Natural Climate Solutions for Zero South East

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Contents

Abstract

Reducing greenhouse gas emissions from human-based activity is just one side of the equation when it comes to tackling climate change. The other is the sequestration ("drawdown") of more carbon from the atmosphere into natural assets such as forests, soils and oceans. This study evaluates the opportunities for carbon drawdown in the South East region of NSW via 13 different 'natural climate solution' pathways. There are large opportunities from small (1-10%) changes in current land use practices in State Forests and on grazing lands. Emissions avoidance from stopping 1% p.a. land clearing (e.g., logging or conversion of native grasslands to improved pasture) is more effective than 10% changed land use practice that leads to increased carbon drawdown (e.g., planting trees on farms) but both are economically attractive to landholders when there is an accessible carbon market. These carbon mitigation solutions also generate significant co-benefits to agricultural productivity, biodiversity and local economies.

Introduction to Natural Climate Solutions

'Natural Climate Solutions' use land-based natural resources to draw down carbon from the atmosphere into forests, soils and wetlands, thereby contributing to the world's goal of net zero emissions by 2050. Globally, they have the potential to remove 10 $GtCO_2/y$ from the atmosphere when deployed at cost-effective levels [1]. At the same time, global emissions from power, transport, heating and industry must be reduced from >40 $GtCO_2/y$ to <10 $GtCO_2/y$ if temperature increases are to stabilise below 2^0C [2].

Australia, owing to its vast land mass, has enormous potential to generate natural climate solutions. This opportunity coincides with the urgent need to restore productivity to agricultural land damaged by long-term over-extraction (e.g., tree clearing, soil degradation) and climate change (e.g., drought, bushfires). The South East region of NSW, one of Australia's key meat and fibre producing areas [3], is an excellent example of how co-addressing climate change and land restoration can generate win-win outcomes for Australia's regional communities [4].

In this study, the potential for carbon mitigation (either by drawdown or avoiding land use emissions) is calculated for each of 14 local government areas (LGAs) in the predominantly rural South East region of NSW[1] (Fig. 1). Thirteen land use change pathways - selected for local relevance from 20 of the most potent, achievable and cost-effective pathways identified for the globe [1] - are applied to one of three types of land resource - forests, grazing land or wetlands (Fig. 2, Table 1, Table 2). Within the study area, 35% of the land is reserved for conservation purposes (mostly in National Parks), 46% is used for grazing of native vegetation and improved pastures, 12% is used for forestry (predominantly logging of native trees in State Forests) and the remaining 7% is occupied by urban and rural residential areas, industry, cropping land and water bodies (Table 1).

General Methodology

The quantity of land use resource type available, split by the 14 LGAs, was calculated from public databases. This quantity was then multiplied by the rate (intensity) of carbon mitigation for the relevant land use pathway to give the LGA's total carbon mitigation potential (Table 4) Land use pathways fall into two types – those for carbon drawdown and those for avoided emissions from land use practice (Table 3). Where possible, intensity values were chosen to fit local conditions (i.e., south east Australia): for most pathways, however, lack of local information necessitated using global intensity values derived from a large number of primary studies [1,6].

Intensity values were applied as fixed rates across the region after applying LGA-specific adjustment factors for average carbon sequestration rates in the LGA (Table 4). These adjustment factors were calculated by taking the LGA's average of pixel-level sequestration rates [7] across all areas designated as woodlands or forests prior to European settlement [8] then standardising by the average value across all LGAs (1.22tC/ha/y). This is considerably lower than the global rate of 2.82tC/ha/y in temperate forests assumed by Griscom et al. (2017), reflecting the lower carbon sequestration rates in Australia in general (Fig. 3b). Pixel-level rates of carbon sequestration in the study area ranged from 1 – 2.5tC/ha/y (4 - 9tCO_2/ha/y) (Fig. 3). This is somewhat lower than the 1.5 - 3tC/ha/y assumed in the Fullcam [9] carbon accounting method used by the Australian government's Clean Energy Regulator and the CSIRO's LOOC-C calculator [10]. There was an approximately two-fold difference in the average rate of sequestration between coastal vs. tableland LGAs (Table 4), reflecting differences in carbon productivity due to climate and soils. These LGA-specific rates were applied to all pathways, including those for drawdown and avoided emissions in vegetation, soil and livestock.

Pathways differed in the form of carbon being targeted (carbon, carbon dioxide or methane, Table 3) but all results are given in CO_2 units. Further details of calculations for specific pathways are given in table footnotes.

Analyses were performed using QGIS software [11].

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[1] The South East as defined in this report includes the 14 LGAs encompassed by the Federal Electorates of Eden-Monaro, Gilmore and Hume (Fig. 1). Note that this differs to the definition of 'South East' used by the NSW State Government for the purposes of regional planning [5] which excludes Kiama, Wollongong, Shellharbour, Shoalhaven and Snowy Valleys) and by that used by NSW Local Land Services (which excludes Snowy Valleys but includes Yass Valley, Upper Lachlan, Wingecarribee, Wollongong, Shellharbour, Goulburn Mulwaree and about one third of Hilltops).

Results

The impacts of 13 pathways to land-based natural climate solutions in the South East region of NSW are described below. In general, results are described in terms of 10% land use change for pathways involving extra drawdown and 1% land use change in pathways involving avoided emissions. While the focus was on quantity of greenhouse gas mitigation, the associated economics, environmental co-benefits and policy aspects are also addressed.

Reforestation of farmland

Introduction

The South East region of NSW comprises a tableland-mountain landscape (altitude typically 500-1000m) to the west and an escarpment and coastal strip to the east. It falls in a dry temperate zone with 500-1000 mm annual rainfall. Prior to European settlement, the area was covered in trees with the exception of a large area of basalt on the Monaro that was naturally grassland [12], Fig. 3d). Since European settlement, much of the grassy woodland found on the central tablelands of the region has been heavily cleared for livestock grazing purposes. The dry and wet sclerophyll forests in the surrounding mountains remain largely intact and within National Parks and State Forests (Fig. 3). Thus, the opportunities for reforestation fall predominantly on farmland held under private tenure.

Pathways

The 'trees on farms' (reforestation) pathway involves planting trees on ridgelines, creek lines, erodible areas and as shelterbelts in order to promote water retention, soil life, livestock well-being, biodiversity, ecosystems services and buffering against weed invasion (Table 2). In the harsher climate of the Monaro tableland, tree planting is best achieved through planting seedling tubestock while in the wetter and warmer coastal areas to the east, direct seeding is more economical and less labour-intensive.

Land resources

Griscom et al. (2017) provided a high resolution global map of 'reforestation opportunities' based on satellite imagery data combined with broad-scale ecosystem mapping [7]. This map gives estimated sequestration rates, at the pixel level, in areas where trees existed prior to industrialisation (i.e., excluding naturally treeless areas such as natural grasslands) after masking out areas currently under intensive food and fibre production or being managed for biodiversity conservation. After subsetting this map for the South East region of NSW, further masks were applied using locally relevant databases, namely: (**a**) National Parks and State Forests (Fig. 3e); and (**b**) areas predicted to be natural grasslands prior to European settlement [12]. This highly conservative approach to defining reforestation opportunities is designed to protect both biodiversity and food and fibre production.

Around 2 million ha (Table 3, 29%) of the 6.9 million ha in the South East LGAs in this study (Table 1) are suitable for reforestation, most of which fall in the Upper Lachlan Shire (Fig. 3).

Rates of Sequestration

The average rate (intensity) of carbon sequestration from reforestation across the study area was assumed to be 0.97tC/ha/y. This was based on the average of pixel-based values for only the areas cleared of forest or woodland since European settlement: it is lower than the average (1.22tC/ha/y) from forest and woodland areas prior to European settlement because the majority of clearing was in the less carbon-dense woodland areas. LGA-specific adjustment factors (Table 4) were applied to drawdown in vegetation and soils under this pathway.

Carbon Outputs

Table 4 gives the total potential annual rate of carbon sequestration (in CO_2 units) by LGA for all 13 pathways. The analysis shows that if all the land suitable for reforestation was planted with trees, it would draw down the equivalent of 40% of total domestic and industrial annual emissions from the South East at 2022/2023 levels. Assuming a realistic goal for the region of reforestation of 10% of suitable farmland (1% per year over a period of 10 years at a rate of 20,200 ha/y), the expected rate of annual extra carbon drawdown would be 0.55 million tonnes of CO_2. This equates to 3% of the South East region's current total domestic and industrial emissions or, for LGAs with a predominantly grazing economy (Upper Lachlan, Bega Valley, Hilltops, Snowy Monaro, Snowy Valleys), 11-23% of these LGAs' total emissions (Table 5). Note that these estimates are based on an assumed sequestration rate averaged over the lifetime of the tree: since carbon sequestration rates in the first 30-50 years of the life of a tree are higher than the lifetime average [13], these estimates are an underestimate of the impact of reforestation in the next few decades.

Economics

The economics of reforestation at the regional scale are uncertain because of rapid changes in the carbon market price and uncertain adoption rates. An example calculation of the estimated costs and returns to individual landholders, and to the South-East economy as a whole, as summarised in Table 6, nonetheless allows some general conclusions to be drawn.

The first conclusion is that the current (March 2025) carbon price on the Australian market (around $30 per tCO_2) needs to at least triple for landowners to break even on their investment within 25 years. The current European price of $113/t suggests this may soon be possible. Other barriers are the high start-up costs (approximately $10,000/ha for tubestock planting, $3,000/ha for direct seeding) and that returns on investment are relatively slow (10 to 25 years).

The second conclusion is that, owing to the high fixed costs and complexity of marketing (certification, monitoring, professional fees), large planting areas (>100 ha) are required in order to achieve economies of scale. Thus, under current methods for tree carbon farming via the Clean Energy Regulator [14], most individual landholders would be unable to access the market directly but would, instead, need to engage a carbon aggregator in order to achieve economies of scale.

The third conclusion is that the economic potential for the South East region from tree planting on farmland is very high. A 10-year program to revegetate 10% of cleared farmland (1% p.a.) would inject $48 million into the regional economy and create around 1300 jobs for 10 years.

To date, more than 20 tree carbon projects have been registered in the South East by the government's Clean Energy Regulator [15] indicating the likely economic viability of this industry.

Messages for Landholders

- Trees on farms can generate significant extra on-farm revenue.
- Many non-productive areas of the farm such as creek lines, ridgetops, steep slopes and fence lines will benefit from trees through improved water retention, protection. of soils, buffering from weed invasion and restoration of biodiversity.
- Start-up costs are high but so are long-term carbon market yields.
- It is already possible to earn money from tree planting for the carbon market.
- While complexity and costs of carbon marketing are currently high, there are an increasing number of initiatives to address this.
- There is an increasing number of tree planting contractors and nursery suppliers available in the South East region.

Actions for Government

- Instruct the Clean Energy Regulator to devise incentive scheme for small-scale tree carbon farming by individual landholders.
- Regulate and set policy in order to expand demand for tree carbon credits.
- Provide and promote tree planting methodology to landholders.
- Support growth of local workforce for land regeneration.
- Rezone land to promote environmental plantings.
- Promote ‘buy local’ of tree carbon and biodiversity credits.
- Support community tree carbon projects.
- Communicate the links between healthy forests, healthy landscapes and healthy livelihoods.

Soil carbon

Introduction

Management of soil carbon is recognised as having a major role to play in climate regulation [1,2,6]. Soil carbon can help mitigate climate change in two ways. First, changed agricultural practices can lead to more drawdown of atmospheric carbon into soil organic carbon (SOC) thus expanding the land carbon sink. Second, unnecessary emissions of CO_2 from SOC can be avoided by protecting perennial pastures from being ripped up for cropping or other land use. Thus, soils act on both sides of the carbon budget ledger – increased drawdown and emissions avoidance (Table 3).

Australia, with its large land mass and generally poor soil fertility, possesses a large opportunity for climate mitigation through soil carbon management. For this reason, soil carbon has received priority attention from the Federal government’s Clean Energy Regulator as a means towards net emissions reduction [16]. In the South East region of NSW, where 50% of land use is devoted to livestock grazing, 9% to production forests and 29% to conservation (Table 1), there is enormous opportunity to conserve as well as sequester more soil carbon on working land. There are now many soil carbon projects in the South East region registered under the government’s carbon credit scheme [15].

Both conserving and restoring soil carbon stocks have additional benefits of improved soil fertility, reduced soil erosion, enhanced resilience to climate change, and conservation of ecosystems and biodiversity. Thus, using SOC as a climate mitigation method has significant co-benefits of building resilience of natural ecosystems as well as enhancing long-term profitability of agricultural land.

Building up soil carbon stocks can be applied to grazing land, cropping land, forests and wetlands. Importantly, doing so does not involve a change in land use and so provides added value to existing land management practices while also avoiding risks to food and fibre security. It must be recognised, however, that SOC stocks become saturated after a period (decades): therefore, building SOC should be viewed as a short-term measure for climate mitigation. Its relatively rapid impact, on the other hand, fits well with the current imperative for rapid reversal of net global emissions.

Pathways

Specific actionable pathways involving SOC that are relevant to the South East region are listed below. Details of these pathways are given in Table 2 and Table 3. These pathways separate into those that avoid emissions and those that sequester more carbon.

Emissions avoidance

- Avoided forest conversion
- Avoided grassland conversion
- Protection of coastal and inland wetlands and peatlands

Carbon drawdown

- Reforestation
- Grazing - optimal intensity to maximise forage production
- Grazing - adding legumes to improved pastures
- Restoration of coastland wetlands
- Restoration of freshwater wetlands and peatlands

Resources

The quantities and types of land use suitable for changed management practices under these pathways are shown in Table 1 and Table 2, respectively. A total of 5.7 million hectares - 84% of the whole South East region covered in this study - are available for enhanced soil carbon drawdown. 2.2 million hectares are available for avoiding emissions due to land use conversion (native perennial pastures to fodder crops or annual pastures, or wetlands to agriculture or urban development).

Rates of Sequestration and Avoided Emissions

The values for intensities of carbon drawdown and avoided emissions from soil carbon were drawn from Bossio et al. (2020) [6], an updated version of Griscom et al. (2017) [1] (Table 3). Intensities were adjusted for LGA average sequestration rates (Table 4), as described above, before applying to the available resource quantities.

Carbon Outputs

Table 4 shows that the region has large amounts of carbon stored in soils under its pastures and forests. If 1% of these pastures were converted to annual fodder crops each year, an estimated 2.7 million tonnes of CO_2 is expected to be released into the atmosphere, 35% of it from the Snowy Monaro (Table 7). A further estimated 0.13 million tonnes is expected to be released as a result of logging in State Forests at a rate of 1% p.a.

On the other hand, a further 0.34 million tonnes of CO_2 equivalents each year could be stored as soil carbon if 10% of native and improved pastures were sowed with legumes and optimally grazed. A further 0.05 million tonnes per year would be sequestered by reforesting 10% of cleared grazing land (Table 7). Combined, these changed land use practices would equate to a net gain in soil carbon of 3.1 million tonnes of CO_2 equivalents per year, equivalent to 19% of the total emissions from all the LGAs and worth $243 million on the international carbon market (equivalent to $72/ha of all grazing land).

Protecting and enhancing soil carbon in all agricultural grazing lands yields the same order of magnitude of CO_2 mitigation as managing forests differently and planting trees on grazing lands (Table 4). Importantly, these two types of activities do not trade off against each other, thus allowing almost the full potential of the 68% of South East land that is not under conservation management or infrastructure to be harnessed for climate solutions.

Economics

The economic values of changed management of grazing land at the individual farm enterprise level and wetland restoration in order to draw down more carbon were not estimated in this study as there is a general lack of data relevant to the South East region on soil carbon stocks and rates of flux. One study of the Monaro soils and pastures by Monaro Farming Systems found stocks of 40 to 60 t/ha of soil carbon in the top 30cm, depending on base geology (granite, basalt, sedimentary) and pasture type, with potential improvement of up to 10t/ha through soil additives and pasture improvement [17]. Assuming an international carbon price of $80/t$CO_2$, this equates to around $2.9 million of carbon income from a 1000 ha farm that achieves this increase across its full extent.

Messages for Landholders

- Globally, increasing carbon stored in organic matter in soils through drawing CO_2 down out of the atmosphere can account for 15% of land-based carbon drawdown potential [1]. This is additional to the CO_2 that could be absorbed into long-lived plants, wetlands and oceans.
- 40% of this can be achieved from rebuilding depleted carbon stocks, while 60% is achieved by avoiding soil disturbance through land use change.
- Every additional tonne of carbon added to soil means 3.7 tonnes of CO_2 is drawn down from the atmosphere.
- Most Australian soils are not at full carbon storage capacity.
- Soil carbon is lost more easily than it can be gained. Loss occurs whenever soil is laid bare with pasture change, cropping and land clearing. Wetland ecosystems, in particular, suffer high losses at a rate of ~150 tC/ha.
- In the South East region of NSW, where 50% of land use is devoted to livestock grazing, 9% to production forests and 29% to conservation, there is enormous opportunity to conserve as well as sequester more soil carbon on working land.
- In terms of CO_2, the soil alone drawdown opportunities include:
    - Legume addition to pastures 2.1 tCO_2/ha/y
    - Reforesting of farm land 0.3 tCO_2/ha/y
    - Optimal grazing intensity 0.2 tCO_2/ha/y
- Both conserving and restoring soil carbon stocks have additional benefits of improved soil fertility, reduced soil erosion, enhanced drought resilience, and conservation of ecosystems and biodiversity thus enhancing sustainability and long-term profitability of agricultural land.

- There are significant potential financial returns to the South East region from soil carbon via the carbon market (Table 7) thus providing a potential significant economic boost to its economy.
- The volume of tradable carbon, if used at its potential, is of the same order of magnitude as emissions from private and industry use of electricity, transport and agriculture in the region.
- However, it must be recognised that SOC stocks become saturated after a period (decades) and thus building soil carbon is a short-term measure for climate mitigation. Its relatively rapid impact, however, fits well with the current imperative for rapid turn-around in net global emissions.

Actions for Government

As for Reforestation of Farmland (above).

Livestock emissions

Introduction

Livestock emissions account for 6% of global greenhouse gas emissions and around 80% of all agricultural emissions. Ruminant livestock produce both methane and carbon dioxide as a by-product of their digestive process. Methane is 28 times more potent as a climate warming agent than CO_2 over 100 years (80 times over the first 20 years). So, while 20% of livestock belches is CO_2, it is the methane that is doing the most damage to the climate. Since 1950, methane has increased 70% while carbon dioxide has increased 28% [18].

Nitrous oxide (NO_2), another greenhouse gas, is emitted from ruminant manure and urine and is 300 times more potent than CO_2 as a climate warming agent.

In Australia, a vast amount of land is devoted to red meat production thus providing an opportunity for this industry to contribute to global emission reductions through changes in livestock management systems [19,20] .

Pathways

A number of methods are available for reducing the production of methane from ruminant animals used for production. These fall into two categories. The first involves increasing the growth and health of animals in order to maximise production, minimise lifetime and reduce the overall number of animals needed to meet consumer demand, thereby avoiding needless methane (and CO_2) emissions. In the context of production in the South East region of NSW, this pathway would include genetic breeding, pasture improvement, grazing management, parasite control and other measures that increase overall growth, fibre and reproductive performance of beef cattle, dairy cattle, wool sheep and meat sheep.

The second method is to manipulate the diet of the animal such that it leads directly to reductions in methane as a by-product of digestion. In this study, only one of the several ways to do so, namely, supplementation with *Asparagopsis* seaweed [21], is considered (Table 2, Table 3).

While research is ongoing as to the potential co-benefits (e.g., increased feed efficiency) and possible drawbacks (e.g., taste, meat and fibre quality) of *Asparagopsis* supplements, and there is much yet to be achieved to scale up its production for commercial use, early indications are that this technology has realistic prospects for widespread application to achieve large emissions reductions within the Australian livestock industry [22,23].

Resources

To each of the three types of grazing areas in the South East (native pasture, improved pasture and irrigated pasture, Table 1), carrying capacities in dry sheep equivalent (DSE) units (i.e., the maintenance energy requirement of a 50kg dry ewe) of 1.5, 2.5 and 7 per hectare were assigned to compute the total DSE carrying capacity for each LGA (Table 3). As for trees on farm land and soils above, these carrying capacities were then adjusted for the LGA's relative carbon sequestration intensity calculated from the map of reforestation opportunity in ref. [1] (Table 4).

Rates of Avoided Emissions

Estimates for emissions from livestock in the South East context [17] and in Australia in general [24][24,25] are around 240kg of CO_2 equivalents per DSE. If use of *Asparagopsis* is 60% efficient in reducing methane emissions [26], this would translate to a rate of 0.039tC/DSE, which was applied to the 'Grazing – feed additives' pathway (Table 3).

The estimated global value of emissions avoided through feed additives (the 'Grazing – feed additives' pathway [27], Table 3) is 0.13tC-equivalents/head of cattle, or 0.016tC/DSE. These avoided livestock emissions are assumed to be achieved through use of energy dense cereal grain and improved pastures that enable more efficient protein production [27] (Table 3) and are based on a large review of livestock emissions data from many different livestock systems [28]. To put this global value into the local context, growing a 350kg beef animal (equivalent to 8 DSE) in south east Australia at an emissions intensity of around 240kgCO_2/DSE [25] is expected to emit the equivalent of 1.92tCO_2/head of cattle, equivalent to 0.52tC/head of cattle. Thus, the feed additives pathway is assumed in the global study [1] to reduce emissions by 25% in a south east Australian beef production setting.

In the global analysis [1], a further emissions reduction of 0.04tC/head (0.005tC/DSE) was assumed to be possible through improved growth, reproduction and health (the 'Grazing – improved management' pathway, Table 3). This represents a further reduction of 8% of emissions under conditions typical of south east Australia.

Carbon Outputs

If 10% of animals in the South East region had *Asparagopsis* added to their feed, the total amount of methane emissions would reduce by an estimated 0.084 million tonnes of CO_2 each year or 0.5% of the total annual emissions from the region. Improved quality of feed and herd management would contribute a further 0.045 million tonnes in emissions reduction. Most of these gains would come from the Snowy Monaro and Upper Lachlan LGAs.

Cattle emit proportionately more than sheep on a DSE basis. Since estimates of emissions reductions intensity were based on head of cattle [1], but the grazing industry in this study is comprised of both cattle and sheep, the avoided livestock emissions calculated here are likely to be over-estimates.

Economics

Assuming DSE/ha rates of 1.5 and 2.5 and 7 for native, improved and irrigated pastures, respectively, the reduced emissions from *Asparagopsis* treatment used in 10% of the herd translates to annual returns of $2, $3 and $8/ha at the international carbon price of $80/tCO$_2$-e. Since *Asparagopsis* is only just becoming commercially available, however, the costs are unknown and so the economic benefits to the livestock producer have not been calculated in this study.

Messages for Landholders

- Emissions from belching of ruminant livestock contribute a large amount to the overall greenhouse gas emissions of Australia and the world.
- Feed additives such as high energy and protein-rich feed, or *Asparagopsis* seaweed can directly reduce the amount of methane released by an animal.
- *Asparagopsis* can be grown on the south east coast of Australia.
- *Asparagopsis* production is still under development but should soon be widely available if further studies on livestock growth and improvement give favourable results.
- Increasing growth and reproduction rates of livestock to reduce through changed feed and management practices can also substantially reduce the total lifetime emissions from ruminant livestock.
- Carbon marketing options from reduction of livestock emissions are available.

Actions for Government

- Support investment in *Asparagopsis* and other feed additive technologies
- Support investment in technologies that allow higher intensity production in Australia's livestock systems.
- Incentivise farmers to adopt more intensive production systems.

Native Forest Management

Introduction

Preservation and regrowth of natural forests is predicted to make a major contribution to climate mitigation at the global level [2,27,29]. The South East region of NSW is rich in NSW State-owned forests that are logged at a rate of around 1% per year, mainly for wood pulp production. An analysis of this industry strongly argues the economic case for cessation of logging, which produces a net loss, in return for carbon credits [30]. The region is also well endowed with National Parks, all of which are forested and which could contribute climate solutions through changed management.

Pathways

Opportunities for climate mitigation via changed management of the South East forests and woodlands are described in Table 2 and Table 3. First, emissions could be avoided by ceasing logging of 80-200 year-old trees. This would also avoid loss of soil organic carbon caused by the disturbance. Second, carbon drawdown can be achieved through forest regrowth in areas saved from logging or extension of logging cycles. Third, emissions could also be avoided through fire management (reducing intensity and extent of fires through pre-emptive action) in State Forests, National Parks and areas of private land with forests or woodlands.

Resources

The South East region considered in this analysis is comprised of native State Forests (6%), 3% pine plantation forests (3%) and National Parks (25%). Across the full study area, 16% is classified as wet sclerophyll forests, 23% as dry sclerophyll forests and 12% woodlands [8].

Rates of Sequestration and Avoided Emissions

The intensity value for avoided emissions from forest removal was set at 48.8tC/ha in this study. This value was derived by multiplying the global rate of 112tC/ha [1] by the ratio of the South East average rates of sequestration (1.22t/C/ha) to the global rate of sequestration of (2.82) [1] (Table 3). The value for intensity for onward growth of areas saved from logging (the 'Growth of non-logged forests' pathway), was assumed to be the average sequestration rate across all areas that were forests or woodland prior to European settlement (1.22tC/ha). The global value for intensity of avoided emissions from fire management in temperate forests of 11.1tC/ha [1] was used. All values were adjusted for LGA-specific carbon sequestration rates using the factors given in Table 4, as described above.

Carbon Outputs

The estimated amount of avoided emissions from stopping 1% p.a. logging of native trees in State Forests was 1.1m tCO_2/y (Table 4): this is similar to the estimate of 0.95tCO_2/y from an independent on the native forest logging industry in the South East region [30]. A further 0.13 tCO_2/y could be avoided from the loss of soil carbon in logged areas. Combined, this represents 7% of the total emissions from the South East LGAs included in this study. Fire management could account for a further 1.6 million tCO_2/y if effectively applied to 1% of all 3.6m ha of the burnable forests and woodlands in the study area (Table 4). In the 2019-2020 bushfires, 1.86 million hectares of the study area (25%) were burned [31], releasing an estimated 50 million tCO_2 into the atmosphere [32] which is 3.1 times the annual emissions from domestic, industrial and agricultural activities in the South East LGAs studied here.

Economics

A full economic analysis of the State Forest logging industry is given in [30] and so is not replicated here.

Actions for Government

- Exchange logging of native forests for carbon credits and other activities (e.g., tourism) in native State Forests
- Prioritise and implement fire management in the region's National Parks and State Forests

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Figures and Tables

Fig. 1. The South East Region of NSW covered in this report. The 14 local government areas (LGAs, capital letters) within the Eden-Monaro, Gilmore and Hume federal government electorates were included. The area excludes several other LGAs within the South East Local Land Services boundary, or within the area defined as 'South East' by the NSW government for regional planning purposes [5]. Major towns are indicated by black and white circles.

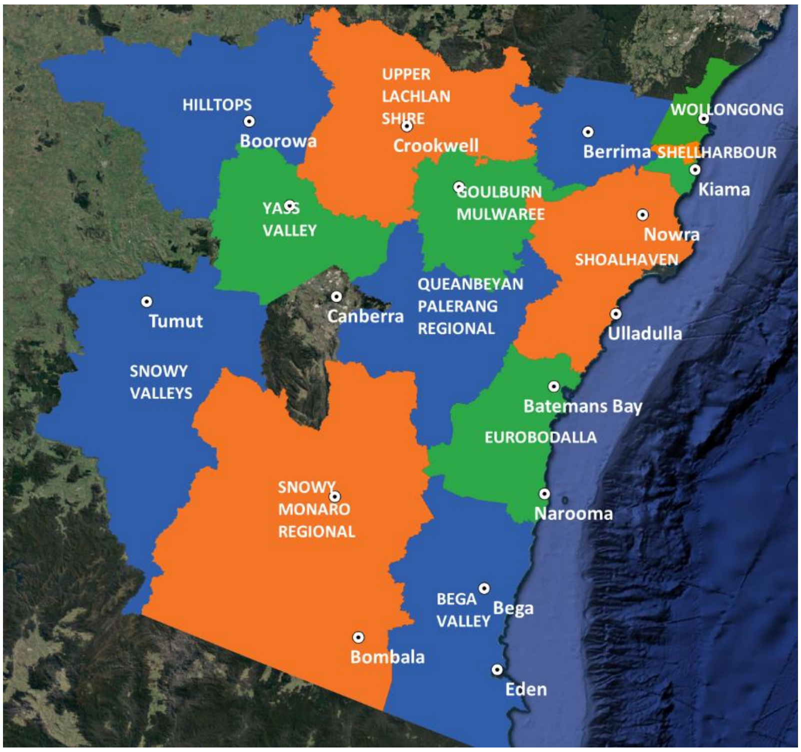


Fig. 2. Land use map for the South East. Data are for 2020 and are sourced from [33]. Corresponding summary data by LGA are found in Table 1.

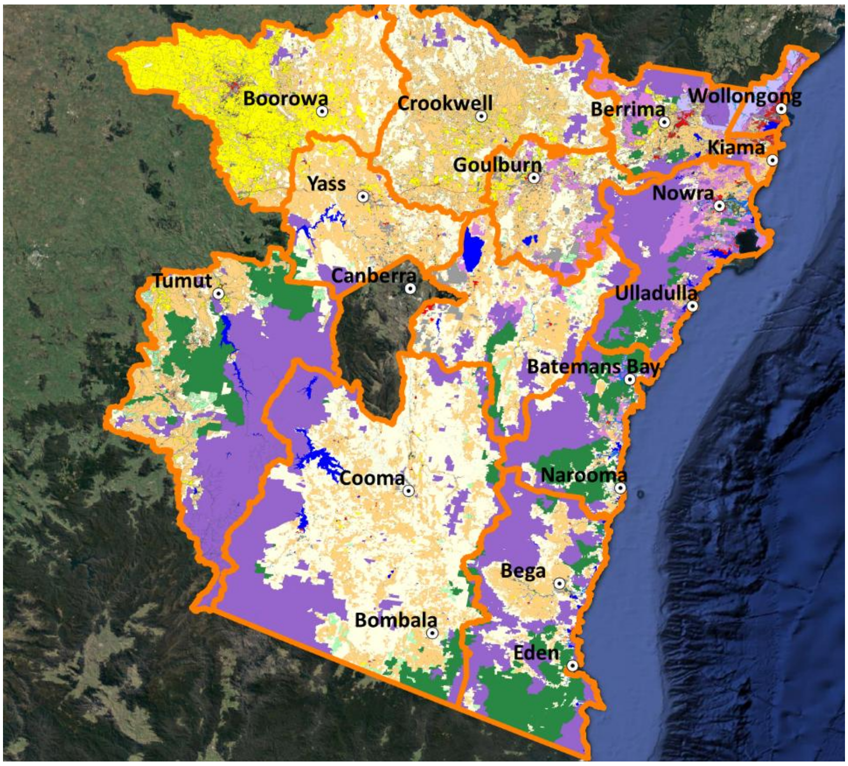
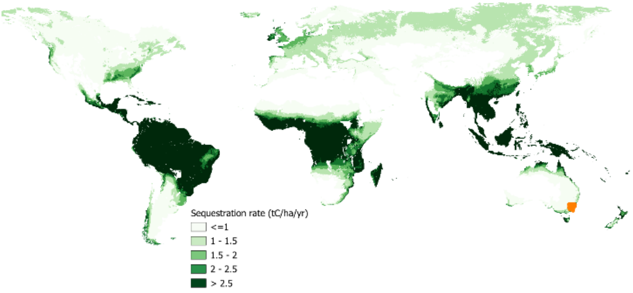
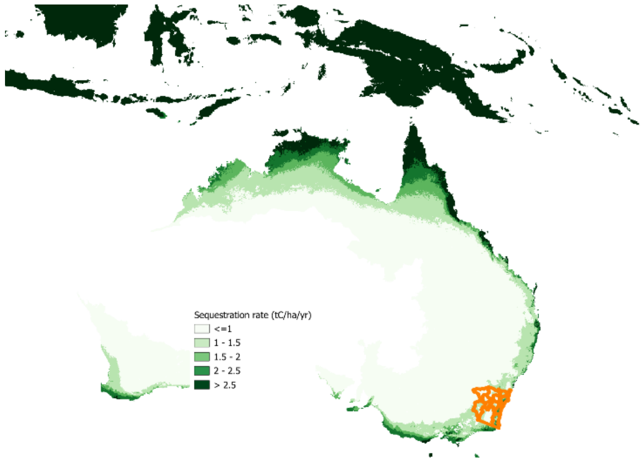


Fig. 3. **Reforestation opportunities** in the (**a**) world, (**b**) Australia and (**c**) the South East region of NSW. Opportunities defined in (**c**) are confined to areas where (**d**) trees used to grow historically (dark green) but have since been cleared (light green), and exclude areas in (**e**) National Parks, State Forests and areas where native grasslands occurred prior to European settlement. (**f**) Woody vegetation prior to European settlement: most reforestation opportunities occur in areas that were grassy woodland prior to clearing and most of these are on privately owned grazing land. Images in (**a)** and (**b)** are derived from data in f. [27]. Data in (**c**) derive from [7]. Data for (**d**) and (**e**) derive from maps in references {.} [12,34–36].

(a)



(b)



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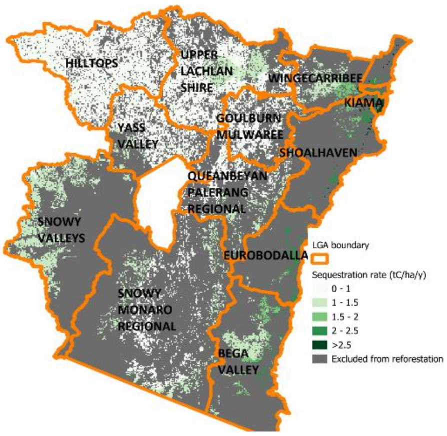

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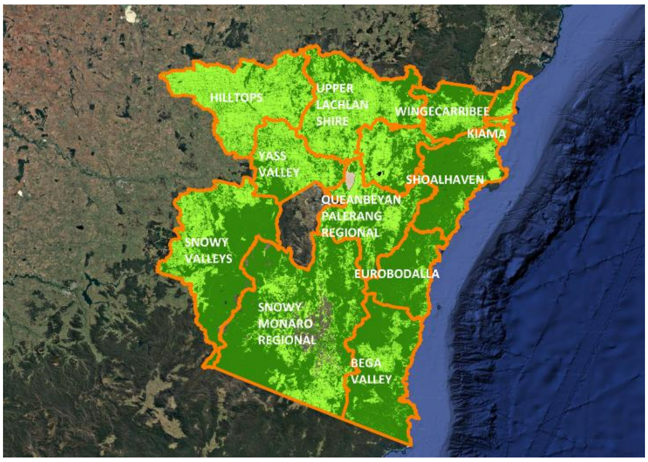
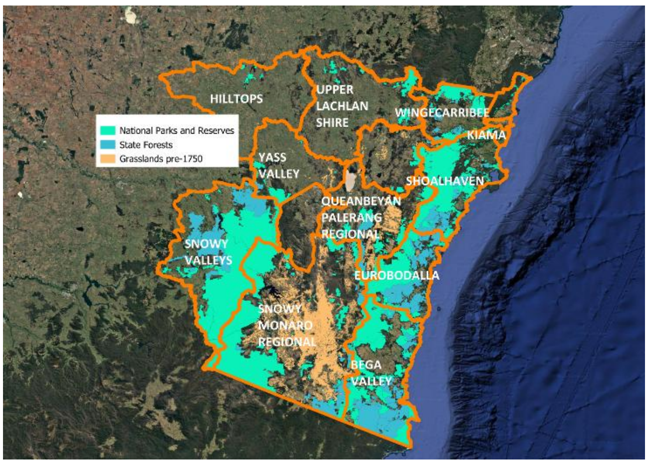


(e)



(f)

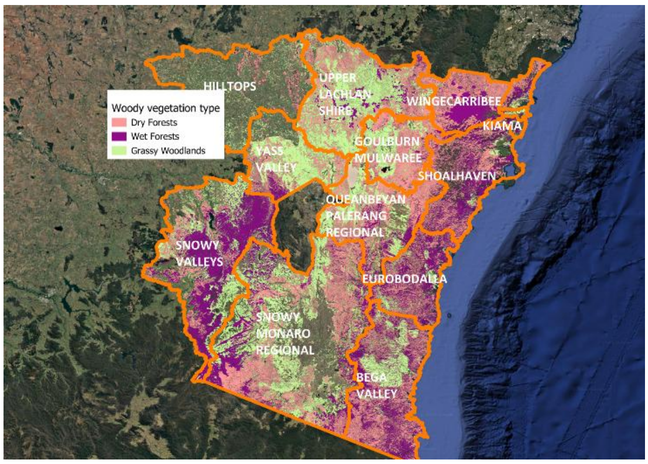


Table 1. Areas of Land Use Types by Local Government Area. Data are from 2020 taken from ref. [33] with the exception of forests and plantations where more accurate data from ref. [36] are used. Units are hectares.

Land use type		Bega Valley	Eurobodalla	Goulburn Mulwaree	Hilltops	Kiama	Queanbeyan-Palerang Regional	Shell harbour	Shoalhaven	Snowy Monaro Regional	Snowy Valleys	Upper Lachlan	Wingecarribee	Wollongong	Yass Valley	Total
Livestock production	Grazing native vegetation	111,470	45,392	106,546	156,710	2,725	201,222	1,903	17,998	694,640	98,221	292,632	39,710	1,488	125,675	1,896,333
	Grazing modified pastures	83,372	14,835	83,087	176,669	5,676	113,926	2,446	29,288	271,623	175,765	304,047	44,251	1,740	180,468	1,487,192
	Irrigated pastures	1,835	426	260	14	378	-	-	4,716	580	367	187	110	-	-	8,874
Cropping	Dryland cropping	745	1,241	23,624	333,202	2,908	11,717	1,282	1,662	16,354	10,311	35,732	8,484	483	18,228	465,973
Nature	Nature conservation	251,983	139,743	23,572	7,764	5,364	85,147	989	227,043	402,707	402,405	43,879	71,592	7,344	27,211	1,696,743
	Other protected areas	287	739	778	4,154	93	544	62	2,368	465	830	2,409	18,262	28,837	1,517	61,346
	Minimal use	508	11,264	43,894	25	5,783	22,936	3,141	79,273	63	186	4,669	41,041	11,497	139	224,417
Forests and plantations	Production native forests (hardwood)	140,291	106,075	-	-	-	21,864	-	52,012	28,964	61,923	-	-	-	-	411,129
	Plantation forests (softwood)	10,218	88	5,298	89	46	14,318	7	25	50,247	117,137	800	7,747	-	11,040	217,060
Intensive uses	Urban & rural intensive uses	2,823	3,720	5,388	3,773	1,588	5,425	3,595	10,947	7,064	3,898	4,364	7,630	12,009	4,418	76,642
	Rural residential and farm infrastructure	4,891	8,623	22,037	1,946	476	33,834	180	12,310	10,113	3,373	7,780	15,476	1,356	16,079	138,474
Water	Water	67	186	1,655	157	114	919	394	332	354	179	180	370	344	197	5,448
Other	Mining, waste, horticulture, infrastructure	883	1,269	631	4,258	197	508	426	13,360	466	2,963	407	1,658	2,053	1,046	30,126
Total		**609,372**	**333,601**	**316,770**	**688,762**	**25,348**	**512,361**	**14,424**	**451,333**	**1,483,640**	**877,559**	**697,086**	**256,331**	**67,152**	**386,018**	**6,719,757**

Table 2. Natural Climate Solutions applicable to the NSW South East Region. Extracted from Supplementary Information in Griscom et al. (2017) [1].

Pathway	Description	Relevant Land Resource in South East	Co-benefits
Forests			
Natural forest clearing	Avoided carbon emissions from clearing of native forests for timber production	State Forests under native hardwood logging operations	Biodiversity (insect species richness); Water (erosion and freshwater ecosystems); Soil (health and productivity from debris); Air (ozone abatement, air filtration)
Natural forest management	Additional carbon sequestration in above- and below-ground tree biomass of native forests under non-intensive management for wood production under scenario of timber harvests deferred for >50 years across all native forests currently under timber production.	State Forests under native hardwood logging operations	Biodiversity (insect species richness); Water (erosion and freshwater ecosystems); Soil (health and productivity from debris).
Fire management	Additional sequestration and avoided emissions in above- and belowground tree biomass due to early season fires to avoid higher emissions from late season fires in temperate forests. .	All forests and woodlands in National Parks, State Forests and on private land	Biodiversity (mimic natural fire regimes); Water (retention and infiltration from saved soil organic matter); Soil (saved organic matter increase); Air (negative impact on health of smoke particulate matter)
Reforestation	Converting grazing land to forest or woodland where ecologically suitable and not set aside for conservation or cropping. Includes integration of trees into grazing lands (i.e., silvopastoral systems) and growing trees for biodiversity and carbon credits.	All native and improved pasture areas that have been cleared of trees after 1750, are outside National Parks, State Forests, and are not predicted to have been native grasslands prior to European settlement.	Biodiversity (wildlife corridors, buffer conservation areas); Water (land rehydration, drought-proofing, avoided erosion); Soil (increased soil fauna); Air (ozone abatement, air filtration); Social (new industry); reduced financial risk associated with reduced environmental risk–implications for borrowing capacity and insurance cover
Agriculture and grasslands			
Avoided grassland conversion	Avoided soil carbon emissions by avoiding the conversion of perennial grasslands to fodder or other crops. Assumes losses of 30% from top 30 cm of soil upon conversion to cropland.	All native pastures[a]	Biodiversity (habitat for nesting and foraging birds and reptiles); Natural insect and pest control; Water (flood control, ecosystem water balance); Soil (forage for birds)
Grazing – optimal intensity	Additional soil carbon sequestration due to grazing optimisation resulting from a decrease in stocking rates in areas that are over-grazed and an increase in stocking rates in areas that are under-grazed, but with the net result of increased forage offtake and livestock production	All native and improved pastures	Biodiversity (plant-insect-soil microbe interactions); Water (capture and retention, flood control, ecosystem water balance); Soil (trapping of contaminants and suspended sediments)

Grazing – legumes in pastures	Additional soil carbon sequestration due to sowing legumes in planted pastures. Net sequestration after taking into account the increases in N2O emissions associated with the planted legumes.	All native and improved pastures	Biodiversity (plant-insect-soil microbe interactions); Soil (structure, erosion protection).
Grazing – improved feed	Avoided methane emissions due to reduced enteric fermentation from the use of more energy dense feed (cereal grains, improved pastures, cut and carry forages, single cell protein feeds) and the associated reduction in total animal numbers needed to supply the same level of meat and milk demand. Alternatively or additionally, use of feed supplements such as *Asparagopsis* seaweed to reduce methane emissions.	All ruminant livestock (sheep, beef cattle, dairy cattle)	
Grazing – improved management	Avoided methane emissions due to reduced enteric fermentation as a result of improved management techniques that increase reproductive performance, animal health, and weight gain, and the associated reduction in total animal numbers needed to supply the same level of meat and milk demand.	All ruminant livestock (sheep, beef cattle, dairy cattle)	
Wetlands			
Avoided coastal wetland impacts	Avoided emissions of above- and below-ground biomass and soil carbon due to avoided degradation and/or loss of salt-water wetlands (mangroves, salt marshes, and seagrass beds), e.g., for shrimp farms.	Coastal wetlands	Biodiversity (structure, nutrients and primary productivity and nurseries for commercially important fish and shrimp); Water (waste water treatment); Soils (cross-system nutrient transfer to coral reefs); Air (tree capture of airborne particles and pollutant gases).
Avoided freshwater wetland impacts	Avoided emissions of above- and below-ground biomass and soil carbon due to avoided degradation and/or loss of freshwater wetlands, e.g., marshes, bogs, peatlands.	Freshwater wetlands and peatlands	Biodiversity (distinct fauna ecosystems); Water (attenuated flooding, reduced peat fire risk); Air (reduced exposure to pollutants from peat fires)
Coastal wetlands restoration	Avoided oxidation of soil carbon and enhanced soil carbon sink due to soil re-wetting in mangroves, salt marshes, and seagrass beds.	Coastal wetlands	Biodiversity (structure, nutrients and primary productivity and nurseries for commercially important fish and shrimp); Water (waste water treatment); Soils (cross-system nutrient transfer to coral reefs); Air (tree capture of airborne particles and pollutant gases).
Freshwater wetland restoration	Avoided oxidation of soil carbon due to soil re-wetting in freshwater wetlands, e.g., marshes, bogs, peatlands.	Freshwater wetlands and peatlands	Biodiveristy (re-establish diverse communities); Water (waste water treatment, storm water remediation); Soils (restored structure and fertility); Air (reduced exposure to pollutants from peat fires)

a. This could also apply to improved pastures with predominantly perennial species but, to provide conservative estimates of mitigation potential, the latter are ignored here.

Table 3. Assumed Rates of Emissions Reductions and Carbon Sequestration for Natural Climate Solutions Pathways. Values are separated into vegetation, soils and livestock and derive from refs. [6,7,27]. Total quantity of available resource in the South East is also shown.

Pathway[a]	Vegetation		Soils		Livestock	Units	Resource type	Resource Available in South East (ha)
	Avoided emissions	Sequestration	Avoided emissions	Sequestration	Avoided emissions			
Forest pathways								
Natural forest clearing[a]	48.8		6.5			tC/ha	State Forests under native hardwood logging	411,129
Growth of non-logged forests[a]		1.219				tC/ha/y	State Forests under native hardwood logging	411,129
Natural forest management[a]		0.06				tC/ha/y	State Forests under native hardwood logging	411,129
Reforestation[b]		0.973		0.079		tC/ha/y	Cleared areas excluding native temperate grasslands[b]	2,024,706
Fire management	11.13		0			tC/ha/y	Burnable forests and woodlands[c]	3,597,417
Agriculture and grazing								
Avoided grassland conversion			43.4			tC/ha	Native pastures[d]	1,896,333
Grazing - optimal intensity				0.06		tC/ha/y	Native and improved pastures	3,383,525
Grazing – legumes				0.56		tC/ha/y	Improved pastures	1,496,066
Grazing - improved feed[e]					0.016	tC/DSE	Livestock[f]	6,624,598
Grazing - feed additives (*Asparagopsis*)[e]					0.039	tC/DSE	Livestock[f]	6,624,598
Grazing - animal management[e]					0.005	tC/DSE	Livestock[f]	6,624,598
Wetlands[g]								
Avoided coastal wetland impacts			150			tC/ha	Coastal wetlands	4,506
Avoided freshwater wetland impacts			142			tC/ha	Peatlands & freshwater wetlands	243,776
Coastal wetland restoration				5.10[h]		tC/ha/y	Coastal wetlands	4,506
Freshwater wetland restoration				3.55		tC/ha/y	Peatlands & freshwater wetlands	243,776

a. The global rate of loss from deforestation of 1.128 tC/ha [27] was adjusted to carbon productivity levels in the South East region of NSW by multiplying by the average rates of carbon sequestration in the South East (1.219 tC/ha/y, calculated From the sequestration rate layer provided in [7], divided by the global average estimate of 2.82 tC/ha/y for temperate forests [27] (Table S1). Soil rates of avoided emissions from deforestation of 15tC/ha from [6] (see Methods section) were likewise adjusted for global vs. global carbon productivity. Sequestration rates for forest management were similarly adjusted down from global estimates for temperate and boreal forest of 0.14 tC/ha/y forests [27].

b. Sequestration rates obtained from Griscom et al. (2021) [7] were applied to land areas available for reforestation on a pixel-by-pixel basis rather than using a fixed average value for the South East. The average sequestration rate for areas available for reforestation in the South East was 0.973 tC/ha, and for all south East areas was 1.219 tC/ha, considerably lower than the global average value for temperate forests of 2.82 tC/ha/y forests [27]. The average rate for soil carbon sequestration of 0.092t from [6] was similarly adjusted. Downstream LGA-based calculations were further adjusted for each LGA's average rate as calculated from Griscom et al [27] This includes all areas currently without >25% canopy cover but which contained trees prior to white settlement, as derived from refs. [27] and [8] , and further excluding areas predicted to be natural grasslands at the time of European settlement [12] and National Parks and State Forests.

c. 'Burnable' includes all forests and woodlands, including in National Parks and State Forests, as derived from [8].
d. 'Native pastures' includes all native vegetation used for grazing, including woodlands and forests.
e. The global estimate for emissions avoided through the 'Improved feed' pathway for livestock is 0.13t C/head of cattle [1]. Here, this was converted to tC/DSE by dividing by 8 DSE/head of cattle. Use of *Asparagopsis* in feed was assumed to be effective in mitigating 60% of methane emissions per livestock unit. The global estimate for emissions avoided through the 'animal management' pathway of 0.04 tC/head of cattle from ref. [1] was converted to DSE using the same method as for 'Improved feed'.
f. Units for livestock are DSEs, not hectares.
g. Freshwater wetland areas were defined as those with Keith formations of 'Forested wetlands', Freshwater wetlands' or 'Alpine bogs' and coastal wetlands were defined as those with Keith formation as 'Saline wetlands' as recorded in ref. [8]. Rates for temperate areas given by [6] were applied.
h. Combined sequestration and avoided emissions due to restoration [6].

Table 4. Potential[a] for Carbon Drawdown and Avoided Emissions by Natural Climate Solutions Pathways in South East LGAs. Colours indicate natural resource type (forests and woodlands, grazing and agriculture, wetlands).

Pathway	Carbon source	Bega Valley	Eurobodalla	Goulburn Mulwaree	Hilltops	Kiama	Queanbeyan-Palerang Regional	Shellharbour	Shoalhaven	Snowy Monaro Regional	Snowy Valleys	Upper Lachlan	Wingecarribee	Wollongong	Yass Valley	Total
Drawdown (million tCO_2/y)																
Natural forest management	Vegetation	0.05	0.04	0	0	0	0	0	0.02	0.01	0.01	0	0	0	0	0.13
Reforestation	Vegetation	0.46	0.1	0.36	1.23	0.06	0.4	0.02	0.16	0.63	0.64	1.09	0.25	0.03	0.55	5.98
Reforestation	Soil	0.04	0.01	0.03	0.1	0	0.03	0	0.01	0.05	0.05	0.09	0.02	0	0.04	0.47
Grazing - Optimal intensity	Soil	0.06	0.02	0.03	0.05	0	0.06	0	0.02	0.18	0.06	0.1	0.02	0	0.05	0.65
Grazing - legumes	Soil	0.26	0.05	0.13	0.23	0.03	0.2	0.01	0.11	0.47	0.36	0.47	0.1	0.01	0.29	2.72
Coastal wetland restoration	Soil	0.03	0.05	0	0	0	0	0	0.05	0	0	0	0	0	0	0.13
Peatland restoration	Soil	0.21	0.15	0.07	0.02	0.06	0.27	0.01	0.54	0.88	0.71	0.1	0.09	0.15	0.05	3.31
Avoided emissions (million tCO_2/y)																
Natural forest clearing	Vegetation	36.9	30.2	0.0	0.0	0.0	3.3	0.0	15.2	4.3	10.9	0.0	0.0	0.0	0.0	100.8
Natural forest clearing	Soil	4.9	4.0	0.0	0.0	0.0	0.4	0.0	2.0	0.6	1.5	0.0	0.0	0.0	0.0	13.4
Fire management	Vegetation	28.1	17.5	4.6	3.4	0.7	10.0	0.3	19.4	27.3	22.0	8.9	7.1	3.1	4.9	157.2
Avoided grassland conversion	Soil	26.1	11.5	12.8	15.8	0.9	27.3	0.6	4.7	92.4	15.4	35.4	6.8	0.5	15.4	265.4
Grazing - improved feed	Livestock	0.034	0.010	0.017	0.025	0.003	0.030	0.001	0.013	0.086	0.035	0.054	0.011	0.001	0.029	0.349
Grazing - feed additives (*Asparagopsis*)	Livestock	0.082	0.025	0.040	0.062	0.006	0.072	0.003	0.031	0.207	0.084	0.131	0.026	0.002	0.071	0.842
Grazing - animal management	Livestock	0.010	0.003	0.005	0.008	0.001	0.009	0.000	0.004	0.026	0.011	0.017	0.003	0.000	0.009	0.106
Avoided coastal wetland impacts	Soil	0.92	1.34	0	0	0.09	0	0.07	1.5	0	0	0	0	0.02	0	3.94
Avoided freshwater wetland impacts	Soil	8.3	5.9	2.8	0.7	2.4	10.8	0.3	21.6	35.4	28.5	4.1	3.8	6.2	1.9	132.6
Carbon stored (million tCO_2)																
Vegetation - forests and woodlands		123.4	76.7	20.1	15.0	2.9	43.9	1.3	85.1	119.7	96.5	38.9	31.1	13.6	21.3	689.4
Soils - forests and woodlands		16.4	10.2	2.7	2.0	0.4	5.8	0.2	11.3	15.9	12.9	5.2	4.2	1.8	2.8	91.8
Soils - all pastures		46.1	15.3	22.7	33.5	2.9	42.8	1.4	13.5	128.6	43.1	72.2	14.4	1.1	37.6	475.0
Soils - wetlands		9.2	7.2	2.8	0.7	2.4	10.8	0.4	23.0	35.4	28.5	4.1	3.8	6.2	1.9	136.3
Total carbon stored		195.1	109.5	48.3	51.2	8.6	103.3	3.2	132.9	299.5	180.9	120.3	53.4	22.7	63.7	1392.5
Other																
LGA average carbon sequestration rate[b]		1.79	1.94	1.94	1.94	2.51	1.04	1.04	1.98	1.02	1.20	0.93	1.31	2.48	0.77	1.22
LGA-specific adjustment factor		1.47	1.59	1.59	1.59	2.06	0.85	0.85	1.63	0.83	0.99	0.76	1.08	2.04	0.63	1.00
Total emissions (million tCO_2/y)[c]		0.40	0.33	0.83	0.38	0.59	0.82	8.63	0.19	0.64	0.56	0.60	0.58	0.47	1.16	16

a. Potential assumes 100% uptake: to avoid double counting across pathways. Realistic uptake levels of 1% or 10% are assumed in tables that follow. **b**. LGA-specific average sequestration rate calculated from pixel-based sequestration potential map from ref. [7] including all forested and woodland areas prior to European settlement [8]. **c**. Total LGA emissions for 2022/2023 from ref. [37].

Table 5. Reforesting 10% of the 2 Million Available Hectares of Cleared Agricultural Land over 10 years (1% per year)

Available Resource		Carbon Drawdown	Economic Value			Emissions
Shire	1% of Cleared Farmland Reforested Annually (hectares)	Annual Drawdown from 10% Reforestation of Cleared Farmland (t CO_2)	Annual Value ($m) of Drawdown at International Carbon Price of $80/t$CO_2$	25-year value of 10% Reforestation of Farmland ($m)	Reforestation Jobs Over 10 Years (FTE-years)	Annual Emissions from Shire (tCO_2)
Bega Valley	900	46,000	3.7	93	550	395,000
Eurobodalla	200	10,500	0.8	20	120	329,000
Goulburn Mulwaree	1,400	36,200	2.9	73	850	589,000
Hilltops	5,500	123,000	9.8	245	3450	823,000
Kiama	100	6,000	0.5	13	50	194,000
Queanbeyan-Palerang Regional	1,300	39,900	3.2	80	830	636,000
Shellharbour	0	2,500	0.2	5	20	562,000
Shoalhaven	300	16,300	1.3	33	180	1,163,000
Snowy Monaro Regional	2,100	63,100	5.0	125	1340	596,000
Snowy Valleys	1,800	64,500	5.2	130	1160	580,000
Upper Lachlan	4,000	109,100	8.7	218	2550	467,000
Wingecarribee	600	24,600	2.0	50	410	834,000
Wollongong	0	3,200	0.3	8	30	8,626,000
Yass Valley	2,000	5,500	4.4	110	1270	380,000
Total	**20,200**	**550,400**	**48**	**1,200**	**12,810**	**16,174,000**

Table 6. Economics of Reforestation at the Landholder level.

	Scenario 1	Scenario 2	Scenario 3
Assumptions			
Carbon price ($/tCO2)	$30	$90	$90
Maintenance costs/ha/y	$50	$50	50
Installation costs ($/ha)	$10,000	$10,000	$10,000
Time of cashing in offsets (years)	25	10	25
Assumed tCO_2/ha at time of cash-in[a]	229	92	229
Area reforested/landholder (ha)	100	100	100
Income			
Returns on carbon market at time of cash-in	$688,125	$825,750	$2,064,375
Costs			
Installation	$1,000,000	$1,000,000	$1,000,000
Maintenance	$125,000	$50,000	$125,000
Carbon marketing cost	$50,000	$50,000	$50,000
Total cost	$1,175,000	$1,100,000	$1,175,000
Landholder net profit/loss	-$486,875	-$274,250	$889,375

a. Assuming an average annual drawdown rate of 2.5tC/ha/y over the first 25 years, i.e., around 2.5 times the lifetime average assumed elsewhere in this study.

Table 7. Current and Future Stored Soil Organic Carbon (SOC) by LGA

LGA	Soil Carbon Drawdown		Economic value	Emissions		Resource	
	Annual Drawdown of SOC from Improvement of 10% Grazing Land (tCO2)	Annual Drawdown of SOC from 10% Reforestation of Farmland (tCO_2)	Annual Value of SOC Drawdown at International Carbon Price of $80/tCO_2$	Annual Avoided SOC Emissions from Non-Conversion of 1% Grazing Land (tCO_2)	Annual Emissions from Shire (tCO_2)	Stored SOC in Grazing Lands, Forests and Wetlands (tCO_2)	Amount of Soil CO_2 Stored Relative to Annual Emissions of LGA
Bega Valley	32,000	3,700	$2,856,000	261,000	395,000	72,000,000	182x
Eurobodalla	7,100	900	$640,000	114,800	329,000	33,000,000	100x
Goulburn Mulwaree	16,000	2,900	$1,512,000	127,500	589,000	28,000,000	48x
Hilltops	27,500	10,000	$3,000,000	157,500	823,000	36,000,000	44x
Kiama	2,900	500	$272,000	8,900	194,000	6,000,000	31x
Queanbeyan-Palerang	25,900	3,200	$2,328,000	273,300	636,000	59,000,000	93x
Shellharbour	1,200	200	$112,000	6,000	562,000	2,000,000	4x
Shoalhaven	13,100	1,300	$1,152,000	46,600	1,163,000	48,000,000	41x
Snowy Monaro	64,500	5,100	$5,568,000	923,600	596,000	180,000,000	302x
Snowy Valleys	41,600	5,200	$3,744,000	154,200	580,000	84,000,000	145x
Upper Lachlan	57,500	8,900	$5,312,000	353,900	467,000	81,000,000	173x
Wingecarribee	11,800	2,000	$1,104,000	68,000	834,000	22,000,000	26x
Wollongong	900	300	$96,000	4,800	8,626,000	9,000,000	1x
Yass Valley	33,800	4,500	$3,064,000	154,200	380,000	42,000,000	111x
Total	**335,800**	**48,700**	**$30,760,000**	**2,654,300**	**16,174,000**	**702,000,000**	**43x**