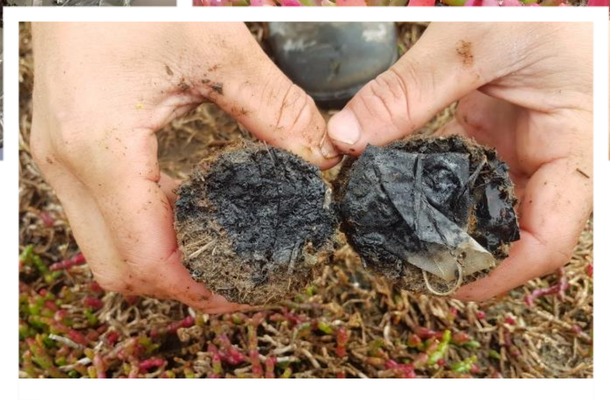
TeaComposition H_2O Project
(AKA the teabag project)

September 2021





Derwent Estuary Program

The Derwent Estuary Program (DEP) is a regional partnership between local governments, the Tasmanian State Government, businesses, scientists, and community-based groups to share science for the benefit of our estuary. The DEP was established in 1999 and has been nationally recognised for excellence in coordinating initiatives to reduce water pollution, conserve habitats and species, monitor river health and promote greater use and enjoyment of the foreshore.

Our major sponsors include Brighton, Clarence, Derwent Valley, Glenorchy, Hobart and Kingborough councils, the Tasmanian State Government, TasWater, Tasmanian Ports Corporation, Norske Skog Boyer, Nyrstar Hobart Smelter and Hydro Tasmania.

Contents

1 PROJECT AIMS

- Contribute data to a global project regarding effectiveness of carbon sequestration in wetlands.
- Test a hypothesis that a degraded saltmarsh in the Derwent estuary is less effective at sequestering carbon compared to a nearby healthy saltmarsh.

2 BACKGROUND

In December 2017, the Derwent Estuary Program (DEP) joined the 'TeaComposition H_2O Project', a three-year Global Wetland Litter Decomposition Initiative coordinated by the Blue Carbon Lab at Deakin University (https://www.bluecarbonlab.org/teacomposition-h2o/), which DEP referred to as the "tea bag project". The project is an extension of a similar, but terrestrial-focused project (Djukic *et al.*, 2018).

The project aims to establish which wetland environments are most effective at carbon sequestration and to place a value on their sequestration potential. Atmospheric and oceanic carbon is captured and stored (i.e., sequestered) by marine environments, especially mangroves (of which Tasmania has none), saltmarshes and seagrasses, where, if not disrupted, carbon can be stored for millennia. Plant litter decomposition is the key process in the early sequestration and emission stages of the carbon cycle, with microbial soil communities dictating whether carbon is sequestered or emitted as a greenhouse gas.

The novel idea in this research is the standardised method used for investigating carbon retention, by use of the humble teabag. In a nutshell, tea bags are buried and later recovered. Across the world, about 19,000 teabags were buried as part of the project (Figure 2-1).

Figure 2-1. Locations where 19,000 tea bags have been deployed at 300 sites across 30 countries as part of the TeaComposition H_2O Project (Blue Carbon Lab Deakin University, 2020).

Rapid degradation of the tea inside the bags indicates that condition at the site is favouring breakdown of new organic matter that then is not available to be preserved in the soil. However, if the tea stays relatively intact and decays slowly, the wetland, by comparison, may likely be able to preserve and sequester more organic matter in the long-term. Two types of tea were used: Rooibos tea, characterised by a slow decomposition rate (recalcitrant, stable) and green tea, characterised by a faster decomposition rate (labile). The decay patterns of the two types of tea can be similar to those of natural litter types in different wetland habitats (Blue Carbon Lab, 2017).

3 HOW IT WORKS UNDERGROUND

In the top few centimetres of a saltmarsh there is aerobic decomposition occurring, meaning oxygen is assisting the decomposition of organic matter. Below that top level, in a healthy saltmarsh, there is very little oxygen, i.e., it is an anaerobic environment, which slows the organic matter decomposition, ensuring the carbon stays put. In a healthy saltmarsh, there is a hypoxic environment, where oxygen is quickly depleted, followed by a sequence of anaerobic processes starting with denitrification and finishing with methanogenesis (the production of methane). These conditions are absent in a degraded, e.g. a drained saltmarsh, where there will be increased oxidation penetration (down to 10 cm or more) leading to loss of organic matter and reduced sediment carbon concentration (Anisfeld, 2012).

Figure 3-1 shows a conceptual representation of the TeaComposition H_2O Project process. Tea bags are buried at time zero, and over time, depending on conditions, microbial soil communities dictate whether carbon is sequestered or emitted as a greenhouse gas to the atmosphere.

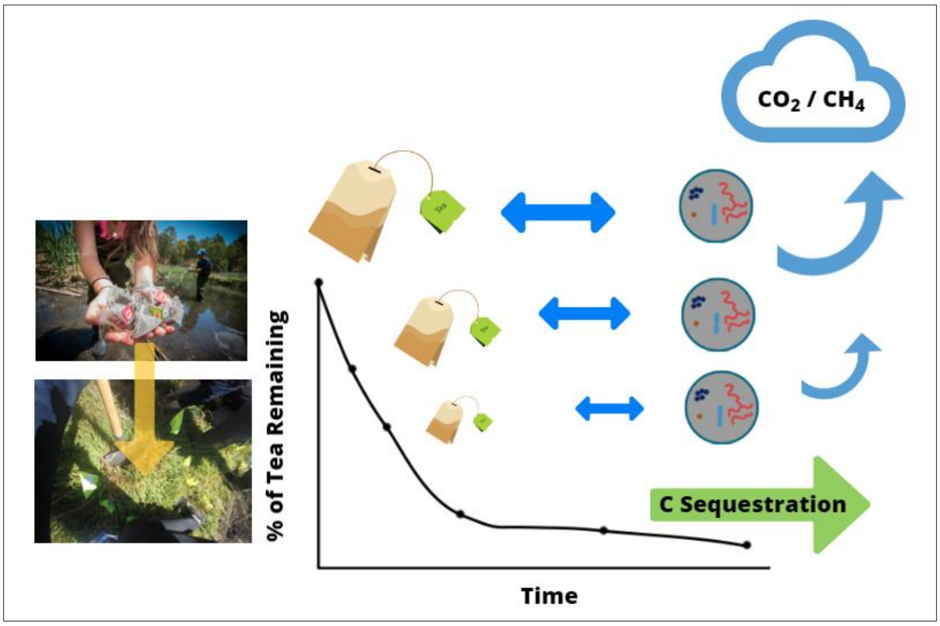


Figure 3-1. Conceptual representation of the TeaComposition H_2O Project, described in-text
http://www.bluecarbonlab.org.

4 DEP PROJECT

The DEP was keen to participate in this research project for two reasons. Firstly, to contribute data to important global research questions, and secondly, to take the opportunity to use this relatively easy method to compare a healthy saltmarsh (Dorans Road) and a degraded saltmarsh (Racecourse Flats), both at Lauderdale, as part of building our knowledge and line of reasoning for rehabilitating the degraded Racecourse Flats saltmarsh. Detailed information about the environmental issues at the Lauderdale saltmarshes, including lack of tidal connectivity at Racecourse Flats, are outlined in a recent Derwent estuary-wide saltmarsh report (Visby and Prahalad, 2020) and the Lauderdale Saltmarsh Reserves Activity Plan 2020-30 (North Barker Ecosystem Services, 2020).

From the start of the project, our hypothesis has been that the tea would decompose quicker at Racecourse Flats due to its degraded state.

Thus, starting in Dec 2017, the DEP team buried 240 nylon mesh tea bags across two Lauderdale saltmarshes, using the methodology set out by the Blue Carbon Lab (Blue Carbon Lab, 2017). The tea was left in-situ for three months, when the first row of tea bags was dug up, gently washed, dried, and weighed. After six months, one year, two years, and finally in Dec. 2020 after three years, the rest of the tea bags were retrieved, a row at the time, and given the same treatment (Figure 4-1). The Blue Carbon Lab produced a colourful ArcGIS StoryMap that shows videos of some of the methods utilised: https://storymaps.arcgis.com/stories/7bd2e5e693b24d92804172ae6d1eb05e.

Each tea bag was weighed before *and* after burial, and the data provided to the Blue Carbon Lab along with information about the individual saltmarshes and the surrounding climate. Some project participants, not DEP, also provided community microbial data and other information. Section 7 lists the papers that the Blue Carbon Lab has produced about this project to date (as of Sept 2021).

Figure 4-1. Photos from the Derwent estuary tea bag project. Top left: representative locations were identified; a quadrate is placed to help with spacing; and a corer was used to dig 20 holes per site, Dec 2017. Top right: in each hole, a tea bag, either Green or Rooibos, is buried, Dec 2017. Bottom left: a Green tea bag recovered after two years of burial. Bottom right: Tea after drying, ready for weighing, Dec 2020. All photos by DEP.

5 RESULTS

This section will primarily focus on the results from the DEP aim of comparing two local estuary marshes, not the overall global project, where much data is still being analysed (Section 7).

The key was to find out how quickly the tea would decay, i.e., the decay rate. One early finding from the global project was that Green tea, consistently, showed initial mass loss at a higher rate than Rooibos (Trevathan-Tackett *et al.*, 2021). Figure 5-1 shows this early site difference, and the ongoing decay rate for each tea type in each saltmarsh, with more Rooibos left than Green tea in both marshes. The proportion of Green tea remaining at Racecourse Flats by the Year 1, 2 and 3 marks is likely slightly overestimated as tiny roots contaminated the teabags, adding to their weight (though considerable time was spent picking them out by hand!).

Overall project data from the Blue Carbon Lab team suggests that the Rooibos tea more closely represents saltmarsh vegetation litter, though Green tea is still useful for assessing the environmental effects on leaching early on in the decaying process (pers. comm. S. Trevathan-Tackett, Deakin University Aug. 2021). The collective data also suggested that Green tea more closely resemble the decay dynamics of seagrass leaves (Trevathan-Tackett *et al.*, 2020).

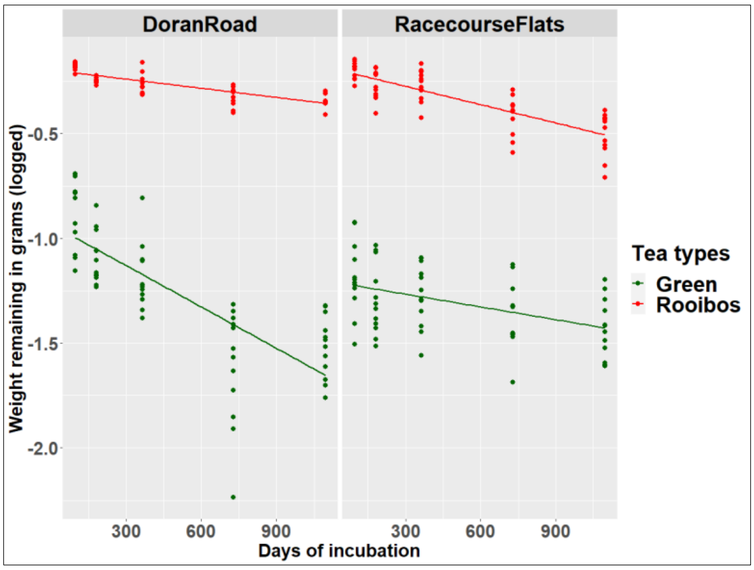


Figure 5-1.Decay rate for green and Rooibos tea at Dorans Road saltmarsh and Racecourse Flats saltmarsh over the five incubation periods (three months, six months, one year, two years and three years). Each dot represents logged weight remaining in recovered tea bags, with lines indicating decay rate after three years (decay rates after two and three years stated in text).

Thus, in our final comparison of two saltmarshes, we are focussing on the Rooibos tea decay rate:

After two years, our data showed that Rooibos decayed faster at Racecourse Flats (decay rate per day: -2.91×10^{-4} (95% CI: $--3.84\times10^{-4}$, -1.99×10^{-4})), compared to Dorans Road (decay rate per day: -1.45×10^{-4} (95% CI: -2.37×10^{-4}, -5.33×10^{-5})).

After three years the daily decay rate of Rooibos at Racecourse Flats had increased further (-1.45×10^{-4} (95% CI: -2.37×10^{-4}, -5.33×10^{-5})), compared to Dorans Road (-2.91×10^{-4} (95% CI: -3.84×10^{-4}, -1.99×10^{-4})). As Figure 5-2 show, the difference after three years is now weakly significant because the confidence intervals for each site do not overlap each other's estimates of decay rate.

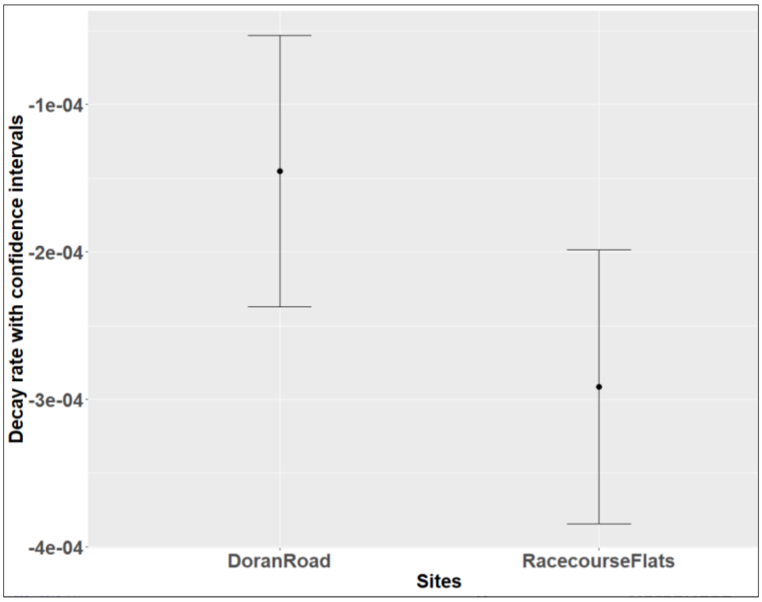


Figure 5-2. Decay rate with confidence intervals, for Rooibos tea at the two Lauderdale saltmarshes, Racecourse Flats and Dorans Road, after three years.

6 CONCLUSION

We hypothesised that a degraded saltmarsh would be less effective at sequestering carbon compared to a nearby healthy saltmarsh. In other words, that our degraded Lauderdale saltmarsh, Racecourse Flats, with no regular tidal connectivity, would break down tea quicker than the nearby healthy marsh, Dorans Road, with its access to free-flowing tidal flushing.

The data we obtained supported our hypothesis.

Further, when saltmarsh litter breaks down at a site cut off from the marine environment (such as Racecourse Flats), there is minimal sediment to supplement what is being broken down in the top layer, as occurs in healthy saltmarshes (such as Dorans Road). This results in actual subsidence of the marsh, as discussed in Anisfeld (2012). This condition was highlighted as existing at Racecourse Flats in a previous scoping for a restoration project (Cook, 2012).

The comparison of tea decay rate of the two Lauderdale sites suggests that, possibly because of its degraded state, the Racecourse Flats saltmarsh is less effective at sequestering carbon compared with Dorans Road, thus less effective at combating climate change.

This project has contributed to our knowledge of why we need to restore the tidal connectivity to Racecourse Flats, the largest remnant saltmarsh in the Derwent estuary.

7 BLUE CARBON LAB PROJECT

Papers produced by the Blue Carbon Lab (as of Sept 2021) in connection with this project include:

- Ecosystem type drives tea litter decomposition and associated prokaryotic microbiome communities in freshwater and coastal wetlands at a continental scale (Trevathan-Tackett *et al.*, 2021).
- Effects of elevated temperature on microbial breakdown of seagrass leaf and tea litter biomass (Trevathan-Tackett *et al.*, 2020).
- The TeaComposition Initiative: Unleashing the power of international collaboration to understand litter decomposition (Djukic *et al.*, 2021)

There are multiple other papers being prepared for this project – which can be followed on https://www.bluecarbonlab.org/teacomposition-h2o/ .

8 ACKNOWLEDGEMENTS

DEP thanks Dr Stacey Trevathan-Tackett from the Blue Carbon Lab for the opportunity to participate in this interesting project. Field and lab work was conducted by DEP staff Akira Weller-Wong, Bernadette Proemse and Inger Visby, kindly assisted by Dr. Anne Watson (UTAS). Data analysis and lab facilities were generously supported by Associate Professor L. Barmuta (UTAS).

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