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Impacts of urbanization in a biodiversity hotspot: Conservation challenges in Metropolitan Cape Town

A.G. Rebelo [a,*], P.M. Holmes [b], C. Dorse [b], J. Wood [b]

[a] Threatened Species Research Programme, Applied Biodiversity Research, South African National Biodiversity Institute, Kirstenbosch, Cape Town 7735, South Africa
[b] Biodiversity Management Branch, Environmental Resource Management Department, City of Cape Town, PO Box 11, Maitland Abattoir Building, Berkley Road, Maitland 7405, South Africa

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Abstract

The City of Cape Town (City) covers 2460 km^2 in the southwestern corner of the Cape Floristic Region biodiversity hotspot. Established in 1654, by 1700 there were no animals larger than 50 kg within 200 km of the City. However, apart from an appreciation that timber and firewood were becoming scarce, it was only in the 1930s that the first farm near Cape Point was set aside for conservation. Table Mountain was declared a National Monument in 1958, while it was largely covered by pine and gum plantations. Conservation of the montane areas thereafter expanded, whereas the lowlands were largely ignored, except for a few bird sanctuaries. Only in 1982 was the plight of the lowlands highlighted. Although *ad hoc* conservation planning was undertaken subsequently, 1997 saw the first priority categorization and conservation plan. The current situation is perilous: a huge effort will be required to meet basic conservation targets for the lowland vegetation types and threatened species. Local and international partners and funders will be key to achieving this. In eight of the City's 19 national vegetation types the minimum conservation targets are not achievable. Of the 3250 plant species estimated to occur in the City, 13 are extinct and 319 are threatened according to the IUCN Red List: this is 18% of the threatened Red List species in South Africa. Now for the first time, implementation is being attempted holistically across the metropole with discussion between internal City and external stakeholders to implement the conservation plan. However, the interim plans towards achieving this — that 60% of the unproclaimed target is secured by 2014, requires that over 40 km^2 be conserved per annum. This leaves 340 km^2 that should be secured by 2020 when projections from City spatial growth indicate that the last critical remnants will be urbanized.

Keywords: Conservation planning and implementation; Ecosystem transformation and threats; Lowland fynbos and renosterveld; Red List threatened species

1. Introduction

The City of Cape Town (hereafter referred to as City) is renowned for its high plant species richness, high beta and gamma diversity and high endemicity (Helme and Trinder-Smith, 2006; Simmons and Cowling, 1996). The area is thus an important component of the Cape Floristic Region (CFR), one of the World's Heritage Sites (Anon, 1999) and biodiversity Hotspots (Myers et al., 2000). The CFR is a member of the Mediterranean Biome (Underwood et al., 2009) (recognized locally as the Fynbos Biome(Rutherford et al. 2006)), recognized as one of the world's most imperilled ecosystems and a global priority for conservation (Underwood et al., 2009). The CFR has the second highest human population growth rate in the Mediterranean Biome, after Chile (Underwood et al., 2009). Urbanization is concentrated in lowlands of the City.

This high concentration of biodiversity within the urban matrix poses challenges for conservation. The Table Mountain chain lies within the City: it is an area of scenic beauty and wild landscapes that challenge development and is thus well conserved. Unfortunately, the Table Mountain chain is not representative of biodiversity in lowland ecosystems in the City (Rebelo et al., 2006). The assumption that the City has met its conservation goals with 17% of the City's area formally conserved, well above the 10% national targets suggested by the

* Corresponding author.
E-mail address: rebelo@sanbi.org.za (A.G. Rebelo).

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IUCN, is unfortunately false, as the conserved mountainous areas are not representative of the City's biodiversity.

There is a high incidence of threatened species (Wood et al., 1994, and detailed later): the City has 18% of South Africa's threatened plant species in 0.1% of the area of the country. Thirteen plant species within the City are already globally extinct, making it one of the most acute areas in the world for plant extinction. Unless urgent action is taken as many as 85 additional plant species may become globally extinct in the next decade.

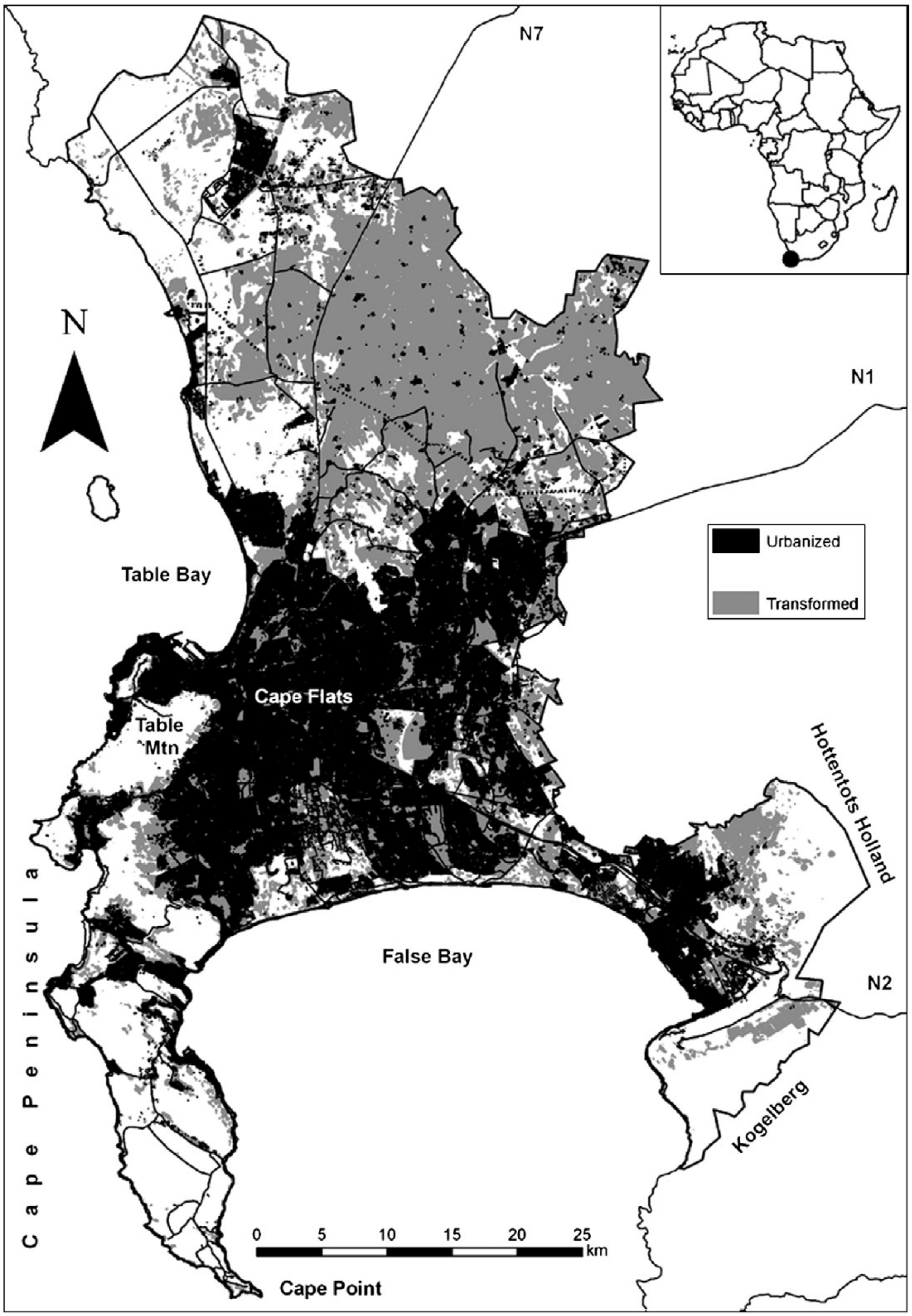

Fig. 1. Location of the City of Cape Town, South Africa, showing the urban extent (2004) and the area transformed by agriculture, afforestation and dense aliens (Lloyd et al., 1999). The major national roads (N1, N2 and N7) leading to the City are shown.

This paper analyses the historical loss and current status of terrestrial biodiversity in Cape Town, as well as conservation planning and current initiatives to halt the loss of remaining biodiversity.

1.1. Study site

The City of Cape Town occurs in the southwestern-most portion of the Cape Floristic Region (CFR), the Western Cape Province and South Africa (Fig. 1). It occupies 2460 km^2, extending from Silverstroomstrand in the northwest to Kogelbaai in the southeast. The City comprises four separate landscapes: in the centre lies the sandy Cape Flats, bordered on the western and southern coastal edges by the dune-dominated strandveld. Inland on the flats are the low shale and granite hills which have historically been converted to farmland, chiefly wheat in the drier lower areas, and vineyards on the wetter slopes. In the southwest and the east are the sandstone mountains of the Table Mountain chain and the Hottentots Holland — Kogelberg ranges, respectively (Fig. 1).

Historically the City itself was confined to Table Bay on the north side of Table Mountain, now known as the City Bowl. Expansion began at the turn of the 20th century along the two major routes out of the City, with another node at Somerset West, accelerating after WWI. However, it was only in the 1960s, under Apartheid planning, that the sandy and often seasonally water-logged Cape Flats started being developed in earnest (McDowell et al., 1991), a process that escalated rapidly from the late 1980s to cover much of the Cape Flats (Low and McKenzie, 1989).

In 2008 some 3.5 million people (70% of the population in the Western Cape Province) were resident in Cape Town (Sinclair-Smith, 2009). The City contributes 76% of the provincial economy and 11% of the National GDP of South Africa (Anon, 2006).

2. Methods

2.1. Vegetation status

Vegetation boundaries were obtained from the 1:250 000 scale National Vegetation Map (Rebelo et al., 2006). These were integrated with the City vegetation map developed during the Mining Structure Plan project (Anon, 2000) at a 1:50 000 scale. Differences between the City and National maps were considered subtypes of the national types, except for three cases: Peninsula Granite Fynbos was divided into Northern and Southern subtypes, Peninsula Shale Fynbos was extracted from part of Cape Winelands Shale Fynbos, and Cape Flats Dune Strandveld was divided into West Coast and False Bay subtypes (Benn, 2008; Laros and Benn, 2007).

GIS coverages of remnant natural vegetation were prepared by the City from 2005 aerial photographs, and were ground-truthed between March 2007 and April 2008. These were classified as “High”, “Medium” or “Restorable” condition or “Transformed.” Restorable includes land with depleted indigenous vegetation cover and soil-stored seed banks, but with intact soils that are amenable to natural vegetation restoration. By contrast transformed sites either had been developed or severely altered so that restoration would be very difficult.

National biodiversity targets — the area required to conserve 70% of the plant taxa within the vegetation type 0 were obtained from the National Spatial Biodiversity Assessment (NSBA; Rouget et al., 2004), and the national ecosystem status was obtained from SANBI (South African National Biodiversity Institute) (DEAT, 2009) as legislated in the NEMBA (National Environmental Management: Biodiversity Act: No.10 of 2004, Section 52).

2.2. Plant species

IUCN Red Lists were obtained from SANBI’s Threatened Species Programme, as of September 2008 update (Raimondo et al., 2009); for the Peninsula from the SANParks (South African National Parks) monitoring data as of September 2008 (A.G. Rebelo et al., in preparation). Recent and herbarium data for threatened and near-threatened Red List species were obtained from CREW (Custodians of Rare and Endangered Wildflowers), a volunteer-based organization using amateurs to monitor and locate rare plant species (Raimondo, 2007). These were overlaid with the national vegetation types (Rebelo et al., 2006), and records unambiguously present in a type were used to generate species lists of threatened and near-threatened Red List species. All species nomenclature follows Goldblatt and Manning (2000).

2.3. Current conservation status

Existing conservation area boundaries, as supplied by the City of Cape Town, were used. Conservation areas were categorized as proclaimed (national, provincial and local; and private reserves proclaimed under the Protected Areas Act (National Environmental Management: Protected Areas Act: No. 57 of 2003)). Official dates of proclamation were used to determine area of conservation estate over time. Managed (non-proclaimed sites), Core Flora Sites without status or management, and Natural Heritage Sites with no legal conservation status were not considered as conserved.

2.4. Conservation planning

Species locality data from the following sources were combined:

- Protea Atlas Project (Rebelo, 1991), with 30 405 record localities for 105 Proteaceae species;
- Sites and Species (SAS) database (A.B. Low, pers. comm., data as at 2002), with 11 631 locations for 2335 plant species; and,
- CREW (Custodians for Rare and Endangered Wildflowers) species database, with 229 locations for 110 threatened and near-threatened Red List (RDL) plant species.

Conservation target for species was set as 100% of locations for species with fewer than 5 historical locations, and for CREW (RDL) species. Other species were assigned a target of 80% of known historical locations.

A threats layer was compiled using the following 3 sets of data from City Spatial Planning (outlined below). The summed threat was determined as the highest threat per planning unit. “High” and “Medium” threat categories were combined and used as a rule in C-Plan and as a cost surface in the MARXAN analysis.

- Urban and human settlement areas, based on the 2008 urban edge layer. Urban and settlement areas were assigned to a “High” threat category, and areas outside the urban edge to a “Low” threat category;
- Potential agricultural areas, using the 2006 agriculturally significant areas layer. The agricultural potential classifications were grouped into “High”, “Medium” and “Low” threat categories; and,
- Potential mining areas, using the 2001 mineral resources layer. The mining potential classifications were grouped into “High”, “Medium” and “Low” threat categories.

Potential corridors for ecological connectivity were mapped by City biodiversity staff during 2008.

Planning units were cadastres intersecting with the remnants GIS layer, classified by their vegetation type and habitat condition (see Vegetation Status: methods; and Laros and Benn (2007) for details). All planning units greater than 100 ha were further subdivided by a hexagon grid into units of 100 ha or less. This resulted in 3 244 planning units, of which 141 were conservation areas, ranging in size from <1 ha to 100 ha. National conservation targets for vegetation types as derived for the NSBA (Rouget et al., 2004) were used. All subtypes were assigned the same conservation target.

Ecosystem status is based on the current extent of each vegetation type relative to the historical area. This was determined for each vegetation type (both National and City subtype) using the standard NEMBA categories and thresholds (DEAT, 2009):

- Critically Endangered — remaining natural area less than target area;
- Endangered — current natural area less than target + 15% of original area;
- Vulnerable — current natural area < 60% of original area;
- Least threatened — current natural area > 60% of original area.

ArcView 3.2 extension C-Plan was used to calculate irreplaceability and to select an optimal and efficient set of remnants to meet the conservation targets. To ensure that High and Medium condition planning units were selected preferentially over Restorable condition planning units, the latter were initially excluded from the analysis. Irreplaceability was then calculated, and those planning units with 100% irreplaceability scores (planning units for which no alternatives exist if targets are to be met) selected. Outstanding target values were then met by running a MinSet algorithm with the following rules:

1. Highest Irreplaceability score;
2. Habitat condition = High or Medium;
3. Lowest threat value (to reduce potential conflict);
4. Location of planning unit in one of the expert mapped corridors;
5. Highest percentage contribution to meeting targets;
6. Feature rarity;
7. Summed rarity;
8. Richness; and
9. Select first site in list.

After all sites were selected, the Restorable planning units were placed back as potential sites for selection, and irreplaceability recalculated for those units with targets still outstanding. As a final step Restorable planning units with 100% irreplaceability were included. At this point, all achievable targets were attained.

In order to obtain a connected network, MARXAN was run on the results from C-Plan (i.e. these were considered as “conserved”), using all land units except transformed. A Boundary Length Modifier of 0.5 yielded the most efficient configuration.

Detailed mapping of remaining natural wetlands was completed during 2008 and will be incorporated into future conservation plans.

2.5. Implementation and management challenges

Most management and implementation challenges in the City are undocumented. Consequently, we requested managers to highlight the major challenges they perceive in preventing them from managing biodiversity. These were collated and circulated. At this stage these have not been rigorously delimited, prioritized or costed.

3. Results and discussion

3.1. Vegetation and ecology

The vegetation in the City is strongly tied to the geology. Given that most of the area has been transformed by urbanization and agriculture, geology has been used as a surrogate to determine historical occurrences of vegetation types (Fig. 2). This is reflected both in the national vegetation types (see below: Rebelo et al., 2006), as well as the local vegetation types (Anon, 2000). The climate is Mediterranean with hot, dry summers, and rain in winter. Annual rainfall ranges from 350 mm along the west coast to well over 2000 mm on highest mountain summits.

On the nutrient-poor Table Mountain Group sandstone soils, often associated with steep and rugged topography, the Sandstone Fynbos vegetation types are largely intact (with the exception of some degradation by stands of invasive alien trees). Two major centres of endemism occur within the City on this substratum: Cape Peninsula and Kogelberg Sandstone Fynbos. Below the sandstone belt, and also to the northeast of the City occur expanses of subdued Malmesbury Shale landscapes (containing mainly Swartland Shale Renosterveld, with localized Winelands Shale Fynbos in the more elevated, wetter areas), and intrusive granites of the Cape Granite Suites (with Swartland Granite Renosterveld in the lower lying and more arid areas, and Boland and Peninsula Granite Fynbos on the more elevated and wetter areas). At the interface of shale and

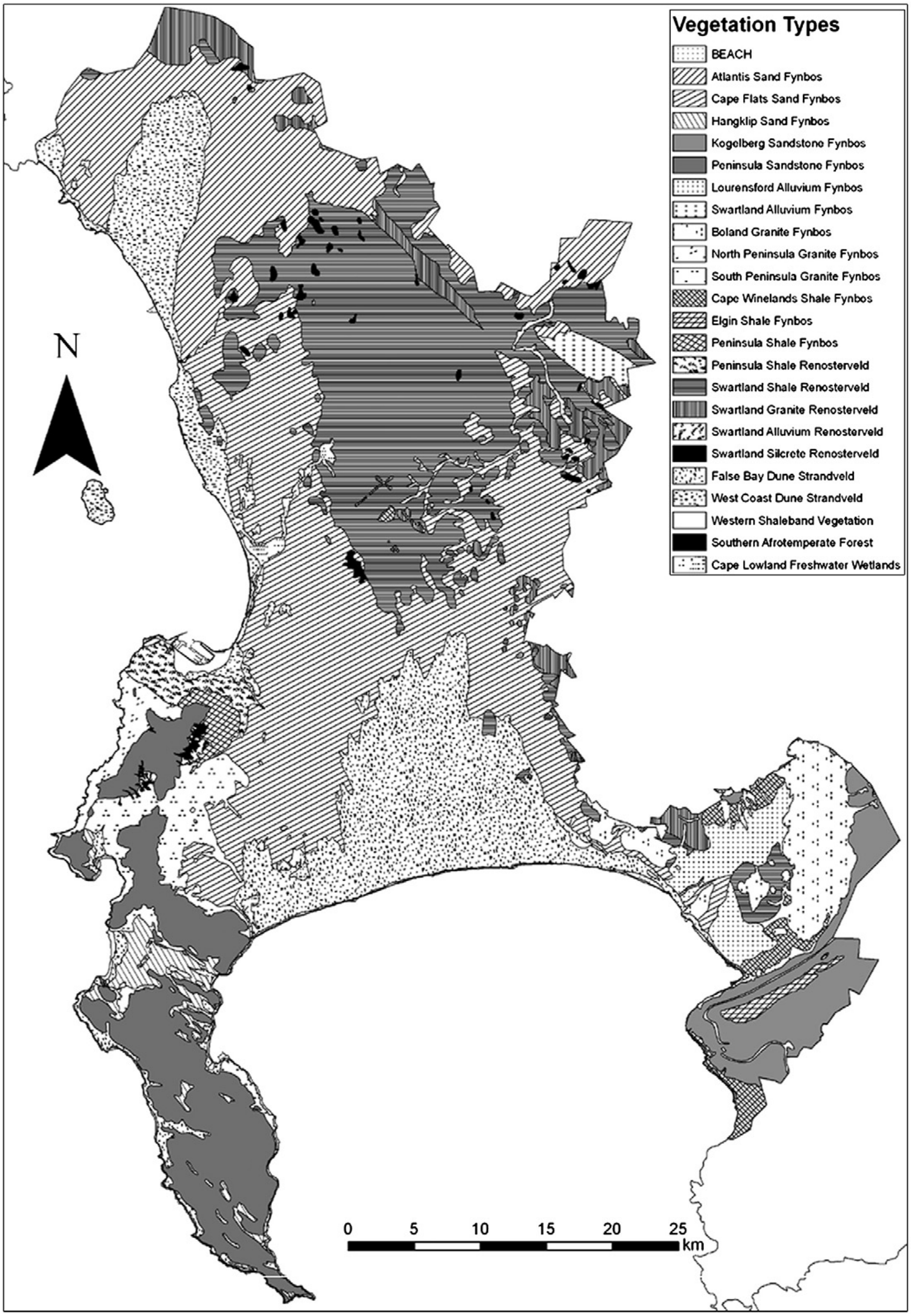

Fig. 2. Original extent of vegetation types within the City of Cape Town, South Africa, largely reconstructed from the geology. This is based on the National Vegetation types; subtypes are not shown.

sandstone, Swartland and Lourensford Alluvium Fynbos vegetation types occur, largely on alluvial sediments from the mountains.

The coastal flats between the shales or granites and the sandstone mountains are covered with Tertiary aeolian sands. Inland these are old, leached, acidic sands that are topographically subdued, and covered with Sand Fynbos, with two centres of endemism: Atlantis in the north and Cape Flats in the south. Plumes of ancient sand dunes on the Peninsula itself have been affiliated with Hangklip Sand Fynbos. On the coastal areas the dune landscape of younger, alkaline, aeolian sands is covered with Cape Flats Dune Strandveld.

With the exception of the strandveld all these vegetation types are fire-driven ecosystems, with natural fire return times of 10–20 years for fynbos and 2–7 years for renosterveld (De Villiers et al., 2005). Southern Afrotemperate Forest occurs in ravines and fire-safe habitats associated with Sandstone Fynbos and screes, these being confined to relatively small areas on the northern Peninsula and Helderberg.

Historically the renosterveld contained large herds of game, but these were wiped out before the 1700s (Rebelo, 1992). Renosterveld was most heavily farmed for grain, but rapid transformation occurred with increased mechanization after WWI, although cultivation on steeper slopes, inaccessible to tractors, was abandoned (Wood and Low, 1998).

Although other ecosystems were less affected, the lack of trees and wood in the local ecosystems resulted firstly in heavy exploitation of forests, then removal of the overstorey canopy in fynbos. Especially on the Flats this resulted in some areas being destabilized with subsequent mobile dune formation, followed by the introduction of aliens to stabilize the dunes and provide wood – primarily for fuel – in the mid 1800s (Shaughnessy, 1986).

Although fires were a hazard to early settlers (but were apparently actively set in certain habitats such as Renosterveld), they are largely unrecorded. Botanists noted that fires were too frequent in the late 1800s, leading to deliberate fire suppression policies, which appear only to have been really effective after WWII. Catastrophic fires in the 1960s led to a reassessment of fire management, which together with the realization that fynbos recruitment was fire-mediated, resulted in fire being used as a management tool (Van Wilgen et al., 1992). However, in the 1990s much of this experience was lost due to post-Apartheid retrenchments, and recent fire legislation (National Veld and Forest Fire Act: No. 101 of 1998) prohibits controlled burning under natural conditions, with fire exclusion again being practiced.

Wetlands and rivers form important habitats within most of the major vegetation types in the City. Unfortunately much transformation, of especially the seasonal wetlands, has occurred through drainage and in-filling for developments (Brown and Magoba, 2009) and most urban lowland wetlands now receive input from stormwater (Holmes et al., 2008). The historical extent of the different wetland types is largely unknown. The extent and condition of wetlands across the City is currently under review, and will not be dealt with here. However, wetlands were treated as critically important habitats in conservation planning.

3.2. Vegetation status

Some 19 national vegetation types and 4 azonal vegetation types occurred historically in the City (Table 1). These can be subdivided into 12 fynbos, 5 renosterveld, a strandveld, a forest and azonal (mainly wetland) types, that historically covered 69%, 23%, 16%, 0.1% and 0.6% of the area, respectively. However, seasonal wetlands are nested within the broad terrestrial units with 0.6% undoubtedly underestimating total wetland distribution. The most widespread vegetation types in the City were Cape Flats Sand Fynbos (22%), Swartland Shale Renosterveld (19%), Cape Flats Dune Strandveld (16%) and Atlantis Sand Fynbos (11%) (Fig. 2).

Ten City vegetation types are nationally classified as Critically Endangered ecosystems, with eight of these having too little natural vegetation remaining to meet the national biodiversity targets (24–34%), four are Endangered and four are Vulnerable (DEAT, 2009; Table 1). Only five are rated Least Threatened. Thus the City had 42% of the 24 South African Critically Endangered (CR) vegetation types identified in the 2004 national plan (Rouget et al., 2004), and 52% of the 21 current CR vegetation types (DEAT, 2009).

Six vegetation types are endemic to the City, of which currently three are Critically Endangered and three are Endangered (Table 1). Five of the other vegetation types are more transformed within the City than nationally, but this may in part be due to the national remnant coverage, dating from 1996, being older than the City's data.

Renosterveld vegetation types, being on more fertile soils, are among the most transformed, ranging from 74 to 100% (Table 1). However, Alluvium Fynbos is the most transformed (94%). The least transformed type within the City is Afrotemperate Forest with less than 1% transformed, with Sandstone Fynbos (2–3%) also among the least transformed.

Of the 56 vegetation subtypes in Cape Town, four are globally extinct (100% transformed), 19 are Critically Endangered (less than the City's target remains); seven are Endangered, nine are Vulnerable and six are Least Concern (Supplementary Table 1). However, of the six Least Concern subtypes, four are nationally Critically Endangered and one is nationally Endangered.

It is clear from the vegetation-level analysis alone that Cape Town's biodiversity is in trouble and that the City should, at least nationally, be flagged as an urban biodiversity hotspot.

3.3. Plant species

The number of indigenous plant species in the City is unknown. Estimates put the figure at over 3250 species based on available lists from nature reserves and a few other sites. Comprehensive data exist only for the Cape Peninsula, where some 2285 (Adamson and Salter, 1950) to 2572 (A.G. Rebelo, unpublished) species are documented, and an additional 424 naturalized alien species have been recorded (A.G. Rebelo, unpublished), putting the aliens at 14% of the total flora. Endemicity in the region, typical of fynbos, is very high (Helme and Trinder-Smith, 2006). The Cape Peninsula alone has 194 near-endemic (with over 80% of populations or numbers confined to the Peninsula) species of which nine are confined to Granite-, 16 to Sand-, and 140 to Sandstone Fynbos (Table 2).

Of the 1736 IUCN Red List threatened species (CR, EN and VU) in the CFR, 319 (18%) occur in the City (Table 3; Raimondo et al., 2009). Some 13 species are extinct in the wild. Some 85 species are Critically Endangered, 112 Endangered and 122 Vulnerable. A further 67 are rated Near Threatened and

Table 1
Status of national vegetation types within the City of Cape Town, South Africa in March 2009. "Planned" has been identified as crucial for conservation in the City Biodiversity Network, "Extra" is superfluous to meeting the minimum City targets, "Managed" includes areas proclaimed, core or unprotected but managed by the City. National status is Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Threatened (LT).

National vegetation type ***	Historical area in City (ha)	% of total area in City	% Transformed	% Managed	% Planned #	% Extra — not needed #	National target	National status 2004	National status 2008 **
Atlantis Sand Fynbos (4)	27770	40	43	12	35	9.8	30	EN	CR_d
Boland Granite Fynbos (3)	9575	19	37	5.7	45	13	30	EN	VU_a
Cape Flats Dune Strandveld (3+3)	38932	100*	51	19	11	12	24	EN	EN_d
Cape Flats Sand Fynbos (4)	54448	100*	84	1.5	14	n/a	30	CR	CR_{a+d}
Cape Lowland Freshwater Wetlands	2121	15	26	68	19	1.4	24	VU	LT
Cape Winelands Shale Fynbos (2+3)	3929	38	39	47	7.1	6.8	30	EN	VU_a
Elgin Shale Fynbos	841	0.9	64	7.4	28	n/a	30	CR	CR_a
Hangklip Sand Fynbos (2)	3349	42	42	41	5.0	13	30	VU	VU_a
Kogelberg Sandstone Fynbos	9500	12	1.9	78	16	4.1	30	LT	CR_d
Lourensford Alluvium Fynbos	4819	100*	92	4.0	4.5	n/a	30	CR	CR_a
Peninsula Granite Fynbos (2+4)	9179	100*	57	30	7.9	5.2	30	EN	EN_a
Peninsula Sandstone Fynbos (3)	22360	100*	2.5	79	16	2.7	30	LT	EN_d
Peninsula Shale Renosterveld (2)	2375	100*	87	11	2.3	n/a	26	CR	CR_a
Southern Afrotemperate Forest	301	0.4	0.1	86	14	0	34	LT	LT
Swartland Alluvium Fynbos	1742	3.7	94	0	6.2	n/a	30	CR	CR_a
Swartland Alluvium Renosterveld	62	1.0	100	0	n/a	n/a	26	CR	VU_a
Swartland Granite Renosterveld (2)	5912	6.2	67	5.5	27	n/a	26	CR	CR_{a+d}
Swartland Shale Renosterveld (3)	46319	9.4	92	2.3	6.2	n/a	26	CR	CR_{a+d}
Swartland Silcrete Renosterveld	1009	10	81	5.5	13	n/a	26	CR	CR_a
Western Shaleband Vegetation	329	3	0.1	100	0	0	30	LT	LT

* Endemic vegetation types with 100% of area within the City.
** "a" criterion based on area lost, "d" criterion based on number of threatened species (DEAT, in prep.).
*** The number of subtypes is given for the National Vegetation Types in parentheses, with major subtypes summed separately (see Supplementary Table 1).
*** Four additional azonal vegetation types (Mucina and Rutherford, 2006) are not included herein. Cape Inland Saltpans (LT) and Cape Seashore Vegetation (LT) are too small (<300 ha) and linear to be accurately mapped. Cape Vernal Pools (CR in 2004, now EN) is extinct in the City and has not been mapped: all current known natural examples are outside the City and its original extent is unknown. Some occurrences of Southern Coastal Forest (localized patches of strandveld comprising large stands of Milkwood *Sideroxylon inerme*, *e.g.* groves at Noordhoek, Macassar and Gordons Bay) are not mapped in the region.
\# n/a = not available for consideration.

53 species are Data Deficient. Some 19% of South Africa's CR species occur in the City (Table 3). As can be expected for a relatively transformed and well-explored area, the provincial and national proportions represented within the City are strongly biased to the higher categories of extinction threat. Thus half of the province's and a third of the nation's extinct species occur in the City. A quarter of the province's CR species, a fifth of the EN and an eighth of the VU occur in the City (Table 3). By contrast only 6% of the province's Data Deficient species occur in the City.

Separate threatened and near-threatened Red Lists for vegetation types are only available from georeferenced herbarium specimens (Table 4). Adequate locality lists do not exist to augment this data and should be seen as a monitoring priority. The only historical figures are from 1992 (McDowell et al., 1991; Wood et al., 1994), where 82 species were recorded for Sand Fynbos and four for Strandveld, using the old national Red Book criteria (Hilton-Taylor, 1996). Current figures are 108 threatened and near-threatened IUCN Red List species for Cape Flats Sand Fynbos and 22 for Cape Flats Dune Strandveld (Table 4).

The vegetation type with the most threatened and near-threatened Red List species is Cape Flats Sand Fynbos which has four extinct species among its total of 108 species (Table 4). Fortunately three of these survive in cultivation and are being reintroduced into apparently suitable remnants.

With 450 threatened and near-threatened Red List plant species, the City (affectionately known as the Mother City) is arguably internationally in a league of its own as the mother of all biodiversity disasters.

3.4. Animal species

The City is well-endowed with animal species (Table 2). Although birds dominate numerically, the amphibian and mammal species are also diverse, especially compared to the South Africa totals.

The City is particularly rich relative to South Africa in terms of amphibians (Table 2). Two species are endemic to the City, viz. the Table Mountain Ghost Frog (CR) and Cape Moss Frog (NT): these constitute the only two endemic vertebrates to the City. An additional six species have more than half their home range within the City (Cape Platanna (CR), Cape Rain Frog (VU), Micro Frog (CR), Rose's Mountain Toad (VU), Western Leopard Toad (EN) and Landdroskop Moss Frog (NT)); and the Cape Caco (VU) has about one-quarter of its range within the City. Most of these (80%) are threatened and near-threatened Red List species (Table 3; Minter et al., 2004).

Table 2
Total species counts in the City of Cape Town, South Africa, for higher plants (Raimondo et al., in press) and vertebrates — mammals (Minter et al., 2004), birds (Barns, 2000), reptiles (Branch, 1998, currently under RDL revision using SARCA data — M. Burger (pers. comm.)), amphibians (Minter et al., 2004) and fish (Impson, 2007; Tweddle et al., 2009, currently under taxonomic and RDL revision).

Taxon	Total indigenous in City	Endemic to City	Red List [a]	Locally extinct in City	Naturalized	City endemic to RSA	% RSA in City	% RSA RDL in City
Plants	>3350	>190	450>	49	+450	>2800	17	17
Mammals [b]	83	0	24	8	7	16	28	16
Birds	364	0	22 [c]	9	10	16	44	21
Reptiles	60	0	8	2	6	28	14	8
Amphibians	27	2	10	0	3	25	32	30
Fresh water fish [d]	8	0	5	1	12	7	6	10

[a] Extinct, Threatened (CR, EN and VU), Near Threatened and Data Deficient species.
[b] Excluding vagrant and pelagic species.
[c] Including locally extinct species.
[d] Under revision with *Galaxius zebratus* and *Sandelia capensis* to be split into several threatened species, two and one of which may be largely endemic to and threatened in the City, respectively (Denis Tweddle, pers. comm.).

All animal (mainly mammal, plus Ostrich) species larger than 50 kg were hunted out from the City by 1700 (Rebelo, 1992). Initial attempts at reintroducing large game in the Cape Point Nature Reserve during the 1960s resulted in the introduction of species not typical of the region (*e.g.* Springbok, Hartman's Zebra, Bontebok, Wildebeest). These animals have largely died out or been replaced by more appropriate game (although the Bontebok, an extremely localized endemic to renosterveld 200 km to the east, remains), as Sandstone Fynbos does not naturally support large populations of herbivores (Rebelo, 1992). Currently it is not possible to entertain the reintroduction of large animals (Black Rhino, Eland, Red Haartebeest, Mountain Zebra, Lion, Spotted Hyaena, Leopard (to the Peninsula, Leopard are still present in the Kogelberg)) to most of the nature reserves in the City, and especially the renosterveld areas where the large grazers have been lost, mainly because of fragmentation and fencing issues. In 1981 Hippopotamus were reintroduced into Rondevlei Nature Reserve after an absence of nearly 300 years. The reintroduction was largely motivated by the need to control the invasive Vleigras (*Paspalum vaginatum*) which was smothering the wetland (Holmes et al., 2008). Tygerberg Nature Reserve is augmenting their Grey Rhebok population and there are plans to introduce Grey Rhebok and Red Hartebeest within the Blaauwberg Conservation Area once all the land parcels have been consolidated and the area adequately fenced. Klipspringer and Grey Rhebok have been recently reintroduced to the Table Mountain National Park, following Haartebeest and Eland during the 1950s. Some Burchells Zebra were being bred on the lower slopes of Devils Peak as part of the Quagga restoration programme (Harley, 1988).

The absence of endemic reptiles within the City is surprising (Table 2), as the west coast and mountains to the east are renowned for localized endemics (Rebelo, 1992). Six of the seven fynbos endemic bird species occur in the City (Hockey et al., 2006; Rebelo, 1992), but no species have distributions largely contained by the City. Similarly, freshwater fish are poor in species (Table 2), unlike the Olifants River System to the north which is rich in endemics.

Invertebrates are poorly known (Picker and Samways, 1996): some 21 spider and scorpion, 21 millipede and centipede, 18 crustacean, 16 beetle and 12 earthworm species are recorded as endemic to the Peninsula alone — the number for the total City is unknown. The Lion Velvetworm *Peripatopsis leonine* from Signal Hill is considered extinct and two Waterbeetles (*Algophilus lathridoides*, and *Allocotocerus mixtus*) endemic to Table Mountain are also probably extinct (Rebelo et al., in preparation).

About 10 mammal, seven bird, six reptile and amphibian and many fish species have naturalized in the City, and many bird species from the subtropics have expanded their ranges following urban habitats. However, of these only the Himalayan Tahr has had a major ecological impact on natural ecosystems. Species with lesser impacts include the invasive House Crow, which is currently confined to urban areas and the focus of an eradication programme; Mallard which hybridizes with indigenous Yellow-billed Duck; and two frog species (Painted Reed Frog *Hyperolius marmoratus* and Guttural Toad *Amietophrynus gutturalis*). The effect of alien invertebrates is unknown and poorly documented (Picker and Samways, 1996): for instance, the impact of European earthworms on the 12 earthworms endemic to the Peninsula area is unknown.

Table 3
The status of Red List plant and vertebrate species in the City of Cape Town, South Africa. References and details as in Table 2. Red List categories are: Extinct in the Wild (EW), Extinct (EX), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) or Data Deficient (DD); Least Concern (LC) species are not enumerated.

Taxon	Threatened Red List taxa	EW	EX	CR	EN	VU	NT	DD
Higher plants	319	4	9	85	112	122	67	53
Plants as % of Western Cape's RDL								
	17%	100%	39%	25%	20%	13%	29%	6%
Plants as % of South Africa's RDL								
	12%	57%	27%	19%	16%	9%	18%	4%
Mammals	6	0	0	0	1	5	9	9
Birds	9	0	0	0	2	7	13	0
Reptiles	3	0	0	1	1	1	3	2
Amphibians	7	0	0	2	2	3	3	0
Fresh water fish	2	0	0	0	2	0	0	3

Table 4
Red List status of plant species (Raimondo et al., in press) and natural endemics (Rebelo et al., 2006) by vegetation type. Data are based on herbarium specimens with adequate locality information for georeferencing and are probably serious underestimates until comprehensive species surveys of remnants are undertaken. Endemics are defined as species largely confined to the vegetation type. Red List categories are given in Table 3.

Vegetation type	For City portion only						Total vegetation type area		
	EW	EX	CR	EN	VU	NT	Total	Threatened [a]	Endemics
Atlantis Sand Fynbos	1		8	18	14	4	45	84	6
Boland Granite Fynbos				6	4	5	15	49	23
Cape Flats Dune Strandveld			6	6	6	4	22	18	1
Cape Flats Sand Fynbos	3	1	28	34	32	10	108	92	16
Cape Inland Salt Pans				1			1	10	6
Cape Lowland Freshwater Wetlands			1	1			2	10	0
Cape Winelands Shale Fynbos				7	4	12	23	17	1
Elgin Shale Fynbos							0	19	2
Hangklip Sand Fynbos		1	3	2	7	1	14	27	5
Kogelberg Sandstone Fynbos			3	5	7	13	28	84	176
Lourensford Alluvium Fynbos			2	9	9	7	27	20	0
Peninsula Granite Fynbos		1	2	13	7	4	27	24	9
Peninsula Sandstone Fynbos	1		14	24	30	7	76	64	140
Peninsula Shale Renosterveld			1	6	2	3	12	8	0
Southern Afrotemperate Forest							0	8	14
Swartland Alluvium Fynbos				1			1	55	13
Swartland Granite Renosterveld			3	6	8	1	18	120	27
Swartland Shale Renosterveld	1	1	19	28	21	10	80	141	35
Swartland Silcrete Renosterveld			4	4		2	10	11	4

[a] Threatened comprises CR, EN and VU.

3.5. Rate of habitat transformation

Historical data on the rate of habitat transformation are not readily available. Although the urban area increased dramatically after the turn of the 20th century, only after WWII did it rapidly increase, trebling between 1946 and 1977, and then doubling again by 2002 (Fig. 3; Sinclair-Smith, 2009). Urban areas account for 16% of the metropole, or a quarter of the total transformed area. Agriculture was localized at the turn of the 20th century, rapidly increasing around WWI, and slowly increasing thereafter (Fig. 3; C. Peterson, pers. comm., original data extrapolated to the entire City area). Today it accounts, with smallholdings, for three-quarters of the transformed area of the City. In total, 60.2% of the metropole is transformed. The 1970s was the period when the transformation from a City within natural vegetation to natural vegetation within the City occurred. Presumably about this time free-ranging fires were increasingly being suppressed and brought "under control".

3.6. History of the protected area network

Prior to the 1980s natural area conservation was haphazard. The first realization that conservation was required occurred in 1938 when land was acquired at Cape Point for conservation, but conservation efforts then focussed on large mammals (Rebelo, 1992).

The earliest conservation plan for the City was the 1982 "Greening the City" report. Conservation planning was first initiated for lowland areas in the southwestern Cape by Jarman (1986), but areas within the 1986 urban edge were largely excluded. Flora surveys during the 1980s and 1990s assessed species on remnants (Daines and Low, 1993; McDowell and Low, 1990; Wood and Low, 1995), but these were not prioritized in City planning.

Jarman (1986) proposed a large park – the False Bay Coastal Park – to link the Peninsula with the Hottentot Hollands via the Kuilsriver Wetlands, the Cape Corp military conservation areas and the coastal strip, but only two small portions – Wolfgat and Driftsands – were proclaimed in 1986, with Pelican Park scrapped in favour of conserving Driftsands (Wood et al., 1994). However, in 1984 it was decided by national politicians to develop the majority of this area as the Khayelitsha Township to cope with a rapid increase in people translocating to Cape Town (Small, 2008).

In 1997 the Botanical Society commissioned a study to identify the most important remaining remnants. Some 20 Core Flora Sites were identified from the 47 sites with species lists (McKenzie and Rebelo, 1997). Core Flora Sites were defined as sites containing one or more species for which the site was essential for their conservation within the City. This study was repeated in 1999, with 118 sites, resulting in 37 Core Flora Sites being identified (Maze and Rebelo, 1999). Although the report was well received and formally accepted by the City Council, no action resulted: no sites were proclaimed or protected. In 2002 certain sites became managed for biodiversity whereas previously they were unmanaged reserves or natural open space when Cape Flats Nature (a partnership between SANBI and the City) was established under the umbrella of CAPE (Cape Action for People and the Environment (www.capeaction.org.za)). This project has demonstrated the value of onsite management and local community involvement in conservation initiatives (Maze et al., 2002).

In 2002 the first systematic conservation planning study was done to identify a City-wide biodiversity network that incorporated

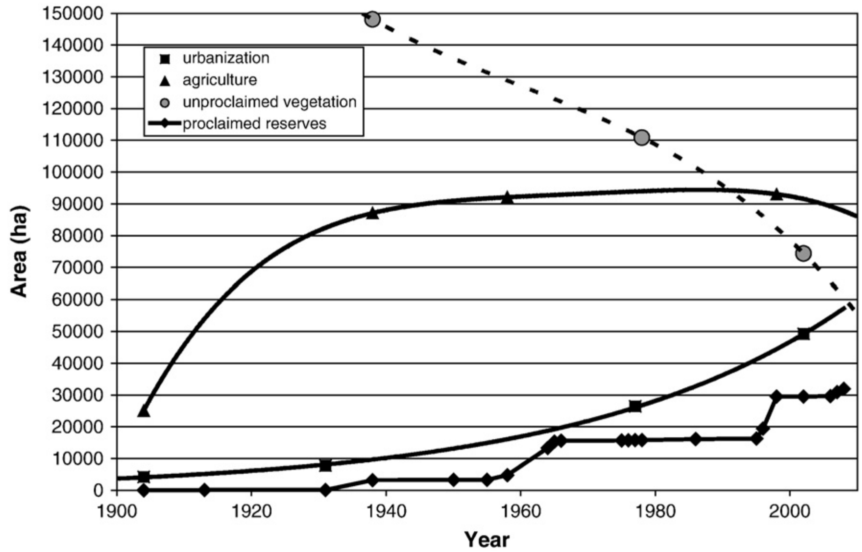

Fig. 3. Growth of urban areas, agriculture and the proclaimed conservation estate in the City of Cape Town, South Africa, over the last century.

all conservation areas and Core Flora Sites (Laros, 2004). This study pre-dated the NSBA and the 2006 National Vegetation Map, thus biodiversity representation targets and the prioritization decision tree were agreed during workshops with local experts. A local vegetation map (Anon, 2000) and species data from the "Protea Atlas" and "Sites and Species" databases were used as informants. Planning units numbered 886 (from 0.3 to 12,693 ha in size) and comprised cadastral units intersecting with the vegetation remnant layer that was digitized from 1997 aerial photographs.

The study identified a total of 369 remnants (of which 108 were already conserved) to meet the targets of adequate representation of species and vegetation types. This was equivalent to 92% of the remaining natural areas in 2002 (Laros, 2004). This and future iterations of the fine-scale systematic conservation plan is known as the Biodiversity Network.

A linkage study was also undertaken (Laros, 2004), ostensibly to link core conservation nodes together to allow migration and movement of biota. Although a thorough and detailed computer study, it was never adequately ground-truthed and corridors and conservation nodes, due to the lack of suitable alternatives, were linked to road verges and degraded wetlands, resulting in a suboptimal network for biodiversity conservation in terms of plant species or ecosystem conservation. Specifically, four of the 15 nodes contained no land suitable for conservation.

A second systematic conservation planning study was undertaken in 2008, with updated information aligned to the NSBA and National Vegetation Map, as well as an improved, ground-truthed vegetation remnant layer. The results showed that to meet the targets of adequate representation of species and vegetation types in 2008, 97% of the remaining natural areas would have to be protected (Benn, 2008).

3.7. Current conservation status

Some seven vegetation types are sufficiently conserved to have met their national targets, although for South Peninsula Granite Fynbos this is only because the pine and gum plantations and areas degraded by Afrotemperate Forest invasion (together totalling 16% of the type) are categorized as restorable. Three vegetation types are not conserved at all, and a further seven have less than 10%, or one-third of their target, conserved.

Some 17.7% of the City is managed in protected areas or unproclaimed reserves. Of this 54.5% occurs on the Peninsula in the Table Mountain National Park, 6.4% in private nature reserves, 6.4% in provincial nature reserves, with City managed reserves totalling 16.4% (of which more than half (56.0%) does not have statutory protection). The remaining 16.0% in the Kogelberg is managed by the City Bulk Water Branch for provision of water. The high proportion of mountain land managed reflects the bias towards conservation of mountain landscapes, and a lack of conservation in the lowlands. The area of vegetation types conserved is 1–32% for lowland, compared to 16–99% for mountain (excluding Elgin Shale Fynbos) vegetation types. Some 2.0% of the City area, identified since 1997 as "Core Flora" conservation sites, has neither formal protection nor conservation management.

Several milestones have occurred in the acquisition of the reserve network. These include the first large-scale conservation acquisition in the 1960s in the southern Peninsula, the handover of State Forests to conservation in the 1980s in the Kogelberg and Hottentots Holland, and the proclamation of the Table Mountain National Park on the Peninsula in 1998. This however conceals the fact that prior to formal protection, many of these areas enjoyed protection under various acts unrelated to conservation (*e.g.* Mountain Catchment Areas, Forestry Reserves).

Two biosphere reserves that are registered with UNESCO under the "Man and Biosphere programme" encompass land within the City: Kogelberg Biosphere Reserve and Cape West Coast Biosphere Reserve. Although these exist on many conservation maps, they have never been explicitly incorporated into conservation planning within the City.

3.8. Conservation planning

By definition, all eight Critically Endangered vegetation types as defined by area lost (Table 1; Fig. 4) cannot meet their conservation target, and all natural remnants of these are 100% irreplaceable. The two additional Critically Endangered vegetation types, identified on their rare species (as containing more than 60 threatened Red List plant species), had land surplus to their conservation targets, but these are subject to environmental impact assessments to ensure that any specific area does not contain unrecorded populations of threatened Red List species. An additional eight vegetation types had natural vegetation surplus to the needs of the targets set. Two types are effectively totally conserved, and are not available for future development.

Although some 17.7% of the City area is conserved or managed, this is inadequate to conserve the biodiversity within the City. A further 15.9% of the total area is required to meet vegetation targets, 0.9% is required to meet Protea species targets, and 0.7% required to meet other species targets. Thus 17.7% is currently managed of a total target of 35.2%. Assuming that all the currently managed conservation areas will be proclaimed, the City is just over half way (50.3%) to meeting its biodiversity conservation targets. However, additional land may be required as Critical Ecological Support Areas (CESA; Fig. 4) to maintain ecosystems processes such as fire regimes and large faunal movement.

If current trends of urban development continue (Fig. 3) we have only until 2020 to secure all the remnants required to meet minimum conservation targets in the City. According to the draft City Environmental Agenda 2009–2014, 60% of biodiversity targets should be secured in the next five years. Excluding already proclaimed areas this amounts to securing 200 km^2 or 40 km^2 per annum over the next five years. Assuming that this target is achieved, this still leaves 347 km^2 that will have to be secured by 2020 before these habitats are lost to urbanization.

3.9. Implementation and management challenges

Conservation management challenges in the City are strongly tied to vegetation type (De Villiers et al., 2005; Table 5). Most obvious is that fire-prone fynbos rapidly degenerates if mowed or not burned, whereas strandveld (and forest) appears far more urban-compatible. Fynbos must be burned, which requires planning, permission, firebelts and firefighting preparedness. Furthermore, the lower nutrient-soils are more easily enriched with groundwater pollution, alien nitrogen-fixers or by accident: these rapidly transform the ecosystem to a degraded state. Consequently, small reserves in fynbos are less viable than for other vegetation types, and fynbos reserves need to be as large and with as low an edge to area ratio as possible. All fire sensitive infrastructure needs to be outside any reserve. However, throughout most of the City lowlands only small patches of fynbos remain, and consolidation and enlargement (via restoration) are not usually options.

There is also a cultural difference that incidentally relates to vegetation type. Fynbos and renosterveld areas were relatively easily urbanized, and settled earlier, whereas the strandveld dunes required heavy machinery for levelling the dunes and trenching equipment to allow colonization of winter-flooded areas. Consequently, the older, more established, better resourced and formerly “white” suburbs tend to occur in the former; and the younger, poorer suburbs occur in strandveld. Urban problems associated with fynbos and renosterveld tend to relate to small-scale dumping of garden refuse, odd cases of picking flowers and vagrants sleeping over, domestic cat and dog walker problems with wildlife, with relatively interested local conservation groups supporting nature reserves and assisting conservation officers. By contrast, strandveld tends to have large-scale dumping of industrial and builders rubble, extensive removal of medicinal plants and firewood, illegal hunting with dog packs, and largely disinterested communities who either see the reserves as “bush of evil” due to drug-, rape- and safety issues, and who are antagonistic to conservation officers, or where interest groups exist, these tend to be community-focussed and under-resourced (Table 5).

4. Way forward

In order to halt the loss of irreplaceable biodiversity remnants, spatial urban planning design must change from one of urban sprawl to densification. Although this is occurring to some extent, the current 6.5 km^2/annum rate of transformation for development must be reduced further through a strong focus on redevelopment projects. Forward spatial planning should direct the City’s major growth axes away from major biodiversity areas. Greenfield development projects should be directed towards degraded land of low biodiversity value. To this end, biodiversity personnel are ensuring that the Biodiversity Network is a key informant in the City’s spatial development framework and district plans. In addition, the City’s environmental management frameworks incorporate the Biodiversity Network and the new integrated zoning scheme includes a category for conservation land. Environmental and biodiversity management staff, at all levels of government, recognize the Biodiversity Network as the main biodiversity informant for the City in commenting on development applications and in securing conservation land. The City has also committed to the conservation of biodiversity by adopting the Biodiversity Strategy (Anon, 2003), through the signing of the IUCN Countdown 2010 (www.countdown2010.org), and signing the Durban Commitment in 2008 as a participating municipality in the ICLEI Local Action for Biodiversity (LAB) Project (www.iclei.org/lab), which commits participants to regular biodiversity monitoring and reporting. Although all these initiatives commit the City to the conservation of biodiversity, reversing the trend of biodiversity loss has yet to be achieved.

Most landowners adjacent to or inside the urban edge have development aspirations and may not be interested in biodiversity conservation. In these cases, substantial funding will be required to purchase important land in order to realize the Biodiversity Network. By contrast, landowners in rural areas may be interested in conserving natural remnants on their land through a formal stewardship agreement. This can be negotiated with the provincial

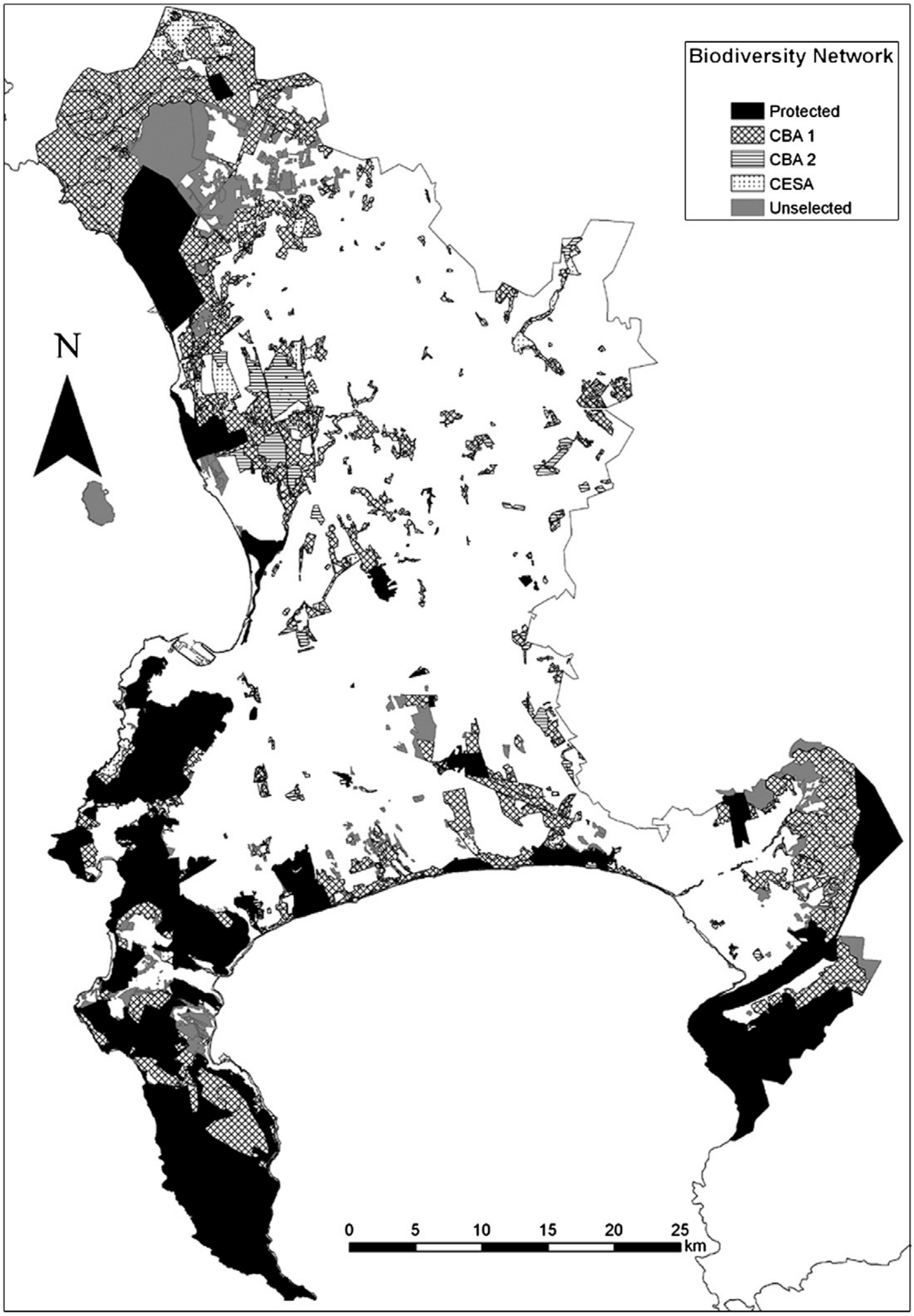

Fig. 4. City of Cape Town 2008 fine-scale systematic conservation plan: the Biodiversity Network. "Protected" are areas proclaimed or unproclaimed but managed for conservation. CBA1 are Critical Biodiversity Areas comprising Core Flora Sites not protected or managed, 100% irreplaceable sites of High and Medium quality and the minimum set sites. CBA2 are irreplaceable sites of restorable quality. CESA are sites additional to biodiversity targets for maintaining ecosystem processes. Unselected areas are remaining natural vegetation not required to meet minimum conservation targets.

conservation authority, CapeNature, in the form of a contract or biodiversity agreement. Alternatively, for properties adjacent to the Table Mountain National Park, a contract can be negotiated between the landowner and SANParks. For sites not considered a priority by the former agencies, the City can enter a conservation agreement with landowners. Incentives to the landowner include

Table 5
Threats to conservation management and implementation of the Biodiversity Network, other than the main threat of habitat transformation.

Threat	Occurrence	Notes
Invasive alien plants	All ecosystems. Different species in different ecosystems — most important species are: *Acacia cyclops* in Strandveld; *A. saligna* in Sand Fynbos; *A. melanoxylon* in Granite Fynbos, *Pinus radiata* in Sandstone Fynbos.	The greatest threat by area after land transformation. Ranked second greatest threat to threatened and near-threatened Red List species (Raimondo et al., in press). In conservation areas is probably the greatest and most expensive threat, even though in most reserves aliens are "under control" (Richardson and Van Wilgen, 2004). May result in ecosystem transformation from shrubland to grassland (owing to nitrogen enrichment) (Milton, 2004; Yelenik et al., 2004). Granite Fynbos – with almost 350 naturalized species – is the most alien-rich vegetation type (A.G. Rebelo, unpublished data).
Unwillingness to burn in correct season	Sandstone, Granite, Shale and Sand Fynbos	Results in poor recruitment and population crashes (Bond, 1997)
Fire exclusion	Fynbos	If too cool or too long-return interval *Passerina* takes over and thicket species invade (Sand Fynbos) or Afrotemperate Forest species invade (Granite and Shale Fynbos).
Lack of megaherbivores	Strandveld; Renosterveld; smaller reserves	Bush encroachment by larger shrubs (Joubert, 1991; Rebelo, 1995)
Lack of larger predators	Smaller reserves	Overgrazing of shrubs, antelope populations well exceed carrying capacity, loss of susceptible plant species (C. Dorse, pers. obs.). Cape Dune Mole Rat population explosions creating grazing lawns: obstacle to restoration (Holmes, 2008) and transforms vegetation from edges and firebelts
Frankenflora/fauna (hybrid swarms and extralimital relatives)	All ecosystems	Lack of appreciation of gene pools led to many early conservation decisions that appear odd by today's standards. The Namibian Hartman's Zebra was introduced at Cape Point, rather than the historically recorded Cape Mountain Zebra. Similarly, Black Wildebeest, Springbuck and other extralimital animals were introduced into the reserves (Rebelo, 1992). Plants were similarly brought in from other areas of the CFR, all indigenous to the CFR, but alien to the Peninsula, some of which hybridize indigenous and endemic species. Similarly, large-scale planting of threatened species has not considered genetic variation within populations (Rebelo, 2009). Frogs, reptiles and fish have been similarly translocated, but hybridization has not been recorded, although *Xenopus laevis* and *gillii* have hybridized due to wetland dynamics alterations (Minter et al., 2004). Mallard Ducks.
Alien animals	Peripheral: mainly edge effects Sandstone Fynbos Granite Fynbos	Argentine Ant, Indian House Crow, Grey Squirrel, Himalayan Tahr, Sambar Fallow Deer
Domestic alien animals		Dogs (walking and hunting) and cats (hunting)
Plant collection and utilization	Mainly Strandveld and Forest; also bulbs	Multi collection, "Traditional" (but by cultures alien to the CFR) plant harvesting
Edge effects in small remnants	General Sand Fynbos	Urban fauna (dogs, cats, Argentine Ant) Alien annual grasses Cape Dune Mole Rat disturbance in fire belts
Air pollution	All	Increased nitrogen from car exhausts and other pollution results in ecosystem transformation, *e.g.* increased grassiness and more frequent fires (D'Antonio and Vitousek, 1992; Wilson et al., 2009)
Sewage pollution	Mainly Sand Fynbos, but also Strandveld	Although mainly a problem in wetlands, sewage spills in nature reserves are fixed last, not cleaned up, and kill most fynbos plant species.
Eutrophication of water tables	Sand Fynbos and Strandveld	By dog faeces, lawn fertilizers and sewage spills. Promotes indigenous and alien grasses over shrubs.

Table 5 (*continued*)

Threat	Occurrence	Notes
Loss of habitat integrity	Sand and Alluvium Fynbos	Particularly susceptible to disturbances (sewage, air and ground water pollution, water table alteration, invasion by annual grass, and mowing), resulting in transformation from shrubland to *Ehrharta calycina* and *Cynodon dactylon* lawns or alien thickets, and the loss of overstorey species.
Green Belts failing as conservation corridors	Fynbos	Without fire, green belts and corridors become invaded by Afrotemperate trees and thicket elements, or are maintained as lawns that are not suitable for fynbos animal or plant species
Dumping	Strandveld and Sand Fynbos	Garden waste – introducing aliens and nitrification – in upmarket areas, rubble and refuse – degrading ecosystems – in poorer areas (P.M. Holmes, pers. obs.)
Canalization and weirs in rivers	Wetlands	Results in solid waste being washed into reserves; Fixes water levels in dynamic systems that should dry out in summer and flood over in winter
Off-road vehicle use.	Strandveld, Sand Fynbos Sand and Sandstone Fynbos	4×4s, quadbikes destroying vegetation and causing erosion. Off-road mountain cycling destroying vegetation and causing erosion
Emergency services access	Wetlands and Fynbos	Helicopters removing water from bird sanctuaries for fire-fighting; fence and wetland damage for emergency access to fires
Unrealistic demands	General	Deflects staff from biodiversity management to peripheral issues: *e.g.* mosquitoes from wetlands, dust from seasonal wetlands, *Typha* seeds and pollen. Demands to prepare urban fire belts and put out frequent, small wildfires in urban non-conservation areas.
Lack of security and law enforcement	In poorer neighbourhoods	Prevents managers and public from accessing reserves; results in poaching
Public and political ignorance and apathy	General	Oppose conservation areas. Establish gardens in conservation areas. Desire lawns and shade trees in conservation areas.
Ignorance and lack of communication	General	Lack of coordination and recognition of partner and volunteer groups; Lack of coordination of data and management among City departments; Poor town planning adjacent to remnants.
Lack of clarity of roles and responsibilities	Problem animals (baboons, snakes, and porcupines); invasive plants and animals.	Among different conservation agencies, especially areas off or neighbouring reserves.
Conflict with mining	Sand mining in Strandveld and Sand Fynbos	Department of Mineral and Energy can grant prospecting and mining permits in existing and priority conservation areas.
Operational management inefficiencies	All ecosystems	All government agencies: legislated procurement process complex and arduous — delays appointment of contractors for urgent management interventions

advice and assistance with conservation management and a rates rebate for land under an agreed and audited conservation management plan.

The actions above, both reactive and proactive, are unfortunately insufficient to halt the biodiversity crisis facing the City. In order to secure the Biodiversity Network, funding far beyond the resources currently available to biodiversity management in the City is needed. To date, significant funds have been secured with CAPE (Cape Action for People and Environment, a CFR Bioregional Programme) partners from agencies such as the Table Mountain Fund (TMF, WWF-SA), GEF (Global Environmental Facility) and CEPF (Critical Ecosystem Partnership Fund). Furthermore CAPE has funded capacity-building initiatives in the conservation sector. Significant assistance for alien plant clearance has been funded for the Table Mountain National Park by the GEF and the national Working for Water and Working for Wetlands expanded public-works programmes (Van Wilgen et al., 2002).

Potential sources of future funding for securing biodiversity at the regional level include unlocking development contributions, implementing the provincial draft biodiversity offsets policy, and landowner levies for management of conservation areas within or adjacent to development projects. In the case of biodiversity land being set aside as a recommendation in the environmental authorization or land use planning ordinance process, it is essential that the authorization includes a mechanism to manage the land. This has not been done in the majority of cases to date, to the detriment of biodiversity in these remnants.

City Biodiversity Management has developed a five year prioritization and action plan to secure and manage Biodiversity Network remnants (the Local Biodiversity Implementation Plan) as part of a larger Local Biodiversity Strategy and Action Plan approved by the City council. Within the plan, four focal area priorities will be tackled, with action plans developed for each site following communication with the landowners. The City's Environmental Agenda (2009–2014) (www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Pages/PoliciesandStrategies.aspx) includes the environmental target of "At a minimum, 60% of areas identified to meet our biodiversity targets will be under formal management and secured for future generations". This requires that 40 km^2 (1.6% of City and 12.5% of existing proclaimed areas) be proclaimed per year.

Reserves that currently do not have proclamation status will be submitted for official status under the Protected Areas Act. For City land managed by other line functions, biodiversity agreements and MOUs will be drawn up for Biodiversity Network land, according to the CapeNature stewardship criteria, in order to ensure appropriate management.

It is important that existing proclaimed areas are being adequately managed. This will be ensured by preparing strategic plans, implementing biodiversity monitoring and evaluation on reserves and monitoring personnel performance. The City is implementing the internationally recognized Management Effectiveness Tracking Tool system. Management has also developed a more detailed Protected Areas Review to assess management on the ground. A strong emphasis on people-centred conservation and community-based resource management is required to ensure that communities learn to appreciate their natural heritage.

We strongly contend that adaptation and mitigation to global climate change are best served by retaining as much natural area as needed for the Biodiversity Network and restoring degraded areas where possible (Anon, 2008). There are too many species and too many threatened diverse ecosystems to risk moving species between reserves. However, restoration of ecosystems in degraded areas and the reintroduction of Extinct in the Wild and Critically Endangered species to suitable nature reserves are essential. Predictions for increased storm surge and sea level rise highlight the importance of maintaining natural coastal ecosystems such as Cape Flats Dune Strandveld and keeping vegetation in other flood-prone areas intact. This would also serve the economy of Cape Town, which is strongly based on tourism that is underpinned by healthy natural ecosystems.

An urgent, high level and synergistic initiative is required among conservationists, planners, natural resource managers and politicians to save the last remaining examples of the City's unique biodiversity. The timeframe for achieving this is short: 5–10 years; and a significant injection of national and international funding is needed to ensure that both the biodiversity and people (through job opportunities) benefit.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.sajb.2010.04.006.

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