Given your goal is to achieve change on the ground, can I start by saying, it is human nature that how people see the world, influences the decisions they make. For this reason, achieving change relies on helping people see the world differently. My talk will focus on presenting new information to producers so that they see their paddocks differently.

It will focus on the carbon flows concept. Please don’t think I am about to talk about the carbon cycle. The carbon cycle diagram is a one dimensional discussion. It goes no further than saying that carbon cycles. It simply discusses the different pools carbon moves between.

The carbon flows concept, discusses the role of carbon as it keeps moving through the paddock, above and below ground, including through livestock. The concept explains what carbon does as it moves and the processes it activates, before returning to the atmosphere. It highlights that carbon is the organiser as it flows through the landscape. It discusses the different speeds of carbon to help producers focus on what matters most.

It goes into how management increases or decreases the flow of carbon through paddocks. It identifies feedback loops, such as why the level of current flows is influenced by the management of previous flows.

With carbon flows, once you visualise the flows, you see the dynamics of the whole system and how it functions.
The Carbon Grazing principle, which I will discuss later, relates to maximising carbon flows from what rain does fall. It links decision making to the level of carbon flowing in the first phase of carbon flows. The first phase being when carbon is initially introduced to the paddock as part of plant growth.

Because you guys are literate in the area of land management, I will be skipping a lot of detail I would explain to producers.

A CSIRO scientist commented to me, that in the event of better information being made to available to producers, BMP may alter how it assesses properties in the future.

He said that what is currently assessed as A grade country might be assessed as B grade, if there is actually more potential in pastures than we currently realise.

I know that Grazing BMP is simply a benchmarking tool and not an educator. However, the outcomes of the BMP process is limited to the content of the resources you suggest that graziers utilise.

Today I am going to make the case for a new resource that Grazing BMP and other processes could call on. It would be based on the carbon flows concept.

All of you here want proof that this is a good idea, so I will start with the outcomes of a producer who changed his management, after grasping the carbon flows concept.

I want to share the main points of a presentation by cattle producer Stephen Martin. He gave it at a workshop convened by the Queensland Department of Agriculture at Boggo Road last year (30 October 2014). Steve’s family has been on the same property at Gladstone for generations. What he discovered was that the potential of the property was greater than previous generations thought. He also observed that a lot less water was running off his paddocks. He had photos to back up everything he said.

I quote what Steve said:

1. Increased carrying capacity (Was 130, now carrying the equivalent of 190 adult cattle). That is a 46% increase.
2. Improved calving rates – Now around 80%, was 40-50%
3. Quicker pasture recovery following dry periods
4. Getting a greater number of stock to market in a shorter period of time.

He said, “The light bulb moment for me was visualising the flow of carbon through the landscape.”

He also documented improved soil moisture.

“In November 2012 we had about 30mm of rain spread over 3days. I sampled the top 100mm of
The samples were taken after 3 fine days. I made no attempt to remove any root matter but did skim the grass off the surface to prepare the site prior to sampling.

The neighbour’s side had 13.6% moisture whilst my side had 17.6% moisture. I have assumed a value of 1.6t/m² for the density of the topsoil. This means that there is an extra 6.4 litres of water per square metre in the top 100mm in my paddock.

He then commented on Reef rescue.

“Three years ago, I became involved in a Reef rescue project run by the Burnet catchment care association.

The objective of the project from a reef rescue perspective was to reduce erosion and minimise runoff that would ultimately get to the reef.

I spoke to 2 extension officers about the process of improving soils and pasture growth. Whilst they were knowledgeable people and could talk about soil profiles, water contents, root growth, stocking rates and grass cover, neither appeared to know about the carbon flows that were happening in the process.”

During personal communication, Steve communicated that apart from improved financial outcomes, he now has better control of his destiny and is not suffering human stress the way he did before with dry spells. He said that the person who made him aware of Carbon Grazing and loaned him the book is also achieving much better outcomes.

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**Difference between stocks and flows**

To understand the difference between the concept of carbon flows and carbon stocks, any carbon that is flowing through the paddock at the time of measurement, is recorded as a stock.

Carbon flows are ongoing while carbon stocks are a measurement at one point in time.

Carbon stocks at the time of measurement are called short term (labile), medium term and long term.

Carbon flows involve virtually no long term carbon.

Long term carbon does flow but at an incredibly slow speed, which is why it has little involvement in carbon flows.

Management of carbon flows relates to current decision making. Carbon stocks relate to past decision making. A paddock is dynamic, not static.

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The natural world can’t function without carbon flows

I only put this slide up to convince you that graziers really do need to be thinking carbon flows when they are making decisions. It is flowing carbon that keeps the whole landscape functioning. Without carbon flows, paddocks would be bare and lifeless.

Rural profits and Reef protection are directly linked to management of carbon flows.

I know you have a constant struggle getting people to think differently.

Is it likely that a landholder would link the different outcomes on each side of the fence to different carbon management? Or more specifically, different management of carbon flows in both the short term and medium term.
The right hand side of the fence is a grazing paddock, not a farming paddock. Look at the surface water right up to the fence and nothing on the other side. I will return to this image later and explain why the outcome is more than just soil structure.

Nobody knows better than you guys, that at a paddock level, we have to stop water getting together in volume and gathering speed. As that is when it collects top soil and gouges out gullies on the way to the Reef.

Producers want to be shown things they can relate to, not a scientific discussion. Also, information has to be seen as relevant to what they do before they will show any interest.

I will now show you one example of how I approach producers to convince them of the logic in thinking carbon flows when making decisions. The pictures will demonstrate carbon flows in action in a paddock. I used the approach recently when speaking to producers on the five main Hawaiian islands.

The following images will demonstrate how increasing the amount of carbon moving through a paddock, led to a long term claypan turning into productive country. The images will help you understand the important processes that carbon activates. You will note I used the word moving, not sequestration. Why I make this point will become clear later.

This slide is about restarting carbon flows. It is an extreme example to highlight that functional landscapes rely on carbon flowing through them.

This is a long term claypan, where the soil component of resilience had failed years ago. This is planting a source of carbon flows, when nothing could establish naturally from seed to do the job.

The left hand image is Old Man Saltbush 12 months after seedlings were planted. The second image is another year later. Sheep are responsible for the lack of leaves on the saltbush as they
were chasing a bit of protein. The saltbush is reducing the amount of methane produced per kg of production, but that is another story.

In this slide, you will notice carbon is now flowing into the area around the shrubs (POINT). In other words, the landscape is becoming more resilient. The carbon flows introduced by the planted saltbush provided a food source for soil life, with the resultant soil life improving the soil. As the soil improved, grass and other plants were able to germinate and further expand the area that carbon is flowing through.

All this happened over a two year period at Yelarbon, when rainfall was well below average.

This photo was taken 3 years after the saltbush was planted. The clover is now adding nitrogen to the system as it further contributes to carbon flows.

This photo was taken 5 years after the saltbush was planted.
This is another photo after five years.

After carbon started flowing again, energy, nutrients and water all followed. *All producers appreciate the importance of energy, nutrients and water, so this puts carbon in a new perspective for them.* Plants are now growing, which is introducing energy. The build up of organic matter in the soil is increasing nutrient supply. Looking at the prolific grass, water is obviously getting in now. It wasn’t before as the next slide shows.

This photo was taken immediately after a few mm of rain. By now I am sure you are forming the linkage between management of carbon flows and keeping sediment and nutrients off the Reef.

The wet decade of the 1970’s, with all the rain that arrived, couldn’t repair this claypan. Nor the big rain in the early 1990’s. However, during a period of below average rainfall, the claypan repaired because of carbon flows introduced by the planted saltbush.

The point I am alluding to, is that many producers form too close a linkage between rainfall, rural
production and healthy landscapes. This linkage is only true up to a point.

Producers have no control over how much rain arrives but they do have control over the level of carbon flows generated by what rain does arrive. It is the level of carbon flows that determine rural production and landscape health.

After seeing the positive outcomes in these pictures, I tell producers to think in reverse to appreciate how management that reduces the flow of carbon into paddocks, also reduces production and degrades paddocks. As paddocks become less resilient, droughts turn up sooner. This claypan was in a state of drought during normal years.

Think of carbon as the organiser. It organises so many processes as it flows through paddocks.

It is by following the path of carbon that producers gain a better understanding of how everything fits together.

**What does it take to make producers see carbon flows as relevant?**

Carbon supplied by carbon flows, is the main building block of all life in a paddock, be it grass, soil life or cows and is responsible for keeping all life functioning by carrying energy.

You will notice, I am linking the flow of carbon to the maintenance of life, especially the life that producers associate production with.

All rural producers sell something that has lived, be it meat, fibre, grain, hay or vegetables. Their day job is managing life.

I ask them if they know cows are 18% carbon.

I also ask them if they had considered the fact that grass is 45% carbon (when dried).

I tell them that the reason the natural world can't function without carbon flows, is because carbon is the main building block of life. Producers really get it when you explain it this way.

Agriculture produces and sells carbon products.

A producer’s day job is recycling carbon. They set out to turn some of the carbon that is flowing through the paddock, into saleable carbon products like meat and grain. The more carbon that flows, the more cattle they have to sell. Remember Steve Martin who is now running a lot more cattle.

Selling cattle is harvesting carbon when it has entered the cattle part of the food chain.

Carbon moves from one life form to another via consumption. Above ground, when cattle eat grass, carbon moves into them. Then it moves into us when we eat meat. Below ground, carbon also keeps moving to maintain soil life that is responsible for keeping the soil well structured and fertile. Remember the fence line photo of the pooled water on just one side. Part of the problem
was a shortage of soil life over time. With the claypan, it didn’t become productive and full of life until carbon started to flow through it.

All of the above is why carbon is a good starting point if you are a systems thinker.

When I was a producer, I always concentrated on working out what really mattered.

Let me tell you a story.

Some years back I was in the Blackall Newsagency and a woman put dieting into perspective for me. She said the expensive dieting programs in the city were a total waste of money. All you have to do is keep your mouth shut and move.

This woman got back to the basics. Get the basics wrong and nothing else will fall into place.

My point, management of carbon flows is concentrating on the basics. It is the most fundamental thing a producer has to get right. You have no control over how much rain arrives but you do have some control over the level of carbon flows the rain generates.

Discussing carbon flows is a different way for graziers to look at the landscape and understand how it functions. The paddock with the highest flows will be the most productive and more resilient, therefore producers need to operate with a new paradigm, a different function in their brain. They have to be able to imagine what is happening on a multitude of levels and time frames. At the moment, most producers can see only the outcomes, but don’t understand how they occur. They need to be able to visualise the processes they can’t see happening.

The Carbon Grazing approach is seen as innovative. It has been utilised by the Colorado State University and now written into a NRM plan.
As an aside, I want to show you the effect of too much tree clearing.

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**Proposed module**

Now the proposed module and what it would contribute.

It would be an introductory module that would prepare producer’s minds to better understand current extension in the area of land management and livestock production. It would take a systems approach and supply the underlying scientific principles of current extension in this area.

The module would introduce producers to the carbon flows concept, not to be confused with the carbon cycle as portrayed by the carbon cycle diagram. It would shift producers from a static perception of carbon, to appreciating that carbon is always moving in the paddock and at different speeds. The module would explain the important role of this carbon movement in supporting landscape function, both above and below ground, including through livestock.

It would enhance environmental outcomes such as protecting the Great Barrier Reef and supporting greenhouse outcomes, including reducing methane per kg of production by livestock. It would support Direct Action, because long term carbon has to start the journey as short term carbon in the first phase of carbon flows.

A possible title for the module is, “Better managing carbon flows for increased profits and better environmental outcomes”.

The module would give direction on how to increase the amount of carbon flowing through the landscape.

The module would not lead to any rewriting of current resources.
People are more likely to change decision making if they understand why. This module would provide the big picture understanding a producer requires in order to see things differently.

This is not personal, but I am about to challenge aspects of what you would have been taught. I take a systems approach but teaching institutions have traditionally taken a reductionist science approach.

Reductionist science is sometimes referred to as putting information in silos. To be successful, extension needs to take a systems approach that starts with the big picture and then looks at the finer detail second. This is because producers manage paddocks, not a collection of isolated processes.

Back when I was writing the Carbon Corner column, I was invited in to give a presentation to the Reef Policy unit (March 2011). At a meeting a week after the presentation, a very honest scientist commented to me that she was really struggling with the way I explained things. She said she didn’t disagree with anything I was saying, but it was simply not the way she was taught at Uni. This woman put current extension into perspective for me, because reductionist science dominated when she was at University.

And now I am going to challenge something else that would have been put to you.

When people get their head around the flows way of thinking, they quickly discover that the bulk of the carbon that is moving in the paddock, involves short term carbon compounds, not long term carbon compounds.

Over a twelve month period, maybe 2% of the flowing carbon in a paddock involves long term carbon. In other words, virtually none. As you know, long term carbon is moving, but it is moving very slowly.

What I have just told you, is that in the short term, long term carbon is not driving change in the landscape.

The grazing industry does not manage long term carbon, it manages short term carbon, long term carbon is an outcome. The management decisions graziers make, relate to short term carbon.

This begs the question, has extension to the grazing industry focused on the wrong aspect of carbon from a management perspective.

I will back up this point using soil carbon as an example.

Before I do, I want to state that I am not suggesting that long term soil carbon is not important, because it is. It is a resource for production and protection of the environment. The reality is that
it shouldn’t be the starting point of discussion around best management.

This slide demonstrates the short term outcomes of changed management. The red section is the fast moving short term carbon and the black section is the slow moving long term carbon.

It demonstrates how the ratio of short and long term carbon changes as soil organic carbon increases.

When soil organic carbon went from 1.5% to 2.5%, the change was driven by increases in short term carbon – the red section. Look closely at the size of the black section, which is long term carbon, and there is virtually no change. The percentage of long term carbon has changed on the left hand diagram, but this is because the increase in short term carbon has changed the total.

This diagram sums up what happens when you change the management of carbon flows.

The energy agriculture relies on, is sitting in the red pool.

The bulk of the carbon movement in your paddock, is the red section.
This slide reinforces the previous one.

If you look at the change out of cropping to pasture, the increase in carbon flows immediately showed up in the short term carbon stocks (particulate) and the long term carbon hardly changed initially.

For those of you only interested in long term carbon. Long term carbon has to start the journey as short term carbon, in the first phase of carbon flows. Even people focused on sequestration have to be focused on carbon flows.

The next slide speaks for itself.

Two paddocks can have equal long term carbon stocks, but it is the one that has the most carbon flowing through it, that will have the highest level of production.
Now a few more reasons why producers should be thinking carbon flows.

Phosphorus is known to be a production issue in a lot of pastures. The availability of phosphorus to plants is influenced by how much soluble carbon is released by plant roots to soil life. Soluble carbon is some of the fastest moving carbon, and it’s only source is a growing plant.

This plant is struggling to come out of dormancy after good rain because it is short of stored energy. Energy reserves in plants are short term carbon brought in by carbon flows.

(LH) Grazed 6 times at one leaf stage
(Middle) Grazed 3 times at two leaf stage
(RH) Grazed twice at three leaf stage

The longer and more expansive the root system of grass, the more water and nutrients available
to it. Roots are 45% carbon. They are also short term carbon and rely on carbon flows to exist.

Roots play a very important role in Reef protection. Roots act as wicks to take water down through the soil profile, especially important with harder soils. The water travels down beside the roots. In the diagram, the plant on the right hand side provides the best penetration. The pooling in the fence line photo was not just poor soil structure, it was also due to lack of roots in the paddock.

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**Depth of water penetration**

- Extensive bare soil 150 mm (6”)
- Isolated perennial grass plant 200 mm (8”)
- Grass clumps at least 2 M square 450 mm (18”)

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This exercise occurred in a degraded area of the Traprock after 50 mm of rain had fallen over two days. I used a piece of high tensile fencing wire many times to establish how far water penetrated depending on the configuration of grass cover and the health of the area being sampled. When management of carbon flows changed for the better following this exercise, the isolated grass plants acted as a catalyst to see small clumps develop in exactly the same way the claypan regenerated away from the planted saltbush.
Why we have to keep management focused on ongoing introduction of carbon

This diagram highlights that it is critical to keep introducing new carbon into a paddock because carbon keeps leaving the system. The arrows on the CO2 sections represent the loss of introduced carbon via consumption i.e. oxidation. Apart from fire oxidising carbon compounds (above ground), the oxidisation process relies on one life form consuming another and releasing CO2 in the process. The diagram highlights that the outcome of photosynthesis is being reversed with every consumption event. You can see some of the original carbon introduced as short term carbon heading towards longer term carbon as it becomes less and less digestible. This is represented by the horizontal red bare becoming shorter.

The carbon that flows in after rain initially goes into the fast moving carbon pool. Then some finds its way into the medium term pool and finally a little into the long term pool.

As a general comment, 75-80% of carbon that enters the soil will be gone within twelve months. The actual amount is determined by moisture levels and temperature. This highlights that if your management is not focused on carbon flows, then you run the risk of running short of this commodity.

It took me years to develop my current understanding of stocks versus flows and how best to explain the difference. What worked for me is that measurement of stocks is taken at just one point in time. Any carbon that happens to be moving through the paddock at the time is measured. There is a lot of carbon that moves through the paddock that misses measurement. Root exudates, which are carbon flows released by roots, are outside measurement. I am informed that only about ten percent of the carbon that enters the soil is actually measured as soil organic carbon (SOC).
You can be confident with the long term carbon measurement as it is measuring slow moving carbon. However with the faster moving carbon, you have to be careful of the circumstances under which you measure. It is very easy to catch a spike that is not representative.

Now coming back to the Carbon Farming Initiative. Any carbon that is in the stable long term pool has to start the journey as fast moving carbon, so soil carbon trading relies on the same management as making more money. You have to increase carbon flows. In fact this is the first example of the broader rule – “The greenhouse outcomes of the grazing industry are a reflection of economic efficiency”.

Back to rural production, there is a reason why a paddock is more productive when carbon moves faster. It is simply because everything that is joined to carbon as it moves through the soil, becomes available to plants sooner. Think energy and nutrients.

I want to pause and stress that the long term soil carbon is also flowing. Just flowing a lot slower.

Short term carbon moves faster if more nitrogen is joined to it. This is because carbon compounds can be consumed faster. Time is too short to discuss how this same process applies to cows digesting high protein diets quicker than straw.
Remember the fence line photo I showed you at the start where water was pooled only on the right hand side, this shows the productive capacity of each side of the fence at a later date. It demonstrates that current carbon flows are influenced by past management of carbon. This is one of the feedback loops I referred to. This is why water use efficiency over time is linked to management of carbon flows.

It is paddock resilience that leads to one producer getting a response from a marginal fall of rain in a dry year and another not. If ever you need something to grow, it is in marginal years. This also applies to Reef protection.

Paddock resilience is a combination of plant resilience and soil resilience. Both aspects of resilience are directly linked to management of carbon flows. Plants fail first and then the soil fails. Put another way, plant resilience reduces first then soil resilience reduces.
Relating to different ways carbon flows are reduced

These sheep have been sent in to totally shut down carbon flows and force plants to keep calling on stored energy in their roots as they keep trying to grow from 30 mm of rain.

When perennial grasses are not exposed to grazing, they become moribund. Moribund grass introduces a lot less carbon than grass correctly grazed.
This photo was taken inside Idalia National Park west of Blackall. There are no sheep or cattle involved in this outcome, just kangaroos and wallabies. If you are a plant, it is irrelevant what stopped you growing. The carbon flows concept has to be integrated into management of public land as well as privately owned land.

Cluster fences now being built to control dingoes will also regenerate the Rangelands by helping control the kangaroo component of total grazing pressure.

I know carbon is now being treated very differently in extension, to when I was a producer. However, it would be fair to say that a lot of landscape carbon that producers rely on, is still not referred to in a carbon context. I will generalise by saying, these carbon compounds are the ones outside the focus of climate change policy.

A good example is ground cover. We never talk about it in terms of being carbon based. Institutional extension services focus on stocking rate, pasture utilisation rates and maintaining a minimum level of ground cover. This is 1980’s science as a government employee explained to me.

How much of the ground cover is consumed is important, but it is the second decision a producer makes. Not the first. What sets the level of ground cover is how much carbon a particular form of management allows to come in after rain. Remember grass is 45% carbon when dry. If you are just thinking stocking rate, then carbon flows are not part of your thinking.

Also, we are too focused on just soil carbon in extension. With land management, carbon only seems to be discussed as carbon when it is below ground. The only time we seem to think about carbon being above ground is in trees, but this is only because trees are long term carbon. Grass is short term carbon.

Because carbon is the organiser as it flows through the paddock, it is explaining the path of carbon above and below ground that helps producers better understanding how the whole paddock functions. It gives them a better understanding of how everything fits together. Decision making is
only successful if you have a big picture understanding. Big picture people think about how the different cycles work together. They don’t think of them working in isolation. The carbon:nitrogen ratio is a good example. This ratio determines the outcomes of so many processes.

Producers need to be able to mentally follow the path of carbon and have an understanding of what it does. This makes it easier for them to understand how the landscape functions.

A person who understands the principle of carbon movement can see the flows because they are thinking over time. They see the processes that are operating and understand how management influences them.

Steve Martin the Gladstone producer who explained his increased production at the Boggo Road workshop is a good example. He can now see in advance the results of management decisions.

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**Speed of carbon**

We currently talk about carbon being short term, medium term and long term. Talking about speed of carbon is probably a better way to structure peoples thinking. It couches the debate in terms of decision making. It makes the debate even more practical than thinking stocks versus flows.

Some of the carbon moves very quickly through the paddock on its way back to the atmosphere. Some stays a bit longer and some of the carbon is moving very slowly. Short term carbon moves a lot faster than long term carbon.

This suggestion of thinking speed of carbon may seem like a radical proposal, however it brings discussion of land management back to discussing exactly what all the different forms of carbon are doing.

It is much easier for producers to understand the role of carbon if they are thinking individual carbon atoms in their paddock. The individual atoms are moving at different speeds. The speed they are traveling at gives an insight into what processes they are involved in. It is the fast moving carbon that runs down quickly and needs constant replacement. Also, carbon atoms form different compounds as they keep moving. Moving from grass into a cow is just one path for a carbon atom.

The faster moving carbon has a different role to the slower moving carbon.

Carbon trading is more interested in the slow moving stable carbon, while rural producers make decisions that apply to the faster moving short term carbon.

If you want to increase production in the short term, it is the fast moving carbon that increases production, not slow moving carbon. It is accepted in the scientific community that stocks of long term soil carbon are slow to change, which reinforces the point that long term carbon can’t to be
Producers also need to understand the decisions they need to make to increases the speed of short term carbon. This is where the carbon:nitrogen ratio enters the debate and it needs to be shown to producers how better management of carbon flows improves this ratio.

If management increases the speed of carbon through cows, then they get to market quicker. Producers also need to speed up the flow of carbon in the soil, to make nutrients available to plants sooner. What speeds up carbon in a cow is the same as what speeds up carbon in the soil, and this is why big picture principles need to be explained to producers.

Short term resilience is linked to the faster moving carbon and long term resilience is linked to the slow moving carbon. Short term resilience can be very variable but long term resilience is not, unless there is erosion.

This explains why long term carbon on its own couldn’t make the claypan productive. After the saltbush was planted, the resultant carbon flows introduced the necessary short term carbon. The long term carbon that was present then became valuable by helping store water and nutrients now entering the soil.

Improving the first phase of carbon flows, being when carbon transfers from the atmosphere to the landscape via plant growth, improves short term resilience which is the biggest variable in protecting the Reef.

One objective of discussing carbon flows, is to ensure producers visualise carbon always moving. Part of this new mind set is the awareness that carbon levels will run down if you do not keep on top of carbon flows. Obviously I am referring to the faster moving short term carbon. However in the longer term, long term carbon will also be affected. Another way long term carbon runs down is if a shortage of short term carbon leads to wind and soil erosion, which is a sudden drop in long term carbon.

Financial analogy

To put fast and slow moving carbon into a commercial analogy, think of cash flows versus capital. Cash flows are the fast moving money that keeps you viable, just like it is the fast moving carbon that keeps you viable. Think of the slow moving carbon as really part of your capital base, just like cattle yards and buildings.

The fast moving carbon makes money for you because it feeds all the life in the paddock, including your cattle. Remember cattle are 18% carbon, all coming from the fast moving short term carbon. It maintains larger root systems in your plants so that they can access more moisture and nutrients to grow. It is part of energy reserves that determine how well plants respond to what rain falls, especially important in marginal years when perennial plants have to come out of dormancy. Ground cover is fast moving carbon.

It is organic matter that supplies nutrients.
Erosion is an immediate reduction in earning capacity, because it removes both short term and long term carbon.

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**Two elements behind change**

- **Do producers have access to all the necessary information?**

- **What will make a producer consider changing management?**

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**THE FIRST DOT POINT:**

My belief is that what extension is currently explaining to producers is technically correct but is not the full story, especially in the area of carbon. Just discussing carbon stocks is too narrow and needs to be complimented by a module explaining the carbon flows concept. Carbon stocks and carbon flows while related debates, are separate debates, as the first power point explained. Also an understanding of the carbon flows concept prepares the mind of producers to better understand the multitude of issues current extension discusses, including animal production. The carbon flows module would supply the underlying scientific principles of current extension.

*The first disconnect:* Before discussing the need for a more comprehensive approach to carbon in extension, it helps to understand why we are taking our current approach to carbon in extension.

For the thirty years that I was a grazier up until 2000, not once was the word carbon mentioned to me. Land management was never explained in terms of carbon management, or more specifically, management of carbon flows. Nobody suggested to me that my day job was recycling carbon. It was never explained to me that the meat and wool I sold were actually carbon compounds, which is why I needed to maximise the flow of carbon through my paddocks. Nobody ever couched the debate in a way that made it obvious that the severity of droughts and how often they arrived could be reduced by managing carbon flows better.

Dr David Freudenberger, a former CSIRO rangelands scientist and now lecturer at ANU, said my claim is true. He said land management simply wasn’t discussed in terms of carbon. Dr Allan Wilson, another former CSIRO rangelands scientist said the same thing. Allan said that they only
got as far as discussing organic matter but did not couch it in terms of carbon. A Queensland Country Life journalist said that if carbon was seen as relevant, they would have been writing about it.

When I was on the land, extension took a reductionist science approach to land management and this approach still lingers in many quarters.

I want to acknowledge that most extension processes are now including carbon in discussion.

Processes are always slow to change, so if carbon wasn’t part of the debate in 2000, then it is unreasonable to expect that current extension would have fully matured in the area of carbon. To highlight that change takes time, I was given this copy of Meat & Livestock Australia’s “Grazing Land Management” (GLM) manual two years ago and the word carbon only appears twice. Once in the word carbon dioxide and a second time in a reference to carbon being in trees.

It is not fair to level the blame at the feet of people writing extension. They are only calling on the approach they were taught at University and reductionist science prevailed in their formative years.

The second disconnect: As we all know, it was climate change policy that introduced the word carbon into extension. And herein lies a lot of the current problem. Funding favours applications around measurement and carbon stocks. This sequestration perspective has become imbedded in extension to this day because funding processes encourage this line. You only have to look at the Carbon Farming Initiative to see that funding is being directed towards stocks projects and not carbon flows projects.

Future Beef modules showing the word sequestration

Future Beef
- Carbon management
- Drought
- Fire
- Land condition
- Land types
- Pasture budgeting
- Soils
- Stocking rates
- Wet season spelling
- Resources — tools, workshops, publications and links

Carbon management
- Soil organic matter and carbon sequestration in pastures
- Risks and returns of selling trees for carbon credits
- Soil carbon sequestration — myths and mysteries

This is how the system expects you to approach carbon. You will notice the word sequestration is in two of the headings under carbon management. The middle one is tree carbon credits, which is
sequestration again. These information papers are very well written and factual, so I am not passing judgement on the actual content. The wet season spelling module makes no reference to carbon because there is no continuity with carbon thinking past the sequestration paradigm.

Carbon flows are not in favour, because of all the carbon flowing in the landscape, virtually none of it is long term carbon. What is being overlooked is the reality that long term carbon has to start the journey as short term carbon in the first phase of carbon flows. All stocks rely on flows.

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**Two elements behind change**

- Do producers have access to all the necessary information
- What will make a producer consider changing management?

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THE SECOND DOT POINT: It is human nature that how somebody sees the world influences the decisions they make. For this reason, achieving change relies on helping people see the world differently. The grazing industry is no different.

In 2008, Dr Greg McKeon wrote - Future graziers will see themselves as “managers of carbon”. This is a different view of the world to what Dr David Freudenerberger said existed in 2000. Today I am sure Greg would write – Future graziers will see themselves as “managers of carbon flows”.

My suggestion of an introduction module on the role of carbon flows would broaden how producers see the world. Producers need to understand all aspects of how their paddocks function, including the role of carbon flows. Also how their decisions impact the level of carbon flowing through their paddocks.
This is saying they should harvest what resides above ground after adequate carbon has flowed to all parts of the landscape, including below ground. This approach will ensure future animal production and ongoing resilience of the production base. It will also ensure better environmental outcomes, including better water quality in waterways.

Think of plants as the entry point of carbon. It then flows everywhere above and below ground. Carbon even flows through cattle. Some of the introduced carbon returns to the atmosphere very quickly and some takes a lot longer.

This slide leads into the Carbon Grazing principle.

**The Carbon Grazing principle**

A more detailed explanation of the Carbon Grazing principle is at end of this document on page 29 under the heading, “The logic behind the Carbon Grazing principle”.

Carbon Grazing is not new science, it is a new focus.

The principle relates to the first phase of carbon flows, which is the introduction phase i.e. when carbon moves from the atmosphere to the paddock via photosynthesis during plant growth.

The principle has as its basis that pasture rest is sufficient when enough carbon has flowed above and below ground to all the areas it needs to. The level of carbon flows sets soil and plant resilience AND ground cover for current livestock production.

It highlights management that maximises carbon flows. In this sense, the principle is an action plan.
There are some subtle realities that underpin the Carbon Grazing principle. Because there is no pattern to when rain arrives, in other words, when carbon arrives, the message is that pasture rest is TIMING and not TIME. Basing resting decisions on a certain period of TIME is no guarantee that carbon will arrive.

Carbon Grazing is short term removal of animals from pastures after grass growing rain. It is practical, as an alternative home for the animals only has to be found for a short period of time.

Carbon Grazing is 4 - 6 weeks pasture rest after rain. How long depends on the resilience of the paddock. One producer here in Australia with really healthy pastures is of the opinion that he can achieve full recovery after about four weeks.

Scientists I met in South Africa suggested that with average pastures, removing animals for 3 - 8 weeks after rain, increased pasture production by 50 - 80%. Given pasture is about 45% carbon when dried, this gives an indication of the increased carbon flows, including below ground.

When people say they can't afford to rest pastures, it begs the question, can you afford not to.

When it comes to engaging rural producers, a rangelands scientist told me recently that they like recipes. However recipes are prone to fail if circumstances change. Carbon Grazing is not your normal recipe, it is a flexible recipe. The instruction left in the rain gauge to act and remove the animals from a paddock may be random. However the instruction to act is always based on the same criteria (grass growing rain) and always requires the same action. The only variable is that the required rest period shortens as landscape resilience improves due to better management of carbon flows over time.

I can’t stress enough, that Carbon Grazing is a principle and not a new land management system. It underpins all successful land management systems.

Cell grazing is just one way Carbon Grazing can be implemented. This is because when the rain arrives, the bulk of the cells do not have animals in them. A well respected cell grazer commented to me that although he locks his cells up for 120 days, which is a TIME approach, the bulk of the outcomes he achieves occur in the first 28 days after rain.

Stating the obvious, continuous grazing never implements the Carbon Grazing phase of rest after rainfall.

Carbon Grazing is not the same as wet season spelling as many people mistakenly think.

A rangeland scientist looked up Treasury figures to find the value of the beef and sheep industry to Queensland. With a small uptake of managing carbon flows better, it translated into $70 million.
more in the Queensland economy every year on average.

The term Carbon Grazing was coined in 2001 and registered the same year. So I have had 14 years to get my head around the carbon flows concept.

Principles allow us to understand how paddocks function and need to be managed.

**Conclusion**

The carbon flows concept extends past what happens in the soil to also include what happens above ground, including carbon flowing through sheep and cattle.

Management of carbon flows is the basis of sustainable food production.

Thinking carbon flows and how much carbon is entering the paddock, is to be aware of how much activity is occurring in the paddock.

The landscape is all interactive – self organised – however we “disorganise” it when we mismanage carbon.

The only time you can build resilience is in the short period after rain.

If you can’t measure a change in carbon stocks, then the carbon has to be in the flows.

With carbon flows, once you see the flows, you see the dynamics of the whole system and how it functions.

Because carbon is the organiser as it flows through the paddock, it is explaining the path of carbon above and below ground that helps producers better understanding how the whole paddock functions.

Changes in the way we farm must be linked to changes in the way we think.

You have no control over how much rain falls but you do have control over how much carbon flows into the paddock from what rain does fall.

The natural world can’t function without carbon flows.

The development of a new carbon module does not require a change to anything that is currently presented in extension. It is just a case of bolting on a big picture introduction module that makes it easier to understand current extension, by refining how producers see their paddocks.

Pasture rest is long enough when enough carbon has flowed to all of the areas in the landscape above and below ground that it needs to. This underpins production and the maintenance of landscape resilience.

**END OF PRESENTATION**

*Note: While giving this talk, I was reminded once again of the difficulty in getting mainstream*
extension to consider including alternative ways of explaining things to producers.

Not a long way into the presentation, an extension officer working for the Queensland Department of Agriculture interrupted with the comment, “Maybe I am stupid, but none of this is making any sense to me”.

The sad part about his comment is that what is discussed in the above talk had been raised with his department for some years prior to his comment. Only a year earlier, it was again put on the table with the people in his department who were responsible for making decisions on extension content. They pretended to show interest but took it no further. The extension officer would not have made his comment if the department had been discussing the carbon flows concept with extension staff.

The first comment was quickly followed by a comment from another extension person, “Look, we have been measuring carbon and it is not changing”. To which I responded, “Well if you can’t measure a change in stocks, all the carbon has to be in the flows. You have just confirmed the thrust of what I am saying”. This second comment highlighted a singular focus on carbon stocks and forced me to make my sixth conclusion point much earlier than planned.

A non government person involved in the BMP process then took the floor and proceeded to explain that he had witnessed the approach working with producers and leading to good outcomes. His support was welcome even although it meant time ran out for the full talk.

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“The logic behind the Carbon Grazing principle”

**Background:**

Humans and cattle are about 18% carbon while grass is about 45% carbon.

The natural world can’t function without “carbon flows”. This is because carbon is the main building block of all life on the planet and responsible for supplying energy that all life relies on.

The best way to understand what life includes is to think of what dies. Grass dies, cows die, soil microbes die and worms die.

Carbon is always moving. After entering the landscape via photosynthesis, one path of carbon involves moving along the two food chains, one above ground and the other below ground. This involves moving from one living thing to another living thing.

Above ground, when cattle eat grass, carbon is moving from one life form to another life form. Then on to another when we eat meat. Below ground, carbon also keeps moving and maintains soil life that is responsible for keeping the soil well structured and fertile.

When we breathe out carbon dioxide, this is simply some of the carbon that has entered our bodies (via food) moving on.

All rural production sells something that has lived.

A rural producer’s day job is managing carbon flows i.e. recycling carbon and in the process turning a portion of the inflows into saleable carbon products, be they meat, fibre, grain, hay or vegetables.

To understand the importance of carbon: energy, nutrients and water all follow the path of carbon.
How successfully pastures are able to introduce carbon into the landscape is determined by animal management. Plants and animals have evolved together and rely on each other. However, if animals dominate plants, then carbon flows are reduced. In the absence of animals, pastures become moribund and again have a lower capacity to introduce carbon.

All else being equal, the grazing paddock that has the most carbon flowing through it will be the most productive and resilient.

Plants rely on carbon inflows to construct themselves. Roots, stems and leaves are about 45% carbon. It is plants that make carbon available to the two food chains that underpin commercial production and positive environmental outcomes.

The two components of paddock resilience are plant resilience and soil resilience.

Allowing carbon to flow into plants increases their resilience in two ways;

- increasing internal energy reserves for them to call on; and
- creating a more extensive root system to give them access to more water and nutrients

Soils with more carbon flowing through them are more resilient because they have improved water infiltration, increased water holding capacity and are more fertile.

Long term soil carbon is very important however its existence over time has to be seen as an outcome of carbon flows and how well they are managed.

Without the ongoing flow of carbon and all the compounds it forms as it keeps moving, the landscape would become bare and lifeless. This point reminds us that "carbon flows" and "carbon stocks" are related but different debates.

Everything discussed to this point makes management of carbon flows the cornerstone of food production, rural profit, reducing the effect of dry times, improved water quality and meeting the expectations of the broader community for better environmental outcomes, including the atmosphere.

Those who take a systems approach, place a high emphasis on carbon, while those who take a reductionist science approach see water as more important. The reality is that a grazing operation has no control over how much rain arrives, however, there is some control over how effective it is. How effective rain is depends on whether it enters the soil or ends up in gullies and in the case of water that enters the soil, whether plants are healthy enough to fully utilise it; both these issues are determined by management of carbon flows i.e. the level of carbon flowing into the soil and plants over time. When we take a big picture approach (a systems approach), it quickly becomes obvious that better management of carbon flows increases water use efficiency.

Removing sheep and cattle for just a short period following grass growing rain, achieves a lot more than simply growing more grass for the commercial animals to eat in the short term. It is an exercise in increasing carbon flows to all sections of the landscape.

Pasture rest is long enough when enough carbon has flowed to all the parts of the landscape that it needs to.

The logic behind the principle:

The only way that carbon can move from the atmosphere to the paddock, is via photosynthesis as plants grow.

Given that it is moisture that promotes photosynthesis, then it is moisture that promotes the introduction of carbon.

Nature has designed the system so that water activates the flow of carbon into the landscape.

Thinking logically, the bulk of the carbon enters the landscape in the short period following grass growing rain. This highlights the need to focus management around this point in time.

Letting animals eat plants when they are trying to grow after rain, reduces photosynthesis and in some cases, completely shuts it down.
There are some subtle realities that underpin the Carbon Grazing principle. Because there is no pattern to when rain arrives, in other words, when carbon arrives, the message is that pasture rest is TIMING and not TIME. Basing resting decisions on a certain period of TIME is no guarantee that carbon will arrive.

This is not an attack on cell grazing, where cells may be locked up for 120 days. Cell grazing implements the Carbon Grazing principle, because when rain arrives, the bulk of the cells do not have animals in them.

Stating the obvious, continuous grazing never implements the Carbon Grazing phase of rest after rainfall.

The obvious question is, "How long do pastures need to be rested for after rain, to approach maximum potential carbon inflow i.e. to approach maximum ground cover and also maintain plant and soil resilience?"

Scientists in South Africa suggested that with average pastures, removing animals for 3 - 8 weeks after rain, increased pasture production by 50 - 80%. To relate this to increased carbon arriving above ground, pasture is about 45% carbon when dried. The increase in carbon flows that the increased ground cover represents, provides an insight into the increase in carbon flowing below ground to increase pasture resilience and support soil life.

When people say they can't afford to rest pastures, it begs the question, can you afford not to.

The South African research documented a slowing of flows towards the eight week period. Producers in Australia have made similar observations.

Carbon Grazing is 4 - 6 weeks pasture rest after rain. The period does not commence until the plants actually start growing. Also, it is important to not get caught up on the exact time between four and six weeks, as factors like temperature influence the necessary time. Also, the health/resilience of the pasture, based on past management of carbon flows, influences the period of rest required. One producer in Australia with really healthy pastures is of the opinion that he can achieve full recovery after about four weeks.

The basis of the Carbon Grazing principle is that rest is achieved when enough carbon has flowed into the paddock above and below ground. This explains why paddocks lacking resilience require a longer rest period.

Carbon Grazing is not "wet season spelling" which involves a much longer time period and places added grazing pressure on the remainder of the property not being rested.

The practical aspect of seeing pasture rest as a short period of time, is that an alternative home for the livestock only has to be found for a short time. The Carbon Grazing book details where the animals can be put without selling them.

The Carbon Grazing principle is about maximising potential inflows. It is the window of opportunity too many people miss. It is important to remember that it is a general principle, and not a new land management system. It is a procedure all successful land management systems incorporate. The more times the better. We can't change how much rain falls however we can change how much carbon flows into the paddock from what rain does fall. Put simply, it is the management just after rain that sets the level of carbon that becomes available to start its journey through the landscape.

Carbon Grazing is strategic pasture rest. It is actually a flexible recipe (see comment below). It is instigated on the basis of one parameter and requires only one action. This simplifies application. Carbon Grazing always succeeds because it addresses the most fundamental thing a producer has to get right. Get the basics wrong and nothing else will fall into place the way they should.

Discussion:

The Carbon Grazing principle is not new science, it is a new focus.

It is based on the premise that nature does not have a predictable pattern. Stated simply, we must allow nature to transfer carbon from the atmosphere to the landscape according to its time frame.

The Carbon Grazing principle relates to the first phase of carbon flows, which is the introduction phase i.e. when carbon moves from the atmosphere to the paddock via photosynthesis.

The best way to gauge how well we are managing carbon flows over time, is to observe the outcomes or lack of outcomes after rain. Past management of carbon flows does influence the level of current carbon inflows.
Because carbon is always moving, with some returning to the atmosphere on a regular basis, **there is a need to keep bringing in new carbon.**

In the case of new carbon entering the soil, on average 80% will be gone in twelve months. The above ground exit of carbon can be even more extreme depending on livestock management or fire.

In dry years, the potential for bringing in replacement carbon is much lower. This is the time when applying the Carbon Grazing principle is even more important.

When looking at landscape resilience, the faster moving carbon provides short term resilience, while the slow moving carbon provides long term resilience.

It is while grasses are growing after rain, that they make soluble carbon available to mycorrhizal fungi which are located on the roots. This allows the fungi to extend out into the soil and source extra nutrients for the plants.

For those interested in the trading aspect of soil carbon, the introduction phase of carbon flows only includes short term carbon. This highlights that long term soil carbon has to start the journey as short term carbon in the first phase of carbon flows.

When it comes to engaging producers, recipes are more likely to engage them, however recipes are prone to fail when circumstances keep changing. Carbon Grazing is not your normal recipe, it is a flexible recipe. The instruction (in the rain gauge) to act and remove the animals may be random, however the instructions are always the same and based on the same criteria i.e. rain capable of producing carbon flows. The only variable is that the required rest period shortens as landscape resilience increases with better management of carbon flows.

It is following the path of carbon that provides a better understanding of how landscapes function. Unfortunately this is not the approach that has been taken by rural extension programs in the past, so will take time to gather general acceptance.

One industry extension program in Australia discusses ground cover in terms of not consuming too much (important), but does not discuss land management in terms of increasing carbon flows to provide more ground cover. Level of consumption is the second decision producers need to make, with the first one being management of carbon flows to increase ground cover prior to consumption. **Over consuming carbon flows after they have arrived is very different to reducing the flow of carbon in the first place, and is by far the lesser of the two evils.** Carbon flows end up above and below ground, while animal consumption only involves what ends up above ground.

When soils become less fertile because of poor management of carbon flows over time, plants allocate a higher percentage of the incoming carbon below ground which means livestock have less to eat. This is another reason why poor land managers are at a bigger disadvantage during marginal years when rainfall is below normal.

Discussing carbon flows is a different way for graziers to look at the landscape and understand how it functions. If extension discusses all the processes carbon becomes involved in as it flows through the landscape, then it quickly becomes clear to producers why the paddock with the highest flows will be the most productive and more resilient.

Producers need to operate with a new paradigm, a different function in their brain. They have to be able to imagine what is happening on a multitude of levels and time frames. At the moment, a lot of producers can see only the outcomes, but don’t understand how they occur. They need to be able to visualise the processes they can’t see happening.

**Timing the harvest of carbon flows:**

When graziers let animals harvest carbon flows too early following rain, they interfere with the biophysical conduit (leaves) that are responsible for introducing carbon into the landscape.

In other words, **grazers should only be letting animals harvest the surplus, not the means by which a usable surplus is generated.** They should harvest what resides above ground after adequate carbon has flowed to all parts of the landscape, including below ground. This approach will ensure future animal production and ongoing resilience of the production base. It will also ensure better environmental outcomes, including better water quality in waterways.