Windecker, S. M., Trevathan-Tackett, S. M., & Vesk, P. A.

Fs

\frac{d\alpha}{dT}\_{total} = \sum\limits\_{i=1}^3 \frac{d\alpha}{dT}\_{i}

\frac{d\alpha}{dT} = h\ exp\bigg\{-\frac{ln2}{s^2}\Big[ln\Big(1 + 2s \frac{T- p}{w}\Big)\Big]^2\bigg\}

trialled innovative technology to test for variability in the intrinsic chemical composition of wetland plants that might ultimately affect the contribution of different wetland plant types to wetland carbon sequestration (Ch2). This allowed you to rank plant types in their likely contribution to wetland carbon sequestration based on their inferred intrinsic recalcitrance.

Despite the utility of functional trait research for understanding both vegetation community response to environmental change as well as impact on ecosystem functions, application of these approaches in wetland systems is lagging. The leaf economic spectrum theory postulates a single dominant axis of variation separating species by resource investment in photosynthesis or structure. This spectrum does little to capture trait effects on soil carbon storage, as leaf traits do not identify litter recalcitrance. While litter of any type can become recalcitrant in the soil for a variety of reasons, including the absence of necessary decomposer communities or required environmental conditions, intrinsically chemically complex litter will almost always become recalcitrant. Typical leaf traits cannot identify complex compounds in leaves, and wet chemistry approaches to measure lignin and other compounds are costly as well as risky and so are not widespread in the trait literature. We need to marry traditional plant traits with traits more tightly related to allocation of carbon resources in order to use traits in carbon science and management. In this study, I examine a novel method in ecology for calculating lignocellulosic biomass using mixture modelling of thermogravimetric analysis (TGA), typical in the biofuel field. I found that TGA coupled with modelling approaches is a rapid, low-cost assessment method that can be used to estimate partitioning of leaf carbon.

I collected litter samples of 29 plant species from wetlands in Victoria. I measured four typical leaf economic spectrum traits of these 29 wetland species: leaf carbon (LCC), leaf nitrogen (LNC), specific leaf area (SLA), and leaf dry matter content (LDMC). In addition, I estimated composition of hemicellulose, cellulose, and lignin in the dry litter using thermogravimetric analysis. In this method, dry ground litter is pyrolised in a N2 atmosphere over a temperature ramp of 900 C. The derivative of the mass loss curve produces a multipeaked curve that can be used to identify the three main phases of mass loss, which approximately correspond to the hemicellulose, cellulose, and lignin fractions. The three internal peaks were deconvolved from the overall derivative curve by modelling a three-part Frazer-Suzuki mixture model, as used in the biofuel literature (Equation 1). I found that lignin and hemicellulose are highly correlated, and also increase with LDMC. Selected results presented below: flowchart of mass partitioning and traits measured in this study (Figure 1), sample deconvolution curve (Figure 2), heatmap of principle component analysis of traits (Figure 3), and pairs plot of trait correlations (Figure 4).

we talk about recalcitrant litter as high C:N, but not about what kind of C.

Introduction

Freshwater ecosystems and carbon storage

* But not perfect for c storage, so maybe relevance should also be related to role in global C cycle – as the kidneys.
* ‘teal carbon?’ is there a name??
* C donors to C rich sediments
* Allochthonous v autochthonous contributions

Local litter contribution to C

* Fate of C: eaten by microbes and other invertebrates and taken in to new biomass
* respired
* what is not decomposed…
* of form that it contributes to long-term storage in soil
* something about methanotrophs… some types even they don’t eat?
* Volume and decomposability of the litter it leaves behind, either to the area it is in (autochthonous carbon) or if it is carried downstream as allochthonous litter in other sites.
* Mainly examine patterns of litter contribution via examining drivers of decomposition rates.

Wetland plants and traits related to soil C

* …
* Decomposition is a part of this
* Global studies have found that leaf litter quality biggest predictor for decomp rates.
* This trait approach used to generalise about litter quality types.
* Which traits
* Decomposition rate is not only affected by traditional litter quality traits, but also by structural complexity because of specifics of wetland veg.

We need a targeted approach in wetlands

* wetland-system specific approach to traits and C storage is necessary – cite ecology article.
* Photosynthetic material that is deposited as litter is not just leaves
* Different species require different structures in their cell walls due to requirements for rigidity. Emergent macrophytes need to maintain their structure whereas a submergent species do not.
* Also bigger variation in type of tissue used for photosynthesis. In wetlands often the culm or stem, used for structure, is also photosynthetic material subject to dying and contributing to either autochthonous litter or allochthonous litter taken downstream to be deposited in other sites.
* This high variability may not be visible in the traits we traditionally measure in vegetation.

Traits related to C cycling

* Structural complexity means we need new traits, but also C storage in the soil is not only determined by decomposition rate.
* No matter the rate of decay, C donation will be related to what and how much material remains after decomposition occurs.
* Traits related to lignocellulosic composition may help deal both with separating the effects of structural complexity in wetland veg and also identifying how species contribute as C donors.
* We don’t see them listed in the trait handbook.
* Discuss where this has indeed been done before – in decomposition, but purely as predictors of rate, and limited by methods used.

Problems with these methods

* But these methods are costly and risky.
* Wet chemistry does not produce exactly the values we are after.
* Limits application of these methods

TGA

* alternative to wet chemistry
* mainly used in the biofuel field
* Involves pyrolysis of biomass in along temperature ramp and recoding mass loss with temperature.
* Typically used to estimate kinetic parameters of materials.
* Some examples of how its been used in the past to isolate amounts of lignocellulosic compounds.

Aim

Our aim is to infer the traits that relate to C sequestration contribution by wetland vegetation. There is reason to believe that lignocellulosic biomass components are reasonable effect traits for C storage. So we want to look at the relevance of these as traits. It is hard to do so with traditional techniques, so we ask these three questions:

* How do lignocellulosic compounds vary in a wide suite of wetland species?
* Can TGA be used to quantify these compounds in this type of litter?
* How do lignocellulosic traits relate to other, more commonly measured, leaf economic spectrum traits?
  + Hypothesis 1: leaf traits would separate predominantly herbaceous species from those with structural photosynthetic tissue.
  + Hypothesis 2: nutrient rich species would also be associated with higher hemicellulose components, and nutrient poor (high quality) species would be associated with higher lignin
  + Hypothesis 3: those with higher C would also have higher recalcitrant, and lose less total C over span of thermal decay.

We measured a suite of leaf traits of 29 wetlands species, as well as applied TGA under N2 (pyrolysis) to assess thermochemical stability of organic and inorganic C components and to assess the efficacy of this method for trait analysis on litter samples.

*Results in traits themselves*

* SLA values ranged from [] (sp) to [] (sp). As expected herbaceous species were of low quality… graminoids or stem. High nutrient values in those not expected to be contributing very much to structure.
* LDMC
* C, N

TGA

* overall we can see that the three peaks were pretty consistent with the literature.
* Primary component one centred around xx K, primary component two around xxK and was the narrowest band, and compoenent three centred at the highest temepratrue and the widest band. These roughly equate to hemi, cell, and lignin components.
* The shape of the derivative curves was very consistent for stem graminoid species. Reflected in the very similar and clustered values for the total amounts of the three components.
* High variation among other species in the shapes of the curves.
* Which ones has highest and lowest of the compoennts.
* How did the bands differ.
* Summarise total mass loss by the end (at 900 or whatever) X temp as well.

Relate lignin to total mass lost?

*Trait comparisons*

Discuss pair plot. What is related with what.

Add linear models to anything?

And PCA – check out how the ordination indicates what the patterns are for the main dividers.

Is there a trend of which species fall along which line? Is one more indicative of the structural photosynthesizers v. primarily photosynthesis ers?

Can I use one trait in linear predictor model for relationship between two others?

Is relationship between LDMC and lignin moderated by cellulose?

Show a few models here.

Discussion

1. Leaf traits did separate

2. but leaf traits did not track with hemi v lignin

3. higher c and recalcitrant portions would also be associated with more total mass remaining at final levels.

We expect litter quality to be related to labile/refractiveness.

Litter quality is related to microbial breakdown. So more recalcitrant litter would remain more in the soil as not broken down as much.

Why some species would have wider bands at certain intervals than others.

As expected, leaf traits did separate species by

Leaf traits are more characteristic of the nutrient and water mass levels. SLA actually looks at how much mass there is. Presumably in situ, these leaves would contribute less per mg to litter as water weight would be lost.

However, surprisingly not related to the type of carbon in the tissue.

This means that it is an important separate predictor to include in trait studies.

As shown in XXXXX papers, lignin or cellulose proved useful predictors for a range of ecosystem effects.

Indicated a diverging pathway, where these characteristics of leaf carbon are XXXX

These indicate the traits are indicators of diverging strategies. Those with photosynthetic tissue that also play important structural role will be characterised by intermediate leaf traits but strong levels of cellulose.

Ex. Marsilea – maybe more cellulose because included the little stem.

With respect to traits that may affect C donor level/strategy, examining the entire green tissue that would be left behind to be deposited is important.

Link back to C donor levels

* While traits have been found to be important predictors of decomposition rates, worldwide, when thinking about C donor ability both to autochthonous C by platn biomass and as contribution of litter to allochthonous carbon, must think about what remains after decomposition occurs.
* Lignin is more relatively difficult to degrade by bacteria, and so is expected to have a greater impact on C stores.
* Lignin content varies greatly. Plant composition may therefore be an important predictor of lingnin concentrations in soils.
* Organic matter stability may tell us how these materials would be processed by detrital organisms and microbes and therefore how they would impact leftover carbon in the soil

If these are the traits that affect C donor ability, what drives them in wetlands?

Where are plants that match these types of abilities located, and what determines that?

Main conclusions

TGA as useful, quick and relatively cheap way to calculate mass proportions of these types of materials.

Not a direct link between traditional leaf traits and C types.

Lignocellulosic materials important to include in characterisation of traits important for C donor and decomposition awareness as characterise different items in a species’ chemistry/arsenal.

The traits we currently look at don’t let us understand how useful species will be as C donors, but these traits separate out on the new spectrum, and divide out the other traits in unpredicted ways.