Equus zebra zebra – Cape Mountain Zebra

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Red List status (2016)	Least Concern*†‡
Red List status (2008)	Vulnerable C1
Red List status (2004)	Vulnerable D1
Reasons for change	Genuine change: Increased population
TOPS listing (NEMBA) (2007)	Endangered
CITES listing (1975)	Appendix 1
Endemic	Yes

*Watch-list Data †Watch-list Threat ‡Conservation Dependent

Historically, Cape Mountain Zebra were widespread in the mountainous regions of the southern parts of South Africa, but by the late 1980s only three natural subpopulations remained; those conserved in the Kammanassie Nature Reserve, the Gamka Mountain Nature Reserve and the Mountain Zebra National Park (Watson & Chadwick 2007).

Taxonomy

Equus zebra ssp. *zebra* (Linnaeus 1758)

ANIMALIA - CHORDATA - MAMMALIA - PERISSODACTYLA - EQUIDAE - *Equus - zebra - zebra*

Common names: Cape Mountain Zebra (English), Bergkwagga, Kaapse Bergsebra (Afrikaans), Daou (Khoikhoi), Dou (San), iDauwa (Xhosa)

Taxonomic status: Subspecies

Taxonomic notes: Groves and Bell (2004) investigated the taxonomy of the Mountain Zebras and concluded that the Cape Mountain Zebra (*Equus zebra zebra*) and Hartmann's Mountain Zebra (*Equus zebra hartmannae*) are distinct, and suggested that the two would be better classified as separate species, *Equus zebra* and *Equus hartmannae*. However, in a genetic study that included 295 Mountain Zebra specimens, Moodley and Harley (2005) found no genetic evidence to regard the two taxa as anything more than different populations of a single species. They concluded that the Cape Mountain Zebra and Hartmann's Mountain Zebra should remain subspecies. Therefore, no taxonomic changes have been made since the previous assessment.

Assessment Rationale

The Cape Mountain Zebra is a subspecies endemic to the fynbos, grassland and karoo habitats of the Western and Eastern Cape provinces, extending marginally into the Northern Cape Province. Although reduced to fewer than 80 individuals in the 1950s, the current (2014/15) mature population size ranges from 1,714 to 3,247 individuals. In formally protected areas alone, there are a recorded 1,714–2,338 mature individuals. Furthermore, a preliminary analysis reveals that 81–98% of individuals existing on private land constitute wild and free-roaming subpopulations and are thus eligible for inclusion in this assessment. This brings the total current population size within the natural distribution range to 2,381–3,247 mature individuals. Only including subpopulations with 50 individuals or more yields an estimate of 1,973–2,691 mature individuals. Around 28% of the population is currently at risk of hybridisation, leaving 1,641–2,237 mature individuals in unaffected subpopulations. Although extra-limital subpopulations exist in the Free State and Northern Cape provinces, they are not included in this assessment. Overall, the population has been increasing steadily over a period of approximately three generations (1986–2013): average annual rate of subpopulation growth was 8.6% from 1985–1995; 9.6% from 1995–1998; 8.3% from 2002–2009; and 9.2% from 2009–2014.

Major threats to Cape Mountain Zebra include a loss of genetic diversity through inbreeding and genetic drift, hybridisation with Hartmann's Mountain Zebra and Plains Zebra (which is a recently identified emerging threat), a shortage of large areas of suitable habitat, and the absence of a metapopulation management strategy. Genetic testing for hybrids and subsequent management of affected/at risk subpopulations is a priority. This may require a reassessment once more comprehensive genetic data are available. The primary interventions are to establish a scientifically-based metapopulation management plan with the aim of enhancing genetic diversity amongst isolated subpopulations, and an ongoing drive to secure suitable habitat within the natural distribution range through protected area expansion, biodiversity stewardship agreements and the growth of private subpopulations.

Since the population has been consistently increasing for over 4 decades, and the minimum number of mature animals in the subpopulation is estimated to be 1,714, Cape Mountain Zebra are listed as Least Concern. The downlisting is legitimate as the population size has been above 1,000 mature individuals in formally protected areas alone for the last five years (1,032–1,408). Similarly, removing the key protected area, Mountain Zebra National Park, from the population would still leave a minimum of 1,060–1,726 mature individuals and, the average annual growth rate would still be positive (8.3% between 2009

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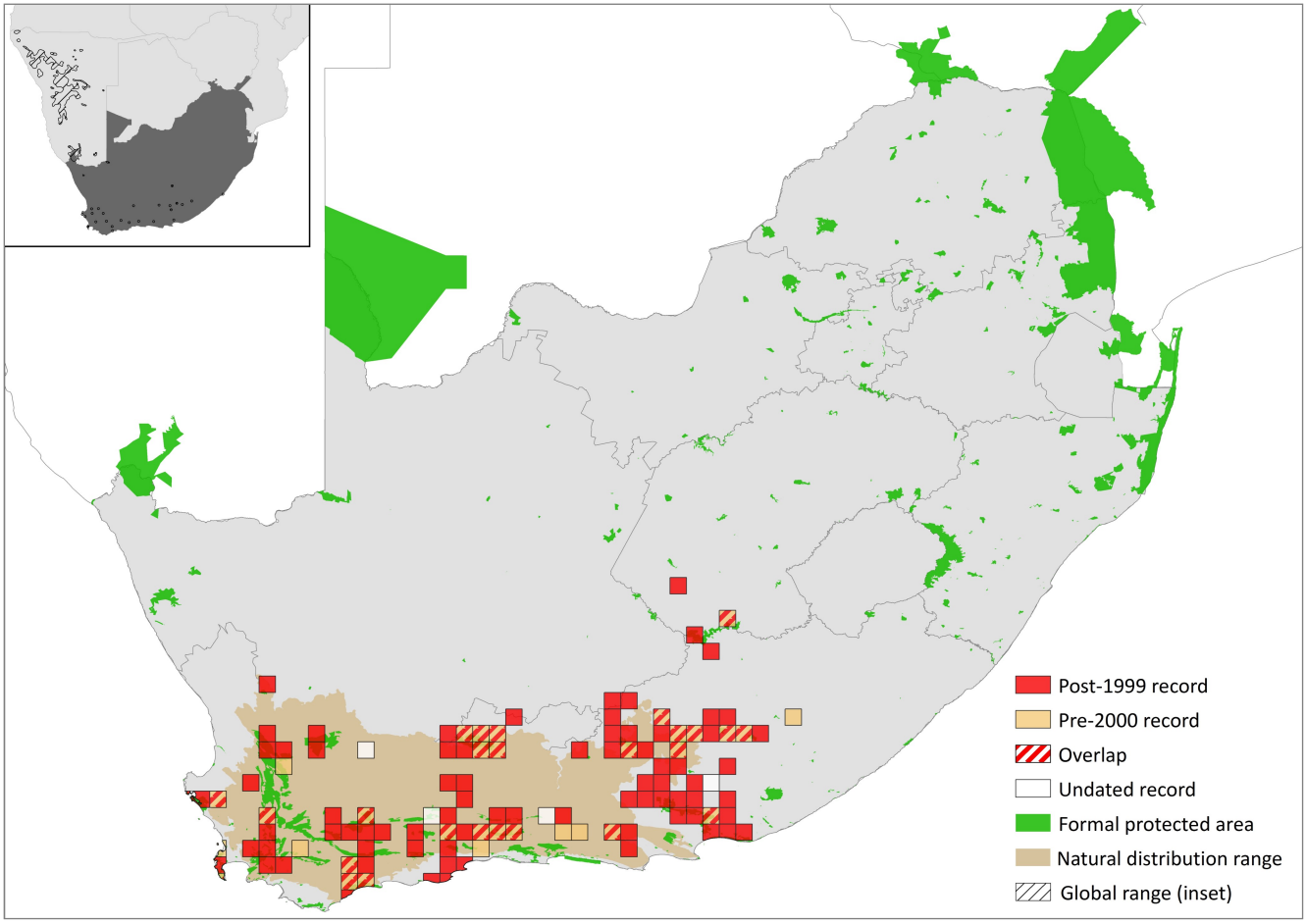

Figure 1. Distribution records for Cape Mountain Zebra (*Equus zebra zebra*) within the assessment region (global range)

Table 1. Countries of occurrence within southern Africa

Country	Presence	Origin
Botswana	Absent	-
Lesotho	Absent	-
Mozambique	Absent	-
Namibia	Absent	-
South Africa: Eastern Cape	Extant	Native
South Africa: Western Cape	Extant	Native
South Africa: Free State	Extant	Introduced
South Africa: Northern Cape	Extant	Native and introduced
Swaziland	Absent	-
Zimbabwe	Absent	-

and 2014). Finally, recent Bayesian modelling work has estimated a total increase of 572% in numbers across nine primary source subpopulations over the past three generations (1985–2015) with an estimated total population size of 2,748 (CI: 2,488–3,000) animals (1,511–2,061 mature individuals) in 2015, and supports a Least Concern listing with a probability of 100%. Thus, the Least Concern listing is appropriate. However, we stress that this is an endemic subspecies that requires a Biodiversity Management Plan (BMP) for successful conservation and is facing emerging genetic threats (inbreeding and hybridisation). As such, this is a Conservation Dependent subspecies, the management of which requires coordination between multiple stakeholders. This is a conservation success story, but further action and collaboration between stakeholders is required to ensure that it continues on its positive trajectory.

Distribution

The Cape Mountain Zebra is endemic to the Cape Floristic Region of South Africa, and occurs in the Nama Karoo, Succulent Karoo, and Grassland Biomes (Skead 2007, 2011; Boshoff et al. 2015) (Table 1, Figure 1). Its historical distribution extended throughout the great escarpment range in the Cape, south of the Orange River, including the Cape Fold Belt Mountains (the southern parts of the current eastern Western Cape Province), and the southern extent of the Northern Cape Province (Figure 2). Thus, although once widely distributed throughout the mountainous regions of the Cape, over-hunting and agricultural expansion reduced the population to fewer than 80 individuals located in just five areas of the former Cape province by the 1950s (Millar 1970). Only three remnant subpopulations from the former natural distribution survived: Mountain Zebra National Park, Kammanassie and Gamkaberg Nature Reserves (Smith et al. 2008). It is postulated that in historical times they were separated from Hartmann's Mountain Zebra (which occur mainly in Namibia), by an area devoid of mountainous habitat, the Knersvlakte, which separates the Kamiesberg in the north from the Roggeveldberge in the south (Novellie et al. 2002). However, there are no historical (pre -1920) records of Hartmann's Mountain Zebra south of the Orange River (Skead 2011).

The current distribution is limited to (at least) 75 fenced and isolated subpopulations spread throughout the former

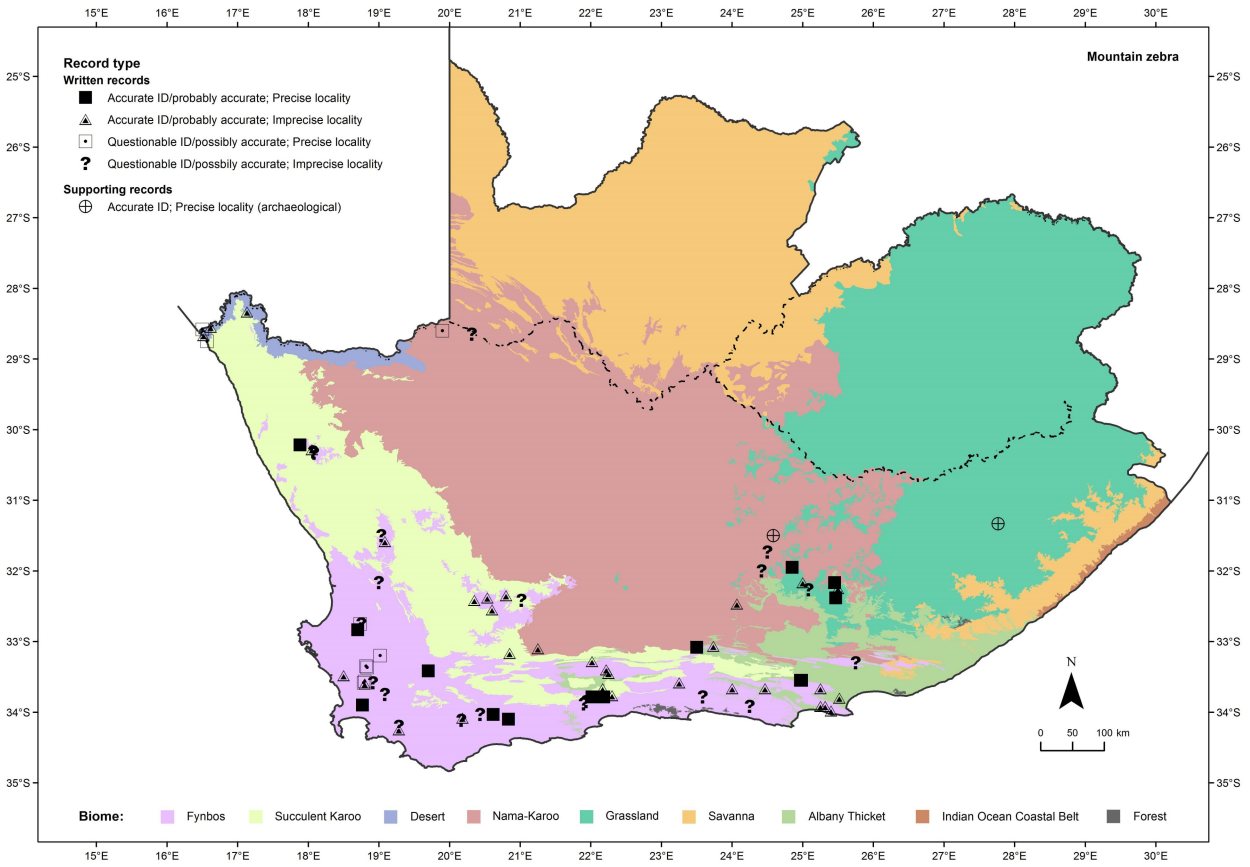

Figure 2. Historical distribution of Cape Mountain Zebra (*Equus zebra zebra*) within the assessment region; background colours represent biomes (Source: Boshoff et al. 2015)

range. Subpopulations have been reintroduced to, amongst others, Karoo, Addo Elephant, Bontebok, Tankwa Karoo and Camdeboo national parks, De Hoop Nature Reserve, Commando Drift Nature Reserve, Baviaanskloof Wilderness Area and Tsolwana Nature Reserve (Hrabar & Kerley 2015). Two of these reserve subpopulations (Commando Drift and Tsolwana) are possibly extralimital, as there are no historical records of the species east of the Great Fish River (Skead 2007). The subpopulation at Gariep Dam Nature Reserve in the Free State Province is significantly extra-limital (Boshoff & Kerley 2013) and not included in this assessment. Novellie et al. (2002) regarded the West Coast National Park as being within the historical range but there is some doubt about this given that it is on the coast and 70 km from the closest historically-recorded subpopulation in Picketburg (Skead 2011). The issue of whether to include West Coast National Park within the subspecies' range has not been resolved (Figure 1). The subpopulation at Oorlogskloof Nature Reserve in the Northern Cape lies within the historical range of Cape Mountain Zebra. It was founded in 2003 with six males and 11 females from Gariep Dam Nature Reserve. In 2010, 18 animals (five males, 13 females) from Bontebok National Park, that appeared to be free of sarcoids, were translocated to Oorlogskloof Nature Reserve (Zimmermann et al. 2010). A number of Cape Mountain Zebra have also been translocated to private properties located significantly outside of the natural range (for example, in the Free State and Northern Cape provinces) but these animals are not included in this assessment. There is no need to introduce this subspecies outside its natural range for conservation purposes.

In 2014/15, 66% of the area of occupancy (AOO) constituted formally protected areas (5,625 km^2) and 34% private areas, which yielded a total AOO of 8,566 km^2 (Hrabar & Kerley 2015). Although formally protected areas have not increased in number, many have increased in size since 2009 (for example, Anysberg Nature Reserve increased by 1,200 km^2 in 2012 and Tankwa Karoo National Park has increased by 354 km^2), thereby resulting in a 20% increase in formally protected habitat. Despite this expansion of protected areas and the rapid growth of the private sector contribution (including biodiversity stewardship sites), Cape Mountain Zebra habitat is likely to remain severely fragmented due to game fencing. Translocations between subpopulations as part of a metapopulation plan can potentially reduce the impacts of this fragmentation (such as loss of genetic diversity), but this does not take place consistently enough (Hrabar & Kerley 2015). Thus, further reintroductions, to both formally and privately protected areas, should be facilitated by a biodiversity and metapopulation management plan and follow the International Union for the Conservation of Nature (IUCN) guidelines on reintroductions (IUCN SSC 2013).

Population

Cape Mountain Zebras were once widespread and numerous but hunting and habitat loss to agriculture reduced them to just 80 individuals remaining in three relict populations in the 1950s (Bigalke 1952; Millar 1970): the Mountain Zebra National Park (MZNP) subpopulation consisted of 19 individuals, and the Kammanassie Nature

Reserve and Gamka Nature Reserve subpopulations consisted of no more than five and six individuals at their respective nadirs (Millar 1970; Lloyd 1984). The total population therefore bottlenecked at around 30 individuals at this time. Subsequently, two thirds of the subspecies genotypic variation is located in just two of the subpopulations (Kamannassie and Gamkaberg Nature Reserves); all other subpopulations (except one, De Hoop Nature Reserve) originate from MZNP alone. Active metapopulation management is thus needed, and always will be needed, to ensure genetic diversity.

MZNP has provided founder individuals for around 30 subpopulations (Novellie et al. 2002), which has led to the undesirable state of over 91% of the genetic variability in the metapopulation deriving from one stock (Moodley & Harley 2005). Individuals have thus far not been removed from the other two remnant subpopulations, Kammanassie and Gamkaberg Nature Reserves, as they are currently too small, nor have these populations been supplemented with MZNP stock. Only De Hoop Nature Reserve has been founded with individuals from two of the original subpopulations (MZNP and Kammanassie), making it an important genetic source (Moodley & Harley 2005). However, the subpopulation at De Hoop Nature Reserve has experienced an annual decline of 6.6% (1995–1999) to 4.5% (1999–2005) (Smith et al. 2008). Overall, though, the combined population is increasing. From 1985 to 1995 the annual rate of increase was reported as 8.6% (Novellie et al. 1996), 9.6 % between 1995 and 1998 (Novellie et al. 2002), 8.33 % between 2002 and 2009 (Hrabar & Kerley 2013) and 9.16% between 2009–2015 (Hrabar & Kerley 2015). However, estimating annual growth rate trends is challenging because most subpopulations are actively managed (maintained at sustainable stocking levels) and animals are often removed or augmented, which masks true growth rate. Recently, a Bayesian state-space model was fitted to count data between 1985 and 2015 (c. three generations, see below), which estimated a 572% increase across nine formally protected subpopulations over this time and provided 100% for a Least Concern listing (Winker et al. 2016)

Currently (2014/15), there are estimated to be between 1,714 and 3,247 mature individuals (using a 55% and 75% mature population structure respectively, Table 2), with the upper estimate including subpopulations on private land. In formally protected areas alone, there are an observed 1,714–2,338 mature individuals (Table 2). This is congruent with the estimate of 1,511–2,061 mature individuals (2,748 animals in total; confidence intervals: 2,488–3,000; 2015 counts) in the nine main formally protected source populations (Winker et al. 2016). Tankwa Karoo National Park, Western Cape, is included as it is within the natural distribution range. Similarly, Oorlogskloof Nature Reserve in the Northern Cape Province is included as it is within the historical range (Boshoff et al. 2015). A preliminary analysis to determine which private subpopulations can be considered wild, revealed that 81–98% of individuals on private land are eligible for inclusion in the assessment (N = 21 properties; A. Taylor unpubl. data), which corresponds to "Extrapolated eligible total" in Table 2. This brings the total current population size within the natural distribution range to 1,582–2,157 mature individuals. Only including subpopulations with 50 individuals or more yields 1,386–1,890 mature individuals. Hybridisation with Plains Zebra has been identified as an emerging threat, where currently 28% of the population is at risk (Hrabar & Kerley 2015), with one confirmed case in Mountain Zebra National Park (Taplin et al. 2015). If we subtract the number of individuals (1,346) currently co-occurring with Plains Zebra (Hrabar & Kerley 2015) from the total eligible population, an estimated 1,641–2,237 pure mature individuals remain. Repeating the same calculation including all individuals that have previously been kept with Plains Zebra (2,959 in total), yields a mature population size of 753–1,027 pure individuals. Although there is currently no evidence that hybridisation has occurred or that their relative abundance threatens the genetic integrity of Cape Mountain Zebra subpopulations (*sensu* Piett et al. 2015), these calculations highlight the need to systematically test existing Cape Mountain Zebra populations for genetic purity to more accurately estimate total mature population size.

Table 2. Subpopulation numbers of Cape Mountain Zebra (*Equus zebra zebra*) aggregated by province, 2009 to 2014/15

Province	Type	Inside natural distribution range	No of reserves/ properties (2009, 2014)	Sub-population total (2009)	Sub-population total (2013–2015)	Mature 55%	Mature 75%
Eastern Cape	Formally protected	Yes	6	1,022	1,903	1,047	1,427
	Private	Yes	10, 26	319	868	477	651
Northern Cape	Formally protected	Yes	2	34	35	19	26
Western Cape	Formally protected	Yes	10	821	1,179	648	884
	Private	Yes	23, 27	473	628	345	471
Free State	Formally protected	No	1	93	112	62	84
	Private	No	1	Unknown	8	4	6
Northern Cape	Private	No	Unknown	Unknown	Unknown		
Total formally protected (eligible)			18		3,117	1,714	2,338
Total privately protected (eligible)			53		1,496	823	1,122
Extrapolated total eligible (81%)			53		1,212	666	909
Grand total			55		4,733	2,603	3,550
Total eligible adjusted			53		4,329	2,381	3,247

The population size in 2009 on formally protected areas alone was 1,032–1,408 mature individuals, and 1,385–1,889 in total, which satisfies the IUCN rule of not meeting a threatened category for at least 5 years (IUCN Standards and Petitions Subcommittee 2014).

An intensive survey of Cape Mountain Zebra numbers in 2009 revealed that there were at least 2,790 animals on both formally protected and private properties in the Western and Eastern Cape (Hrabar & Kerley 2013). These surveys were based on aerial surveys for national parks and questionnaires for private landowners and thus the estimated population size is based on reasonably robust data. The survey revealed that, of the 52 subpopulations (compared to 29 in 2004), 17 were formally protected (1,888 individuals) and 35 were privately-owned (902 individuals). The survey has recently been repeated (2014/15) and it was found that the total population has grown to over 4,790 animals in 75 subpopulations (Hrabar & Kerley 2015). Fifty-six populations (1,487 individuals) are on privately-owned land and 19 are on formally protected areas (3,304 individuals). The majority of the population (69%) remains on formally protected land and the proportion on privately-owned land (31%) has not risen since 2009, despite the increase in subpopulation number. The MZNP and Karoo National Park subpopulations continue to make up a significant proportion of the population, namely 25% and 18%, respectively. Interestingly, Karoo National Park's contribution to the population has remained stable, at 18%, since 2002 and the proportion on MZNP shows a tendency to increase from 20% in 2002 to 22% in 2009 and 25% in 2015. If it is argued that Cape Mountain Zebra conservation relies on the existence of MZNP, removing the subpopulation leaves 1,927 individuals remaining in formally protected areas, which, at worst, equates to 1,060 mature individuals (55% mature structure). However, when adding the eligible private subpopulations, this increases population size to 3,139 individuals, which corresponds to a minimum of 1,726 mature individuals. Even in the absence of MZNP, there is no continuing decline as other protected areas exhibit an average annual growth rate 8.3% from 2009–2014 (5-year period).

The increase in available suitable habitat, is one reason for the sustained growth rate: for example, Anysberg and Gamkaberg nature reserves have both been expanded in area and a number of stewardship agreements (contractual nature reserve) are underway – some of which specifically favour the establishment of Cape Mountain Zebra. Privately-owned land played a crucial role in the conservation of the Cape Mountain Zebra when the last few groups in the Cradock area were saved from extinction by local farmers in the 1930s (Skead 2011). This subpopulation was formally protected in 1937 by the proclamation of the MZNP, which was expanded in 1964 to incorporate Cape Mountain Zebra groups occurring on neighbouring private farms (Penzhorn 1975). The expansion of formally protected areas such as the MZNP and Karoo National Park have facilitated the growth of the two largest subpopulations. The subsequent increase of the MZNP subpopulation enabled the translocation of individuals to 25 other protected areas during the 1980s and early 1990s, a number of which were private game ranches (Novellie et al. 2002). Similarly, Eastern Cape Parks and Tourism Agency (and its predecessors) have, since 2002, removed 235 Cape Mountain Zebra from Commando Drift and Tsolwana Nature Reserves (166 from Command Drift and 69 from Tsolwana), of which 29 were


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translocated to the Baviaanskloof Nature Reserve and a further 206 were sold to the private sector. The translocation of animals out of established subpopulations not only reduces density-dependent feedback in these subpopulations but creates subpopulations in new areas, each with the potential to increase, while at the same time securing additional habitat. This approach has greatly improved the conservation status of the Cape Mountain Zebra. Subpopulations maintained by private landowners have since increased considerably (Hrabar & Kerley 2015).

Demographic data from nine subpopulations from the Western Cape (in systems with minimal mortality/few predators) reveal a mature population size of *c.* 67% based on average numbers of mature individuals in both breeding and stallion herds (C. Birss unpubl. data): To compensate for variation between areas, we use a mature population structure of 55–75%. Similarly generation length has been calculated as 16 years (C. Birss unpubl. data): The age of first reproduction for females is 5 years and 3 months, and they remain fertile for 21 years; inter-foal periods are 25 months (0.5 foals / year; 12-month gestation period); individuals live up to *c*. 26 years; and there is *c*. 26% mortality in foals (Lloyd & Rasa 1989). This is higher than the 11 years estimated for *Equus zebra* overall by Pacifici et al. (2013). The average breeding group size ranges from 3.4–3.8 individuals (Klingel 1968; Penzhorn 1984; Smith et al. 2008). Bachelor group size has been estimated at 2.5 ± 1 (Lloyd & Rasa 1989). Generation length has been calculated as 10.4 and 8.6 years for males and females, respectively, based on data from De Hoop Nature Reserve from 1995–1999 (Smith et al. 2008). Similarly, Smith et al. (2008) calculated that to maintain an effective subpopulation size of 50 individuals (thus preventing a significant loss of genetic diversity), 78 individuals should be present at the end of the breeding season (based on ten males breeding annually). A theoretical minimum subpopulation would be composed of ten herd stallions, seventeen bachelor males, 24 females of breeding age and 27 immature animals. Effective subpopulation size will change as subpopulation parameters change (Smith et al. 2008). For example, on the basis of the performance of different subpopulations, Novellie et al. (1996) suggested a minimum founder number of 14 individuals.

Current population trend: Increasing

Continuing decline in mature individuals: No

Number of mature individuals in population: 1,714–3,247

Table 3. Use and trade summary for the Cape Mountain Zebra (*Equus zebra zebra*)

Category	Applicable?	Rationale	Proportion of total harvest	Trend
Subsistence use	Yes	Localised bushmeat consumption.	Minimal	Stable
Commercial use	Yes	-	100%	Stable
Harvest from wild population	Yes	Translocations/sales occur in most protected areas as part of management plans.	No hunting from formally protected areas, only translocations and game sales to the private sector.	Stable
Harvest from ranched population	Yes	All private populations considered here.	Hunting is minimal. Translocations/ sales are the majority.	Increasing
Harvest from captive population	Yes	Six populations may be considered captive-breeding populations, totalling 143 individuals in 2015. Individuals from these populations are sold to privately-owned, managed areas.	Minimal	Increasing

Number of mature individuals in largest subpopulation: 654–892 (Mountain Zebra National Park)

Number of subpopulations: At least 75 (18 formally protected inside the natural distribution range).

Severely fragmented: Yes. Many reserves contain too few individuals for a viable subpopulation and all are fenced. Translocations from two of the key reserves (Kamannassie and Gamkaberg) are limited, which limits the sustenance of genetic diversity for this species.

Habitats and Ecology

Cape Mountain Zebras inhabit mountainous terrain in the semi-arid regions of South Africa, often in areas dominated by highly palatable grasses, such as Red Grass (*Themeda triandra*). They select grasslands throughout the year (Smith et al. 2008), especially habitat with leafy, tufted grasses. They typically utilise only the large-tufted, leafy perennial species (*Themeda triandra, Cymbopogon pospischilii, Sporobolus fimbriatus* and *Panicum stapfianum*) and low-growing, creeping grasses (*Tragus koelerioides, Cynodon incompletus* and stemmy annuals) are not favoured (Winkler 1993). More recently, Weel et al. (2015) found that grasses contribute 95% (with *Tristachya leucothrix* and *Themeda triandra* contributing 39% and 28%, respectively) to their annual diet in the Baviaanskloof Wilderness Area. They are predominantly grazers, and only browse as the quality and quantity of grass declines in winter (Penzhorn 1982; Novellie et al. 1988; Penzhorn & Novellie 1991). They do not graze as closely to the ground as many antelope species that may be found in the same habitat (Grobler 1983) and, as hindgut fermenters, require large volumes of forage, hence they tend to avoid the "grazing lawns" favoured by other species (Novellie 1990). Thus, they forage in grass and shrub mosaics with sufficient grass cover and in rugged terrain. Access to open grassland is therefore crucial in maintaining large Cape Mountain Zebra subpopulations and, although fynbos is prevalent throughout the historical range of the Cape Mountain Zebra, fossil evidence suggests that such vegetation is unlikely to support dense populations (Faith 2012).

The understanding of habitat suitability is changing for the subspecies as there is the suggestion that they are perhaps a refugee subspecies in fynbos habitats, whereas grass-dominated habitat is far more suitable (Faith 2012). Corroborating this, recent studies in Gamka and Kammanassie Nature Reserves and Bontebok National Park have found that the subspecies prefers recently-burnt grass-rich areas (Watson et al. 2005, 2011; Watson & Chadwick 2007). For example, 80% of the subpopulation growth at Gamka Nature Reserve occurred within 3 years of burning due to the stimulation of grass-rich habitats (Watson et al. 2005). Subpopulations may also be cut off from nutrient-rich lowlands by the fragmented nature of protected areas, which has been documented in the Baviaanskloof Wilderness Area (Weel et al. 2015), and Bontebok National Park (Strauss 2015). Water availability is also important to Cape Mountain Zebra and groundwater abstraction by neighbouring farmers appears to be impacting the subpopulation at Kammanassie Nature Reserve at least (Cleaver 2004).

The Cape Mountain Zebra is the smallest living zebra, and differs from Hartmann's Mountain Zebra by its smaller size, slightly thicker black stripes, minor striping variations on the rump, and in that its mane does not extend as far forward between the ears (Novellie et al. 2002). The typical social structure consists of small harems comprising an adult stallion and one to three (maximum five) mares and their dependent foals; non-breeding groups consist primarily of bachelor stallions, but sometimes include juvenile females (Penzhorn 2013). The reproductive rate is slow due to the long gestation period of approximately 12 months resulting in a single foal produced approximately every 25 months (range 12–69 months; birth rate of 0.337–0.46 foals per female per year for females > 30 months; Smith et al. 2008). Age at first foaling has been recorded at 38–105 months and females > 21 years old can still reproduce (Penzhorn & Lloyd 1987). In the absence of predators in De Hoop Nature Reserve, survivorship during the first year of life was found to be 82.9% and 77.5% for male and female foals, respectively. Seventy-six percent of surviving male foals survived to maturity and 84% of females (Smith et al. 2008). In the presence of a full set of competitors, the Cape Mountain Zebra is a specialist that is adapted to rugged terrain and a selective grazer. They are poor dispersers with a restricted range and, at present, natural dispersal is severely limited by fences. The subspecies is tolerant of human activities and adapts well to certain transformed habitats such as old lands or fallow fields that have been taken over by grasses (Smith et al. 2011).

Ecosystem and cultural services: Flagship species of the Cape Floristic Region; ecotourism attraction.

Use and Trade

Cape Mountain Zebras are mostly traded as live animals on game auctions (Table 3). The overall aim of harvesting on formally protected areas at present is population management but also to increase the national metapopulation. Overall, the offtake number is lower than the rate of population increase. No hunting takes place in any provincial or national parks where the species occurs, although translocations are used as a tool to manage subpopulation sizes. The local trade of live animals is mainly between private landowners on lands large enough to support free-roaming subpopulations. For example, at least 254 were translocated within the private sector between 2009 and 2015 (Hrabar & Kerley 2015). Formally protected areas also sell to private landowners (102 out of 112 animals translocated from formally protected areas between 2009 and 2015 were onto private land), but do not reintroduce animals from the private sector or captive-bred facilities (Hrabar & Kerley 2015).

Private landowners may harvest for sale purposes to generate income. Trophy hunting occurs on private properties in the Eastern Cape and Western Cape, where permits are issued if the criteria relating to monitoring and provision of data are met – applications are evaluated on a case by case basis (12 animals were hunted between 2009 and 2015). There is increasing demand for hunting quotas. The occasional offtake of small numbers of animals, to be sold to suitable buyers or at game auctions to generate income, takes place in the absence of quotas. This, however, is not a loss to the total population and thus are not considered to be harvested individuals. Unlike several other wild ungulate species maintained in the private sector, Cape Mountain Zebras have not so far been subjected to artificial selection for economically or aesthetically desirable characteristics. Most subpopulations on private land can thus be considered wild and free-roaming, but the number of subpopulations contained in camps (of 180–500 ha) is increasing: two in 2009 versus six in 2015 (Hrabar & Kerley 2015).

Illegal translocations and poaching occur on a limited scale. Some poaching for bushmeat occurs in at least one subpopulation (Camdeboo National Park). Cases of Cape Mountain Zebra being hunted and sold or exported as Hartmann's Mountain Zebra have also been reported. The CITES hunting quota is zero and thus there is no international trade.

The private sector has nearly tripled the number of Cape Mountain Zebra subpopulations in the last 17 years (Hrabar & Kerley 2015), thereby increasing the amount of occupied habitat, and thus has a net positive impact on the subspecies (Table 4). Additionally, private owners are becoming increasingly important in purchasing available animals from existing subpopulations, thereby ensuring continued growth of these populations by reducing

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density-dependent effects (as observed in the De Hoop subpopulation; Smith et al. 2008). However, all subpopulations are isolated and fenced and thus there are few true free-roaming populations. Permits are required to purchase Cape Mountain Zebra. In the Western Cape habitat suitability and founder population size is a primary determinant of permit approval, which has ensured that Cape Mountain Zebra remain within their natural distribution range and in sufficiently large areas.

The effects of harvesting (for example, on behaviour, heterozygosity and fitness) are not currently monitored. The national management system is informal: there is no set structure where activities are measured against a larger adaptive management framework. In some cases, local management plans are available but there is no approved national plan that is aimed at managing the genetic integrity of the Cape Mountain Zebra.

Threats

The greatest current threat to the subspecies is further loss of genetic diversity through inbreeding, caused by small subpopulation sizes and/or small property sizes, and hybridisation with Plains Zebra. Cape Mountain Zebra were once extensively hunted for their skins, because they competed with livestock for grazing, and allegedly because they broke fences (Penzhorn 1988). These historical threats reduced the population to around 50 individuals spread across three subpopulations in the 1950s, which further bottlenecked to around 30 individuals. New subpopulations have been created through translocation of animals with all but one of these subpopulations originating from MZNP; the exception being De Hoop Nature Reserve which consists of individuals from MZNP and Kammanassie Nature Reserve. Two thirds of the entire genotype is therefore located in just two populations (Kammanassie and Gamkaberg Nature Reserve; Moodley & Harley 2005), while the remaining third comprises MZNP and reintroduced populations. De Hoop Nature Reserve has the highest

Table 4. Possible net effects of wildlife ranching on the Cape Mountain Zebra (*Equus zebra zebra*) and subsequent management recommendations

Net effect	Positive
Data quality	Estimated
Rationale	Private landowners have successfully increased total population size and available habitat.
Management recommendation	Cooperate with provincial authorities in implementing a scientifically sound metapopulation plan aimed at creating a genetically diverse and resilient population.

genetic variation of any subpopulation (Moodley & Harley 2005) but is currently declining possibly due to limited resource availability (Smith et al. 2008), as only 4.6% of De Hoop contains grassland (Smith et al. 2011) (see below).

Worryingly, Hrabar and Kerley (2013) made a number of recommendations to improve metapopulation performance that have not been adopted. Currently, the national population is highly fragmented into a large number of small subpopulations yet little metapopulation management is practised. Founder groups are often small (50% of subpopulations have had a founder population smaller than the recommended 14 animals; Hrabar & Kerley 2015), and genetic exchange between subpopulations is poor (73% of privately-owned subpopulations have only ever had a single introduction event; Hrabar & Kerley 2015), thereby increasing the risk of inbreeding and genetic drift. Novellie et al. (1996) noted the wasted effort in introducing a small number of founder individuals, as this tends to result in either a failed reintroduction or poor subpopulation performance in the long term, which echoes general findings that the growth rate of reintroduced subpopulations increases with higher initial founder sizes (plateauing at 20 individuals; Komers & Curman 2000). Currently, only 18% of the population has a limited threat of inbreeding (founder populations > 14 animals) as well as no hybridisation threat.

Exacerbating the problems associated with small subpopulation size, are the potentially reinforcing effects of poor hunting and offtake management practices. Hunting (which is permitted on private properties, subject to permit approval) and offtake not linked to a Biodiversity Management Plan can retard recruitment and

Table 5. Threats to the Cape Mountain Zebra (*Equus zebra zebra*) ranked in order of severity with corresponding evidence (based on IUCN threat categories, with regional context)

Rank	Threat description	Evidence in the scientific literature	Data quality	Scale of study	Current trend
1	*5.1.1 Hunting & Collecting Terrestrial Animals:* historical overhunting caused a population bottleneck of 30 individuals. Current stresses *2.3.5 Inbreeding* and *2.3.6 Skewed Sex Ratios*: continued loss of genetic diversity through inbreeding and skewed sex ratios.	Sasidharan et al. 2011	Empirical	Regional	Increasing due to proliferation of small, isolated private subpopulations and lack of biodiversity and metapopulation management plan.
		Smith et al. 2008	Indirect	Local	Subpopulations with low genetic diversity shown to be susceptible to sarcoid outbreaks.
2	*8.2.2 Problematic Native Species*: Hartmann's Mountain and Plains Zebra. Current stress *2.3.1 Hybridisation*.	Taplin et al. 2015	Empirical	Local	Suspected to be increasing due to continued co-occurrence of Cape Mountain Zebra, Hartmann's Mountain Zebra and Plains Zebra.
		Hrabar & Kerley 2015	Empirical	National	28% of population is currently at risk of hybridisation, while 35% has been previously exposed to hybridisation threat.
3	*2.3.2 Livestock Farming & Ranching*: fenced, isolated habitat patches. Current stress *2.3.7 Reduced Reproductive Success*: low growth rate through small founder groups.	Komers & Curman 2000	Indirect (review)	Global	Increasing due to proliferation of small, isolated private subpopulations and lack of biodiversity and metapopulation management plan.
		Hrabar & Kerley 2015	Empirical	National	Most subpopulations < 14 individuals and have not reintroduced new individuals in past ten years.
4	*5.1 Hunting & Collecting Terrestrial Animals*: unregulated hunting. Current stresses *2.3.6 Skewed Sex Ratios* and *2.3.7 Reduced Reproductive Success*: reduced growth rate through skewed sex ratio and disruption of social systems.	Milner et al. 2007	Indirect (review)	Global	Increasing due to growing demand for trophy hunting and offtake not connected to Biodiversity Management Plan.
5	*2.1 Annual & Perennial Non-Timber Crops*: farmlands fragment available habitat. Current stresses *1.2 Ecosystem Degradation* and *1.3 Indirect Ecosystem Effects*: degradation and fragmentation of remaining ecosystems limits resource availability and subpopulation growth.	Weel et al. 2015	Indirect	Local	Stable. Core protected areas are fragmented and often confined to mountainous regions, thus inhibiting access to nutrient-rich lowlands. However, some formally protected areas have increased in size in the last 5–10 years.
		Strauss 2015	Indirect	Regional	
6	*8.2.2 Problematic Native Species*: Lion and Cheetah reintroduced into protected areas. Current stress *2.1 Species Mortality*: increased predation from high predator densities.	-	Anecdotal	-	Increasing due to continuing reintroduction of carnivores onto formally protected and private nature reserves.

subpopulation growth rate by skewing sex ratios and disrupting social structures (Milner et al. 2007). When animals are sold and captured for translocation it is common practice to capture and translocate family groups and to ignore bachelor groups. This is particularly true when only small groups are sold or relocated. This practice can lead to an accumulation of males in the donor population which in turn can impact on the growth rate of these populations if not properly managed. Surplus males are also required for the establishment of new herds with dispersing females, and a 1:1 sex ratio is therefore recommended for all removals. The problem is further exacerbated by the social structure of the Cape Mountain Zebra, where a fraction of the males can dominate herds for an extended period of time, thereby reducing the effective population size further.

Anthropogenic environmental changes, particularly fragmentation of habitat and isolation of populations, increase the risk of hybridisation (Hill 2009). Hybridisation with Hartmann's Mountain Zebra, as a result of introductions onto the same properties, is also a threat as offspring are viable and decreased genetic integrity can potentially spread within the population. Hybrids are difficult to detect phenotypically. Although it is illegal to keep the two subspecies together, cases of hybridisation do still occur and deliberate mixing of herds has occurred. One Hartmann's/Cape Mountain Zebra hybrid subpopulation has been confirmed within the Eastern Cape (through genetic testing; all stallions have been culled and replaced with Cape Mountain Zebra stallions). Individuals from this hybrid population have been used to establish at least two additional subpopulations. The need for genetic testing to be a pre-requisite for translocations is thus paramount. In the Western Cape, there are five legal Hartmann's Mountain Zebra subpopulations within the Cape Mountain Zebra's natural distribution range (C. Birss unpubl. data). There is also at least one subpopulation in the Eastern Cape. Since phenotypic assessments will not provide reliable results, the National Zoological Gardens have initiated the development of genetic markers to test for hybrids, although testing for hybrids is presently not a requirement, albeit a recommendation, for translocation. The risk of hybridisation with Hartmann's Mountain Zebra has reduced over time as steps have been taken to remove this extra-limital subspecies from within the Cape Mountain Zebra range.

Cape Mountain Zebra rarely occur in sympatry with Plains Zebra as they are adapted for life on rugged terrain due to their harder and faster growing hooves, thereby making them less suitable for habitation of soft flat plains (Skinner & Chimimba 2005). Until recently, hybridisation with Plains Zebra was not of great concern as fertile hybrids were thought to be unlikely due to the relatively large difference in chromosome numbers between the two species (2n = 44 versus 2n = 32 in Plains Zebra and Cape Mountain Zebra, respectively) (Ryder et al. 1978; Cordingley et al. 2009). Plains Zebra were therefore introduced into four formally protected areas, including the MZNP in 1999 and Karoo National Park in 1998 (the two largest Cape Mountain Zebra populations) and into about 10 private populations. More recent evidence, however, shows that differences in chromosome number do not constitute a barrier to exchange of genes between equid species (Jónsson et al. 2014), and in 2014 two Plains/Cape Mountain Zebra hybrids in MZNP were confirmed through genetic testing (Taplin et al. 2015). More than 27% of the global population (> 1,300 Cape Mountain Zebra) remain exposed to Plains Zebra at present and at least 1,600 Cape Mountain Zebra have had previous exposure. In total, 62% of the total population has been/is at risk of hybridisation (Hrabar & Kerley 2015). All Plains Zebra have since been removed from MZNP, but not the Addo Elephant or Karoo national parks. Importantly, the Kammanassie subpopulation (a unique gene pool) may be under threat of hybridising with Plains Zebra, although management interventions have been put in place for mitigation. The fertility of hybrids is, however, still unclear and further research into the threat is needed before conclusions can be drawn. Genetic testing for hybridisation should be a pre-requisite for reintroductions (with hybrid individuals then being euthanised), to prevent the spread of hybrid animals and to conserve the genetic integrity of Cape Mountain Zebra.

Vulnerability to disease also increases due to inbreeding. The subpopulations at both Bontebok National Park and Gariep Dam Nature Reserve, which have been shown to be inbred and lack genetic diversity, have both had an outbreak of sarcoid tumours (53% and 22% of the subpopulations, respectively), indicating a general immune system breakdown (Sasidharan 2006; Sasidharan et al. 2011). Although equine sarcoids is not fatal, it is recommended that animals with visible lesions be euthanised or quarantined as they are thought to act as a source of infection. Furthermore, the virus is not yet well understood, which adds to the potential severity of the threat. Cape Mountain Zebra is also a carrier of African Horse Sickness (AHS) and restrictions (Animal Diseases Act, No. 35 of 1984) are in place for the movement of individuals, especially into the AHS-controlled areas of the Western Cape (set out by the Department of Agriculture in 2003).

Problems associated with the fragmentation of the population are largely due to a lack of integrated, cross boundary, management action. Firstly, there is currently no Biodiversity Management Plan or metapopulation management strategy and secondly, even with a plan, inability to carry out necessary management actions due to shortfalls in human and financial resources is a concern. The few management recommendations which have been developed have not been consistently implemented (such as founder population size and reinforcement of existing populations) due to the inability to carry out and enforce such recommendations. The development of a metapopulation management plan (and adoption of such plan into provincial and national conservation policy) which incorporates "resource


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mobilisation strategies" (how human and financial resources will be utilised for successful implementation of the plan) is essential in ensuring the long-term survival of this species in nature.

A poorly understood, but emerging, threat is that of reintroduced large predators into areas containing subpopulations of Cape Mountain Zebra. This includes Lion (Addo Elephant, Mountain Zebra and Karoo national parks) and Cheetah (MZNP, some private reserves). Data indicate that Cape Mountain Zebra were the preferred prey for Lion in Karoo National Park (C. Tambling unpubl. data), and anecdotal evidence suggests that Cheetah suppressed population growth in at least one privately-owned population. Further research is needed to assess the extent and implications of this threat.

Current habitat trend: Stable. Although habitat has been lost to agriculture in the past, and may be threatened by shale gas extraction in the future, there is a recent increase in the range and distribution of this species. This is partly due to protected area expansion and the implementation of stewardship schemes, but also largely due to the rapid growth of the private wildlife industry in recent years. The last 10 years have seen many farmers converting from livestock production to game ranching and this has increased the overall area available to Cape Mountain Zebra. The subspecies is tolerant of transformed landscapes (anecdotal evidence from the reproductive output of a herd of zebras that escaped onto neighbouring farmland suggests that this likely to be the case (Watson & Chadwick 2007), and thus it is not the habitat quality per se that is limiting but the availability of additional grass-rich habitat amidst a matrix of competing land uses.

Conservation

Past conservation measures, including strict regulations on trade (CITES), regulation of hunting and regulation of translocations have effectively mitigated the major historical threats responsible for the critical losses in the 19th and first half of the 20th century. However, although the Cape Mountain Zebras have been reintroduced to many formally and privately-protected areas (Hrabar & Kerley 2013), the overall genetic diversity of the population is low. Kamannassie and Gamkaberg nature reserves are crucial for the genetic conservation of the subspecies, as

Table 6. Conservation interventions for the Cape Mountain Zebra (*Equus zebra zebra*) ranked in order of effectiveness with corresponding evidence (based on IUCN action categories, with regional context)

Rank	Intervention description	Evidence in the scientific literature	Data quality	Scale of evidence	Demonstrated impact	Current conservation projects
1	*3.3.1 Reintroduction*: translocations and reintroductions under a metapopulation strategy as informed by a Biodiversity Management Plan, including both private and formally protected areas.	Hrabar & Kerley 2013	Review	National	Mean annual growth rate was 10% between 2002–2009 compared to 8.6% from 1985–1995. The % on privately owned land rose from 14% in 1998 to 32% in 2009.	Cape Mountain Zebra Research Project, Nelson Mandela Metropolitan University
2	*3.1.2 Trade Management*: subject animals to be translocated to genetic testing to detect hybrids and euthanise hybrids to prevent spread of hybrid genes.	Taplin et al. 2015	Empirical	-	Detected hybrids were removed.	SANParks
3	*1.1 Site/Area Protection*: formal protected area expansion to include grassy habitats.	-	Anecdotal	-	Gamkaberg expanded to include grassy areas.	CapeNature
4	*1.2 Resource & Habitat Protection*: biodiversity stewardship as potential reintroduction sites.	-	Anecdotal	-	-	Biodiversity Stewardship programme, CapeNature (e.g. Denel Overberg Test Range)
5	*2.1 Site/Area Management*: habitat management of patches or private lands using integrated fire thresholds aimed at maintaining landscape diversity inclusive of grass-rich areas.	Watson et al. 2005 Watson & Chadwick 2007	Indirect Indirect	Local Local	Subpopulation growth spurts (80% of growth in Gamka Nature Reserve) following burns.	-
6	*6.3 Market Forces* and *6.4 Conservation Payments*: designing incentives for private landowners to participate in biodiversity stewardship and metapopulation management.	-	Anecdotal	-	-	-

these two subpopulations contain two thirds of the entire genotype. An increase in suitable available habitat is vital for the long-term conservation of these subpopulations, whether it be in the adjacent areas or through translocations to other areas. Mixing of the original subpopulations to ensure increased genetic variation in the metapopulation should be top priority. MZNP and Karoo National Park are important as they contain the two largest subpopulations, exist in optimal habitat for the subspecies (Weel et al. 2015), and provide large enough areas for a degree of natural seasonal migration to take place. Thus, a combination of three main interventions is required:

- Develop and implement a metapopulation management strategy to maximise genetic diversity and subpopulation growth;
- Expand range and number of subpopulations; and
- Improve habitat management, to conserve and restore the grass-rich habitats needed by this subspecies.

The development of a Biodiversity Management Plan, underway since 2013, will be strengthened by incorporating findings from the 2015 survey (Hrabar & Kerley 2015) and is nearing completion. The establishment of the herd at Oorlogskloof Nature Reserve serves as a good experiment in adaptive management to investigate disease prevalence as well as mixing of two genetically isolated and inbred subpopulations. Monitoring this subpopulation is essential to provide knowledge and tools to inform future translocations as part of the metapopulation management plan. Model projections suggest that MZNP and Karoo National Park will reach subpopulation saturation by 2020, and thus expansion of available habitat to establish new subpopulations from the main source subpopulations is required (Winker et al. 2016).

Managing the hybrid threat with both Hartmann's Mountain Zebra and Plains Zebra relies on active participation in the Biodiversity Management Plan. Incentives should be developed to encourage private landowner participation in the mooted metapopulation plan. In the private sector, conservation of the subspecies was reportedly the most common motivation behind acquiring Cape Mountain Zebra, while hunting was the least common reason (Hrabar & Kerley 2015). Most private owners agreed with regulating the possession, translocation and hunting of Cape Mountain Zebra through a permit system (as long as the process is efficient), but around 50% of owners did not agree that the subspecies should be restricted to within their natural distribution range (Figure 1). Such considerations should be taken into account in designing an incentive system. The urgent need to eliminate the threat of hybridisation with Plains Zebra has been recognised by SANParks and plans are in place to remove all remaining Plains Zebra from areas with Cape Mountain Zebra (Hrabar & Kerley 2015). Furthermore, all individuals captured for translocation from affected SANParks subpopulations will be subject to genetic testing and will be kept in holding camps until confirmed as pure. Hybrid individuals will be euthanised to prevent further genetic contamination. As the genetic integrity of Cape Mountain Zebra depends on their relative abundance to Plains Zebra in a subpopulation (*sensu* Piett et al. 2015), it is important to sustain large subpopulations of Cape Mountain Zebra.

Fire management and access to nutrient-rich lowlands are important management tools to prevent herds from becoming limited by resources (Weel et al. 2015). Although fynbos typically burns at an interval of 12–15 years (van Wilgen et al. 1994), burning at shorter intervals to stimulate grass-growth is recommended for Cape Mountain Zebra (Watson et al. 2005). Since formally protected areas have a mandate to conserve greater biodiversity, the majority of which is fynbos, management options for properties with Cape Mountain Zebra need to consider the implementation of integrated burn thresholds aimed at maintaining landscape diversity, which includes areas of grassy fynbos. Suitable areas surround many of the formally protected areas (Watson et al. 2005; Watson & Chadwick 2007; Smith et al. 2011), and the establishment of Cape Mountain Zebra on such properties containing reclaimed agricultural fields, provided that adequate natural habitat exists, can be considered as favourable sites for expansion. The primary constraints in achieving this are the costs involved in translocation and establishment, security (fencing), management and monitoring. Additionally, biodiversity stewardship schemes should be established to protected further natural habitat and prevent further transformation, especially in lowland habitats (Weel et al. 2015), with effects on Cape Mountain Zebra subpopulations monitored. Management within such conservancies, biodiversity stewardship sites, or leased land should restore grassy habitats and employ ecological stocking rates to reduce grazing competition.

Through such efforts, the chances for the long-term conservation of the subspecies would be greatly enhanced. These recommendations have been passed on to the appropriate authorities and private land owners (Hrabar & Kerley 2015). Furthermore, it is now possible to access current Cape Mountain Zebra management recommendations and general information from a website dedicated to the subspecies (see **Encouraged citizen actions** below).

Recommendations for land managers and practitioners:

- A Biodiversity Management Plan (BMP) must be drafted and adopted by all stakeholders. There is currently no approved national management plan for Cape Mountain Zebra. SANParks does not have a specific management strategy, but management of the subspecies follows the general policy for the management of large mammals. According to CapeNature, a conservation management plan is not required, although recommended, for the introduction or keeping of Cape Mountain Zebra on private land. Eastern Cape Parks and Tourism Agency has a management plan for the three subpopulations they manage. A priority for management is thus the development of an integrated BMP. A vital component of a successful management plan in the long-term is a sound understanding of population viability. The minimum viable population size has not yet been determined (through a Population Viability Analysis) and management actions required to ensure the viability of subpopulations of various sizes are poorly understood (for example, the number, sex, and frequency of additions/removals required in order to prevent any further loss of genetic variation).
- Within the BMP, a metapopulation strategy should be detailed. The priority is to mix the relic

subpopulations (MZNP, Gamkaberg and Kamanassie nature reserves) to halt the further loss of genetic diversity. Until now, the management plan for the two most genetically important subpopulations, Kamannasie and Gamkaberg, has been to allow these subpopulations to increase before being harvested for translocations into other subpopulations. Unfortunately, both subpopulations are at relatively low numbers – both being less than 100 animals and one being below 50 animals, requiring thorough assessment of the impacts of any removals. This has not been successful though, and actions are now urgently needed to rectify this and reduce the vulnerability of these gene pools. Attempts have been made to increase the suitable habitat available to both subpopulations by incorporating surrounding properties, or increasing burning frequencies to promote grassland (Watson & Chadwick 2007). This has not yet been achieved due to crucial corridors not being incorporated.

- Translocations and reintroductions within the metapopulation strategy should comprise entire family units (Smith et al. 2008; Sasidharan et al. 2011), and founder subpopulations should consist of at least 14 individuals to sustain subpopulation growth and genetic diversity (Novellie et al. 1996; Komers & Curman 2000). Genetic testing for hybridisation should be a pre-requisite for reintroductions. Any hybrid individuals should then be euthanised.
- Reclaimed agricultural lands within the natural distribution range that have been converted to grasslands for livestock can be key resource areas, as such landscapes are likely to be similar to the late Pleistocene when grasslands were widespread and supported large numbers of Cape Mountain Zebra (Faith 2012). A habitat suitability index for Cape Mountain Zebra has been developed and tested in the MZNP (Novellie & Winkle 1993), and further tested in the Bontebok National Park (Watson et al. 2011). These studies indicated that the quality of the habitat for Cape Mountain Zebra can be predicted on the basis of cover of large-tufted, leafy, palatable grass species. However, the habitat suitability index needs further testing over a wider range of habitats. Managers should utilise the habitat suitability index prior to reintroduction and monitor the subsequent habitat use to refine the index. Monitoring habitat suitability should also incorporate drainage lines and kraal lawns, microhabitats favoured by the subspecies (Watson et al. 2011).
- A system of collecting genetic samples, such as collecting faecal or hair samples, needs to be adopted by all stakeholders. This would create a database of genetic material, which is crucial to determine, monitor, and/or manage genetic heterogeneity within the metapopulation.
- Impacts of reintroduced large predators on Cape Mountain Zebra subpopulations must be researched, and appropriate management interventions developed and implemented to mitigate such impacts.
- Captive breeding and *ex situ* management are not necessary.

Research priorities:

- Research to determine effective subpopulation size and minimum viable population size overall. Given that the minimum viable population (breeding individuals) for large mammals is *c.* 4,000 (Traill et al. 2007), a more appropriate population target could potentially be as large as 12,000 individuals.
- Analysis of the potential expansion of the population within the available habitat, based on an improved understanding of habitat suitability, is needed. Firstly, the historical distribution range and seasonal movements need to be compared to the current distribution of subpopulations. The degree to which the subpopulation occurs in historically marginal habitat areas can then be determined. Subpopulation performance across a range of habitat types then needs to be assessed to understand habitat suitability and the possible refuge status of the subspecies in fynbos-dominated habitats (such as Maximum Entropy modelling). Similarly, assessing the effectiveness of using integrated fire thresholds aimed at maintaining diversity inclusive of grassy habitats and subpopulation performance.
- The severity of genetic threats need to be evaluated: for example, the extent of hybridisation with Hartmann's Mountain Zebra and Plains Zebra; and the extent and consequences of inbreeding, including an improved understanding of how it relates to the sarcoids virus.

Encouraged citizen actions:

- Private land owners are encouraged to report their annual count data (with detailed demographic information) to the Cape Mountain Zebra Research Project, Nelson Mandela Metropolitan University. This would greatly enhance the understanding of their subpopulation and appropriate management actions could then be implemented accordingly.
- Any sales/purchases can be reported to keep track of subpopulations, and tissue samples can be collected opportunistically (during captures/hunts) so that researchers can analyse the genetic diversity of the subpopulations. CapeNature has developed a biological sample protocol which can be made available on request.

Data Sources and Quality

Table 7. Information and interpretation qualifiers for the Cape Mountain Zebra (*Equus zebra zebra*) assessment

Data sources	Census (literature and unpublished), field study (literature, unpublished)
Data quality (max)	Observed
Data quality (min)	Estimated
Uncertainty resolution	Confidence intervals
Risk tolerance	Evidentiary

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Details of the methods used to make this assessment can be found in *Mammal Red List 2016: Introduction and Methodology.*