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# The roles of habitat features, disturbance, and distance from putative source populations in structuring alien plant invasions at the urban/wildland interface on the Cape Peninsula, South Africa

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ABSTRACT

Natural areas are becoming increasingly fragmented and embedded in an urban matrix. Natural and semi-natural areas at the urban/wildland interface are threatened by a variety of 'edge effects', and are especially vulnerable to invasion by introduced plants, with suburban gardens acting as significant sources of alien propagules. Urban/wildland interfaces also provide access for humans, leading to various types of disturbance. Alien plant invasions are one of the biggest threats facing remaining natural areas on the Cape Peninsula, South Africa. The area provides an ideal opportunity to study the dynamics of invasions at the urban/wildland interface, since the largest natural area, the Table Mountain National Park (TMNP), is surrounded by the city of Cape Town. We explored invasion patterns in Newlands Forest (a small section of the TMNP) and detailed the roles of habitat features and distance from putative source populations in three main habitat types: natural Afromontane forest, riverine woodland habitats, and plantations of exotic pines (*Pinus radiata* and *P. pinaster*). We also examined the role of disturbance in driving invasions in two of these habitat types (Afromontane forest and pine plantations). We hypothesized that alien richness and alien stem density would decrease with distance from the urban/wildland interface, and that alien richness and alien stem density would increase with increasing levels of human disturbance.

Distance from putative source populations and levels of anthropogenic disturbance influenced alien richness in Newlands Forest but not alien stem density. Alien richness decreased significantly with distance from presumed sources in the pine habitat, and increased significantly with disturbance in the forest habitat. Percentage overstorey cover and soil pH were important environmental variables associated with alien plant species. A socio-economic approach is discussed as being the most effective approach to the management and prevention of alien plant species in Newlands Forest.



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## 1. Introduction

As urbanisation increases, natural areas are becoming increasingly fragmented and surrounded by human settlements (Saunders et al., 1991; Hobbs and Yates, 2003), creating ever more urban/wildland interfaces. These interfaces are subject to edge effects generally associated with fragmentation (Saunders et al., 1991) and to a range of pressures resulting from their proximity to urban environments. Types of edge effects include changed environmental conditions, especially microclimates in fragmented forests (Fraver, 1994; Murcia, 1995; Hobbs and Yates, 2003), increased abundance of alien species (Brothers and Spingarn, 1992; Hobbs and Yates, 2003), and altered disturbance regimes (Hobbs and Yates, 2003).

Natural environments at the urban/wildland interface experience increased levels of air and water pollution (Struglia and Winter, 2002) and erosion or sedimentation through augmented water run-off from the hard surfaces characteristic of urban areas (Gill and Williams, 1996). Urban/wildland interfaces are also vulnerable to invasion, partly because suburban gardens are important sources of alien plants (Sullivan et al., 2001; Raloff, 2003). Also, garden refuse is frequently dumped into surrounding ecosystems, and gardens are often extended illegally (Gill and Williams, 1996). Alien plant establishment and soil nutrient enrichment have been identified as two important influences of urban areas at urban/wildland interfaces (Gill and Williams, 1996).

Horticulture is an important pathway for the introduction of alien plants (Reichard and White, 2001; Richardson et al., 2003), and horticultural plants are among the most important invaders in many parts of the world (Reichard and Hamilton, 1997; Baskin, 2002). Many ornamental plants have 'showy' fruit displays, attracting generalist seed dispersers; such species, grown by gardeners at numerous foci near the urban/wildland interface, are well placed to spread into natural areas.

Until about 1910, most plant introductions to South Africa entered the country via the southwestern Cape, particularly the Cape Peninsula which has the country's oldest port (Wells et al., 1986). The Cape Peninsula is situated within the Cape Floristic Region (CFR), an area of exceptional biodiversity and endemism (Trinder-Smith et al., 1996; Richardson et al., 1998). Three main factors threaten the region's biodiversity: agriculture, urbanization, and alien plant invasions (Richardson et al., 1996; Rouget et al., 2003; Latimer et al., 2004). In 1994, dense stands of woody alien species covered about 11% of the remaining natural vegetation of the Peninsula and another 33% was lightly invaded (Richardson et al., 1996). If left unmanaged these alien plants could potentially spread to cover over 89% of the Cape Peninsula (Higgins et al., 1999). Preventing further spread of alien plants is a clear priority for conservation managers (Richardson et al., 1998).

The problem posed by alien plant invasions on the Cape Peninsula is made worse by the fact that the area is surrounded by one of South Africa's fastest growing metropolises, Cape Town (Cowling et al., 1996). Natural and semi-natural areas on the Cape Peninsula are increasingly subjected to the edge effects posed by human settlements. Settlements also contain many open areas with high levels of disturbance and solar radiation conditions, such as roadsides, which then promote establishment through transport via vehicles. Distance from human habitation is also an important factor in alien plant invasion (Sullivan et al., 2001).

Disturbance is an important determinant of invasibility (Hobbs and Huenneke, 1992; Davis, 2003). Invasion may be facilitated through disturbances associated with roads and streams, both of which create disturbance channels and dispersal corridors, removing competition and creating open areas or dispersing propagules (Parendes and Jones, 2000). The urban/wildland interface facilitates access and opportunities for humans to disturb natural habitats, for example through trail construction and detrimental vegetation management (Bolger et al., 1997); e.g. vegetation trampling and refuse dumping (Sullivan et al., 2001), plant collecting and illegal bark harvesting (Geldenhuys, 2000), and erosion and soil damage (Rose and Fairweather, 1997).

Invasion is also influenced by propagule pressure: the greater the number of propagules, the greater the chance of establishment, persistence, naturalization and invasion (Lonsdale, 1999; Rouget and Richardson, 2003). Initial stages of invasion are usually constrained by the availability of propagules and high propagule pressure can, in some instances, be a better predictor of alien plant cover than any suite of environmental factors (McKinney, 2002; Rouget and Richardson, 2003; Foxcroft et al., 2004).

Many of the factors discussed above interact. For example, disturbance creates edges that threaten plant communities with increased solar radiation, higher temperatures, altered soil conditions, and may result in plant mortality through regeneration failure (Fraver, 1994; Hobbs and Yates, 2003). Alien plants may in turn exploit these edges, invading from sources with a high availability of propagules (Parendes and Jones, 2000).

We explored invasion patterns in a section of the Table Mountain National Park (until 2003 the Cape Peninsula National Park) dominated by Afromontane forest that adjoins suburban gardens. We provide an inventory of invasive alien plants and explore the roles of habitat features, dispersal distance and disturbance in structuring invasion patterns in the three main habitat types in the area. We tested two main hypotheses: (1) alien richness and alien stem density decreases with increasing distance from the suburban/wildland interface; (2) alien richness and alien stem density increases with increasing levels of disturbance. We also explore the implications of the results for long-term management of Newlands Forest.

## 2. Methods

### 2.1. *Study area*

Our study area was Newlands Forest (33°58′S 18°26′E), located on the lower eastern slopes of Table Mountain, and forming part of the Table Mountain National Park (Fig. 1). Soils in the area are generally deep (300–1200 mm) with a high clay