dust generation. These include:

- Road management through application of emulsified waste oil as a dust suppressant and restricting access
- The use of sprinklers and water carts
- Spraying exposed banks with bitumen
- Applying wood mulch

Rehabilitation and Restoration Strategies Used by Alcoa to Minimise the Impact of Land Lover Change Compared with Other Mining Companies:

Alcoa is a recognised world leader in mine site rehabilitation and restoration and was the first mining company to achieve 100% plant richness 2001, plus other achievements including 60-70% species return in the rehabilitated mine site areas. Each year 600 hectares of mined land is rehabilitated helping restore mediterranean forests, woodlands and scrub in the Darling Scarp. Rehabilitation refers to repairing the services that ecosystems provide, thus repairing its overall level of productivity. Restoration is the process and act of restoring land cover within ecosystems back to it's original state following disruption or degradation to the area from either anthropogenic or natural interactions. The long term objective of Alcoa's mine rehabilitation is to establish a self-sustaining Jarrah Forest ecosystem, planned to enhance or maintain conservation, timber, water, recreation and other forest values.

Alcoa has implemented multiple rehabilitation and restoration strategies to combat the negative impact of commercial mining on land cover change. These strategies including recalcitrant planting and ongoing monitoring and management. Recalcitrant planting occurs in recently mined areas and is the planting of native floral species that rep sprout such as grasses and sedges, these species account for 20% of the returned vegetation. Ongoing monitoring and management of rehabilitated areas takes place to ensure the return of native flora and fauna into rehabilitated areas. In March each year when the rehabilitated land is nine months old, the previous years rehabilitation is monitored to check that the number of established plants meets targets agreed by Department of Parks and Wildlife (DPAW) and Alcoa, and to identify any areas which need further treatment.

Relinquishment of mined areas to the State is the aim of Alcoa's rehabilitation. Alcoa's regulatory body the Mining and Management Program Liaison Group in consultation with the community and other stakeholders have developed a set of competition criteria for rehabilitated areas within Alcoa's mining lease. Due to Alcoa's improvement in rehabilitation techniques two sets of competition criteria exist. This criteria was developed to allow government agencies to assess wether Alcoa's rehabilitation is at satisfactory standard level so that Alcoa can hand the land back to DPAW for future management.

The Premier Coal Mine in Collie WA, is an open cut mine located in Western Australia along the Darling Scarp. They first began mining operations in 1950, becoming one of the three mining companies on the Collie coal fields. The primary aim of Premier Coal's rehabilitation programme is to establish stable and compatible landforms revegetated with local, native species. This will allow the original flora and fauna communities to re-establish. Revegetation first commenced in 1975 at the Premier Coal Mine in Collie and by 2004, 1702ha had been rehabilitated. This is up to 47% of previously mined land that has been successfully rehabilitated. At present, the Premier Coal Mines rehabilitation program varies between 30ha and 200ha of land being rehabilitated annually. Their plan is to rehabilitate at least as much as the annual clearing requirement.

As a result of long term historical mining practises in Kalgoorlie, land within the mining lease had become extremely degraded and was a significant source of wind generated dust. Shortly after Kalgoorlie Consolidated Gold Mines (KCGM) was formed plans were put into place to create a green belt or buffer zone between mining operations and the city of Kalgoorlie Boulder, to separate the two and rehabilitate the degraded land within the mining lease. KCGM is the management company of Kalgoorlie's mining Operations. During KGCM's Golden Mile project that commenced in 1991, 210,000 trees were planted and 730 hectares of degraded was rehabilitated within the mine site. KGCM's Operations include the Fimiston mine which is the biggest open pit gold mine in

Australia. Mining at the Fimiston mine site is due to finish around 2021. Upon completion, the Fimiston Open Pit will measure at approximately 3.5 km in length, 1.5 km in width and up to 700 metres in depth.

All three of the mine sites referenced follow the policies of the Western Australia Mining Act (1978) and the Environmental Protection Act (1986). These policies are governed by DPAW. However when compared, Alcoa's rehabilitation success rates are significantly higher then both the Premier Coal Mine and KCGM, with Alcoa Huntly mine site being the only mining company to achieve their goal of 100% species return and plant richness in 2001 in rehabilitated land. This suggests that Alcoa has implemented more effective rehabilitation and restoration strategies when compared with KGCM and the Premier Coal Mine in Collie WA. Alcoa has a guaranteed 60-70% species return for rehabilitated land and rehabilitates 600 ha annually while the Premier Coal Mine only rehabilitates between 30ha and 200ha annually. This shows a significant difference between the rehabilitation and restoration processes between these two mining companies. KGCM has only recorded 730ha of rehabilitated land within their mining lease. All three mining companies have implemented rehabilitation and restoration strategies to minimise the impact of land cover change on local environments and ecosystems, however Alcoa has proven to be the most efficient and successful in their rehabilitation and restoration strategies.

World's best mined land rehabilitation to return a self-sustaining jarrah forest ecosystem to enhance or maintain water, timber, recreation and conservation values.

Fimiston Open Pit in Kalgoorlie, also known as the Kalgoorlie super pit.

Flow chart of the R+R strategies used by Alcoa to minimise LCC

Landscaping
This is where the open pit mine site is flattened and smoothed to blend the mined area into surrounding landscape. Large logs and boulders that were removed and stored from mine site are returned to the area to create fauna habitats. Drainage is also created in the reshaped area to allow for natural water flow.

Pre-Ripping
Soil on the floor of the mine that was compacted during the mining of bauxite is broken up to ensure roots of plants will able to penetrate the soil profile. Alcoa pre-rips all pits to a minimum depth of 1.2 metres

Soil Return
The overburden (gravelly soil material that lies 20-80cm below the ground) and topsoil layer (nutrient rich layer that lies 0-15cm in the ground) that was stockpiled when the mine was created is returned using large scrapers to spread the soil to it's original depth.

Final Contour Ripping and Seeding
The top soil of overburden is ripped to a minimum depth of 0.8 metre to increase the soils water storage capacity. Mounds are also created to minimise soil erosion. Native mixed-seeds from the Jarrah forest, containing 50-80 flora species are immediately applied to the soil. The type of flora reintroduced to the area is the same as the original vegetation planted there prior to mining.

Fertilising
A single application of fertiliser is applied in August by helicopter to promote growth of the new seedlings. The fertiliser contains nitrogen, phosphorus, potassium and micronutrients.

Recalcitrant Planting
The planting of flora species that re-sprout instead of growing from seed, including grasses and sedges. These species account for 20% of the returned vegetation

Ongoing Monitoring and Management
In March, 9 months after rehab has occurred, the are is checked to assess the success of the rehab and to identify areas where re-work is required.

Effectiveness of the Rehabilitation and Restoration Strategies Implemented by Alcoa to Mitigate the Adverse Effects of Land Cover Change:

Rehabilitation refers to repairing the services that ecosystems provide, thus repairing its overall level of productivity. Restoration is the process and act of restoring land cover within ecosystems back to it's original state following disruption or degradation to the area from either anthropogenic or natural interactions. The long term objective of Alcoa's mine rehabilitation is to establish a self-sustainingJarrah Forest ecosystem, planned to enhance or maintain conservation, timber, water, recreation and other forest values.

Prior to Alcoa's commencement of mining activity their are many processes enabled to mitigate potential land cover change. Pre-mining surveys are conducted in all new mining areas to provide information on fauna and flora, to map the extent of of dieback disease and to identify any Aboriginals or European heritage sites. If rare or protected species or significant sites are present, they are avoided or management plans are developed to minimise the impact of mining on them. Exploration drilling is also conducted to identify specific locations of areas within the mine lease that are suitable for mining, therefore land not suitable for mining will not be directly impacted through mining activity. Mine planning takes into account any significant flora, fauna or heritage sites identified during the pre-mining surveys as well as decreasing the anthropogenic cause of the spread of dieback disease. Dieback is a condition in which a tree or shrub begins to die from the tip of its leaves or roots backward, naturally it spreads about a metre per year but mining encourages mass spreading of dieback.

The rehabilitation and restoration strategies implemented by Alcoa to mitigate the adverse affects of land cover change are extremely effective, with Alcoa reporting 100% native flora and fauna return in 2001. 600ha of Alcoa's land impacted by mining is rehabilitated annually. Alcoa's rehabilitation process has been significantly developed and improved since their mining operations first commenced in 1963. Prior to 1971 Alcoa's rehabilitation consisted of plantations of Eucalyptus trees, these trees were predominately native to the Eastern side of Australia not Western Australia but now there is large population of Eucalyptus trees found in Western Australia. This shows how Alcoa has strengthened their rehabilitation and restoration strategies through movements in knowledge, advancements in technology and community expectations. This has helped Alcoa to mitigate the adverse effects of land cover change as a result of mining activity as Alcoa now has a better understanding of the environment their degrading, therefore Alcoa will be able to successfully implement rehabilitation and restoration strategies best suited to returning and ecosystem to it's original status.

Alcoa currently guarantees a 60-70% native flora and fauna return in all areas that have suffered land cover change as a result of mining. This shows the effectiveness of Alcoa's rehabilitation and restoration strategies as they have the highest species return compared to any other mining company i.e the Premier Coal Mine or KCGM.

However Alcoa's rehabilitation and restoration strategies suffer some weaknesses as they rely heavily on the soil return process. Soil return takes place with overburden (gravelly soil material that lies 20-80cm below the ground) and topsoil layers being returned. Wherever possible, fresh topsoil is directly returned to rehabilitated areas from pits that have been recently cleared. The topsoil accounts for approximately 80% of the native species return in an area being rehabilitated and restored. Disturbance associated with the direct return of topsoil results in a loss of approximately 50% of the seed contained in the pre mining forest seed store.

Fauna can also cause significant problems to successful rehabilitation. Grazing done by naive species such as kangaroos and wallabies on establishing flora has also proven to be a significant problem. This may require the use of tree guards or other methods not harmful to native wildlife. Introduced herbivores (such as rabbits and goats) can decimate newly established plants. Feral predators present another problem to the establishment of a functional ecosystem as they can significantly reduce the number of native fauna. A fauna management plan would be required to address these issues. Alcoa has yet to introduce a fauna management plan as despite having a high species return rate of 60-70% per rehabilitated land. Alcoa could significantly increase the percentage of species return and in turn their effectiveness if they introduced a fauna management plan.

Alcoa has proven to have extremely effective and successful rehabilitation and restoration programs. However it still takes hundreds of years for rehabilitated land to be fully restored. This is because mining significantly impacts the land, and open pit mining (the mining technique used by Alcoa) is the most invasive type of mining that there is. Clearing the land results in the fragmentation of ecosystems, which may never be fully restored to their original status but the same productivity levels. Despite Alcoa having extremely effective rehabilitation and restoration strategies implemented at their mine site, there are still many weaknesses that follow.

Strengths and Weakness's Of Alcoa's Rehabilitation and Restoration Strategies

Strength	Weakness
Alcoa has a guaranteed 60-70% species return as part of their rehabilitation process	Only 1 in 20 of mature grass trees are successfully rehabilitated to new areas.
Alcoa achieved 100% species return in 2001 in an area previously cleared for mining that had been successfully rehabilitated.	Open pit mining is the most invasive form of mining their is and therefore the hardest to fully rehabilitate and restore.
They have successful dieback management programs to prevent the spread of dieback between dieback infected areas and non dieback infected areas.	It will take hundreds of years for an area to be fully restored as the natural ecosystem has been fragmented.
Alcoa has one of the strongest restoration and rehabilitation strategies in the world.	The rehabilitation and restoration strategies are less effective as they rely heavily on topsoil, therefore if the topsoil is not properly redistributed then the entire rehabilitation process would be negatively impacted and there would be a significant decrease in the percentage of native species return.
All progress made by Alcoa is monitored by DPAW to ensure Alcoa is meeting requirement and determine if any interference is necessary.	Increased clearing of jarrah forrest for mining means loss of habitat for endangered crown species including the Baudin's black cockatoo.


Climate Action Now!
Save the future

- **the spatial distribution of the world's rainfall and temperature patterns**

Temperature:

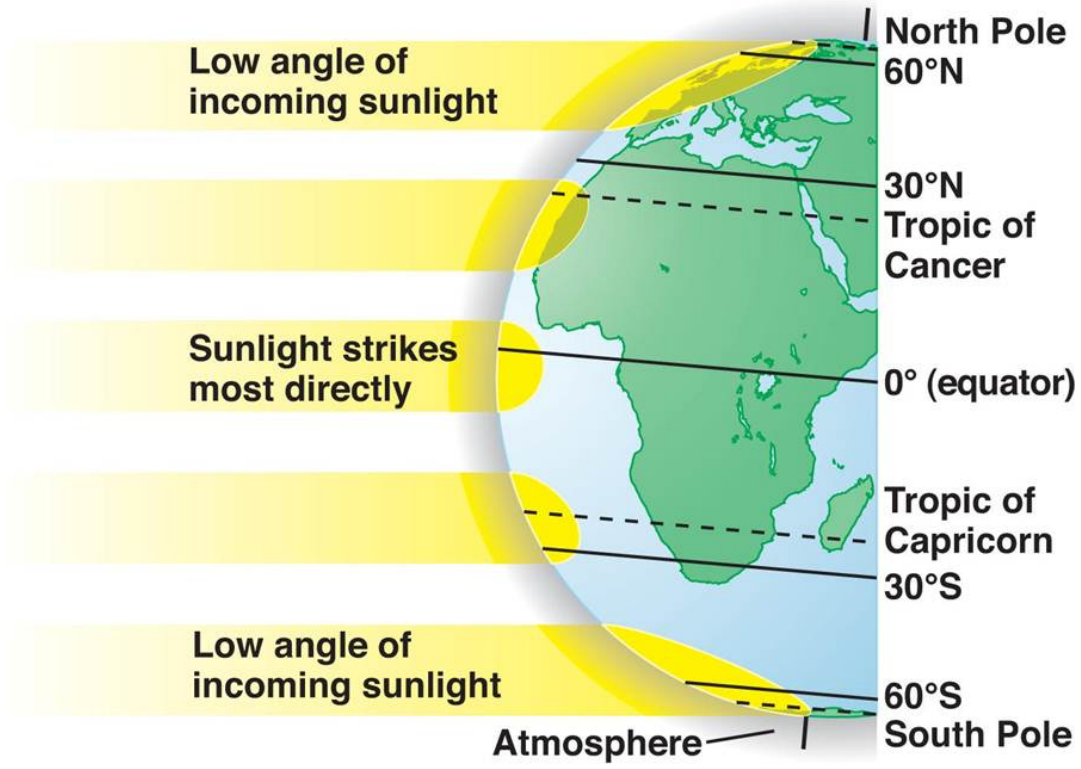
- Greater extremes in the Northern Hemisphere due to larger land masses.
- Greater variations in land temperatures compared with the ocean.
- Temperatures decrease with more proximity away from the Equator.
- Seasonal temperatures fluctuate with humidity.
- Coastal temperatures are more moderate than inland.
- Temperature at the surface of the Earth depend largely upon how much heat energy (insolation which refers to INcoming SOlar radiATION). This will vary due to latitude and time of the year.

Precipitation:

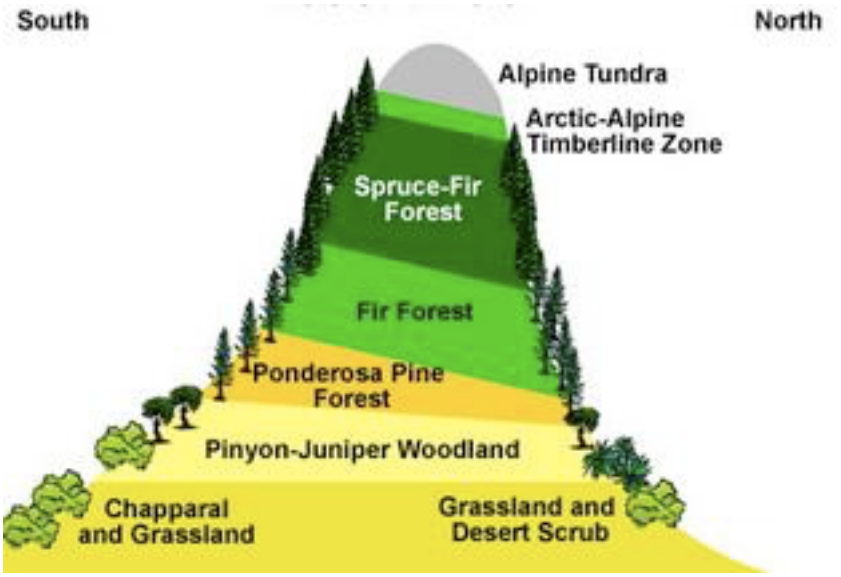
- Equatorial regions have the highest average precipitation due to the tropical
- climatic zone.
- Deserts occur in the interiors of continents, in the latitudes of high-pressure
- systems.
- Proximity to cool ocean currents leads to less precipitation.
- Cold air masses over polar regions contain little to no rainfall.
- When humid maritime meets cold air masses, precipitation forms.
- Windward mountain slopes are locations for high precipitation, with leeward
- slopes producing less.
- Precipitation is primarily located within regions of rising moist air and low pressure. As air rises it cools, the moisture within it condenses, changing its physical state from gas to liquid and usually coalescing or forming clouds. If enough coalescence occurs, precipitation is produced.

LAPDOG:

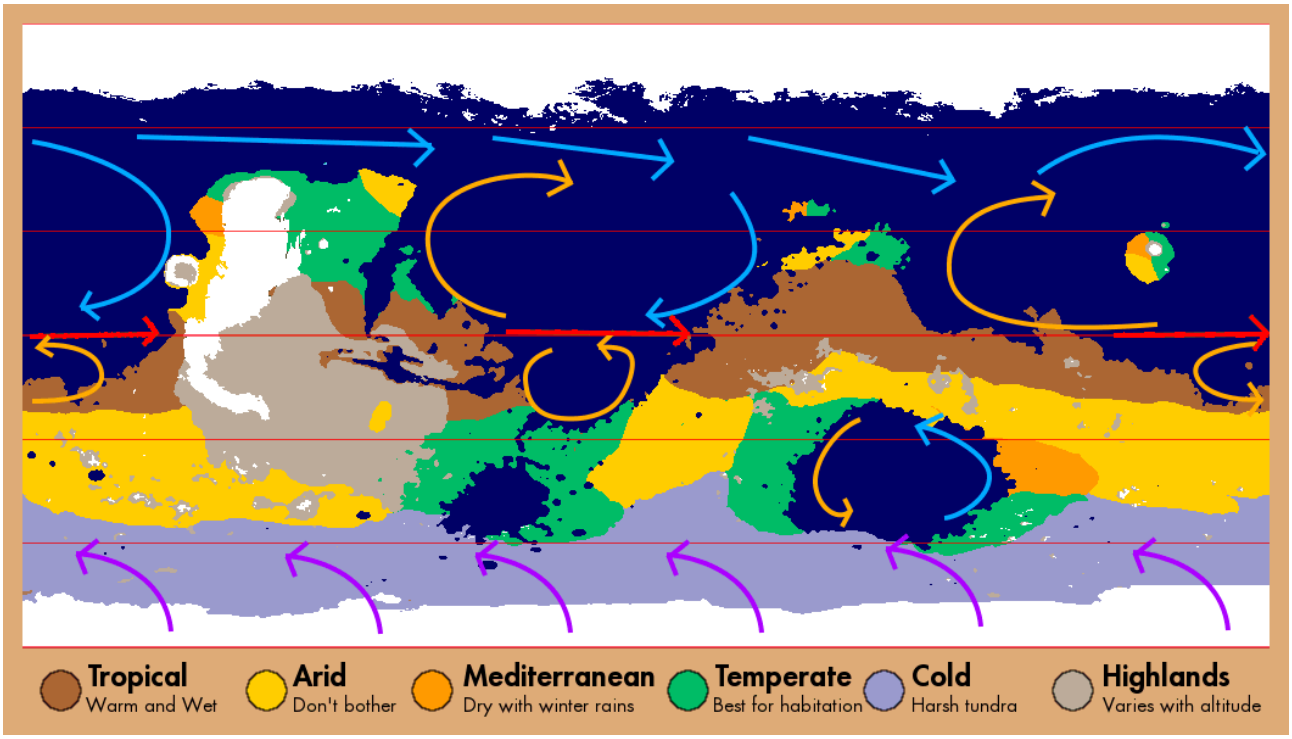
- Latitude



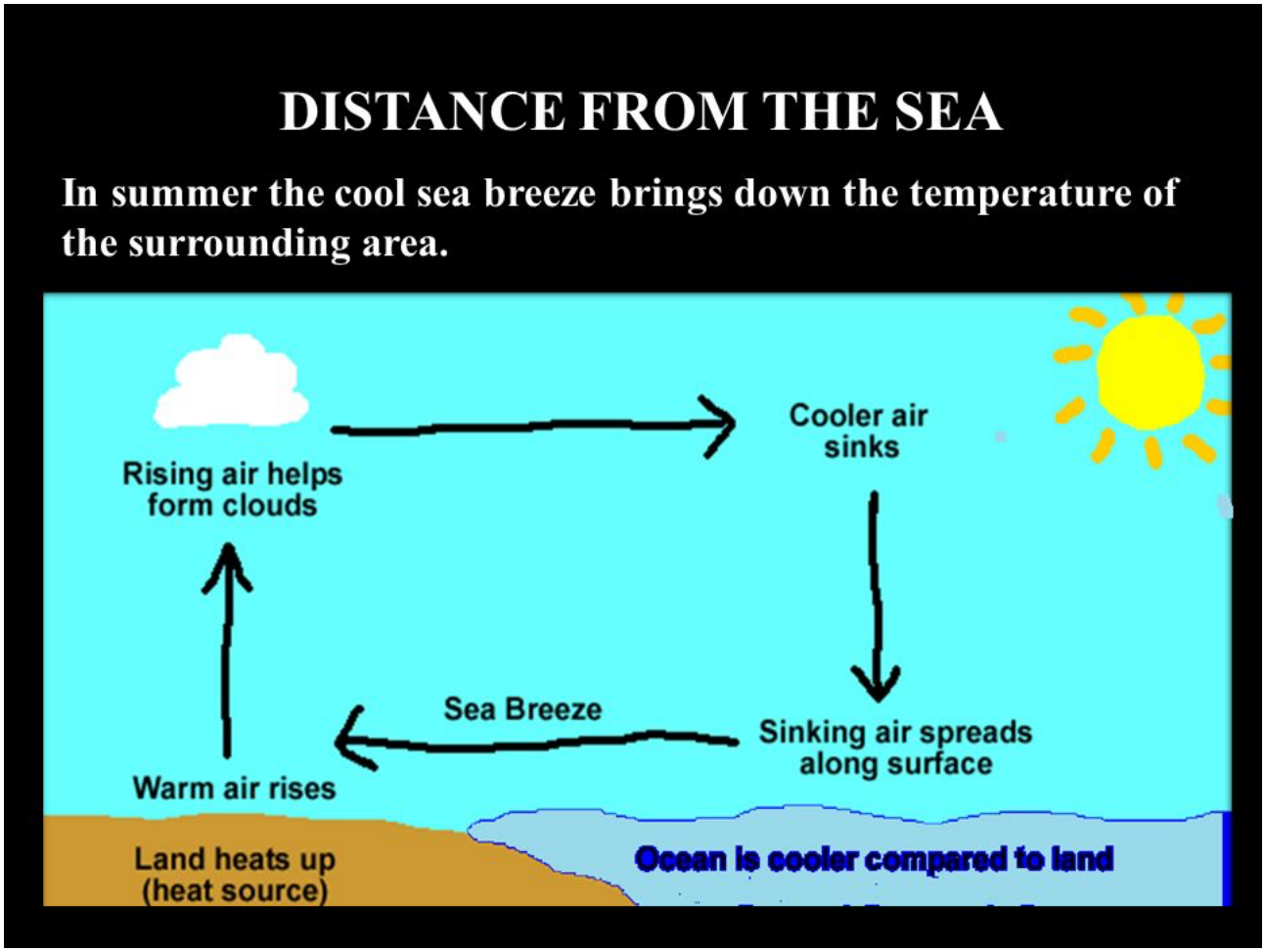
- Altitude



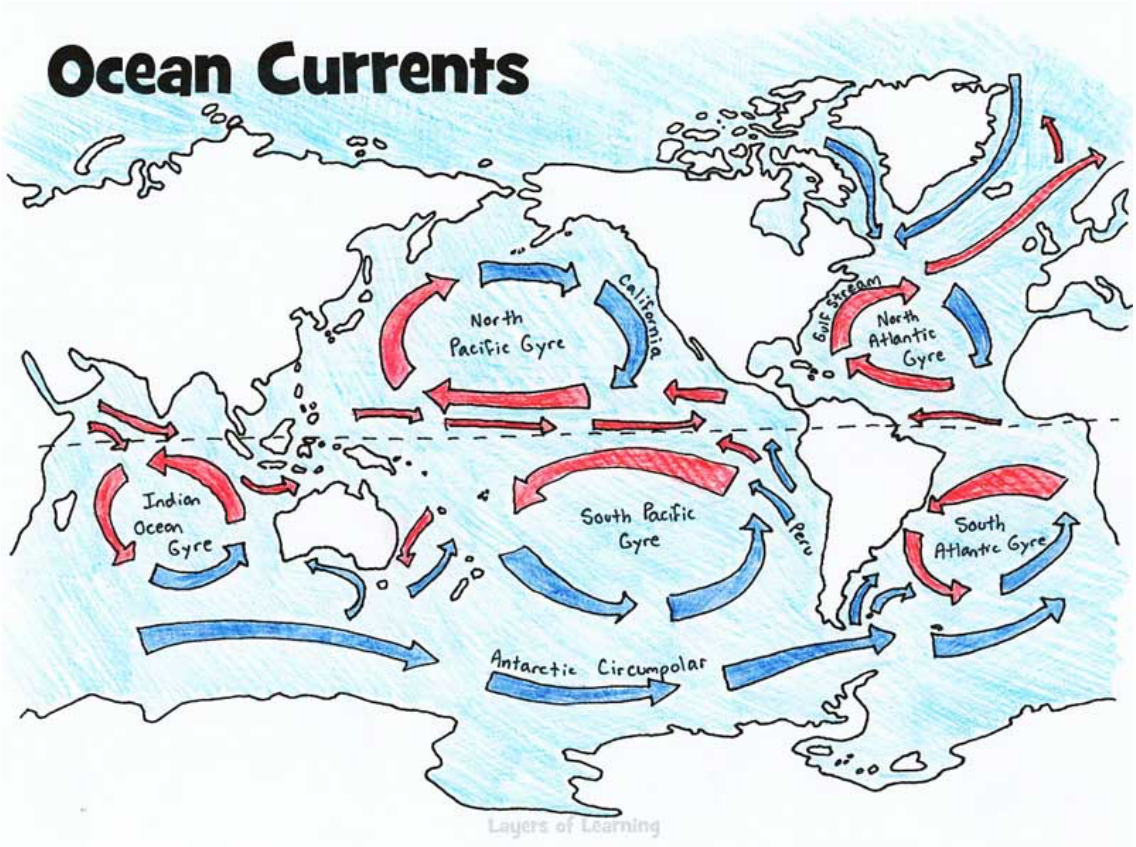
- Prevailing Winds



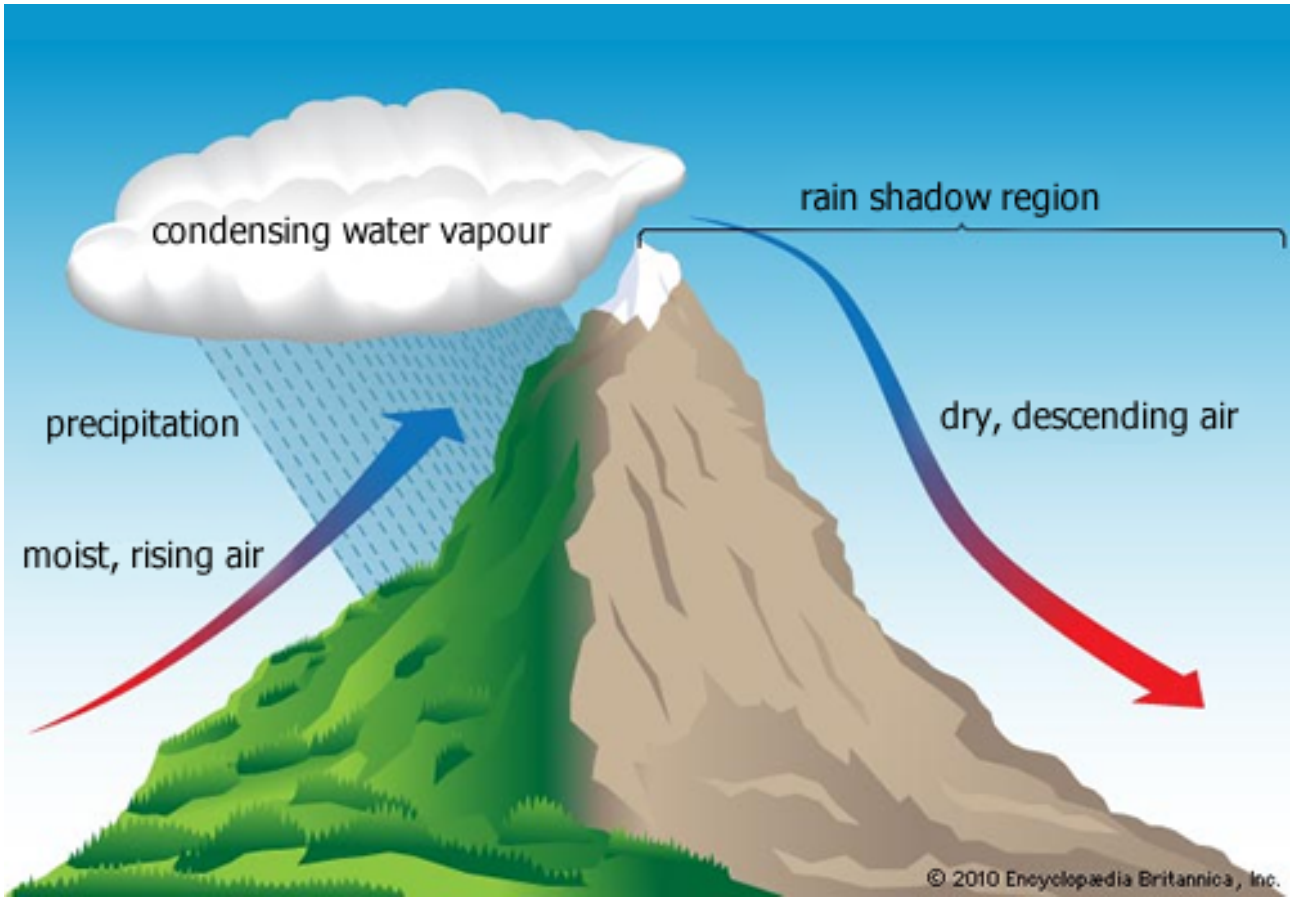
- Distance From the Sea

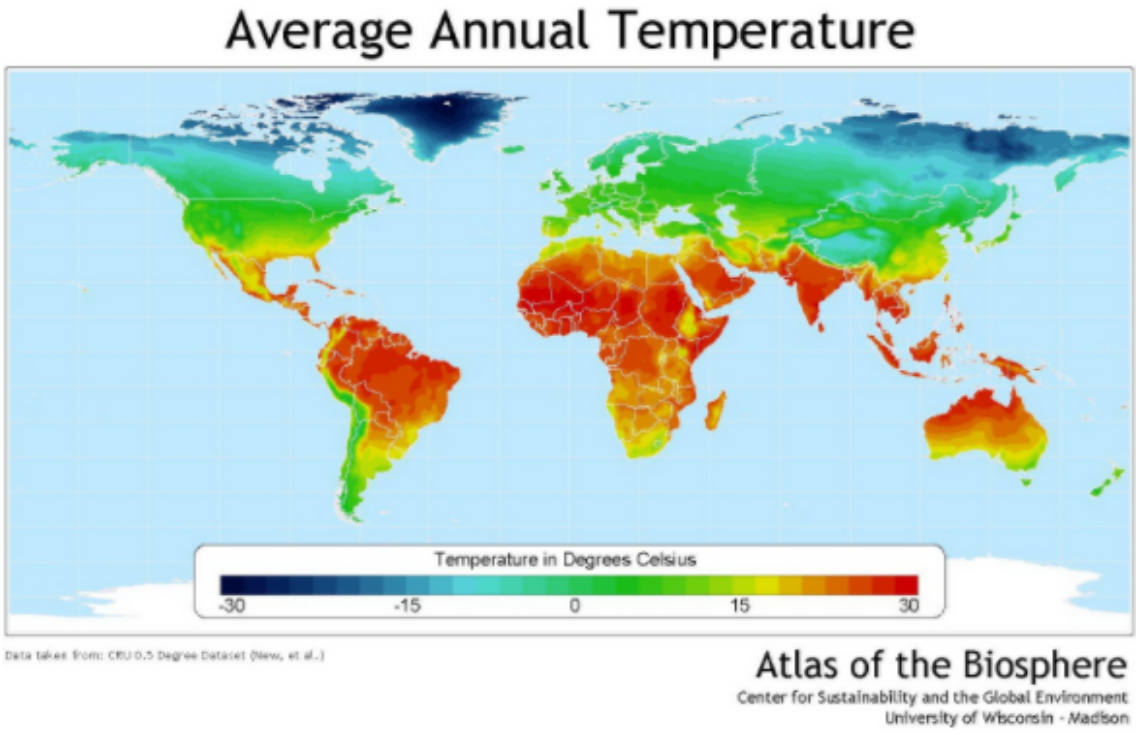


- Ocean Currents



- Great Mountain Barriers

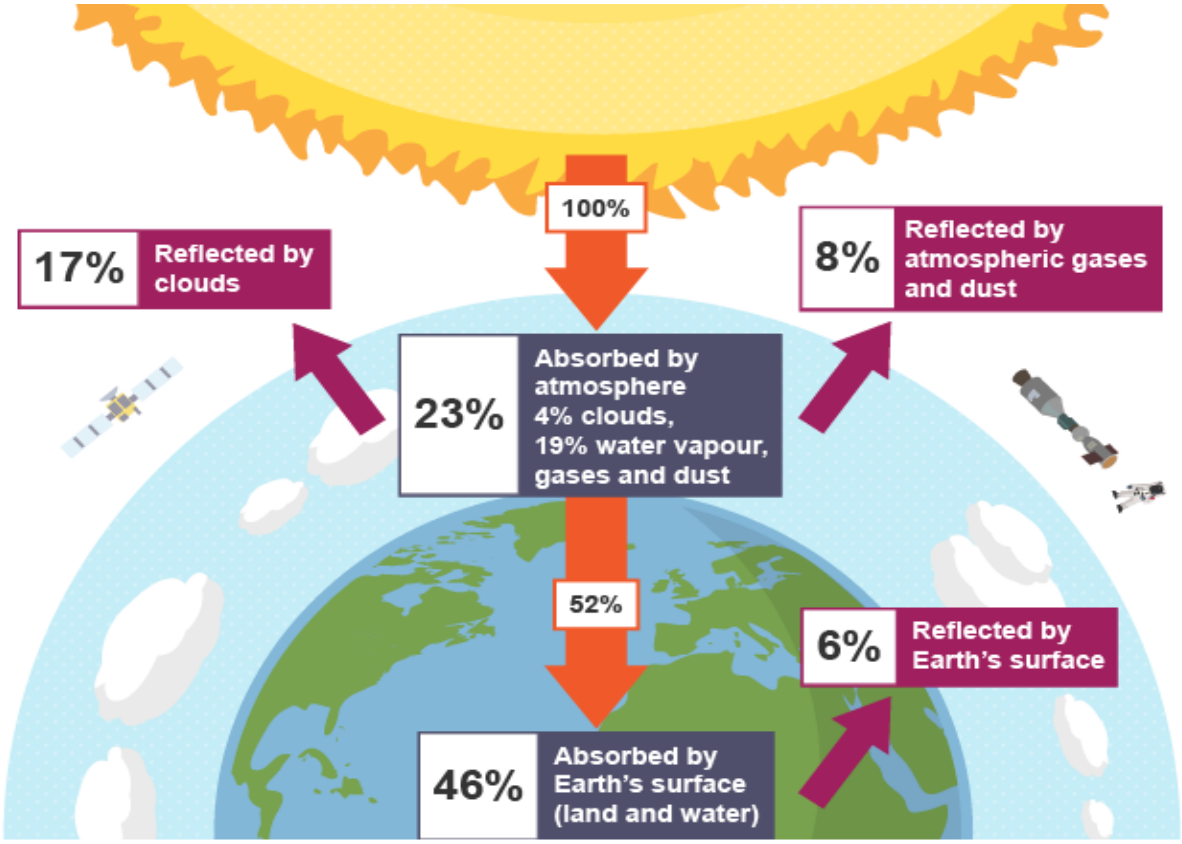




- **the key elements of the following natural systems: heat budget (including the greenhouse effect), hydrological cycle, carbon cycle and atmospheric circulation, and the ways in which they interact to influence the Earth's climate**

Each climate system has spatial and temporal variations that influence the overall climate on the planet.

Heat Budget:



- **Insolation**: It takes heat eight minutes to travel to Earth, with orbital tilts
- producing small changes depending on season.
- **Atmospheric filtering**: Light and heat is scattered and reflected by
- airborne particles.
- **Earth's surface**: Reflects and absorbs heat.
- **Greenhouse gases**: Very effective in trapping heat (approximately 15% of
- incoming insolation).

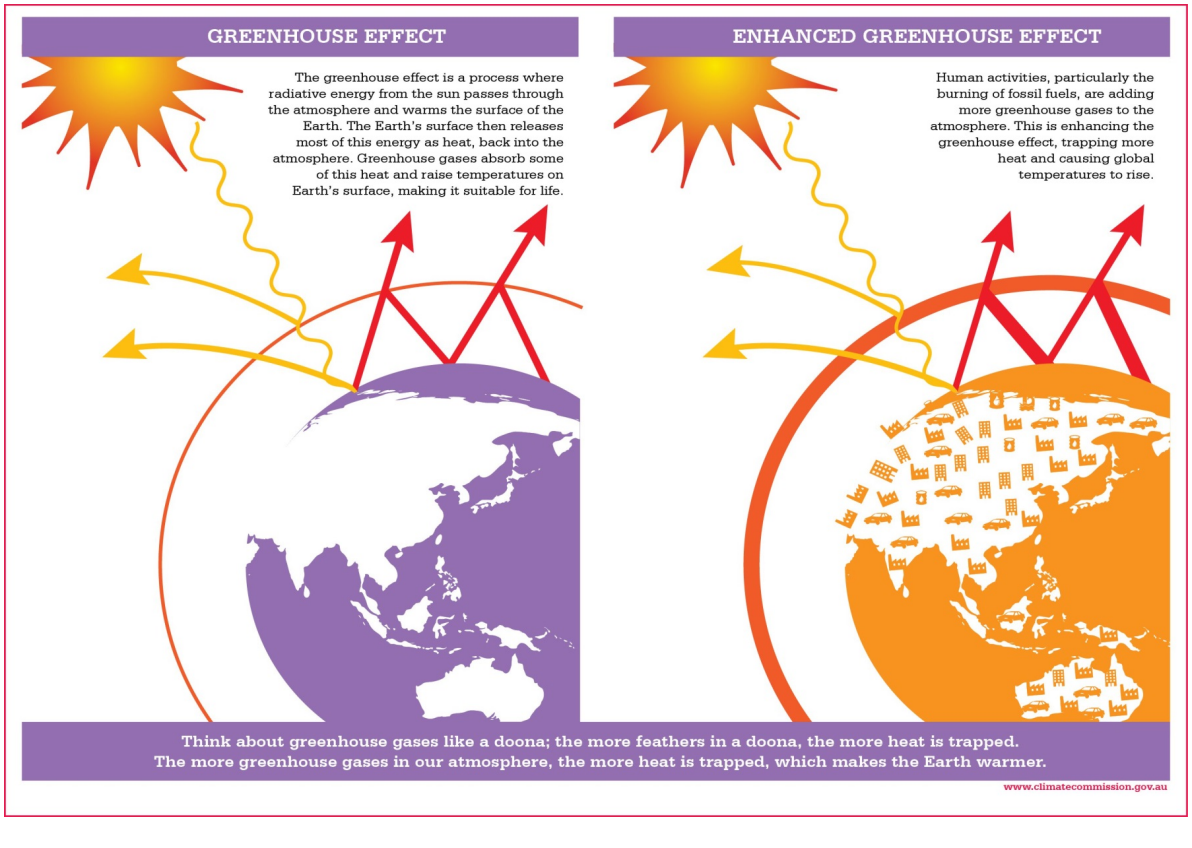
Spatial Variations through curvature of Earth's surface, aspect, altitude, albedo and ocean currents.

Temporal Variations through day and night, seasons, climate variability, El Ninó Southern Oscillation (ENSO) and climate change.

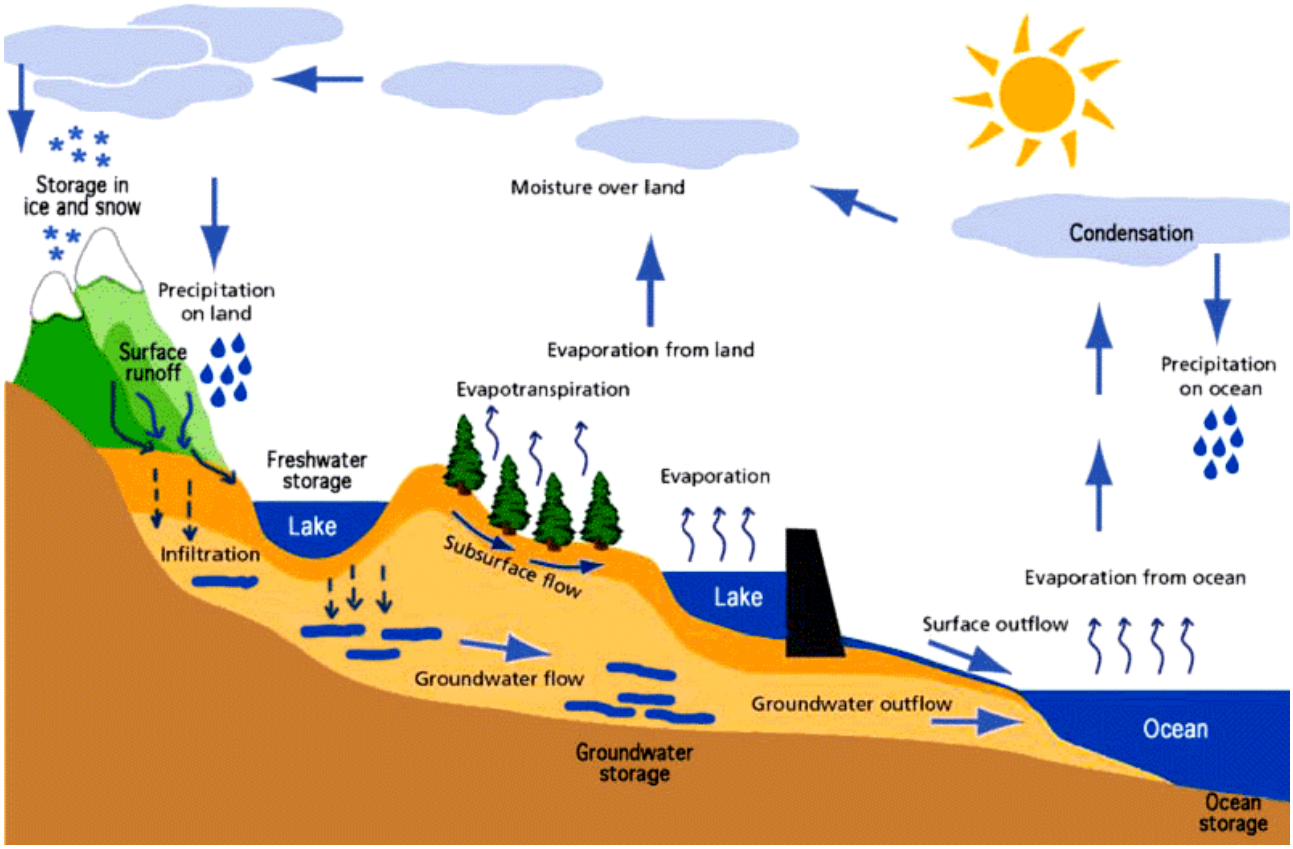
The heat budget refers to the balance between the input of heat energy reaching the earth as short-wave radiation and output of heat energy emitted back into space as long-wave radiation. As the short-wave insolation passes through the atmosphere approximately 26% is reflected back into space by clouds and particulate matter. Approximately 4% of it is reflected from light coloured surfaces on the earth such as ice and snow with high albedo accounting for 30% of incoming short-wave radiation. Approximately 20% of this insolation is absorbed by clouds, aerosols, water vapour and ozone molecules. This leaves about 50% of short-wave energy actually being absorbed by the earth's surface where the solid earth changes this radiant energy to heat energy and becomes warm. This leads to a warming of the lower atmosphere through the processes of conduction, convection, radiation and evaporation.

For the energy budget at the earth's surface to balance processes on the ground must get rid of this incoming solar radiation that has been absorbed by the oceans and land surfaces. This outgoing heat radiation has become long wave energy. With conduction, the atmosphere is heated by direct contact with the sun-warmed earth. With convection the heated air becomes buoyant and rises and expands allowing cooler air to come into contact with the source of heat. This accounts for approximately 7% of this heat loss. About 23% of this heat loss is through evaporation where liquid water molecules absorb incoming solar energy and becomes latent heat. Water vapour can transport considerable distances before removal by precipitation and therefore provides an efficient heat transport mechanism.

A net surface emission of about 21% of the insolation leaves as thermal infrared energy radiated by atoms and molecules on the surface. Some of this passes through the atmosphere and escapes space (6%) but not all heat escapes the atmosphere immediately as it is absorbed by gases in the atmosphere such as water vapour, carbon dioxide and methane. This is responsible for keeping the atmosphere warmer during the night and is referred to as the natural greenhouse effect. It is estimated that the natural greenhouse effect raises the earth's average surface temperature to about 15 degrees Celsius on average, about 30 degrees Celsius warmer than if there was no atmosphere. Even though the earth's atmosphere holds the energy for a length of time it continually radiates the energy back into space so that there is a balance between incoming and outgoing energy so as to maintain the earth's temperature at a relatively constant level. Radiation lost to space comes from cloud tops and parts of the atmosphere.



Hydrological Cycle:



- **Water reservoirs:** 97% of all water is found in the oceans with 2% being found in ice caps and glaciers. The remaining 1% is distributed in rivers, lakes, soil, atmosphere and biosphere.
- **Evapotranspiration and condensation:** Most of the water that enters the atmosphere as water vapour begins its journey in the tropics.
- **Advection and precipitation:** Atmospheric air movements move the tropical water vapour towards the poles, producing alternating regions of low and high precipitation.
- **Infiltration and runoff:** Water is returned to the seas or on to the land by precipitation. On the land it can infiltrate the soils and sometimes go deeper to become artesian water.

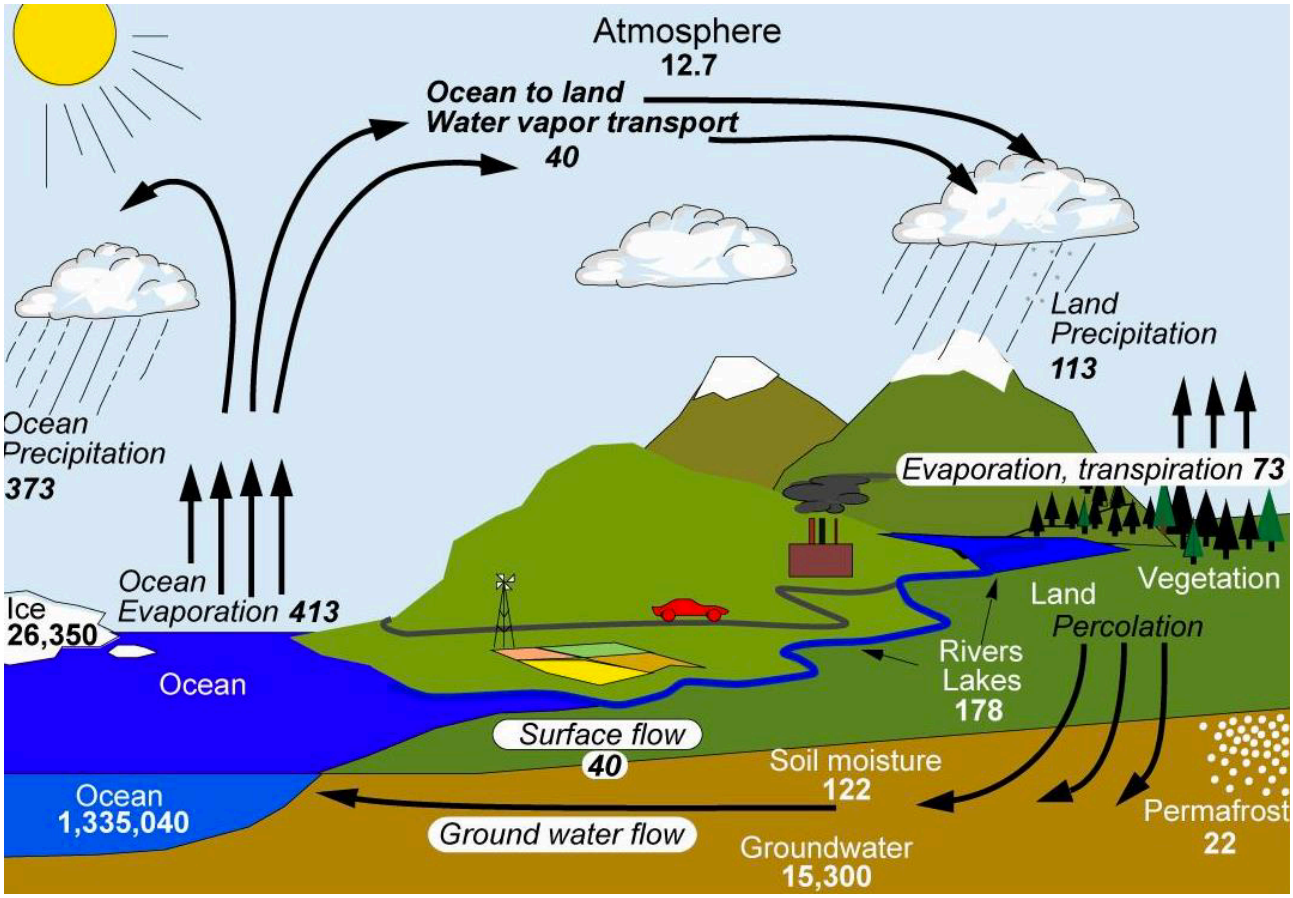
Spatial Variations through Heat Budget, Atmospheric Circulation, landforms, land and sea proximity and soil.

Temporal Variations through time of day, seasons, climate variability and climate change.

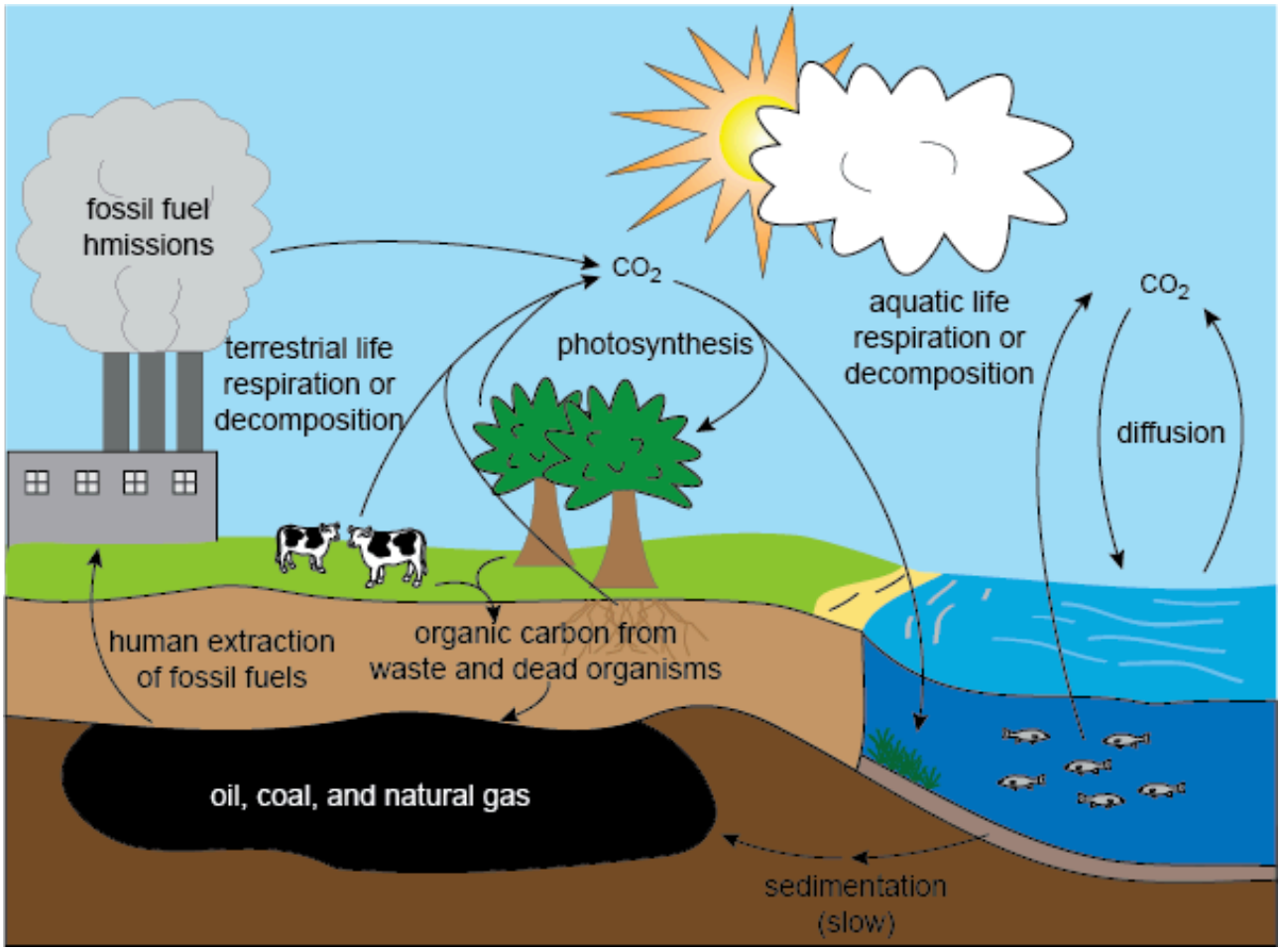
The hydrological cycle is the movement of water in the form of gas, liquid and solid through land, the atmosphere and oceans. The continuous movement of water is known as the hydrological cycle. It is essential for all life on earth. As the water moves through the cycle, it changes state from gas (water vapour) to liquid (rainwater, freshwater, seawater) and liquid can freeze to solids (ice and snow). This natural cycle can remove impurities whilst constantly recycling the Earth's fresh water supplies. The driving force of the water cycle is solar energy which powers the process of evaporation. Only 3% of the Earth's water is fresh (most is inaccessible; 69% held in glaciers and 30% groundwater).

The hydrological cycle is driven primarily by the energy from the sun. This solar energy drives the cycle by evaporating water from the oceans, lakes, rivers, and even the soil. Evaporation is the process of water changing its physical state from liquid to gas and requires an input of energy to occur. As insolation for the sun heats the rivers, lakes or ocean, the rate of evaporation increases. The vast majority of evaporation comes from oceans as they cover 75% of the earth's surface, with smaller amounts coming from other water bodies such as lakes and rivers. As ocean water evaporates, it leaves behind salt, minerals and metals so only fresh water makes its way into the atmosphere. Once evaporated, a water molecule spends about 10 days in the air on average. Condensation is the process of water changing from gas to liquid. As water vapour rises, it becomes cooler and its physical state change back into liquid water droplets. During this process, the latent heat of evaporation is released back into the atmosphere. Even in a clear blue sky, water is still present in the form of water vapour and droplets that are too small to be seen. Depending on weather conditions, water molecules will combine to form water droplets, which coalesce, grow and develop into clouds. Water droplets vary greatly in size 10 microns to 1 mm. As water droplets combine with each other and grow in size, clouds develop and precipitation may also occur.

Precipitation occurs when rain, snow, sleet or hail falls from the sky. When enough liquid water has condensed and the atmosphere cannot support its weight, gravity ensures that the water falls from the clouds back to Earth. Water can take liquid (rain) or solid (hail) form depending on the air temperature. Virga is when precipitation may also evaporate before it reaches the Earth's surface. Infiltration is when the water falls back to the Earth, some it soaks or infiltrates into the ground. It can be collected underground in aquifers (layers of permeable rock, sand or gravel) and is known as groundwater. Groundwater will eventually seep into rivers, creeks and lakes to provide a steady flow of water even after the rain has stopped. Run-off occurs when water does not soak into the ground, but rather flows across the land instead. This water is referred to as surface water, and collects in creeks, streams, rivers and lakes that may flow into seas and oceans, allowing the cycle to continue.



Carbon Cycle:



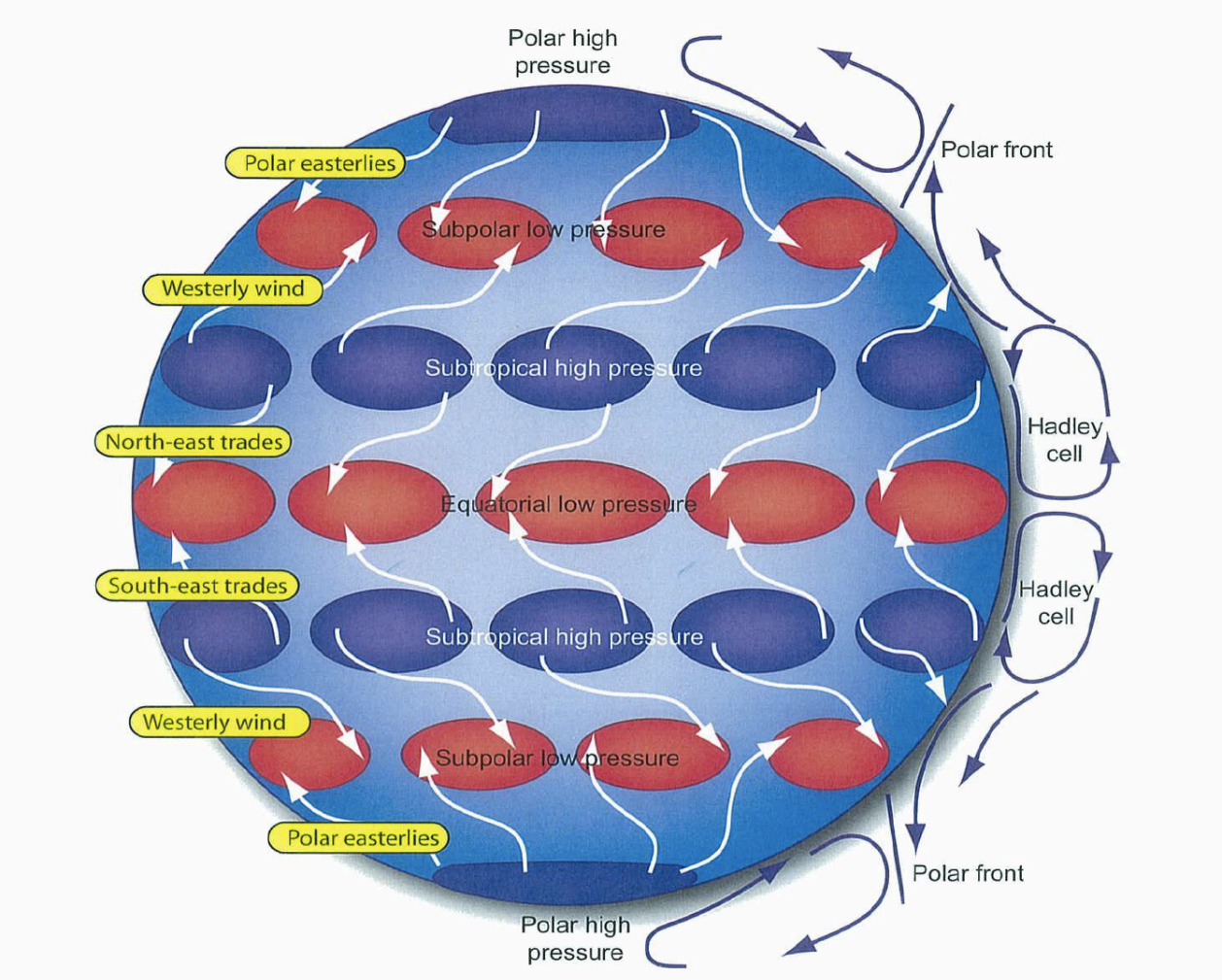
The biochemical cycle through which carbon moves through various stores within the earths system. These stores are in the various:

- Carbon sinks
- Lithosphere
- Hydrosphere
- Biosphere
- **Atmosphere:** Atmospheric carbon has increased over the last 200 years from about 280ppm to 380ppm.
- **Vegetation:** Vegetation and phytoplankton are important in the removal of CO2 from the atmosphere.
- **Soil and fossils**: Soils, rocks and fossil fuel deposits are major stores of carbon, some of which can be released into the atmosphere. Permafrost soils lock/freeze carbon away and release it when they thaw.
- **Oceans:** The oceans act as a major carbon sink, especially when it is taken down into the deep ocean.
- **Anthropogenic carbon:** Increasing amounts of carbon are being released into the atmosphere from human industrial, urban and rural activities.

Spatial Variations through atmospheric carbon distribution, ocean and terrestrial distribution (e.g. sinks and stores).

Temporal Variations through seasons and climate change.

Atmospheric Circulation:



Atmospheric circulation – is the large scale movement of air, and controls the distribution of thermal energy across the Earth (together with the much slower ocean circulation)

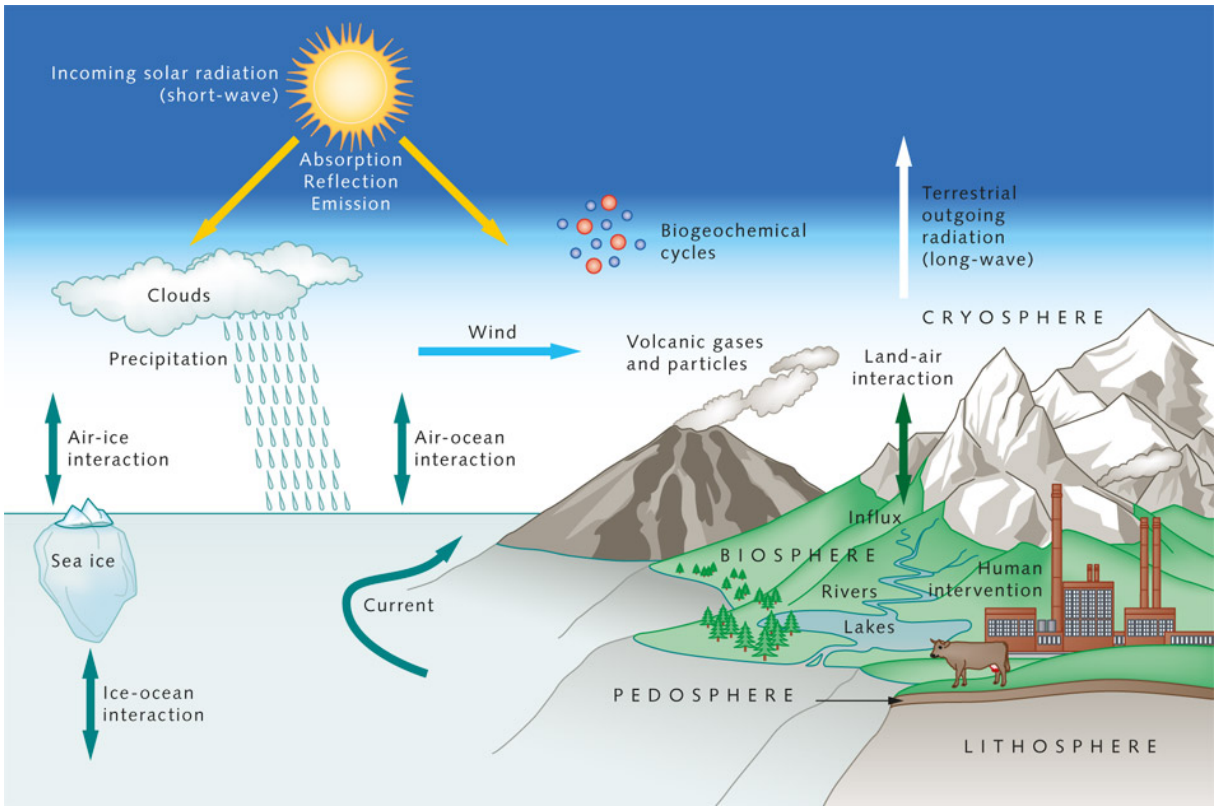
- **High and low pressure belts:** Pressure belts form alternating bands of high and low pressure with winds blowing from high pressure to low pressure cells.
- **Prevailing winds:** Winds moving away from high pressure systems blow towards adjacent low pressure cells. These prevailing wind systems are deflected to the right in the northern hemisphere and to the left in the southern by the rotation of the earth on its axis (when facing the Equator). This is called the Coriolis Effect.

Spatial Variations through altitude, latitude, and land and sea proximity.

Temporal Variations through day and night, season, climate variability and climate change (e.g. shifting climatic belts).

Climate System Interactions

Natural System	Interaction
Heat Budget	• Utilises the Carbon Cycle for storage of heat in the Greenhouse Effect • Utilises the Hydrological Cycle for transfer of heat in ocean currents and reflection off clouds. • Utilises Atmospheric Circulation for transfer • of heat in pressure systems.
Hydrological Cycle	• Utilises the Heat Budget for processes of evaporation, condensation and precipitation. • Utilises Atmospheric Circulation for advection currents and upward rain-bearing systems.
Carbon Cycle	• Utilises Atmospheric Circulation for locations of the enhanced greenhouse effect. • Utilises the Heat Budget for enhanced heating and cooling. • Utilises the Hydrological Cycle for the transfer of CO2 from oceans.
Atmospheric Circulation	• Utilises the Heat Budget for creation of high and low pressure systems and their intensity. • Utilises the Hydrological Cycle for locations of high and low precipitation. • Utilises the Carbon Cycle for the intensity and prevalence of rain, drought, storms, etc.



▪ the causes (natural and anthropogenic) and rate of global climate change

The nature of climate change is dictated primarily through:
- An overall global temperature rise.
- Shift in the spatial distribution of precipitation and its amount.
- The increase in the intensity and frequency of extreme weather events.

The nature of climate change is dictated secondarily through:
- Sea level rise.
- Distribution of vectors and disease.
- Alterations to structure and dynamics of ecosystems.
- Alterations to climatic interactions.
- Impacts to economic activity.

Natural causes of climate change include:
- **Volcanic Activity:** Ash deflects insolation away from the Earth's surface, thus producing a cooling effect. Quieter eruptions produce a heating effect.
- **Albedo:** The change in sea ice land cover affects reflectivity between seasons.
- **Earth's axis and orbit:** More tilt on the axis produces more intense seasons. The degree of roundness influence winter and summer extremes and the expansion and retraction of ice sheets.
- **Biosphere:** Ice is replaced by vegetation, with dead organisms emitting CO2.
- **Solar output:** Sunspots occur on an 11-year cycle, which has a temporary impact on insolation.

Anthropogenic causes of climate change include:
- **Fossil Fuels:** Burning and extraction of dead organisms causes the release of CO2 and CH4, which contributes to the enhanced greenhouse effect.
- **Mining:** Mixed impact through open-cut release of CO2/CH4 into the atmosphere and pollution of streams and drainage systems.
- **Cement manufacture:** Chemical reaction produces large amounts of CO2 as well as the energy required to produce it.
- **Smelting:** Production of metals requires large amounts heat, coal and electricity.
- **Deforestation:** Forest soils dry and reduce evaporation. The lack of vegetation leads to extreme temperatures and the reduction in the ability to remove excess CO2 from the atmosphere.
- **Agriculture:** Clearing of land affects CO2 exchange.

▪ one major type of evidence for climate change through geological time

Rock striations are rock scratchings that are evidence to suggest the existence of climate change in geological time. These are found on the edges of rocks, along mountain ranges and coastal land shelves. The retraction of glaciers, ice sheets and frozen ground cause these striations to occur, primarily in the cryosphere.

▪ one major type of evidence for climate change in recent human history

The continued rise in sea levels is evidence to suggest the existence of climate change in recent human history. As a result of increasing temperatures, sea level rise is attributed to the reduction in the ice sheet biome and permafrost of the tundra biome. Ice sheets like the Antarctic, contribute to sea level rise at a rate of approximately 0.42mm a year.

- **the interrelationship between land cover change and climate, including changes to surface reflectivity (albedo) and the process of natural carbon sequestration**

Climate is responsible for the natural processes of land cover change. Land cover change creates a positive feedback loop for climate change to act.

Land Cover Change and Albedo:

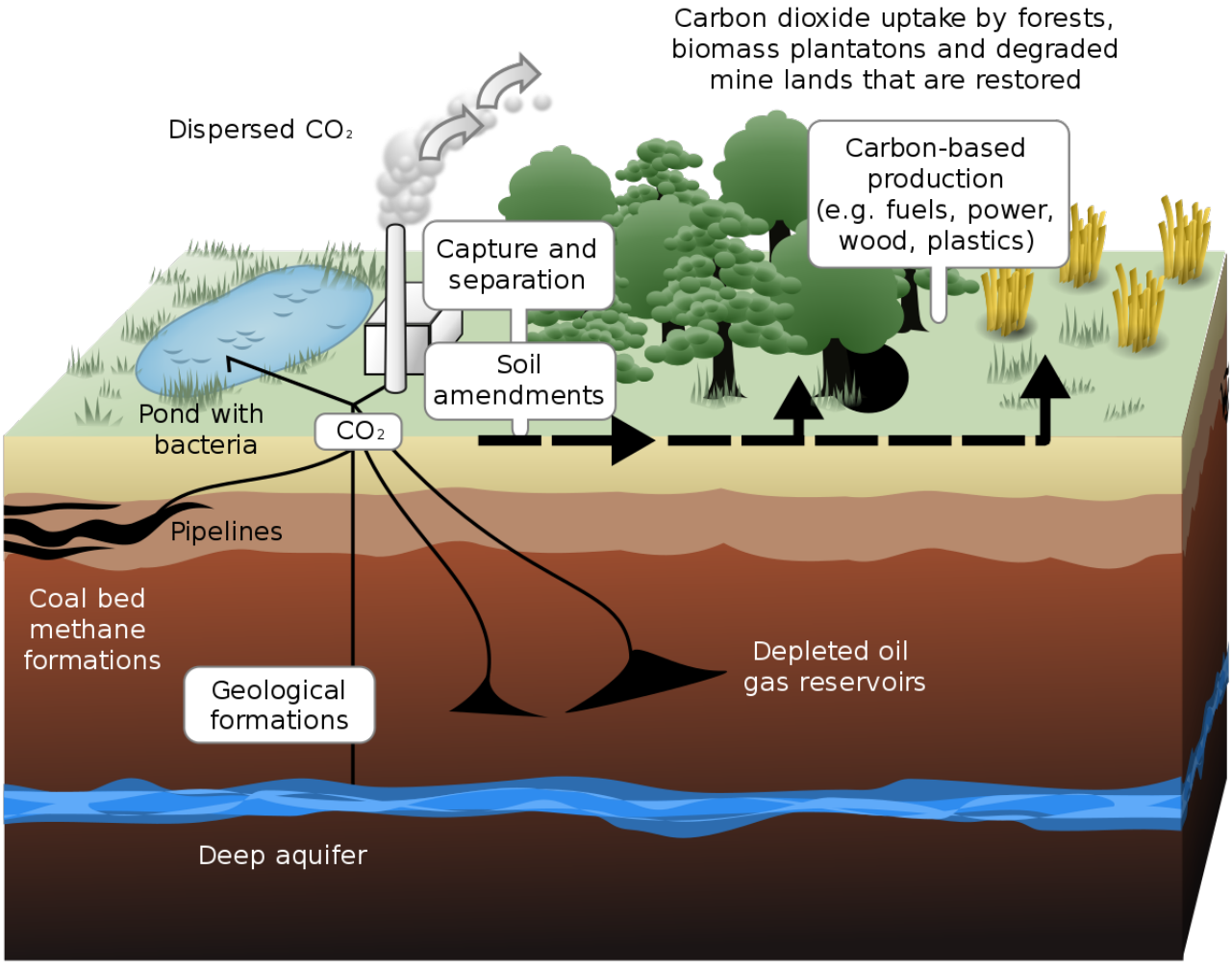
- Lack of albedo due to creation of darker surfaces and the prevalence of more intense heat in localised regions (e.g. urban heat islands).
- Fluctuates between seasons and with agricultural crop growing and harvesting.

Land Cover Change and Carbon Sequestration:

- Deforestation and other degradation activities provoke change in the density of CO_2 stores, which also release stored CO_2 from trees and other plants.
- Changes to the soil structure, composition and biology affect the interaction with the biosphere, due to practices and methods that cause decomposition and erosion.

Land Cover Change and the Hydrological Cycle:

- Irrigation systems increase surface runoff and chances of poor soil percolation.
- Urban areas influence natural drainage systems.
- Forest clearing leads to increased groundwater discharge.



- **the effects of climate change on land cover in natural and anthropogenic biomes (vegetation, ice sheets, glaciers, coastal systems and coral reefs, agriculture, urban settlements and industry)**

Current Effects of Climate Change on Land Cover

Biome	Direct	Indirect
Desert Vegetation Characterised by vegetation, limited biodiversity, low soil nutrients, and extreme diurnal temperatures in sub-tropic and arid inland regions.	• Deserts have warmed up an average of 0.2 to 0.8ºC per decade between 1976 and 2000, with a combined increase of between 0.5 and 2.0ºC, higher than the average global temperature rise of 0.45ºC.	• Flora and fauna are already at the limits of tolerance in the environment, with anthropogenic climate change enhancing the already extreme temperatures.
Ice Sheet Characterised by areas of land ice accumulated over time due to snowfall as a result of short summer/ long winter periods of below freezing temperatures.	• Ice sheet reduction leads to released CO2, which enhances heat energy, which contributes to sea level rise (positive feedback loop).	• Loss of albedo contributes greatly to the increase in rate and extent of global climate change.
Agriculture Characterised by the use of the land for soil, farming, and animal cultivation either intensively or extensively.	• Agriculture both causes and is affected by climate change. Land cover change practices in degradation, clearing and use of chemicals release CO2, CH4 and NO. • Past and current climatic trends have decreased food production (e.g. wheat, maize yields).	• Increase in food price index since 2002 is correlated to the rise in frequency/intensity of extreme weather events. • Flow on effect through disease and invasive species (e.g. Europe blue-tongue virus and ticks).
Urban Settlements and Industry Characterised by high population densities living near human made infrastructure and in access to secondary or tertiary industries in the form of manufacturing or services.	• Differences in demographics, climate and landscapes promote mixed vulnerabilities for urban settlements, with similar fluctuations in industry with the role of comparative advantage, centralisation or specialisation. • Growth of urban settlements and industry cause and are affected by climate change through creation of urban heat island effect (pockets of above average night time temperatures). • Coal burning for urban energy use acts in a positive feedback loop with degradation to heath, safety and productivity.	• Transport, mining and tourism are impacted through the effect that the intensity and frequency of extreme weather events have on an inter connected world, land degradation in finding resources and changes to the aesthetics of different parts of the world.

- **the projected impacts of global climate change**

Projected impacts of global climate change include:

- **Temperature changes:** An increase of 1 – 5ºC by 2100, with greatest warming occurring in the Northern Hemisphere as a result of a larger land mass.
- **Precipitation changes:** Patterns of rainfall are becoming less certain, with storms and precipitation to intensify and shift polewards.
- **Climate boundary shifts:** Shifting polewards due to changes in ocean temperatures, atmospheric circulation and jet streams.
- **Extreme weather events:** To become more intense in duration, severity and frequency.
- **Sea level changes:** A 0.4 – 0.8m rise by 2100 will impact on coastal lowlands, low-lying islands and storm-surge prone areas.
- **Ecosystems:** A 2ºC rise in temperature will lead up to a 30% extinction of all species. For the species that require cooler environments, they will need to be planted in in further north or south environments to avoid dying out. Plants may die out if there is no frost in winter. For example, in North America the forests are threatened by the southern pine beetle as winters are becoming warmer and not killing the beetles off before they attack the trees to lay their eggs.
- **Landform changes:** Retreating coastlines and coastal erosion will impact on landform development as a result of sea level rise.
- **Agriculture:** Influences the quality, quantity and variance of different products, with declining yields, rising food prices and a shift in location of food production (food bowls) projected to occur.
- **Urban:** Relocation and sourcing of new water supplies will impact on human life (e.g. climate refugees on islands in the South Pacific).
- **Health:** A projected 250,000 deaths as a result of climate change by 2030 – 2050, with costs around USD$2 – 4 billion by 2030.

The Great Barrier Reef World Heritage Area is one of the most biologically diverse regions in the world. Climate change is now recognised as the greatest long term threat to the GBR with implications for nearly every part of the ecosystem. The GBR stretches 2100 km from the tip of Cape York along the Queensland coast and covers close to 350 000 square km. Climate projections for the reef show that sea and air temperatures will continue to increase, sea level is rising, the ocean is becoming more acidic, intense storms and rainfall will become more frequent and ocean currents will change. These changes will have consequences for many reef species & habitats, as well as ecosystem processes and the industries and communities that depend on the reef. The reef's tourism, commercial and recreational fishing together contribute $6.9 billion to the national economy per year.

Unusually warm sea temperatures have already caused serious and lasting damage to 16% of the world's coral reefs. The GBR has experienced eight mass bleaching events since 1979 triggered by unusually high sea surface temperatures. The most widespread events occurred in 1998 and 2002 with more than 50% of reef's bleached. Coral reefs are among the most vulnerable of all ecosystems to climate change, due in large part to the high sensitivity of corals to small increases in water temperature. When sea temperatures exceed the long term summer maximum by as little as 1 degree Celsius for only six weeks, extensive coral bleaching occurs, leading to widespread coral mortality if temperatures do not return to normal levels. A vast array of organisms depends on corals for habitat and food, and many more will be affected directly or indirectly by shifts in environmental conditions brought about by climate change. Coral reefs, pelagic environments, coasts and estuaries and island and cays will be particularly vulnerable under climate change. Signs of this vulnerability are already evident, same further degradation is inevitable as the climate continues to change but the extent of the decline will depend on the rate and magnitude of climate change and the resilience of the ecosystem.

Short Answer Questions:

- **Explain the concept of climate change (3 marks)**
- **Identify one process responsible for land cover change and outline it's impact on local or regional environments (4 marks)**
- **Describe two projected impacts of global climate change or biodiversity loss (6 marks)**
- **Define the term 'anthropogenic biomes' (2 marks)**
- **Define ecosystem structure (2 marks)**
- **Explain the concept of sustainability (3 marks)**
- **Identify one land management practice followed by indigenous peoples and outline its impact on land cover change over time (3 marks)**
- **Select one of the following factors and explain how it has led to differences in the process of land cover change between any two countries (3 marks)**
  -Government Policy
  -Land ownership
  -Type of economy
  -Ideology and culture
- **What is a natural biome? (2 marks)**
- **Outline the difference between the terms weather and climate (2 marks)**
- **Define the process of invasion and succession (3 marks)**
- **Describe how world population growth has influenced the rate and extent of land cover change and loss of biodiversity (4 marks)**
- **Provide one example of a human modification to the hydrological cycle (5 mark)**
- **Explain the difference between an ecosystem and a biome (2 marks)**
- **Explain one implication of anthropogenic biomes to the functioning of the world's ecosystems (4 marks)**
- **Describe three characteristics of the spatial distribution of the world's biomes (3 marks)**
- **How the heat budget influences climate (3 marks)**
- **Using Perth as a spatial location, briefly describe how the hydrological cycle helps drive the local climate (6 marks)**
- **Briefly explain the key elements of the carbon cycle (5 marks)**
- **Describe how any of the following natural systems interact to influence the earth's climate; hydrological cycle, atmospheric circulation, carbon cycle, heat budget. (6 marks)**
- **Explain how earth's heat budget and atmospheric circulation are linked and describe how they jointly influence temperatures across the planets (6 marks)**
- **Describe three major causes of global carbon emissions over time (6 marks)**
- **Account for the climate cycles or variations that result from any of the following processes; solar output, orbit variations, volcanoes, atmospheric gases + chemistry, El nino and La nina, Indian ocean dipole, pacific decadal cycle, polar ice variations. (6 Marks)**

Extended Answer Questions:

- **Describe how any two natural systems interact to influence the earth's climate (10 marks)**
- **Describe and account for the variations in atmospheric carbon dioxide concentrations in recent human history (8 marks)**
- **Describe the key elements of the heat budget, including the natural greenhouse effect (8 marks)**
- **Describe the effects of either climate change or biodiversity loss on natural and anthropogenic biomes (12 marks)**
- **Describe the key elements of ecosystem structure and dynamics (12 marks)**
- **Discuss one approach to land cover restoration and rehabilitation and explain how it mitigates future land cover changes (10 marks)**
- **Describe any two of the following natural systems: (12 marks)**
  - **heat budget**
  - **hydrological cycle**
  - **carbon cycle**
  - **atmospheric circulation**
- **Identify and discuss a program designed to address the impacts of land cover change on local and regional environments (8 marks)**
- **Describe the spatial distribution of the world's rainfall and temperature patterns (8 marks)**
- **Describe the spatial distribution of the world's natural biomes (8 marks)**
- **Discuss two approaches to land cover restoration and/or rehabilitation (8 marks)**
- **Describe the nature, scope, causes and consequences of one process of land cover change (10 marks)**
- **With reference to specific examples, explain the interrelationships between land cover change and biodiversity loss (12 marks)**
- **With reference to specific examples, explain how climate change alters the location and distribution of natural environments (10 marks)**