Farming soil carbon calculator (FSCC) – Estimation of soil carbon by improved land management practices in Central West NSW

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Abstract
Excel spreadsheet 'Farming Soil Carbon Calculator' (FSCC) has been developed to determine the expected soil carbon levels for different soil types, land management practices and climatic zones throughout the Central West Region of NSW. This simple tool was developed to rank farmers, so that those increasing soil carbon levels could receive a financial incentive to continue their improved land management practices. This poster paper explains the logic that drives the spreadsheet, providing three examples of a grazier on the tablelands, a mixed cropping and grazing enterprise on the slopes, and a cropper on the plains.

Key Words
Farming, soil carbon, calculator, spreadsheet, land management, incentive payment, Central West NSW.

Introduction
Since 2004, the Central West Catchment Management Authority (CMA) has implemented hundreds of on-ground projects in conservation farming machinery, perennial pasture establishment, improved grazing management through fencing and water projects and the application of sodic soil ameliorants. A total of 582,777 ha farming lands throughout the Central West catchment have been managed for improved soil health (CWCMA 2008). By working closely with relevant government agencies and regional organisations such as Carbon Farmers of Australia, the Central West CMA has promoted the benefits of 'carbon farming'. In the past three years the Central West CMA has conducted 'Carbon Cocky' competitions and sponsored three conferences to create awareness and flag the possibility of a voluntary 'Carbon Credits' scheme. Carbon credit schemes for agricultural lands is problematic because it is costly to accurately measure and monitoring soil carbon on farms, and there is a need to account for the green house gas emissions.
In 2009-10, the Central West CMA commenced a project titled 'Land Management Activities for Increasing Soil Carbon' to provide financial incentives for landholders who are practicing improved land management activities that increase soil carbon on their properties (Lawrie *et al.* 2010). To facilitate this project, an excel spreadsheet FSCC was developed to calculate the amount of soil carbon sequestered under different farming systems, soil types and climate zones throughout the Central West Region of NSW. The Central West CMAs Increase Soil Carbon project and FSCC spreadsheet is an initial step in developing a practical and affordable methodology that rewards farmers for the soil carbon sequestered. The main advantage of this approach is that it allows the limited CMA incentive dollars to be allocated to eligible farmers in an 'open and transparent' manner, and can be easily modified and refined as further soil carbon farming data becomes available.

Methods
The spreadsheet is based on the maximum known soil carbon levels for various soil types found throughout the region (Murphy *et al.* 2003) which is then linked to the 'best soil management practices' that can be implemented on agricultural lands. The formulas used to estimate the Soil C levels for the different scenarios, are based on the following logic:

- Clayey soils on the Slopes can store up to 70 Mg Soil C /ha under Woodlands, 50 tonnes / ha under Pastures and 35 Mg/ha under Cropping. Soil C on the Tablelands is multiplied by 1.3 to reflect improved soil sequestration under the cooler / wetter climate, while values for the Plains are multiplied by 0.65 reflecting the drier / hotter conditions.
- Soil clay content has a big bearing on the amount of Soil C that can be sequestered. Fine Textured Soils have a factor of 1 as these soils have the greatest potential to store soil carbon, Medium Textured Soils have a factor of 0.85, Coarse Textured Soils have a factor of 0.70 and Sodic Surface Soils have a factor of 0.60.
- Total Soil C (Mg /ha) and Soil C % calculations are based on 0 - 30cm depth which is the Kyoto protocol depth, with an assumed bulk density of 1.3.
- The spreadsheet takes into account the various management practices (Geeves *et al.* 1995; Charman

et al. 2000) that affect soil carbon levels under Pasture Land, Cropping Land and Woodland Areas which are described below. Each of the Land Management Actions has a range from 'Optimum Management' to 'Poor Land Management' and only one option can be selected for each action.

Pasture Lands

1. Grazing Management

a. Optimum Time Control Grazing for environmental outcomes (80 to 200+ days) with grazing charts
b. Time Control Grazing for production / livestock outcomes (80 to 200+ days) with grazing charts; Remove stock less than optimal circumstances
c. Optimal Rotational Grazing (20 to 80 days rest) Ground cover 70% - 80%; Pasture Biomass 1.0 Mg /ha; Pasture height 10cm - 15cm
d. Rotational Grazing (20 to 80 days rest); Remove stock less than optimal circumstances Ground Cover substantially < 70%
e. Optimal Set Stocking Stock numbers adjusted to pasture production
f. Set Stocking Stock numbers not adjusted to pasture production (overstocking)

2. Soil Nutrition

a. Optimal Management of Soil Nutrition Factors include Grazing Legume/Grass mixes, Regular Soil Testing, Lime, Sulphur and Phosphorus applications
b. Minimal Management of Soil Nutrition Factors include Legume/Grass mixes, Occasional Soil Testing, Some Lime, Sulphur and Phosphorus applications when affordable
c. Soils not Management for Soil Nutrition Minimal / No Soil Testing, No Lime, Sulphur and Phosphorus applications (obvious nutrient deficiencies / acidity), use of volunteer pastures

3. Soil Structure Management

a. Optimal Management of Soil Structure Use Ameliorants (Lime, Gypsum, Bio-solids), Regular Soil Testing, Managing stock to prevent compaction e.g. restricted grazing in wet areas
b. Soil structure problem not being addressed effectively

4. Pasture Species Composition

a. Well established perennial grasses Approx. 50% perennially and approx. 30% legumes
b. Pastures dominated by annual species < 50% perennially, and little or no legumes

5. Extensive Tree & Shrub Establishment

a. Saltbush Plantings / Alley Farming Systems / Agroforestry
b. No extensive tree and shrub establishment

6. Catchment Engineering Works

a. WaterPonding / Water Spreading / Natural Sequence Farming / Keyline / Extensive Soil Conservation Structures
b. No catchment engineering works

Cropping Lands

1. Tillage Practices

a. Zero Till Cropping (disc) < 5% topsoil disturbance
b. No Tillage 5% - 20% topsoil disturbance Narrow knife tynes or disc at sowing
c. Direct Drill One pass full disturbance at seeding
d. Reduced Tillage One pass before seeding, and full disturbance at seeding i.e. two cultivations
e. Multiple Tillage Two or more cultivation before seeding, and full disturbance at seeding

2. Stubble Management

a. 100% Stubble Retention (no grazing)
b. 50% to 80% Stubble Retention (grazing management, Coolamon harrows etc.)
c. 30% - 50% Stubble Retention (late, cool burning, baling)
d. Complete Stubble Removal (early hot burn)

3. Soil Nutrition

a. Optimal Management of Soil Nutrition Factors include Legume Rotation, Regular Soil Testing / Applications of N, P, K, S and Lime / Gypsum for Maximum Yield
b. Minimal Management of Soil Nutrition Occasional Soil Testing, Some N, P, Lime, Sulphur applications and some Legumes in rotation
c. Soils not Management for Soil Nutrition Minimal / No Soil Testing, No Nitrogen, Phosphorus, Lime, Sulphur applications (obvious nutrient deficiencies / soil acidity)

4. Soil Structure Management

a. Optimal Management of Soil Structure Use of Ameliorants (Lime, Gypsum, Bio-solids), Regular Soil Testing
b. Soil structure problem not being addressed effectively
c. Pasture / Crop Rotation
d. Pasture Cropping Direct seeding annual crop into a perennial pasture
e. Mostly well established perennial pastures > 50% time e.g. 6 years pasture, 4 years cropping
f. Mostly annual cropping or volunteer species > 50% time cropping e.g. 4 years pasture, 6 years cropping
g. Continuous Cropping

5. Cover Cropping

a. Cover Cropping Planting cover crop straight after harvest, then spraying / rolling before next years sowing
b. No Cover Cropping

6. Double Cropping

a. Double Cropping Sowing second crop immediately after harvest (opportunity cropping when seasonal rainfall is favourable)
b. No Double Cropping

7. GPS Controlled Traffic

a. GPS Controlled Traffic Machinery used confined to same wheel track
b. No GPS Controlled Traffic

Woodland Areas

a. Woodland Protection Livestock Excluded, Zero Cropping / Grazing, Ground Cover > 90%, All structural layers present (Trees, Shrubs and Grasses)
b. Woodland Management Strategic Grazing, Ground Cover > 70%, Area managed for production / biodiversity outcomes
c. Woodland Management Grazing, Ground Cover < 70%, Area managed for production

Each of the above land management practices were weighted by an expert panel within the Central West CMA to reflect their contribution to sequester soil carbon by:

- Increasing biomass production for improved groundcover and a biological food source
- Reducing soil disturbance and compaction
- Balancing soil chemistry and nutrition for optimum plant growth
- Increasing pasture or crop perenniality and / or increasing the rooting depth of annual plants such as crops
- Increasing pasture and reserve species biodiversity and crop rotations
- The total scores for Pasture Lands, Cropping Lands and Woodland Areas are expressed as a percentage to a maximum of 100%. If optimum farm management practices are implemented then the score is 100%, and the quantity of Soil Carbon Sequestered is calculated as the maximum amount possible for that specific soil type and climatic zone. The scores range from 15% to 100% under Pasture Lands, 8% to 100% under Cropping Lands, and 72% to 100% under Woodland Areas. These weightings are initial 'best estimates' for the different farming systems employed, and will be adjusted as better soil carbon data becomes available. The amount of soil carbon stored under the various land management practices are expressed as Total Soil Carbon Stored (tonnes/hectare) and (Soil Carbon %).

Farms were assessed and ranked using the FSCC spreadsheet and land management actions accurately mapped using GIS technologies. Importantly, farmers selected by this process received incentive funding, and have agreed to undertake detailed soil testing and monitoring so that this information can be used to further our knowledge of soil carbon sequestration on agricultural lands.

Conclusion

The FSCC spreadsheet has proven to be a useful tool for selecting leading farmers who are increasing soil carbon through improved land management practices. It is an integral component of the Central West CMA incentive project that rewards good farming practices, with estimated soil carbon levels linked to specific land management activities, soil type and climatic zones. The land management practices defined within the spreadsheet have been used in the development of a soil carbon matrix model (Murphy 2009), and the formulas can be modified in the future as more accurate soil carbon data is obtained.

In addition, the FSCC spreadsheet has been an important educational tool and has helped CMA staff and landholders increase their understanding of land management and soil carbon issues. The Central West CMA soil health program and the development of the FSCC spreadsheet have greatly increased the level of understanding of carbon farming principles throughout the Central West Region of NSW. The FSCC spreadsheet offers a simple and rapid method for determining soil carbon sequestered in agricultural landscapes, and could be adapted to other regions and farming systems.

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