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Composition of the soil seed bank in alien-invaded grassy fynbos: Potential for recovery after clearing

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Abstract

Indigenous soil seed banks play a very important role in facilitating the natural recovery of indigenous fynbos vegetation after clearing invasive alien vegetation. In densely invaded areas, there is a reduction in fynbos cover and seed production, and these ecosystems rely heavily on the remaining soil seed bank as a reservoir of plant propagules. This study used the seedling emergence approach to assess recovery potential based on the soil seed banks of riparian and hillslope grassy fynbos communities that had been densely invaded for three decades, with *Acacia longifolia* as the dominant alien species. Forty-eight species (of which five were aliens), representing 30 genera and 18 families, emerged from the soil seed bank, with Asteraceae and Cyperaceae being best represented. The mean density of indigenous seedlings for the study area was 1582 seedlings/m^2. *Senecio rigidus* exhibited the highest density, with 274 seedlings/m^2, followed by *Chironia baccifera* (151 seedlings/m^2) and *Rumohra adiantiformis* (136 seedlings/m^2). Forbs were the most numerous growth form. Two other alien species exhibited comparable seedling densities, i.e. *Solanum nigrum* (181 seedlings/m^2) and *Conyza canadensis* (98 seedlings/m^2). *A. longifolia* seed densities of up to 4528 seeds/m^2 were found by sieving the soil. Results revealed that alien-invaded grassy fynbos had a diverse and viable soil seed bank with relatively high seed densities. Pioneer species were well represented, as well as graminoids in the riparian zone. Species representing some guilds were missing; e.g. serotinous species from the genera *Leucadendron* and *Protea*, and few geophytes were present in the hillslope soil seed bank, although ericoid shrubs were well represented. Riparian species such as *Cliffortia graminea* and common Cyperaceae and Restionaceae species were also not represented in the seed bank. It would appear from this data that the soil seed bank would be adequate to enable a functional cover of indigenous vegetation to re-establish after clearing. In order to improve vegetation structure and composition, the addition of some missing guilds would facilitate restoration, provided that post-clearing follow-up treatments do not prevent or hinder the establishment of these indigenous species.

Keywords: Germination; Grassy fynbos; Recovery; Riparian; Soil seed bank

1. Introduction

The invasion of indigenous ecosystems by alien plants poses a threat worldwide, with major impacts on ecosystem functioning and biodiversity (Richardson and Van Wilgen, 2004). In 1998, it was estimated that about 8% of South Africa had been invaded (Versfeld et al., 1998). Riparian ecosystems are vulnerable to invasion (Galatowitsch and Richardson, 2005; Holmes et al., 2005), and in response to the negative impact of invasion on water resources, a government programme, Working for Water, was initiated in 1995 to clear woody alien species from catchment areas.

Implicit in the alien plant removal programme is the assumption that indigenous ecosystems will recover naturally after the removal of invasive species. However, especially in long and heavily invaded systems, vegetation resembling the pre-invasion structure and composition does not recover naturally, and these areas are often further degraded through soil erosion and reinvasion.

One of the factors influencing the recovery of natural vegetation is the nature of the indigenous soil seed bank, and its persistence may play a very important role in facilitating the recovery of ecosystems after the clearance of invasive alien vegetation. Seed banks act as a reservoir of plant propagules (Clemente et al., 2007), and it is generally assumed that soil seed banks contribute to vegetation recovery after disturbance such plant invasion (Holmes, 2001; Holmes and

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Newton, 2004; Sakai et al., 2005). In densely invaded ecosystems, there is a rapid reduction in fynbos cover and seed production, and these ecosystems rely heavily on the persistent soil seed bank for recovery. A persistent seed bank remains in the soil for more than one season, and is a common strategy in areas where the probability of adult survival and reproduction may vary temporally (Kalisz and McPeek, 1993; Holmes and Cowling, 1997a,b), such as in fire-dependent ecosystems.

Fynbos, including riparian fynbos, is adapted to periodic fire events and adaptations for the survival of species during these events also, to a degree, equip fynbos species to survive invasion. During fire events, several plant species are killed by fire and depend on germination of the seeds stored in the soil or canopy for the regeneration of their populations (Cowling, 1992; Van Wilgen and Forsyth, 1992; Clemente et al., 2007). Species which have life cycles shorter than the fire return interval have persistent soil-stored seeds which are fire-stimulated (Van Wilgen and Forsyth, 1992). Although most fynbos species are adapted to cope with regular fire, the increased biomass in invaded systems can cause extreme temperatures during the fire which can damage the soil and cause erosion (Scott, 1993). These fires may also kill resprouters and seeds near the soil surface.

A number of studies in South Africa have investigated the soil seed bank in fynbos (Musil, 1991; Pierce and Cowling, 1991; Holmes and Cowling, 1997a,b), including the effect of alien invasion on the indigenous soil seed bank (Vosse et al., 2008-this issue). However, no studies have looked at the effect of invasive species on the soil seed banks in grassy fynbos communities of the Eastern Cape. A decline in seed bank density has been recorded for invaded areas (Holmes and Cowling, 1997a,b), generally declining with increasing invasion age. Holmes and Foden (2001) found that although a viable soil seed bank is present in invaded areas for up to 30 years, by comparison the soil seed bank from areas that have been invaded for more than 40 years is impoverished. Thus there may be an irreversible threshold of good recovery potential for invaded fynbos ecosystems.

This study aims to assess the recovery potential of a riparian and adjacent terrestrial fynbos community, based on the soil seed bank composition, in an area that has been densely invaded for approximately 30 years.

1.1. Study area

The study area is located in the upper reach of the Palmiet catchment, a tributary of the Kariega, in the Albany District near Grahamstown (33° 20′S, 26° 29′E) (Fig. 1).

The original vegetation in the area consisted of grassy fynbos on the hillslopes, dominated by *Erica chamissonis* and *E. demissa* (Martin, 1966; Richardson et al., 1984), with a patch of Afrotemperate forest at the top of the catchment, 200 m upstream. There are no detailed accounts of the pre-invasion riparian vegetation of this catchment, but riparian vegetation in nearby similar catchments is dominated by Restionaceae and Cyperaceae such as *Carpha* spp. and *Eleocharis* spp, as well as *Cliffortia graminia*, interspersed with woody species such as *Halleria lucida*, *Burchellia bubalina*, *Rapanea melanophloeos*, and *Erica brownleea*.

By 1974, the south-facing slopes in the catchment were covered almost entirely by alien species (*Pinus* species, *Hakea sericea*, *A. longifolia*, *A. saligna* and *Solanum mauritianum*) (Jacot-Guillarmod, 1983). At that time, it was estimated that most of the pine trees were from 15 to 17 years old, and many of them from 45 to 60 years in age. The remaining grassy fynbos was in poor condition, with straggly *Protea cynaroides* and *Erica* species under the alien canopy.

A section of the south-facing slopes adjacent to the study area was cleared during a 12 month period, and was almost

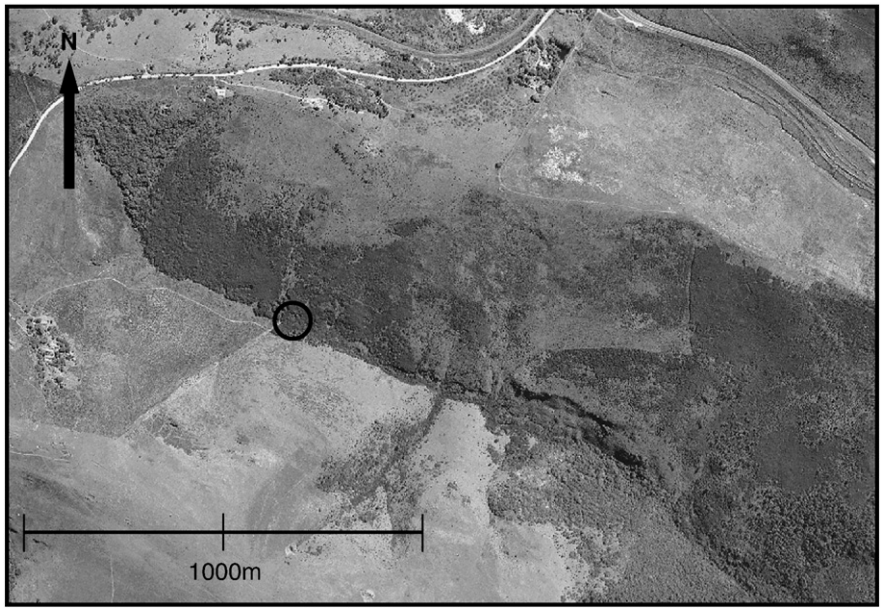

Fig. 1. The Palmiet catchment, indicating the study area (circled in black). The darker patches are dominated by the invasive alien tree *Acacia longifolia* (Chief Directorate: Surveys and Mapping, 2003).