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PALAEOLITHIC: OLD STONE AGE = 20,000 TO 11,700 YEARS AGO

TURNING POINTS

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Our climate is changing. This is not the first time it has changed as this exhibition shows, but it is the first time it has been changed by us.

By burning fossil fuels, cutting down forests and intensive animal farming we are increasing greenhouse gases which trap the Sun's heat and stop it from leaking back into space.

As a result our planet home is heating up.

In Scotland, temperatures are increasing across all the seasons. Our weather is becoming more variable and extreme – our hottest days are getting hotter and our wettest days are getting wetter – leading to more droughts and flooding.

A rapid decline in biodiversity, closely linked to climate change is also being driven by our behaviour. The methods we use to generate energy and our levels of consumption have begun the sixth mass extinction in the Earth's history. In Scotland, wildlife decline is faster than in the rest of the UK.

These twin global crises of climate change and biodiversity loss require us to rebalance with nature if we are to secure a healthier planet.

This decade is the turning point for how we achieve that new balance.

Our exhibition shows how humans adapted throughout history when faced with similar challenges.

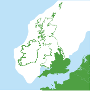
Will we use these lessons from the past to shape a brighter future?

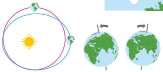
www.cateranecomuseum.co.uk

circa **20,000** years ago

ICY

All of Scotland is buried under 1-3km deep sheet of ice as the Earth's temperature falls naturally due to 'Milankovitch cycles'.

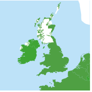




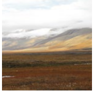
Milankovitch cycles are the long periods of natural warming and cooling cycles of the Earth (glacials and interglacials) caused by changes in its tilt and orbit around the Sun over tens and hundreds of thousands of years.

circa **16,000** years ago

THAWING



The Scottish ice sheet starts to melt despite the country remaining cold, because less rain and snow falls.



There is almost no vegetation cover and no people during this period.

PALAEOLITHIC: OLD STONE AGE = 20,000 TO 11,700 YEARS AGO

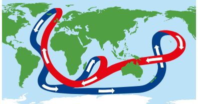
circa

14,700 years ago

WARMER

The Earth receives more energy from the Sun and the increase in temperature brings the glacial period to an end.

The North Atlantic Current or 'gulf stream', which carries warm water to Scotland, is established.



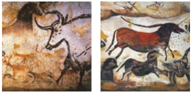
Driven by saltiness and temperature the 'global ocean conveyor' creates water currents around the Earth.

12 Summer temperatures reach 12ºC in eastern Scotland, and ice cover disappears completely from the Grampians.

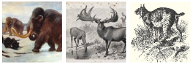
MIGRATION

Grasslands, shrubs, and small trees arrive, including birch, juniper, crowberry, and willow.

People return to Scotland, perhaps to hunt reindeer.



At this point, Britain is connected to Europe. Large mammals including the aurochs (a wild cow), and saiga (an antelope now found in the Black Sea steppe) arrive in Scotland as they migrate from neighbouring Europe.



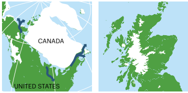
Woolly mammoth, Irish elk and lynx become common too.

circa

12,850 years ago

COLDER

The Atlantic Ocean circulation is disrupted by the North American ice sheet partly collapsing. Water pours down rivers into the Arctic Ocean and forms a freshwater lid — stopping the warm salty water that usually travels north across the North Atlantic.



As a result the warming 'gulf stream' stops working and glaciers return to Scotland.

MIGRATION

5 Summer temperatures in eastern Scotland fall below 5ºC.

The ice sheet on Rannoch Moor and the highlands expands.

Corries in Glen Clova and the across the Gaick plateau west of The Cairnwell become glaciated.

The high ground in Glen Clova is covered in ice.

People and animals are forced to leave the British Isles, retreating to southern Europe.

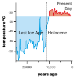
MESOLITHIC: MIDDLE STONE AGE = 11,700 TO 5800 YEARS AGO

circa

11,700 years ago

WARMER

Our present interglacial period (the Holocene) begins. Sustained warmth is established across the globe. Summer temperatures jump to over 10ºC in much less than a decade. Most change occurs very rapidly over a 2-3 year period.



14

The 'gulf stream' re-establishes. In eastern Scotland temperatures rise rapidly to 14ºC and rainfall increases.

Soils start to form. Peat vegetation begins to spread throughout the northern hemisphere. Atmospheric methane concentrations fall because peat traps methane.

MIGRATION

Animals return, migrating from Europe as conditions improve.

Trees return slowly to Scotland as they migrate long distances from the Pyrenees and Italian Alps.

trees returning to Scotland

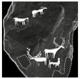
birch	hazel	Scot's pine*	elm	oak
11250	9500	9200	8700	8300

years ago

*north of the Cairnwell

EXTINCTION

Grassland is lost as dense woodland grows. As a result reindeer become extinct after 8,300 years ago, and tarpan (wild horses) disappear 9,330 years ago.



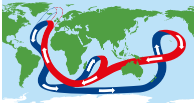
circa

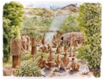
8,200 years ago

COLDER & DRYER

The North American ice sheet collapses finally, dumping fresh water into the North Atlantic Ocean. The 'gulf stream' slows or stops entirely.

As a result, summer temperatures lower by 2ºC and it becomes very dry for around 150 years.





Hunter-gatherers in western Scotland may have been decimated by collapsing marine resources, but they survived in the Cairngorms.

circa

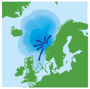
8,100 years ago

DISASTER!

The 'Storegga submarine slide' occurs. This enormous rock-mass falls from western Norway into the North Atlantic. The slide may have been triggered by the collapse of the North American ice sheet. A huge tsunami impacts the surrounding land including much of eastern Scotland.

Doggerland was where the North Sea is now. It shrinks with the impact of the Storegga slide. Hunter-gatherers flee the rising water, moving west.

There have been at least six other submarine landslides in the last 20,000 years.



The Storegga tsunami based on Computer modelling.

MESOLITHIC: MIDDLE STONE AGE = 11,700 TO 5800 YEARS AGO

NEOLITHIC: NEW STONE AGE = 5800 TO 4200 YEARS AGO

circa

7,500 years ago

GREENHOUSE GASES INCREASE

Large areas of peat starts to blanket Scotland storing carbon and methane. The flow country in northern Scotland begins to form.

circa

6,400 years ago

COLDER

A sharp natural reduction in the Sun's energy occurs. Less radiation reaches the Earth, rapidly cooling it. This reduction lasts a couple of centuries.

circa

5,800 years ago

FARMING

Small numbers of farmers cross the newly formed North Sea, pushed by population growth or climate change. They bring wheat and barley, cattle and sheep.

For the first generation of new migrants life focuses around timber halls.

Reconstruction of a timber hall from this period.

Remains of a timber hall discovered at Balbridie in Aberdeenshire.

Small farms surrounded by woodland appear. Long distance networks form between farming communities.

Cattle ownership imbues status.

It is likely that native hunter-gatherers gave up their way of life as the natural environment was unable to support their needs during the global cooling.

circa

5,250 years ago

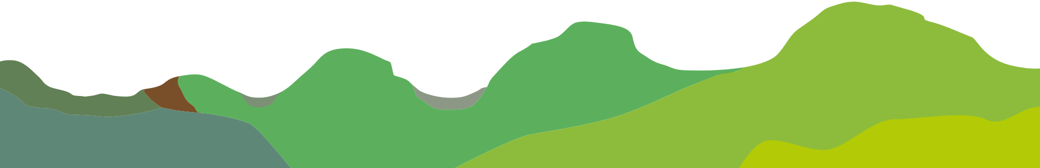
SHIFTING WORLD VIEWS

Hunter-gatherers rarely disturb their surroundings. They live in harmony with the natural world. Farmers on the other hand have to alter the earth.

They cut down trees and move stones to create fields. We began to manipulate nature and to bend it to our will, disturbing the natural environment in the process.

COLDER

A sharp, natural reduction in energy from the Sun occurs. A as a result it becomes cold in parts of north west Europe for around 200 years. People, all farmers by this time, begin to struggle. The population falls as growing crops becomes more difficult. Livestock (cattle) become more important.



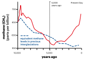
BRONZE AGE = 4200 TO 2800 YEARS AGO

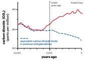
circa
5,000 years ago

GREENHOUSE GASES INCREASE

Did people change Earth's climate in prehistory?

'Greenhouse' gas (CO_2 and methane) concentrations in ice cores started increasing 5,000 years ago.





Some scientists argue that this was the effect of early rice cultivation and forest clearance in Asia. So human-caused 'global warming' may have begun at this point.

circa
4,200 years ago

COLDER

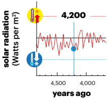
Changing natural variations in the Earth's tilt and orbit, and therefore its relationship to the Sun, gradually impose sustained global cooling.

Glacier advances in mountainous areas become common again, but not in Scotland because the mountains are too low and Scotland is influenced by the warming waters of the 'gulf stream'.

COLDER

The effect of the Earth's orbital relationship with the Sun progressively weakens, allowing other factors to influence global and regional climates including

- ⓐ changes in the Sun's energy output. These occur at 2,100-2,500 year intervals,
- ⓑ volcanic eruptions throwing ash and droplets of acid into the air, obscuring sunlight and creating volcanic 'winters' lasting several years,
- ⓒ fluctuations in 'greenhouse gas' concentrations caused by human activities. These trap heat that would normally escape into space.



Long-term fluctuations in chemical elements from cosmic rays are measured in ice cores. These are drawn here as changes in radiation levels.

WETTER

A reduction in energy from the Sun causes further climatic changes throughout the northern hemisphere.

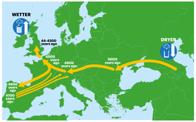
There is a wetter climate in Britain for 200 years.

In Scotland, Scot's pine tree populations growing on peat collapse because a wetter climate makes the water table rise, 'drowning' the trees.

IRON AGE = 2800 TO 1970 YEARS AGO

MIGRATION

Early Mesopotamian civilisations collapse in a sustained drought. A wave of migrants (the Beaker people) are pushed west by the intensely dry climate in the Black Sea region.



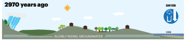
Subsistence farming of crops and livestock recovers. Farmers colonise the hills despite the deteriorating climate.

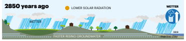
circa

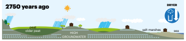
2,700 years ago

COLDER & WETTER

Another sharp, natural reduction in energy from the Sun occurs. The Earth rapidly cools, and remains colder for around 200 years. The cooler climate reduces evaporation and north west Europe becomes much wetter.







MIGRATION

Low-lying areas around the North Sea may have been abandoned due to flooding and waterlogging. Much internal migration occurs throughout Europe.

The Scottish population may have collapsed. Perhaps upland farms were abandoned in a 'retreat from the margins', or the farming system was re-structured to compensate for the colder, wetter climate.

circa

2,400 years ago

WARMER

The climate improves. Sustained population growth in lowland Europe leads to extensive deforestation. Fewer trees mean more atmospheric CO_2.

It is probable that aurochs were driven to extinction through human-driven habitat loss and predation.

**ROMAN IRON AGE =
1970 TO 1610 YEARS AGO**

MEDIEVAL: MIDDLE AGES = 1610 TO 520 YEARS AGO

circa

2,300 years ago

SHIFTING WORLD VIEWS

The Philosopher, Plato, lays the foundations for our still predominant western-world view that we are separate from nature.

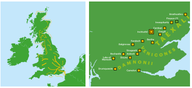
He proposes an ideal world perceived by the soul, existing in a separate sphere from the material world experienced by the body.

AD

50 1,970 years ago

WEALTH CREATION

The Romans advance northward in Britain.



Farmers in the Scottish lowlands begin to trade with the Romans. The economy is invigorated by this new market and commerce replaces subsistence for some. People clear more land for farming to create a surplus by which to trade.

AD

410 1,610 years ago

TRADE DECLINES

Rome abandons Britain and a subsistence economy returns for everyone.

AD

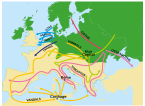
450 1,570 years ago

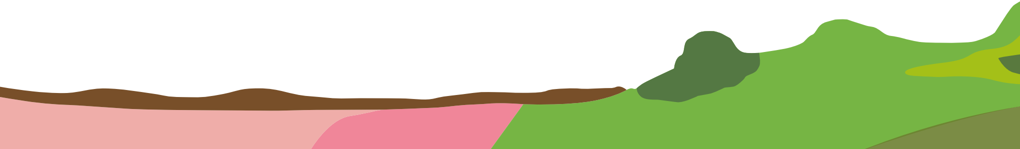
COLDER

A sharp reduction in energy from the Sun begins a 'little ice age' forcing the fall of the Roman Empire.

MIGRATION

Human migrations become common across Europe.





AD

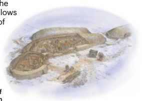
650 1,350 years ago

WARMER

The end of this ‘little ice age’ leads to higher temperatures and increased rainfall. This leads to a warm period now known as the Medieval Climatic Anomaly.

The Scottish farming economy revives. Oats and rye became more important than wheat because they cope better with the new climate.

The ending of the ‘little ice age’ allows recolonisation of the Perthshire hills.



A reconstruction of life in a typical farm in the Perthshire hills.

Chris Mitchell, courtesy of Perth and Kinross Heritage Trust.

AD

1000 1,021 years ago

EXTINCTION

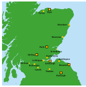
Brown bears, a keystone species, are thought to have become extinct in Scotland, perhaps due to habitat loss caused by people clearing woodland. This would have had a large effect on the natural environment.

AD

1124 897 years ago

WEALTH CREATION

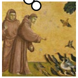
David I cements Anglo-Norman interests in Scotland. Burghs and regional markets are established, creating a vibrant economy in the drier lowlands. The always less productive highlands become further isolated.



AD

1220 800 years ago

SHIFTING WORLD VIEWS



Saint Francis of Assisi.

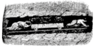
The Christian Church in Rome promotes the belief that “dominion” over nature means its subjugation to man, opposing the Franciscan order’s idea of stewardship and responsibility for nature.

MEDIEVAL: MIDDLE AGES = 1610 TO 520 YEARS AGO

AD

1250 750 years ago

GREENHOUSE GASES INCREASE



Coal mining begins in the Midland Valley and replaces peat as the fuel used in coastal salt-panning.

Burning peat and coal add to atmospheric 'greenhouse' gases.

AD

1300 700 years ago

COLDER

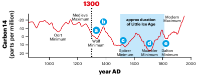
The Earth receives less energy from the Sun and another 'little ice age' begins. Scientists today call these sudden changes in solar events 'grand solar minima'. Glaciers form in northern hemisphere mountains including the Cairngorms.

The north-facing Coire an Loachain in the Cairngorm would have been covered in ice throughout the year.

Such low solar activity might also have affected the jet stream. As the Earth becomes cooler, the increased clouds and ice reflect the Sun's energy back into space, cooling the Earth further. Scientists call this albedo.

Other scientists think clusters of large volcanic eruptions triggered the cooling when ash in the atmosphere filtered out light from the Sun.

Solar activity events established from Carbon 14 fluctuations sampled from ancient tree rings (these reflect changing solar radiation).



ⓐ **AD 1280-1350 (720-650 years ago)**

The Wolf Minimum
A major famine occurs in 1315-1318 making the population vulnerable to the Black Death (1348-50) when a quarter to a third of Europe's population dies.

ⓑ **AD 1350 (650 years ago)**

The climate improves.

ⓒ **1450-1550 (550-450 years ago)**

The Spörer Minimum

ⓓ **1645-1715 (355-285 years ago)**

The Maunder Minimum
Scots are driven to emigrate to the Six Counties (Northern Ireland).

ⓔ **1790-1820 (210-180 years ago)**

The Dalton Minimum
A profound agricultural recession took place.

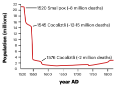
AD

1500 520 years ago

EPIDEMIC

Within 20 years of Columbus' arrival new diseases from Europe create several epidemics. This causes a massive population crash in the Americas.

Population Collapse in Mexico



With fewer people around the Amazon forest recovers. This may have led to a fall in atmospheric CO_2 levels.

MODERN AGE = 520 TO 170 YEARS AGO

AD

1550 470 years ago

EXTINCTION

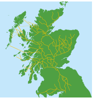
The beaver, a keystone species in aquatic ecosystems is driven to extinction by hunting for pelt and medicines, and by habitat loss caused by farming. This would have had a large effect on the natural environment.

AD

1620 400 years ago

WEALTH CREATION

Highland landowners began to be drawn into more commercially motivated activities.

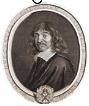


A network of cattle drove roads are established throughout the Highlands, taking animals to English markets. The Cateran Trail uses many of these.

AD

1649 371 years ago

SHIFTING WORLD VIEWS



René Descartes, the 'father of modern philosophy' argues (as had Plato) that we are different and removed from nature. He believes that only humans could think: "Cogito ergo sum" (I think; therefore I am).

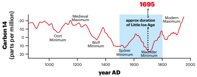
These ideas could have led to our sense of superiority and that nature is there for us to use.

AD

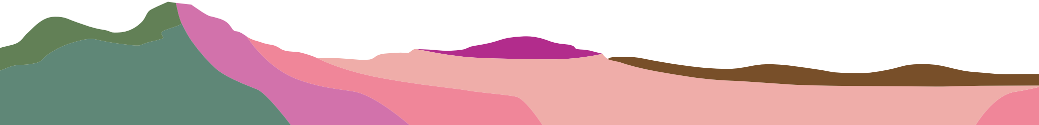
1695 325 years ago

COLDER

The middle of 'King William's III Years' is the harshest part of the Maunder Minimum. Summer temperatures drop around 0.5ºC. Crops fail and prices rise leading to rent arrears and famine in eastern Scotland. The Scottish population falls 13% due to higher mortality and emigration. This, in part, drives Scots to the Act of Union 1707.



Solar Activity Events established from Carbon 14 levels sampled from ancient tree rings.



MODERN AGE = 520 TO 170 YEARS AGO

AD

1750 270 years ago

POPULATION INCREASE

Scotland's urban population expands greatly.

Edinburgh became known as Auld Reekie due to the high levels of pollution from burning coal.

AD

1759 262 years ago

INDUSTRY

The Industrial Revolution begins in Scotland. The Carron Ironworks near Falkirk were founded with coal providing the fuel for iron smelting. This is the start of a huge increase in fossil fuel pollution throughout the west.

It also introduces very harsh working conditions.

In 1787 Rabbie Burns reacted to the Carron Ironworks thus:

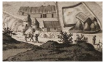
"We cam na here to view your warks,
In hopes to be mair wise,
But only, lest we gang to hell,
It may be nae surprise"

AD

1760 261 years ago

MIGRATION

An agricultural revolution begins in lowland Scotland as English farming practices are adopted. Farming methods such as enclosure and artificial fertilisers intensify productivity.



The rural population falls as people move to the cities.

AD

1763 257 years ago

EXTINCTION

After centuries of persecution, the last wolf in Scotland is reputedly killed. The loss of this keystone species will have had a large effect on the highland's ecosystem.

TURNING POINTS

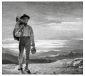
MODERN AGE = 520 TO 170 YEARS AGO

AD

1780 241 years ago

MIGRATION

‘The Lowland Clearances’ in the Perthshire hills begin a period of rural depopulation as people migrate to the industrial centres of Edinburgh and Glasgow and abroad to Canada and America.

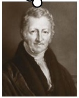


The introduction of sheep leads to overgrazing which in turn affects the biodiversity of native grassland.

AD

1798 223 years ago

SHIFTING WORLD VIEWS



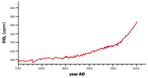
Thomas Malthus predicts that human populations will always be limited by food shortages. As he writes, he is proved wrong as the UK population rockets. The agricultural revolution and improved health care has lowered the mortality rate.

AD

1800 221 years ago

GREENHOUSE GASES INCREASE

Global atmospheric CO_2 levels are around 280 parts per million. Human made ‘global warming’ begins.



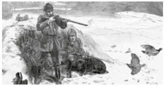
Measurements of CO_2 levels trapped in bubbles in an ice core from Antarctica.

AD

1840 181 years ago

EXTINCTION

Sporting estates devastate populations of mammals and birds. The osprey, goshawk, white-tailed sea eagle, red kite and polecat become extinct.



ANTHROPOCENE
= 170 years ago to now

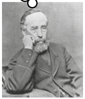
AD
1850 170 years ago

POLLUTION

Industrial pollutants in the air begin to fall across Scotland in high enough concentrations to affect soil health and biodiversity.

AD
1892 129 years ago

SHIFTING WORLD VIEWS



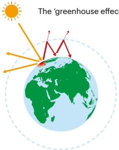
James Croll (born nearby at Wolfhill, Perthshire in 1821) develops a theory of the climate cooling and warming due to natural changes in the Earth's tilt and orbit around the Sun. His ideas were more recently developed by Milutin Milankovitch and are now known as Milankovitch cycles.

A pair of grey squirrels are introduced to Scotland around Loch Long. Within 25 years greys cover an area of 800 sq-km.

AD
1896 125 years ago

CLIMATE SCIENCE REVOLUTION

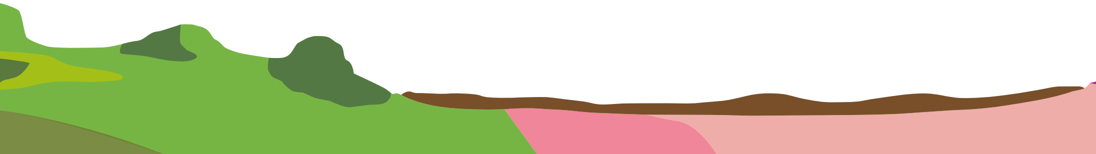
The 'greenhouse effect is first theorised.



AD
1911 110 years ago

SHIFTING WORLD VIEWS

John Muir, born in Scotland, heralds a return to understanding our interdependence with nature when he writes "When we try to pick out anything by itself we find it is hitched to everything else in the universe."



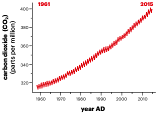
ANTHROPOCENE = 170 years ago to now

AD

1959 62 years ago

CLIMATE SCIENCE REVOLUTION

Charles Keeling begins high-resolution measurement of atmospheric CO_2 and proves the ‘greenhouse’ effect.



The wavy red line shows natural changes created by plant annual growth cycles. The increase over time is caused by human activities, especially the burning of fossil-fuels.

AD

1962 59 years ago

SHIFTING WORLD VIEWS

Rachel Carson describes the impact of pesticides in *Silent Spring*, one of the first warnings of our negative impact on the environment.

AD

1968 53 years ago

SHIFTING WORLD VIEWS

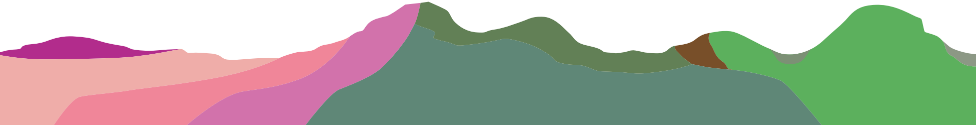
While in orbit around the Moon, Apollo astronaut William Anders photographs the Earth rising, showing how small and fragile our planet is.

AD

1970 51 years ago

WETTER

The ‘gulf stream’ conveyor starts to slow down as higher rainfall increases river flows into the Arctic Ocean.



ANTHROPOCENE = 170 years ago to now

AD

1972 49 years ago

SHIFTING WORLD VIEWS

A return to understanding our interdependence with nature begins as *Limits to Growth* by Donella Meadows and others is published.

AD

1987 34 years ago

CFCs OPTIMISM?

International action is taken to mend the hole in the Ozone layer caused by man-made 'CFC's'. These damaging chemicals are banned across the globe.

A few years later the hole stabilizes and begins slowly healing. It is expected to recover by 2070, thanks to the World's nations acting together.

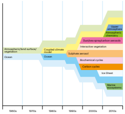
The Montreal Protocol
over 30 years of healing our ozone together

AD

1990 31 years ago

CLIMATE SCIENCE REVOLUTION

A revolution begins in our understanding of climate change. Improvements in computer technology and climate simulations massively expand our knowledge.



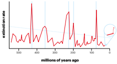
As computing power improves additional influences on global temperature and climate can be added to climate models.

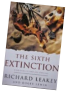
AD

1995 26 years ago

EXTINCTION

Richard Leakey publishes *The Sixth Extinction* describing a mass extinction and biodiversity collapse caused by us, potentially every bit as large as the previous five geological extinction events.





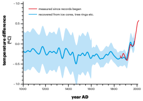
ANTHROPOCENE = 170 years ago to now

AD

1998 33 years ago

CLIMATE SCIENCE REVOLUTION

Three palaeo-climatologists publish what is called the "hockeystick" graph of changing northern hemisphere temperature in the last few centuries. This was among the first articles to show that post-AD1850 warming cannot be natural. It shows a rapid man-made climb in temperature over the past century.



AD

2009 12 years ago

SHIFTING WORLD VIEWS

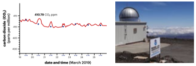
Nobel prizewinning Elinor Ostrom's research shows that local communities regularly devise rules (and ways to enforce them) that help stop the degradation of nature and ensure its stewardship for the common good as opposed to private gain.

AD

2019 2 years ago

GREENHOUSE GASES INCREASE

Global atmospheric CO_2 reach levels around 410 parts per million and continue to climb.



CO_2 reaches record levels at Muana Loa Observatory, Hawaii in March 2019.

WARMING

Air temperatures in Siberia and Canada jumped by several degrees Celsius in the previous two years. This would have been impossible under natural climatic conditions in an interglacial period – it is more like changes seen during glacial periods.

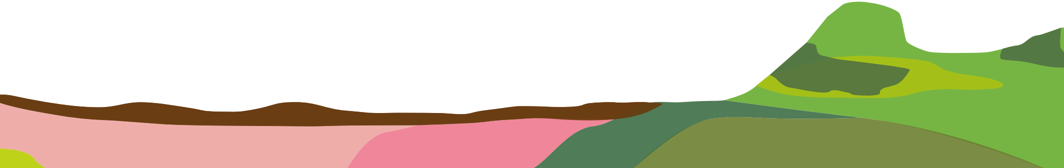
2021 NOW

GLOBAL WARNING

The Intergovernmental Panel on Climate Change publishes its report, hailing it a 'Code Red For Humanity'.

The UN Secretary General António Guterres warns "If we combine forces now, we can avert climate catastrophe. But, as today's report makes clear, there is no time for delay, and no room for excuses".

THERE IS NO PLANET B



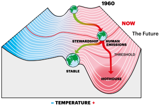
THE NEXT 10 YEARS

WILL WE USE THESE LESSONS FROM THE PAST TO SHAPE A BRIGHTER FUTURE?

As our timeline shows, over the last 20,000 years our Earth's climate changed naturally by small amounts.

People adapted by changing their livelihoods, migrating to more habitable areas and inventing solutions.

The past 60 years have seen large climate changes caused by human emissions of greenhouse gases. If this continues we will reach a stage where it will become impossible to reverse the damage.



TURNING POINTS

ROLL FROM THIS END

ROLL FROM THIS END

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Exhibition credits

Exhibition content: **Dr Richard Tipping**

Exhibition design: **Cavan Convery**

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With special thanks to **Murray Pennycuik** for allowing us to exhibit on this fence.

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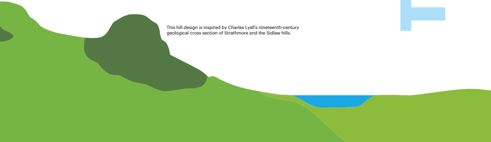

This hill design is inspired by Charles Lyall's nineteenth-century geological cross section of Strathmore and the Sidlaw hills.