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Assessment and management of the invasive shrub, *Cistus ladanifer*, in South Africa

S.P. Du Plessis [a], A. Rink [b], V. Goodall [c,d], H. Kaplan [b], N. Jubase [b,*], E. Van Wyk [b,e]

[a] Department of Conservation and Marine Sciences, Cape Peninsula University of Technology, P.O. Box 652, Cape Town 8000, South Africa
[b] South African National Biodiversity Institute, Private Bag X7, Claremont, 7735 Cape Town, South Africa
[c] Statistics Department, Nelson Mandela University, , Summerstrand Campus, P.O. Box 77000, Port Elizabeth 6031, South Africa
[d] Centre for African Conservation Ecology, Nelson Mandela University, South Africa
[e] ICLEI – Local Governments for Sustainability, Africa Secretariat, Knowledge Park III, Heron Crescent, Century Boulevard, Century City, Cape Town 7441, South Africa

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ABSTRACT

This research provides the first detailed assessment of *Cistus ladanifer*, a woody, perennial shrub native to the Mediterranean, as an invasive species in South Africa. Three small naturalising populations (all less than 0.1 ha) of this species were discovered in 2012 in native heathland vegetation ("Fynbos") of the Western Cape Province of South Africa. Prior to this discovery, *C. ladanifer* had not previously been recorded or recognised as an invasive species in South Africa. It poses a significant threat to the local endemic vegetation, largely due to its pre-adaptation to similar environmental conditions, and, if left unmanaged, it has the potential to invade further. However, given the small size of currently known populations and its ease of management, we propose that eradication of *C. ladanifer* is feasible in South Africa. Here we provide insights into options for the management of *C. ladanifer*, in particular its eradication from South Africa. Based on the weed risk assessment presented here, we recommend that *C. ladanifer* be listed as an invasive species under national legislation, thus requiring compulsory management. The results of this study provide detailed information on the extent of the invasion by *C. ladanifer* and the aspects of its biology pertinent to management (e.g. its reproductive ability, soil-stored seed banks). We show that complete removal of *C. ladanifer* populations is feasible and results in a steady decline in population size over time. Local extirpation of populations of *C. ladanifer* can be enhanced through fire-stimulation of the seed bank, but this may not be feasible in an urban setting. Our study emphasises the importance of scientific research in the development and evaluation of species-based management plans for invasive species.

1. Introduction

Cistus ladanifer (L.) (Cistaceae) is a fire-adapted, woody perennial shrub native to the Iberian Peninsula, southern France, Morocco and Algeria (Demoly and Monserrat, 1993). It has been reported to have naturalised in other Mediterranean systems, for example Cyprus (Meikle, 1977; Hadjikyriakou and Hadjisterkotis, 2002), New Zealand (Sykes, 1982), California (Ditomaso and Healy, 2006) and in the Canary Islands (Fernández-Mazuecos and Vargas, 2011) although it has not been noted as invasive in any of these localities. Within the context of this paper, we understand *naturalised* to mean the occurrence of alien plants in the wild which establish reproducing and self-sustaining plant populations in close proximity to the point of introduction without direct human intervention and *invasive* to mean the spread of naturalised plants in the wild beyond the point of introduction with the establishment of reproducing and self-sustaining plant populations in large numbers (Richardson et al., 2000; Blackburn et al., 2011). There are no previous records of its naturalisation in South Africa, although the earliest record of its introduction was in 1934 in the Kirstenbosch National Botanical Gardens in Cape Town [Hort. Economic Garden, Kirstenbosch; *ex* La Mortala Ventimiglia, Italy; November 1934, *NBG121418* (NBG)], presumably for its known medicinal uses such as treatment of various skin diseases, as an anti-diarrheal, and as anti-inflammatory agents (Zidane et al., 2013). The discovery of naturalising populations of *C. ladanifer* prompted an assessment of its invasive ecology, the potential invasive risk posed by the species and options for its management. Of major concern is the threat posed by *C. ladanifer* to valuable fragments of native heathland vegetation or "Fynbos" in urban areas where the use of fire as a tool to manage fire-adapted alien invasive plants is not always possible (Richardson et al., 1996; Prestemon et al., 2002; Van Wilgen et al., 2010) and where disturbance favours the spread of invasive alien species (Alston and Richardson, 2006). Since *C. ladanifer* is a newly discovered species (with a residence time of a few decades) with apparent invasive tendencies and is currently not listed according to South African legislation (i.e. The

* Corresponding author.
E-mail address: N.JubaseTshali@sanbi.org.za (N. Jubase).

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Department of Environment Affairs' *National Environmental Management: Biodiversity Act* 10 of 2004 [NEMBA] Alien and Invasive Species Regulations, 2014) a detailed species risk analysis is required (Wilson et al., 2013; Panetta, 2015).

Detection of an invasive species prior to significant population growth and expansion potentially allows for the use of feasible offensive strategies (eradication), as opposed to defensive strategies such as containment and impact reduction which require more extensive resources (Rejmánek and Pitcairn, 2002). Assessment of the known invasive populations of *C. ladanifer* was required to determine whether eradication is desirable and feasible and under what conditions it may be possible (McNeely et al., 2001; Wittenberg and Cock, 2001; Simberloff, 2009). In this paper we used a weed risk assessment tool (Pheloung et al., 1999; Gordon et al., 2010) in combination with a framework devised by Panetta (2015) to determine weed eradication effort and feasibility. When considering the feasibility of eradication, important factors include the time of plant maturation, the persistence of the seed bank and dispersal functional groups. Two dispersal functional groups are recognised by Panetta (2015). (1) High containment feasibility indicates short seed dispersal through natural means with or without human mediated dispersal and (2) low containment feasibility indicates long seed dispersal through natural means which results in more demanding management. Information about dispersal can be used to formulate a structured viewpoint on dispersal patterns to inform the relative eradication feasibilities and therefore guide decisions around financial investment in an eradication attempt or otherwise (Cacho et al., 2006; Panetta, 2015).

The purpose of this paper is to provide the first detailed assessment of *C. ladanifer* as an invasive species in South Africa. Our assessment is based on two aspects: (1) the potential of *C. ladanifer* to become a major invader in South Africa and (2) the distribution, abundance and reproductive characteristics of known populations of *C. ladanifer* as indicators of eradication feasibility. We discuss the results in the context of control measures conducted over a period of five years and within the context of fire-suppressed environments. Finally, we consider policy implications (i.e. the legal categorisation of *C. ladanifer* under NEMBA in South Africa).

2. Materials and methods

2.1. Species description and ecology

C. ladanifer is an erect perennial shrub with a mature height of between 2 m and 3 m, lanceolate leaves and an attractive white papery flower of approximately 64 mm in diameter (Fig. 1a and b) sometimes with a maroon-coloured spot on each flower petal (Talavera et al., 1993; Alados et al., 1999). This pioneer species thrives on nutrient poor degraded soils and produces abundant pollen and nectar which

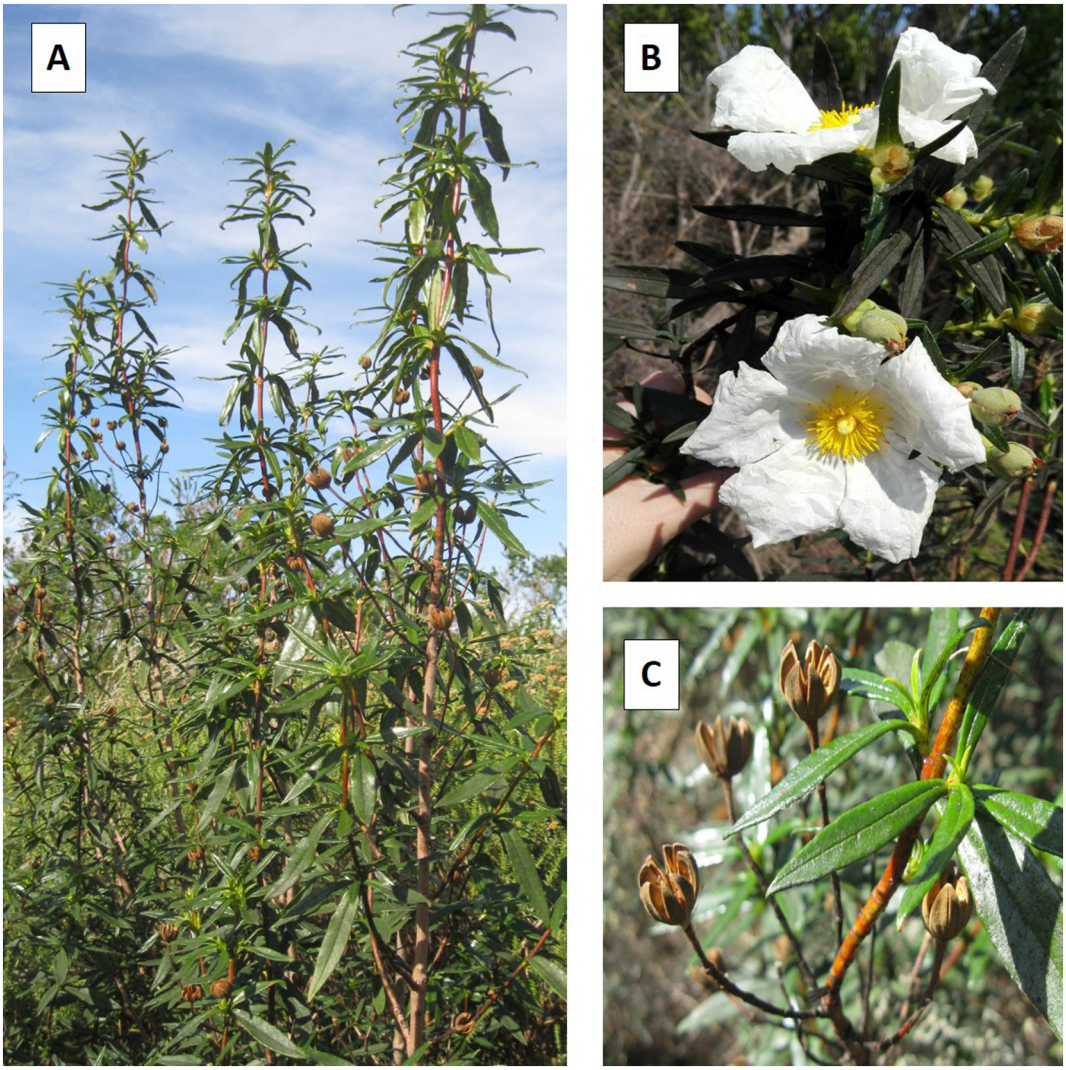

Fig. 1. Growth form and reproductive structures of *Cistus ladanifer*, showing A) an adult plant; B) the flowers; and C) the seed pods.