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Analysis

Cost–benefit analysis of alien vegetation clearing for water yield and tourism in a mountain catchment in the Western Cape of South Africa

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ABSTRACT

Economic analysis is used to assess the costs and benefits of restoration following clearing of invasive alien trees in the floristically rich Fynbos mountainous area near Franschhoek, Western Cape of South Africa. The Groot Drakenstein, Franschhoek and Jonkershoek mountains receives more rainfall than the surrounding areas and is an important source of water for the city of Cape Town. The costs of alien invasive plant removal, gully-erosion repair and reseeding with indigenous plants are considered in a case–study cost–benefit analysis of restoration, in terms of the water and tourism benefits derived. Three different options of restoration (comprehensive, moderate, basic) were analysed under three different economic scenarios (optimistic, realistic, pessimistic) and the costs of which have been weighted up against the income derived from the supply of water and tourism. The results have shown that despite the high costs of restoration, the basic restoration option costs were out-weighed by the water and tourism benefits derived. This was also true of the moderate restoration option, when evaluated under the optimistic scenario and using an 8% discount rate, or a 3% discount rate under any scenario. However, this was not the case in the moderate restoration option when using an 8% discount rate in conjunction with the realistic and pessimistic scenarios. Neither was it the case when using a 12% discount rate, irrespective of the scenario. Under no scenario was the cost of a comprehensive restoration option outweighed by the benefits quantified, irrespective of the discount rate used. It was concluded that further restoration, in addition to the mere clearing of alien invasive plants, would be economically viable under certain assumptions and conditions.
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1. Introduction

When commercial plantations of *Pinus* species have dominated the natural plant community for lengthy periods exceeding seed longevity of indigenous plant species, clearing of the alien vegetation alone is insufficient to achieve natural vegetation recovery. The transformed area fails to revegetate and erosion problems, as well as further invasions, are experienced (Richardson and Van Wilgen, 2004; Galatowitsch and Richardson, 2005). Following clearfelling after 35 years under plantation, a reduction and even permanent loss or elimination of 58% of indigenous plant species can be expected (Richardson and van Wilgen, 1986). Further restoration is therefore required to reinstate the natural vegetation structure and baseline ecosystem functioning.

This study addresses the question of whether the water and assumed tourism benefits derived from restored Fynbos can justify the costs of reseeding and erosion control in addition to plantation removal and alien vegetation clearing. An economic analysis has been generated by performing a cost–benefit analysis of restoration of the Assegaaibos mountain catchment, which includes alien invasive plant removal, gully-erosion control and reseeding, in terms of the water and tourism benefits derived.

2. Methods

2.1. Study area

In a desk top study the economic benefits derived from two nearby mountain catchments, one of which (Assegaaibos) had been afforested with alien plants and later cleared, and the other (Swartboskloof) remained under natural Fynbos vegetation, were compared.

The Assegaaibos mountain catchment (33°58′S and 19°04′E), is located in the Western Cape Province of South Africa, approximately three kilometres south west of the town of Franschhoek. It is 806 ha in extent and ranges from 300 m to 1350 m in altitude. It receives an average of 3296 mm of precipitation per year. The area is state-owned and was afforested as part of the 4200 ha La Motte Plantation that was established in the late 1920s, during an economic depression (Department of Water Affairs and Forestry, South Africa, 1996). The Assegaaibos mountain catchment is also the source of the Berg River and upstream of the newly built Berg River Dam. Assegaaibos remained under pine plantation until 2000 when the plantation was

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destroyed by fire (Barend Gerricke, *personal communication*, 7 June 2006). A further two fires in 2004 and 2006 followed.

Commercial forestry ceased in the area and in 2001 the Working for Water Programme, funded by the Trans Caledonian Tunnel Authority, started the removal of all remaining pines (70% *Pinus radiata*, 25% *Pinus canariensis* and about 5% *Pinus pinaster*), together with other invasive alien plants *Acacia longifolia* (long leafed wattle) and *Acacia mearnsii* (black wattle) that had invaded certain portions of the riparian vegetation (Jones and Boucher, 2004) in the study site. The Working for Water budget was used to estimate the costs of clearing the invasive alien plants. Clearing was not followed by spontaneous recovery of natural vegetation. The upper storey proteoid component of the indigenous vegetation had not recovered seven years after clearing. This is because of the prolonged forestry activity and the frequent, intensive fire regime. Frequent fire causes the soil to become water repellent which in turn accelerates erosion (Scott and Van Wyk, 1990) and could carry a serious environmental and economic cost (Scott, 1993). Hot fires also destroy most soil-stored seed (Vlok and Yeaton, 1999) and, return of seed is slow because seed dispersal distances for most Fynbos plant species are very short being moved either by ants or, following seed release after fire, tumbling across the soil surface in the wind (Bond, 1988). It is necessary to sow seed on sites where the natural seed bank has been lost and the transformed site exceeds 50 m in diameter because natural re-colonization will not occur beyond the dispersal ranges of seeds (Holmes and Richardson, 1999). The lack of natural vegetation leaves the soil surface exposed allowing erosion gullies to form after the pines were removed.

Swartboskloof catchment (33°57′S and 18°55′E, 373 ha in area) is situated 15 km east south east of the town of Stellenbosch in Jonkershoek Nature Reserve. Altitude ranges from 285 to 1200 m above sea level (Van Wilgen et al., 1992). It was selected as the Fynbos vegetation benchmark reference site due to its close proximity to the study site, and similarity in geology, climate and slope.

2.2. Methods for costing restoration and estimating benefits

A cost–benefit analysis was used to determine whether potential water-yield increment and tourism benefit of the Assegaaibos mountain catchment area outweigh the costs of restoring the catchment to a condition similar in structure, function and composition to that of an undisturbed site (Swartboskloof, the benchmark site).

In order to restore the Assegaaibos mountain catchment to a state comparable to that of Swartboskloof mountain catchment, three operations are required. Firstly the removal of alien invasive plants, which entails the removal of pine plantations long established at Assegaaibos. Secondly the repair of gully erosion which has developed over time and thirdly reseeding of species lost through the negative impacts of forestry activity and high-intensity fires. Each of these operations and their costing is explained.

2.2.1. Alien invasive plant-removal operation

The alien invasive plant-removal operation entailed the removal of pine plantations over an area of 806 ha (Barend Gerricke, *personal communication*, 7 June 2006). It was cleared using labour-intensive techniques, including hand tools, such as bow saws, hatchets, knives for young trees and chainsaws for mature trees. This approach is in line with the Working for Water Programme methods and current South Africa policy for job creation (Department of Labour, 2002).

Costing of clearing was based on the work standards of the Working for Water Programme for a greater area of 7640.32 ha inclusive of the study area in 1996. The costs included initial clearing and follow-up operations calculated on a per-person-per-day basis of US$18.5 (at an exchange rate of ZAR7:$1) inclusive of wages, protective clothing and transport. The costs also included project-management (salaries, transport, telephone, computer and other day-to-day management costs) and regional-management costs calculated as a standard 10% of the operational costs and inclusive of the regional services provided by the Department of Water Affairs and Forestry, Western Cape Province office (Nigel Rossouw, *personal communication*, 18 July 2006). How ever the management costs were isolated and dealt with separately and are not inclusive of the removal costs given.

The costs were reduced to a per hectare cost and then extrapolated to the study site area of 806ha. The actual CPI (Consumer Price Index) for 1996 to 2006 was used to escalate the total cost from 1996 to the base year of 2006. The total costs of removing the alien invasive plant species over a period of 6 years was $124,761 in 1996 and using the actual CPI was increased to $215,257 in 2006 were costs have been incurred each year. The total follow up clearing cost of removing the alien invasive plants over a period of 8 years was calculated to be $1047 in 1996 and was escalated using the actual CPI (Statistics South Africa, 2008) to $1806 in 2006. Despite this calculation for the cost of follow-up clearing being based on the Working for Water figures for the area, the ratio of follow-up clearing to initial clearing costs appears to be very low in comparison with other published cost estimates such as Marais et al. (2004). One reason for this could be that the density of invasion is not taken into account, which as Marais et al. (2004) point out, can make a significant difference in terms of removal costs and furthermore the management and overhead costs have been dealt with in isolation to the actual removal cost and are not included in the removal costs provided.

The management and overhead costs associated with the removal of alien invasive plants were calculated to total $29,586 in 1996. This figure was escalated using the actual CPI for the years 1996 to 2006 and increased to $51,047 for the full 8 year duration of the alien invasive plant-removal project.

2.2.2. Repair of gully-erosion operation

The repair of eight erosion gullies requires the construction of weirs at two-metre intervals down the slope of each gully. Rocks and dry plant material are packed behind each weir to act as a soil trap. In the case of Assegaaibos, in situ materials (logs) left behind after the alien invasive plant-removal operation are used. Rocks from the riverbed are used as a packing material for the soil traps positioned behind the weirs.

The costs associated with repairing the gully erosion were based on the labour costs of $18.50 per person day to construct a total of 7348 m of weir and the in situ or ex situ material costs required for their construction. The erosion-control operation also requires a five-year follow-up programme, at a cost of 20% of the total gully-erosion operation cost (4% per year).

It was determined that the labour costs for repair of the eight erosion gullies would be $2843, and the material costs using ex situ material would amount to $25,193 in comparison with using in situ material at a cost of $5200. The follow up programme would cost $323 annually over a period of five years using in situ material.

2.2.3. Seed bed preparation

Soil preparation is required before seeds can be sown. This entails the mechanical scarification of 40.3 km of old forestry road (Barend Gerricke, *personal communication*, 7 June 2006). It is necessary to rake the soil surface of the roads after scarification, as well as raking around the gully-erosion sites. These costs were calculated at $8794 for seedbed preparation, $20,150 for the scarification of the old forestry roads and a further $8794 for a mulch application.

2.2.4. Reseeding operation

Two species lists were compiled for Assegaaibos, both of which are based on the species found at the Swartboskloof benchmark site. The first list formulated for reseeding consisted of a comprehensive mix of 60 different species, the choice of which was based on cost and ease of harvesting. Focal issues were the establishment of a pioneer grass cover for soil stabilisation and the restoration of the over-storey *Protea*

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