Mistletoe, Friend and and Foe; Ecosystem implications of mistletoe infection

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# Abstract

Shitcunt. Biotic disturbances are affecting a wide range of tree species in all climates, and their occurrence is contributing to increasing rates of tree mortality globally. Mistletoe is a widespread group of parasitic plants that establishes long-lasting relationships with a diverse range of host tree species. Over 1300 species of mistletoes world-wide have developed a remarkable range of adaptations for mimicking various morphological traits specific to their local hosts; at least 20 species are listed as endangered. With climate change, ecophysiological stress is increasing, potentially making trees more susceptible to mistletoe infestation, which in turn leads to higher forest mortality rates.

The perception of mistletoe presence in individual trees and forest stands is divided within the scientific community, leading to an ongoing debate regarding its impacts. Forest managers concerned about stand health and carbon sequestration may view mistletoe as a foe that leads to reduced productivity. In contrast, ecologists may see mistletoe as a friend, in light of the wildlife habitat, biodiversity and nutrient cycling it promotes. However, individual studies typically focus isolated effects of mistletoe presence within their respective research area and lack a balanced, interdisciplinary perspective of mistletoe disturbance.

With this conceptual paper we aim to bring together the positive and negative impacts of mistletoe presence on tree physiology, soil nutrient cycling as well as stand health and stand dynamics. We will focus on the implications of mistletoe-induced tree mortality on changes in stand succession and implications for biodiversity. In addition, we will present potential modifications of mistletoe presence on the energy budget and on forest vulnerability to climate change, which could feed back into stand dynamics and disturbance patterns. Lastly, we will identify the most pressing remaining knowledge gaps and highlight priorities for future research on this widespread agent of biotic disturbance.

# Keywords

mistletoe, biodiversity, mortality, climate change, ecosystem processes

# Introduction

## Background

Forests ecosystems have large economical values, as they contain 80% of aboveground carbon and 40% of belowground global carbon stocks (Watson and Climate Change. 2000) along with the capacity of storing carbon over centuries. Disturbances have the potential to alter ecosystem processes and functioning, yet they are part of the natural cycle of any ecosystem (Kulakowski *et al* 2017). Climatic induced disturbances, such as heatwaves and droughts, can significantly lower carbon sequestration rates in forests (Yuan *et al* 2016, Yi *et al* 2015, Reichstein *et al* 2013) and cause wide-ranging tree mortality (Kara *et al* 2017). Similarly detrimental effects were reported from cyclones and an increase in wildfires as the climate changes (Hutley *et al* 2013, Schoennagel *et al* 2017). Furthermore, such climate induced disturbances can weaken ecosystem resilience and alter the occurrence and life-cycle of biotic disturbances such as pest and insect outbreaks(Dukes *et al* 2009, Johnson *et al* 2010, Allen *et al* 2010), the most prominent being the bark beetle outbreaks that affected vast areas across the central and western United States. However, while the latter caused a substantial increase in stand mortality (almost 80%), atmospheric carbon sequestration rates remained unchanged (Reed *et al* 2014), indicating potential for a substantial mis-match between changes in stand dynamics and carbon cycling.

While insect attacks and large-scale disturbances like cyclones and wildfires often cause wide-spread stand mortality, the presence of parasitic plants is typically less obvious as they are slower and more sublte in modifying ecosystem processes and stand dynamics. And unlike cyclones and wildfires, which are concentrating in lower latitudes and are not necessarily a threat in every climate region, parasitic plants are globally distributed and an itegral component of most ecosystems. The relationship between the parasite and the host is often symbiotic, e.g. vasucluar epiphytes rely on the structural support of a host plant and in return enhance nutrient cycling by fertilizing nutrient-enriched litter to the soil (Bartels and Chen 2012, March and Watson 2010). The largest group of areal parasitic plants are mistletoes, which are widespread hemiparasites that portrait epiphytic behaviour and belong to the order of Santalales(Bell and Adams 2011). Mistletoes have been studied across a large range of ecosystems (see e.g. Mathiasen *et al* 2008, Bell and Adams 2011), and the process of host infection can be considered similar for all mistletoes : the mistletoe attaches to a branch and taps into the xlem of the host tree. Although they are capable of photosynthesizing and producing basic sugars (Lamont 1983), they maintain lower xlem water potentials to absorb water and nutrients from the host. However, mistletoes are longlived (exceeding 30 years) and it can take decades to notice their damaging effect on the host. This resulted in an increasing number of studies examining potential positive effects of mistletoe infestation beyond the parasite-host symbiosis, and their ability to boost biodiversity in e.g. bird and understory species richness sparked a debate about the role of mistletoes as keystone species and ecosystem engineers (Press and Phoenix 2005, Hatcher *et al* 2012, Watson and Herring 2012).

Recent reviews concatenated our current state of knowledge on the the functional relationships between parasitic plants and their hosts (e.g. Bell and Adams 2011, Mathiasen *et al* 2008) and the effect of parasitism on community processes and biodiversity (e.g. Hatcher *et al* 2012, Watson 2001, Press and Phoenix 2005). However, our current research focussed predominantly on a process-based understanding of parasate infestation, and we are just starting to reckognize the dryad role of parasites in biodiversity. Therfore, parasites being friends or foes depends on the respective research focus and the interaction between local management history, climate and stand-specific characteristics. Parasitic presence modifies ecosystem processes from the tree to the stand level, but we are still limited in our ability of scaling functional relationships to the ecosystem level, as well as understanding how changes in functional relationships are regulating biodiversity. Thus, the complexity and interaction of the underlying processes still impedes our ability to assess the future fate of the host-parasite symbioses within our globally changing climate (Bell and Adams 2011, Way 2011), which is modifying rainfall patterns and increasing the mean and maximum temperatures in almost every ecosystem (Collins *et al* 2013). These climatic dynamics, in addition to parasitic infestation, might further increase hosts stress and exacerbate tree mortality rates in heavily infested forests, which in return will feedback into biodiversity dynamics. Thus, we consider it necessary to synthesizethe the temporal dynamics of the host-parasite symbioses, which assesses the winners and losers of parasite infection under a changing climate. We will use mistletoe infestation in Australia as an example for parasite infection, since mistletoe is widespread throughout Australian ecosystems and recent studies indicated an increase in mistletoe abundance within existing distributions in Australia (Bowen *et al* 2009, Turner and Smith 2016). Mistletoe infection has clearly been associated with a decrease in tree growth and tree survival rates (Reid *et al* 1994), which was especially detrimental in young trees (Carnegie *et al* 2009). In addition, the Australian climate is already imposing regular heat and drought stress on most ecosystems, which is expected to further increase in the coming decades, making this an ideal example of potential increases in tree mortality due to parasitic infestation under a changing climate.

Figure 1 conceptualizes the temporal dynamics of the parasitic life cycle on tree physiology, the cycling of water, energy, carbon and nutrients, and ultimately the impact on floral and faunal diversity.

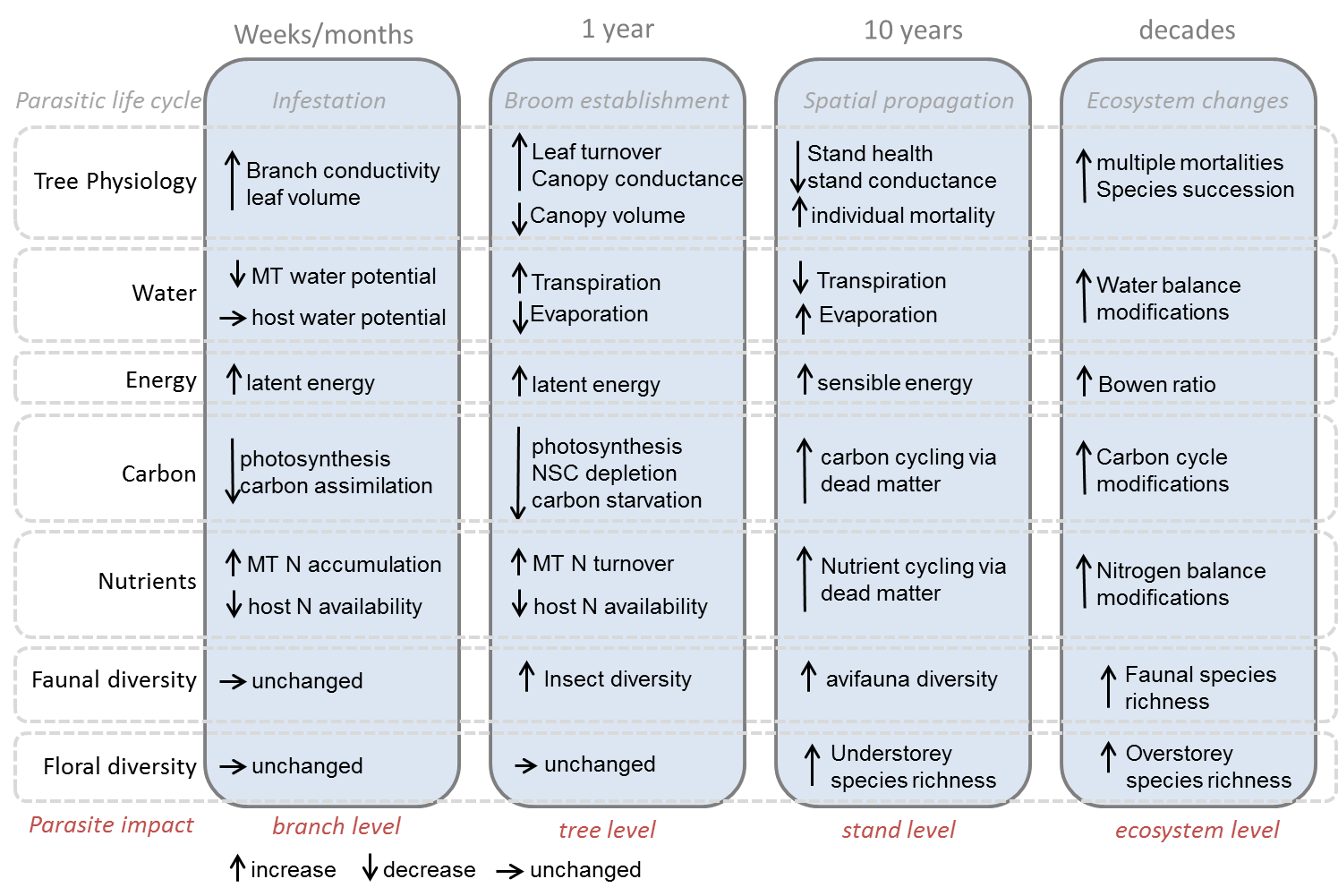


Figure 1. Conceptual figure indicating the temporal dynamics of mistletoe infection from the branch to the ecosystem level with a focus on tree phsysiology, matter and energy fluxes, and floral and faunal diversity.

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# Advancements in monitoring and management

There were many.

# Mistletoe and biodiversity

David will talk about this.

# Ecosystem processes

This will host Figure 2

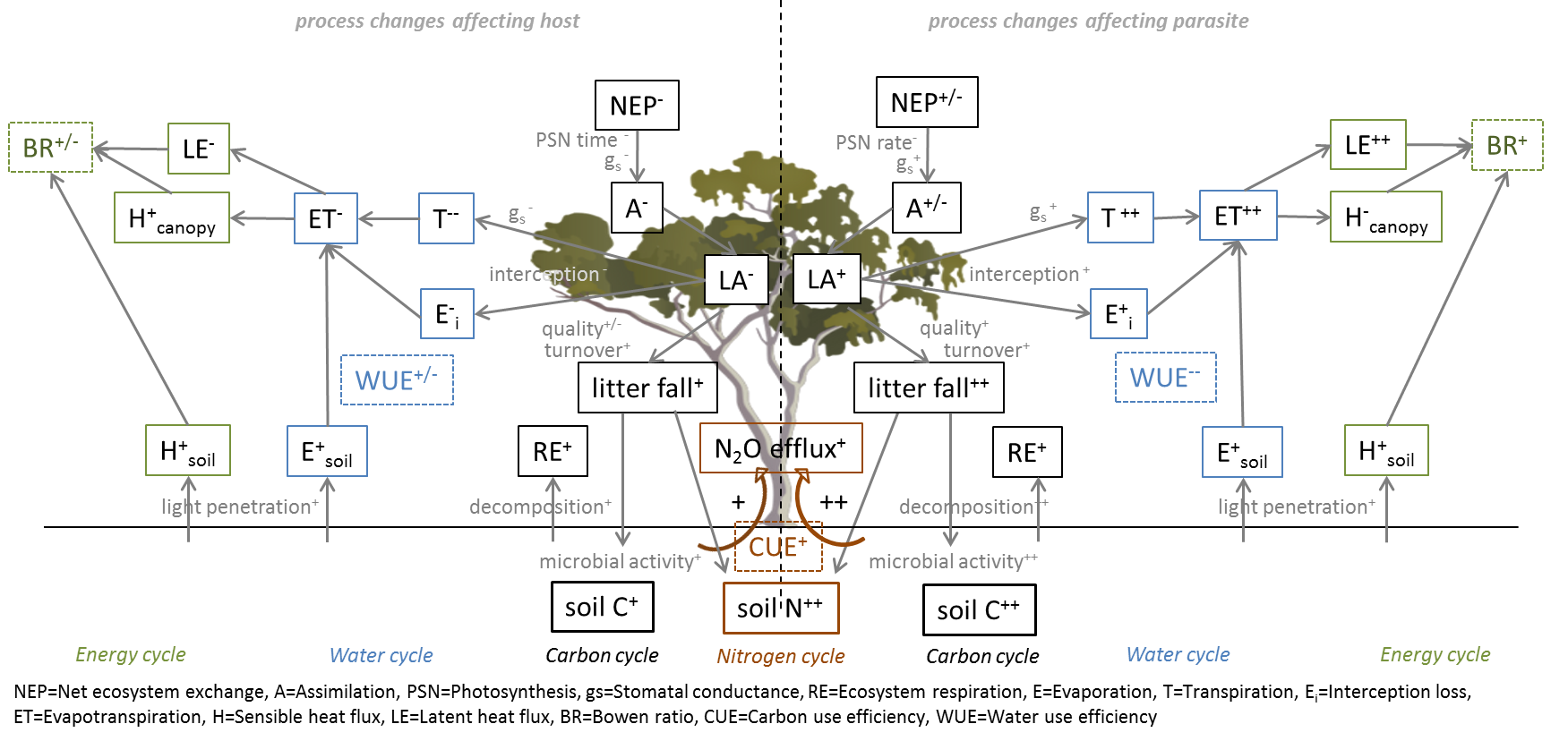


Figure 2. Mistletoe affects processes.

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