

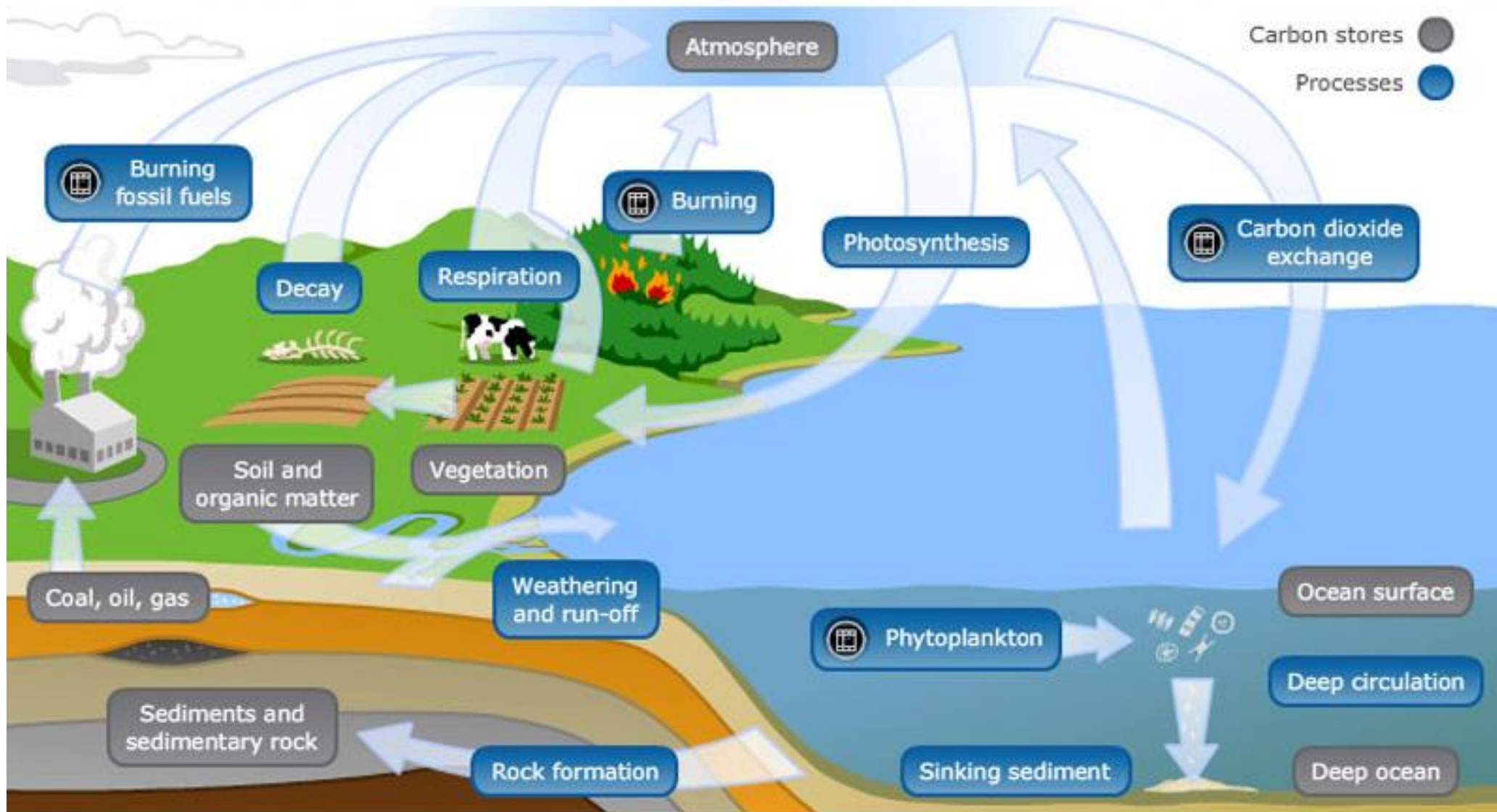
Chapter 2

The Benefits of the Soil Food Web

Lecture 14 - Carbon Sequestration and The Carbon Cycle

N.B. Numerical Data Included Herein are Estimates Based on Averages of Data from Various Sources
Provided by Jimmy Sinton, Fair Carbon Exchange

The Carbon Cycle



How Carbon Leaves the Soil

- Soil microorganisms release CO₂ through respiration as dead plant, microbial and animal biomass is decomposed.
- When the soil is tilled, the surface area of soil organic matter (SOM) accessible to microorganisms is greatly increased.
- However, other important soil organisms are crushed and torn apart, providing food for bacteria not-crushed by tillage.
- Bacterial blooms then occur as a result of increased oxygen levels, limited competition, and greater access to previously unavailable SOM. The increased bacterial populations consume the newly available food resources at great speed, thus increasing the rate at which carbon is released from the soil in the form of CO₂ gas.

Conclusion: Tillage is the main cause of Carbon leaving the soil

How Carbon is Measured

Soil Carbon

- Soil Carbon levels and Soil Organic Matter (SOM) are correlated – It is generally accepted that SOM contains ~50% Carbon.
- Soil Carbon is typically measured in Tons per Hectare (T/Ha)
- Methods for measuring SOM and Soil Carbon vary. The most reliable is the Combustion Method, that comprises weighing the sample, combustion, and then weighing again to establish the mass of combustible materials, which equates, approximately, to the mass of the Carbon content.

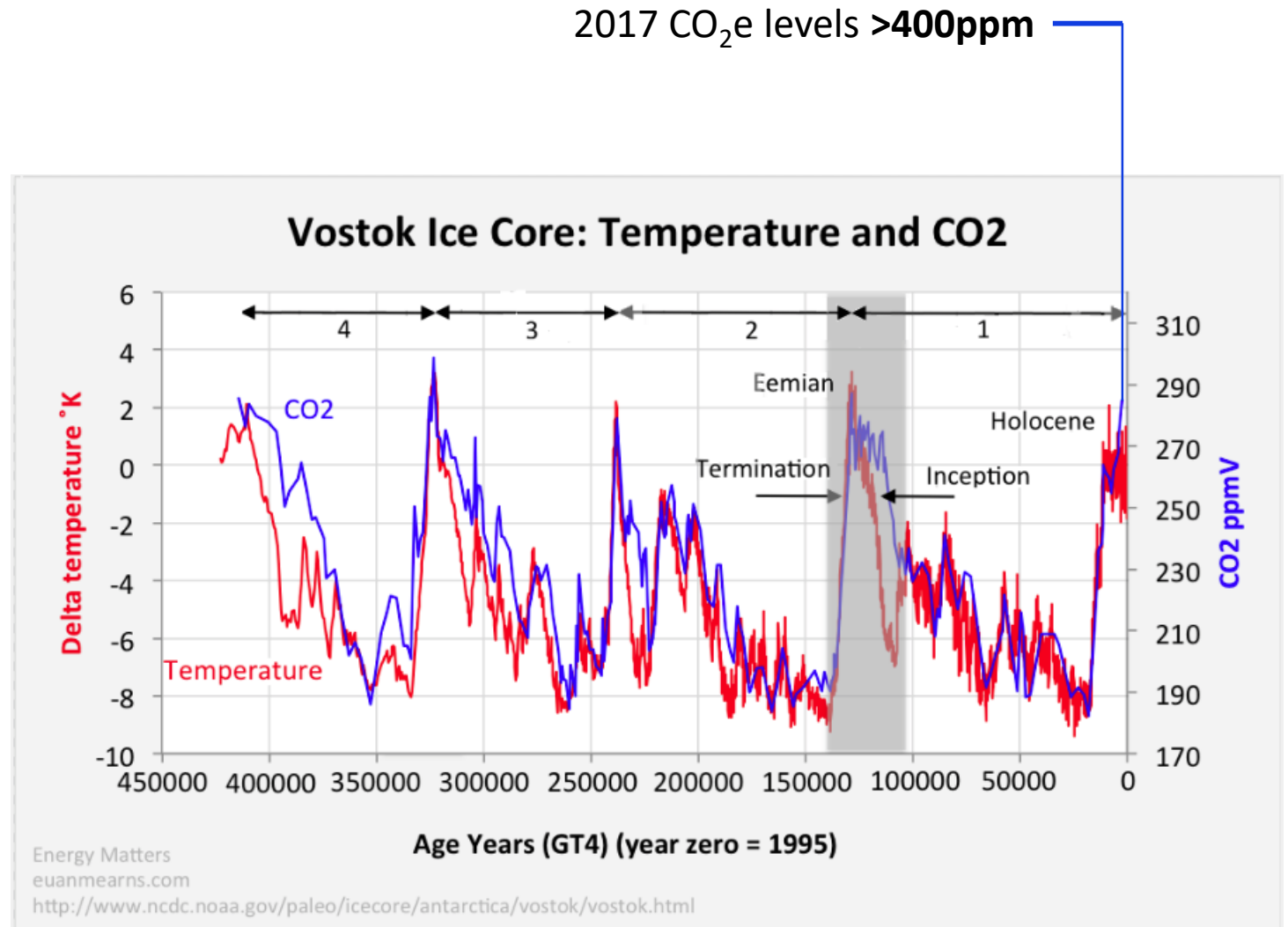
Atmospheric Carbon

- Green House Gasses (GHG) include CO₂ and many other gasses, some of which are more potent than CO₂ in terms of their Global Warming Potential (GWP) – the measure of how much heat they will trap in the atmosphere over a period of time.
 - e.g. Methane (GWP of 25*) and Nitrous Oxide (GWP 298*)
- For this reason, **CO₂ equivalence (CO₂ e)** is used as a general unit of measurement
- Note: 1T Atmospheric Carbon = 3.66T CO₂ e

[* GWP indicates heat trapping capacity relative to CO₂, over 100 years]

Climate Change – How big is the problem?

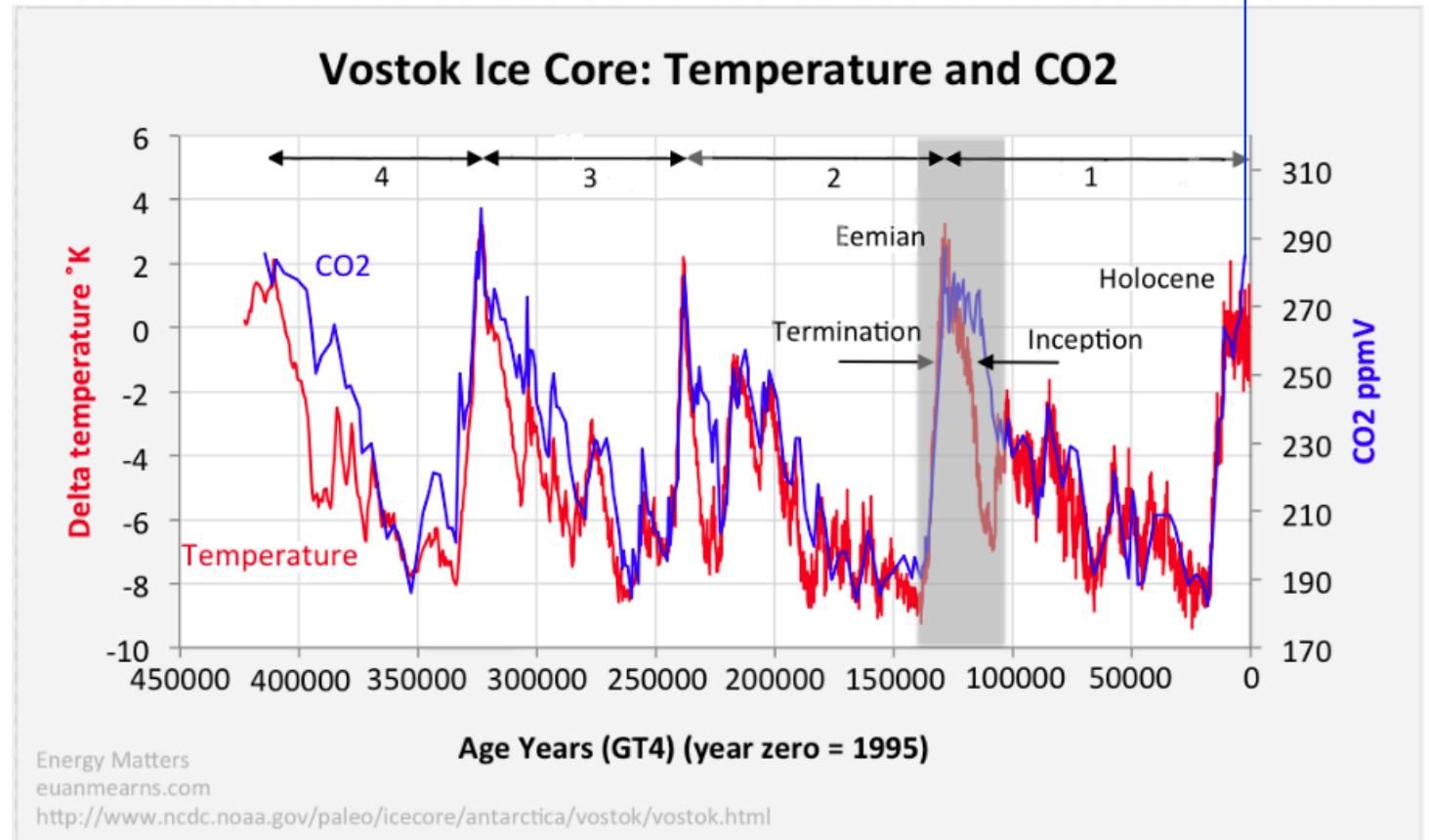
- The graph shows the correlation between Atmospheric CO₂ levels and Global Temperatures over the last 450,000 years, spanning 4 ice-age cycles.
- Current CO₂ levels are **completely off the charts** at over 400ppm. This level is over 30% greater than anything seen during the last ~3Million years.
- This represents a huge and very urgent risk to the survival of human civilization. Humans were not around 3Million years ago.



Climate Change – How big is the problem?

- If the temperature (red) line continues to follow the CO₂ (blue) line then we are looking at increases in Global temps. in excess of 6 degrees C. The IPCC has warned that just a 1.5 degree change would be catastrophic to humanity and many other species.
- Scientists have also warned that we must bring the CO₂ level down to 350ppm to have any chance of avoiding catastrophe. **Can this be done?**

2017 CO₂e levels >400ppm



Can this be stopped?

- Pre-industrial CO₂ levels were ~280ppm (2,100BnT CO₂e). In 2018 that figure is 410 (~3,000BnT CO₂e). This is an increase of 900BnT CO₂e, or approximately 42%
- Current annual global Green House Gas (GHG) emissions total approx. 18BnT (net of natural absorption factors).
- To get from 410ppm (current levels) down to 350ppm (the “safe” level) we need to sequester 60ppm or approx. 450BnT plus an additional 18BnT/yr to offset emissions.

Can this be done??

How GHG Changes Climate

GHG molecules absorb heat radiating back towards space from the Earth's Surface.

Energy from Billions of Hiroshima Nuclear Bomb Explosions Added to the Atmosphere.

Warmer air = Higher Humidity

This Doubles the Heating Effect

Because Water is a GHG.

Increased Energy = Increasing Instability = More Droughts and Floods



“4 Hiroshima Bomb Explosions per Second Since 1990”
Energy Added to the Accumulated Biosphere Energy Each Second

Source: <https://www.skepticalscience.com/4-Hiroshima-bombs-worth-of-heat-per-second.html>

The Soil Carbon Pool

How much of the Carbon in the atmosphere came from the world's soils?

- Estimates vary greatly. One conservative estimate: 133BnT has been released from the soils over the last 12,000 years, since humans transitioned from being nomadic to building settlements and *cultivating the soil*.
- The Soil Carbon Pool is currently approx. 2,500BnT
- So it's possible that we can put at least ~133BnT back into this relatively large Carbon Pool. This would be an increase of only **5.2%** in the Soil Carbon pool.

Could we put 450BnT (which would take us back to “safe” levels) into the soil? That would represent ~18% of the soil carbon pool.

Soil Carbon Sequestration Potential

At what rate can we pump Carbon into the soil?

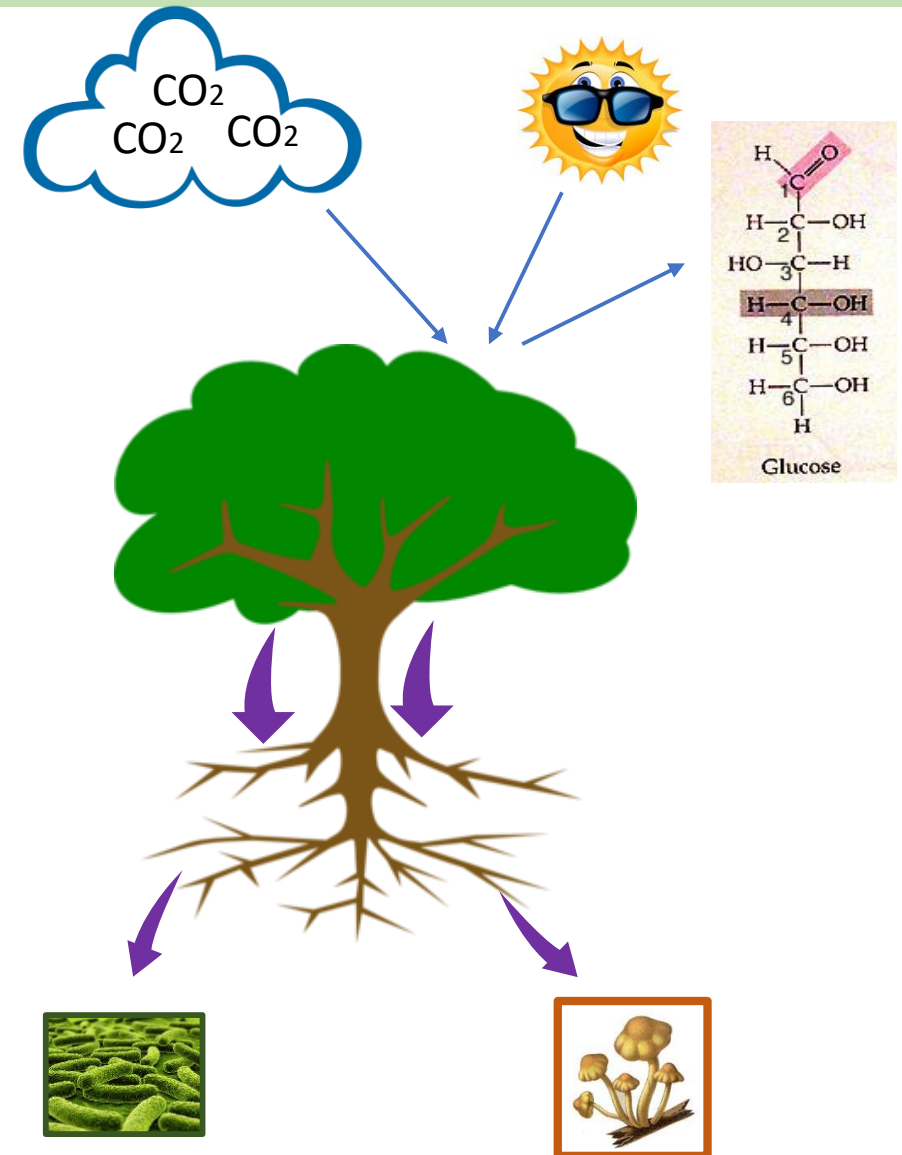
- Humans effectively manage ~5Bn Ha worldwide
- We are currently able to sequester upto ~10T/Ha/yr (Dr. Richard Teague)
[Whilst it may not be realistic to assume that we can achieve this on all soils today, this may be a possibility in, say 5-10 years, with further investment in research.]
- This equates to a maximum of approx. 50BnT/yr
- Current net Global Emissions are approx. 18BnT/yr
- That leaves ~30BnT/yr in additional sequestration – working towards Climate Change reversal. To sequester 450BnT (thus getting us to “safety”) that would take ~15 years, assuming we transitioned all the world’s soils tomorrow. Factor-in reductions in emissions and the prospects become a little more optimistic.

Conclusion: Soil Carbon Sequestration can be VERY impactful!

The Carbon Pump: Atmosphere to Soil

How Does Soil Carbon Sequestration Work?

- Atmospheric CO_2 is absorbed by plants during photosynthesis and used to produce *exudates*.
- The exudates feed microorganisms which then multiply and form a symbiotic relationship with the plant.
- *Fungi* can store Carbon in their hyphae for hundreds of years.



Permafrost & The Methane Cycle

- Methane gas has a GWP of 25 and is therefore a very potent Green House Gas.
- It is released in very large quantities from areas of the world where the permafrost is melting - caused by rising temperatures.
- This sudden melting results in pooled surface water, and anaerobic conditions below.
- Anaerobic microorganisms then digest the Soil Organic Matter beneath the water, thus releasing Methane gas.
- Experiments have shown that this can be greatly mitigated by introducing certain kinds of aerobic microorganisms.