



The benefits and costs of clearing invasive alien plants in northern Zululand, South Africa

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ARTICLE INFO

Keywords:

Invasive alien plants
Costs and benefits
Clearing
Northern Zululand
System dynamics

ABSTRACT

More than 60% of northern Zululand is tribal land with a substantial area falling within protected areas. Much of the land is invaded by invasive alien plant species (IAPs) such as *Chromolaena odorata* and *Lantana camara*. Most of these species do not have any economic value and compromises communal livelihoods and biodiversity. This paper aims to investigate the benefits and costs of clearing IAPs in northern Zululand. A system dynamics model was developed specifically for this analysis. A number of scenarios characterised by various IAP spread rates and clearing investment interventions were formulated and evaluated. The study finds that the highest net returns from clearing the IAPs were generated by value-added products (VAPs), followed by the value of water not consumed by the IAPs. The clearing of IAPs was found to be more cost-effective than augmenting water supply. Supplementing clearing investment operations through private sector co-finance reduces the stock of invasion, increases the area cleared, increases biomass for VAPs, saves more water and clears a greater area for livestock and maize production. The co-finance scenario proved to be the better management option. This scenario generated the most benefits and had a positive net present value (R2.5 million).

1. Introduction

Invasive alien plant species (IAPs) are one of the biggest threats to biodiversity loss at a global scale (Turpie, 2004), as they outcompete and displace indigenous vegetation with knock-on effects on the functioning of the entire ecosystem. IAPs are also a growing threat to natural systems that provide a range of ecosystem goods and services (EGS) (Le Maitre et al., 2000; Milton et al., 2003; Richardson and Van Wilgen, 2004; Millennium Ecosystem Assessment, 2005; Van Wilgen et al., 2008), and have deleterious effects on natural stocks that maintain the provisioning of the EGS (Milton et al., 2003). In addition to threatening conservation, IAPs are considered as agricultural pest species, hence, they are of priority within the Conservation of Agricultural Resources Act (1983). Ndhlovu et al. (2011) estimates that IAPs can reduce the grazing capacity of an area by as much as 34% due to a *Prosopis* canopy cover of as little as 15%, and clearance of the invaded area improved the grazing capacity by 110% in a period of less than six years. A reduction of the grazing capacity has a direct negative impact on the livelihoods of societal members who depend on ecosystems good and species, as in the case of grazing (García-Llorente et al., 2008).

To counter this adverse impacts of IAPs, the South African government established the Working for Water (WfW) programme in 1995, through partnership with the Expanded Public Works Programme (EPWP), for the purpose of managing/controlling the spread of IAPs (Van Wilgen et al., 1998). Through an integrated clearing programme that includes mechanical, chemical and biological control, the Department of Environmental Affairs: Natural Resource Management (DEA: NRM – which hosts the WfW programme) seeks to stop and control the spread of IAPs (Van Wilgen et al., 2011; McConnachie et al., 2012). Since the inception of the WfW programme, it has grown to one of South Africa's largest conservation programmes (Hosking and Du Preez, 2004). Much of this growth was, in addition to the environmental benefits, motivated by job creation and poverty alleviation which has provided access to expanded funds and a higher budget allocation (Turpie et al., 2008; De Wit et al., 2001; O'Farrell et al., 2011). Still, however, there is pressure on the WfW programme to motivate its budget allocation as there are several initiatives that are competing within the same pool of funds (Turpie, 2004; Turpie et al., 2008), and there is therefore a need to justify further control programmes and to maximise efficiency (Turpie, 2004).

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<http://dx.doi.org/10.1016/j.ecoser.2017.04.011>

Received 29 July 2016; Received in revised form 12 April 2017; Accepted 25 April 2017
2212-0416/ © 2017 Published by Elsevier B.V.

It therefore goes without saying that the application of economic principles to assist in the management of IAPs and the restoration of invaded sites have become increasingly important. While several studies have used valuation techniques to motivate for future funding of the WfW programme (Turpie, 2004; Blignaut et al., 2007, 2010; O'Farrell et al., 2011) the growing problem of IAPs has recently led to a growth in research that seeks to quantify the benefits and costs of clearing IAPs in South Africa (Mudavanhu et al., 2016; Vundla et al., 2016; Morokong et al., 2016) and globally (Perrings et al., 2010). Earlier studies in South Africa on the economic consequences of IAPs focused on estimating water saved as the benefit of clearing invasive alien plants (Le Maitre et al., 1996; Van Wilgen et al., 1997; Hosking and Du Preez, 1999) and this recognition of the economic implications of IAPs in terms of water-supply costs became fundamental in the formation of the Working for Water programme. Later investigations in addition to water saved (Marais and Wannenburgh, 2008) also considered biodiversity (Van Wilgen et al., 2004; De Lange and Van Wilgen, 2010), the economic value of land (Van Wilgen et al., 2004), natural pasture for livestock (De Lange and Van Wilgen, 2010) and tourism opportunities (Currie et al., 2009) as the benefits of clearing IAPs. However, in spite of these studies, information relating to the economic benefits and costs of controlling IAP in South Africa is still regarded insufficient (Van Wilgen et al., 2011) and the studies suffer by not considering a dynamic approach that simulate the economic benefits and costs of IAPs (Turpie, 2004) plus from concentrating on IAPs that have economically exploitable benefits. Fewer studies have been conducted on species like *Chromolaena odorata* and *Lantana camara*. These species were initially introduced mainly as ornamental plants but have subsequently become problematic in northern Zululand impacting agriculture and biodiversity (Van Wilgen et al., 2008). Unpalatable species, such as *Lantana camara*, not only reduce grazing capacity, but also have been shown to be poisonous to cattle, and it becomes difficult to clear and control once it is naturalised and established, making extensive areas deemed agriculturally useless (Bani, 2002). *C. odorata*, a species that thrives in disturbed ecosystems, has also been found to be prevalent in agricultural areas (Macdonald, 1983; OTA, 1993), particularly in areas under improper management activities and subjected to slash and burn activities (OTA, 1993; Mahlalela et al., 2015). When dry, *C. odorata* has been shown to increase the fuel load and thus increasing fire incidences and intensity (Zachariades and Goodall, 2002; McFadyen, 2004). Although the yield reduction in agriculture and its economic repercussions have not yet been fully estimated in South Africa, more comprehensive studies have been conducted in the USA and Australia (Koch, 1992).

IAPs further have a detrimental impact on conservation and tourism, which is of concern as there are five areas of conservation importance with high tourism value in northern Zululand (Zachariades and Goodall, 2002). However, despite its importance, this area has received less attention in terms of research compared to, for example, the fynbos region.

In the light of the discussion above and the shortcomings of previous studies highlighted, this paper aims to investigate, through the application of a system dynamics model, the benefits and costs of clearing IAPs in northern Zululand with the ultimate goal of establishing the implications of early restoration versus restoration after an area is densely invaded. A number of scenarios characterised by various IAP spread rates and clearing investment interventions were formulated and evaluated.

2. Study site description: Northern Zululand

The study site covers approximately 10,000 km² within the UMkhanyakude and Zululand district municipalities in KwaZulu-Natal (see Fig. 1) and comprises the W31_{A-L} and W32_{A-H} quaternary catchments. Two vegetation types are found at the study site namely, Indian Ocean Coastal Belt along the coastal area and Savanna inland.

Indigenous Acacia species, including *A. Karro*, *A. Nilotica* and *A. Seberana*, are common in the Northern KwaZulu-Natal landscape (Dumalisile, 2008). However, climate change in recent years is increasingly problematic in the region leading to bush encroachment (Ward, 2005).

The study area lies in the eastern parts of the country, and has wet and hot summers. Average rainfall levels in the area range between 500 and 2000 mm per annum (South African Weather Services, 2015). Most of the study area is dominated by the Dwyka Group that is overlain by the Ecca Group. The land tenure is mostly communal and conservation, with private land being mainly agricultural. The geology of the study area is dominated by Karoo dolerites, and coal and other mineral deposits are common. Unemployment is high and education levels are low in the rural landscape of the study area. StatsSA (2011) report an unemployment rate of 35–40%, which makes the study area poverty stricken.

Within the study area there are five areas of conservation importance at a provincial level (listed in Table 1) showing the importance of this area as a refuge of large game and other mammals in South Africa.

Of concern, however, is the prevalence and spread of IAPs with no or low economic value, and high negative impacts on biodiversity.

In a biome-scale assessment by Van Wilgen et al. (2008), the impacts of IAPs on biodiversity and agricultural systems are estimated and quantified as summarised in Table 2. Species that have a very high impact on grazing potential reduce the grazing potential by up to 80% when very abundant and by 5% when occasional. Without any invasion, the Savanna biome in northern Zululand could potentially support the largest number of livestock units (Van Wilgen et al., 2008).

3. Data and methods

3.1. Data collection

Data for this study was sourced from a number of primary and secondary sources. These include site visits (meetings with DEA: NRM project managers and site leaders), telephonic interviews, meetings with experts, extensive desktop analysis, Statistics South Africa, DEA: NRM database, municipal documents and websites. In addition, the parameters used in the various sub-models that were built in this study were sourced mainly from published scientific research. The sub-model parameters and associated data sources are presented after the discussion of each sub-model in Section 3.2.2 and Annexure B.

The extent of invasion within the study area is shown in Table 3. Only the dominant species are reported here individually with the less dominant species being grouped together as “other species”. *Chromolaena odorata* is by far the most invading species in the study area. During consultation with site managers of DEA: NRM they indicated that species such as *Solanum mauritianum* and *Syringa vulgaris* are some of the most dominant species, while *Eucalyptus* and wattle species are said to be not so dominant. Follow-up consultations with the personnel, however, did not yield supporting data. For this reason, IAPs invasion data from Kotzé et al. (2010) was used as this is the most current and nationally recognised IAPs database, with its base year being 2008.

Given that the data from Kotzé et al. (2010) is for 2008, we report here on the level of effort to control IAPs subsequent to that in northern Zululand (Table 4). While the person days peaked in 2008, the financial investment in restoration was the highest in 2011 at over R7 million. This information was used to, among others, validate the model – see Annexure A.

3.2. System dynamics model

A system dynamics model was conceptualised, constructed, simulated and analysed using the Vensim® software. Causal-loop and stock-and-flow diagrams as well as simulation modelling are done with

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