South African Journal of Botany 108 (2017) 110–116

Contents lists available at ScienceDirect

South African Journal of Botany

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

Invasive potential and management of *Melaleuca hypericifolia* (Myrtaceae) in South Africa

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ARTICLE INFO

Article history:
Received 11 March 2016
Received in revised form 24 August 2016
Accepted 7 October 2016
Available online xxxx

Edited by ME Light

Keywords:
Early detection
Eradication
Extirpation
Invasion potential
Melaleuca hypericifolia
Myrtaceae
Tree invasions

ABSTRACT

This paper presents the first detailed assessment of the invasive potential of *Melaleuca hypericifolia* Sm. in South Africa. This woody, fire-adapted shrub, native to Australia, is considered a high risk invader which could potentially occupy 4% of the country if allowed to spread. As such, it is a listed invader under South African legislation. *Melaleuca hypericifolia* is known to have naturalised at five sites in the Western and Eastern Cape of South Africa and several introduced but non-spreading populations represent a further risk of invasion. An integrated management approach involving mechanical and chemical control was tested on an invasive population (20.4 ha extent) on Chapman's Peak in Cape Town, Western Cape Province. Management interventions began in 2012 and were repeated annually. The number of reproducing individuals was reduced over the four year period reported on here. The treatment used was shown to be effective as no re-sprouting occurred although some plants were overlooked during clearing operations owing to the density of the surrounding native vegetation. Low detectability presents a major impediment to extirpation of the population despite the distinctive flowers and leaf arrangement of this species. We recommend the use of fire where feasible to increase visibility and stimulate seed germination. We estimate that extirpation of *M. hypericifolia* from the Chapman's Peak site will be possible with an annual investment of ZAR 10000 over the next 10 years. Uncertainty around the extent of plantings of *Melaleuca hypericifolia* around the country limits the suitability of the species as a national eradication target. However, based on the invasive risk it poses and given encouraging results from the extirpation effort as shown in this study, we conclude that site-specific extirpation is a feasible management goal for this species.

1. Introduction

Human-aided movement of species and subsequent invasions have exerted damaging impacts on biodiversity and ecosystem services globally (Richardson et al., 2003). In South Africa, established woody invaders such as pines, eucalypts and Australian acacias dominate some natural systems, depleting scarce water resources and outcompeting indigenous flora (Le Maitre et al., 2000). Reversal of these impacts is expensive and not always achievable (Richardson, 1998). Halting invasions in their early stages is a cost-effective way to prevent the accrual of widespread impacts (Wittenberg and Cock, 2001).

Myrtaceae, a predominantly woody family native to subtropical and tropical Asia, America and Australia, contains several important horticultural species and as such has a long history of dissemination world-wide (Gordon, 2011). While invasions by certain members of the Myrtaceae are well-documented in South Africa (e.g. eucalypts; Forsyth et al., 2004; Jacobs, 2012; SAPIA database), some species (such as *Callistemon* R. Br. and *Melaleuca* L. spp.) have a very recent invasion history and represent a new wave of Myrtaceae invasions. In particular, several species of the genus *Melaleuca* could become problematic in South Africa (Van Wyk et al., 2012). As currently circumscribed (Craven, 2006) the genus *Melaleuca* comprises more than 200 species native to Australia and Malaysia (Turner et al., 1998). *Melaleuca* species have become problematic in South Africa due to their ability to invade wetlands and rivers (Jacobs et al., 2014; Van Wyk and Jacobs, 2015). In addition, serotinous re-seeding allows them to capitalise on fire events and therefore are able to compete with, and invade, native Fynbos (heathland) vegetation (Ne'eman et al., 2009; Hickley, 2013). In the case of some species, such as *M. quinquenervia* (Cav.) S.T. Blake, adult plants are able to survive fire and long periods of inundation by water due to a thickly layered bark. Canopy-held seeds are released after fire (serotiny) in large quantities. *Melaleuca* species are prolific seed producers but the seeds are typically short-lived once released and germination requires a wet habitat (Laroche, 1999; Rayamajhi et al., 2002; Van et al., 2005).

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http://dx.doi.org/10.1016/j.sajb.2016.10.007
0254-6299/

Two *Melaleuca* species are listed in the South African Alien and Invasive Species Regulations of the National Environmental Management: Biodiversity Act (10 of 2004; NEM:BA). Under this legislation, propagation and trade of species listed in both categories 1a and 1b is prohibited and naturalised populations of these species require compulsory control. Category 1b species have high invasive potential and qualify for control and containment under a government sponsored invasive species programme (such as Working for Water) while category 1a species should be targeted for eradication (Zenni et al., 2009; Kaplan et al., 2012; Wilson et al., 2013). Two *Melaleuca* species, namely *M. hypericifolia* Sm. (category 1a) and *M. quinquenervia* (category 1b, with heritage trees exempt) have recently been recognised by South African legislation as problematic invaders and *M. parvistaminea* Byrnes was recently assessed and recommended for listing as a category 1a species (Jacobs et al., 2014).

Melaleuca hypericifolia is native to south-eastern Australia. It is a woody shrub with a weeping habit (Fig. 1a) that can reach a height of up to 6 m. Leaves are arranged in alternate, opposite pairs, 10–40 mm long, 4–10 mm wide, narrowly elliptic in shape (Fig. 1a) with a central groove on the upper surface. The flowers are solitary within each bract and red in colour (Fig. 1a). Adult plants have a corky, papery bark (Fig. 1b). Seeds are stored in woody capsules in the plant canopy (Wilson, 1991) (Fig. 1b,c). Like other melaleucas, *M. hypericifolia* was most likely introduced to South Africa as a garden ornamental. The date of its first introduction is unknown but judging from the large size (>4 m) and spread (~5 m) of the plants in the Tokai Arboretum, these were probably part of the early plantings and development of the Tokai Arboretum since 1885. The Arboretum was initially an educational resource for students of the Forestry School at Tokai (King, 1938) and may have incorporated experimental species (for timber and hedging) by the Forestry Department of the time (Van Wyk and Jacobs, 2015). The earliest record of an invasive population of *M. hypericifolia* is in the Southern African Plant Invader Atlas (SAPIA; Henderson, 2007). The record was lodged in 1998 and referred to plants on the western slope of Chapman's Peak near Hout Bay, Cape Town. Prior to the present study, no systematic effort had been made to control the species.

The purpose of this study is to assess the invasive potential of *M. hypericifolia* in South Africa, to determine whether eradication (nationally) of this plant species is feasible as a management goal and to provide management recommendations for extirpation (i.e. local scale eradication) of invasive populations. This work contributes to the growing knowledge on *Melaleuca* as an invasive genus in South Africa.

2. Materials and methods

2.1. Invasive potential of *M. hypericifolia*

2.1.1. Risk assessment

In order to assess the risk of invasion and collate relevant literature on *M. hypericifolia* a formal weed risk assessment was conducted for this species (see supplementary data). The risk assessment scheme of Pheloung et al. (1999) was applied, using the guidelines for application outside Australia (Gordon et al., 2010). This approach consists of 49 questions that fall into eight categories that evaluate a species' invasive potential based on its invasiveness elsewhere, invasive traits and environmental preferences. Although the risk assessment used was designed to inform pre-border risk, it was used as a tool for post-border risk determination to support an understanding of the species' invasive characteristics (also see Jacobs et al., 2014, 2015).

2.1.2. Bioclimatic modelling

Using species distribution models, the potential distribution of *M. hypericifolia* in South Africa was predicted. Native and introduced occurrence data *of M. hypericifolia* were gathered from internet sources (The Global Biodiversity Information Facility - GBIF) and a local database (Southern African Plant Invader Atlas - SAPIA). Prior to analysis, all records were carefully checked and only records with a locality precision less than or equal to 1 km were included. A total of 86 records were used to fit the models. Environmental data for all occurrence

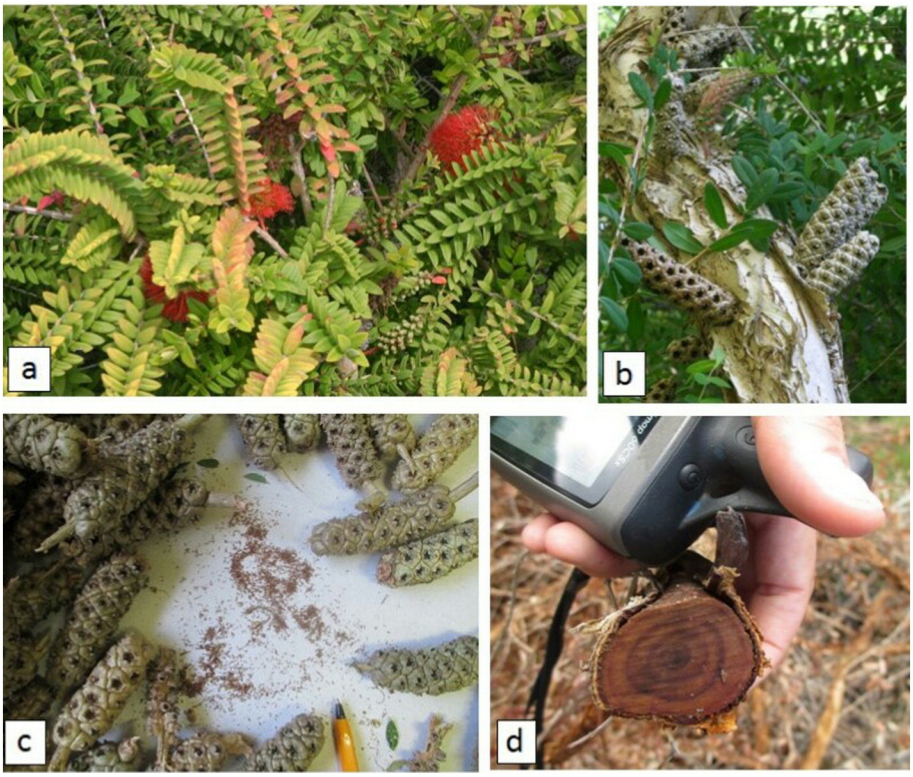

Fig. 1. *Melaleuca hypericifolia* a) Flowers and leaves; b) seed capsules and flaky white bark; c) abundant, small seeds released from woody seed capsules; d) age rings.