

Updating the distribution range of the maned wolf *Chrysocyon brachyurus* in Argentina

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Abstract The maned wolf *Chrysocyon brachyurus*, the fourth largest canid, is categorized as Near Threatened on the IUCN Red List. The objectives of this study were to update information on the occurrence of this species in Argentina, compare the current distribution to that previously described for 1988–2008, and indicate the areas in which the species is exposed to particular hazards. We created a database that included 1,051 new records of *C. brachyurus* for 2009–2021, in addition to records for 1988–2008 that had not been reported previously. We calculated the area of occupancy of the species in Argentina to be 500,000 km². Most of the new records of *C. brachyurus* are in the Chaco Seco, Espinal and Pampas ecoregions. Our findings indicate a current area of occupancy 61% higher than that calculated from records for 1988–2008. However the location and frequency of reported threats and the intense environmental transformation that characterizes the areas for which we obtained new records suggest

counterintuitive implications for the conservation of the species because of increased human–wildlife interactions. Our study reveals the need for systematic research to improve the understanding of the ecological processes that affect the maned wolf in Argentina, and will aid in the development of conservation strategies for the species.

Keywords Argentina, *Chrysocyon brachyurus*, ecoregions, hazard, maned wolf, South America, spatial distribution

The maned wolf *Chrysocyon brachyurus*, the fourth largest canid, is categorized as Near Threatened on the IUCN Red List (Paula & DeMatteo, 2015). In Argentina it was categorized as Endangered until 2019, then reclassified as Vulnerable (Cirignoli et al., 2019) for non-genuine reasons related to new information available since the previous assessment (IUCN, 2022). Habitat loss is considered one of the main threats facing the maned wolf, in addition to road kills, illegal hunting and diseases (Soler et al., 2005; González Ciccía et al., 2010; Orozco et al., 2014, 2015; Paula & DeMatteo, 2015). In 2018, data published previously (Queirolo et al., 2011; Torres et al., 2013) were used to model the distribution range of the maned wolf, with the results suggesting that the most favourable areas for the species are in south-eastern and central Brazil, southern Paraguay and north-eastern Argentina (Coelho et al., 2018). Here we update existing information on the range of *C. brachyurus* in Argentina, report new records and compare the current distribution to that reported previously.

We used the latest published distribution of the species (Queirolo et al., 2011; Coelho et al., 2018) as a baseline to generate a database of new records of the maned wolf in Argentina for 2009–2021. We also added records for 1988–2008 not reported by Queirolo et al. (2011). We obtained data through a bibliographical review that encompassed peer-reviewed articles, local publications and grey literature (Muzzachiodi, 2007; Massoia et al., 2012; Mannise, 2013; Lodeiro Ocampo et al., 2020; Nagy-Reis et al., 2020; Nigro et al., 2020; SIB, 2022; Mac Allister et al., 2021). Data collection included confirmed sightings and tracks (our own or provided by local collaborators), individuals rescued in urban areas, museum and zoo records, and records in peer-reviewed articles and government reports. To differentiate records representing individuals exposed to hazards from those representing free-living maned wolves, we grouped

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them into two categories: maned wolves exposed to particular hazards (road-killed, live-captured, roaming in urban areas, hunted, injured, sick, attacked by dogs or affected by drought and/or fire) and free-living maned wolves not exposed to such hazards.

We generated a map of all records and visualized the records of maned wolves exposed to hazards using a heatmap. For comparative purposes we also added a layer showing the distribution of the records reported by Queirolo et al. (2011). We then superimposed these three layers on a map of the Argentine ecoregions. We estimated the maned wolf's range using the area of occupancy and extent of occurrence, and compared two sets of data: (1) 1988–2008, referring to records reported by Queirolo et al. (2011) plus new records for the same period; (2) 1988–2021, referring to the whole dataset (records from Queirolo et al., 2011, plus our new data for 1988–2008 and 2009–2021). We calculated the area of occupancy by adding the area of the squares of the grid in which the species was present (using 50 × 50 km grid cells) and the extent of occurrence using the minimum convex polygon calculated with *GeoCAT* (Bachman et al., 2011).

We obtained 1,051 new records of *C. brachyurus* in Argentina for 2009–2021 (Fig. 1), 423 of which were of wolves exposed to hazards (292 killed on roads, 53 captured alive, 31 roaming in urban areas, 18 hunted, 18 injured or sick, seven attacked by dogs and four affected by drought and/or fire). The geographical distribution of the records of maned wolves exposed to hazards were concentrated in marginal areas of the Chaco Humedo and near the transition area between the Chaco Humedo, Espinal and Chaco Seco, overlapping with the south-western marginal areas of the range reported by Queirolo et al. (2011). We found 178 records for 1988–2008 that had not been reported previously. The area of occupancy calculated from the data for 1988–2008 was 310,000 km² (extent of occurrence: 513,268 km²), whereas the area of occupancy calculated from the data for 1988–2021 was 500,000 km² (extent of occurrence: 838,474 km²).

Large canids have undergone significant changes in distribution ranges, associated with climatic and biogeographical environmental factors (Wolf & Ripple, 2017). The maned wolf is no exception to this global phenomenon. Projections for 2050 predict there will be a 33% reduction in the habitats where the maned wolf currently occurs in South America, with some stable areas remaining in the central part of its range (Torres et al., 2013). The species has been increasingly recorded in deforested areas in Brazil (Paula & DeMatteo, 2015). In Argentina, records of the maned wolf have increased since 2010 and there is intense modification of the species' habitat (Nanni et al., 2020).

Most of the new records reported here are in the Chaco Seco, Espinal and Pampas ecoregions, and many correspond to marginal areas of the distribution range reported by Queirolo et al. (2011), where habitat suitability for the

maned wolf is intermediate or low (Coelho et al., 2018). In such areas, local threats could have a significant impact on the conservation of the species, given the high frequency of exposure to anthropogenic factors and identified hazards (Fig. 1). A high proportion of these three ecoregions is modified and/or transformed, with few protected areas (Nanni et al., 2020). Livestock and crop production have been identified previously as the greatest pressures in the Argentine ecoregions where the maned wolf occurs (Nanni et al., 2020). These pressures have increased in the Chaco Seco and Espinal during the last 10 years, where the species was formerly less prevalent, except in a small transitional area between ecoregions. Although the Pampas ecoregion was initially the main area of agricultural development in Argentina, deforestation has expanded into the Espinal and Chaco ecoregions, which account for 80% of deforestation in the country (Nanni et al., 2020). Additionally, in recent years the increase in global temperature associated with anthropogenic activity has led to successive fires in a large part of the maned wolf's range, resulting in the disappearance of a large proportion of the wetlands typically used by the species in Argentina (Saucedo et al., 2022). The environmental changes associated with high rates of deforestation in some ecoregions and the increase in croplands throughout the range of the species, together with the potential effects of changes in rainfall and temperature (Torres et al., 2013; Coelho et al., 2018), could, to some extent, explain the records in new areas.

The results of our study show that the current area of occupancy of the maned wolf in Argentina is 61% higher than that for 1988–2008. However the location and frequency of reported hazards and the intense environmental transformation in areas where the species has been newly documented suggest counterintuitive implications for the conservation of the species because of increased human–wildlife interactions. The threats faced by maned wolves in these areas appear to be increasing and the species is exposed to road accidents, urbanization, hunting and diseases (Soler et al., 2005; González Ciccía et al., 2010; Orozco et al., 2014, 2015).

This update identifies the areas in Argentina where conservation efforts for the maned wolf are urgent because of exposure to identified hazards. Historically, most research and conservation projects have focused on areas where the species appears to be abundant and has been recorded frequently. Long-term studies on the presence of the maned wolf in marginal areas of its range are necessary for evaluating habitat use and determining environmental suitability for the species across its entire range. We highlight the importance of a risk analysis to identify the hotspots of threats to the maned wolf in Argentina. Until knowledge of the demographic and ecological characteristics of the marginal populations of the maned wolf is improved, we emphasize the importance of protected areas as biological corridors

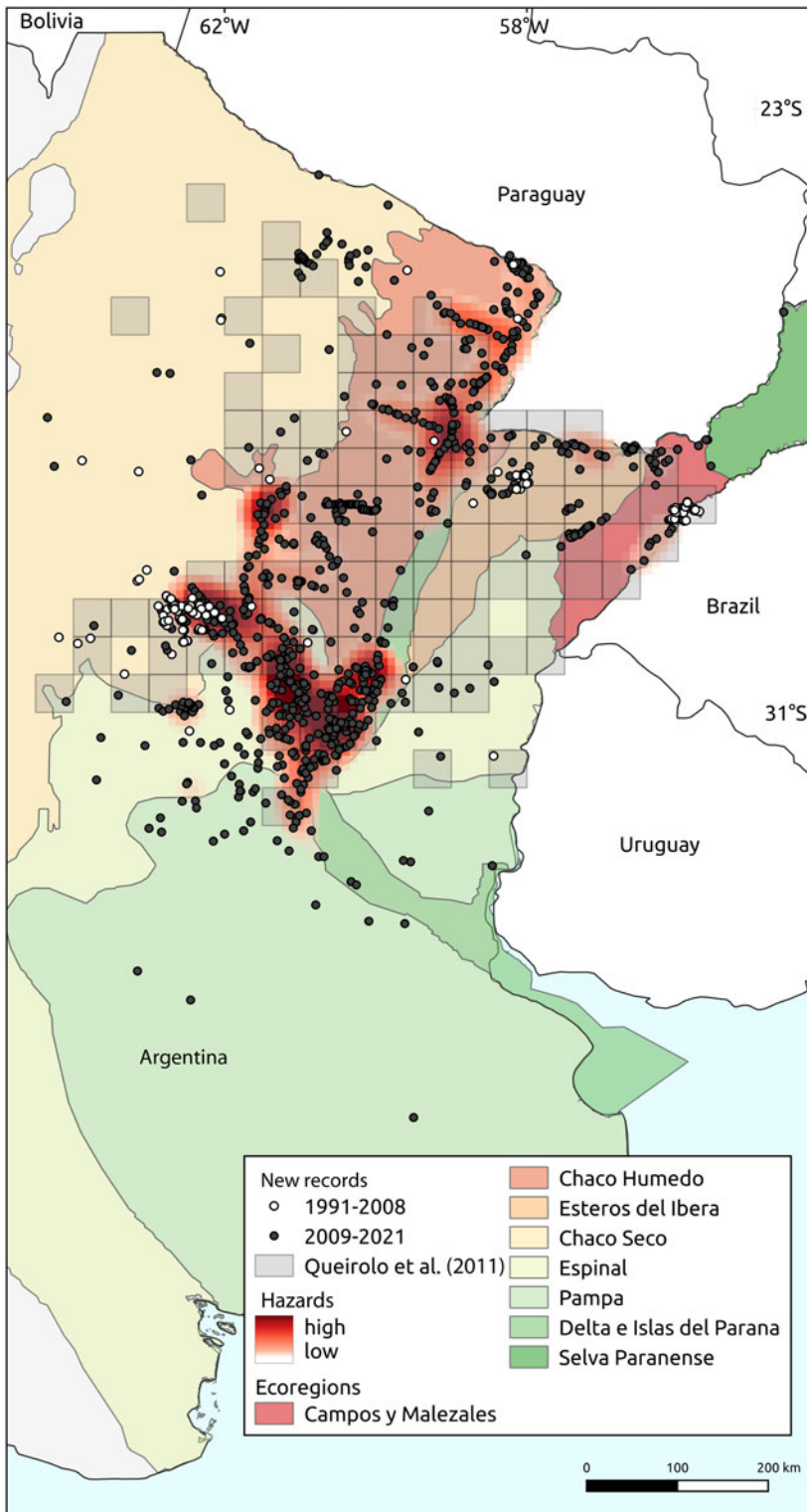


FIG. 1 Records of the maned wolf *Chrysocyon brachyurus* in Argentina. New records indicate the previously uncollected records that we found for 1988–2021, in two periods. The heatmap visualizes the records of individuals exposed to particular hazards (see text for details). The presence records reported by Queirolo et al. (2011) are shown as a shaded grid of 50 × 50 km cells. (Readers of the printed journal are referred to the online article for a colour version of this figure.)

for the species and recommend focusing threat mitigation strategies on marginal areas of its range. Future systematic recording of information on the maned wolf, together with ecological modelling, is required to improve our understanding of the main factors that affect colonization by, and survival of, this species.

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Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards.

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