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Spatial congruence and divergence between ecosystem services and biodiversity in a tropical forested landscape

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ABSTRACT

Tropical forests are the storehouse of both ecosystem services and biodiversity but the interlinkages between these two components of ecosystems are yet to be fully explored. We utilized expert opinion to assess the key and multiple ecosystem services, and biodiversity in a tropical landscape. We found that key and multiple ecosystem services supply varies across the landscape and that forest disturbances reduce the capacity to supply those ecosystem services. We also found that a spatial congruence is likely to occurs between high-potential biodiversity and high-potential global climate regulation ecosystem service in the intact rainforest areas while a spatial divergence is likely to occurs in the sclerophyll and other disturbed and low tree abundance forested areas. Overall in a tropical forested landscape, a spatial congruence between high-potential multiple ecosystem services supply and high-potential biodiversity values is likely to occurs provided that the multiple ecosystem services are forest-based. Along with conserving relatively intact forests, management intervention priorities should focus on increasing tree abundance both in non-tree vegetated land cover areas and within disturbed forested areas to increase the high-potential multiple ecosystem services supply at the landscape level. A careful selection of multiple ecosystem services is required to integrate both high-potential multiple ecosystem services and high-potential biodiversity in tropical forest management.

1. Introduction

Tropical forests supply more than two-folds higher amount (monetary values) of ecosystem services than other terrestrial biomes (Costanza et al., 2014; de Groot et al., 2012) and harbor a number of global biodiversity hotspots (Myers et al., 2000). An ongoing widespread decline in both ecosystem services (Costanza et al., 2014; de Groot et al., 2012; Martínez et al., 2009) and biodiversity (Barlow et al., 2007; Butchart et al., 2010; Sodhi et al., 2004) in tropical forests has consistently been reported. The effective management of such areas are crucial, so that ecosystem functioning can be maintained to supply key and multiple ecosystem services and at the same time supporting biodiversity conservation in a landscape (de Groot et al., 2010; Egoh et al., 2007).

Despite the wide development of both ecosystem services and biodiversity literature many challenges are still remain on how to integrate both ecosystem services and biodiversity in a tropical forested landscape management (de Groot et al., 2010; Mace et al., 2012; Naidoo et al., 2008; Reyers et al., 2012). Although, ecosystem services and biodiversity are identified as the two most important, distinct but interlinked components of the ecosystems (de Groot et al., 2010; MA, 2005). The challenges commonly arise from two sources- the indistinct common response of both ecosystem services and biodiversity to management decision (Daily and Matson, 2008; Daily et al., 2009; de Groot et al., 2010; Naidoo et al., 2008; Reyers et al., 2012), and multilayered complex interactions among multiple ecosystem services, and between ecosystem services and biodiversity (Bennett et al., 2009; Mace et al., 2012).

Landscape management solely focused on biodiversity conservation may not ensure the supply of certain ecosystem services in a landscape, and vis-versa (Naidoo et al., 2008). For example, management decision to maximize the carbon sequestration ecosystem service in a landscape may not increase biodiversity values in the landscape, and vis-versa (Nelson et al., 2008). However, management decision focused on maximization of supply of multiple ecosystem services (rather than a single ecosystem service) may enhance biodiversity values in a

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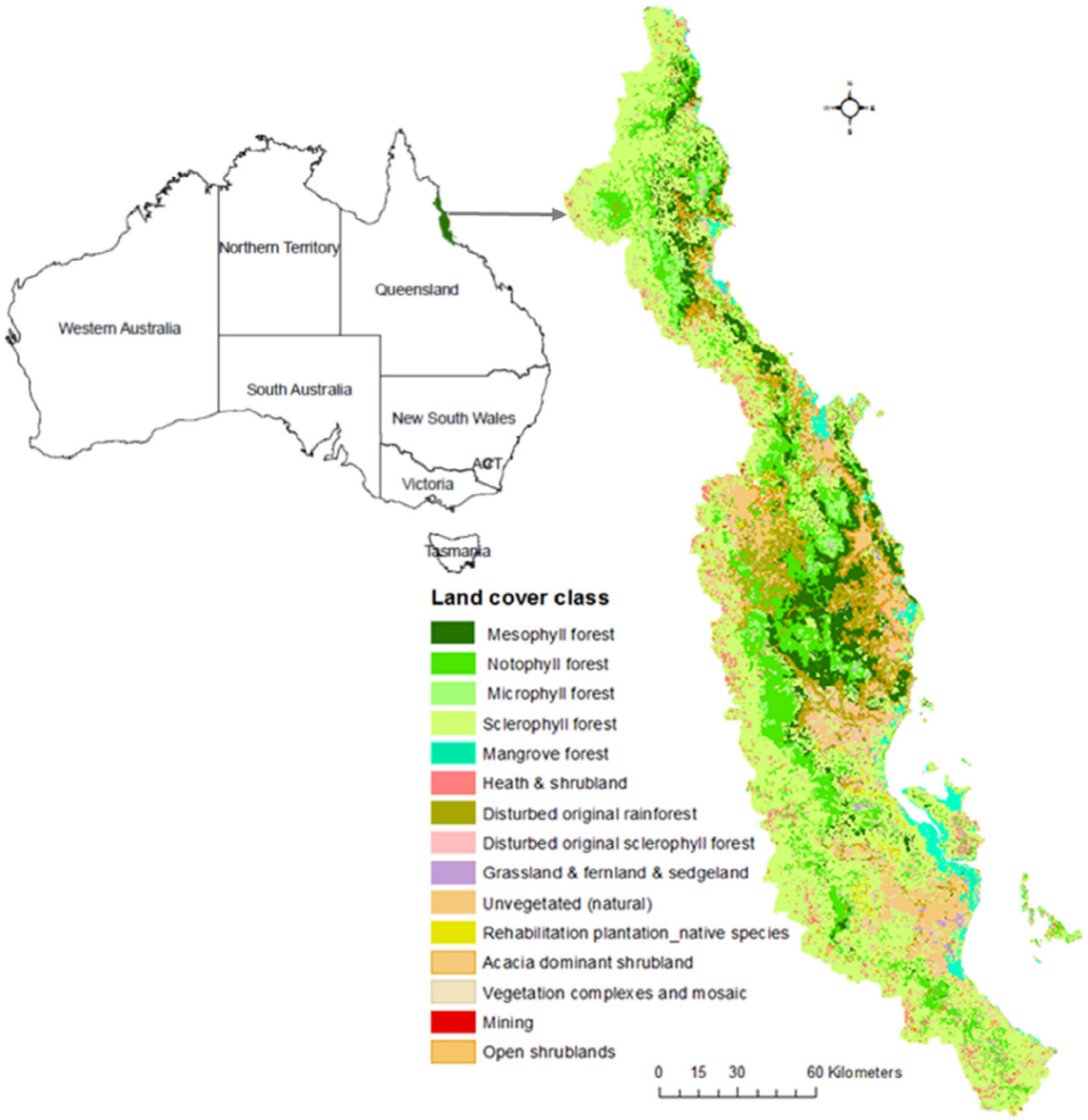

Fig. 1. Wet Tropics bioregion, northeast Australia with major Land Use and Land Cover type considered in this study.

landscape (Bullock et al., 2011). Furthermore, management decision solely focused on maximization of supply of one ecosystem service may have a profound negative impact on the supply of other ecosystem services in a landscape (Bennett et al., 2009). For example, management decision to increase nutrient regulation ecosystem service in a tropical forested landscape likely to reduce the supply of carbon sequestration ecosystem service (Alamgir et al., 2016c).

Current available literatures rarely show clear evidence on the interaction between ecosystem services and biodiversity in a landscape (Chan et al., 2006; Egoh et al., 2009; Harrison et al., 2014; Reyers et al., 2012). Chan et al. (2006) reported a positive correlation between biodiversity and forest based ecosystem services (e.g. carbon storage and outdoor recreation). Harrison et al., (2014) ascertained that improvement of landscape aesthetics ecosystem service in most cases delivers biodiversity values in a landscape. Egoh et al. (2009) reported that biodiversity values and certain ecosystem services provision in a landscape are weakly positively correlated. Furthermore, Labrière et al. (2015) found that biodiversity and certain ecosystem services provision in a tropical forested landscape are positively correlated.

The linkages among ecosystem services, biodiversity and ecological process needs to be well understood to support both goals-sustained ecosystem services and biodiversity conservations- in a landscape management (Di Minin et al., 2017; Zeller et al., 2017), otherwise management strategies may not safeguard both biodiversity conservation and ecosystem services supply in a landscape (Alamgir et al., 2016c; Liquete et al., 2016). Therefore, spatially explicit mapping is required for the effective integration of ecosystem services and biodiversity together into a landscape management (Chan et al., 2006). Spatially explicit mapping at the landscape level brings together spatial and temporal information indicating where management intervention should be focused for integrating ecosystem services and biodiversity (Baral et al., 2014; García-Nieto et al., 2013; Schneiders et al., 2012; Schulp et al., 2012).

The problem is that the approaches of making ecosystem service assessment spatially explicit and the integration of necessary ecological information into the ecosystem service assessment are both still unclear (Eigenbrod et al., 2010; Martínez-Harms and Balvanera, 2012). The difficulties arise partly from finding appropriate indicators to assess each ecosystem service at varying spatial scales and partly from the unavailability of relevant spatial data for each indicator. One of the main reasons is that ecosystem services are the products of multiple interactions between landscape components and ecological processes