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Abundance and correlates of the *Acacia dealbata* invasion in the northern Eastern Cape, South Africa

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ABSTRACT

An increase in the density and biomass of woody invasive plants contributes to the intensification of ecological impacts and can often be met with dissatisfaction by local communities. Despite their reliance on *Acacia dealbata* as a source of livelihood, villagers in the northern Eastern Cape have expressed concerns about the high densities of the species. This study sought to quantify the current abundance and growth of *A. dealbata* in selected landscapes in the northern Eastern Cape, around nine villages in rural Matatiele, Mount Fletcher and Maclear. Standard vegetation survey techniques were adopted to quantify the density, biomass and growth rate of *A. dealbata*. Overall, the average density, biomass and productivity of *A. dealbata* were estimated at approximately 7000 stems ha^{-1}, 12 Mg ha^{-1} and 4 Mg ha^{-1} $year^{-1}$, respectively. However, the abundance and productivity of *A. dealbata* were spatially variable between study areas. *Acacia dealbata* stems experienced significant growth over the period of a single year, contributing to substantial biomass production at the landscape level, despite continued harvest. Furthermore, relatively few biophysical variables were significantly influential correlates with the abundance of *A. dealbata*. Indeed, the degree of biological invasion can be highly variable across the landscape, shaped by the interaction of local-scale biophysical conditions.

1. Introduction

Demographic aspects of plant invasion are largely shaped by factors at the local level (Vilà and Ibáñez, 2011). Assessing the abundance and growth of an invasive alien plant (IAP) at the ground-level can therefore offer deeper insights into the dynamics of invasion. For example, the abundance and growth of an IAP population, as well as the local-scale biophysical conditions of the area, often determine the overall success of the biological invasion (e.g. Carboni et al., 2016). Additionally, the abundance of an IAP influences both the perceived and quantified magnitude, scale and directionality (i.e. whether positive, negative or bidirectional) of its impacts (Jeschke et al., 2014), as well as the overall perceptions surrounding the species (e.g. Ngorima and Shackleton, 2018; Shackleton et al., 2007). These factors are critical considerations in devising appropriate strategies for managing invasive species.

Acacia dealbata Link is a particularly widespread, abundant and problematic invader, with the ability to transform its surrounding environment (Le Maitre et al., 2011; Lorenzo et al., 2010a; Nel et al., 2004). Indigenous to the southeastern provinces of Australia, this small to medium-sized invasive tree or shrub has become naturalised across many parts of southern Europe, South America and southern Africa (Lorenzo et al., 2010a; Lorenzo and Rodríguez-Echeverría, 2012; Richardson and Rejmánek, 2011). According to Souza-Alonso et al. (2014), the patterns of growth of *A. dealbata* may differ from distinct individuals in their native range to dense, maze-like monoculture in their invaded range. Lorenzo et al. (2010a) attribute the invasiveness of *A. dealbata* to propagule pressure; its introduction life history, phenotypic plasticity and geographical range; its enhanced competitive ability, preadaptation to disturbance and adaptability to change; and its abilities to reproduce vegetatively and produce novel allelopathic weapons. The invasiveness of *A. dealbata* is further enhanced due to the abundance and persistence of its seedbanks, with a high number and density of seeds remaining viable in the soil following disturbance events and clearance efforts even after extended periods of dormancy (Passos et al., 2017; Richardson and Kluge, 2008).

As a pioneer species and r-strategist, *A. dealbata* thrives in early-successional or recently-disturbed habitats, grows and matures rapidly after germination, reaches reproductive maturity at a young age (after about five years) and produces an abundance of seeds (De Neergaard et al., 2005). Typical of leguminous species, *A. dealbata* forms a symbiotic relationship with nitrogen-fixing bacteria in its root nodules (De Neergaard et al., 2005), which allows the species to rapidly and efficiently accumulate and fix available nitrogen in the soil (Lorenzo et al., 2010a). Furthermore, *A. dealbata* can increase its own competitive

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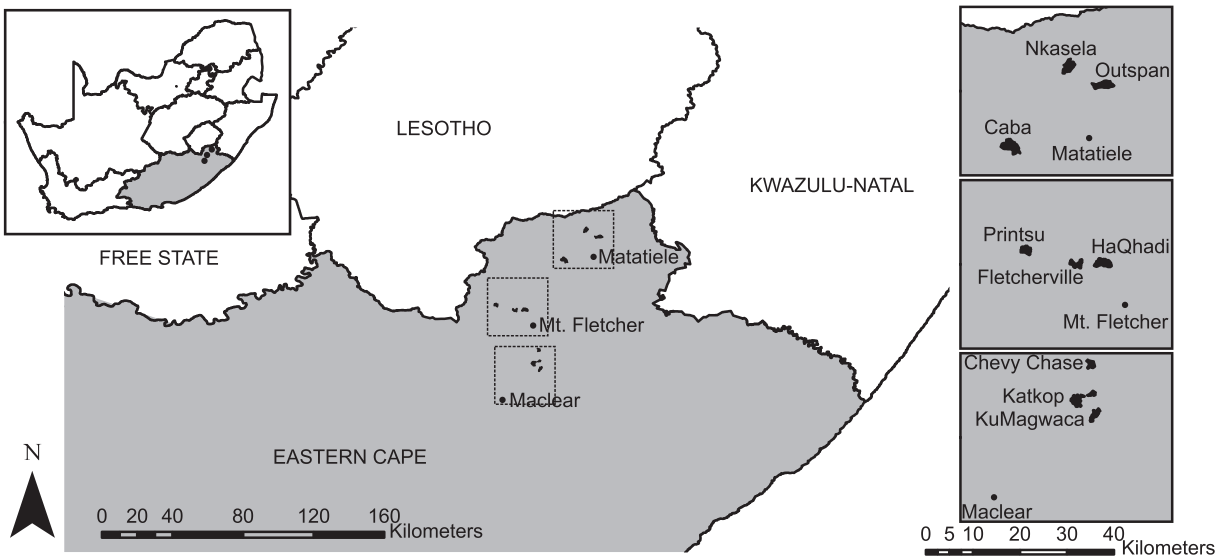

Fig. 1. Study areas and villages in the northern Eastern Cape, South Africa.

ability while simultaneously deterring the growth of competing vegetation by changing the physical properties of the soil, increasing soil nitrogen levels and releasing secondary compounds with inhibitory or phytotoxic allelopathic effects, even enhancing its intraspecific competitive ability by generating autotoxicity in seedlings (Aguilera et al., 2017; Lorenzo et al., 2010a, 2017).

Acacia dealbata invasions are therefore frequently responsible for biochemical changes in the composition of soil communities, as well as for decreases in the abundance, cover and richness of native plant species (e.g. Fuentes-Ramírez et al., 2011; González-Muñoz et al., 2012; Lorenzo et al., 2017; Lorenzo and Rodríguez-Echeverría, 2012). In South Africa, dense stands of invasive *A. dealbata* are even known to detrimentally impact the abundance and diversity of native fauna, including Coleoptera and avifauna (e.g. Coetzee et al., 2007; Seath, 2017). Together with the threat the species poses to native biodiversity, its voluminous consumption of water and the resulting impact on national water resources are touted as the most dire of impacts inflicted by *A. dealbata* in South Africa, due to the semi-arid and drought-prone climate in the country (De Neergaard et al., 2005).

On the other hand, *A. dealbata* has several commercial and subsistence uses. For example, *A. dealbata* was first introduced into South Africa around 1850 (Poynton, 2009; Van Wilgen et al., 2011) as a commercial plantation species, specifically for the production of timber and tannins (De Neergaard et al., 2005). Although it has experienced limited commercial success, *A. dealbata* has long retained a local utilitarian and socio-economic value in the livelihoods of South African rural communities, used primarily for fuelwood and construction materials (De Neergaard et al., 2005; Poynton, 2009). For example, De Neergaard et al. (2005) found that almost all households in the Madlanga community of Eastern Cape use a combination of *A. dealbata* and *Acacia mearnsii* De Wild. wood for fuelwood and construction, and almost a fifth of the households earn a cash income from selling the firewood. *Acacia dealbata* can also be used for its bark products (e.g. tanbark, medicines, etc.), as a natural fertiliser or as fodder for livestock (De Neergaard et al., 2005; Ngorima and Shackleton, 2018; Van Wilgen et al., 2011). However, despite the beneficial utilitarian value of *A. dealbata*, the net tradeoff between the costs and benefits of an IAP is often shaped by the abundance of the invader in the landscape (Ngorima and Shackleton, 2018; Shackleton et al., 2007).

An increase in the density and biomass of woody invasive thicket contributes to the intensification of ecological impacts and can often be met with dissatisfaction by some local communities (De Neergaard et al., 2005; Shackleton et al., 2007). According to Ngorima and Shackleton (2018), villagers in the northern Eastern Cape, South Africa, have already expressed concerns about the high densities of *A. dealbata*, linking dense thickets to recent criminal activity, including cases of livestock theft burglaries and a general sense of fear for the safety of children on the way to school and for women harvesting firewood. Consequently, most villagers (> 80%) reportedly stated that although *A. dealbata* is a valued resource and should not be eradicated, they would prefer lower densities (Ngorima and Shackleton, 2018). This study sought to quantify the current abundance and growth of *A. dealbata* in selected landscapes in the northern Eastern Cape, answering the following ecological questions: (i) What is the growth and production rate of *A. dealbata*?; (ii) What is the current density and biomass of the invasion in different landscapes?; and (iii) Which biophysical conditions correlate with the density and biomass of *A. dealbata*?

2. Materials and methods

2.1. Study areas

The abundance of *A. dealbata* was quantified from 77 plots, situated in and around nine villages in the northern Eastern Cape, South Africa: Nkasela, Outspan and Caba near Matatiele; Printsu, Fletcherville and HaQhadi near Mount Fletcher; and Chevy Chase, Katkop and KuMagwaca near Maclear (Fig. 1). These villages, known to be invaded by *A. dealbata*, were selected based on supporting evidence of the use of *A. dealbata* by local communities, primarily as a source of firewood (Ngorima and Shackleton, 2018). Despite the availability of alternative species, such as *Populus canescens* and *A. mearnsii*, the abundance and easy-of-access of *A. dealbata* ensure that it is more frequently and widely used compared to the alternatives (Ngorima and Shackleton, 2018).

The study areas fall largely within the East Griqualand Grassland vegetation unit of the Sub-Escarpment Grassland bioregion, characterised by hilly terrain at an altitudinal range of 920–1740 m above sea-level and well-drained, erosion-prone soils, with underlying geologies of Beaufort Group mudstone and sandstone, as well as sedimentary rock from the Molteno, Elliot and Clarens formations (Mucina and Rutherford, 2006). The region receives summer rainfall and winter snowfall (at high altitudes), with approximately 30 days of annual frost, mean annual precipitation readings of approximately 780 mm and mean annual temperatures of 14.7 °C (Mucina and Rutherford, 2006). Approximately one-quarter of the East Griqualand Grassland has been transformed for maize production, plantations and urban development,