THE AUSTRALIAN RIVER RESTORATION CENTRE

Rivers of Carbon

What is biodiverse carbon, where is it found, and how does it relate to river management?

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- The living world around us, on the land and in the water, is based on carbon. Carbon is one of the most abundant elements in the universe and is an essential part of us and our environment—we need carbon to survive.
- The carbon cycle comprises a sequence of events that make the Earth capable of sustaining life.
- Similar to the glass of a greenhouse, carbon dioxide (CO_2) traps heat, and for this reason is a primary greenhouse gas (GHG). Other primary GHGs are water vapour, methane, nitrous oxide and ozone.
- The amount of CO_2 in the atmosphere today is around 30 per cent higher than it was 200 years ago. Greater concentrations of GHGs trap more heat, raising the Earth's surface temperature (known as the greenhouse effect).
- CO_2 is the most important human-contributed GHG. Many ways have been identified to reduce its impact in the atmosphere. One way is to sequester (trap) carbon by revegetating landscapes and creating carbon sinks.
- Biodiversity is the variety of all life forms on Earth—the different plants, animals, micro-organisms and ecosystems of which they are a part. The removal and fragmentation of habitat has impacts on our biodiversity.
- Biodiverse carbon sinks can be established by planting a mix of regionally-native trees and shrubs on cleared land, thereby restoring a long-lived and self-replacing diversity of native vegetation.
- A river of carbon describes the total of carbon that is found and can be captured in rivers, riparian habitats and the terrestrial systems they connect with.
- The 'Rivers of Carbon' project enables farmers to achieve production and biodiversity goals now, while also getting carbon into the landscape at subsidised rates for which they may later be able to claim carbon credits.

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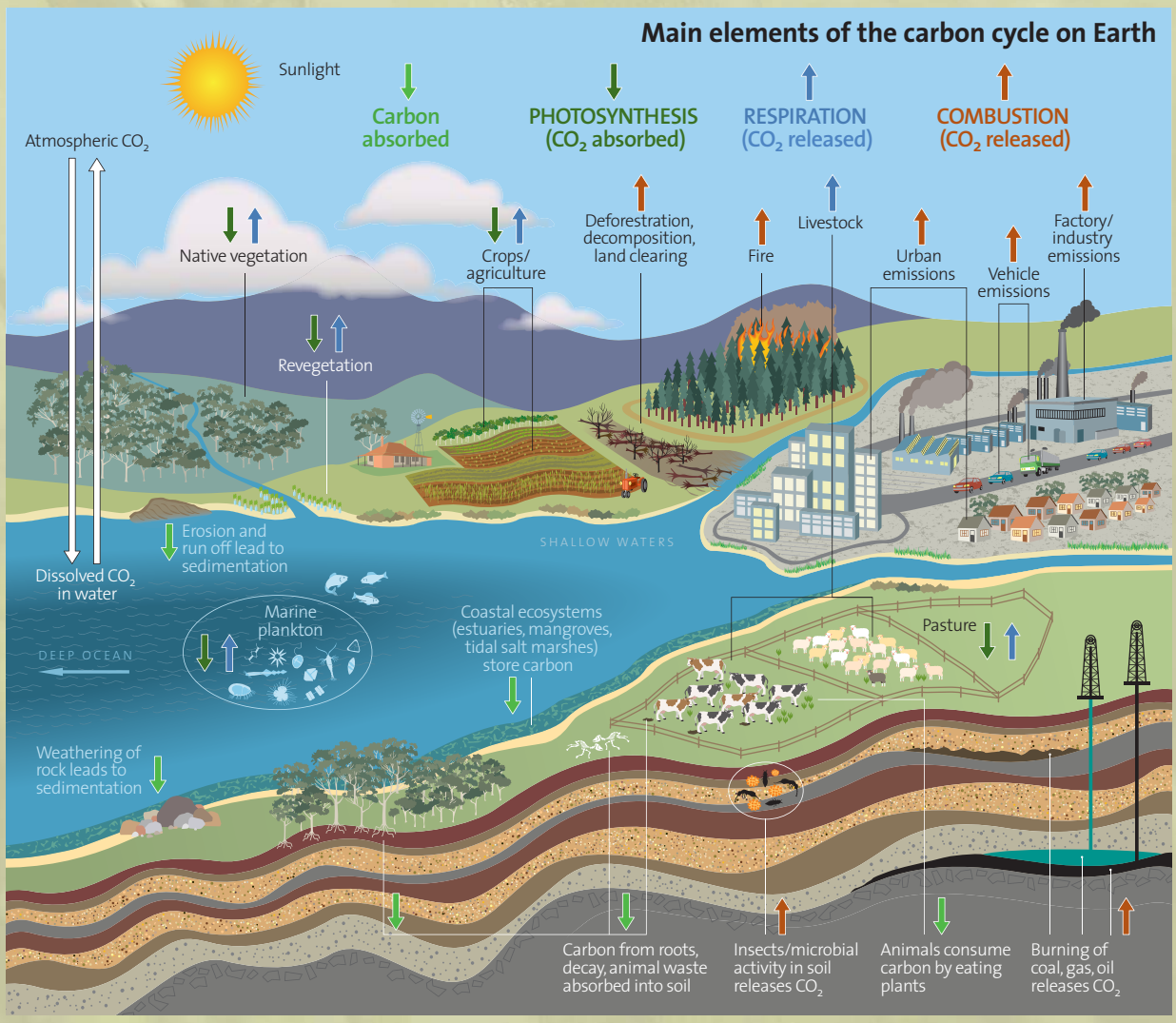
The living world around us, on the land and in the water, is based on carbon. Carbon is one of the most abundant elements in the universe and is an essential part of us and our environment—we need carbon to survive.

Carbon found in something living is called organic carbon. The organic carbon in living organisms comes from carbon dioxide (CO_2) in the atmosphere. Plants and certain microbes use water and CO_2 taken in from the atmosphere to produce sugars and starch. This process of carbon fixation is called *photosynthesis* and is driven by sunlight catalysed by enzymes, with oxygen released as a waste product. Animals get their organic carbon by eating plants or by eating other animals. Carbon can be stored in living organisms for extended periods, particularly in plants that have long life spans, for example, trees. The carbon found in non-living things such as rocks, shells, the atmosphere and oceans, is called inorganic carbon.

The *carbon cycle* describes the complex processes carbon undergoes as it is transformed from organic carbon to inorganic carbon and back again. Carbon is returned to an inorganic state in a number of ways—it is the ultimate in recycling! Both animals and plants release CO_2 into the atmosphere through a process known as *respiration*, in which complex carbon-containing compounds are broken down and energy released. When an animal or plant dies, it is broken down by bacteria and fungi and once again the carbon is released. This process is called *decomposition*. Living organisms also return carbon to the atmosphere when they are burnt.

Instead of completely decomposing, a plant or animal may sometimes be fossilised. This leads to its carbon being stored in rocks. After millions of years and under the right conditions, these fossils may turn into fuels like oil, coal and natural gas.



Why is carbon important?

The carbon cycle comprises a sequence of events that make the Earth capable of sustaining life. It is as important as the nitrogen cycle and the water cycle. Carbon dioxide in our atmosphere not only serves as a source of inorganic carbon for plants and certain microbes, it also helps prevents heat from escaping and, in doing so warms up the Earth's atmosphere. In a similar way to the glass of a greenhouse, CO_2 traps heat and for this reason is a primary greenhouse gas (GHG). Other primary GHGs in the Earth's atmosphere are water vapour, methane, nitrous oxide and ozone. The heat trapping capacity of GHGs helps keep the Earth's temperature at a level necessary to support life.

Human activities release GHG into the atmosphere—particularly through the burning of fossil fuels (coal, oil and natural gas) and land clearing. The carbon released when fuels are burned is called a carbon dioxide emission, with each fuel emitting a different amount of CO_2, as well as carbon monoxide and soot. The amount of CO_2 in the atmosphere today is around 30 per cent higher than it was 200 years ago. Greater concentrations of greenhouse gases such as CO_2 will trap more heat and raise the Earth's surface temperature—this is known as the greenhouse effect. This process has been linked to changes in rainfall, temperatures and extreme climate events, often with negative consequences for humanity and our environment.

Carbon dioxide is the most important human-contributed greenhouse gas. Many ways have been identified to help reduce its impact in the atmosphere by reducing or stabilising concentration levels. One approach that is being increasingly adopted is to create 'carbon sinks', where carbon sequestration (capture) is greater than releases over the same time period. Revegetating areas enables CO_2 in the atmosphere to be absorbed by plants through photosynthesis, and stored as carbon in biomass (tree trunks, branches, foliage and roots) and soils, creating a carbon sink that can have multiple economic, social and environmental benefits.

What is biodiversity?

Biodiversity is the variety of all life forms on earth—the different plants, animals and micro-organisms and the ecosystems of which they are a part. Biodiversity in Australia is very special, with over 80 per cent of our mammals, reptiles and flowering plants only found in this country. The removal and fragmentation of habitat, particularly vegetation clearing for agriculture and the impact of feral animals and invasive weeds, has had a substantial impact on our biodiversity.

Why do we need biodiverse carbon?

As our understanding of the importance of biodiversity to sustaining life on earth grows, many projects are bringing people together to protect and restore the unique diversity of life in Australia. Revegetating and rehabilitating sites can provide a biodiverse carbon sink with multiple benefits, particularly when a diversity of native plants is incorporated. While single species plantations will do the job of sequestering carbon, 'biodiverse carbon' provides an additional array of ecosystem services such as habitat for native wildlife, a mix of native vegetation species, a supply of food, leaves, litter and shade for aquatic animals, a reduction in soil erosion, and improved aesthetic, social and cultural values.

Biodiverse carbon sinks can be established by planting a diversity of regionally-native trees and shrubs on cleared land, thereby restoring a long-lived and self-replacing diversity of native vegetation. These plantings aid the repair of whole landscapes and improve agricultural sustainability in the face of a changing climate. Importantly, this restoration approach also improves soil health. Our soils are fundamentally important for supporting the diverse living organisms that are found underground, as well as for nutrient cycling, water retention and carbon sequestration.

Why are we focusing on rivers?

Rivers are the life blood of our continent—environmentally, socially and economically. Protecting, restoring and rehabilitating riparian environments is a high priority in Australia and across the globe because rivers are hotspots for biodiversity, encompassing both aquatic and terrestrial systems. A diversity of plants and animals such as trees, shrubs, grasses, native mammals, birds and fish are associated with rivers and riparian zones. These can include the iconic river red gums along the river bank, as well as aquatic plants such as bulrushes and sedges in the water. Terrestrial and aquatic vegetation, both living and dead, provides in-stream habitat and food for animals such as fish, crustaceans and bird life, and can be particularly rich along the diversity of habitats that waterways provide.

Depending on the environment and management practices in place, soils in particular can contain enormous numbers of diverse living organisms assembled in complex and varied communities. For example, bacteria are responsible for the greatest diversity of biogeochemical transformations of any group of soil organisms. Positive relationships have also been found between increased levels of soil carbon, the diversity of 'good' soil microbes and disease suppressive soils in crops. These and other findings help us view soils in riparian systems in a new light, better appreciating their important contribution to biodiversity and production outcomes.

What is a river of carbon?

A river of carbon describes the sum total of carbon that is found and can be captured in rivers, riparian habitats and the terrestrial systems they connect with. The phrase encompasses the carbon in the plants, animals and soils that are found in-stream and on the land connected to river systems. As with the carbon cycle, rivers of carbon is a dynamic concept that is influenced by the cycle of the river itself, the prevailing climate and the management practices in place.

Carbon typically enters rivers in one of two ways. 'Terrestrial' carbon originates from the surrounding landscape, that is, from plants, animals and soil, carried into the river by rain, snow melt and wind. 'Riverine' carbon comes from algae and plants in the water that make their own carbon. Organic matter in the waterways is digested by micro-organisms, insects, and fish. The CO_2 they generate and the dissolved inorganic carbon carried into the rivers from on land, then return to the atmosphere or are buried in sediments. Rivers create corridors through the landscape for both terrestrial and aquatic species, and provide the perfect system for maximising both carbon sequestration and biodiversity conservation at both local site and regional scales.

Farming carbon

A lot of publicity has been given to the potential for landholders to 'farm' or manage carbon in ways that could enable them to earn additional income and boost productivity through better management of, for example, soil carbon. This has increased following the establishment of the Carbon Farming Initiative (CFI). The CFI is a voluntary Australian Government carbon offsets scheme, with rules for participation established in legislation. It aims to help farmers and land managers earn extra income by reducing emissions of GHGs, and/or by sequestering (storing) carbon in vegetation and soils through changes to agricultural and land management practices. By participating in the CFI, farmers and land managers who reduce GHG emissions or sequester carbon will be able to generate credits (Australian Carbon Credit Units, or ACCUs) for this abatement, that can then be sold to other individuals and businesses wishing to 'offset' their own GHG emissions.

Establishment of the CFI is a welcome development for most landholders, but it is likely to be some time before all aspects are bedded down, and its potential for the practical earning of additional income becomes clear. Activities for which the granting of ACCUs might be sought must be 'additional', that is they must be additional in type or extent to what the farm business already does; farmers will not be able to claim credits for things they already do as part of their 'business as usual' activities, or that are common practice within an industry or region.

Carbon Farming Initiative: The CFI is a legislated carbon offset scheme which sets up the framework for the creation of ACCUs from land sector activities.

The CFI officially commenced on 8 December 2011, and since 2 April 2012 land managers have been able to apply to the Clean Energy Regulator to undertake CFI projects.

The scheme is established under the following three pieces of legislation:

- *Carbon Credits (Carbon Farming Initiative) Act 2011*
- *Carbon Credits (Consequential Amendments) Act 2011*
- *Australian National Registry of Emissions Units Act 2011*

The CFI is underpinned by the Act and the *Carbon Credits (Carbon Farming Initiative) Regulations 2011* (the Regulations). These set out common requirements for offsets projects, including the eligibility criteria, crediting periods, and requirements for reporting, auditing and verifying abatement activities. The Act and Regulations are available from: http://www.comlaw.gov.au.

More information on the CFI is available from http://www.climatechange.gov.au/cfi, and in the CFI Handbook.

(Extract adapted from Department of Climate Change and Energy Efficiency website.)

The CFI positive list will indicate activities and situations where activities are considered 'additional'.

The 'CFI methodologies' used to measure and calculate the amounts of GHG emissions, or of carbon stored by different types of on-farm activities, are being continually developed by both government and private organisations. While there are only a few methodologies approved for use at this stage, more are in the pipeline. Methodologies must be proven to be robust and effective under the situation or 'scope' they are designed to cover—which means that any biophysical or geographic limits, and the specific set of activities, will be prescribed within the methodologies.

With the carbon market in Australia only newly formed there are many uncertainties for participants. A primary consideration for farmers will be how best to finance projects and market the outcomes in order to realise the financial returns. Carbon farming is not a short-term enterprise but rather, represents a long-term commitment to changing or adapting practices.

The methodologies do not provide step by step guidance to project implementation and allow flexibility on how they are integrated within farm activities. Given the long-term commitment being made to carbon sequestration projects it is important projects are well planned and thought out, and that impacts on farm business are fully understood before making a financial commitment.

Native vegetation activities

The creation of carbon credits under the CFI requires the use of methodologies to guide the scope of activities, monitoring and reporting requirements, and carbon accounting methods. Eligible CFI projects are also governed by the CFI positive and negative list of activities.

Methodologies have been approved for the afforestation and reforestation of forests, and establishment of permanent plantings. Both a modelled approach and an in-field measurements approach is provided, ensuring flexibility for project proponents.

Permanent planting means a planting:

- that is not harvested other than:
  - for thinning for ecological purposes, or
  - to remove debris for fire management, or
  - to remove firewood, fruits, nuts, seeds, or material used for fencing or as craft materials, if those things are not removed for sale, or
  - in accordance with traditional indigenous practices or native title rights, and
- that is not a landscape planting.

Methodologies are in development for the human-facilitated regeneration of native vegetation, on land that is not conservation land by the:

- exclusion of livestock, or
- management of the timing and the extent of grazing, or
- management, in a humane manner, of feral animals, or
- management of plants that are not native to the project area, or
- cessation of mechanical or chemical destruction, or suppression of regrowth.

Assisted regeneration is an alternative to adding seed or seedlings to a site. Seed stores in the soil or from remnant plants (e.g. trees, shrubs, grasses), and/or rootstock and lignotubers already present at the site, are encouraged to sprout or germinate, usually in areas where regrowth has been routinely suppressed, or on cleared areas around existing remnant vegetation. The activity is the management or removal of external pressures that prevent regrowth from occurring.

Over time methodologies are likely to be developed for native forest protection and enhancement projects where land owners could be rewarded for management practices that either protects forests from wholesale clearing or human disturbance impacts, or that enhance the sequestration of these forests.

Other activities that may be considered in the future include:

- establishment of tree belts for carbon and commercial outcomes such as biofuel
- establishment of farm forestry plantations
- establishment of native forest that include selective harvesting.

Extracts taken from http://www.climatechange.gov.au/cfi

Kyoto and non-Kyoto offsets projects

Establishment of a permanent planting could be a Kyoto or a non-Kyoto offsets project. The CFI Administrator will determine whether a project is a Kyoto or non-Kyoto offsets project prior to declaring an eligible offsets project. Projects made up of a combination of both Kyoto and non-Kyoto activities can be split into these components in the project approval stage, and offer further opportunities for farmers to include offsets into their farming enterprise.

To be declared a Kyoto offsets project, the planting must:

- be of trees that have a potential height of at least 2 metres and 20 per cent crown cover across the area at maturity in situ; and be greater than 0.2 hectares in area, and take place on land that was not forest on 31 December 1989, or
- take place on land that was forest on 31 December 1989 and has since been deliberately converted to a non-forest use such as cropping or grazing.

Projects are excluded on land that was cleared:

- illegally;
- legally within seven years of the lodging of an application for the project to be declared an eligible offsets project, or
- legally within five years of the lodging of an application for the project to be declared an eligible offsets project if there is a change in ownership of the land that constitutes the project area after the clearing.

Landholders and the CFI

As the CFI is still in its development phase, what can landholders do now? One option is to keep up with developments by periodically checking the websites provided at the end of this document, to see when new methods for offsetting GHG emissions and claiming ACCUs have been approved and become operational. Another is to consider the potential for future gains from the CFI for things that might be started now. Carbon sequestration is a good example. Although it is possible to store carbon in soil by increasing the organic matter content, this is a very slow process because much of that carbon is *labile*, that is, it is processed quickly by soil organisms. Leaf litter from pasture plants and residues (leaves and stems) from annual crops decompose quickly when in contact with warm and moist soil, so that much of the carbon is lost as CO_2 within a few weeks. Even after 10–20 years of conservation farming, the soil organic carbon content may have increased by only 0.5 per cent in the top 10 centimetres or so and the amount of additional carbon being stored is therefore quite low.

Storing carbon in trees, however, can be quicker because much of the carbon produced by the plants is not in contact with soil, is not in an easily decomposed form, and the amount stored continues to increase for many years. This means the amount of carbon for which it may be possible to seek ACCUs in the future is higher, and measurement of stored carbon (whether above or below ground) is easier.

There are risks for the landholder to consider in 'farming' carbon. Fire has negative impacts on vegetation and can wipe out carbon sinks when out of control. Changing management practices can also reduce the amount of stored carbon, for example, if the landholder increases the use of nitrogen fertiliser or decides to cultivate a paddock that has been under ley pasture, carbon is released and stores reduced. This is known as the 'risk of reversal' and must be managed as part of any carbon farming project.

What can landholders do now?

For the landholder the current situation is one in which revegetation works could be undertaken now, for multiple purposes (see Table 1 overleaf), with the added incentive of potentially being able to also claim carbon credits in the future. The Rivers of Carbon project supports such works, enabling farmers to achieve production and biodiversity goals now, while also getting carbon into the landscape at subsidised rates for which they may later be able to claim carbon credits. Managing the riparian zone within the context of the overall farm or land management plan means that different, yet integrated strategies can be used to boost soil productivity along streams and rivers, as well as revegetating the area to create biodiverse carbon sinks. The multiple benefits that can be accrued by landholders prepared to invest in their riparian areas, make projects like Rivers of Carbon attractive, as it enables co-investment with government to achieve short- and long-term productivity and biodiversity goals.

Table 1: Multiple benefits of riparian vegetation 'biodiverse carbon'

For on-farm productivity and income	For biodiversity and sustainability	For adaptation to climate change and carbon sequestration
Riparian vegetation stabilises stream banks, reducing erosion and protecting valuable agricultural land.	Healthy riparian vegetation, with a mix of trees, shrubs and grasses, traps sediment and particle-bound nutrients, pesticides and contaminants washing off paddocks before they reach the stream, reducing risks to water quality.	Climate change is likely to result in more frequent extremes of weather, including temperature extremes. Farmers and landholders will need greater flexibility to alter decisions in the face of a more variable climate.
Healthy riparian vegetation in the upper catchment helps to detain and slow flood flows, reducing damage downstream and the loss of productive floodplain lands.	Trees shade the adjacent stream, protecting its water from extremes of temperature during summer that can reduce aquatic life and fish numbers.	Managing riparian areas as a special land category can help to increase flexibility, by providing additional sources of income or feed reserves to be used in extreme circumstances.
Riparian vegetation provides a windbreak and reduces wind drying of and damage to adjacent crops, as well as protection from extreme temperatures for livestock.	In cold climates the protection provided by riparian vegetation reduces bank erosion due to frost heave and subsequent flow abrasion.	Revegetated riparian land can store significant amounts of carbon in the form of tree trunks and large branches, tree roots, and increased soil organic matter.
Fencing out of river bends and dense vegetation can reduce fencing and maintenance costs as well as making mustering easier.	Tree roots protect and strengthen banks, reducing the potential for erosion and providing important habitat for aquatic ecosystems.	Carbon farming programs and emissions trading provide potential for landholders to sell carbon credits based on the additional carbon stored in revegetated riparian areas.
Healthy riparian vegetation outcompetes and shades weeds reducing control costs, and providing a barrier to fire.	Leaves, twigs, flowers and fruit that drop from riparian vegetation into the stream are important sources of food and nutrients for aquatic ecosystems.	Revegetated riparian land can store significant amounts of carbon in the form of tree trunks and large branches, tree roots, and increased soil organic matter.
Riparian fencing can reduce the risk of stock crossing the stream at low flows onto a neighbour's property, and the risk of losing valuable animals to flood or drowning.	Some insects and larger animals require access to riparian vegetation to complete their life cycle, while some have both aquatic and terrestrial phases to their life.	Revegetating riparian land can subsidise the cost of fencing and create carbon sinks along the stream.

Table 1 (continued)

For on-farm productivity and income	For biodiversity and sustainability	For adaptation to climate change and carbon sequestration
Riparian vegetation provides habitat and food for beneficial insects and birds, which then exert control on adjacent pest species.	Large limbs and whole trees that fall into the stream provide essential habitat for many aquatic animals, including fish, and also help to control flood flows and to protect the channel bed.	Revegetated riparian areas create 'micro-climates' providing refuge for plants and animals that are unable to survive in the wider landscape.
Some revegetated riparian land can be grazed if this is managed carefully, providing a 'living haystack' in times of drought or to cover a seasonal feed gap.	Vegetation in the lower parts of the landscape is usually the last to dry out during times of drought, and provides a crucial refuge from which plants and animals recolonise surrounding areas when better conditions return.	Revegetated riparian land can be used as a drought refuge for stock in times of need.
A decision to fence and revegetate riparian land is often a trigger to reconsider grazing management at a whole property scale, leading to increased feed utilisation elsewhere and higher stocking rates.	Changing land management practices to include wildlife corridors and protected riparian areas provides habitat for native fauna and flora, as well as a range of benefits (shelter, shade) for farm animals in adjoining paddocks.	Farming carbon can be integrated into the overall property management plan, with the establishment of different grazing regimes and practices boosting soil productivity and revegetation.
Riparian vegetation can provide additional income if managed with care, through the harvesting and sale of poles and posts, saw timber, foliage, flowers or honey production.	Beneficial insects such as bees, and predatory fauna such as owls can flourish in areas managed for additional income. In these situations improving biodiversity can also improve productivity gains on-farm.	Planting a mix of harvest and non-harvestable timber creates carbon sinks that can be managed over the long term for both productivity and environmental outcomes.
Anecdotal evidence suggests that a well vegetated riparian area can increase a property's value.	People tend to seek out riparian areas for recreation as the biodiversity, water and 'sense of place' has high social and cultural value.	Farming carbon enables aesthetic, social and cultural values to be realised, further adding to the economic value of the property.

Southern Pygmy Perch (pictured).

What is the Rivers of Carbon project doing?

The Rivers of Carbon project is working in partnership with landholders, natural resources management (NRM) regional bodies and other organisations in the Southern Tablelands region of New South Wales to enhance carbon sequestration and biodiversity conservation in riparian and adjacent systems. The project has a big and bold vision to create 'carbon sinks' while at the same time rehabilitating waterways and terrestrial habitats.

The Rivers of Carbon project aims to form intact riparian corridors by revegetating, restoring and enhancing existing sites in order to link native vegetation and previously rehabilitated sites. In particular, linking biodiversity hotspots (centred on riparian vegetation of high conservation value and threatened species throughout the upper Lachlan and Murrumbidgee catchments) to intact vegetation and expanding their habitats will be a priority. The project aims to increase the habitat for, and populations of, important threatened species including the Southern Pygmy Perch, Southern Bell Frog, Macquarie Perch, Murray Crayfish and the Superb Parrot (shown at right).

Both in-stream and riparian habitat will be restored by enhancing and linking existing native vegetation and revegetation sites, enabling movement of wildlife across the landscape. In certain areas, for example areas of Southern Pygmy Perch habitat, strict guidelines will be adhered to in order to ensure that specialised habitat requirements are being met. The project will also extend riparian corridors into the wider terrestrial landscape to facilitate species movement in the face of climate change, as well as leveraging biodiverse Carbon Farming Initiatives in these highly productive areas. The strong on-ground focus of the project aims to provide 'win-win' solutions to land managers by managing for both environmental and production outcomes.

Where can I go for more information?

- Rivers of Carbon — http://riversofcarbon.org.au/
- Carbon Farming Initiative — http://www.climatechange.gov.au/cfi
- Australian Government Biodiversity Fund — http://www.environment.gov.au/cleanenergyfuture/biodiversity-fund/index.html
- Australian River Restoration Centre — http://australianriverrestorationcentre.com.au/
- Greening Australia Biodiverse Carbon — http://www.greeningaustralia.org.au/our-projects/biodiverse-carbon
- The Regenesis Toolkit: A guide to establishing locally native mixed species carbon forests in urban and rural environments — http://www.australiancarbontraders.com/regenesis/resources/TheRegenesisToolkit.pdf
- The Soil Knowledge Health Bank — http://soilhealthknowledge.com.au/

Australian Government

working together for a cleanenergyfuture

The Australian River Restoration Centre

Greening Australia

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