Biological Conservation 155 (2012) 128–135

Contents lists available at SciVerse ScienceDirect

Biological Conservation

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

Evaluating the cost-effectiveness of invasive alien plant clearing: A case study from South Africa

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ARTICLE INFO

Article history:
Received 21 January 2012
Received in revised form 1 June 2012
Accepted 5 June 2012
Available online 17 July 2012

Keywords:
Ecological restoration
Biological invasions
Ecosystem services
Adaptive management
Pest control
Public works

ABSTRACT

Conservation projects spend billions of dollars clearing invasive alien plants, yet few studies have measured the cost-effectiveness of doing this, especially over larger spatial and temporal scales, relevant to operational contexts. We evaluated the cost-effectiveness of South Africa's national invasive alien plant control programme, Working for Water, in reducing invasive alien plant cover in the Krom and Kouga river catchments over 7 years. We assessed change in invasive alien plant cover by comparing post-treatment cover with the first recorded pre-treatment cover across all 740 of the two project's treatment sites (ranging from 0.03 to 227.6 ha in size). We also used regression analysis to estimate the effect of predictor variables on the cost-effectiveness of invasive alien plant clearing. We found – by dividing the total costs by the change in invasive alien plant cover – that it cost 2.4 times more (1.5 times for the Krom, and 8.6 times for the Kouga project) to clear invaded land than the highest equivalent estimate made elsewhere. At current rates of clearing, it would take 54 and 695 years to clear the catchments, in the Krom and Kouga, respectively, assuming no further spread. If spread is considered, current control efforts are inadequate, and invasions are likely to continue to spread in the catchments. Pre-treatment invasive alien plant cover and treatment costs per hectare had the greatest positive and negative influence, respectively on cost-effectiveness. Our assessment suggests that invasive alien plant control projects urgently need to monitor their cost-effectiveness so that management practices can be adapted to use scarce conservation funds more effectively.

1. Introduction

Invasive alien plants pose a significant threat to the biodiversity and functioning of the world's ecosystems (Mack et al., 2000; Pimentel et al., 2005); consequently, billions of dollars have been spent controlling them (Pyšek and Richardson, 2011). The most cost-effective approach is prevention, followed by early detection and eradication (Hulme, 2006). When the invasive population is established, biological control can be highly effective for some species and contexts (van Driesche et al., 2010; de Lange and van Wilgen, 2010); however, in most cases, costly mechanical clearing treatments are also required (Pyšek and Richardson, 2011).

Few studies have measured the cost-effectiveness of clearing invasive alien plants over time (Kettenring and Adams, 2011). Furthermore, most studies make measurements over small temporal and spatial scales making it difficult to extrapolate findings that are relevant to operational contexts (Kettenring and Adams, 2011). Having no reliable measurement of cost-effectiveness hampers the optimal allocation of scarce conservation funds (Murdoch et al., 2007; McCarthy et al., 2010). It also makes it difficult to learn from successes and failures, and to adapt accordingly to achieve desired outcomes (Sutherland et al., 2004; Grantham et al., 2011).

Large numbers of alien plant species, including many trees and shrubs (Henderson, 2001), have invaded South African ecosystems (Henderson, 2007; Kotze et al., 2010). Some of these plants reduce scarce water supplies and negatively affect biodiversity and the functioning of riparian zones (Le Maitre et al., 2000; van Wilgen et al., 2008). Growing awareness of the problem resulted in the formation of the government-funded invasive alien plant control programme 'Working for Water' (WfW) in 1995. It is arguably the largest conservation project in Africa (van Wilgen, 2009) and the world's most ambitious invasive alien plant control programme (Koenig, 2009). Unlike other national control programmes that focus on prevention and early detection, WfW spends most of its funds on labour-intensive clearing because, as a public works project, it is expected to create employment in South Africa's impoverished rural areas (van Wilgen et al., 1998; Koenig, 2009).

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0006-3207/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biocon.2012.06.006

Despite its size, WfW appears to be falling short, at a national scale, of the expectation that it would have brought invasive alien plant problems under control within a reasonable timeframe (van Wilgen et al., 2012). Little is known about the cost-effectiveness of its clearing treatments at a project scale, because of a lack of clear, time-based goals, and a system of monitoring and evaluation to assess progress towards these goals (van Wilgen et al., 2012; Levendal et al., 2008). Currently, WfW only records plant cover, treatments and costs on specific sites where contracts are awarded for clearing work. Thus, there is no assessment of the effectiveness of the work done at a landscape scale because only the input variables (money spent, area cleared, and jobs created) are recorded. It is therefore not possible to assess effectiveness in terms of progress towards the goal of restoring ecosystem health.

In a recent national assessment of WfW, van Wilgen et al. (2012) found that despite substantial spending on control operations (3.2 billion South African rands (ZAR) or 432 million US dollars if 1 US$ = approximately ZAR 7.4), the extent of invaded areas in South Africa had grown since the inception of WfW in 1995. Using records of WfW treatment areas, van Wilgen et al. (2012) showed that only a small fraction of the total invaded area was treated. They concluded that WfW should modify its strategy by focussing control efforts in high priority areas (Forsyth et al., 2012). However, the study did not address WfW's cost-effectiveness in reducing invasive alien plant cover at the scale of treatment sites, nor did it explain the factors that influence the cost-effectiveness of treatments.

In this paper, we evaluate the cost-effectiveness of reducing invasive alien plant cover in two of WfW's river catchment clearing projects over 7 years. We based this on a before-and-after evaluation by comparing post-treatment cover with pre-treatment cover across all 740 sites within the two larger catchment areas. We also assessed the variables that had the greatest effect on the cost-effectiveness of invasive alien plant clearing.

2. Methods

2.1. Study area and background to the projects

We conducted our study in the Krom (1556 km^2) and Kouga (2426 km^2) river catchments in the Eastern Cape Province of South Africa (Fig. 1), specifically, in those parts of each catchment where WfW had implemented projects to clear invasive alien plants. These two projects are among WfW's oldest (operating since 1995) and largest in terms of hectares cleared and jobs created.

WfW managers allocate contracts within each project that specifies a treatment site of alien-plant-invaded land that must be cleared within a month. Each treatment site is assigned to a team comprising a team leader (contractor) and 10–15 labourers, recruited from the large numbers of unemployed people in local towns. Each project has, on average, five to seven operational clearing teams at any time.

The principal invasive alien plant species in both catchments is the tree *Acacia mearnsii* (black wattle), native to eastern Australia. When mature, *A. mearnsii* is 5 and 10 m tall. This species is the most prolific invader in South Africa in terms of its spread and impact on ecosystem services (de Wit et al., 2001), and as a result WfW have spent the most money on this species (van Wilgen et al., 2012). Of less importance in the study area are other Australian *Acacia* species, along with species of *Pinus*, *Eucalyptus* and *Hakea*.

The successful control of coppicing species like *A. mearnsii* requires felling, followed immediately by the careful application of herbicide to the cut stems. This kills the plant and thus prevents coppicing. Clearing also stimulates the germination *en masse* of seeds from a large and persistent soil-stored seed bank (Holmes et al., 2008). Numerous and timely follow-up treatments are required to treat both seedlings and coppice re-growth by spraying with herbicide, and is compounded when previous treatments were poorly executed. Re-growth taller than 1.8 m is unaffected by herbicide and plants must be re-felled, which is far more costly (Holmes et al., 2008). During the evaluation period, WfW's policy regarding clearing on private land was that the landowners would agree to maintain cleared sites after WfW's second follow-up treatment.

Both catchments support predominantly fynbos vegetation associated with nutrient-poor, sandy soils that prevail in the area. Fynbos is a fire-prone shrubland (Cowling, 1991) that is vulnerable to invasion by alien trees, even in the absence of anthropogenic disturbance (Richardson and Cowling, 1992). Rainfall is evenly distributed throughout the year in both catchments. The Krom catchment has a higher mean annual rainfall (690 mm) than the Kouga catchment (472 mm) (Schulze, 2008).

The catchments supply 80% of the water for Port Elizabeth, the largest city in the Eastern Cape and an important economic development node in the province. Water is increasingly limiting economic growth in South Africa (Blignaut and van Heerden, 2009), and extensive invasions of alien plants exacerbate this problem

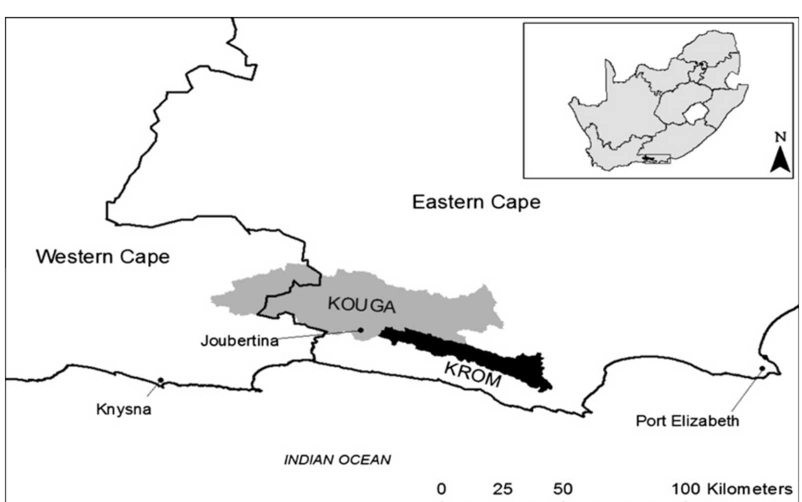

Fig. 1. Location of the Kouga and Krom river catchments within the Eastern Cape Province, South Africa.