Manaaki Whenua
Landcare Research

Carbon sequestration on the West Coast

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Summary

Project and client

- West Coast Regional Council (WCRC) contacted Manaaki Whenua – Landcare Research and requested information on how to estimate carbon sinks for the region, and whether there is existing data to carry out such a project. WCRC wishes to estimate the region's carbon footprint given the implications of the proposed Zero Carbon Act, which will commit New Zealand to net zero long-lived greenhouse gases by 2050 or sooner, including accounting for carbon sinks.
- This work was carried out with funding from Envirolink Grant: 1930-WCRC177.

Objectives

- To refine the questions in relation to carbon sequestration
- To identify the most appropriate data sets, methods and analyses to estimate net carbon sequestration for the West Coast.
- To estimate the size of the task, and costs, required to answer these questions.

Methods

- Existing data and analytical methods were drawn on as a basis for outlining the steps required to estimate carbon sequestration on the West Coast.

Results

- A plan was developed, and information sources described, for how to estimate net carbon sequestration for the West Coast, covering:
  - mature natural forest
  - plantation forest
  - new forest regeneration and cleared shrublands.
- Sequestration rates need to be sourced or calculated for each of the classes above.
- The balance of net gains versus losses and uncertainty could then be calculated.

Discussion

- The term 'forest carbon stocks' simply refers to the quantity of biomass carbon present. Sequestration is the measured increase in those stocks over time resulting from anthropogenic management actions and forest stand development.
- Net sequestration occurs as vegetation develops from a low biomass condition to a higher biomass condition per unit area over time.
- Although there may be large carbon stocks in mature forest, it is broadly treated as being in a net stable state of near-zero sequestration because, on average and at large scales, new growth by existing trees is matched by mortality of old stems, fallen branches and deadwood (woody debris and litter) and decomposition.

- This would be the case for almost all of the vast area of native forest on the West Coast.
- The Emissions Trading Scheme treats all forest existing prior to 1990 as being in a mature state. This is an arbitrary baseline date adopted by all countries that signed the Rio Declaration on Environment and Development (1992).

Recommendations

- Core estimation of net biomass carbon sequestration should be undertaken as a useful starting point for understanding an overall emissions budget for any region considering future options.
- Completing the tasks outlined for West Coast Regional Council alone would cost around $60,000, but by including other regional councils the cost per council could be considerably reduced, as the same national data sources, processes and calculations would be used.

1 Introduction

How much carbon (C) is sequestered on the West Coast? West Coast Regional Council (WCRC) wishes to estimate the region's carbon footprint given the implications of the proposed Zero Carbon Act[1], which would commit New Zealand to net zero long-lived greenhouse gases (CO_2 and N_2O) by 2050 or sooner, including accounting for C sinks.

2 Background

Climate change predictions indicate an imbalance of net greenhouse gas exchanges between land and the atmosphere driven by anthropogenic actions. The West Coast has large areas of both indigenous and exotic forests, along with reverting or cleared shrublands, and needs to clarify the status of forests there. This means determining the sources and sinks, and actual C sequestration ($Mt{\cdot}CO_2e{\cdot}yr^{-1}$)[2], along with the methods and assumptions associated with any calculations of them.

The first step to understanding the net biomass C footprint of any area is to estimate all greenhouse gas (CO_2e) *sinks* (e.g. afforestation by planting, or reforestation by natural regeneration or restoration), and *sources* (harvested forest, natural forest disturbance, land-use conversion from forest or wetland into grazed grassland, as examples).

We focus here on the steps required to achieve an estimation of net C sequestration by biological sinks for the West Coast region. We also comment on some of the key characteristics of biological sequestration that are often misunderstood, such as the difference between C stocks and sequestration, the Emissions Trading Scheme (ETS), the rules covering native forests, and why pre-1990 native forests are not included.

Manaaki Whenua – Landcare Research has substantial data on New Zealand's vegetation and vegetation change over time, and the capability to make these kinds of calculations. It carries out similar calculations for all New Zealand, which feed into national reporting, and at the other end of the scale has made estimates for smaller entities such as individual properties. Discussions with WCRC as part of this Envirolink Advice project have clarified details of key questions and specific information availability. We also provide an indication of the cost to complete the assessment.

We discussed with WCRC expectations for this exercise. The initial goal is to account for ETS-compliant sequestration. We don't know whether the current review of ETS by the Ministry for Primary Industries and the forthcoming Zero Carbon Act will result in additional C sinks that might be included in the future (e.g. soil C, small woodlots, shelterbelts, etc.; see Burrows et.al. 2018), nor do we know what might result from the current review of agriculture and the ETS, which may result in significant policy changes.[3]

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[1] https://zerocarbonact.nz/assets/Uploads/ZCA-summary-FINAL.pdf

[2] $Mt{\cdot}CO_2e{\cdot}yr^{-1}$ = million tonnes of carbon dioxide equivalents per year. The term 'carbon dioxide equivalent' (CO2e) is used to describe all greenhouse gases with a common unit.

[3] https://www.pce.parliament.nz/

3 Objectives

This Envirolink Small Advice Grant was used for phone discussions, email discussions and a video conference meeting held on 30 January 2019 between WCRC and Manaaki Whenua – Landcare Research to:

- refine the questions relating to carbon sequestration
- identify the most appropriate data sets, methods and analyses to estimate net C sequestration for the West Coast
- estimate the size of the task, and costs, required to answer these questions.

4 Methods

We drew on knowledge of existing data and analytical methods to outline the steps required to estimate C sequestration for the West Coast.

5 Results

Substantial data estimating vegetation C stocks and changes in C stocks exist in the form of repeated measurements of plot-based forest samples in West Coast native and exotic plantation forests. Some information also exists for the recent reversion of native shrublands and new planting of exotic plantations.

5.1 Method for estimating carbon sequestration for the West Coast

Following is a summary of the steps that would need to be undertaken, and the data sources required, in order to carry out a C sequestration estimation for the West Coast.

Step 1. Estimate the area (ha) of, and changes in, **mature natural forest** already present in1990.

> *Work required:* an estimation of the change in the extent and/or stocks of carbon using the MfE Land Use and Carbon Analysis System (LUCAS) plot data and remeasurements.
>
> *Data sources:* approximately 163 LUCAS plots, 2002–2007 and 2009–2014. Data quality: high. Source: Holdaway et al. 2014, MfE.

Step 2. Estimate the area (ha), species and age-classes of **plantation forest**, including new planting and harvesting.

> *Work required:* an estimation of the extent and changes in extent, species and age classes of plantation forest.

Data sources: National Exotic Forest Description (NEFD)[4] tables and New Zealand Forest Association (NZFOA)[5] summary data up to 2017. Data quality: high. Note: Ngāi Tahu Forest Estates is the largest plantation owner on the West Coast (>85%), and so derived data could be confirmed with them.

Step 3. Estimate the area (ha) and age of post-1989 **new regenerating and cleared shrublands**. (Note: there will be some overlap between this class and newly established plantations.)

Work required: estimation of the net of increase and decrease in the area of clearance and afforestation/reforestation (ha).

Data sources: Land Use Map (LUM)[6] summaries - a new 2016 version has just been released. Data quality: moderate (afforestation is difficult to identify in the LUM).

Step 4. Apply calculated or sourced **sequestration rates** to the area and age classes in steps 1 to 3.

Data sources: Use Ministry for Primary Industries look-up tables[7] for step 2, use Holdaway et.al. 2014 for steps 1 and 3.

Step 5. Calculate the balance of **net gains/losses** and the uncertainty relating to these estimates.

5.2 Constraints and uncertainties: new regeneration, recently cleared shrublands and new plantations.

These land classes have the most uncertainty because they are difficult to identify remotely in the LUM, but they are potentially the most important due to their sequestration potential. The most recent available data sources for the classes above in 5.1 are all from the 2014 to 2016 period. The most recent high-resolution aerial imagery available for the West Coast (2015/16 for north Westland and 2016/17 for south Westland[8]) could be used to check on land-use change by new regeneration, planting or recently cleared shrublands for this same period.

If the results from the LUM are inconclusive in any way, then a trial within a selected West Coast district or two should be considered using ground-based assessment of aerial imagery.

[4] https://catalogue.data.govt.nz/dataset/national-exotic-forest-description-nefd-yield-tables
[5] https://www.nzfoa.org.nz/images/stories/pdfs/2016-NEFD-report_web.pdf
[6] https://data.mfe.govt.nz/layer/52375-lucas-nz-land-use-map-1990-2008-2012-2016-v006/
[7] https://www.mpi.govt.nz/growing-and-harvesting/forestry/resources/
[8] https://data.linz.govt.nz/ - West Coast 0.3m Rural Aerial Photos Index Tiles

6 Discussion

6.1 C stocks and biomass sequestration.

C stocks are simply the quantity of biomass C present in forest, soil, peat, coal, etc. Sequestration is a positive change and accumulation (i.e. growth or increase) in biomass over time resulting from forest stand development. C stocks and flows are often confused and it is common for there to be significant C stocks and yet no net sequestration 'sink'.

Net sequestration occurs as vegetation develops from a low biomass condition to a higher biomass condition per unit area over time, and then slows or stops (Figure 1). The C accumulation curve from an 'empty' to a 'full' or mature condition is normally sigmoidal in shape, and actual sequestration rates vary with time along that curve. Rates tend to be slow initially (when plants are small and space is not fully occupied), then accelerate to a peak rate, and eventually decline again (once maximum biomass stocks are approached) to a relatively stable state, when new growth is matched by mortality and there is virtually no net sequestration. As a result, new establishment of forest onto previously non-forested land is the most important land-use change that results in significant sequestration.

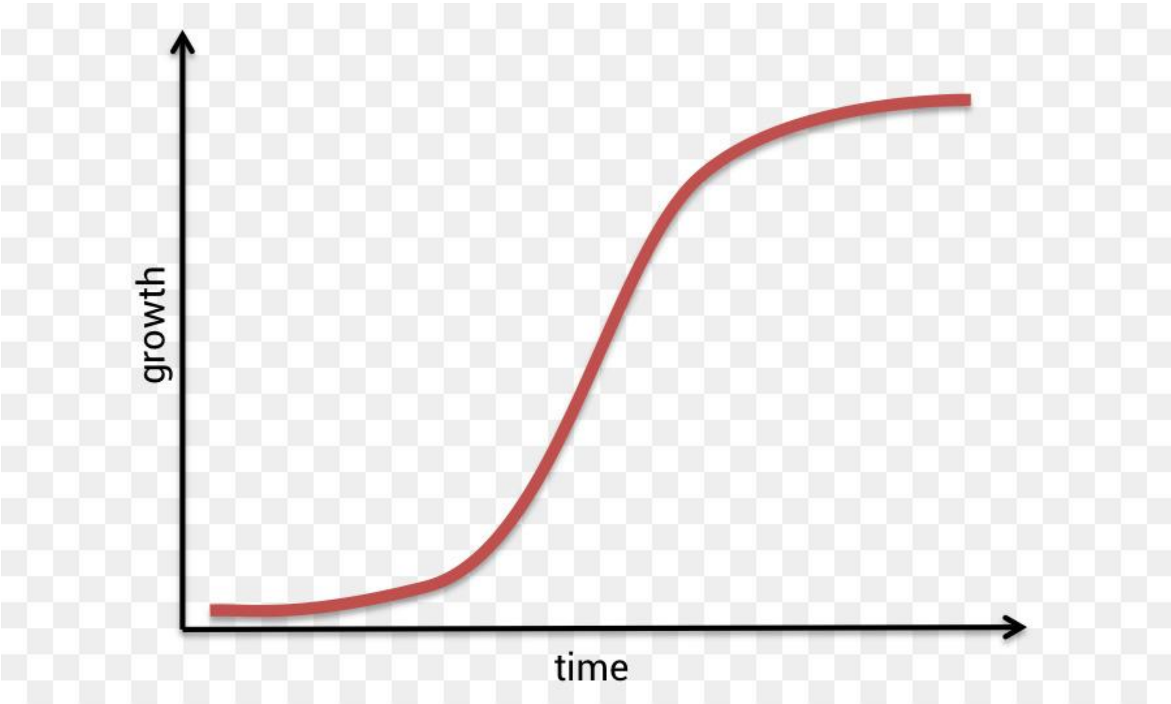

Figure 1: The pattern of net sequestration (growth) in a forest follows a sigmoid shape increasing slowly to start then more rapidly for a period before declining again to a relatively stable state at maturity when new establishment and growth are matched by mortality in a forest stand. The period of time and rate of growth vary for each location and forest species.

6.2 Mature forest and the 1990 baseline

Although there may be large C stocks in mature forest, it is broadly treated as being in a net stable state of near-zero sequestration because, on average at large scales, new growth by existing trees is matched by mortality of old stems, fallen branches and deadwood (woody debris and litter) and decomposition. This can be expected to be the case for almost all the vast area of native forest on the West Coast, but it is an assumption that will be tested by the next full re-assessment of the complete LUCAS national sampling network.

Total C stocks of mature forest (and soil) may actually be changing slightly positively or slightly negatively depending on many background variables, such as:

- the age of the forest
- legacy effects of historical clearances
- the impacts of pests and diseases
- climate differences from year to year (including concentrations of greenhouse gases themselves)
- changing species composition and wood density
- environmental impacts, such as storms or droughts.

The ETS treats all forest existing prior to 1990 as being in a mature state, which is an arbitrary baseline date adopted by all countries that signed up to the Rio Declaration on Environment and Development (1992). Without a baseline date as a starting point, it is not possible to determine change in either anthropogenic emissions or sequestration.

6.3 Forest offset sinks and the ETS rules

ETS forestry, and the parallel Permanent Forest Sinks Initiative (which requires a covenant on the land to ensure permanence), allows registration of post-1990 planted forests and naturally regenerating indigenous forests under strict eligibility rules. New Zealand adopted a definition of 'forest' under the Climate Change Response Act 2002 as an area of land of at least 1 hectare that has, or will have, tree crown cover from forest species of more than 30% in each hectare and that covers an area at least 30 m wide. The Act defines 'forest species' as a species that is capable of reaching at least 5 metres in height at maturity in the place it is located. Many publications on ETS forestry can be found at the Ministry for Primary Industries website.[9]

As described in 6.2 above, when a forest becomes mature, sequestration slows and can stop or even reverse. In other words, sequestration by afforestation is finite. Further, when a forest is harvested, C units earned while it was growing need to be repaid as the harvested material cleared off the land begins to be re-emitted to the atmosphere. The rate at which this happens depends on the end use of timber. The recent review of the ETS by the Ministry for Primary Industries has indicated that an averaging methodology will probably be

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[9] https://mpi.govt.nz/growing-and-harvesting/forestry/forestry-in-the-emissions-trading-scheme/registering-post-1989-forest-land/

implemented for plantations, whereby as long as harvested forests are replanted it won't be necessary to repay units upon harvesting. However, the level of attainable sequestered C will be reduced to a long-term average, and will reach an equilibrium state after a couple of decades.

Estimating C sequestration for the West Coast as described above at a regional level takes no account of land or forest ownership. It is possible that forest owners on the West Coast may have already registered their forests into the ETS. If they have, and have subsequently earned credit units and then sold them, it is possible that ownership of those units may have left the West Coast. In those instances they should ideally be deleted from any net budget, but we have no way of determining if that is the case.

6.4 Tasks and costs to complete estimation of C sequestration for the West Coast

Calculating C sequestration for a region the size of WC will involve gathering and analysing considerable quantities of data. Those data will need to estimate the area (ha) and changes over time of mature indigenous forest, the area, species and age-class distribution of plantation forests, and clarify the status of reverting indigenous shrublands, cleared indigenous shrubland and newly planted plantations. Some of those data will require access permissions.

Any difficulties encountered when estimating shrubland landcover changes may benefit from re-analysis of aerial imagery in combination with a site visit, which would incur extra costs. This need would only become obvious after partially analysing LUM data.

Data providing appropriate sequestration rates for all these classes will need to be extracted and applied. At that stage the results would be collated and uncertainties calculated, followed by preparation of a draft report.

Our estimation of the cost to complete this exercise for West Coast alone would be around $60,000. There would be considerable cost benefit to complete the same exercise for additional regions at the same time, as the same national data source, processes and calculations would be used. Each region would require their own report, and there will be local idiosyncrasies; but, for example, if there were three regional councils interested, an indicative cost per region could be around $33,000, or if there were eight it could be around $25,000.

7 Recommendations

- Core estimation of net biomass C sequestration should be undertaken as a useful starting point for understanding an overall emissions budget for any region considering future options relating to the proposed Carbon Zero Act.
- Completing the tasks outlined for WCRC alone would cost around $60,000, but by including other regional councils at the same time the cost per council could be considerably reduced, as the same national data sources, processes and calculations would be used.

8 Acknowledgements

We thank Hadley Mills (WCRC) for initiating the inquiry that led to this report as well as useful discussions and feedback, and Ray Prebble for editing the report.

9 References

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