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Current and future threats to plant biodiversity on the Cape Peninsula, South Africa

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The biodiversity of the Cape Peninsula (49 127 ha in extent) has been considerably affected by various factors since European settlement in 1652. Urbanization and agriculture have transformed 37% of the original area of natural vegetation. Lowland vegetation types have been worst affected, with almost half of the transformation occurring in one of the 15 recognized vegetation types. Vegetation at high altitudes has been little affected by urbanization and agriculture, but alien trees and shrubs are now threatening biodiversity in these areas. Of the area not affected by urbanization and agriculture 10.7% is currently under dense stands (>25% canopy cover) of alien plants and another 32.9% is lightly invaded. Dense stands of *Acacia cyclops*, the most widespread invader, cover 2510 ha, 76% of the total area under dense alien stands. This paper assesses the impacts of these factors on aspects of the plant biodiversity of the area, namely, the distribution of major vegetation types and of endemic, rare and threatened plant taxa and of taxa in the Proteaceae (a prominent element in almost all communities, taken as an indicator of overall plant biodiversity).

Possible future impacts on biodiversity are assessed by considering the effects of several scenarios involving increased urbanization and changes to alien plant control strategies and further spread over the next 50–100 years. The worst-case scenario for urbanization sees the area under natural vegetation reduced to 12 163 ha (39.3% of its extent in 1994, or 24.8% of its original extent). Under this scenario almost a quarter of the 161 endemic, rare and threatened ('special') taxa are confined totally to urban areas; 57.4% of the known localities of these taxa, and 40.1% of the remaining localities of Proteaceae taxa are transformed. Dense alien stands currently affect 29.8% of the localities of special taxa known from herbarium records and 8.4% of these taxa currently occur only in areas at present affected by aliens. Clearing all dense stands would result in 62.9% of special taxa having less than half of their known localities affected (49.1% at present). Under this scenario, 92% of Proteaceae taxa have more than 75% of their localities unaffected by aliens. If clearing is confined to specific areas (the Cape Peninsula Protected Natural Environment or all publicly-owned land) and the aliens spread further outside these areas, the area of natural vegetation remaining shrinks (to 82.4% of the current extent if control is confined to public land). The further losses in biodiversity associated with these scenarios are described. If control programmes collapse and all potentially invadable land is occupied by dense alien stands, only 407 ha of natural vegetation would remain (1.5% of the current extent).

The probability of the various scenarios materializing is discussed. To minimize further losses in biodiversity it is essential that: (1) a major initiative is launched immediately to clear (firstly) the

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10 184 ha of lightly invaded vegetation and then the 3313 ha of densely invaded vegetation; (2) no urban development be permitted within the boundaries of the Cape Peninsula Protected Natural Environment; (3) a systematic programme of prescribed burning (linked to the alien control programme) is initiated; and (4) contingency measures are implemented to improve the status of seriously threatened taxa, habitats and vegetation types.

Keywords: Biodiversity; biological invasions; Cape Floristic Region; GIS; landscape ecology; urbanization; fynbos.

Introduction

Mediterranean-climate areas worldwide are currently the focus of human immigration and population expansion, making them disproportionately susceptible to environmental stress and degradation (Di Castri, 1994). This global pattern is reflected in the Western Cape Province of South Africa where there has been, and continues to be, massive immigration from elsewhere in southern Africa. The population of the Greater Cape Town area (*sensu* Bridgman *et al.*, 1992) is currently about 3.2 million; with an annual increase of 5%, this will reach 4 million by the year 2000, and 10 million by 2019. The considerable biodiversity of the Cape Peninsula (Cowling *et al.*, 1996; Trinder-Smith *et al.*, 1996a; Simmons and Cowling, 1996) is severely threatened by various factors related to human pressure; 141 plant taxa in the area are currently classified as threatened according to IUCN criteria, with at least 39 having become extinct on the Cape Peninsula in the 20th century (Trinder-Smith *et al.*, 1996a), and the threats are escalating rapidly.

The Peninsula's biodiversity is directly threatened by urbanization and other pressures, including agriculture and plantation forestry. Human settlement and the rapid growth of human populations has produced other threats to biodiversity, for example through the introduction and dissemination of invasive alien trees and shrubs, and possibly through alterations to the natural fire regime. There are other existing and potential threats in the area, including pollution, human recreational pressure, and the non-sustainable harvesting of natural plant products (Hall and Veldhuis, 1985). Agriculture has had a marked impact on biodiversity, but there is unlikely to be an appreciable expansion in this form of land-use on the Peninsula in the near future. Our analysis concentrates on the effects of urbanization and alien plants, as these are likely to be the major threats in the future.

Urbanization and agriculture affect biodiversity directly through the physical destruction of habitats for plants and animals, and indirectly through fragmentation of habitats which disrupts important processes such as gene flow and the spread of fires. There are also many important 'edge effects' caused by the spill-over of human influences into remaining unmodified habitats (Moll *et al.*, 1978). Alien trees and shrubs impact on biodiversity most obviously by replacing the indigenous vegetation, thereby supplanting native taxa (Richardson *et al.*, 1989) and providing habitat for other alien organisms which may further disrupt natural processes (e.g. European starlings, *Sturnus vulgaris*, in stands of alien *Acacia* spp. which change seed dispersal patterns). Alien plants also cause many other less direct impacts on biodiversity, such as changed fire regimes and nutrient budgets (Richardson *et al.*, 1992). Plant recruitment in fynbos is driven by fire, and modifications to the frequency, seasonal occurrence and intensity of fires has a marked influence on biodiversity (van Wilgen *et al.*, 1992), especially if these changes are concurrent with other threats.

The threats to biodiversity on the Cape Peninsula, although widely appreciated (e.g., Moll *et al.*, 1978; Hall and Ashton, 1983; Hall and Veldhuis, 1985; Hall, 1987; Macdonald *et al.*, 1987; Wood *et al.*, 1994), have not been documented in a systematic and quantitative way that facilitates the prediction of future impacts. This paper aims: (1) to assess these impacts of humans on plant biodiversity since European settlement in 1652; and (2) to provide an objective framework for predicting the impact of future developments on the biodiversity.

In exploring the future of the region's biodiversity we have constructed various scenarios that take account of the biological and socio-political factors that are likely to regulate the pressure on biodiversity in the area over the next 50–100 years.

Approach and methods

DEFINING BIODIVERSITY

Biodiversity encompasses the heterogeneity that occurs at all levels in a region's biota. It includes the variety of species of plants, animals and other organisms, and the genes they contain and the communities and ecosystems of which they form part. Patterns of biodiversity form a nested hierarchy, with genotypic variability forming the basis upon which diversity at the population, species, assemblage and ecosystem levels is built (Hobbs *et al.*, 1995). Strategies for conserving biodiversity usually give priority to the preservation of endemic or threatened taxa and to rare and/or unique ecosystems (which presumably accommodate unique assemblages of biota). The elimination of populations of native plant species is a particularly serious threat in the fynbos where many taxa exist in small, isolated populations (4% of the native plant taxa on the Peninsula are endemic to the area, and 6% of taxa are currently threatened; Trinder-Smith *et al.*, 1996a). Less often emphasized, but also very important, is the need to conserve populations of common taxa and widespread habitat types, since these house vital reservoirs of genetic diversity. Sound strategies for conserving biodiversity should therefore also make allowance for conserving portions of all representative community types and populations of widespread species. We have used this reasoning in deciding upon how to 'measure' biodiversity (and the extent of various threats to it) on the Cape Peninsula for the purposes of this study.

But how does one arrive at a practical and yet meaningful 'measure' of biodiversity for an area such as the Cape Peninsula? We suggest that the extent and distribution of major vegetation types (defined and mapped on the basis of floristics, dominant taxa and structure; Cowling *et al.*, 1996) provides a reasonable delineation of the major habitat types on the Cape Peninsula. Although defined solely on the basis of dominant plant growth forms, this delineation probably also provides a reasonable basis for classifying habitats for other taxa (Cowling *et al.*, 1996), and therefore serves as a crude index for overall biodiversity. We created GIS (Geographic Information System) coverages of the distribution of 161 endemic and threatened plant taxa (species, sub-species and varieties; hereafter called 'special taxa'), including 82 of the 90 endemic taxa (68 taxa in these categories were also classified as 'rare'), and of 38 of the 45 native Proteaceae taxa for which detailed distribution data were available as descriptors of biodiversity (see Table 1 and Trinder-Smith *et al.*, 1996b for further details of biodiversity in these vegetation types). The Proteaceae is a prominent and conspicuous family whose taxa range from common and widespread to rare, localized and threatened. Some Proteaceae are endemic to the Peninsula whereas others have ranges that extend across large parts of the fynbos biome (e.g. see Rourke, 1980 for *Protea*). We reasoned that a detailed assessment of the impacts of urbanization and alien plants on taxa in this family should provide a reasonable indication of the fate of the entire flora (see Rebelo and Siegfried, 1990). The data from herbarium records (for 'special taxa') include many records from localities that have already been transformed by agriculture or urbanization. These records date back to 1854, with the approximate spread of collections as follows: 1854–1885 (5%); 1885–1910 (20%); 1910–1940 (30%); 1940–1975 (35%); 1975–1994 (10%). These data are therefore suitable for assessing the impacts of recent changes in the magnitude of the major threats to biodiversity. The data for Proteaceae from the Protea Atlas Project are much more recent (mostly 1990–1994); they reflect the distribution of species in the remaining vegetation and facilitate a more detailed assessment of future changes in biodiversity under various scenarios than is possible with the data for special taxa.

Table 1. Data used to quantify biodiversity and the major threats to this biodiversity on the Cape Peninsula. The data were used to create Arc/Info coverages

Data layer	Description	Source
Biodiversity		
Vegetation types	A classification of the vegetation based on floristics, structure and dominant taxa; extended by interpolation to cover the whole Peninsula (including areas now transformed)	Mapped on 1:10 000 orthophotos (Cowling *et al.*, 1996)
Distribution of endemic and threatened plant species and 38 species of Proteaceae	Distribution data (at a resolution of 1 km^2) for endemic and threatened taxa from over 22 000 herbarium records dating back to 1854. Actual locality data from field record cards for 38 indigenous Proteaceae taxa	Bolus Herbarium, Botany Department, UCT (Trinder-Smith *et al.*, 1996a), and the Protea Atlas Project
Threats		
Urbanization	The extent of urban areas, agricultural land, and natural vegetation (including invaded fynbos)	LANDSAT thematic mapper image, October 1992. Land use was classified in 30 m × 30 m pixels
Alien plant species	Data are recorded for each species, divided into seven density classes based on aerial cover (Le Maitre and Versfeld, 1994)	Mapped during field surveys in 1994 on 1:10 000 orthophotos

DEFINING THE THREATS CAUSED BY URBANIZATION, AGRICULTURE AND ALIEN PLANT INVASIONS

The major threats to biodiversity were assessed by surveying the extent of invasion by alien woody plants in various density classes and of various categories of land transformation (Table 1). For the purposes of this study we have assumed that alien trees and shrubs only affect plant biodiversity when their projected canopy cover exceeds 25% ('dense stands' in this paper); see Richardson *et al.* (1989) for justification. All mapped categories of transformation through agriculture and urbanization (Table 1) are considered to affect biodiversity since these usually involve total removal of the natural vegetation.

The effects of urbanization and alien plants on the above-mentioned elements of biodiversity were assessed by overlaying coverages depicting threats on coverages containing the various biodiversity features using a GIS (ARC/INFO version 6.1.1.; Environmental Systems Research Institute, Redlands, California).

To assess the impact of various land-use categories on the vegetation it was necessary to extend the classification of extant vegetation (1994) to the whole Cape Peninsula (i.e. to determine what natural vegetation existed in areas where none remains at present). This was done by studying relationships between the existing natural vegetation and various physical features (notably soil features and topography), and interpolating to cover the whole area (see Cowling *et al.*, 1996).

SCENARIOS

The above-mentioned data were used to assess the current status of plant biodiversity. To assess the impacts of changes in the extent and magnitude of the two major categories of threat, urbanization and alien plant invasions, we developed several scenarios based on socio-political and ecological factors. We first developed 'profiles' (sets of attributes describing the distribution and extent of urbanization and dense stands of alien plants) using coverages of altitude, slope and vegetation types. We defined the 'urbanization profile' for the Cape Peninsula in terms of slope and altitude (since development is limited by steep slopes and is unlikely at high altitudes where exposure and access are restrictive). Our 'urbanization profile', therefore, described conditions suitable for urbanization as those with slopes of less than 45 degrees and elevations of between 0.2 and 250 m above sea level. Exploratory analyses revealed that the distribution of alien plants was largely determined by soil type and altitude. Available data on the distribution of soil types were inadequate for modelling, and we used the delineation of vegetation types (which closely mirror major soil categories; Cowling *et al.*, 1996) as the best available surrogate measure of the adherence of alien plants to particular habitats.

These profiles were used to predict how urbanization and alien plants could spread by occupying currently untransformed areas with the same characteristics as those currently affected. These predictions on their own are simplistic as they make no allowance for socio-political realities. Factors that must be considered when defining scenarios for changing threats to biodiversity on the Cape Peninsula include the following: (1) The relaxation, in the early 1980s, of rigid influx control regulations lead to the massive influx of impoverished people to the Western Cape. Most of these people now live in conditions of poverty and over-crowding on the resource-poor Cape Flats which adjoins the Cape Peninsula (see Bridgman *et al.*, 1992; Wood *et al.*, 1994 for details). The pressure on local authorities to re-zone large parts of the Cape Peninsula for urban development will undoubtedly increase markedly over the next few decades. These developments may place increasing pressure on authorities to review the current regulations that preclude development on publicly-owned land and within the boundaries of the Cape Peninsula Protected Natural Environment (CPPNE; see Cowling *et al.*, 1996; van Wilgen, 1996). There are, as yet, no informal settlements proclaimed within the CPPNE, and the most recent structure plans for the region affirm the status of the CPPNE, but this could change. (2) The control of invasive alien plants is extremely expensive, and a large part of the funds previously allocated for this purpose (averaging around 17% of the total budget for nature conservation in the Western Cape in recent years) is likely to be diverted to issues more closely associated with the reconstruction and development of a post-apartheid South Africa. The negative effect of reduced funding for mechanical control may be reduced to some extent by the increasing efficiency of biological control measures (as existing agents become more widely established and new agents are released) and by increasing utilization of the alien plants (e.g. co-ordinated harvesting of alien *Acacia* spp. for firewood; Azorin, 1994). We considered three scenarios for urbanization, and four for alien plant invasions that take account of these factors (Table 2).

Results

VEGETATION TYPES, PLANT SPECIES DIVERSITY AND THE OCCURRENCE OF SPECIAL TAXA

Three of the 15 recognized vegetation types (sandplain proteoid fynbos, mesic oligotrophic fynbos and mesic mesotrophic fynbos) originally covered almost 60% of the Peninsula, with another three types (dune asteraceous fynbos, wet restioid fynbos and wet mesotrophic proteoid fynbos) contributing another 24% (Fig. 1; Table 3). Table 3 shows salient elements of plant biodiversity of each vegetation type (see also Simmons and Cowling, 1996; Trinder-Smith *et al.*, 1996a for further discussion).

THE CURRENT EXTENT OF URBANIZATION AND AGRICULTURE

Urbanization and agriculture have transformed 18 172 ha (37%) of the original area of natural vegetation of the Cape Peninsula (Fig. 2; Table 4). Almost half of the urbanization has occurred in one vegetation type (sandplain proteoid fynbos) and almost all the rest in another five types that occur mainly on level areas at low altitudes (Fig. 1; Table 4). Similarly, 90% of agricultural transformation has occurred in three lowland vegetation types (types SND, MMP and WMP in Table 4). These two categories of land transformation have together destroyed 48% of dune asteraceous fynbos, 77% of sandplain proteoid fynbos, 75% of wetlands, 70% of wet mesotrophic proteoid fynbos, 60% of renosterveld and grassland, and 32% of the area of vleis (Fig. 1; Table 4). On the other hand, vegetation types that occur predominantly at high altitudes (types WRF, ERI, MOP, CLF, WOP and URF in Table 4) have been little affected by agriculture and urbanization, and more than 90% of their original area remains (for types ERI, CLF, WOP and URF, most of the remaining area is lightly invaded; Table 5).

Table 2. Seven scenarios of possible changes in the extent of urbanization and invasion by alien trees and shrubs on the Cape Peninsula. The CPPNE is the Cape Peninsula Protected Natural Environment (see Cowling *et al.*, 1996)

Scenario		Assumptions
Urbanization		
U1	No further urbanization within the boundaries of the CPPNE, but all remaining areas suitable for urbanization are developed	CPPNE legislation maintained in the face of increasing demand for land; large-scale development elsewhere
U2	All areas suitable for urbanization outside public land are developed	Relaxation of regulations restricting development in the CPPNE; only public land remains for conservation
U3	Development of all suitable areas, irrespective of land ownership	Total break-down of legislation governing development on protected sites, or the modification of legislation to permit development over a larger area
Alien plants		
A1	All dense stands of alien plants are cleared	Major investment of funds towards integrated control; effective liaison between landowners, conservation authorities and volunteer groups to compile and implement effective strategies; biological control is effective and prevents re-establishment of dense stands after mechanical control
A2	All dense alien stands within the CPPNE are cleared, but all other potential sites become covered with dense stands	Substantial investment of funds, but efforts (see A1) are confined to the CPPNE; control efforts outside CPPNE poorly co-ordinated and ineffective; biological control moderately effective, but little effect on dense stands
A3	All dense alien stands on public land are cleared, but all other potential sites become covered with dense stands	Available funds restrict co-ordinated integrated control to public land; biological control moderately effective, but little effect on dense stands
A4	Alien plants spread to form dense stands in all potentially invadable areas	Reduction, in real terms, of funding available for control; existing dense stands persist and become even denser after each fire; dense stands serve as foci for further spread; stand density increases in lightly invaded areas; efforts by volunteer groups are ineffective; net effect of biological control and harvesting insufficient to contribute to overall control

Table 3. Salient features of plant biodiversity in 15 vegetation types on the Cape Peninsula. Numbers in brackets in column 2 are the areas of each vegetation type expressed as percentages of the total area. In column 3, numbers in brackets are the numbers of plant species per ha (original area) for each vegetation type. Asterisks in columns 4 and 5 indicate vegetation types with higher than average numbers of endemics (mean = 23.7) or threatened plant taxa (mean = 32.5)

Vegetation types	Original area (ha)	Number of plant species	Number of endemic plant taxa	Number of threatened plant taxa
1. Forest and thicket (FOR)	1 315 (2.7)	924 (0.70)	11	17
2. Dune asteraceous fynbos (DUN)	4 331 (8.8)	873 (0.20)	29*	44*
3. Coastal scree asteraceous fynbos (CSA)	256 (0.5)	170 (0.66)	4	5
4. Wet restioid fynbos (WRF)	3 244 (6.6)	333 (0.10)	32*	40*
5. Ericaceous fynbos (ERI)	1 342 (2.7)	764 (0.57)	29*	34*
6. Sandplain proteoid fynbos (SND)	10 576 (21.5)	1 133 (0.11)	40*	55*
7. Mesic oligotrophic proteoid fynbos (MOP)	8 830 (18.0)	1 122 (0.13)	59*	87*
8. Mesic mesotrophic proteoid fynbos (MMP)	9 161 (18.6)	1 589 (0.17)	49*	79*
9. Undifferentiated cliff communities (CLF)	722 (1.5)	524 (0.73)	17	21
10. Wetlands (WET)	1 434 (2.9)	965 (0.67)	20	29
11. Wet oligotrophic proteoid fynbos (WOP)	1 054 (2.1)	396 (0.38)	23	20
12. Wet mesotrophic proteoid fynbos (WMP)	4 081 (8.3)	1 139 (0.28)	24*	23
13. Renosterveld and grassland (REN)	2 419 (4.9)	974 (0.40)	8	18
14. Upland restioid fynbos (URF)	149 (0.3)	153 (1.03)	9	12
15. Vleis (VLE)	213 (0.4)	86 (0.40)	2	4
TOTAL	49 127	2285	90	141

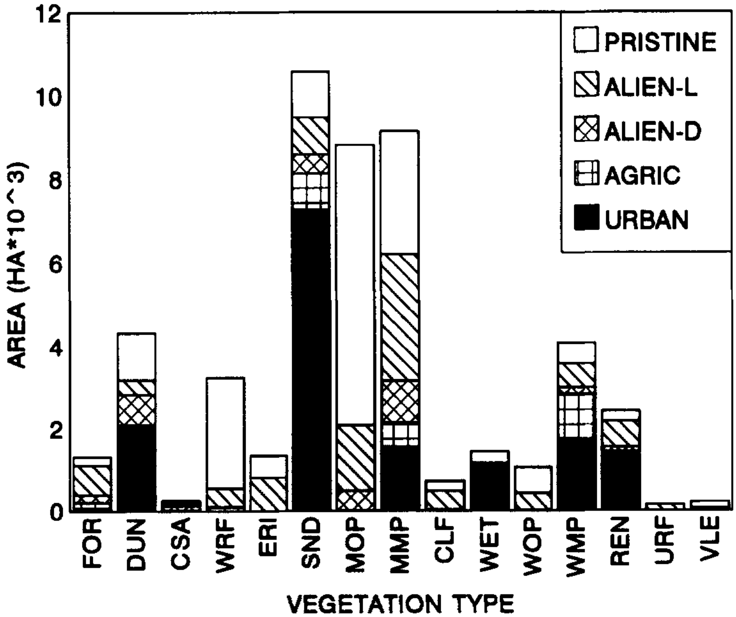


Figure 1. The original extent and status (in 1994) of 15 vegetation types on the Cape Peninsula (total area = 49 127 ha). Categories are: URBAN, AGRIC (land transformed by urbanization and agriculture), ALIEN-D, ALIEN-L [areas under dense (>25% canopy cover) and light (<25% canopy cover) stands of alien trees and shrubs], and PRISTINE (areas not affected by agriculture, urbanization or alien plants). Codes for vegetation types refer to those in Table 3.

THE CURRENT EXTENT OF INVASIVE ALIEN PLANTS

Of the 30 955 ha of natural vegetation remaining on the Cape Peninsula (i.e. that not affected by agriculture or urbanization), 3313 ha (10.7%) are covered in dense stands (>25% canopy cover) of invasive alien trees and shrubs, and another 10 184 ha (32.9%) is lightly invaded (<25% canopy cover; Fig. 3; Table 5). Vegetation types with the largest parts of their remaining area under dense stands of aliens are coastal scree asteraceous fynbos (46%) and dune asteraceous fynbos (32.8%), although the most extensive stands of dense aliens (1013 ha; 30.6% of the total) occur in mesic mesotrophic fynbos (Fig. 1; Table 5). The large dense stands in this vegetation type, comprising mainly *Acacia cyclops* and *Eucalyptus* spp., are affecting 23 (14.3%) of the special plant taxa on the Peninsula. *Acacia cyclops* is the most important invader in seven vegetation types (Table 5); dense stands of this species cover 2510 ha, 76% of the total area of dense alien stands. Of the 10 184 ha of lightly invaded areas, the largest area occurs in mesic mesotrophic proteoid fynbos (43.6% of the remaining area of that type). Vegetation types with more than half of their untransformed area under light infestations of alien trees and shrubs are forest and thicket, ericaceous fynbos, undifferentiated cliff communities, renosterveld and grassland, and upland restioid fynbos (Fig. 1; Table 5).

The altitude ranges and preferred vegetation types of the ten most widespread alien species are given in Table 6. All species occur over a wide range of altitudes and invade several vegetation types. Dense stands of alien plants are affecting 23 endemic, rare and

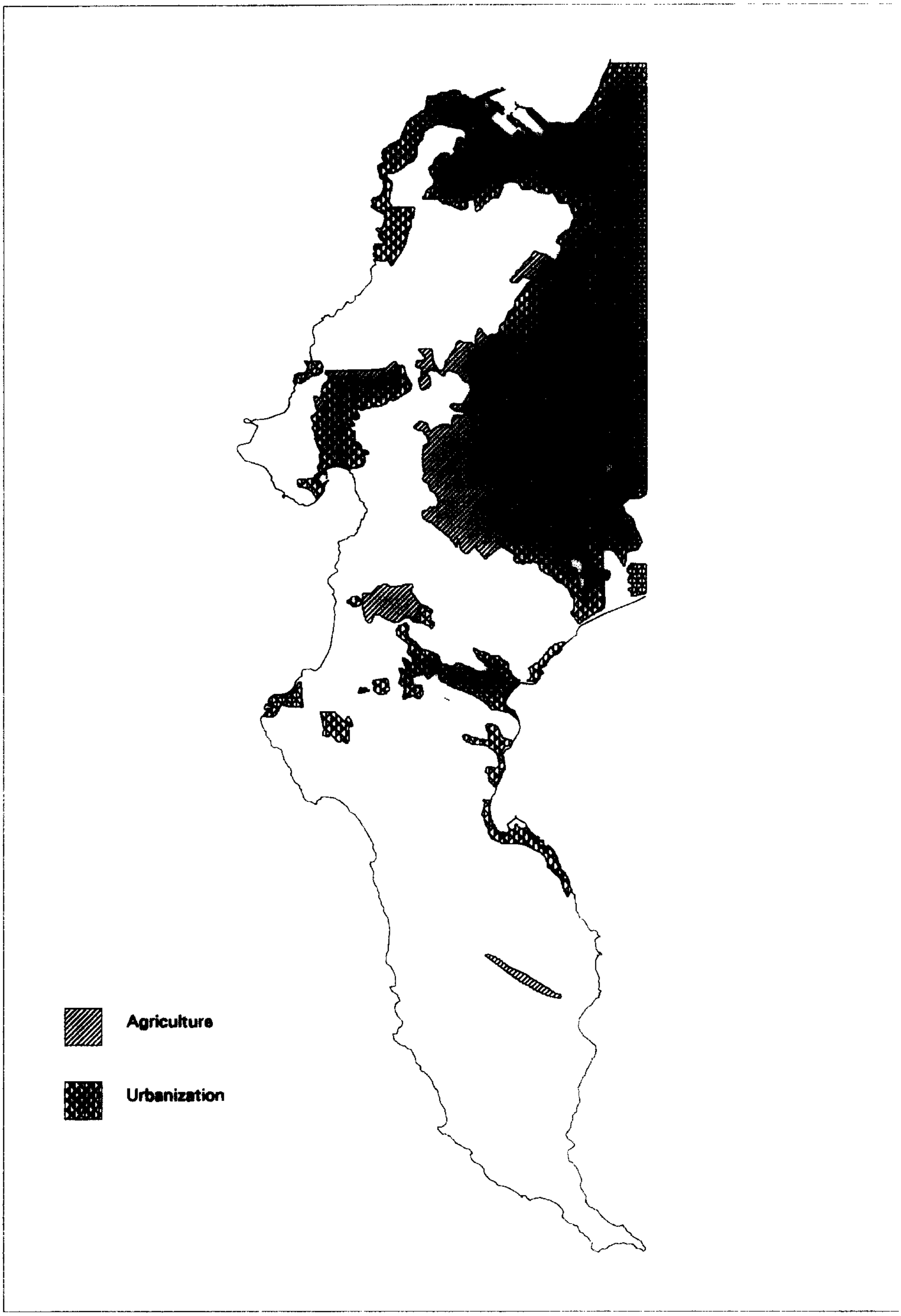


Figure 2. The current extent of urbanization and agriculture on the Cape Peninsula (see Tables 1 and 4 for details).

Table 4. The extent of urbanization and agriculture in 15 vegetation types on the Cape Peninsula in 1992 and the impact of these transformations on endemic, rare and threatened plant taxa (a taxon is deemed to be affected if urbanization or agriculture encroaches into the 1 km^2 square in which it occurs)

Vegetation type	Original area (ha)	Urbanization		Agriculture		Extent of natural vegetation remaining (ha) (% of original)
		Area (ha)	Number of endemic, rare and threatened taxa affected	Area (ha)	Number of endemic, rare and threatened taxa affected	
1. Forest and thicket (FOR)	1 315	75	0	133	0	1 107 (84.2)
2. Dune asteraceous fynbos (DUN)	4 331	2 096	26	0	0	2 235 (51.6)
3. Coastal scree asteraceous fynbos (CSA)	256	19	0	0	0	237 (92.6)
4. Wet restioid fynbos (WRF)	3 244	0	0	93	3	3 151 (97.1)
5. Ericaceous fynbos (ERI)	1 342	0	0	0	0	1 342 (100.0)
6. Sandplain proteoid fynbos (SND)	10 576	7 277	57	866	2	2 433 (23.0)
7. Mesic oligotrophic proteoid fynbos (MOP)	8 830	2	0	15	0	8 813 (99.8)
8. Mesic mesotrophic proteoid fynbos (MMP)	9 161	1 561	16	582	11	7 018 (76.6)
9. Undifferentiated cliff communities (CLF)	722	0	0	0	0	722 (100.0)
10. Wetlands (WET)	1 434	1 072	33	11	0	351 (24.5)
11. Wet oligotrophic proteoid fynbos (WOP)	1 054	0	0	24	0	1 030 (97.7)
12. Wet mesotrophic proteoid fynbos (WMP)	4 081	1 741	10	1 106	2	1 234 (30.2)
13. Renosterveld and grassland (REN)	2 419	1 428	15	2	0	989 (40.9)
14. Upland restioid fynbos (URF)	149	0	0	0	0	149 (100.0)
15. Vleis (VLE)	213	69	3	0	0	144 (67.6)
TOTAL	49 127	15 340		2 832		30 955 (63.0)

Table 5. The extent of dense (>25% canopy cover) and light stands (<25% canopy cover) of alien trees and shrubs (including pine plantations) in 15 vegetation types on the Cape Peninsula in 1994, and the number of endemic, rare and threatened plant taxa affected by such stands. Numbers in brackets are areas invaded expressed as percentages of the area remaining (i.e. not affected by urbanization and agriculture) for each vegetation type

Vegetation type	Area remaining (ha)	Area invaded (ha)		Endemic and threatened taxa			Major alien species (in order of importance)
		Dense (%)	Light (%)	Dense	Light	Uninvaded	
1. Forest and thicket (FOR)	1 107	181 (16.4)	720 (65.0)	1	20	4	*Acacia cyclops, Pinus radiata, Eucalyptus* spp., *P. pinaster, E. lehmannii*
2. Dune asteraceous fynbos (DUN)	2 235	733 (32.8)	358 (16.0)	5	9	21	*Acacia cyclops, A. saligna, Eucalyptus* spp., *E. lehmannii, Pinus radiata*
3. Coastal scree asteraceous fynbos (CSA)	237	109 (46.0)	57 (24.1)	2	5	1	*Acacia cyclops*
4. Wet restioid fynbos (WRF)	3 151	16 (0.5)	445 (14.1)	2	14	36	*Eucalyptus* spp., *E. lehmannii, Acacia longifolia, Pinus pinaster, P. pinea*
5. Ericaceous fynbos (ERI)	1 342	0.2 (0.0)	814 (60.7)	0	34	17	*Pinus radiata, P. pinaster, Eucalyptus* spp.
6. Sandplain proteoid fynbos (SND)	2 433	464 (19.1)	875 (36.0)	4	9	18	*Acacia cyclops, Eucalyptus* spp., *Leptospermum laevigatum, Populus* spp., *A. saligna*
7. Mesic oligotrophic proteoid fynbos (MOP)	8 813	468 (5.3)	1 601 (18.2)	19	31	99	*Pinus pinaster, Acacia cyclops, A. longifolia, Eucalyptus* spp., *P. pinea*
8. Mesic mesotrophic proteoid fynbos (MMP)	7 018	1 013 (14.4)	3 062 (43.6)	23	54	45	*Acacia cyclops, Eucalyptus* spp., *A. saligna, Pinus radiata, P. pinaster*
9. Undifferentiated cliff communities (CLF)	722	35 (4.8)	447 (62.0)	2	19	10	*Acacia cyclops, Pinus pinaster, Eucalyptus* spp.
10. Wetlands (WET)	351	33 (9.4)	43 (12.3)	0	0	1	*Acacia cyclops, Eucalyptus* spp.
11. Wet oligotrophic proteoid fynbos (WOP)	1 030	0.4 (0.0)	408 (39.6)	0	14	21	*Acacia saligna, Pinus radiata, Eucalyptus* spp., *A. cyclops, P. pinaster*
12. Wet mesotrophic proteoid fynbos (WMP)	1 234	154 (12.5)	568 (46.0)	4	11	13	*Pinus radiata, Eucalyptus* spp., *Acacia saligna, Pinus pinaster, A. cyclops, Paraserianthes lophantha*
13. Renosterveld and grassland (REN)	989	107 (10.8)	637 (64.4)	1	15	2	*Eucalyptus* spp., *Acacia cyclops Pinus pinaster, P. pinea*
14. Upland restioid fynbos (URF)	149	0 (0)	149 (100)	0	15	0	–
15. Vleis (VLE)	144	0 (0)	0 (0)	0	0	2	–
TOTAL	30 955	3 313.6	10 184				

threatened taxa in mesic mesotrophic proteoid fynbos, and 19 in mesic oligotrophic proteoid fynbos (Table 5).

THE COMBINED EFFECT OF URBANIZATION, AGRICULTURE AND ALIEN TREES AND SHRUBS

The area currently not affected by agriculture, urbanization or dense stands of alien plants (Fig. 4) amounts to 27 642 ha, or 56.3% of the original extent of natural vegetation. The largest areas of pristine vegetation (i.e. that unaffected by alien trees and shrubs, agriculture and urbanization) occur in mesic oligotrophic proteoid fynbos, wet restioid fynbos, mesic mesotrophic fynbos and dune asteraceous fynbos (Fig. 1), all types with higher than average numbers of endemic and threatened plant taxa (Table 3).

PREDICTED IMPACT OF URBANIZATION AND AGRICULTURE ON PLANT BIODIVERSITY

Increased levels of urbanization result in a steady (more-or-less linear) loss of biodiversity. In 1992, all records for 6.6% of the special taxa occurred in 1 km^2 squares that are already affected by urbanization (Fig. 5A; Appendix 1), and 5.3% of Proteaceae taxa were similarly affected (Fig. 5E); these taxa are seriously threatened. For 42.5% of special taxa and 34.2% of Proteaceae, no mapped localities are currently affected by urbanization. For 86% of the special taxa more than half of the localities are in 1-km^2 squares that are not currently affected by urbanization. All but two of the Proteaceae taxa also have half or more of their range unaffected by urbanization. A scenario of full urbanization outside the CPPNE (U1) results in an 11.4% reduction in the extent of natural vegetation, with sandplain proteoid fynbos (21.5%) and wetlands (36.5%) being worst affected (Fig. 6A; Table 7). Some 26.9% of localities of special taxa (2.9% for Proteaceae) are affected; for 7.8% of special taxa and 5.3% of Proteaceae all known localities are urbanized (Fig. 5, B and F). The percentage of special taxa with more than half of their known localities affected increases from 13.8% to 17.4%; for the Proteaceae the number of taxa thus affected remains unchanged. Scenario U2 (complete urbanization on suitable areas outside public land) leads to further deterioration, reducing the extent of natural vegetation to 24 681, or 79.7% of the area remaining in 1994. Under this scenario, sandplain proteoid fynbos occupies only 842 ha (8% of its extent before human settlement)(Fig. 6B). Just less than half of the special taxa lose 50% or more of their known localities to urbanization, with 8.4% of them now occurring *only* in squares affected by urbanization. The additional habitat loss brought about by scenario U2 (most of it involving loss of vegetation types DUN, SND, MOP and MMP; Fig. 6A) affects 78 Proteaceae localities, but still only 2 taxa (*Diastella divaricata divaricata* and *Leucadendron levisanus*) have 100% of their range affected (Appendix 2). 57.4% of known localities of the 161 special taxa, and 40.1% of Proteaceae localities, are affected by urbanization under scenario U3 which involves development of all suitable areas, irrespective of land ownership (Fig. 5, D and H); this scenario sees the natural vegetation reduced to only 39.3% of its extent in 1994, with dune asteraceous fynbos, wet restioid fynbos, sandplain proteoid fynbos (vegetation types with many endemic and threatened taxa; Table 3) and wetlands being almost totally transformed (Fig. 6, A and B). Under this scenario almost a quarter of special taxa are confined totally to urban areas or areas within less than 1 km of such developments – 24 more taxa than under scenario U2. All mapped

Figure 3. The distribution of alien woody plants on the Cape Peninsula in 1994. (Black = dense stands; >25% canopy cover; grey = lightly invaded areas; <25% canopy cover.) See Table 5 for details on areas of each vegetation type invaded, the most important invaders in each vegetation type, and the number of special taxa threatened by aliens in each vegetation type. Profiles for the ten most widespread aliens are given in Table 6.

Table 6. Profiles for the ten most widespread alien woody species in terms of altitude and vegetation type (see text)

Species	Area of dense stands (ha)	Altitude range (m above sea level)	Vegetation types (numbers refer to types in Table 3)
Acacia cyclops	2510	1–573	1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13
Eucalyptus spp. (excluding *E. lehmannii*)	1121	14–588	1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Pinus radiata	908	52–614	1, 2, 5, 6, 7, 8, 11, 12, 13
Pinus pinaster	568	18–955	1, 4, 5, 6, 7, 8, 9, 11, 12, 13
Acacia saligna	507	20–427	1, 2, 6, 7, 8, 11, 12, 13
Pinus pinea	240	40–319	1, 4, 6, 7, 8, 12, 13
Acacia longifolia	236	32–588	1, 4, 6, 7, 8, 12
Leptospermum laevigatum	201	40–300	6, 7, 8, 13
Eucalyptus lehmannii	201	1–329	1, 2, 4, 7, 8
Hakea gibbosa	131	110–414	6, 7, 8

localities for four Proteaceae taxa (*Diastella divaricata divaricata*, *Leucadendron floridum*, *L. levisanus* and *L. macowanii*) are urbanized.

All but four of the 15 vegetation types (ERI, CLF, WOP and URF) will lose a large part of their area under the three urbanization scenarios described here (Fig. 6A; Table 7). Another four types (DUN, WRF, MOP and MMP) lose major parts of their area only under the worst-case scenario (U3).

PREDICTED IMPACT OF INVASIVE ALIEN PLANTS ON PLANT BIODIVERSITY

The 3313 ha of dense alien stands in 1994 affect 349 (29.8%) of the 1170 localities of special taxa known from herbarium records, and 8.4% of these taxa currently occur only in areas already affected by aliens. Dense alien stands affect 30 of the 38 Proteaceae taxa in part of their range, and the entire range (as shown from our records) for two species (*Diastella proteoides* and *Leucadendron levisanus*) are already affected (Appendix 2). However, more than half of the (recent) records for 35 of the 38 Proteaceae taxa are in areas that are not currently affected by dense alien stands. Clearing of all dense alien stands (with concomitant invasion of all other potential sites; scenario A1) would result in 62.9% of special taxa having less than half of their known localities affected by dense stands (49.1% at present). Under this scenario, 92% of Proteaceae taxa have more than 75% of their localities unaffected by aliens. The vegetation types that would benefit most from this scenario are coastal scree asteraceous fynbos and dune asteraceous fynbos; realization of this scenario would result in 96% and 49% increases in the extent of uninvaded areas of these types, and a 12% increase in the total extent of natural vegetation not under dense stands of aliens (Table 7). If funds allow alien control only within the CPPNE (but invasion continues outside this area; scenario A2), the total area of vegetation not under dense stands would remain virtually the same as it is at present, with the area under uninvaded vegetation increasing for some types (notably CSA and FOR) and shrinking for others (notably SND and WET; Table 7). Scenario A3, whereby control efforts are confined to publicly-owned land, sees the shrinkage of the total area under uninvaded vegetation to 82.4% of its current extent, with marked reductions in the extent of most vegetation types. Only types CSE and CLF would benefit under this scenario. Scenario A4 which sees the collapse of control programmes and the rampant spread of the aliens to all potential sites

Figure 4. The extent of natural vegetation on the Cape Peninsula in 1994 (land unaffected by urbanization, agriculture and dense stands of aliens). This area includes lightly invaded areas.

results in the annihilation of the vegetation, with only 407 ha (1.5% of the current area) remaining.

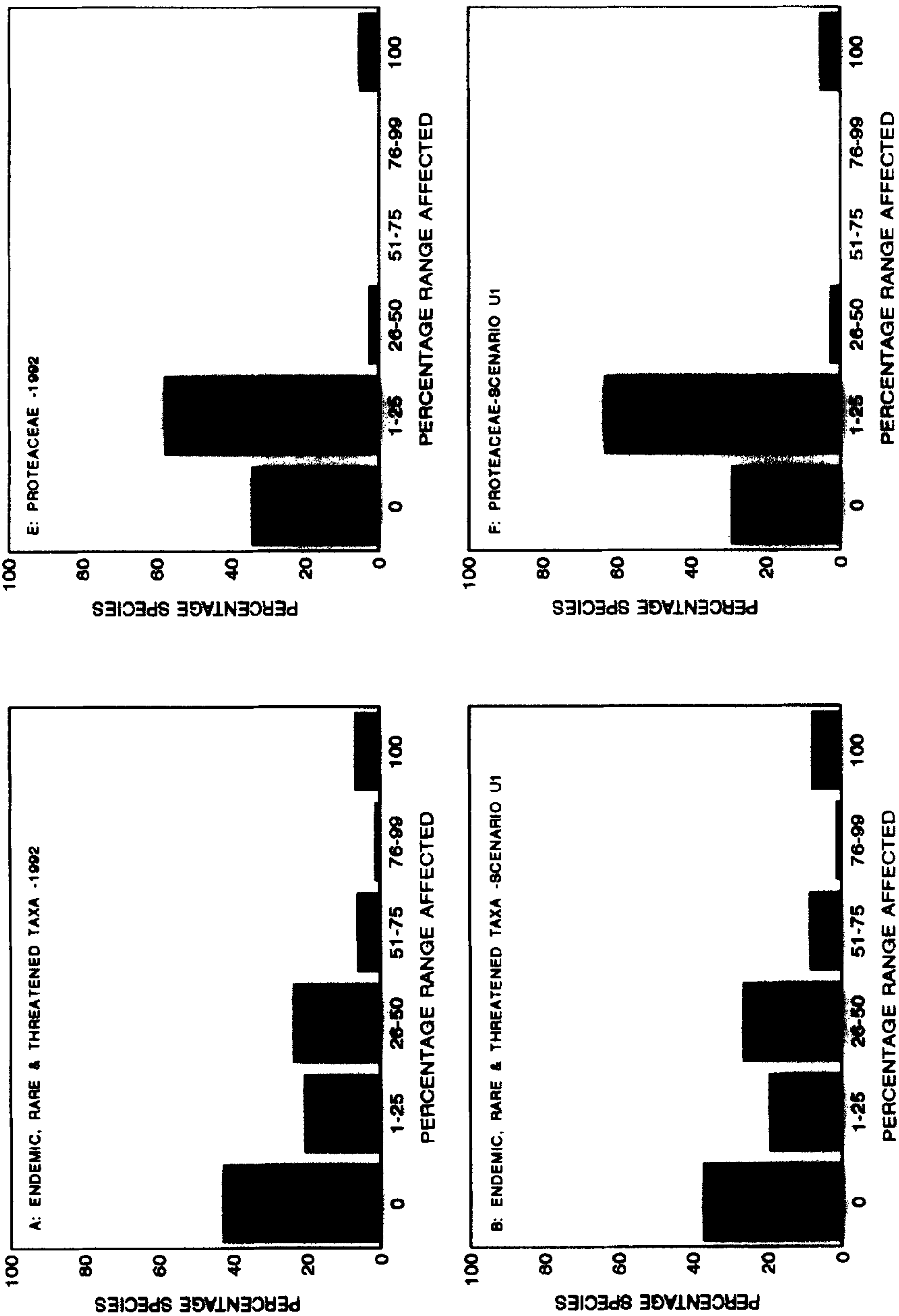
The impacts on special taxa and the Proteaceae under scenarios A2, A3 and A4 are summarized in Fig. 7, and details for each taxon are given in Appendices 2 and 3. The worst-case scenario (A4) results in about a quarter of special taxa and more than 15% of Proteaceae species being confined entirely to densely invaded sites, with most other taxa having large parts of their ranges affected. Species that are currently common and widespread will lose large parts of their range.

Discussion

The Cape Peninsula has already lost a considerable part of the natural vegetation (and therefore biodiversity) that existed in the area at the time of European settlement. Large areas of lowland vegetation have, as in other parts of the Cape Metropolitan Area (Wood *et al.*, 1994), been transformed. Lowland vegetation types, including renosterveld, dune fynbos and sandplain proteoid fynbos, have also been severely impacted in other parts of the Western Cape (Moll and Bossi, 1984; Rebelo, 1992). The rugged topography of the Peninsula has limited the extent of urbanization and agriculture, and the bulk of the remaining vegetation occurs in the mountains, although much of this is threatened by alien trees and shrubs. In this respect, the situation on the Peninsula reflects that of the entire fynbos biome, where most remaining natural vegetation is in the mountains (see Rebelo, 1992 for details).

It is extraordinary, given the extent of transformation of natural vegetation and the fact that many fynbos plant species have small population sizes that are restricted to small areas, that only 39 plant taxa are known to have become extinct on the Peninsula during the 20th century. The extent of recent (post-1900) plant extinctions on the Peninsula (1.7% of the flora) is, however, higher than that for the entire fynbos biome (26 species out of 7300 = 0.36%; Hall and Veldhuis, 1985). Although only 39 taxa have become extinct on the Peninsula, many others now occur over much smaller areas, and have therefore lost much of their genetic diversity. Many taxa now occur in small scattered populations which are separated by tracts of transformed land and are subjected to levels of disturbance to which they are not pre-adapted (e.g. fires at short intervals). The nature and magnitude of the disruptions of essential processes caused by fragmentation have not been studied in any detail. Different taxa respond differently to fragmentation and the other consequences of the threats described in this paper. We therefore do not know exactly how serious (for its continued existence) it will be for a given taxon to lose, for example, 50, 75, or 99% of its current range. It is clear, however, that the likelihood of a taxon becoming extinct increases as populations become smaller and more isolated. Many plant taxa on the Cape Peninsula are critically threatened (see Trinder-Smith *et al.*, 1996a). It follows that major losses in biodiversity will occur on the Cape Peninsula (and throughout the fynbos biome) if urbanization and the area under alien plants are allowed to increase.

The scenarios of changing threats to biodiversity discussed in this paper are a small subset of the possible consequences of changes in the socio-political events that control patterns of urbanization and of the economic and ecological factors that influence the extent of alien plant invasions. We modelled the impacts of changes in urbanization and alien plant invasions separately to keep the patterns interpretable, but these two factors will change together. Nevertheless, the scenarios are useful for assessing the magnitude of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F: PROTEACEAE-SCENARIO U1
A: ENDEMIC, RARE & THREATENED TAXA -1992
B: ENDEMIC, RARE & THREATENED TAXA -SCENARIO U1
PERCENTAGE SPECIES
PERCENTAGE RANGE AFFECTED
0
1-25
26-50
51-75
76-99
100
0
20
40
60
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100

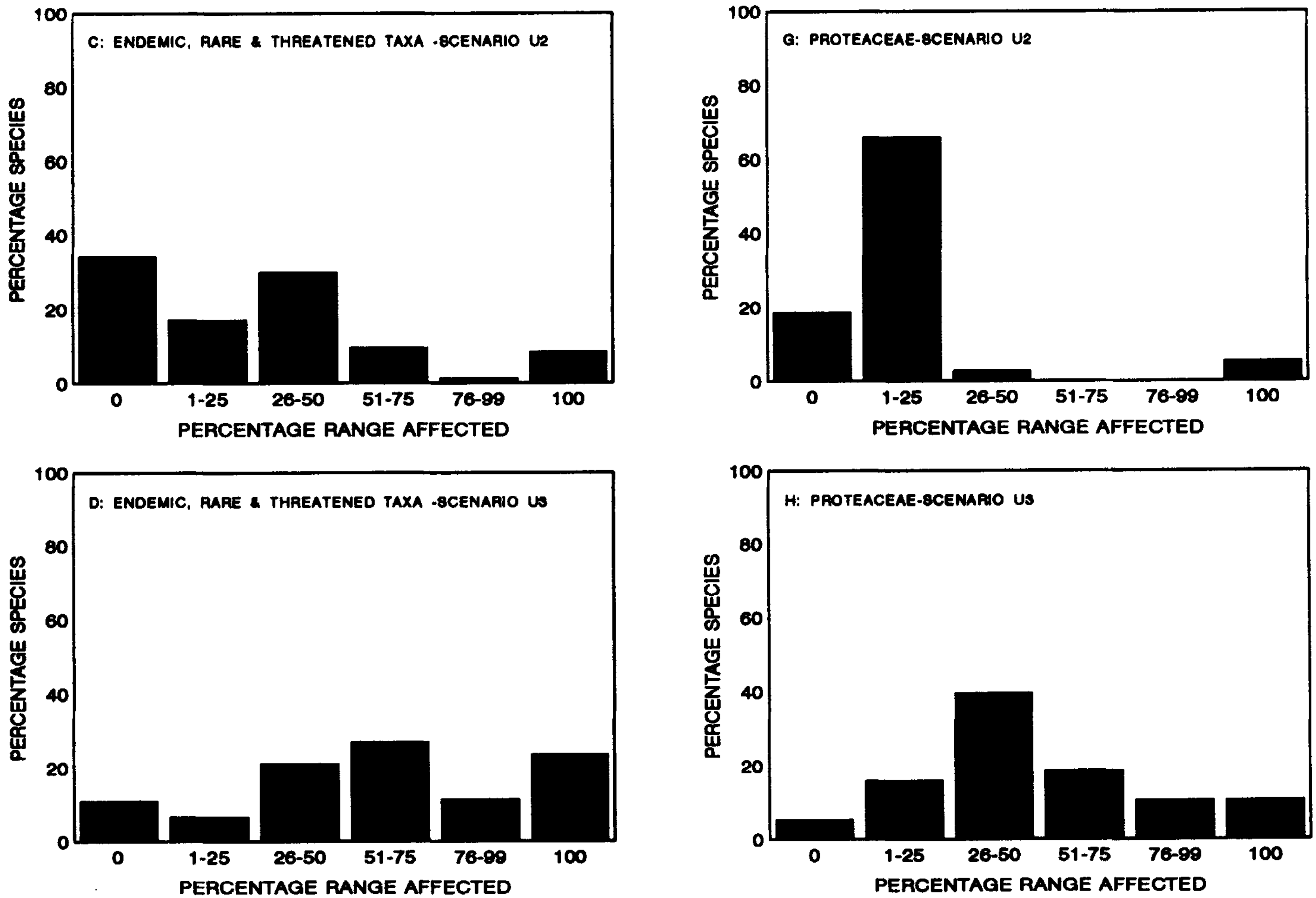


Figure 5. The current impact of urbanization on endemic, rare and threatened taxa (A) and Proteaceae taxa (E), and predicted impacts under three scenarios of urban spread (B–D and F–H) (see Table 2 for descriptions of scenarios).

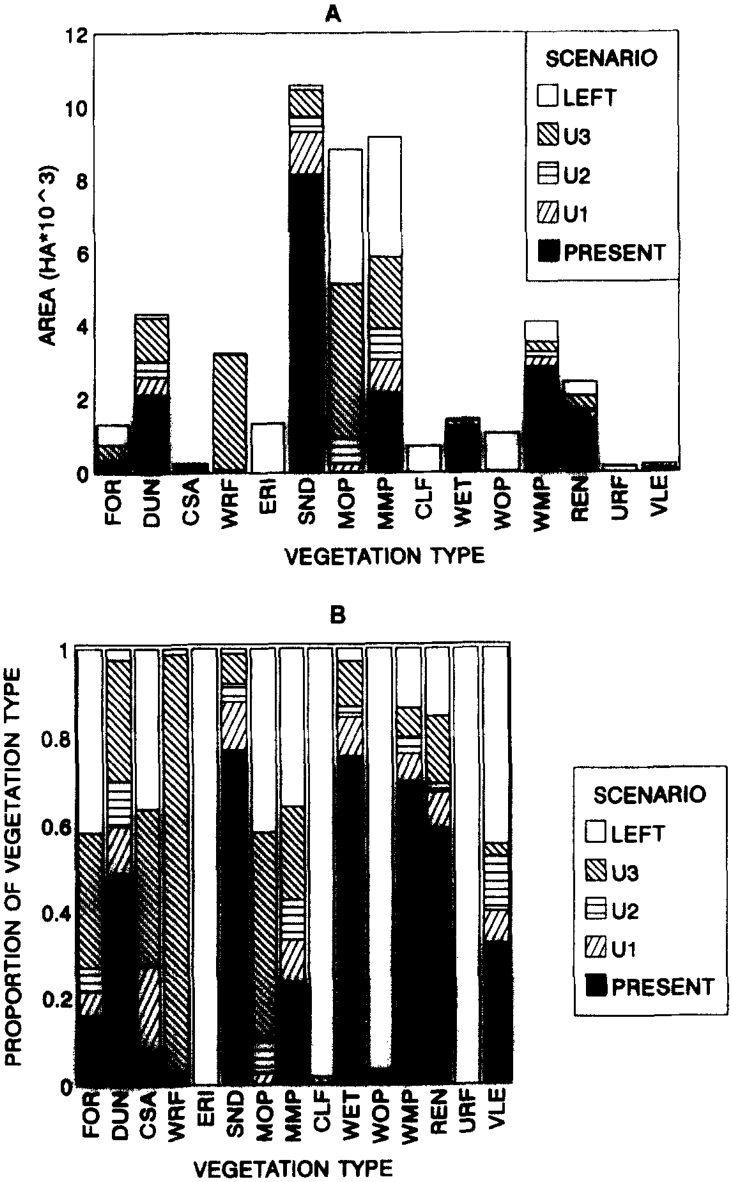
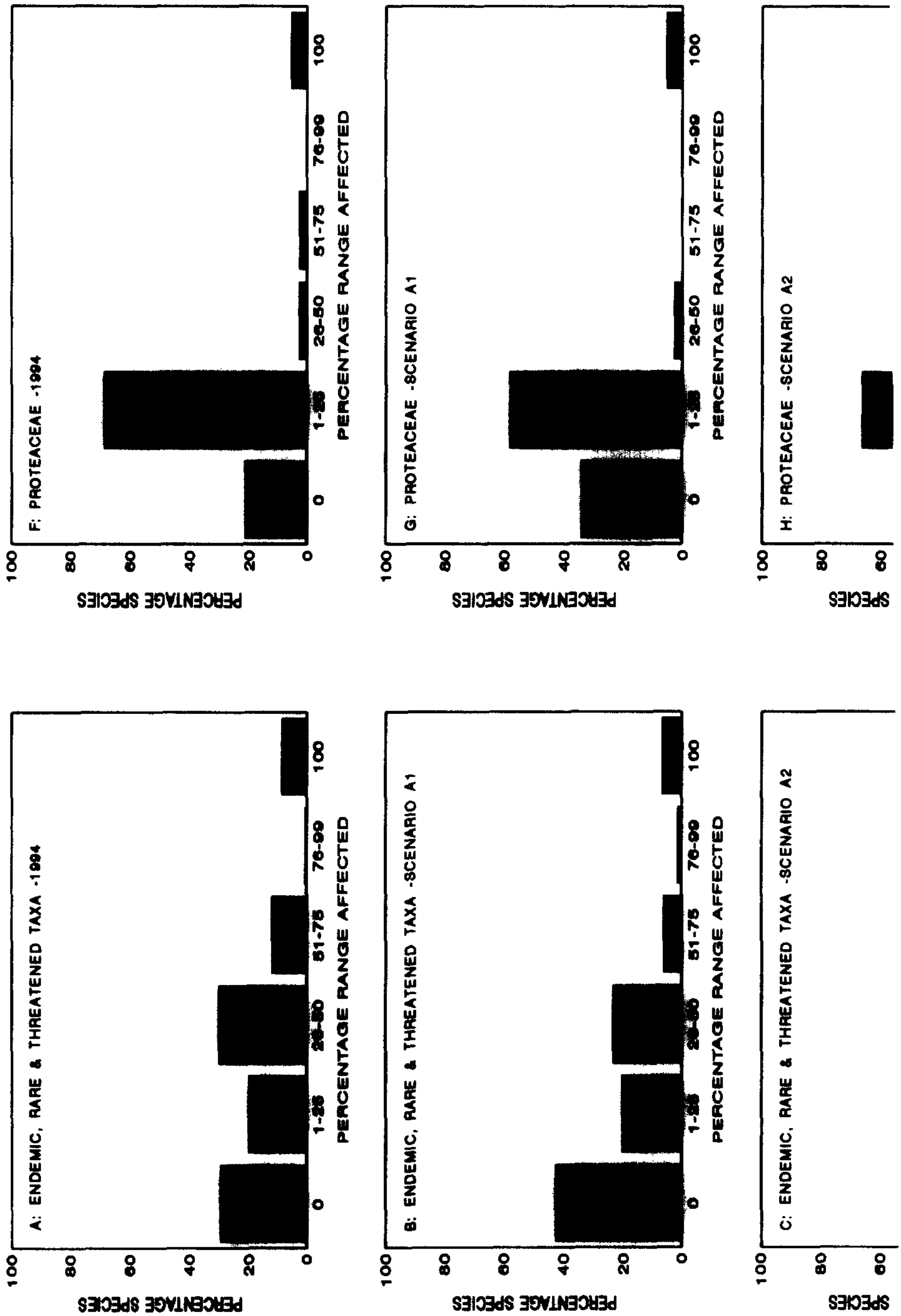


Figure 6. The original extent of 15 vegetation types on the Cape Peninsula and areas currently affected by urbanization (PRESENT) and the predicted extent of urbanization in each under three scenarios (see Table 2). (A) areas (ha). (B) Proportions of total areas affected. Codes for vegetation types refer to those in Table 3.

changes that are likely if certain policy decisions are taken, or if the other eventualities detailed in Table 2 materialize. Increasing urbanization has a steady effect on biodiversity (the linear increase in impacts being the result of limits sets by environmental features and planning) whereas the spread of alien plants is exponential (since the major invaders can colonize almost all habitats and there is virtually no control on population growth).

Table 7. The area of each of 15 vegetation types remaining unaltered under seven scenarios relating to the spread of urbanization and the various control/spread possibilities for invasive alien trees and shrubs on the Cape Peninsula (see Table 2 for details of the scenarios). Note that the areas remaining given for the urbanization scenarios exclude areas under dense alien stands, since these areas are available for urbanization. Numbers in brackets under column totals are the total areas expressed as a percentage of the area remaining in 1994

Vegetation type	Area of each vegetation type remaining under three scenarios relating to urbanization (see table 2)				Area of each vegetation type remaining under four scenarios relating to the spread of invasive alien plants (see Table 2)				
	Area remaining	Sc. U1	Sc. U2	Sc. U3	Area remaining	Sc. A1	Sc. A2	Sc. A3	Sc. A4
Forest and thicket (FOR)	1107	1034	961	548	926	1106	1031	900	1
Dune asteraceous fynbos (DUN)	2235	1733	1295	108	1502	2235	1733	1273	82
Coastal scree asteraceous fynbos (CSA)	237	186	185	93	128	237	178	176	2
Wet restioid fynbos (WRF)	3151	3151	3151	42	3135	3151	3151	3149	0
Ericaceous fynbos (ERI)	1342	1342	1342	1342	1342	1342	1342	1342	33
Sandplain proteoid fynbos (SND)	2433	1272	842	124	1969	2434	1270	816	4
Mesic oligotrophic proteoid fynbos (MOP)	8813	8581	7899	3681	8345	8813	8511	7000	0
Mesic mesotrophic proteoid fynbos (MMP)	7018	6107	5260	3286	6005	7019	6065	4554	4
Undifferentiated cliff communities (CLF)	722	722	720	709	687	722	722	706	17
Wetlands (WET)	351	223	189	41	318	351	223	189	18
Wet oligotrophic proteoid fynbos (WOP)	1030	1029	1019	1019	1030	1029	1029	924	1
Wet mesotrophic proteoid fynbos (WMP)	1234	975	825	554	1080	1234	975	775	11
Renosterveld and grassland (REN)	989	787	742	372	882	989	786	730	1
Upland restioid fynbos (URF)	149	149	149	149	149	149	149	149	138
Vleis (VLE)	144	128	101	95	144	144	128	101	95
TOTAL	30955	27419 (88.6%)	24680 (79.7%)	12163 (39.3%)	27642	30955 (112.0%)	27293 (98.7%)	22784 (82.4%)	407 (1.5%)



F: PROTEACEAE -1994
G: PROTEACEAE -SCENARIO A1
H: PROTEACEAE -SCENARIO A2
A: ENDEMIC, RARE & THREATENED TAXA -1994
B: ENDEMIC, RARE & THREATENED TAXA -SCENARIO A1
C: ENDEMIC, RARE & THREATENED TAXA -SCENARIO A2
PERCENTAGE SPECIES
PERCENTAGE RANGE AFFECTED
0
1-25
26-50
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76-99
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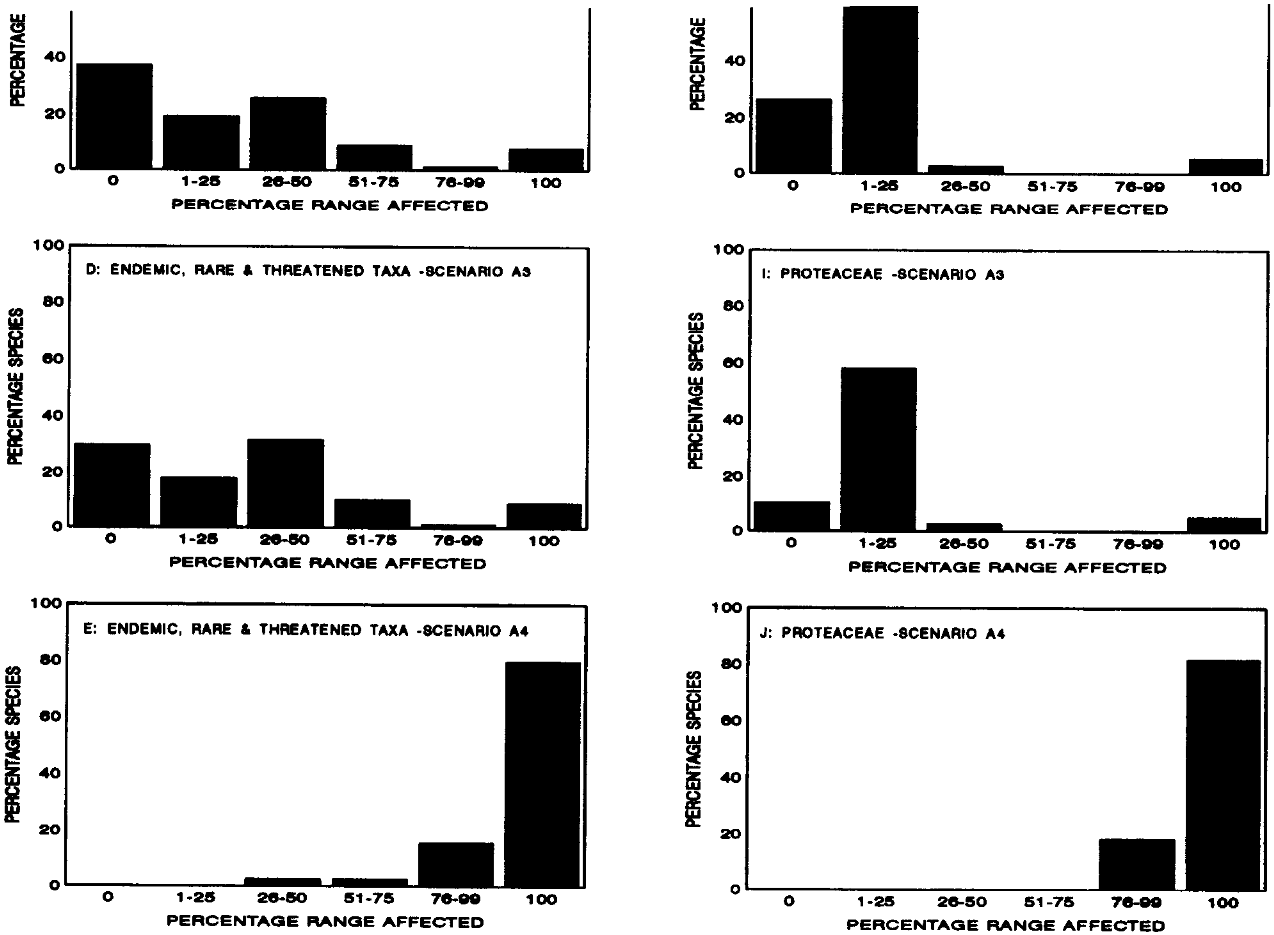

Figure 7. The current impact of dense stands of invasive alien plants on endemic, rare and threatened taxa (A) and Proteaceae taxa (E), and predicted impacts under four scenarios of control/spread (see Table 2 for descriptions of scenarios).

Invasive alien plants almost certainly pose the greatest threat to biodiversity, since new structure plans entrench the status of the CPPNE and this should prevent the encroachment of urbanization into the area (although this could change). At present, 10 184 ha (36.9%) of remaining vegetation (that not affected by urbanization, agriculture or dense alien stands) is lightly invaded. Research in other parts of the fynbos biome has shown that lightly invaded areas, and even areas totally free of aliens, can become densely invaded over two or three fire cycles (Richardson and Brown, 1986). The lightly invaded vegetation, with its many endemic, rare and threatened taxa (Table 5) is, therefore, by no means safe from the influence of invasive alien plants. It is much easier and cheaper to clear aliens before stands become dense, and control programmes should give priority to clearing these areas and keeping them free of aliens. The information gathered for this study can be used to establish priorities for controlling dense stands using objective criteria related to the various indices of biodiversity. For example, we can rank densely invaded areas according to their impact on a particular vegetation type, a particular species, or on any of a number of indices of the overall biodiversity. But there are many unknowns. For example, we have assumed that the pressure on biodiversity is annulled if dense alien stands are cleared. In other parts of the fynbos biome clearance of dense stands of alien trees and shrubs using mechanical felling and burning (which is usually the only practical option) has caused further damage, for example by changing the physical structure of the soil and eliminating those resprouting species that usually persist under dense stands (Richardson and van Wilgen, 1986; Breytenbach, 1989). Research is currently underway to assess the biodiversity under dense stands of different ages and in cleared areas, and to determine ways of clearing dense stands of aliens with the least possible damage to the remaining biodiversity (P.M. Holmes, pers. comm.). The clearing of alien plants is an urgent priority for the Cape Peninsula. A major injection of funds is required to support an integrated programme of alien plant control.

This study has emphasized the importance of considering the impact of the various threats on widespread species, and not just the 'special' taxa. Many plant taxa on the Peninsula (Simmons and Cowling, 1996) and elsewhere in the fynbos biome (Hall and Veldhuis, 1985) are fairly widespread overall, but occur as small scattered populations which are often associated with rare or otherwise peculiar habitats (Cowling and Holmes, 1992). If transformation destroys special habitats, then local (and total, for 'beta rares' *sensu* Cody, 1986) extinction is inevitable. More research is required on all aspects of rarity in the Peninsula flora (see also Simmons and Cowling, 1996).

Changes to the fire regime also pose an important threat to the Peninsula's biodiversity since fynbos ecosystems are fire-prone and fire-dependent (van Wilgen *et al.*, 1990). Before human settlement of the area, the fire regime would probably have comprised fires of moderate intensity at intervals of between 6 and 40 years, usually in summer or early autumn, but with occasional fires in other seasons (van Wilgen, 1987). A number of factors have altered this regime, including fragmentation of the vegetation, the introduction of fire protection policies and artificial sources of ignition, and changes in fuel loads brought about by invasive alien trees and shrubs.

There are no data for constructing a meaningful picture of the current or historic fire regimes on the Peninsula. Fire records are only kept for the Table Mountain, Silvermine and Cape of Good Hope Nature Reserves, and these have only been kept for the past 15 or 20 years. An analysis of the situation on Table Mountain (Richardson *et al.*, 1994) showed that the vegetation was largely mature (57% had a post-fire age of greater than 20 years).

Almost all recorded fires took place in January, and only 5% of the area burnt between May and October. The age at which vegetation burned could not be accurately determined, as the dates of previous fires were unknown for many sites.

Changes to the fire regime on the Peninsula may threaten biodiversity in several ways: increases or decreases in fire frequency, or changes in fire behaviour and intensity brought about by the invasion by alien trees and shrubs. In the first instance, short fire intervals may eliminate species that are killed by fire and rely on seed to reproduce. On the other hand, long intervals between fires eliminate species with short lifespans that rely on fire to trigger seed release and germination (van Wilgen *et al.*, 1992). There is no evidence that any such cases have occurred on the Peninsula to date. Although fire protection and fragmentation of the landscape could have resulted in decreases in fire frequency, increases in the human population and development may have counteracted this by providing additional sources of ignition. Public resistance to an orderly implementation of a programme of prescribed burning may also represent a significant threat; at present very few prescribed burns are conducted on the Peninsula. Mechanical clearing in conjunction with prescribed burning is the only practical way to clear dense stands of most of the major aliens on the Peninsula (Richardson *et al.*, 1996). The failure, due to public pressure, to maintain a systematic programme of prescribed burning means that alien control efforts are wasted, since every wildfire burns through untreated alien stands, resulting in further proliferation and spread. Another fire-related threat to biodiversity is caused by the increases in fuel loads brought about by alien plants. In some areas, these increased fuel loads have been shown to result in substantial increases in fire intensity, inducing water repellant layers in the soil and increasing runoff (Scott and van Wyk, 1990). This phenomenon has been held responsible for increases in erosion following fires on Table Mountain, for example (Scott *et al.*, 1991). van Wilgen *et al.* (1992) discussed the possible impacts of global climate change on elements of fynbos biodiversity under various scenarios. They suggest that the impacts will be greatest on the lowlands, where seed-regenerating shrubs are likely to be most severely threatened.

Conclusions

The Cape Peninsula has already lost a large part of its biodiversity. Without intervention and careful planning the situation will deteriorate rapidly. This study has shown the need to stabilize and defend the boundary of the Cape Peninsula Protected Natural Environment (CPPNE). No urbanization should be permitted within its boundaries and a major injection of funds is required to support an integrated programme of alien plant control. The 10 184 ha of lightly invaded vegetation should be tackled before the 3313 ha of densely invaded vegetation (because less dense stands are easier and cheaper to control, and control at this stage removes the aliens before the major damage is caused). Table 5 provides an objective basis for allocating priority for such control measures. Contingency measures need to be implemented to improve the status of seriously threatened taxa, habitats and vegetation types.

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Appendix 1. The impact of three scenarios of urbanization on 161 endemic, rare and threatened plant taxa on the Cape Peninsula. Localities were mapped at a resolution of 1-km^2 squares; a locality was considered affected if urbanization encroaches into that square. Nomenclature follows the Bolus Herbarium, University of Cape Town

Family	Species	Status of species	Total number of 1 km^2 squares	Number of 1 km^2 squares affected under three scenarios of urbanization			
				Present situation (1994)	Scenario U1	Scenario U2	Scenario U3
Apiaceae	*Apium inundatum*	rare, threatened	3	1	1	1	1
Asteraceae	*Athanasia capitata*	threatened	10	2	3	3	4
	Cotula myriophylloides	endemic, threatened	5	0	1	1	3
	Gerbera wrightii	endemic, threatened	14	0	0	0	9
	Senecio foeniculoides	threatened	5	0	0	0	2
	Stoebe rosea	endemic	13	4	4	4	6
	Ursinia tenuifolia	rare, threatened	16	3	3	4	5
Brassicaceae	*Heliophila cinerea*	endemic, threatened	6	1	2	2	3
	Heliophila pusilla	endemic	6	4	4	4	5
	Heliophila tabularis	endemic, rare, threatened	1	0	1	1	1
Bruniaceae	*Audouinia capitata*	rare, threatened	12	4	4	4	7
	Staavia dodii	endemic, threatened	5	1	2	2	4
	Staavia dregeana	rare, threatened	9	4	4	4	6
	Staavia glutinosa	endemic, threatened	11	9	9	9	10
Campanulaceae	*Roella goodiana*	endemic, rare, threatened	2	0	0	2	2
	Wahlenbergia ciliolata	threatened (possibly extinct)	6	3	3	3	5
Cyperaceae	*Ficinia micrantha*	endemic, rare, threatened	2	2	2	2	2
	Ficinia pygmaea	rare, threatened	1	1	1	1	1
	Isolepis inconspicua	rare, threatened	1	1	1	1	1
	Schoenoxiphium ecklonii	threatened	8	3	3	3	5
	Scirpus delicatulus	rare, threatened	2	0	0	0	1
	Tetraria brachyphylla	endemic, threatened	8	0	0	0	3
	Tetraria compacta	threatened	6	1	2	2	2
	Tetraria paludosa	endemic, rare, threatened	2	0	0	0	0
	Trianoptiles solitaria	rare, threatened	3	0	0	0	1
	Trianoptiles stipitata	threatened	1	0	0	0	1

Ericaceae	*Erica amoena*	endemic, threatened	11	2	2	3	6
	Erica annectens	endemic, threatened	10	3	4	4	6
	Erica blancheana	endemic, threatened	6	4	5	5	5
	Erica capensis	endemic, threatened	12	5	6	6	12
	Erica capitata	threatened	13	3	3	3	10
	Erica clavisepala	endemic, threatened	10	0	0	0	2
	Erica crenata	endemic	12	0	0	0	9
	Erica cyrilliflora	endemic, threatened	7	2	2	2	6
	Erica eburnea	endemic, threatened	8	3	3	3	6
	Erica empetrina	endemic	10	0	0	0	1
	Erica fairii	endemic, threatened	7	0	0	0	7
	Erica ferrea	threatened	17	3	3	3	10
	Erica fontana	endemic, threatened	11	1	1	2	9
	Erica genistifolia	endemic	10	0	0	0	2
	Erica gilva	endemic, threatened	6	0	1	1	1
	Erica haematocodon	endemic	10	4	5	5	8
	Erica heleogena	rare, threatened	2	1	1	1	1
	Erica inops	endemic	10	5	5	5	10
	Erica limosa	endemic, threatened	6	1	1	1	6
	Erica margaritacea	threatened	4	1	1	1	3
	Erica marifolia	endemic, threatened	11	0	0	0	2
	Erica nevillei	endemic	8	0	0	0	0
	Erica paludicola	endemic, rare, threatened	1	0	0	0	0
	Erica patersonia	rare, threatened	4	0	0	0	0
	Erica physodes	endemic	11	0	0	0	0
	Erica pilulifera	endemic, threatened	7	0	0	0	2
	Erica pulchella	endemic	6	4	4	4	4
	Erica pulchella var. major	endemic, rare, threatened	18	0	0	1	4
	Erica pyxidiflora	endemic	23	0	1	2	6
	Erica quadrisulcata	endemic, rare, threatened	4	0	0	0	1
	Erica salteri	endemic, rare, threatened	1	0	0	0	1
	Erica sociorum	endemic, rare, threatened	1	0	0	0	0
	Erica turgida	endemic, rare, threatened	5	3	3	3	3
	Erica urna-viridis	endemic	4	2	2	2	4
Eriospermaceae	*Eriospermum pumilum*	rare, threatened	3	1	1	1	2
	Eriospermum stoloniferum	rare, threatened	1	0	0	0	1
Fabaceae	*Aspalathus borboniifolia*	endemic, rare, threatened	4	0	0	1	3

Appendix 1. (*Continued*)

Family	Species	Status of species	Total number of 1 km² squares	Number of 1 km² squares affected under three scenarios of urbanization			
				Present situation (1994)	Scenario U1	Scenario U2	Scenario U3
	Aspalathus capitata	endemic, threatened	12	6	6	6	8
	Aspalathus globulosa	rare, threatened	2	0	0	0	0
	Aspalathus humilis	endemic, rare, threatened	4	0	0	0	0
	Aspalathus macrantha	threatened	11	0	0	0	0
	Cyclopia buxifolia	endemic, rare, threatened	1	0	0	0	0
	Cyclopia capensis	endemic, rare, threatened	2	2	2	2	2
	Melolobium aethiopicum	threatened	7	3	3	3	4
	Priestleya angustifolia	rare, threatened	1	1	1	1	1
	Priestleya laevigata	threatened	3	2	2	2	2
	Priestleya tomentosa	endemic, threatened	6	1	1	1	1
	Psoralea glaucina	endemic, rare, threatened	2	0	0	0	1
Geraniaceae	*Pelargonium ellaphieae*	rare, threatened (possibly extinct)	3	0	0	0	3
Haemodoraceae	*Dilatris corymbosa*	endemic	17	3	6	7	9
Hyacinthaceae	*Drimia duthieae*	rare, threatened	1	0	0	0	0
	Drimia minor	rare, threatened	3	0	0	0	1
Iridaceae	*Bobartia gladiata* var. *major*	endemic, rare, threatened	2	0	0	0	2
	Gladiolus aureus	endemic, rare, threatened	4	0	1	1	4
	Gladiolus bonaespei	endemic, threatened	14	0	1	1	2
	Gladiolus jonquilliodorus	rare, threatened	3	2	2	2	3
	Gladiolus monticola	endemic	13	4	4	4	6
	Gladiolus ornatus	endemic, threatened	20	7	7	8	19
	Gladiolus pillansii var. *roseus*	rare, threatened	1	0	0	0	1
	Gladiolus quadrangulus	threatened	6	0	0	1	4
	Gladiolus vigilans	rare, threatened	4	0	1	1	3
	Moraea aristata	endemic, rare, threatened	1	0	0	0	0
	Moraea elsiae	threatened	10	5	5	5	6
	Watsonia tabularis	endemic	23	6	8	8	16
	Witsenia maura	rare, threatened	8	5	5	5	6

Mesembryanthemaceae	*Dorotheanthus apetalus*	rare, threatened	5	1	1	3	4
	Lampranthus dunensis	rare, threatened	2	1	1	1	1
	Ruschia filamentosa	endemic, threatened	8	4	5	5	8
	Ruschia promontorii	endemic, threatened	1	0	0	0	1
	Ruschia rubricaulis	endemic, threatened	6	1	1	1	6
	Scopelogena vereculata	endemic, rare, threatened	4	3	3	3	3
Orchidaceae	*Acrolophia bolusii*	threatened	12	11	12	12	12
	Acrolophia ustulata	rare, threatened	2	2	2	2	2
	Corycium excisum	threatened	4	0	0	0	1
	Disa bodkinii	threatened	7	0	0	0	0
	Disa ocellata	rare, threatened	4	0	0	0	0
	Disa salteri	endemic, threatened	5	3	3	3	4
	Disa tenella ssp. tenella	rare, threatened	1	0	0	0	0
	Disa tenuis	threatened	13	4	4	4	7
	Disperis bodkinii	rare, threatened	5	0	0	0	2
	Herschelianthe forficaria	rare, threatened	2	0	0	0	1
	Herschelianthe purpurascens	threatened	6	0	0	0	4
	Herschelianthe venusta	threatened	6	1	1	1	4
	Holothrix mundii	threatened	7	1	1	1	4
	Monadenia densiflora	endemic	13	6	6	6	9
	Monadenia pygmaea	rare, threatened	3	0	0	0	2
	Monadenia sabulosa	rare, threatened	2	0	0	1	1
	Pachites bodkinii	rare, threatened	1	1	1	1	1
	Pterygodium connivens	endemic, rare, threatened	2	1	1	1	1
	Satyridium rostratum	rare, threatened	4	4	4	4	4
	Satyrium carneum	threatened	10	3	3	3	4
	Satyrium foliosum	threatened	6	1	1	1	4
	Schizodium obliquum	threatened	21	4	4	5	10
Oxalidaceae	*Oxalis natans*	rare, threatened	4	0	0	0	0
Poaceae	*Pentaschistis papillosa*	endemic	19	1	2	2	8
Polygalaceae	*Muraltia comptonii*	endemic, threatened	6	2	3	3	5
Proteaceae	*Diastella proteoides*	threatened	6	3	3	3	3
	Leucadendron argenteum	threatened	5	1	1	1	2
	Leucadendron floridum	threatened	14	6	8	8	9
	Leucadendron levisanus	rare, threatened	11	1	3	3	4
	Leucadendron macowanii	endemic, rare, threatened	3	1	1	2	2

Appendix 1. (*Continued*)

Family	Species	Status of species	Total number of 1 km^2 squares	Number of 1 km^2 squares affected under three scenarios of urbanization			
				Present situation (1994)	Scenario U1	Scenario U2	Scenario U3
	Leucadendron strobilinum	endemic	15	2	3	5	7
	Mimetes fimbriifolius	endemic	16	2	3	4	10
	Mimetes hirtus	threatened	8	3	3	3	6
	Serruria collina	endemic, threatened	15	7	8	8	11
	Serruria cyanoides	threatened	11	4	6	6	6
	Serruria decumbens	threatened	10	2	3	3	5
	Serruria foeniculacea	rare, threatened	8	5	5	5	6
	Serruria glomerata	endemic	22	5	5	8	18
	Serruria hirsuta	endemic, threatened	5	1	3	3	5
	Serruria inconspicua	rare, threatened	2	0	0	0	2
	Serruria villosa	endemic	38	9	10	11	24
Restionaceae	*Chondropetalum rectum*	rare, threatened	3	0	0	0	1
	Elegia fenestrata	threatened	6	0	0	0	3
	Elegia prominens	threatened	7	0	1	2	6
	Elegia verrauxii	threatened	3	1	1	1	3
	Hypodiscus rugosus	rare, threatened	2	0	0	0	2
	Restio communis	endemic, threatened	10	0	0	0	5
	Restio dodii	endemic, threatened	4	0	0	0	0
	Restio harveyi	rare, threatened	12	0	0	0	0
	Restio micans	rare, threatened	3	1	1	1	1
	Thamnochortus fraternus	threatened	12	3	3	3	6
	Thamnochortus nutans	endemic, threatened	5	1	1	1	4
	Thamnochortus punctatus	rare, threatened	3	0	0	0	3
	Willdenowia affinis	endemic, rare, threatened	1	1	1	1	1
Rosaceae	*Cliffortia carinata*	rare, threatened	1	0	0	0	1
	Cliffortia cymbifolia	threatened	1	0	0	0	1
	Cliffortia ericifolia	endemic	5	2	2	2	4
	Cliffortia intermedia	rare, threatened	2	0	0	0	2
Rutaceae	*Agathosma lanceolata*	endemic, threatened	21	9	10	10	11

	Agathosma pulchella	endemic, threatened	3	3	3	3	3
Scrophulariaceae	*Harveya squamosa*	rare, threatened	4	0	0	0	2
	Polycarena capitata	threatened	8	1	1	2	7
Selaginellaceae	*Selaginella pygmaea*	threatened	11	0	1	3	7
Sterculiaceae	*Hermannia micrantha*	endemic, rare, threatened	5	1	2	2	3
	Hermannia procumbens	endemic, threatened	6	0	0	0	1
	Hermannia rudis	threatened	13	3	3	5	10
Thymelaeaceae	*Passerina paludosa*	endemic, rare, threatened	3	1	1	1	2
TOTAL			1170	273 (23.3%)	314 (26.8%)	343 (29.3%)	669 (57.2%)

Appendix 2. The impact of three scenarios relating to urbanization and four scenarios relating to invasive alien plant control and spread on the distribution of 38 native Proteaceae taxa on the Cape Peninsula (+ = endemic; # = threatened; * = rare)

Species	Total number of localities	Number of localities affected under three scenarios relating to urbanization				Number of localities affected under four scenarios relating to invasive plants				
		Present situation	Sc. U1	Sc. U2	Sc. U3	Present situation	Sc. A1	Sc. A2	Sc. A3	Sc. A4
Aulax cancellata	3	0	0	0	0	0	0	0	0	3
Brabejum stellatifolium	20	7	8	8	15	9	7	8	8	20
Diastella divaricata	210	0	0	22	128	3	0	4	36	210
D. proteoides#	4	4	4	4	4	4	4	4	4	4
Leucadendron argenteum#	44	4	4	4	29	4	4	4	4	44
L. coniferum	33	2	2	4	26	5	2	2	7	33
L. floridum#	3	0	0	0	3	0	0	0	0	3
L. laureolum	378	1	8	47	186	14	1	14	79	377
L. levisanus#*	5	5	5	5	5	5	5	5	5	5
L. macowanii+#*	4	0	0	2	4	3	0	0	2	4
L. rubrum	5	0	0	0	1	0	0	0	0	5
L. salignum	485	17	28	89	232	39	17	33	147	483
L. spissifolium	10	1	1	1	4	1	1	1	1	10
L. strobilinum+	100	1	2	3	3	1	1	2	7	84
L. xanthoconus	522	16	24	37	112	31	16	25	62	516
Leucospermum conocarpodendron	569	19	38	89	275	41	19	35	52	567
L. hypophyllocarpodendron	46	0	0	4	34	1	0	0	6	46
Mimetes cucullatus	38	0	1	1	11	1	0	2	12	38
M. fimbriifolius+	306	2	5	22	130	6	2	10	53	306
M. hirtus+#	15	0	0	0	13	0	0	0	2	15
Protea acaulos	180	7	8	27	56	8	7	8	51	180
P. aurea	4	1	1	1	2	1	1	1	1	4
P. burchellii	8	0	0	0	3	0	0	0	0	8
P. coronata	36	5	5	5	22	6	5	5	5	36
P. cynaroides	375	4	10	21	60	9	4	11	53	362
P. grandiceps	15	1	1	1	2	1	1	1	1	13
P. lepidocarpodendron	328	9	18	27	100	20	9	19	51	328
P. nitida	240	11	15	28	72	25	11	15	58	236
P. repens	93	1	4	21	62	3	1	4	24	92
P. speciosa	173	1	2	11	22	1	1	6	25	172
P. scolymocephala	39	1	3	15	31	6	1	3	17	39

Serruria collina[+#]	10	0	0	0	0	0	0	0	3	10
S. cyanoides[+#]	20	2	2	6	9	2	2	2	8	20
S. decumbens[+#]	4	0	0	0	2	0	0	0	2	4
S. fasciflora	26	3	3	4	7	3	3	3	4	25
S. glomerata[+]	67	6	6	8	64	8	6	6	8	67
S. hirstua[+#]	16	0	0	1	6	0	0	0	2	16
S. villosa[+]	151	0	1	10	104	2	0	3	21	151
TOTAL	4585	131 (2.9%)	209 (5.6%)	528 (11.5‰)	1839 (40.1%)	263 (5.7%)	131 (2.9%)	236 (5.1%)	821 (17.9%)	4536 (98.9%)

Appendix 3. The impact of four scenarios relating to invasive alien trees and shrubs on 161 endemic, rare and threatened plant taxa on the Cape Peninsula. Localities were mapped at a resolution of 1-km^2 squares; a locality was considered affected if dense stands of alien plants occur in that square. Nomenclature follows the Bolus Herbarium, University of Cape Town

Family	Species	Status of species	Total number of 1 km^2 squares	Number of 1 km^2 squares affected under four scenarios relating to invasive plants				
				Present situation	Scenario A1	Scenario A2	Scenario A3	Scenario A4
Apiaceae	*Apium inundatum*	rare, threatened	3	1	1	1	1	2
Asteraceae	*Athanasia capitata*	threatened	10	2	2	3	4	9
	Cotula myriophylloides	endemic, threatened	5	1	0	1	1	5
	Gerbera wrightii	endemic, threatened	14	2	0	0	1	14
	Senecio foeniculoides	threatened	5	0	0	0	0	4
	Stoebe rosea	endemic	13	4	4	4	4	13
	Ursinia tenuifolia	rare, threatened	16	3	3	3	4	16
Brassicaceae	*Heliophila cinerea*	endemic, threatened	6	1	1	2	3	6
	Heliophila pusilla	endemic	6	4	4	4	4	6
	Heliophila tabularis	endemic, rare, threatened	1	0	0	1	1	1
Bruniaceae	*Audouinia capitata*	rare, threatened	12	5	4	4	4	11
	Staavia dodii	endemic, threatened	5	2	1	2	2	5
	Staavia dregeana	rare, threatened	9	4	4	4	4	9
	Staavia glutinosa	endemic, threatened	11	9	9	9	9	11
Campanulaceae	*Roella goodiana*	endemic, rare, threatened	2	1	0	0	2	2
	Wahlenbergia ciliolata	threatened (possibly extinct)	6	3	3	3	3	6
Cyperaceae	*Ficinia micrantha*	endemic, rare, threatened	2	2	2	2	2	2
	Ficinia pygmaea	rare, threatened	1	1	1	1	1	1
	Isolepis inconspicua	rare, threatened	1	1	1	1	1	1
	Schoenoxiphium ecklonii	threatened	8	3	3	3	3	8
	Scirpus delicatulus	rare, threatened	2	0	0	0	0	1
	Tetraria brachyphylla	endemic, threatened	8	1	0	0	1	8
	Tetraria compacta	threatened	6	1	1	2	2	5
	Tetraria paludosa	endemic, rare, threatened	2	0	0	0	0	1
	Trianoptiles solitaria	rare, threatened	3	0	0	0	0	1
	Trianoptiles stipitata	threatened	1	0	0	0	0	1
Ericaceae	*Erica amoena*	endemic, threatened	11	3	2	2	3	11

	Erica annectens	endemic, threatened	10	3	3	4	4	10
	Erica blancheana	endemic, threatened	6	4	4	5	5	6
	Erica capensis	endemic, threatened	12	5	5	6	6	12
	Erica capitata	threatened	13	3	3	3	3	12
	Erica clavisepala	endemic, threatened	10	0	0	0	0	10
	Erica crenata	endemic	12	0	0	0	0	10
	Erica cyrilliflora	endemic, threatened	7	2	2	2	3	7
	Erica eburnea	endemic, threatened	8	3	3	4	4	8
	Erica empetrina	endemic	10	1	0	0	1	10
	Erica fairii	endemic, threatened	7	0	0	0	0	7
	Erica ferrea	threatened	17	3	3	3	3	16
	Erica fontana	endemic, threatened	11	1	1	1	2	11
	Erica genistifolia	endemic	10	1	0	0	0	9
	Erica gilva	endemic, threatened	6	0	0	1	2	6
	Erica haematocodon	endemic	10	6	4	5	5	10
	Erica heleogena	rare, threatened	2	1	1	1	1	2
	Erica inops	endemic	10	5	5	5	5	10
	Erica limosa	endemic, threatened	6	2	1	1	1	6
	Erica margaritacea	threatened	4	1	1	1	1	4
	Erica marifolia	endemic, threatened	11	1	0	0	0	11
	Erica nevillei	endemic	8	0	0	0	2	8
	Erica paludicola	endemic, rare, threatened	1	0	0	0	0	1
	Erica patersonia	rare, threatened	4	0	0	0	0	4
	Erica physodes	endemic	11	0	0	0	1	11
	Erica pilulifera	endemic, threatened	7	0	0	0	0	6
	Erica pulchella	endemic	6	4	4	4	4	6
	Erica pulchella var. major	endemic, rare, threatened	18	1	0	0	2	18
	Erica pyxidiflora	endemic	23	3	0	1	2	22
	Erica quadrisulcata	endemic, rare, threatened	4	1	0	0	0	4
	Erica salteri	endemic, rare, threatened	1	0	0	0	0	1
	Erica sociorum	endemic, rare, threatened	1	0	0	0	0	1
	Erica turgida	endemic, rare, threatened	5	3	3	3	3	5
	Erica urna-viridis	endemic	4	2	2	2	2	4
Eriospermaceae	*Eriospermum pumilum*	rare, threatened	3	1	1	1	1	3
	Eriospermum stoloniferum	rare, threatened	1	0	0	0	0	1
Fabaceae	*Aspalathus borboniifolia*	endemic, rare, threatened	4	1	0	0	1	4

Appendix 3. (*Continued*)

Family	Species	Status of species	Total number of 1 km² squares	Number of 1 km² squares affected under four scenarios relating to invasive plants				
				Present situation	Scenario A1	Scenario A2	Scenario A3	Scenario A4
	Aspalathus capitata	endemic, threatened	12	6	6	6	6	11
	Aspalathus globulosa	rare, threatened	2	0	0	0	0	2
	Aspalathus humilis	endemic, rare, threatened	4	2	0	0	0	4
	Aspalathus macrantha	threatened	11	0	0	0	0	10
	Cyclopia buxifolia	endemic, rare, threatened	1	0	0	0	0	1
	Cyclopia capensis	endemic, rare, threatened	2	2	2	2	2	2
	Melolobium aethiopicum	threatened	7	3	3	3	3	7
	Priestleya angustifolia	rare, threatened	1	1	1	1	1	1
	Priestleya laevigata	threatened	3	2	2	2	2	2
	Priestleya tomentosa	endemic, threatened	6	1	1	1	1	6
	Psoralea glaucina	endemic, rare, threatened	2	0	0	0	0	2
Geraniaceae	*Pelargonium ellaphieae*	rare, threatened (possibly extinct)	3	2	0	0	0	3
Haemodoraceae	*Dilatris corymbosa*	endemic	17	7	3	6	7	17
Hyacinthaceae	*Drimia duthieae*	rare, threatened	1	0	0	0	0	1
	Drimia minor	rare, threatened	3	1	0	0	0	3
Iridaceae	*Bobartia gladiata* var. *major*	endemic, rare, threatened	2	1	0	0	0	2
	Gladiolus aureus	endemic, rare, threatened	4	0	0	1	1	4
	Gladiolus bonaespei	endemic, threatened	14	0	0	1	1	13
	Gladiolus jonquilliodorus	rare, threatened	3	2	2	2	2	3
	Gladiolus monticola	endemic	13	4	4	4	5	13
	Gladiolus ornatus	endemic, threatened	20	9	7	7	8	20
	Gladiolus pillansii var. *roseus*	rare, threatened	1	0	0	0	0	1
	Gladiolus quadrangulus	threatened	6	0	0	0	1	6
	Gladiolus vigilans	rare, threatened	4	0	0	1	2	4
	Moraea aristata	endemic, rare, threatened	1	0	0	0	0	1
	Moraea elsiae	threatened	10	6	5	5	6	8
	Watsonia tabularis	endemic	23	10	6	8	9	22
	Witsenia maura	rare, threatened	8	5	5	5	5	8
Mesembryanthemaceae	*Dorotheanthus apetalus*	rare, threatened	5	1	1	1	3	5
	Lampranthus dunensis	rare, threatened	2	1	1	1	1	1

	Ruschia filamentosa	endemic, threatened	8	5	4	5	5	8
	Ruschia promontorii	endemic, threatened	1	0	0	0	0	1
	Ruschia rubricaulis	endemic, threatened	6	2	1	1	1	6
	Scopelogena vereculata	endemic, rare, threatened	4	3	3	3	4	4
Orchidaceae	*Acrolophia bolusii*	threatened	12	12	11	12	12	12
	Acrolophia ustulata	rare, threatened	2	2	2	2	2	2
	Corycium excisum	threatened	4	0	0	0	0	4
	Disa bodkinii	threatened	7	0	0	0	0	6
	Disa ocellata	rare, threatened	4	0	0	0	0	4
	Disa salteri	endemic, threatened	5	3	3	3	3	5
	Disa tenella ssp. tenella	rare, threatened	1	1	0	0	0	1
	Disa tenuis	threatened	13	4	4	4	4	12
	Disperis bodkinii	rare, threatened	5	0	0	0	0	5
	Herschelianthe forficaria	rare, threatened	2	1	0	0	1	2
	Herschelianthe purpurascens	threatened	6	0	0	0	0	6
	Herschelianthe venusta	threatened	6	1	1	1	1	6
	Holothrix mundii	threatened	7	1	1	1	2	7
	Monadenia densiflora	endemic	13	7	6	6	6	13
	Monadenia pygmaea	rare, threatened	3	0	0	0	0	3
	Monadenia sabulosa	rare, threatened	2	1	0	0	1	2
	Pachites bodkinii	rare, threatened	1	1	1	1	1	1
	Pterygodium connivens	endemic, rare, threatened	2	1	1	1	1	2
	Satyridium rostratum	rare, threatened	4	4	4	4	4	4
	Satyrium carneum	threatened	10	3	3	3	3	10
	Satyrium foliosum	threatened	6	1	1	1	1	6
	Schizodium obliquum	threatened	21	4	4	4	5	20
Oxalidaceae	*Oxalis natans*	rare, threatened	4	0	0	0	0	4
Poaceae	*Pentaschistis papillosa*	endemic	19	3	1	2	4	19
Polygalaceae	*Muraltia comptonii*	endemic, threatened	6	2	2	3	3	6
Proteaceae	*Diastella proteoides*	threatened	6	4	3	4	4	6
	Leucadendron argenteum	threatened	5	1	1	1	1	5
	Leucadendron floridum	threatened	14	6	6	8	9	12
	Leucadendron levisanus	rare, threatened	11	3	1	3	5	11
	Leucadendron macowanii	endemic, rare, threatened	3	2	1	1	2	3
	Leucadendron strobilinum	endemic	15	4	2	3	5	14

Appendix 3. (*Continued*)

Family	Species	Status of species	Total number of 1 km^2 squares	Number of 1 km^2 squares affected under four scenarios relating to invasive plants				
				Present situation	Scenario A1	Scenario A2	Scenario A3	Scenario A4
	Mimetes fimbriifolius	endemic	16	2	2	3	4	16
	Mimetes hirtus	threatened	8	4	3	3	3	8
	Serruria collina	endemic, threatened	15	9	7	8	8	15
	Serruria cyanoides	threatened	11	6	4	6	8	11
	Serruria decumbens	threatened	10	4	2	3	4	10
	Serruria foeniculacea	rare, threatened	8	5	5	5	5	8
	Serruria glomerata	endemic	22	7	5	5	8	21
	Serruria hirsuta	endemic, threatened	5	3	1	3	3	5
	Serruria inconspicua	rare, threatened	2	0	0	0	0	2
	Serruria villosa	endemic	38	14	9	11	13	37
Restionaceae	*Chondropetalum rectum*	rare, threatened	3	0	0	0	0	2
	Elegia fenestrata	threatened	6	0	0	0	0	6
	Elegia prominens	threatened	7	1	0	1	2	7
	Elegia verrauxii	threatened	3	1	1	1	1	3
	Hypodiscus rugosus	rare, threatened	2	0	0	0	0	2
	Restio communis	endemic, threatened	10	0	0	0	1	10
	Restio dodii	endemic, threatened	4	0	0	0	0	3
	Restio harveyi	rare, threatened	12	0	0	0	0	11
	Restio micans	rare, threatened	3	1	1	1	1	3
	Thamnochortus fraternus	threatened	12	3	3	3	4	12
	Thamnochortus nutans	endemic, threatened	5	2	1	1	1	5
	Thamnochortus punctatus	rare, threatened	3	0	0	0	0	3
	Willdenowia affinis	endemic, rare, threatened	1	1	1	1	1	1
Rosaceae	*Cliffortia carinata*	rare, threatened	1	1	0	0	0	1
	Cliffortia cymbifolia	threatened	1	0	0	0	0	1
	Cliffortia ericifolia	endemic	5	2	2	2	2	4
	Cliffortia intermedia	rare, threatened	2	0	0	0	0	2
Rutaceae	*Agathosma lanceolata*	endemic, threatened	21	9	9	10	10	18
	Agathosma pulchella	endemic, threatened	3	3	3	3	3	3
Scrophulariaceae	*Harveya squamosa*	rare, threatened	4	1	0	0	0	4

	Polycarena capitata	threatened	8	1	1	1	2	8
Selaginellaceae	*Selaginella pygmaea*	threatened	11	2	0	1	3	10
Sterculiaceae	*Hermannia micrantha*	endemic, rare, threatened	5	1	1	2	2	5
	Hermannia procumbens	endemic, threatened	6	0	0	0	0	6
	Hermannia rudis	threatened	13	5	3	3	5	13
Thymelaeaceae	*Passerina paludosa*	endemic, rare, threatened	3	1	1	1	1	3
TOTAL			1170	349 (29.8%)	273 (23.3%)	317 (27.1%)	375 (32.1%)	1130 (96.6%)