

Strategic Analysis Paper

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Photosynthesis and its Role in Climate Change and Soil Regeneration

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Key Points

- Photosynthesis can be considered the fundamental life process for nearly all plants and animals. It provides the source of energy that drives all their metabolic functions and the oxygen required for respiration.
- Photosynthesis can be critical to mitigating the climate changing effects of atmospheric greenhouse gasses and the restoration of soil organic matter promoting regeneration.
- It is estimated 150 – 200 billion tonnes of soil organic matter has been lost over the past century.
- With the implementation of the appropriate management practices, soil organic matter content could be restored to pre-industrial agricultural levels within 50 years.

Summary

Photosynthesis is the chemical reaction by which plants manufacture food in the form sugars such as glucose and sucrose, from carbon dioxide (CO²), water and sunlight. Both animals and plants manufacture complex fat and protein molecules from these sugars; thus glucose can be described as the basic energy source for all living organisms. The oxygen released (with water vapour) as a photosynthetic by-product, provides most of the atmospheric oxygen vital to respiration in plants and animals. Animals in turn produce carbon dioxide necessary to

plants. Photosynthesis can therefore be considered as the ultimate life process for nearly all plants and animals by providing the source of energy that drives their metabolic functions.

Furthermore, the role photosynthesis plays in the natural environment, by absorbing atmospheric CO² may well be essential to mitigating the climate changing effects of atmospheric greenhouse gasses (GHG).

By combining the reestablishment of plant communities with other management measures required to reduce soil loss, photosynthesis can nurture soil health by promoting an increase in soil organic matter and, thus sequestering atmospheric GHG and promoting food production through soil regeneration.

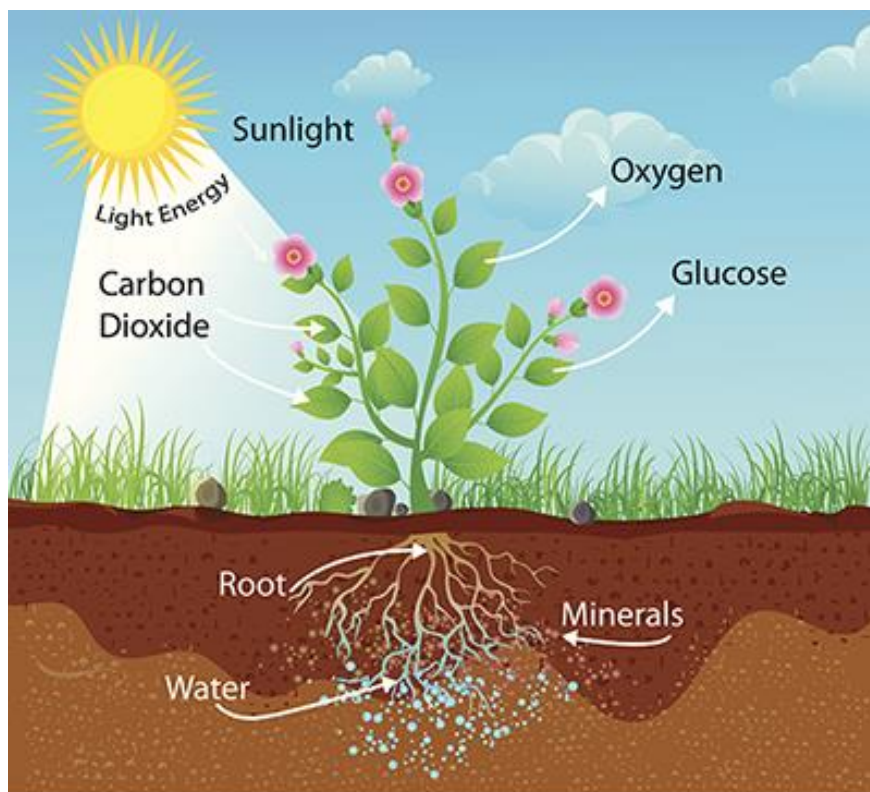


Figure 1: The photosynthesis process. *Source: Squizzes.com*

Analysis

Photosynthesis – Carbon Dioxide into Carbon

Photosynthesis is the biochemical process by which plants convert CO², water and sunlight (generally in the presence of the green pigment chlorophyll) into chemical compounds of carbohydrates, glucose, fats and proteins from which the plant derives its food. Photosynthesis produces oxygen as waste, which is released to the atmosphere through the plant leaves (termed respiration). Plants release some carbon during photosynthesis but a significant proportion is retained and stored in live woody tissue to be utilised for new cell formation and energy. When a plant dies, the absorbed carbon is locked in the slowly decomposing biomass and soil organic matter that is the remains of the dead plant.

Photosynthesis in the Aquatic Environment

Photosynthesis also occurs in the aquatic environment. Aquatic plants and algae use CO², water and sunlight to make their own food in the same way terrestrial plants do. The oxygen by-product of this process is continuously being released into the world's lakes, oceans, rivers and ponds to be breathed by fish, algae and bacteria.

Unlike the terrestrial environment, however, atmospheric CO² dissolves in the surface waters of the ocean where photosynthesis by tiny marine plants (phytoplankton) process it into organic carbon. While some of the carbon remains as dissolved gas, much of it is turned into other chemical compounds to be incorporated into marine organisms as structural calcium carbonate, a building material of shells and skeletons.

When aquatic organisms die, their dead remains sink into deep water and decay to be absorbed on the sea or lake floor where it forms layers of carbon-rich sediments.

Photosynthesis and its Role in Climate Change

The amount of atmospheric CO² absorbed by plants through photosynthesis is enormous. The process is therefore critical to mitigate the effects of GHG. Plants have the ability to absorb and in turn sequester enormous amounts of carbon over the long term. Much of the excess atmospheric CO² is the result from the burning of fossil fuels. In 2012 it was estimated [nine billion](#) tonnes of CO² are annually released in to the atmosphere from fossil fuel consumption. This figure continues to grow.

Critical to reducing carbon is the natural process of photosynthesis in plants. Old-growth forests containing large dominant species of perennial trees are critical to reducing the effects of climate change because they are able to absorb, capture and store enormous amounts of carbon. For example, a tree in a primary or old-growth forest has the capacity, in its lifetime, to absorb CO² equivalent to the carbon released by a car driven 42,000 kilometres.

Primary or old-growth forests are considered one of the world's largest sinks of atmospheric carbon. Forests account for [50 per cent of plant productivity](#) and they still cover 30 per cent of Earth's land surface. Unfortunately, the destruction of old-growth forests for land-clearing and commercial (and sometimes illegal) purposes is continuing globally. In some parts of the world the loss rates are increasing. Not only does this plant loss result in less photosynthesis, the deforestation releases the stored carbon to the atmosphere. Accordingly, some governments are planning and implementing the inclusion of plant based strategies to ameliorate the effects of climate change. These activities include tree planting, landscape greening programmes, agroforestry and regenerating native grasslands and grassy woodlands. Large-scale operations of this kind are necessary in order to tap into photosynthesis as an agent for climate change reduction.

Photosynthesis and its Role in Soil Regeneration

Soil regeneration, broadly defined, focuses on applying processes that change the structure of soil, to enable a quantitative and qualitative improvement of top soil. Many of the associated practices enhance soil health by increasing soil organic carbon. The presence of soil

organic carbon promotes nutrient availability, water retention and the movement of water through the soil. Soil regenerative strategies comprise a range of restorative actions and mechanisms that are normally applied in unison and rarely singularly. They may include aeration by tillage (note that excess tillage can be detrimental to the soil), the application of appropriate amounts and types of fertiliser and other 'soil amendments' and mulching with compost to create humus, the component of soil derived from decomposed plant and animal remains and excrement, that improves the water-retention in soil and makes it more workable. An added strategy becoming increasingly common in soil-regeneration practice is to incorporate and integrate managed programmes of rotational cattle grazing designed to stimulate roots and development of sub-soil biological communities as well as producing green manure or growing plants which are ploughed back into the soil.



Figure 2: Australian eucalypt forest. *Source:* Ashley Groome

Research concludes the world's topsoil available to farming is being depleted of nutrients and is subsequently eroding. The erosion is being caused through a regime that includes extensive mono-cropping over long periods of time, over-tillage and in some countries [fire](#), to manage crop residue and associated problems such as pest and weed infestation. The reliance on harmful nitrate and phosphorus-based synthetic fertilisers and pesticides combined with their long-term residual consequence of destroying the soil, compound the mechanical affects, all of which lead to erosion. At current rates, [Australian](#) scientists concluded that 40 per cent of topsoil is degraded or eroded away as a result of poor and unsustainable farming methods that weaken soils and remove carbon. Soil loss is currently between [10 and 40 times the rate](#) at which it can naturally regenerate. The factors that govern rates of soil regeneration include climate, geology, the base material's ability to retain nutrients and other components

essential for fertility. The presence of soil-borne microorganisms that aid the process of decomposition is also fundamentally important.

A key to soil regeneration is the establishment of plant communities. Plants are vital to soil health because as plants grow their roots penetrate and bind the soil. The binding enables and facilitates microbial action that further adds to the soil structure, thus providing water retention and the exchange of nutrients and naturally occurring chemicals which promote plant growth and development and reduce disease. Importantly, during the photosynthesis process carbon is added (sequestered) in the soil and, when the plant dies, nutrients are introduced through decomposition of roots, stems and leafy materials.

The soil regeneration process can take many years. The time period will depend on the environmental conditions and the degree to which the soil has been degraded.

Farming and Agriculture Can Help to Mitigate Climate Change

Measures intended to mitigate climate change must incorporate a wide range of mutually supporting practices. Such strategies cannot only target the loss of primary or old-growth forest. They must include the re-establishment of plant communities to increase global rates of photosynthesis and the sequestration of carbon in the soil. This includes existing and future agricultural land.

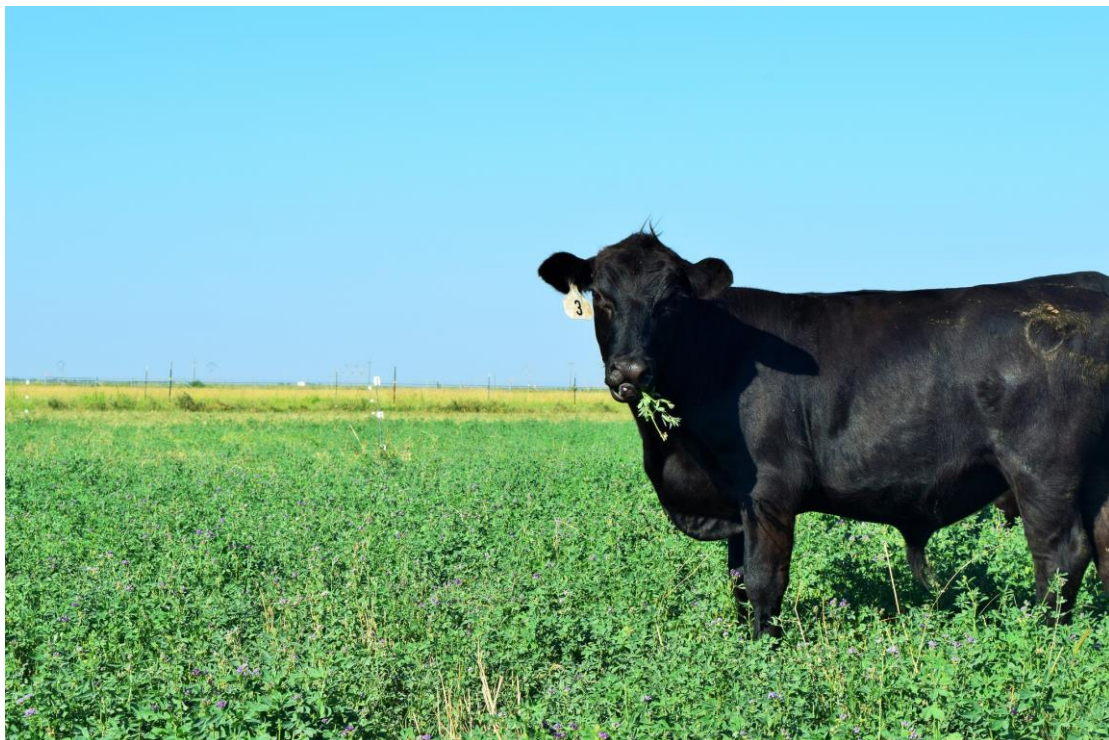


Figure 3: Cattle grazing on alfalfa cover crops. *Source:* Southern SARE

It has been estimated that poor agricultural management practices have caused a loss of between 30 and 73 per cent of soil organic matter during the twentieth century. This has resulted in a loss of soil fertility and subsequent lost productivity. A further consequence has been the release of additional CO² GHG into the atmosphere.

In many parts of the world, however, farmers are adopting 'climate smart' agricultural practices by moving from a land clearing strategy to sustainable and equitable food production which, in turn, enhances food security. The changes result from better soil management from undertaking soil regeneration and improvement, reducing dependency on the use of inappropriate quantities of chemical fertilisers that contain harmful [nitrates and phosphorous](#). Correspondingly, farming practices in [Australia](#) are moving towards 'precision agriculture' which incorporate applying the right amounts of organic fertilisers and manure in the right place in the right amount, leading to less waste of time and money and the potential for over use. Global positioning and digital technology combined with zero or low-tillage and direct-injection seeding, and crop rotation incorporating cover crops, is resulting in greater efficiencies and enhanced crop production.

The introduction of precision farming techniques, a tool in increasing use as a contributor to soil regeneration, is introducing [grazing stock](#) to graze on cover crops for short durations of time. This practice has the effect of breaking plants down and re-directing the energy to producing organic matter below ground, allowing new plants to emerge, as well as adding green manure: the biological activity in the decomposing organic waste matter enhances plant protection against pests and diseases further resulting in improved soil fertility.

A gradual change in agricultural practices is resulting in improved soils from farming efforts that focus on building soil organic content. Those efforts are evidenced by an increasing use in techniques that incorporate varied cropping regimes, integrating crop production with grazing cattle, maintaining soil structure and from photosynthesis through planting and establishing communities of perennial trees, shrubs and herbaceous plants.

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