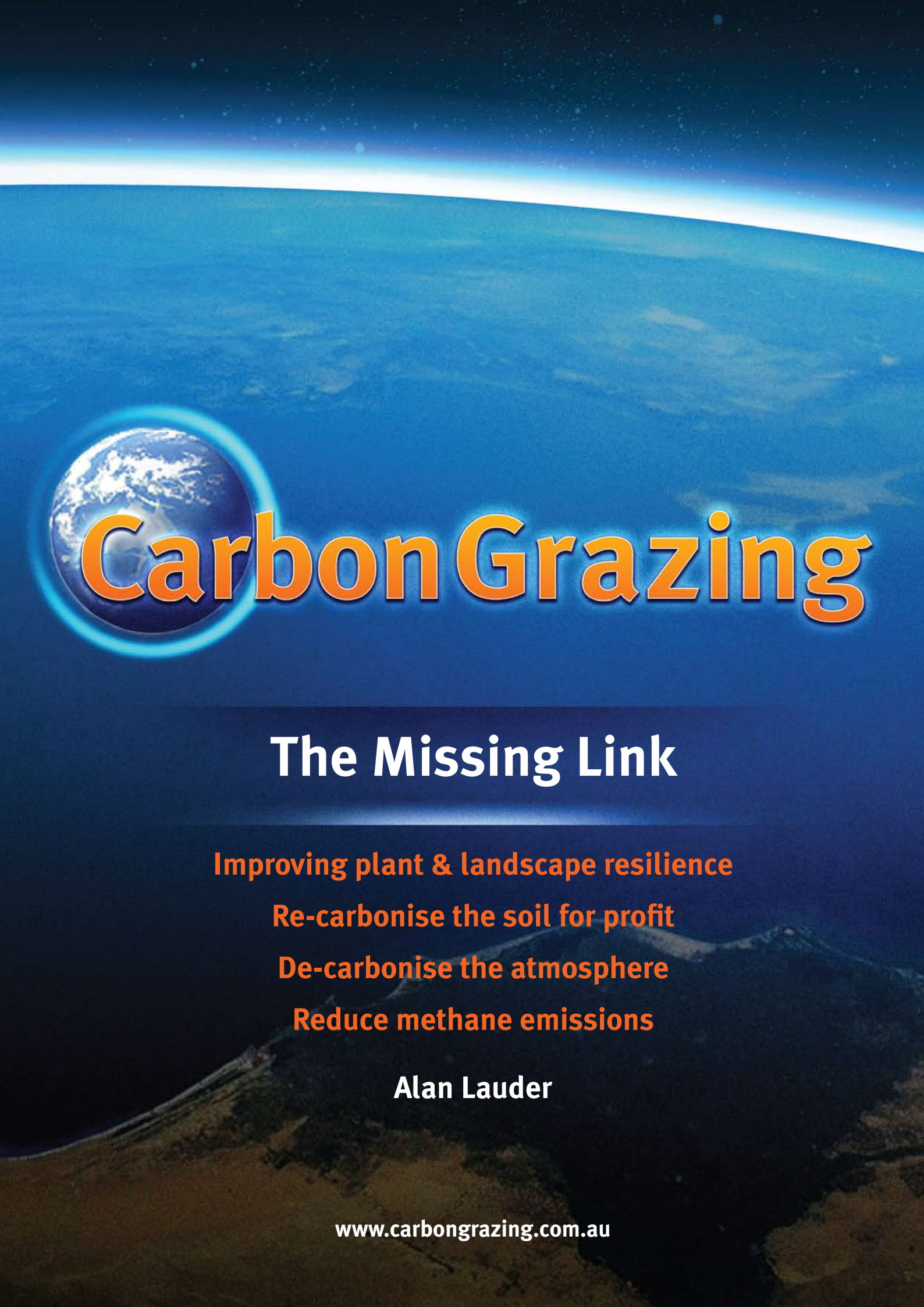

The Missing Link

Improving plant & landscape resilience

Re-carbonise the soil for profit

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Alan Lauder

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CHAPTER 7

ENERGY FOLLOWS CARBON

We normally think of energy in relation to keeping tractors moving, or light bulbs on, but this is only part of the story. Energy is needed by and stored in everything living, regardless of its complexity.

This statement brings us back to the earlier discussion on photosynthesis. It is the plants that catch the energy of the sun and store this energy by forming carbon compounds. This energy is then passed along the two food chains "through consumption". The energy of the sun is stored in carbon compounds in plants, and released through digestion.

In one sense, the food chains can also be seen as energy chains as we are about to discover. We have already established that they are carbon chains.

UNDERSTANDING ETHANOL FIRST

Until faced with the pending energy crisis and all the issues of global warming, for most, fossil fuels were seen as one debate and plants were seen as another. Now plants are being linked to energy via the ethanol debate. As the two debates join, it is the ethanol debate that is better allowing people to understand the linkage between energy, carbon and plants.

In promoting the need for renewable energy sources, one solution is utilising the energy contained in plants. This is referred to as using bio-mass as an energy source.

Ethanol is the current energy from the sun which is trapped by plants through photosynthesis. Oil and coal are the past energy of the sun, which was initially introduced into the landscape by plants. Then over time it transformed into these fossil fuels.

Jose Luiz Oliverio of Brazil recently explained the enthusiasm for plant-based fuel when he said, "Ethanol from sugarcane is good utilisation of biomass, with one hectare of land in Brazil able to produce 7,000 litres of fuel."

Carbon can be in a liquid, a solid, or a gaseous form and still release energy in the form of heat when it is burned. This requires oxygen, just as releasing energy via respiration also requires oxygen.

We are completely reliant on plants because of their carbon processes. Carbon from plants has always been responsible for our internal and external energy needs. Prior to our modern, carbon-based industrial economy, which is based on fossil fuel, whenever wood was burnt, it was the carbon molecular structures (bonds) in the wood that were responsible for producing the required energy. Steam engines relied on the energy contained in wood to make them function.

To put the energy debate into the context of this book, remember that energy and life go hand in hand. The significance of this relationship is that all outputs of rural production are dependent on living things.

PLANT CARBON ENERGY PROVIDES LIFE TO THE FOOD CHAINS

Now that fuel has been discussed it should be noted that we also rely on plants to pass the energy contained in their carbon compounds along the food chains. Energy is extracted from carbohydrates (produced during photosynthesis) by both animals and soil fauna, through digestion.

Energy is the fuel which keeps all processes and life functioning. The storage of energy in living organisms always involves carbon (ie carbon compounds). Carbohydrates are all about the energy we need in food. Digesting carbohydrates provides the energy required to keep our body warm plus the energy needed for movement.

UNDERSTANDING LIFE

In the chapter "putting carbon into perspective", the statement was made, "life is carbon based". It is important to fully understand the concept of living, because then we are capable of understanding what is required for life. The best way to appreciate the extent of life, is to think of what dies. Plants die, animals die, fish die, worms die, and so do the minute soil microbes that we cannot see. The billions of microbes in a cow's stomach (rumen) die. Life comes in all sizes and shapes, and doesn't have to contain blood to constitute life.

We ask the question, is there life on Mars? Not the question, are there animals on Mars? The two food chains are all about the different forms of life. Nothing can live in isolation. Everything living relies on the other living things around it.

All living minute microbes eventually die or are consumed, and in the process, return the resources they contain back to the system. Pushing up daisies is a comment that offends some, but it is a reminder that the basis of life is always becoming available to another form of life. We consume carbon compounds and excrete carbon compounds, so carbon continues to move while we are alive and even when we are dead.

It is critical that we think of the whole landscape as living. This allows us to appreciate that we are managing a collection of living things, which are on the outer shell of a non living structure, called earth. We are not just managing commercial animals. The oceans are the remainder of the earth's shell and they are living also.

WHY ENERGY FOLLOWS CARBON

To better understand why energy follows carbon, we need to return to the process of photosynthesis and look at it in more detail.

The earlier discussion on photosynthesis was more focused on plants storing carbon from the atmosphere to make it available for the construction of the bodies of all living things in the food chains.

Now we need to look closer at how the energy of the sun is actually stored by plants.

$6\ CO_2$	+	$12\ H_2O$	+	Light	=	$C_6H_{12}O_6$	+	$6\ O_2$	+	$6\ H_2O$
Carbon Dioxide	+	Water	+	Chlorophyll	=	Carbohydrates (Glucose)	+	Oxygen	+	Water

During photosynthesis tiny organs inside plant leaves work like solar panels converting sunlight energy into chemical energy. The energy of the sun is required for the chemical reaction to remove the carbon from carbon dioxide. The energy is also used to split water molecules into hydrogen ions, (electrically charged hydrogen) and oxygen. The oxygen from water and carbon dioxide becomes part of what we breathe.

The hydrogen ions are combined with carbon as part of the new molecular structure of carbohydrates contained in plant parts. The energy of the sun is stored in the new molecular structures that carbon forms. Photosynthesis and water build these higher energy compounds by rearranging them. Carbon dioxide is converted into carbohydrates. When we look at the formula of carbohydrates, we note that hydrogen is combined with the original carbon atoms.

The carbon hydrogen bonds contain more energy than the carbon oxygen bonds. The amount of energy contained in different chemical compounds comes down to how many bonds it takes to form a structure. There are more bonds required to hold together the carbohydrate structure than the carbon dioxide structure. Wood has more bonds than grass, so contains more energy. This is why more heat is given off by burning wood than grass. Sometimes this whole concept is referred to as **construction of energy**.

To better understand the relationship between carbon and energy, burn a dead tree, which is 50% carbon. The heat given off is stored energy from the sun, which was gained via photosynthesis as the tree grew; likewise, the heat given off when grass burns. It is the energy of the sun that changes the form of carbon through photosynthesis, and this same energy is given off when carbon returns to the original molecular structure of CO_2.

To make this discussion relevant to the journey of this book and part of a practical debate on what rural producers are trying to achieve, we need to associate the different combinations of atoms linked with carbon to the food chains that rural producers are really managing. Rural producers are managing the rearrangement of atoms until they get them into the form of cattle or sheep, and then they sell them. They send carbon compounds to market. Grain producers sell a high energy carbon compound. Feedlots move the carbon even further along the food chain when they feed grain to cattle.

Later we will investigate how good carbon management invites more nitrogen (protein) into the process to maximise production.

Every time a molecular bond is built, it takes energy and every time a molecular bond is broken, energy is released. This is one of the fundamentals involved in the process of photosynthesis and all the processes of consumption that occur in the two food chains.

ENERGY RELEASED BY DIGESTION

Just as we store water in a tank and then put it into another container to transport it to where we want it, so energy is stored and then transported around the landscape. The carbon compounds have energy stored in them. To get the energy out of these carbon compounds, all forms of life, large and small, rearrange them. The carbon compounds are rearranged during consumption.

Energy is extracted from carbohydrates by animals through digestion. When carnivores digest herbivores, energy is released as well as supplying carbon for building the body of the carnivore.

The next step is to link respiration to digestion (consumption), which is mentioned in the chapter on the two food chains. Respiration is the process that releases energy; this is the issue of oxidising the carbon back to a simpler compound of fewer bonds that contain less energy. This is the process of removing and using the energy contained in the more complex carbon compound.

During respiration, the produced pair from photosynthesis (O_2 and reduced carbon) are reunited to yield energy. Remember that it took the energy of the sun to rearrange the carbon atoms during photosynthesis. Now this same energy is being released when we go back to the carbon dioxide form of carbon. When carbon and oxygen join to form CO_2 the scientists say carbon is oxidised. Rust is iron being oxidised. When nitrogen joins oxygen to form the greenhouse gas nitrous oxide (NO_2), it is said that nitrogen is oxidised.

The reason humans need to breathe in oxygen is so that we can oxidise the carbohydrates in our diet and get the energy out of it to stay warm, move and maintain all body functions. It is in the lungs that oxygen is sent to the digestive process and carbon dioxide is removed from the blood following the digestive process. Not all living things are warm blooded like us, but they all need energy to function.

Fire is the non living consumption of plants, but still requires oxygen. Compared with fire, energy in carbon compounds is released in a more controlled way in the process of respiration.

The purpose of having this energy debate is to fully appreciate the significance of correct pasture management, ie managing so that plants are able to maximise energy collection through photosynthesis and then make it available to the food chains.

Although energy follows carbon, and is responsible for all living things on earth, the carbon cycle is never presented as the energy cycle, as processes like evaporating or freezing water require energy to occur.

OTHER ENERGY ISSUES

The highest energy level of a plant is contained in the grain, as this energy is needed for germination before photosynthesis can occur. Energy is also needed for the plant to rise out of the ground following germination.

When we consider the diet of animals, we look at the level of protein and the level of energy required. Metabolisable energy (ME) is the amount of energy or fattening ability in a feed. Protein is needed for tissue growth, but can be used as an energy source by some organisms.

Solar energy is conveyed underground mainly by plant roots, with some by litter and manure as it is incorporated into the soil. This energy transfer is necessary for a biologically active soil community.

Composting is another process which releases the energy stored in plants. Compost gives off heat as it decays. The heat generated in a compost bin is generated by bacteria as a by-product of their digestion. Composting is changing the carbon compound back to the form it was before photosynthesis (ie CO_2).

WOODY SHRUBS ARE ANOTHER BIO-MASS SOURCE OF ENERGY

Woody shrubs could potentially have a higher net energy value for ethanol production than annuals, as energy is not expended to plant them each year. This would all depend on the efficiency of being able to remove the energy from them in a broadacre situation. The energy would be harvested by cutting them off, and they would restore energy by growing back to full size.

CONCLUSION

The "living world" can't function without energy. The storage of energy in all living things always involves carbon. The sole source of all energy is the sun (solar power). Plants are a store of energy, and this energy is stored in the more complex carbon compounds that are formed as a result of the photosynthesis process. The energy of the sun rearranges the atoms and the new carbon compounds contain more energy than the CO_2 (carbon dioxide) form. It is the plants that store the energy of the sun for all other members of the two food chains to use. Everything is reliant on the energy of the sun, "which is why plants are critical to our very existence". Plants are the mechanism through which the energy of the sun becomes available to us. Without plants, life on earth as we know it would not exist. In the oceans, it is the plankton that store the energy of the sun to pass on to other living things. Managing plants correctly is all about maximising the collection of energy.

"I HAVE FINALLY GOT TO RE-READING CARBON GRAZING. HOW DIFFERENT IT IS ON THE SECOND READ. I AM CAPTIVATED AS YOU REVEAL THE "SECRETS" OF GOOD GRAZING MANAGEMENT."

...SHANE JOYCE, GRAZIER, THEODORE, QUEENSLAND, AUSTRALIA.

"ALAN HAS THE GREAT ABILITY TO THINK ACROSS SCALES FROM THE MOLECULES INVOLVED IN CARBON FIXATION, THE GREEN PICK NEEDED FOR SHEEP AND CATTLE DIGESTION, TO THE GLOBAL CHALLENGE OF CLIMATE CHANGE."

...DR DAVID FREUDENBERGER, FORMER CSIRO SCIENTIST, CANBERRA, AUSTRALIA.