Biological Conservation 207 (2017) 9–16

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/bioc

Trade-offs in carbon storage and biodiversity conservation under climate change reveal risk to endemic species

April Elizabeth Reside [a,b,*], Jeremy VanDerWal [b,c], Catherine Moran [d,e]

[a] Centre for Tropical Environmental and Sustainability Sciences, James Cook University, Townsville, QLD 4811, Australia
[b] Centre for Tropical Biodiversity and Climate Change, College of Marine and Environmental Sciences, James Cook University, Townsville, QLD 4811, Australia
[c] eResearch Centre, James Cook University, Townsville, QLD 4811, Australia
[d] CSIRO Biodiversity & Ecosystem Knowledge & Services, Atherton, QLD 4883, Australia
[e] Centre for Tropical Environmental and Sustainability Sciences, James Cook University, Cairns, QLD 4878, Australia

ARTICLE INFO

Article history:
Received 23 June 2016
Received in revised form 16 December 2016
Accepted 10 January 2017
Available online xxxx

Keywords:
Systematic conservation planning
Biodiversity prioritisation
Cobenefits
Zonation
Carbon
Trade-offs

ABSTRACT

Carbon offset funds provide substantial opportunities for protection and restoration of native ecosystems, with corresponding gains for biodiversity and reductions in atmospheric carbon. However, biodiversity could be disadvantaged if not properly accounted for, particularly under climate change, where high carbon gains do not coincide spatially with biodiversity priorities. While globally there is congruence for species richness and carbon stocks, adequate conservation needs to incorporate more refined measures of biodiversity – and consideration of the impact of future climate change. We investigated the spatial trade-off for carbon and biodiversity priorities in north-eastern Australia based on current and projected climate, using the Zonation prioritisation software. By iteratively weighting carbon against biodiversity we found that prioritising land based on biodiversity value (for 697 vertebrates) included priority areas for potential carbon sequestration (Maximum Potential Biomass). However, if prioritisation was based on carbon sequestration potential alone, substantial areas important for biodiversity would be lost. Policy frameworks need to be strengthened to remove barriers from landholder participation in carbon storage projects that have biodiversity benefits, and to require that both carbon and biodiversity gains are additional. Properly accounting for biodiversity in land-based carbon sequestration and storage prioritisation in this region is likely to generate substantial benefits for both biodiversity and carbon.

1. Introduction

Offsetting carbon emissions by protecting and restoring native ecosystems are major strategies for mitigating and adapting to climate change (e.g., Paris Agreement, 2015) and have resulted in the avoided loss of tropical rainforests and other ecosystems (Magnago et al., 2015). However, carbon and biodiversity priorities do not necessarily align in space (Anderson et al., 2009; Strassburg et al., 2010; Venter et al., 2009) or time (Martin et al., 2013). This is particularly the case for regions rich in narrow-ranged endemic species: neighbouring regions of high carbon value could contain substantially different species assemblages, and thus not have interchangeable conservation value. Furthermore, climate change is likely to alter future priorities for both biodiversity and carbon and this change should be considered to maximise long-term conservation value. For this reason, biodiversity metrics should be carefully selected and examined.

Loss of native ecosystems continues at a rapid rate (Forrest et al., 2015), and is the largest driver of species extinctions globally (Dirzo and Raven, 2003). Furthermore, deforestation is the second largest source of anthropogenic greenhouse gas emissions (Gullison et al., 2007). Therefore, retention of forests and native ecosystems is crucial to reducing carbon emissions and protecting biodiversity, both immediately (by protecting current habitat) and in the future (by mitigating climate change)(Houghton et al., 2015). Mechanisms such as the United Nations' Reducing Emissions from Deforestation and Forest Degradation (REDD+) (Harvey et al., 2010) and various domestic carbon markets have potential to stem deforestation rates and to protect or increase carbon stores (Polglase et al., 2013). These mechanisms also have the potential to facilitate large-scale restoration (Houghton et al., 2015), with potential carbon and biodiversity benefits (Alexander et al., 2011; Martin et al., 2013). However, site-based studies are required to verify global analyses of spatial priorities for carbon and biodiversity to ensure actual gains for both, particularly where endemism is high (Anderson et al., 2009; Magnago et al., 2015).

The substantial body of work investigating carbon and biodiversity priorities indicates a recognition of the risk to systems from climate change – a risk that would persist even with substantial increase of

* Corresponding author at: Centre for Tropical Environmental and Sustainability Sciences, James Cook University, Townsville, QLD 4811, Australia.
E-mail addresses: April.reside@gmail.com, april.reside@gmail.com (A.E. Reside), Jeremy.vanderwal@jcu.edu.au (J. VanDerWal), Catherine.moran@csiro.au (C. Moran).

http://dx.doi.org/10.1016/j.biocon.2017.01.004

land-based carbon storage (Gullison et al., 2007; Metz et al., 2007). Despite this recognition, most studies do not account for biodiversity priorities under future climate change. Instead, studies have focussed solely on the current distribution of biodiversity. Ongoing biodiversity conservation will require protection or restoration of areas that will remain or become suitable under projected climate change, whether or not they are current priorities for biodiversity conservation. Therefore, evaluation of biodiversity and carbon storage trade-offs should include species' current and future requirements (Kujala et al., 2013), or risk suboptimal conservation outcomes. Future planning is also important for evaluating carbon stores – not only where there are high carbon stores currently, but where there is high potential for sequestration. Restoration of cleared and degraded ecosystems is a key biodiversity conservation action that also brings substantial opportunities to sequester carbon and attract carbon offset funds. Restoration is particularly beneficial where species are likely to need to move into areas that are currently unvegetated to stay within their suitable climate space. For this, estimates are required of the potential carbon sequestration and storage (from here on: "carbon storage") value of a site should native vegetation be restored, together with the estimates of potential biodiversity value.

Substantial advances have been made in accounting for future climate change in conservation planning, from advancing conceptual thinking, to practical solutions (Jones et al., 2016; Mawdsley et al., 2009; Schmitz et al., 2015). In particular, many studies have highlighted the priority areas for protection and restoration to facilitate species tracking their climatic niche and provide new habitat (Jones et al., 2016; Williams et al., 2005). What is missing is planning for multiple benefits (in this case biodiversity and carbon storage) and multiple time steps (priorities under current and future climate). Considering multiple benefits not only allows for action for climate mitigation but also creates opportunities to attract revenue from carbon offset markets to a severely under-resourced conservation sector.

This study investigated the potential trade-offs between prioritising for carbon sequestration and storage, and prioritising for biodiversity in the face of climate change. For this we used north-eastern Australia which is rich in endemic vertebrates, particularly in the tropical rainforests. This region has experienced widespread clearing historically, particularly in the south; the north is largely intact but vulnerable to clearing, mostly for pastoralism (Evans, 2016; Preece et al., 2016). This region also has high carbon storage potential (Polglase et al., 2013). Identifying key areas for biodiversity conservation and carbon storage will guide the prioritisation of restoration and protection of areas with high biodiversity value and carbon storage potential. We built in future considerations for both biodiversity and potential carbon sequestration into our prioritisation, accounting for the current distribution of species' climate space and changes under a severe climate change scenario. We used the systematic conservation planning tool Zonation (Moilanen et al., 2014) to identify current spatial conservation priorities as well as for two future time periods (2055, 2085). We evaluated the change in spatial priorities when considering multiple benefits by iteratively increasing the weighting of carbon relative to biodiversity. From this, the optimal solution across all priorities was identified. Our results identify spatial conservation priority areas that are robust for multiple benefits and under multiple time steps.

2. Methods

2.1. Study area

Australia has 56 Natural Resource Management (NRM) regions, grouped into 8 clusters, which are defined by catchments and bioregions (http://www.climatechangeinaustralia.gov.au/en/climate-projections/about/modelling-choices-and-methodology/regionalisation-schemes/). Australia's model of regional NRM planning facilitates landscape-scale programs to achieve landscape resilience, including biodiversity conservation and adaptation to climate change (Dale et al., 2013). However, external resources are required for many of the programs, and carbon offset funds have the potential to be beneficial for this work (Dale et al., 2013). This study was conducted within the Wet Tropics NRM cluster region, in north-eastern Australia from −10.12 to −23.53 degrees latitude (Fig. 1). The Wet Tropics NRM cluster region incorporates four NRM regions across the Torres Strait (Torres Strait Regional Authority), Cape York (Cape York NRM), the Wet Tropics (Terrain NRM) and Mackay-Whitsundays (Reef Catchments NRM). The Torres Strait islands archipelago was excluded from current analyses because few data were available for this region. Vegetation in the Wet Tropics NRM cluster region consists mainly of Eucalypt woodlands, ranging in form from open savanna to wet sclerophyll forests. These dry forests and woodlands are of high biodiversity value, including some endemic vertebrates. However, the small but highly diverse tropical rainforest regions contain many endemic vertebrates, most with extremely restricted distributions, particularly those restricted to high-elevation rainforest (Mackey et al., 2001; Williams, 2006; Williams et al., 2009). Other major ecosystem types in the region include Melaleuca and Acacia woodlands, and grasslands.

2.2. Carbon storage

The potential for carbon storage was estimated using the Maximum Potential Biomass data (MaxBio, Department of Climate Change and Energy Efficiency, 2004). MaxBio is estimated from a Forest Productivity Index, using monthly climate data, solar radiation and leaf area index, to produce a relative scale of 1 to 25. MaxBio estimates the above-ground

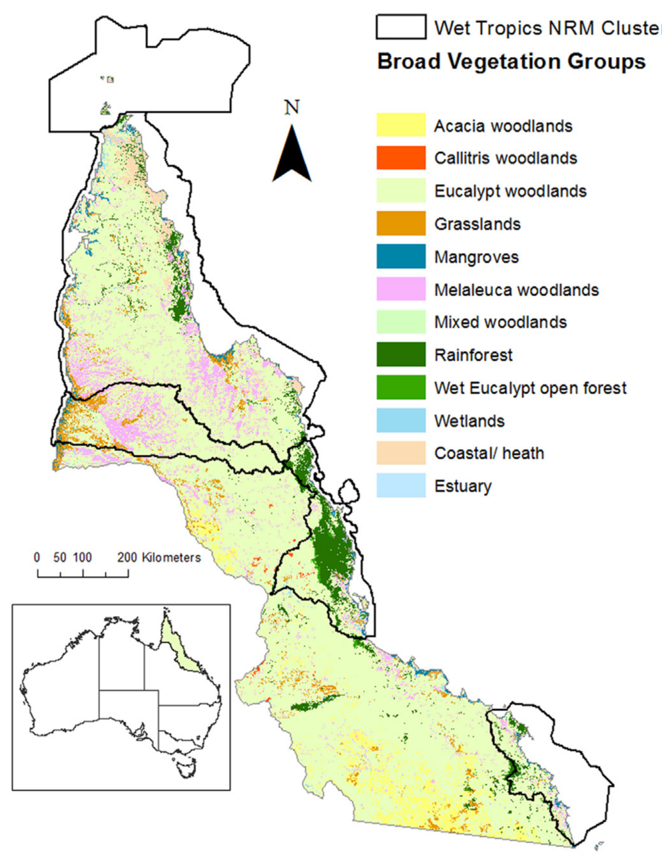

Fig. 1. The Wet Tropics Natural Resource Management (NRM) Cluster region of north-eastern Australia with the major vegetation groups identified. http://www.nrm.gov.au/regional/regional-nrm-organisations