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REVIEW

Taxonomic assessment, conservation status, and future perspectives for New World Marsupials

Gabriel M. MARTIN* *Centro de Investigación Esquel de Montaña y Estepa Patagónica (CIEMEP), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) – Universidad Nacional de la Patagonia "San Juan Bosco" (UNPSJB), Ruta 259 Km 16,41 – Campus Ing. Aldo López Guidi Edificio de Aulas, Esquel, Chubut, CP 9200, Argentina and Laboratorio de Investigaciones en Evolución y Biodiversidad, Facultad de Ciencias Naturales Sede Esquel, UNPSJB, Ruta 259 Km 16,41 – Campus Ing. Aldo López Guidi Edificio de Aulas, Esquel, Chubut, CP 9200, Argentina and New World Marsupials Specialist Group, International Union for the Conservation of Nature (IUCN), Rue Mauverney 28, Gland, 1196, Switzerland. Email: gmartin_ar@yahoo.com*

Ana Paula CARMIGNOTTO *New World Marsupials Specialist Group, International Union for the Conservation of Nature (IUCN), Rue Mauverney 28, Gland, 1196, Switzerland and Laboratório de Diversidade Animal/Sistemática de Mamíferos (LASISMA), Departamento de Biologia, Universidade Federal de São Carlos (UFSCAR), Rod. João Leme dos Santos km 110 – SP-264, Bairro do Itinga, Sorocaba, São Paulo, CEP 18052-780, Brazil. Email: apcarmig@gmail.com*

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*Correspondence
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ABSTRACT

1. New World Marsupials (NWMs) comprise over 135 species ranging from Patagonia (Argentina) to northern North America, classified within the orders Didelphimorphia, Microbiotheria and Paucituberculata.
2. This study examines recent taxonomic revisions and conservation priorities for NWMs, based on the IUCN Red List assessments and current literature.
3. NWMs are included in the following IUCN Red List categories: 2 (1.5%) Critically Endangered (CR), 9 (6.6%) Vulnerable (VU), 7 (5.1%) Near Threatened (NT), 15 (11%) Data Deficient (DD), and 72 (53%) Least Concern (LC), with 32 (23%) species awaiting formal assessments.
4. Population trends remain unknown for more than half of the 137 species ($n = 82$; 60%), with 34 stable species (25%), 30 declining (22%), and only three showing increasing trends (2.2%). Of the 105 IUCN assessed species, 45 (43%) have unknown population trends.
5. Identified threats for assessed species ($n = 32$) include ecosystem conversion and degradation as the main threats, with habitat loss through fragmentation and/or land conversion potentially affecting 26 additional species. When analysed in detail with the proposed classification 'Habitat loss, fragmentation, and conversion' were identified as the main threat to 61 species.
6. Research needs were identified for 85 species (62%), across five categories: Taxonomy (9 species), Life History and Ecology (75 species), Population size, Distribution and Trends (80 species), Threats (78 species), and Actions (2 species).
7. We propose four key steps to enhance the conservation of NWMs: 1) update assessments to include all valid species, 2) identify priority areas for NWM conservation, 3) encourage research collaboration, and 4) integrate data into conservation strategies at various spatial and political scales.

INTRODUCTION

Living New World Marsupials (NWMs) comprise more than 135 species that occur from Patagonia (Argentina) to northern North America (Martin et al. 2021) included in three orders: Didelphimorphia (127 spp.), Microbiotheria (3 spp.), and Paucituberculata (7 spp.) (Astúa et al. 2022, Teta et al. 2022). Didelphimorphia is the most speciose order with more than 127 species, occurring in a variety of habitats, from tropical humid forests to deserts, with the highest richness in tropical and subtropical areas of South America (Martin et al. 2022). Microbiotheria consists of a single species, *Dromiciops gliroides*, living in the temperate rainforest of Chile and Argentina, as understood by some researches (Martin 2010, 2018, Valladares-Gómez et al. 2017, Suárez-Villota et al. 2018, Beck et al. 2022), but treated as three different species by others (Quintero-Galvis et al. 2021, Astúa et al. 2022). Paucituberculata includes seven species with a disjunct geographical distribution along the Andes from Colombia to northern Peru, from southern Perú to northwestern Bolivia, and southern Chile and Argentina (Patterson 2015).

The conservation status of NWMs was recently revised by Martin et al. (2022), where information from IUCN's Red List (1996) and previous works (e.g. Fonseca et al. 2003) were compared and updated with the available data in the IUCN Red List website (https://www.iucnredlist.org). Also, the conservation priorities for South American marsupials were assessed using a spatially explicit index by Martin et al. (2021), where Red List categories were integrated with taxonomy and chorology to map pixel conservation values (PCV) at a continental scale. This study also calculated the protected and unprotected areas for each PCV according to the World Database on Protected Areas in different IUCN categories, showing large areas under high threaten pressure and with no conservation actions, while only 5% of the high-threat-pressure areas are being preserved. Despite these studies, no work has given full consideration to the data available on the IUCN Red List website (https://www.iucnredlist.org/en). Recent taxonomic changes have led to the splitting of some broadly distributed marsupial species into new, narrowly distributed forms (e.g. *Philander opossum*), or new species that were described from isolated and poorly studied areas (e.g. *Marmosops magdalenae*) (Voss 2022). As a result, our understanding of their distribution, ecology, and other natural history traits is now largely uncertain. These taxonomic revisions may significantly impact the conservation status of several species by introducing uncertainty into our knowledge of their distribution and natural history, among other factors. This is directly relevant to the identification of threats these species face and underscores the necessity for specific research to accurately assess their conservation status.

In this study, we compile individual assessments from the IUCN Red List website, discuss current information available for NWMs, provide a comprehensive taxonomic account, outline known population trends, identify major threats, and highlight research needed for these taxa, incorporating data from different sources.

MATERIALS AND METHODS

Individual species assessments were downloaded from the Red List website (https://www.iucnredlist.org/en), and species taxonomic coverage and the topics Red List Category, Population Trends, Threats, and Research Needed were analysed. Comments on changes needed in species IUCN categories were cited when available, and a full taxonomic account is presented. Population trends were downloaded from each species assessment. The topic 'Threats' was analysed in two ways: using the data downloaded directly from the IUCN species assessments (in the appendix of each species), and in detail with a new classification generated by us, by disaggregating the information provided in each assessment under Threats. The latter was divided into six categories: 'Unknown', 'No major threat', 'Habitat loss, fragmentation, and conversion', 'Human consumption', 'Hunting for fur', and 'Introduced species'. The category 'Habitat loss, fragmentation, and conversion' was subdivided into six sub-threat categories, including 'Deforestation and/or logging', 'Agriculture (including coca plantations)', 'Cattle grazing', 'Oil, gas, and mining', 'Drainage of wetlands and water courses degradation', and 'Urbanization and different types of settlements'. These sub-categories were defined by us, to standardise the different threats we identified in each species' assessments. For example, several species assessments include comments like 'This species is probably threatened by selective logging and exploitation in its extremely reduced range' (e.g. *Monodelphis handleyi* Solari 2016), 'Major threats for the species is habitat loss due to agriculture and logging; however, the magnitude of this is unknown' (e.g. *Monodelphis unistriata* Pavan 2016), and 'The major threat is deforestation, which has severely fragmented much of the remaining forest in the region' (*Gracilinanus dryas* Pérez-Hernandez et al. 2016), which clearly mean similar things but are expressed differently, due to how different authors write. The topic 'Research needed' was downloaded from the individual assessments.

Data from the IUCN Red List assessments were compared with recent works on NWMs (e.g. Astúa 2015, Astúa et al. 2022, Beck et al. 2022, Voss 2022, WWF Living Planet Report 2022, Mammal Diversity Database 2024) and information was added or combined, when available. We also included recent works that discuss population trends for NWMs (e.g. Ferreira et al. 2015), or seasonal

fluctuations due to their life history (e.g. Rossi & Leiner 2022). We incorporated information for 'Threats' and 'Research needed' from Astúa (2015) when available. For the latter category, we included species as lacking 'Life History and Ecology' and 'Population size, Distribution, and Trends' when at least two of the following categories from Astúa (2015) were described as 'There is no information for this species': 'breeding', 'food and feeding', 'activity patterns', 'movements, home range, and social organization'. We also inferred that species lacking information in the categories 'Life History and Ecology' and 'Population size, Distribution, and Trends', likely required research in the 'Threats' category, and included these species in the count (marked with a P in Table 2). This approach enabled us to integrate data from the IUCN assessments and from species not yet assessed.

RESULTS AND DISCUSSION

Taxonomic account

The IUCN Red List database lists 106 species covering all NWM orders (i.e. Didelphimorphia, Microbiotheria and Paucituberculata), included in the following Red List Categories (Fig. 1a): 1 (0.9%) Extinct, 2 (1.9%) Critically Endangered (CR), 9 (8.5%) Vulnerable (VU), 7 (6.6%) Near Threatened (NT), 15 (14%) Data Deficient (DD), and 72 (68%) Least Concern (LC).

Of the three NWM orders, Microbiotheria and Paucituberculata have most of their species in NT and VU categories (Fig. 1a), presenting restricted distributions along the Andes, overlapping with four of the Global 200 priority ecoregions (Olson & Dinerstein 2002): the northern Andean Montane Forest, the northern Andean Paramo, the central Andean Yungas, and the Valdivian Temperate Rainforest/Juan Fernández Islands. Three of these ecoregions (i.e. the northern Andean Montane Forest, the central Andean Yungas, and the Valdivian Temperate Rainforests/Juan Fernández Islands) have an estimated conservation status categorised as critical or endangered (CE), while the northern Andean Paramo is relatively stable or intact (RS) (Olson & Dinerstein 2002). Didelphimorphia, the most species-rich and broadly distributed NWM order, has 12 of its species in Threatened or Near Threatened categories, while most species ($n = 70$; 51%) are listed as LC (Fig. 1b). The ongoing recognition of new species, have already changed these percentages, with several taxa (32 species; 23%) not yet assessed (Fig. 1b; Appendix S1).

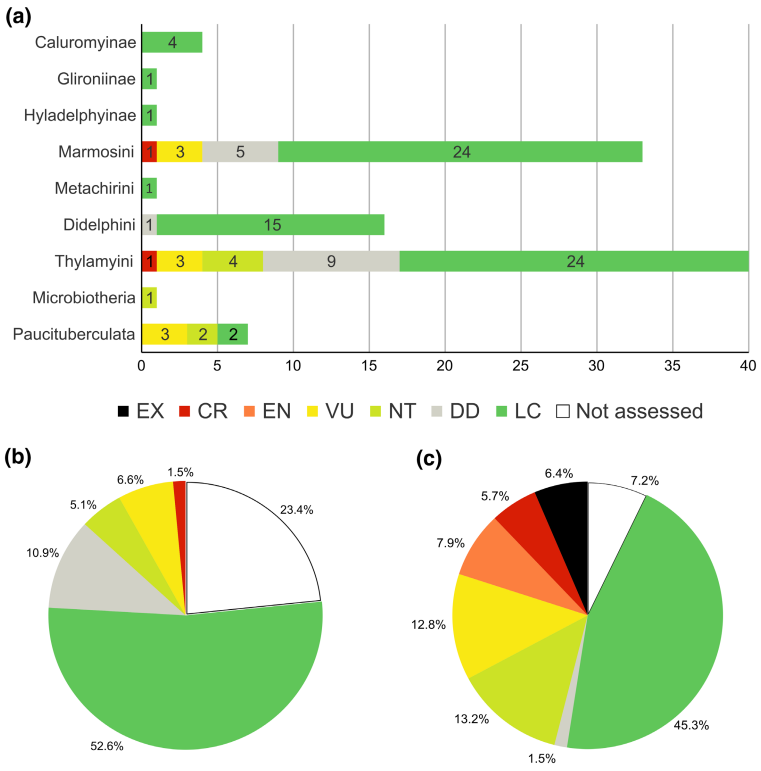

Fig. 1. International Union for the Conservation of Nature (IUCN) Red List category assessment of New World Marsupials (NWMs) for the orders Didelphimorphia (subfamily and tribe), Microbiotheria and Paucituberculata (a). Percentage of NWM species in each Red List category considering the 137 valid species from Astúa et al. (2022) (b). Percentage of Australasian marsupials in each Red List category based on data from Woinarski and Fisher (2023) (c). Colour codes for assessment categories follow IUCN standards.

The only species considered as Extinct, *Cryptonanus ignitus* (Díaz, Flores, and Barquez, 2002), was recently synonymized with *Cryptonanus chacoensis* (Teta & Díaz-Nieto 2019) and should be removed from this category. Only two species are included in the CR category: *Monodelphis unistriata* and *Marmosops handleyi* (Fig. 1a,b; Appendix S1). *Monodelphis unistriata* (Wagner, 1842) is a small marmosine with only two known records from southern Brazil and northeastern Argentina (Pine et al. 2013), which has not been recorded for the past 120 years (Pavan 2016). *Marmosops handleyi* (Pine, 1981) is a thylamyine species only known from five localities around Valdivia (Colombia), and with an extent of occurrence smaller than 100 km^2 (Díaz-Nieto et al. 2011, Pérez-Hernandez & Cáceres 2016). Nine species are listed as VU, including three marmosines (*Marmosa phaea*, *Marmosa xerophila*, and *Monodelphis reigi*), three thylamyines (*Marmosops juninensis*, *Marmosops pakaraimae*, and *Thylamys karimii*), and three caenolestids (*Caenolestes condorensis*, *Caenolestes convelatus*, and *Caenolestes sangay*) (Fig. 1a,b; Appendix S1). The taxonomic status of *Marmosa phaea* Thomas, 1899 was reevaluated by Voss et al. (2020) who found that it presents a wider distribution, from the Colombian Andes to the Amazonian lowlands of northwestern Brazil. Since some species of *Marmosa* are sympatric and morphologically similar, the name *Marmosa phaea* was attributed to other taxa, now identified as *Marmosa adleri* Voss, Giarla, and Jansa, 2021, and *Marmosa perplexa* Anthony, 1922 (Voss et al. 2021, Voss & Giarla 2021). Therefore, the threat status of *Marmosa phaea*, as well as the new taxa recently described or revalidated, need to be reevaluated in light of each current species' range. Seven species are listed as NT, including four Thylamyini didelphids (*Chacodelphys formosa*, *Thylamys fenestrae*, *Thylamys macrurus*, and *Thylamys velutinus*), the microbiotherian *Dromiciops gliroides*, and two Paucituberculata (*Caenolestes caniventer* and *Rhyncholestes raphanurus*). *Thylamys fenestrae* (Marelli, 1931) was revalidated by Martin (2008, 2009) based on morphometric analysis and morphologic data, but synonymized with *Thylamys pallidior* (Thomas, 1902) based on molecular data (Giarla et al. 2010) or considered a subspecies of *Thylamys pallidior* (Palma et al. 2014). Fifteen species are listed as DD, one Didelphini (*Philander olrogi*), five Marmosini (*Marmosa andersoni*, *Marmosa rubra*, *Marmosa tyleriana*, *Monodelphis handleyi*, and *Monodelphis iheringi*), and nine Thylamyini (*Cryptonanus agricolai*, *Cryptonanus guahybae*, *Cryptonanus unduaviensis*, *Gracilinanus emiliae*, *Marmosops cracens*, *Marmosops creightoni*, *Marmosops fuscatus*, *Thylamys tatei*, and *Thylamys venustus*). *Philander olrogi* Flores, Barquez, and Díaz, 2008 was treated as a synonym of *Philander canus* by Voss et al. (2018) based on morphologic data. *Marmosops cracens* (Handley and Gordon, 1979) is now considered a synonym of *Marmosops fuscatus* (Thomas, 1896) (Díaz-Nieto & Voss 2016). The majority of NWMs are listed as LC, including 70 Didelphimorphia and two Paucituberculata (*Caenolestes fuliginosus* and *Lestoros inca*). Of the 70 didelphid species, several have been found to be species complexes and were split into new species, with narrower distributional ranges, including 12 in the genus *Marmosa* (see below), two in the genus *Monodelphis*: *Monodelphis arlindoi* Pavan, Rossi, and Schneider, 2012 and *Monodelphis touan* (Shaw, 1800) (Pavan et al. 2012); one in the genus *Metachirus*: *Metachirus myosuros* (Temminck, 1824) (Voss et al. 2019); five in the genus *Philander* (Voss et al. 2018), one in the genus *Gracilinanus*: *Gracilinanus peruanus* (Tate, 1931) (Semedo et al. 2022), and one in the genus *Marmosops*: *Marmosops woodalli* (Pine, 1981) (Ferreira et al. 2020). Within the genus *Marmosa*, *Marmosa adleri* and *Marmosa nicaraguae* Thomas, 1905, now treated as valid and distinct species, were previously considered as part of *Marmosa alstoni* (Allen, 1900) (Voss et al. 2021); *Marmosa rapposa* Thomas, 1899 (or its junior synonym *Marmosa budini* Thomas, 1920) was previously considered as part of *Marmosa constantiae* Thomas, 1904 (Silva et al. 2019) or *Marmosa regina* Thomas, 1898 (Voss et al. 2020); *Marmosa zeledoni* Goldman, 1911 was treated as part of *Marmosa mexicana* Merriam, 1897 (Rossi et al. 2010); *Marmosa macrotarsus* (Wagner, 1842) and *Marmosa waterhousei* (Tomes, 1860) were splitted from the previously recognised *Marmosa murina* (Linnaeus, 1758) (Voss et al. 2014); *Marmosa germana* Thomas, 1904; *Marmosa jansae* Voss and Giarla, 2021; *Marmosa parda* Tate, 1931 and *Marmosa rutteri* Thomas, 1924 were part of the old concept of *Marmosa regina*, which is now a suppressed name under *Marmosa isthmica* Goldman, 1912 (Voss et al. 2020, Voss & Giarla 2021); and *Marmosa isthmica* and *Marmosa simonsi* Thomas, 1899 were part of *Marmosa robinsoni* Bangs, 1898 (Rossi et al. 2010). Within *Philander*, *Philander nigratus* (Thomas, 1923) was part of *Philander andersoni* (Osgood, 1913) (Voss & Giarla 2020); *Philander canus* (Osgood, 1913), *Philander quica* (Temminck, 1824), *Philander pebas* Voss, Díaz-Nieto, and Jansa, 2018 and *Philander melanurus* (Thomas, 1899) were part of the wide-distributed *Philander opossum* (Linnaeus, 1758) (Voss et al. 2018). Recent taxonomic advances, including data from Astúa (2015), Voss (2022), Beck et al. (2022), Astúa et al. (2022), and the Mammal Diversity Database v 1.12 (Mammal Diversity Database 2024) show an increase in living NWMs from 105 (IUCN Red List) to 137 (Astúa et al. 2022), or 135 species (Mammal Diversity Database 2024) (Appendix S2). Major taxonomic changes occurred in small and highly polytypic genera (e.g. *Marmosa*, *Monodelphis*, *Marmosops*), but also in medium-sized and broadly distributed genera (e.g. *Philander*, *Metachirus*). These changes affect the

conservation status of several species, as available information on some taxa is restricted to forms within their original distribution (see below).

The description of new species, as well as the reevaluation of the taxonomic status of several taxa, especially within Didelphimorphia, has been a common trend for the last 5–10 years, as a result of new research in poorly studied and broadly distributed genera and species (e.g. *Cryptonanus*, *Didelphis*, *Marmosa*, and *Metachirus*) (e.g. Voss et al. 2018, Fegies et al. 2021). As more revisionary studies are being conducted on widely distributed taxa (e.g. *Didelphis albiventris*, *Metachirus myosuros*, and *Caluromys* spp.) it is expected that new species will be described, old nominal taxa might be revalidated, synonymized or even suppressed (Teta et al. 2022, Chemisquy et al. 2023). These changes will be considered non-genuine according to the IUCN terminology, where a new species originates from the splitting of an already known and previously assessed taxon (IUCN Standards and Petitions Committee 2022). The splitting of known species into new, different ones, has a direct impact on their conservation status, since all parameters evaluated change (Voss et al. 2020, 2021).

Australasian marsupials comprise 265 species in 17 families and four orders (Woinarski & Fisher 2023) a pattern clearly different from NWMs, for which most of its richness has become extinct (Goin & Martin 2022). Comparisons between Australasian and NWMs (Fig. 1b,c) show a higher number of extinct Australian species ($n = 17$; 6.4% EX), as well as those in threatened categories (CR = 15, 5.7%; EN = 21, 7.9%; VU = 34, 13%) (Woinarski & Fisher 2023). Also, DD and non-assessed species represent a small percentage of Australasian marsupials ($n = 4$; 1.6%; $n = 19$, 7.2%) compared to the 15 DD NWM species (11%) and 32 non-assessed species (23%) (Fig. 1b,c). This evidences the recent advances in NWM knowledge, with several species being recently validated, and, as well, the lack of studies on rare or narrowly distributed species, mostly represented in DD category. This difference is likely to increase when more species are recognised within broadly distributed taxa.

Population trends

The population trend is unknown for more than half of the species listed ($n = 82$; 60%), with 34 species (25%) considered stable, 30 species (22%) with decreasing trends, and only three species (2.2%), *Didelphis virginiana*, *Monodelphis domestica*, and *Monodelphis kunsi*, with increasing trends (Appendix S1). Of the 105 species with IUCN assessments (excluding *Cryptonanus ignitus*), 45 have unknown population trends, with three of them (i.e. *Gracilinanus agilis*, *Gracilinanus microtarsus*, and *Marmosops incanus*) considered stable by the WWF Living Planet Report (2022), Astúa (2015; only the last one), and Rossi and Leiner (2022, 2023; only the first one). Population trends have not been formally evaluated for 43 species, representing 31% of the currently recognised richness (Astúa et al. 2022), with only one considered stable (*Philander quica*) (Appendix S1). Of the species in which populations are decreasing, all four Caluromyinae are included, one Didelphini, seven Marmosini, 14 Thylamyini (most of them in the genus *Thylamys*), *Dromiciops gliroides*, and three Paucituberculata (*Caenolestes caniventer*, *Caenolestes convelatus*, and *Rhyncholestes raphanurus*) (Appendix S1). Stable populations were described for nine Didelphini (most of them in the genus *Didelphis*), 12 Marmosini (most of them in the genus *Marmosa*), *Metachirus nudicaudatus*, 12 Thylamyini (most of them in the genus *Marmosops*) (Appendix S1). Unknown population trends were recorded for 12 Didelphini (most of them in the genus *Philander*), 36 Marmosini (most of them in the genus *Monodelphis*), 25 Thylamyini (most of them in the genus *Marmosops*), *Metachirus myosuros*, *Glironia venusta*, *Hyladelphys kalinowskii*, and four Paucituberculata (Appendix S1).

Population dynamics in NWM are poorly known, and only a few species have been studied. In their latest review, Gentile et al. (2022) list studies on three Caluromyinae (two *Caluromys* and *Caluromysiops irrupta*), nine Marmosini (four *Marmosa*, four *Monodelphis*, and *Tlacuatzin canescens*), six Didelphini (four *Didelphis* and two *Philander*), one Metachirini (*Metachirus myosuros*), and six Thylamyini (four *Marmosops* and two *Thylamys*). Most of these studies (>50%) were carried out in the Atlantic Forest of Brazil, also showing a strong bias towards tropical species of forest environments (Gentile et al. 2022, WWF Living Planet Report 2022). However, some data was also reported for open area inhabitants in the WWF Report (2022), including population trends for the species *Monodelphis domestica* (Braga et al. 2016) and *Monodelphis kunsi* (AES Tietê 2017), which although based on short-time periods (2–4 years), showed an increase in abundance for both species (Appendix S1).

Apart from these works, Albanese (2010) studied the population ecology of *Thylamys pallidior* in the Monte desert of Argentina, González-Chávez et al. (2019) the population trends in *Caenolestes fuliginosus* in central Colombia, and several studies have dealt with the population dynamics (but no overall trends) of *Dromiciops gliroides* in southern Argentina (Rodríguez-Cabal et al. 2008, Balazote Oliver et al. 2017) and Chile (Fontúrbel et al. 2010, Celis-Diez et al. 2012). Comparisons show Microbiotheria to be one of the best-studied groups of NWMs, despite its limited distribution. Didelphid species living in open areas or extra-tropical environments are poorly represented

taxonomically, and their population dynamics are poorly studied. A similar pattern was found in Paucituberculata, with three of seven species with some information available.

Changes to our knowledge of population trends and other aspects of species biology are likely to change when species are reassessed, especially taking into account the current taxonomic changes. For example, Ferreira et al. (2015) reported the population dynamics of *Metachirus nudicaudatus* from the Atlantic Forest ecoregion of Brazil, but these specimens are now treated as *Metachirus myosuros* (Astúa et al. 2022, Voss 2022). The same is true for the recent split of *Philander opossum* (see Voss 2022), for which population studies throughout their range need to be reassessed. Also, several studies have documented semelparity or partial semelparity as part of the reproductive traits of some NWMs, influencing their population trends in the short term and their potential susceptibility to different threats (e.g. fire) (Mendonça et al. 2015, Rossi & Leiner 2023). Although semelparity or partial semelparity is not a common reproductive pattern of NWMs, it has been documented in two very distinct tribes (i.e. Marmosini and Thylamyini) and three genera (i.e. *Gracilinanus*, *Marmosa*, and *Monodelphis*), indicating it could be more widespread than previously thought. Other population studies (e.g. *Marmosops incanus*, Zangrandi 2011) show that some species of NWMs are highly seasonal, which could impact their long-term population persistence under different disturbances and climate change (Sergio et al. 2018). However, the magnitude and severity of the disturbance may lead to population crashes as observed by Fisher et al. (2014) and Mendonça et al. (2015).

Threats

Only 32 species have identified threats in their current IUCN assessments. However, habitat loss through fragmentation and/or land conversion was described as a possible threat for most species (Fig. 2). We identified 32 species for which ecosystem conversion and degradation represent the main threats (Fig. 2). Of these, small-holder farming ($n=15$), agro-industry farming ($n=13$), small-holder grazing, ranching, farming, or plantations ($n=9$), and housing and urban areas ($n=9$) are the main identified threats. However, many species ($n=16$) present unknown/unrecorded motivations for native habitat loss or conversion (Fig. 2).

When threats were analysed in detail with the proposed classification and other sources of information were included (e.g. Astúa 2015, Table 1), the category 'No major threats' was identified for 69 species, of which 26 species included a conditional threat in the form of 'No threats are known for this species, although/but…' and reported that habitat loss in different forms (e.g. deforestation and

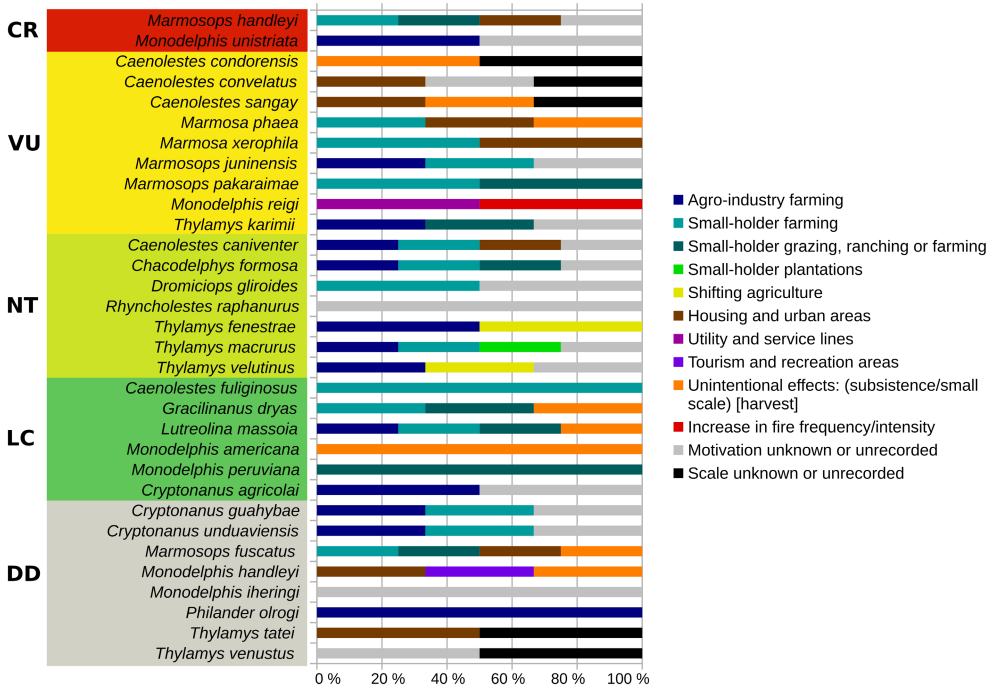

Fig. 2. Identified threats for New World Marsupials based on the International Union for the Conservation of Nature (IUCN) Red List species assessments. CR, critically endangered; DD, data deficient; LC, least concern; NT, near threatened; VU, vulnerable. Colour codes for assessment categories follow IUCN standards.

agriculture) represents possible threats. Of the 61 species in which 'Habitat loss, fragmentation, and conversion' were identified as the main threats, 35 had the sub-category 'deforestation and/or logging', and 34 had 'agriculture (including coca plantations)' as the main threat, 20 species shared 'deforestation and/or logging' and 'agriculture' as their main threats (Table 1). Other threats were identified for 14 species with 'agriculture (including coca plantations)' as their main threat: 10 of them including 'urbanization and different types of settlements', six including 'cattle grazing', and five including 'oil, gas and mining'. 'Urbanization and different types of settlements' were listed as a threat for 10 species, always considered within the main category of 'Habitat loss, fragmentation, and conversion' (Table 1).

Considering the species Red List categories, CR species ($n=2$) have 'Habitat loss, fragmentation, and conversion' as their main threat; VU species ($n=9$) have also 'Habitat loss, fragmentation, and conversion' as their main threat, with 'agriculture (including coca plantations)' as the main sub-threat category affecting seven species; NT species ($n=7$) have 'Habitat loss, fragmentation, and conversion' as their main threat, with 'deforestation and/or logging' and 'agriculture (including coca plantations)' as the main sub-threat categories; DD taxa ($n=15$) present three species with unknown threats, four species with no major threats (one conditional with habitat loss, fragmentation, and conversion), and eight species with 'Habitat loss, fragmentation, and conversion' as their main threat. For species within this category, 'agriculture (including coca plantations)' was identified as the main sub-threat affecting almost half of the species ($n=7$). Within the LC category ($n=72$), 65 species present no major threats (of which 26 species show conditional threats with habitat loss, fragmentation, and conversion), 32 species present 'Habitat loss, fragmentation, and conversion' as their main threat, with 'deforestation and/or logging' and 'agriculture (includes coca plantations)' as their main sub-threat categories ($n=19$ and $n=14$, respectively; Table 1). 'Human consumption' was identified as a threat for only the two black-eared opossums *Didelphis aurita* and *Didelphis marsupialis*; 'Hunt for fur' was identified as a threat also for the black-eared opossum *Didelphis aurita*, and the water opossum *Chironectes minimus*; 'Introduced species' was identified as a threat for the grey mouse opossum *Tlacuatzin canescens* (Table 1). 'Habitat loss, fragmentation, and conversion' was identified exclusively as the main threat for 37 species of Didelphimorphia (32 Didelphinae, 4 Caluromyinae, and *Glironia venusta*), the Microbiotheria *Dromiciops gliroides*, and four species of Paucituberculata (three in the genus *Caenolestes* and *Rhyncholestes raphanurus*) (Table 1). No major threats were conditionally identified for 67 Didelphimorphians (62 Didelphinae, four Caluromyinae and *Hyladelphys kalinowskii*), and two Paucituberculata species (*Caenolestes fuliginosus* and *Lestoros inca*), including 14 Didelphini, 24 Marmosini, *Metachirus nudicaudatus*, and 23 Thylamyini species (Table 1).

The majority of NWMs live in tropical and subtropical biomes, including moist broadleaf forests, tropical and subtropical savannas, and shrublands (Goin & Martin 2022), with higher species richness in South America, concentrated in southern Peru and surrounding areas in northwestern Bolivia and western Amazonia, southeastern Brazil, and central Colombia (Martin et al. 2021). These areas comprise distinct ecoregions (sensu Dinerstein et al. 2017) such as Southwestern Amazonian moist forests, Bolivian Yungas, Cordillera Oriental montane forests, and Alto Paraná Atlantic forest, some of them identified as key Neotropical regions for the conservation of terrestrial vertebrates by Loyola et al. (2009).

When threats were analysed in detail, most species appeared to have no direct threats (e.g. consumption and hunting), but all assessments, explicitly or implicitly, pointed at different forms of habitat degradation (e.g. deforestation and agriculture) and fragmentation as important indirect threats to NWMs (Table 1). Studies show that some marsupials move throughout most of the habitats available to them (Pires & Fernandez 1999, Passamani & Fernández 2011), and are highly resistant to habitat fragmentation (Passamani & Fernández 2011). However, these studies are geographically restricted to the Atlantic Forest of southeastern Brazil, or their ecotone with the Cerrado (Machado et al. 2021), and there is scarce information on how fragmentation affects species in other ecoregions (e.g. Southwestern Amazon moist forests, Bolivian Yungas, and Northern Andean montane forests), especially in areas with high anthropic pressure and deforestation.

Research needed

We identified Research needed (combining IUCN assessments with other sources like Astúa 2015) for 85 species (62%), included in five, non-excluding categories: 'Taxonomy', with nine species; 'Life History and Ecology' with 75 species; 'Population size, Distribution, and Trends' with 80 species; 'Threats' with 78 species; and 'Actions' with two species (Table 2). At the ordinal level, more than 70% of the species of the order Didelphimorphia need information on any of the five categories, with 'Population size, Distribution and Trends' (69%), 'Threats' (66%) and 'Life History and Ecology' (63%) showing the highest values. All Paucituberculata species need more information on 'Life History and Ecology' and 'Population size, Distribution and Trends', while all species in this order need information on 'Threats' (Table 2). The microbiotherian *Dromiciops gliroides* needs information on

Table 1. Identified threats for New World Marsupials based on the International Union for the Conservation of Nature (IUCN) Red List species assessments, using the classification proposed in this work, which includes six broad categories (i.e. no major threats; habitat loss, fragmentation and conversion; introduced species; human consumption; hunting; and unknown), and a division of 'habitat loss, fragmentation and conversion' into six sub-threat categories. Data from IUCN assessments is marked with an X, data from Astúa (2015) is marked with an A. Species highlighted in grey are no more treated as valid according to the checklist of Astúa et al. (2022), which are numbered showing their synonyms, as follows: [1]currently treated as a synonym of *Marmosa macrotarsus*; [2]suppressed name, currently treated as a synonym of *Marmosa isthmica*; [3]currently treated as a synonym of *Marmosops fuscatus*; [4]currently treated as a *nomem dubium*; [5]currently treated as a synonym of *Marmosops caucae*; [6]currently treated as a synonym of *Philander opossum*, but data refers to the currently valid species *Philander quica*; [7]currently treated as a synonym of *Philander canus*; [8]currently treated as a synonym of *Philander canus*; [9]currently treated as a synonym of *Thylamys venustus*; [10]currently treated as a synonym of *Thylamys pallidior*; [11]currently treated as a synonym of *Thylamys bruchi*

Scientific name	Red List category	No major threats	Habitat loss, fragmentation and conversion	Deforestation and/or logging	Agriculture (includes coca plantations)	Cattle grazing	Oil, gas and mining	Drainage of wetlands and water courses degradation	Urbanisation and different types of settlements	Human consumption	Hunted for fur	Introduced species	Unknown
Caluromys derbianus	LC	X	A										
Caluromys lanatus	LC	X	A										
Caluromys philander	LC	X	X										
Caluromysiops irrupta	LC	X	A										
Chacodelphys formosa	NT		X	X	X								
Chironectes minimus	LC	X	X	A	A		A	X			X		
Cryptonanus agricolai	DD		X		X								
Cryptonanus chacoensis	LC	X											
Cryptonanus guahybae	DD		X	X									
Cryptonanus unduaviensis	DD		X										X
Didelphis albiventris	LC	X											
Didelphis aurita	LC	X	X							X	X		
Didelphis imperfecta	LC	X											
Didelphis marsupialis	LC	X								X			
Didelphis pernigra	LC	X											
Didelphis virginiana	LC	X											
Gracilinanus aceramarcae	LC		X	X	X		X						
Gracilinanus agilis	LC	X	X	X									
Gracilinanus dryas	LC		X	X	X	X			X				
Gracilinanus emiliae	DD	X											
Gracilinanus marica	LC		X										

(Continues)

Table 1. (Continued)

Scientific name	Red List category	No major threats	Habitat loss, fragmentation and conversion	Deforestation and/or logging	Agriculture (includes coca plantations)	Cattle grazing	Oil, gas and mining	Drainage of wetlands and water courses degradation	Urbanisation and different types of settlements	Human consumption	Hunted for fur	Introduced species	Unknown
Gracilinanus microtarsus	LC	X	A	A									
Lestodelphys halli	LC	X	X		X								
Lutreolina crassicaudata	LC	X											
Lutreolina massoia	LC		X		X								
Marmosa alstoni	LC	X											
Marmosa andersoni	DD	X	X		X		X						
Marmosa constantiae	LC	X		A	A	A			A				
Marmosa demerarae	LC	X											
Marmosa lepida	LC	X	X	X									
Marmosa mexicana	LC	X											
Marmosa murina	LC	X											
Marmosa paraguayana	LC	X	X		X				X				
Marmosa phaea	VU		X		X				X				
Marmosa quichua[1]	LC	X											
Marmosa regina[2]	LC	X											
Marmosa robinsoni	LC	X											
Marmosa rubra	DD		X		A				A				X
Marmosa tyleriana	DD	X											
Marmosa xerophila	VU		X						X				
Marmosops bishopi	LC	X											
Marmosops caucae	LC	X	X	X									
Marmosops cracens[3]	DD												X
Marmosops creightoni	DD	X											
Marmosops fuscatus	DD		X		A				A				
Marmosops handleyi	CR		X	X	X								
Marmosops impavidus[4]	LC	X											
Marmosops incanus	LC	X											
Marmosops invictus	LC	X		A									
Marmosops juninensis	VU		X		X								
Marmosops neblina[5]	LC	X											
Marmosops noctivagus	LC	X											

(Continues)

Table 1. (Continued)

Scientific name	Red List category	No major threats	Habitat loss, fragmentation and conversion	Deforestation and/or logging	Agriculture (includes coca plantations)	Cattle grazing	Oil, gas and mining	Drainage of wetlands and water courses degradation	Urbanisation and different types of settlements	Human consumption	Hunted for fur	Introduced species	Unknown
Marmosops ocellatus	LC	X											
Marmosops pakaraimae	VU		X	X	X								
Marmosops parvidens	LC	X											
Marmosops paulensis	LC	X											
Marmosops pinheiroi	LC	X											
Metachirus nudicaudatus	LC	X											
Monodelphis adusta	LC	X											
Monodelphis americana	LC		X	X									
Monodelphis brevicaudata	LC	X	X										
Monodelphis dimidiata	LC		X		X								
Monodelphis domestica	LC	X											
Monodelphis emiliae	LC	X											
Monodelphis glirina	LC	X	X	X	X								
Monodelphis handleyi	DD		X	X									
Monodelphis iheringi	DD		X										
Monodelphis kunsi	LC	X	X										
Monodelphis osgoodi	LC	X											
Monodelphis palliolata	LC	X											
Monodelphis peruviana	LC	X	X	X	X								
Monodelphis reigi	VU		X	X			X						
Monodelphis ronaldi	LC	X											
Monodelphis scalops	LC	X	X										
Monodelphis unistriata	CR		X	X	X								
Philander andersoni	LC	X											

(Continues)

Table 1. (Continued)

Scientific name	Red List category	No major threats	Habitat loss, fragmentation and conversion	Deforestation and/or logging	Agriculture (includes coca plantations)	Cattle grazing	Oil, gas and mining	Drainage of wetlands and water courses degradation	Urbanisation and different types of settlements	Human consumption	Hunted for fur	Introduced species	Unknown
Philander deltae	LC	X					A						
Philander frenatus[6]	LC	X											
Philander mcilhennyi	LC	X											
Philander mondolfii[7]	LC	X											
Philander olrogi[8]	DD		X		X								
Philander opossum	LC	X											
Thylamys cinderella[9]	LC	X	X	X									
Thylamys citellus	LC	X	X	X	X								
Thylamys elegans[10]	LC	X	X	A	X								
Thylamys fenestrae	NT		X		X	X							
Thylamys karimii	VU		X	A	X	A							
Thylamys macrurus	NT		X	X	X								
Thylamys pallidior	LC	X	X										
Thylamys pulchellus[11]	LC	X	X	X	X								
Thylamys pusillus	LC	X	X	X	A								
Thylamys tatei	DD		X	X	X				A				
Thylamys velutinus	NT		X	X	X								
Thylamys venustus	DD		X		A				X				
Tlacuatzin canescens	LC	X	X	X								X	
Glironia venusta	LC		X	X									
Hyladelphys kalinowskii	LC	X											
Dromiciops gliroides	NT		X										
Caenolestes caniventer	NT		X	X	X								
Caenolestes condorensis	VU		X	X	X								
Caenolestes convelatus	VU		X	X	X	A			A				
Caenolestes fuliginosus	LC	X	X			X							
Caenolestes sangay	VU		X		X								
Lestoros inca	LC	X											
Rhyncholestes raphanurus	NT		X	X									

Table 2. Identified research needed for New World Marsupials based on the International Union for the Conservation of Nature (IUCN) Red List species assessments (marked with an X) and data retrieved from Astúa (2015; marked with an A). Species with more than one category of research were conditionally included in the 'threats' category (marked with a P). Species highlighted in grey are no more treated as valid according to the checklist of Astúa et al. (2022), which are numbered showing their synonyms, as follows: [1]currently treated as a synonym of *Marmosa macrotarsus*; [2]suppressed name, currently treated as a synonym of *Marmosa isthmica*; [3]currently treated as a synonym of *Marmosops fuscatus*; [4]currently treated as a *nomem dubium*; [5]currently treated as a synonym of *Marmosops caucae*; [6]currently treated as a synonym of *Philander opossum*, but data refers to the currently valid species *Philander quica*; [7]currently treated as a synonym of *Philander canus*; [8]currently treated as a synonym of *Philander canus*; [9]currently treated as a synonym of *Thylamys venustus*; [10]currently treated as a synonym of *Thylamys pallidior*; [11]currently treated as a synonym of *Thylamys bruchi*

Scientific name	Taxonomy	Life history and ecology	Population size, distribution and trends	Threats	Actions
Caluromys derbianus					
Caluromys lanatus					
Caluromys philander					
Caluromysiops irrupta					
Chacodelphys formosa		X	X	X	
Chironectes minimus					
Cryptonanus agricolai		X	X	P	
Cryptonanus chacoensis					
Cryptonanus guahybae		X	X	X	
Cryptonanus unduaviensis		X	X	X	
Didelphis albiventris					
Didelphis aurita					
Didelphis imperfecta					
Didelphis marsupialis					
Didelphis pernigra					
Didelphis virginiana					
Gracilinanus aceramarcae		A	A	P	
Gracilinanus agilis		X	X	X	
Gracilinanus dryas		A	A	P	
Gracilinanus emiliae		X	X	P	
Gracilinanus marica		A	A	P	
Gracilinanus microtarsus		X	X	P	
Lestodelphys halli		X	X	P	
Lutreolina crassicaudata					
Lutreolina massoia		A			
Marmosa alstoni			X		
Marmosa andersoni		X	X	X	
Marmosa constantiae		X	X	X	
Marmosa demerarae					
Marmosa isthmica					
Marmosa lepida		A	A	P	
Marmosa macrotarsus		A	A	P	
Marmosa mexicana					
Marmosa murina			X		
Marmosa paraguayana					
Marmosa phaea		A	X	X	
Marmosa quichua[1]			X		
Marmosa regina[2]		A	A	P	
Marmosa robinsoni	X			X	
Marmosa rubra			X	X	
Marmosa simonsi		A	A	P	
Marmosa tyleriana		X	X	P	
Marmosa xerophila		X	X	P	
Marmosa waterhousei		A	A	P	
Marmosa zeledoni		A	A	P	
Marmosops bishopi		A	X	X	
Marmosops caucae					
Marmosops cracens[3]		X	X	X	X
Marmosops creightoni		X	X	X	

(Continues)

Table 2. (Continued)

Scientific name	Taxonomy	Life history and ecology	Population size, distribution and trends	Threats	Actions
Marmosops fuscatus		X	X	P	
Marmosops handleyi		X	X	X	
Marmosops impavidus[4]		A	X	P	
Marmosops incanus					
Marmosops invictus		X	X	X	
Marmosops juninensis		X	X	X	X
Marmosops neblina[5]		X	X	P	
Marmosops noctivagus					
Marmosops ocellatus		A	X	P	
Marmosops pakaraimae		X	X	P	
Marmosops parvidens			X		
Marmosops paulensis					
Marmosops pinheiroi					
Metachirus nudicaudatus	X		X	X	
Monodelphis adusta		A	A	P	
Monodelphis arlindoi		A	A	P	
Monodelphis americana					
Monodelphis brevicaudata		A	A	P	
Monodelphis dimidiata					
Monodelphis domestica					
Monodelphis emiliae		A	A	P	
Monodelphis gardneri		A	A	P	
Monodelphis glirina		X	X	X	
Monodelphis handleyi	X	A	X	P	
Monodelphis iheringi		X	X	X	
Monodelphis kunsi					
Monodelphis osgoodi		A	A	P	
Monodelphis palliolata		X	X	P	
Monodelphis peruviana		A	A	P	
Monodelphis reigi		X	X	X	
Monodelphis ronaldi		X	X	X	
Monodelphis santaerosae					
Monodelphis scalops		X	X	X	
Monodelphis touan		A	A	P	
Monodelphis unistriata		X	X	X	
Philander andersoni		A	A	P	
Philander deltae		X	X	X	
Philander frenatus[6]					
Philander mcilhennyi		A	A	P	
Philander mondolfii[7]		A	X	X	
Philander olrogi[8]	X	X	X	X	
Philander opossum	X		X		
Thylamys cinderella[9]		X	X	X	
Thylamys citellus	X	A	X	P	
Thylamys elegans	X	X		X	
Thylamys fenestrae[10]		X	X	X	
Thylamys karimii		X	X	X	
Thylamys macrurus		X	X	X	
Thylamys pallidior		X	X	P	
Thylamys pulchellus[11]	X	A	X	P	
Thylamys pusillus		X	X	P	
Thylamys tatei		X	X	X	
Thylamys velutinus					
Thylamys venustus		X	X	X	
Tlacuatzin canescens				X	
Glironia venusta		X	X	X	

(Continues)

Table 2. (Continued)

Scientific name	Taxonomy	Life history and ecology	Population size, distribution and trends	Threats	Actions
Hyladelphys kalinowskii	X		X		
Caenolestes caniventer		X	X	P	
Caenolestes condorensis		X	X	X	
Caenolestes convelatus		X	X	X	
Caenolestes fuliginosus		X	X	X	
Caenolestes sangay		X	X	P	
Lestoros inca		X	X	P	
Rhyncholestes raphanurus		X	X	X	
Dromiciops gliroides		X		X	

'Life History and Ecology' and 'Threats' according to IUCN, although recent work has substantially increased our knowledge of this species, especially regarding aspects of its natural history (e.g. Abarzúa et al. 2023) and spatial ecology and threats (e.g. González-Ancín et al. 2021, Fernández et al. 2022). Although considered as a single species by many authors (Valladares-Gómez et al. 2017, Martin 2018, Suárez-Villota et al. 2018), Quintero-Galvis et al. (2021) presented molecular evidence supporting two species: *Dromiciops gliroides* in the southern part of the distribution, and *Dromiciops bozinovici* in the northern part. If the second species is considered valid, it might be experiencing more immediate threat than *Dromiciops gliroides* due to the dramatic native forest conversion to exotic tree plantations and the expansion of urban areas.

At the subfamilial level within Didelphimorphia, most members of Didelphinae and *Glironia venusta* (Glironiinae) need information on 'Life History and Ecology', 'Population size, Distribution and Trends', and 'Threats', while *Hyladelphys kalinowskii* needs information on 'Taxonomy' and 'Population size, Distribution and Trends'. There is no information on research needed for Caluromyinae, a subfamily that includes four species (Table 2).

At the tribal level within Didelphinae, information is needed for 75% of the species of each tribe for almost all five categories listed except for 'Actions', with the majority needing information on 'Population size, Distribution and Trends' (71%) and 'Threats' (69%) (Table 2). Didelphini presents information on Research need for seven species (44%), Marmosini for 33 species (79%), Metachirini for 1 species (100%), and Thylamyini for 34 species (83%) (Table 2).

Of the 137 recognised species (Astúa et al. 2022), 69 (50%) species have no identified research needed, of which 32 (46%) have not been assessed by the IUCN, and 37 (54%) have assessments without identified research needed. The latter group comprises species that appear relatively common, moderately to well-known, and with broad distributions (e.g. *Didelphis* spp.), which might lead to the perception that no information is needed about them. However, available information for most of these species come from well studied populations in small areas of their range (e.g. *Caluromys* in French Guiana, *Didelphis*, *Marmosa*, and *Marmosops* from the Atlantic Forest).

The information presented and analysed above accounts for 77% of NWM species, with unknown population trends and research needed for more than half of the species. The lack of data for a large number of species in the main categories analysed, together with the outdated nature of some of these datasets, posed limitations on the outcomes of our study. We know so little about the ecology of the majority of NWM species, that revisionary work will inevitably generate more data deficient (DD) or even threatened species (endangered, EN; vulnerable, VU), since several recently delimited taxa have been shown to present restricted distributional ranges (e.g. Pavan et al. 2012). These data highlight the need for overcoming the Linnean and Wallacean shortfalls for most NWMs in time to preserve their habitats, and this becomes even more critical in the face of future climatic changes. Although climate change projections from different sources show contrasting views of how South American biomes will be impacted (Salazar et al. 2007, Lyra et al. 2016, Santos Pereira et al. 2017, Anjos et al. 2021), land conversion and especially deforestation will change ecosystem architecture, affecting marsupials by reducing their 'optimal' habitats (Martin et al. 2022). Fire has also been identified as an important source of 'habitat loss, fragmentation and conversion' (following the terminology used in this study), especially in semiarid ecosystems (Miranda et al. 2002, Mendonça et al. 2015, Giorgis et al. 2021), and has been shown to impact NWM differently (Martin et al. 2021, Rossi & Leiner 2023).

Studying NWM taxonomy, systematics, biogeography, and how ecological features could be applied to less studied, sister species, will be crucial for a rapid assessment of poorly known species, but this information should be precisely stated. Because it is an almost impossible task

to study all species, we should try to find ways to extrapolate broad-scale information to poorly known species within speciose genera (e.g. *Marmosops*, *Marmosa*), and concentrate on monotypic genera (e.g. *Chacodelphys formosa* and *Hyladelphys kalinowskii*), geographically restricted species (e.g. *Caenolestes condorensis*, *Marmosa andersoni*) or those living in unique environments within a genus (e.g. *Cryptonanus chacoensis*, *Thylamys macrurus*).

The IUCN Red List database only provides assessments for 106 species of NWM, while the currently accepted number includes 135–137 species (Patterson 2015, Astúa et al. 2022, Beck et al. 2022, Voss 2022). This means that ca. 23% of all the known species are lacking an assessment and proper distribution maps. Our analyses also showed that there is a need for more information on NWM, as research needed was identified for 65 out of 106 species, plus the 32 (53%) species not assessed by the IUCN. This is likely to increase when the recently described or delimited taxa present their own assessments. The ecology of several species with large distributions are only known from scattered parts of their range (e.g. *Caluromys philander*, Julien-Laferrière & Atramentowicz 1990), and it would be crucial to have information throughout their distribution. Also, many charismatic or large-sized species have been thoroughly studied (e.g. *Dromiciops gliroides*, *Didelphis albiventris*, and *Marmosa robinsoni*), but many of their narrowly distributed counterparts are poorly known (e.g. *Didelphis pernigra* and *Marmosa isthmica*). This is critical from a conservation point of view, as many analyses rely on IUCN data to provide accurate information on distribution trends and conservation priorities (Martin et al. 2021).

RECOMMENDATIONS

Current knowledge about species biology, ecology, threats, and interactions with humans should be updated to provide accurate information for the conservation of NWMs. The uncertainty generated by recent taxonomic changes challenges the identification of threats and research needed, particularly when applied to non-charismatic species like marsupials. This situation underscores the necessity for specific research initiatives aimed at accurately assessing the conservation status of NWMs, recognising the unique conservation needs of these less conspicuous yet ecologically crucial species. Although most NWMs are categorised as Least Concern or will probably be listed as Data Deficient, with the majority of them experiencing no major direct threat, most of the assessments have identified 'habitat loss, fragmentation, and conversion' as the main threat to their conservation.

We identified four main steps to improve the knowledge for the conservation of NWMs: 1) Updated Assessments: conduct comprehensive and up-to-date assessments to include all currently valid NWM species. These assessments should incorporate the latest population data, threats, and distribution maps to provide a robust foundation for conservation planning; 2) Identify biomes, ecosystems and/or areas where the highest values for marsupial conservation occur throughout the New World, and integrate this information with conservation efforts at different spatial scales; 3) Research Collaboration: Encourage collaborations among researchers, institutions, and governments to address the identified research needs. This collaborative approach will allow for the efficient allocation of resources and expertise to fill knowledge gaps; and 4) Conservation Integration: Integrate the gathered information with conservation efforts at different political and spatial scales. This involves working closely with local communities, government agencies, and NGOs to implement targeted conservation actions tailored to the specific needs of each NWM species and their habitats.

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CONFLICT OF INTEREST

Authors to the manuscript 'Taxonomic Assessment, Conservation Status, and Future Perspectives for New World', by Gabriel Martin and Ana Paula Carmignotto, declare no conflict of interest.

DATA AVAILABILITY STATEMENT

This review generated new datasets which are available in Tables 1 and 2 and Appendices S1 and S2. All cited literature from where data was retrieved can be found in the references.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's website.

Appendix S1. New World Marsupial species according to Astúa et al. (2022), classified by their International Union for the Conservation of Nature (IUCN) Red List category, including Population Trend, IUCN Assessment date, and additional references.

Appendix S2. Recognized number of New World Marsupial genera and number of species within, according to different sources: IUCN assessments (2015–2021); Astúa (2015); Beck et al. (2022) and Voss (2022); Astúa et al. (2022); and Mammal Diversity Database (2024).