Available online at www.sciencedirect.com
ScienceDirect
South African Journal of Botany 74 (2008) 526–537
SOUTH AFRICAN JOURNAL OF BOTANY
www.elsevier.com/locate/sajb

Restoration of water resources (natural capital) through the clearing of invasive alien plants from riparian areas in South Africa — Costs and water benefits

C. Marais *, A.M. Wannenburgh

Department of Water Affairs & Forestry, Directorate: Working for Water, Private Bag X4390, Cape Town 8000, South Africa

Received 30 July 2007; accepted 22 January 2008

Abstract

Working for Water forms part of the Expanded Public Works Programme of the South African Government, aimed at the sustainable management of natural resources through the control and management of invasive alien plants while enhancing socio-economic empowerment in South Africa. The programme's name was taken from one of the original motivations: namely, reducing the impacts of invasive alien trees on water resources. A number of studies have looked at the potential impacts of the programme but only one or two have used actual management data to quantify its costs and benefits. This paper is the first, in hopefully a series of papers, on the costs and impacts of the programme over recent years. The paper focuses on the extent, costs and impacts of clearing invasive alien plants from riparian areas. Data were extracted from the Working for Water Information Management System (WIMS) and analysed to assess clearing costs and estimated impacts of clearance on water resources. Some of the most significant findings of the study again illustrate the need to treat invasions as early as possible. Very scattered (1–5%) invasions of selected species for example were between 3 and 25 times cheaper to clear than closed canopy stands (75–100%). On the other hand, unit reference values, used to compare clearing operations in terms of cost efficiency in generating extra water yield, were much higher for low levels of invasion than denser invasions, to the extent that the former's viability could be questioned by the uninformed. However, this was only assessed in terms of extra water generated and not in terms of volumes of water secured, as invasive alien plants spread and become denser if not actively controlled. If left unchecked, water losses increase, which makes the clearing of light infestations much more viable. Overall, it is estimated that around 7% of riparian invasions have been cleared, resulting in significant yield increases. The increased estimated yield of 34.4 million m^3 is about 42% of the yield of the new Berg River Scheme in the Western Cape (81 million m^3). The investment in clearing species known for excessive water use from riparian areas, at a cost of *R*116 million, was found to be a very good investment. However, it is important to note that the clearing of invasive alien plants will seldom result in the total elimination of shortfalls in water supply and should be seen as part of a package of water resource options to optimize supply, aimed at minimizing wastage of water.

Keywords: Clearing unit reference values; Costs; Invasive alien plants; Net present value; Person days; Riparian; WIMS; Workload

1. Introduction

The Working for Water Programme (WfW), initiated in October 1995, aims to restore and maintain natural resources by clearing invasive alien plants while creating jobs and economically empowering unemployed people from historically-disadvantaged communities. The programme's name derives from one of the motivations used to convince the then minister of Water Affairs and Forestry to support the programme: that of conserving water. At that time, Versfeld et al. (1998) estimated that invasive alien plants reduced South Africa's mean annual runoff by some 7%. Since then, a number of studies have attempted to quantify the costs and benefits of the programme, focussing mostly on water and the losses as a result of doing

* Corresponding author. Tel.: +27 21 441 2727, +27 82 551 8316 (Mobile); fax: +27 86 513 5734.
E-mail address: chris@dwaf.gov.za (C. Marais).

0254-6299/$ - see front matter © 2008 SAAB. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.sajb.2008.01.175

nothing. However, many of these assessments did not focus on specific interventions and their impacts. Marais et al. (2004) were the first to make an attempt to quantify the costs of the programme to some extent, but at that stage not enough data were available to do a focussed assessment of specific interventions and these interventions' impacts on specific benefits. Before and since the programme's inception, a number of studies were done focusing on localized impacts of clearance on natural resources. Dye and Poulter (1995) found a substantial increase in stream flow after clearing *Pinus patula* and *Acacia mearnsii* from riparian areas in Mpumalanga. The results showed that stream flow increased by 12 m^3/ha/day immediately after clearing. This work was followed up by Prinsloo and Scott (1999), who found that stream flow increased by 9, 10 and 12 m^3/ha/day in Du Toits Kloof (near Paarl), Oaklands (near Wellington) and Somerset West in the Western Cape respectively, after clearing Australian *Acacia* and *Eucalyptus* species from riparian areas. Dye and Jarmain (2004) looked at net changes in total evaporation, and found invasive alien tree stands to increase evaporation by 1570 to 4240 m^3/ha/annum compared to natural vegetation.

Görgens and Van Wilgen (2004) did an assessment of the current understanding of invasive alien plants on water resources, referring to, amongst others, the above studies and a series of studies on long-term effects of forestation on water resources. Using these assessments, two studies by Cullis et al. (2007) and Blignaut et al. (2007) looked at the implications of invasive alien plant management in the mountain catchment areas (watersheds) and riparian zones for water users in South Africa.

In addition to the impact on water resources, Samways and Taylor (2004) reported significant impacts of clearance on the recovery of the endemic Dragonfly (*Odonata* species) populations. According to this study, of the 31 endemic Southern African Dragonflies, 12 are globally Red Listed and 11 of these are threatened by alien plant invasions in riparian areas. The study found that Dragonfly populations recover rapidly after the clearance of dense stands of Black Wattle. This is but one example of the biodiversity impacts of invasive alien plants in riparian areas.

The Working for Water Programme (WfW), now (2007) in its 12th year, has made significant impacts on the sustainable management, control and containment of invasive alien plant species through its expanded public works clearing projects, biological control programme and inputs to establish a sound legislative framework for the management of invasive alien species. Up to the 2005/06 financial year, the programme has spent more than *R*3.2 billion, creating temporary employment opportunities for up to 30,000 people per annum and clearing more than 1.6 million ha of land (1.666 million initial clearing, and followed up on average 1.83 times, or 3.056 million ha of follow-up treatments — 1 initial + ≈ 2 follow treatments). In order to assess the impacts of this work, it is necessary to look at the impacts across biomes and positions in the landscape. This paper focuses on some costs and benefits of clearing invasive alien plants from riparian areas of South Africa.

2. Materials and methods

2.1. WIMS — Working for Water Information Management System — the database — estimating the overall costs of clearance

The data used for this paper were extracted from WfW's management database, WIMS. All clearing being done by the programme is (now) captured in this database. It was developed on a Geographical Information System (GIS) platform and records alien plant species, densities, costs and person days planned and worked on a specific area (polygon). The database design is *one-to-many* meaning that more than one species and its density can be recorded per polygon. It generates clearing contracts by adding the estimated workload of one or more polygons until the total area is a manageable size for an emerging contractor to clear over a specified period. This is normally the area a contractor, with around 10–15 labourers, can clear in a month. This means that some assumptions need to be made when analysing the data. Firstly, the cost allocation is then per contract, based on the total number of planned person days allocated across all polygons covered by the contract. Furthermore, person days are allocated per species and their densities within and across all polygons per contract.

In order to allocate costs per treatment to specific species, the dominant species per polygon was selected to use as the indicator for natural resource impacts. Generally the dominant species drives the costs as they normally make up more than 50% of the total invasive stand. Cost allocation per polygon was calculated using a simple formula to allocate costs to polygons proportional to their contribution to total contract costs.

$$CP = PdP/PdC \times CC$$

where:

CP	Cost of Polygon
PdP	Person days Planned for polygon
PdC	Person days planned for whole Contract
CC	Cost of Contract as whole.

Workload, or person days per treatment, per polygon were simply derived by adding all person days allocated to a specific polygon. Three variables can then be derived from this data: planned workload (person days) per hectare, actual workload per hectare and costs per hectare. For the purposes of natural resource restoration and management, the latter two are most important. In order to assess the costs and impacts of WfW clearing in riparian areas on water resources and biodiversity (initial and follow-up treatments), the costs per treatment per ha and the workload per treatment per hectare were calculated.

As can be expected from a developing data set such as WIMS, there are some shortcomings. The first challenge was the fact that some of the polygons did not receive an initial treatment according to the data extract. This is explained by the fact that the database was only initiated in 1998 and only became fully functional in 2002/03. Earlier data were recorded in manual systems such as spreadsheets. It was, however, not