Subject strapline: Ecosystems and climate

Title: Mapping classes of carbon

Standfirst: With rising fossil fuel consumption and ongoing land cover change, humanity is burning through its remaining carbon budget. Recent work puts a “Do Not Disturb” sign on biospheric carbon we can’t afford to lose.

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As rising global temperatures and worsening impacts from extreme weather call society’s attention to the urgency of climate action, researchers have quantified our carbon emissions “bank account” by asking: How much more carbon dioxide can we release to the atmosphere and still have a better-than-even chance of avoiding catastrophic damages? Most of that remaining budget will be consumed through fossil fuel combustion, but an additional deduction will come through the intentional management of ecosystems. Writing in this issue, Noon and colleagues report on a new method to categorize potential carbon loss from such management and map hard-to-recover carbon at a global scale and with unprecedented spatial resolution.

Ideas about how to direct action to protect, restore, and improve the structure and function of ecosystems have expanded in scope and scale in recent years. Building on research quantifying biodiversity and its connections to the climate system and ecosystem health, new ways of defining and characterizing the stability and resilience of ecosystems are now being applied to the Earth system as a whole. One motivation of recent work has been to provide practical metrics to guide climate policy and inform land management decisions. Until recently those metrics have focused on carbon quantity as a proxy for importance, with priority given to places with more carbon stored by living organisms, or biomass, and places with more carbon stored as organic matter in soils.

A new approach to defining policy-relevant metrics for potential carbon loss from ecosystems was introduced in the past year (Goldstein et al. 2020), borrowing somewhat from notions of “unburnable fossil fuel reserves” and also from characterizations of threatened and endangered species and “irreplaceable ecosystems”. This approach describes a class of “irrecoverable carbon”, defined as being simultaneously subject to management decisions and actions, at risk of large loss under typical management scenarios, and, crucially, being relatively slow to recover following managed disturbance. Major advances of that work were a) its consideration of both the amount of carbon initially lost from biomass and soil and their typical recovery rates and b) use of this information to estimate how much carbon lost during a typical change in land cover (e.g. forest clearing) could be regained within a specified time. That original concept was demonstrated for 15 aggregated biomes to arrive at an estimate of global total irrecoverable carbon based on a 30 year time horizon, from now until 2050.

Noon and co-authors have improved on the original Goldstein et al. concept and extended the methodology to produce a global map of irrecoverable carbon at a spatial resolution of 300 m. The high spatial resolution itself is a remarkable achievement, requiring the integration of multiple remote sensing and soil-characterization datasets with predictive models of regrowth rates in forest and other ecosystems. Their analysis considers terrestrial, marine, and coastal ecosystems, with special consideration of carbon-rich peatland. Each 300 m gridcell is defined independently as manageable or not, and each manageable gridcell is assigned a carbon density for above and belowground biomass and soil carbon. Depending on the system, severe but typical land cover conversions are considered, and potential carbon losses estimated. With an assigned timeframe of 30 years, as in Goldstein et al. 2020, regrowth and associated carbon accumulation are estimated on the basis of vegetation type, climate, and conversion process. Any carbon lost in the potential conversion and not replaced within 30 years is defined as irrecoverable, resulting in the mapped product together with a careful assessment of multiple sources of uncertainty. They find that almost 140 Gt C is in the irrecoverable category today, with a broad uncertainty range (0 – 583 Gt C).

Using this map, Noon et al. assess which regions with large amounts of irrecoverable carbon are also experiencing high rates of recent management-driven carbon loss. They likewise identify regions of high irrecoverable carbon that are under some form of protection. By examining sources of carbon loss in these regions both from management actions and from inadvertent climate change, they define a useful matrix of potential actions targeting different sectors of vulnerability and current protection status.

Noon et al. are open about acknowledging the many assumptions and simplifications built into their methods, and they also make clear the dependence of their quantification on the selected timeframe of 30 years. While the connection of this analysis to the concept of a remaining carbon budget is compelling, the rationale given for the selection of 30 years and a 2050 endpoint is less so. Here, as with Goldstein et al. previously, the authors contend that 2050 is a logical endpoint given the commitments of nations in the Paris Agreement to net-zero emissions by that date. This net-zero framing could be used as more than a rationale for the 2050 endpoint, and could instead bring a new and more mechanistic focus to the problem of identifying how much conversion is acceptable in vulnerable areas. Land ecosystems are characterized by relatively large and opposing gross carbon fluxes. With disturbance the balance of those fluxes shifts first to a net carbon release, followed in many cases by a return to net-zero emission and later a net carbon uptake. New modeling work could identify the allowable conversion types and extent that would reach net-zero by 2050. That is admittedly a more demanding assessment, one likely subject to even greater uncertainty. Alternatively, declaring 2050 an arbitrary endpoint would not detract from the results of Noon et al., and it would lift the uneasiness that grammarians among us might feel as we consider that some carbon deemed irrecoverable will find its way back into these ecosystems over time.

Competing Interests:

The author declares no competing interests

References

Goldstein et al. 2020 (we might be able to link rather than cite)

Figure Caption (Figure 1):

A new method for mapping a class of carbon subject to human management, vulnerable to loss due to management action, and slow to recover from disturbance. The global map (top) is composed of gridcells with 300 m spatial resolution (lower left). Each gridcell reflects the outcome of three simultaneous criteria: What fraction of the area is manageable (M)? How much carbon is vulnerable to loss in a typical disturbance (V)? And how much time is required for the ecosystem to regain carbon lost in a managed disturbance (T)? The amount of carbon meeting these criteria is deemed irrecoverable (IC).