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An assessment of carbon sequestration potential of riparian zone of Condamine Catchment, Queensland, Australia

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ABSTRACT

Riparian vegetation is crucial for providing a diverse range of ecosystem services. However, the role of riparian vegetation in storing carbon is recently being realised. This study aims to estimate the current status of biomass carbon from riparian vegetation and coarse-woody debris (CWD) along the Condamine River and its tributaries in Queensland, Australia. Trees, shrubs and CWD from 17 sample plots were inventoried using standard protocol and were converted into biomass and carbon mass. The average of total carbon for poor, good and excellent plots were 4.3 t/ha, 134.8 t/ha and 291.7 t/ha, respectively. This indicates that 291.7 tC/ha is easily achievable in riparian zone of Condamine Catchment where the edaphic, topographic and climatic factors are favourable for riparian vegetation. The results of this study would help landholders and policy makers to understand the carbon sequestration potential of riparian zones, and promote current government mixed species environmental plantings (MSEPs) activities under the Emissions Reduction Fund, which ultimately promotes more resilient, economically viable and environmentally sustainable land use practices on a landscape level.

1. Introduction

The riparian zone, one of fifteen globally recognised terrestrial biomes, is the narrow interface between terrestrial and freshwater habitats (Burger et al., 2010). It consists of the bed, banks, vegetation, adjacent land and the floodplain. Riparian vegetation types are rich in biodiversity and provide a diverse range of ecosystem services (Abernethy and Rutherfurd, 1999; King et al., 2009; Opperman et al., 2010; Baral et al., 2014a,b) such as regulating the flow of nutrients and energy and intercepting nutrients and sediments before they enter water bodies (Lake, 2005; Smith et al., 2012). They are crucial for: protecting water quality and the aquatic environment; slowing down the velocity of flood water; stabilising banks and preventing erosion; enhancing groundwater storage; protecting livestock and crops from wind; and providing a productive habitat for pollinating insects, fish and pasture for livestock (QDAFF, 2012; Smith et al., 2012; Williams et al., 2013).

A vast proportion of these important vegetation systems have either been cleared or degraded across the world (Nilsson and Berggren, 2000; Culas, 2007a,b; Gentle, 2000). In some parts of the world they are exposed to logging pressure despite serious concern from the public about the negative impacts of harvest on terrestrial and aquatic ecosystems (Bengtsson et al., 2000; Gentle, 2000; Broadmeadow and Nisbet, 2004; Kreutzweiser et al., 2008). In Australia, riparian vegetation has been cleared for crop and pasture production, resulting in an increase in greenhouse gas emissions (Maraseni et al., 2007; Maraseni and Cockfield, 2011). Without careful management, these production systems can contaminate adjacent waterways with sediments, nutrients, herbicides and pesticides. As a result, the productive, protective, and aesthetic functions and ecosystem services of riparian zones can be severely impacted (Tockner and Stanford, 2002; Burger et al., 2010; Smukler et al., 2010; Baral et al., 2014a,b).

In the context of climate change, the role of riparian vegetation in sequestering carbon in its soils and biomass is increasingly being realised (Burger et al., 2010; Smukler et al., 2010). Therefore, restoration of the riparian zone has been a priority in many parts of world (Bullock et al., 2011; Calmón et al., 2011) including Australia (Department of Environment, 2015) as it has considerable potential to contribute to both forest biodiversity and carbon sequestration, and several other ecosystem services.

More importantly, over the past 200 years, Australia has lost about 40% of total forest cover (Bradshaw, 2012). To reverse the trend Australian Government has included the provision of mixed species environmental plantings (MSEPs) under the Emissions Reduction Fund (ERF) with the expectation of carbon seques-

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tration benefits and several other co-benefits (Department of Environment, 2014). Riparian zones may be better sites for MSEPs in many regions, largely due to their relatively fertile soils and abundant soil moisture. In rural landscapes these areas typically have some remnant vegetation, allowing for the formation of corridors through linking remnants. Therefore, potential co-benefits from MSEPs plantings in the riparian zone are likely to be greater. In addition to several other benefits, in Australia MSEPs along riparian zone can: (1) offset the effects of past deforestation such as dryland salinity and increased rates of sediment and nutrient export (Jackson, 2005; George et al., 2012; Sochacki et al., 2012); (2) purifies freshwater (Daily, 1997) and enhances aquatic diversity by buffering streams from the effects of climatic variability (Thomson et al., 2012); (3) reduces wind and/or water erosion (Bradshaw et al., 2007; Bradshaw, 2012; DCCEE, 2013); and increases agricultural crop pollination efficiency (Hoehn et al., 2008; Carvalheiro et al., 2011).

The ERF allows farmers and other land managers to earn carbon credits by storing carbon or reducing greenhouse gas (GHG) emissions on land. With this initiative, the Australian Government expects to contribute to the unconditional target of a 5% reduction in GHG emissions by 2020 relative to 2000 levels, and the majority of this reduction is expected from sequestration projects (Australian Government, 2015). This study aims to estimate the current status of biomass carbon from riparian vegetation and coarse-woody debris (CWD) along the Condamine River, the major river system in the Condamine Catchment, Queensland, Australia. The results of this study would help landholders and policy makers to understand the carbon sequestration potential of riparian zones, and make appropriate land use management decisions.

2. Methodology

2.1. A brief snapshot of study area

The Condamine Catchment covers an area of 2.5 million hectares and has a subtropical climate, with average annual rainfall of 682–955 mm, and average temperatures ranging from 3 °C to 30 °C. Major industries in the catchment include livestock, intensive animal industries, cropping, horticulture, forestry, tourism, mining and manufacturing. The Catchment has major and minor streams with a total length of 1882 km and 10,174 km, respectively (Apan, 2007). Our targeted riparian area is 50 m on either side of the major and minor streams of the Catchment, which is equivalent to 4.8% of the catchment area. These streams form a central support for biodiversity and provide a key to the connectivity across the catchment (Fig. 1).

2.2. Sampling design

The sites sampled in this study were part of a Riparian Protection and Restoration Program funded through the Australian Government's Clean Energy Futures' Biodiversity Fund between 2012 and 2014. Under this Program the state of riparian zone was assessed within 54 transects, 21 from Killarney–Warwick section and another 33 from Warwick–Cecil Plains section. The assessment was based on 11 indicators/attributes. The focus for this particular study was the current status of biomass carbon in 'excellent', 'good' and 'poor' sites. These sites experience similar climatic conditions, but exhibit great difference in biomass carbon, mainly due to differences in farming and conservation practices.

As the study was interested only in the trees and shrubs and coarse-woody debris (CWD) biomass, the total scores of three related attributes (trees, regrowth and habitat) were considered in this study for the purpose of classification of 'excellent', 'good' and 'poor' sites. Indicators "trees" and "regrowth" are linked with above and below ground biomass and "habitat" indicator is linked with CWD. It is assumed that these three attributes can adequately explain the variation in total biomass (both in trees and shrubs and CWD). Each indicator was assessed against one to ten scales, where one was worst and ten was optimal.

In order to estimate the current carbon sequestration amount in riparian vegetation and CWD, the 54 plots were divided into three classes (excellent, good and poor) based on the total score of the three selected attributes. On this basis, 18 plots were classified as excellent condition, 17 as good condition and 19 as poor condition (Table 1). After the classification/stratification, random sampling was conducted for each class/stratum. Due to limited time and resources, we have decided to sample about 30% from each of excellent, good and poor classes. Access was denied for one of the selected "poor" site reducing the overall representation of poor sites compared to other sites. Finally, in total, five, six and six samples were selected from poor, good and excellent category, respectively, for the in-depth forests and CWD inventory (Table 1 and Fig. 1). In the beginning of the inventory selected transects (sample plots) were located and requested attributes were measured and carbon amounts estimated (discussed below).

2.3. Measurement of diameter at breast height (DBH)

Each sample plot was 10 m × 50 m in size (0.05 ha), along the back of river/creek. In each sample plot, diameter of all trees and shrubs ≥2 cm diameter at breast height (1.3 m height from the ground) was measured using diameter tape. If a tree was in a sloping area, height was measured on the uphill side of the stem. If there was a buttress at DBH, diameter was measured above the buttress. In addition to DBH, as suggested in DCCEE (2013), measured stems were scored for 'health' based on categories described in Table 2.

2.4. Estimation of tree and shrub biomass

Biomass can be estimated from measured DBH data using either biomass tables or growth models. Growth models (allometric equations) are available for most of our riparian species and therefore reasonably accurate estimation of biomass was possible. For the purpose of this study, where possible, species-specific allometric equations were used; where species-specific equations were not available, best available generic equations were used:

- For *Salix babylonica* (Source: Chave et al., 2005)

$$B = 0.49 \times \exp(-1.499 + 2.148\ln(d) + 0.207(\ln(d))^2 - 0.0281(\ln(d))^3) \quad (1)$$

- For *Grevillea robusta* and *Syzygium* sp. (Source: Keith et al., 2000)

$$B = \exp(-1.8957 + 2.3698\ln(d) + (\frac{0.2942^2}{2}) \quad (2)$$

- For *Brachychiton rupestris* (Source: Chave et al., 2005)

$$B = 0.25\exp(-0.667 + 1.784\ln(d) + 0.207\ln(d)^2 - 0.0281\ln(d)^3) \quad (3)$$

- For *Angophora floribunda*, *Eucalyptus camaldulensis*, *Casuarina cunninghamiana*, *Melaleuca* species and other *Eucalyptus* species