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Conservation priorities and early warnings of national mammal loss in Jordan within a lost species framework

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Abstract: Extinction is often preceded by progressive range contraction and population decline, yet species may remain undetected for extended periods before confirmed disappearance. At the national scale, distinguishing between confirmed historical extirpation and recent non-detection is essential for effective conservation prioritization. This study adopts a two-tier analytical approach for Jordan's mammalian fauna. First, it compiles and reviews historical, archaeological, and paleontological evidence to identify taxa that have been extirpated with relatively high confidence from the Early Pleistocene through the twentieth century. Second, it applies a standardized lost species framework, using a ≥ 10 -year threshold for taxa without verified wild records, to systematically screen extant mammalian taxa for recent non-detection and potential national loss. For the latter assessment, all species listed in the *National Red Data Book of Mammals in Jordan* were evaluated based on their most recent documented occurrence using published literature, museum records, and confirmed field observations. Results indicate that 22 mammalian taxa are historically extirpated, representing long-term and largely irreversible national losses. In contrast, seven taxa, *Gazella gazella*, *Nesokia indica*, *Gerbillus andersoni*, *Lutra lutra*, *Capreolus capreolus* (reintroduced population), *Gazella dorcas*, and *Gazella marica*, meet the criteria for being nationally lost, reflecting recent absence of verified detections rather than confirmed disappearance. Six of the seven nationally lost taxa are classified as Critically Endangered, indicating strong concordance between national extinction risk and recent non-detection. By explicitly separating historical extirpations from recently undetected taxa, this study provides an early-warning, precautionary framework that supports targeted surveys, recovery planning, habitat restoration, strengthened enforcement, and transboundary coordination, thereby helping to prevent additional species from progressing toward irreversible national extinction.

Keywords: Conservation prioritization, lost species, national extirpation, species rediscovery, wildlife monitoring

المخلص

غالبًا ما يسبق مرحلة انقراض الأنواع انخفاض تدريجي في نطاق توزيعها وتراجع في أعداد أفرادها، إلا أن الأنواع قد تظل غير مكتشفة لفترات طويلة قبل تأكيد اختفائها وعليه فإن تطبيق إطار معياري لتحديد الأنواع المفقودة على المستوى الوطني يمكن أن يساعد في التعرف على الأنواع المعرضة للخطر قبل استنتاج اختفائها رسميًا. وعلى المستوى الوطني، يُعد التمييز بين الانقراض التاريخي المؤكد وعدم الرصد الحديث للأنواع أمرًا أساسيًا لتحديد أولويات الحماية بشكل فعال. تعتمد هذه الدراسة نهجًا تحليليًا ذا مستويين لتدبيات الأردن. أولاً، تم جمع ومراجعة الأدلة التاريخية والأثرية والأحفورية لتحديد الأنواع التي اندثرت بدرجة عالية من اليقين منذ العصر البليستوسيني المبكر وحتى القرن العشرين. ثانيًا، تطبيق إطار معياري للأنواع المفقودة باستخدام

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عتبة زمنية مقدارها ≤ 10 سنوات للأنواع التي لا تتوفر لها تسجيلات مؤكدة في البرية وفيما يتعلق بالتقييم الثاني، فقد تم تقييم جميع الأنواع المدرجة في الكتاب الأحمر الوطني لثدييات الأردن استنادًا إلى أحدث توثيق لوجودها باستخدام الأدبيات المنشورة، وسجلات المتاحف والمشاهدات الحقلية المؤكدة. تشير نتائج البحث إلى أن ٢٢ نوعًا من الثدييات قد اندثرت تاريخيًا وعلى النقيض من ذلك، فإن سبعة أنواع من الثدييات تستوفي حاليًا معيار اعتبارها مفقودة وطنيًا، بسبب عدم توفر تسجيلات مؤكدة حديثة وهي الغزال الجبلي (*Gazella gazella*) والرُّكَّين المصري (*Nesokia indica*) وعُضَل اندرسون (*Gerbillus andersoni*) وكلب الماء (*Lutra lutra*) والأيل الأسمر (*Capreolus capreolus*) وتحديدًا القطيع الذي تم إعادة إطلاقه وغزال دوركاس (*Gazella dorcas*) وغزال الريم (*Gazella marica*). ويُصنَّف ستة من هذه الأنواع السبعة المفقودة وطنيًا ضمن فئة الأنواع المهددة بخطر الانقراض بشكل حرج بحسب الكتاب الأحمر الوطني لثدييات الأردن، مما يشير إلى توافق قوي بين مستوى خطر الانقراض على الصعيد الوطني وعدم وجود أدلة حديثة لتواجدها. توفر هذه الدراسة إطارًا احترازيًا للإنذار المبكر يدعم تنفيذ مزيد من المسوحات الميدانية المستهدفة وخطط الاستعادة وتعزيز تنفيذ القوانين والتنسيق العابر للحدود بما يسهم في الحد من انتقال المزيد من الأنواع نحو الانقراض على المستوى الوطني.

INTRODUCTION

Extinction is typically preceded by progressive range contraction and population decline, processes that may be detectable through spatial and temporal signals before complete disappearance occurs (Ceballos and Ehrlich 2006; Channell and Lomolino 2000a, 2000b; Gilpin and Soulé 1986). In recent conservation discourse, increasing attention has been given to taxa that are not formally extinct but have remained undetected for extended periods. Terms such as lost, missing, or long-lost have been used to describe species that lack recent confirmed records but have not been declared extinct (Cottee-Jones et al. 2013; Silcock et al. 2020; Twomey and Brown 2008). Long and Rodríguez (2022) proposed a standardized “lost species” framework, defining lost taxa as those with no verified wild record for a specified time period (ten years or more) and absent from ex situ conservation programs. Operational thresholds, however, vary across studies, ranging from shorter temporal gaps to long-lost categories exceeding 50 years (de Lirio et al. 2018; Paglia et al. 2022; Villarroel et al. 2014; Watson and Davis 2017).

At national scales, the disappearance of a species from a country, while not necessarily implying global extinction, represents a significant conservation event. National losses reduce ecological function, erode genetic representation across landscapes, and may signal broader regional declines (Ceballos and

Ehrlich 2002; Channell and Lomolino 2000b; Dirzo et al. 2014). Moreover, distinguishing between confirmed national extirpation and temporary non-detection is often complicated by uneven survey effort, restricted access, and transboundary population dynamics (Long and Rodríguez 2022; Silcock et al. 2020). Applying a transparent operational threshold can therefore help prioritize targeted surveys and guide conservation decision-making before formal extirpation is inferred.

In this study, a conceptual distinction is made between two categories: (1) historically extirpated taxa, which are considered absent with high confidence based on archaeological, paleontological, or historical evidence spanning long temporal scales, typically from the Pleistocene through the twentieth century, and therefore representing irreversible losses at the national scale, and (2) nationally lost taxa, defined as species lacking verified wild records for ≥ 10 years but for which the possibility of continued persistence cannot be excluded. This distinction is critical, as it separates confirmed historical disappearance from recent non-detection, thereby enabling more targeted conservation prioritization.

Jordan lies at the intersection of the Mediterranean, Arabian, and Saharo-Sindian biogeographic zones and supports a diverse mammalian assemblage shaped by both ecological gradients and historical land use (Eid and Abu Azam 2025; Eid et al. 2020). Archaeological and zooarchaeological evidence confirms that

several large mammals formerly occurred in the region during the Late Pleistocene and Holocene, a shift that reflects long-term faunal change (Bar-Oz et al. 2011; Henton et al. 2017; Price et al. 2018). However, the primary conservation concern today relates to recent and contemporary declines driven by hunting pressure, habitat fragmentation, water extraction, and historically weak enforcement of wildlife protection laws (Ceballos and Ehrlich 2002; Dirzo et al. 2014; Eid et al. 2020).

This study applies a standardized lost species framework at the national scale in Jordan to distinguish between historically extirpated mammals and recently undetected ('lost') taxa, and to assess implications for conservation prioritization. It does not aim to provide a comprehensive taxonomic review of all mammalian species occurring in Jordan. Instead, it systematically screens mammalian taxa for absence of documented wild detections for ≥ 10 years, distinguishes these from historically extirpated species, and evaluates the implications of such national losses for conservation prioritization following Long and Rodríguez (2022).

METHODS

A structured literature review was conducted to compile records of mammalian taxa historically extirpated from Jordan. Sources were systematically searched using academic databases, complemented by regional reports, archaeological and zooarchaeological studies, and historical accounts. Search terms included combinations of "Jordan", "mammals", "extinction", "extirpation", "zooarchaeology", "Pleistocene fauna", "Holocene fauna", and species-specific names. Additional sources were identified through reference chaining and regional syntheses. Only records supported by verifiable evidence (e.g., fossil remains, archaeological assemblages, historical documentation, or peer-reviewed studies) were included.

All mammalian taxa listed in the International Union for Conservation of Nature (IUCN)

National Red Data Book of Mammals in Jordan (Eid et al. 2020), together with subsequent peer-reviewed updates, were systematically reviewed to determine the most recent documented national record for each species. The assessment incorporated published literature, museum records, confirmed field observations, and formally reported survey data compiled through national biodiversity assessments and protected-area monitoring programs. The screening encompassed the full taxonomic breadth of the national checklist, including Chiroptera, Rodentia, Carnivora, Artiodactyla, and other mammalian groups. Species historically extirpated from Jordan are not included in the *Red Data Book* and were therefore treated separately from taxa assessed for recent non-detection.

A taxon was classified as nationally lost if (1) no verified wild detection had been recorded within Jordan for ≥ 10 years as of 2026 (year of analysis), and (2) the species was not maintained in any formally documented national ex situ or captive breeding program for reintroduction or population recovery, following Long and Rodríguez (2022). Valid records were restricted to published literature, museum specimens, confirmed field observations, and formally reported survey data, while anecdotal reports were excluded. For the purposes of this study, 'extirpated' refers to taxa considered absent with high confidence based on archaeological, paleontological, or historical evidence, whereas 'lost' refers to taxa lacking recent verified records but for which persistence cannot be excluded.

Conservation status was contextualized using the *National Red Data Book of Mammals in Jordan* (Eid et al. 2020) and the 2024 IUCN Red List of Threatened Species (IUCN 2024). Because detection probability varies among species and survey effort (Long and Rodríguez 2022; Silcock et al. 2020), the lack of recent records was not interpreted as definitive evidence of national absence. The ≥ 10 -year threshold was therefore applied as a precautionary screening tool to prioritize verification surveys before inferring formal national extirpation.

RESULTS AND DISCUSSION

Paleontological and zooarchaeological evidence indicate that several large mammals occurred in Jordan during the Pleistocene but became regionally extinct due to long-term climatic and ecological turnover (Faure 1986; Pokines et al. 2019; Tchernov 1988). These deep-time extirpations are analytically distinct from Holocene and twentieth-century national extirpations, which are primarily associated with hunting, habitat conversion, and human land-use change.

Based on archaeological, zooarchaeological, and historical sources, twenty-two mammalian taxa are considered historically extirpated from Jordan. The timing of extirpation varies widely, spanning the Early Pleistocene through the twentieth century, and for several taxa the last national occurrence can only be estimated within broad chronological windows. While acknowledging variation in uncertainty associated with different spans of time since last known occurrence, these taxa are treated here as historically extirpated based on the best available evidence in Table 1, and are distinguished from recently undetected ('lost') taxa identified using the ≥ 10 -year threshold in Table 2. Among the most recently extirpated taxa within this group were large carnivores, including the lion (*Panthera leo*), Arabian leopard (*Panthera pardus nimr*), cheetah (*Acinonyx jubatus*), and Syrian brown bear (*Ursus arctos syriacus*), primarily driven by persecution, prey depletion, and habitat degradation (Eid and Abu Azam 2025; Eid et al. 2020; Mountfort 1964).

Similarly, based on available evidence, several ungulates appear to have been extirpated during the twentieth century, including the Arabian oryx (*Oryx leucoryx*), onager (*Equus hemionus hemippus*), and the Arabian sand gazelle (*Gazella marica*, historically recorded as *Gazella subgutturosa*), largely due to overhunting and increasing desert accessibility (Eid and Mallon 2021; Tsahar et al. 2009). Forest-associated cervids such as red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) were also extirpated

from the northern highlands following habitat clearance and sustained hunting pressure (Eid and Abu Azam 2025; von den Driesch and Boessneck 1995).

Applying the ≥ 10 -year screening criterion for the designation of lost species, seven additional mammalian taxa can be classified as nationally lost in Jordan (Table 2; Fig. 1). While the taxa discussed above (and shown in Table 1) are considered historically extirpated with relatively greater confidence based on available evidence and previously published reports, the taxa listed in Table 2 are classified as 'nationally lost', reflecting a shorter period without verified observations and therefore greater uncertainty but higher potential value for targeted conservation and rediscovery efforts. All seven taxa meeting the ≥ 10 -year criterion are small- to large-bodied mammals; no other mammalian species recorded from Jordan currently satisfy the nationally lost threshold based on verified records. The absence of most small mammals from the nationally lost category should be interpreted cautiously, as limited survey effort and detectability constraints may obscure recent declines or local loss. Systematic filtering of all mammalian taxa, including rodents and bats, indicates that most species still have relatively recent records in Jordan, although many remain poorly studied. For example, the yellow-necked field mouse (*Apodemus flavicollis*) is restricted to a few forested localities in northern Jordan that represent the southern limit of its global distribution, and its populations are presumed to be declining because of forest degradation. Similarly, extensive surveys of bats, particularly those synthesized by Benda et al. (2010) and subsequent field investigations, indicate that the 26 bat species recorded from Jordan are still present despite variation in population status and threat levels.

One notable exception is Anderson's gerbil (*Gerbillus andersoni*), which has been recorded from a single locality in Jordan representing the easternmost limit of its global range. The last confirmed capture was reported by Abu Baker et al. (2009), and the species is consid-

Table 1. Mammalian taxa extirpated from Jordan with moderate to high confidence from the Pleistocene to the late 20th century. Chronological phases follow standard Quaternary and historical archaeological frameworks: Lower (Early) Pleistocene $\approx$ 2.6–0.8 Ma; Middle Pleistocene $\approx$ 0.8–0.126 Ma; Late Pleistocene $\approx$ 126–11.7 ka; Holocene $\approx$ 11.7 ka–present; Medieval period $\approx$ 5th–15th century CE; and modern historical period $\approx$ 19th–20th centuries CE.

Species	Evidence base for occurrence	Approximate last occurrence window in Jordan	Confidence in timing	Primary drivers (dominant hypotheses)	Key sources
<i>Hippopotamus behemoth</i>	Paleontological (Jordan Valley)	Early Pleistocene (~1.4 Ma)	High	Long-term climatic–hydrological shifts; faunal turnover	Faure 1986
<i>Hippopotamus gorgops</i>	Paleontological (Jordan Valley)	Early Pleistocene (~1.4 Ma)	High	Climatic–ecological turnover	Faure 1986
<i>Palaeoloxodon</i> cf. <i>recki</i>	Zooarchaeological (SM1, Azraq Basin)	Late Middle Pleistocene (~125 ka)	High	Megafaunal turnover; climatic drying	Pokines et al. 2019
<i>Elephas</i> cf. <i>hysudricus</i>	Zooarchaeological (SM1, Azraq Basin)	Late Middle Pleistocene (~125 ka)	High	Climatic–hydrological change	Pokines et al. 2019
cf. <i>Stephanorhinus hemitoechus</i>	Zooarchaeological (SM1, Azraq Basin)	Late Middle Pleistocene (~125 ka)	High	Habitat contraction; climatic aridification	Pokines et al. 2019
<i>Bos primigenius</i> (Aurochs)	Zooarchaeological (SM1 levels 8 & 7b; Azraq Basin)	Late Middle Pleistocene documented ($\geq$ 125–266 ka); later Holocene persistence unresolved	High for Pleistocene presence; Medium for later persistence	Climatic fluctuation; hunting pressure	Pokines et al. 2019; Eid and Mallon 2021
cf. <i>Panthera leo</i> (Pleistocene population)	Zooarchaeological (SM1, Azraq Basin)	Late Middle Pleistocene (~125 ka)	High	Savanna contraction; ecological turnover	Pokines et al. 2019
<i>Gazella</i> sp. (Pleistocene Azraq population)	Zooarchaeological (SM1)	Late Middle Pleistocene (~125 ka)	High	Habitat shift	Pokines et al. 2019
<i>Camelus</i> sp.	Zooarchaeological (SM1)	Late Middle Pleistocene (~125 ka)	High	Environmental change	Pokines et al. 2019
<i>Equus</i> spp. (Pleistocene population)	Zooarchaeological (SM1)	Late Middle Pleistocene (~125 ka)	High	Climatic drying	Pokines et al. 2019
<i>Hippopotamus amphibius</i>	Zooarchaeological–paleontological (Jordan Valley; Early Holocene attribution uncertain)	Secure occurrence to Middle Pleistocene; Holocene persistence unconfirmed (reported ~7000 BCE surface finds require verification)	High for Middle Pleistocene occurrence. Low for last-occurrence timing (owing to unverified Holocene reports)	Hydrological contraction and freshwater habitat loss; long-term climatic–ecological change	Ducos 1978; Tchernov 1988
<i>Ovis orientalis</i>	Zooarchaeological	Holocene (last occurrence uncertain)	Low	Hunting; habitat degradation	Bar-Oz et al. 2011

Species	Evidence base for occurrence	Approximate last occurrence window in Jordan	Confidence in timing	Primary drivers (dominant hypotheses)	Key sources
<i>Panthera leo</i> (historical population)	Historical	By medieval period (~13th century CE)	Medium	Hunting; habitat loss	Eid et al. 2020
<i>Cervus elaphus</i>	Archaeological–historical	By late medieval period (~15 th century CE)	Medium	Habitat clearance; hunting	von den Driesch and Boessneck 1995
<i>Addax nasomaculatus</i>	Historical	19 th –early 20 th century (uncertain)	Low	Hunting; habitat degradation	Eid and Abu Azam 2025
<i>Capreolus capreolus</i> (Roe deer; indigenous population)	Historical	Early 20 th century (early 1900s)	High	Hunting; habitat loss	Eid and Abu Azam 2025; Mountfort 1964
<i>Equus hemionus hemippus</i> (Onager)	Historical	1920s	High	Hunting; desert access	Eid and Abu Azam 2025
<i>Dama mesopotamica</i> (Persian fallow deer)	Historical	1920s	High	Hunting	Eid and Abu Azam 2025
<i>Acinonyx jubatus</i> (Cheetah)	Historical	Early 1920s	High	Hunting; persecution	Eid and Abu Azam 2025
<i>Oryx leucoryx</i> (Arabian oryx)	Historical	1940s (possibly early 1960s)	Medium–High	Overhunting	Eid and Abu Azam 2025
<i>Ursus arctos syriacus</i> (Syrian brown bear)	Historical	1941	High	Hunting	Eid and Abu Azam 2025
<i>Panthera pardus nimr</i> (Arabian leopard)	Historical	1962	High	Persecution; predator control	Eid and Abu Azam 2025

ered Critically Endangered nationally because of severe habitat destruction associated with quarrying activities. Based on the ≥ 10 -year non-detection threshold applied in this study, this species therefore qualifies as nationally lost in Jordan. These cases highlight how limited monitoring and uneven survey effort for small mammals can obscure population trends and complicate assessments of national persistence.

Jordan's pattern mirrors broader regional and global defaunation trends, particularly the disproportionate loss of large-bodied mammals (Betts et al. 2019; Ceballos and Ehrlich 2002; Ceballos et al. 2015; Dirzo et al. 2014). However, the absence of recent detections does

not necessarily imply complete extirpation, and such cases are therefore treated as 'nationally lost' rather than confirmed extirpations. For example, the Eurasian otter (*Lutra lutra*) persists in neighboring countries (Aidek et al. 2021; Reuther et al. 2001), raising the possibility that remnant or transient individuals may occur undetected within Jordan. Riparian habitat degradation, invasive alien species such as coypu (*Myocastor coypus*), and reduced survey effort further complicate detection probability (Eid et al. 2020; Loy et al. 2022). In addition, restricted access to portions of suitable riparian habitats, particularly in border areas, combined with periodic security and administrative constraints, may further limit systematic

Table 2. Species lacking documented wild detections in Jordan for ≥ 10 years as of 2026 (year of analysis), following the definition of ‘lost’ proposed by Long and Rodríguez (2022). IUCN status designations are as follows: EN (endangered) indicates a very high risk of extinction; VU indicates vulnerable, a high risk; NT is near threatened, and LC is least concern, a low risk of extinction.

No.	Species	Last documented wild detection	Years since last record (as of 2026)	National Red Data Book Status (Eid et al. 2020)	Global IUCN Status (2024)
1	<i>Gazella gazella</i> (Palestinian mountain gazelle)	1986	40	CR	EN
2	<i>Gerbillus andersoni</i> (Anderson’s gerbil)	2009	17	CR	LC
3	<i>Nesokia indica</i> (Short-tailed bandicoot rat)	1988	38	DD	LC
4	<i>Lutra lutra</i> (Eurasian otter)	2000	26	CR	NT
5	<i>Capreolus capreolus</i> (Roe deer; reintroduced population)	2008	18	CR	LC
6	<i>Gazella dorcas</i> (Dorcas gazelle)	2013	13	CR	VU
7	<i>Gazella marica</i> (Arabian sand gazelle)	2016	10	CR	VU

field surveys, thereby increasing the likelihood of non-detection despite potential persistence.

Similarly, Arabian sand gazelle (*Gazella marica*) occurs near international borders where access, enforcement, and monitoring are uneven, potentially hindering both verification and recovery (Eid and Handal 2018; Eid and Mallon 2021). These cases illustrate how trans-boundary dynamics and survey limitations can obscure national status assessments. The ≥ 10 -year threshold therefore functions as a structured screening mechanism to prioritize targeted field surveys before definitive extirpation is inferred (Long and Rodríguez 2022; Silcock et al. 2020).

Reintroduction outcomes provide additional insight into conservation priorities. The roe deer (*Capreolus capreolus*) was reintroduced in Ajloun Nature Reserve through a captive breeding program initiated in 1989, with 26 individuals (11 males and 15 females) released in January 2006 after nearly 18 years of on-site breeding management (Eid and Ananbeh 2009). Although the program initially established a free-ranging population, no recent detections have been reported from the wild, and no active national ex situ population cur-

rently exists to support recovery. The species therefore meets both criteria of the ≥ 10 -year nationally lost framework. While this case represents a reintroduced rather than an indigenous population, it is treated here as a distinct analytical category, ‘reintroduced populations meeting lost criteria’, to avoid conflating reintroduction outcomes with declines of native populations. The absence of long-term monitoring, incomplete demographic records, and the lack of a structured post-release population model likely limited evaluation of population viability, highlighting the need for adaptive management, standardized monitoring, and improved landscape connectivity in future recovery efforts. In contrast, regional recovery initiatives for species such as the Arabian oryx (*Oryx leucoryx*) demonstrate that population recovery is achievable under sustained protection, although populations confined to fenced reserves may not fully restore ecological function.

Preventing further national losses will require a coordinated conservation response integrating species-specific recovery planning with landscape-level management. Beyond the seven nationally lost taxa, several additional

mammals classified as Critically Endangered (CR) or Data Deficient (DD) in the *National Red Data Book of Mammals in Jordan* warrant proactive investigation, particularly species with restricted distributions, declining populations, or low detectability (e.g., *Caracal caracal*, *Felis chaus*, *Felis margarita*, *Rhinolophus mehelyi*, *Mellivora capensis*) (Eid et al. 2020). Linking national threat categories to targeted verification surveys may function as an anticipatory mechanism to prevent additional taxa from crossing the ≥ 10 -year non-detection threshold.

Priority actions, therefore, include conducting systematic field surveys for CR and DD species, developing formal recovery plans with measurable demographic targets, strengthen-

ing enforcement to reduce illegal hunting and habitat encroachment, restoring and reconnecting fragmented habitats, and enhancing transboundary coordination for shared populations. Importantly, variation in research intensity, survey coverage, and accessibility across regions may influence the likelihood that a species is classified as nationally lost; strengthening standardized long-term monitoring frameworks is therefore essential to reduce uncertainty and avoid misclassification driven by uneven effort.

Applying a transparent lost species threshold at the national scale provides an early-warning mechanism within conservation planning. By distinguishing between histor-



Figure 1. Mammalian taxa currently lost in Jordan: (A) Arabian sand gazelle (*Gazella marica*), photo credit, Ehab Eid; (B) Roe deer (*Capreolus capreolus*), photo credit, Khalid Al-Masri; (C) Short-tailed bandicoot rat (*Nesokia indica*), photo credit, Adwan Shehab; (D) Anderson's gerbil (*Gerbillus andersoni*), photo credit, Mohammad Abu Baker.

ical extirpations identified with relatively greater confidence and recently undetected or lost taxa, the framework presented here helps triage survey effort and prioritize intervention before permanent loss occurs (Betts et al. 2019; Channell and Lomolino 2000a, 2000b; Long and Rodríguez 2022). In Jordan, the strong overlap between regional CR status and nationally lost taxa suggests that threat assessments can anticipate future national disappearances if proactive measures are not implemented.

CONCLUSIONS

In addition to the 22 taxa historically extirpated from Jordan, the application of the ≥ 10 -year lost species threshold identifies seven additional mammalian taxa currently classified as nationally lost in Jordan and highlights the strong concordance between national Red List threat assessments and recent non-detection, which may precede confirmed extirpation. Preventing further losses requires targeted verification surveys for Critically Endangered and Data Deficient taxa, strengthened enforcement of wildlife protection legislation, and development of science-based recovery and reintroduction frameworks where suitable habitat and regional source populations persist. Future survey efforts should prioritize ecologically suitable but under-surveyed habitats, particularly riparian corridors in the Jordan Valley and Yarmouk Basin, and steppe–desert ecosystems of eastern and southern Jordan. Emphasis should also be placed on medium- and large-bodied mammals, which are disproportionately vulnerable to hunting and habitat fragmentation. Applying the lost species framework at the national scale provides an early-warning mechanism to prioritize conservation action before additional extirpations occur.

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Data accessibility

All data used are from publicly available sources or published literature; no new datasets were generated.

Ethical standards and competing interests

This study did not involve new fieldwork, animal handling, or experimental procedures. All information used in this study was obtained from previously published sources and publicly available data. The author declares no competing interests.

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Literature cited

- Abu Baker MA, Khalil A, Alsheyab F, Amr Z. 2009. A karyotypic study of rodents of the genus *Gerbillus* (Mammalia: Rodentia: Muridae) collected from Jordan. *Vertebrate Zoology* 59: 115–120. doi:10.3897/vz.59.e30962
- Aidek A, Baddour FS, Ibrahim NN, Al-Sheikhly OF. 2021. The first photographic records of the Eurasian otter *Lutra lutra* in Syria: its mysterious occurrence is revealed. *IUCN Otter Specialist Group Bulletin* 38(5): 258–266. https://www.iucnsgbull.org/Volume38/Aidek_et_al_2021.html
- Bar-Oz G, Nadel D, Avner U, Malkinson D. 2011. Mass hunting game traps in the southern Levant: the Negev and Arabah “Desert Kites.” *Near Eastern Archaeology* 74(4): 208–215. doi:10.5615/near-eastarch.74.4.0208
- Benda P, Lučan RK, Obuch J, Reiter A, Andreas M, Bačkor P, Bohnenstengel T, Eid EK, Ševčík M, Vallo P, Amr ZS. 2010. Bats (Mammalia: Chiroptera) of the Eastern Mediterranean and Middle East. Part 8. Bats of Jordan: fauna, ecology, echolocation, ectoparasites. *Acta Societatis Zoologicae Bohemicae* 74: 185–353. doi:10.5281/zenodo.18036980
- Betts MG, Wolf C, Pfeifer M, Banks-Leite C, Arroyo-Rodríguez V, Ribeiro DB, Barlow J, Eigenbrod F, Faria D, Fletcher RJ Jr, Hadley AS, Hawes JE, Holt RD, Klingbeil B, Kormann U, Lens L, Levi T, Medina-Rangel GF, Melles SL, Mezger D, Ewers RM. 2019. Extinction filters mediate the global effects of habitat fragmentation on animals. *Science* 366(6470): 1236–1239. doi:10.1126/science.aax9387

- Ceballos G, Ehrlich PR. 2002. Mammal population losses and the extinction crisis. *Science* 296(5569): 904–907. doi:10.1126/science.1069349
- Ceballos G, Ehrlich PR. 2006. Global mammal distributions, biodiversity hotspots, and conservation. *Proceedings of the National Academy of Sciences* 103(51): 19374–19379. doi:10.1073/pnas.0609334103
- Ceballos G, Ehrlich PR, Barnosky AD, García A, Pringle RM, Palmer TM. 2015. Accelerated modern human-induced species losses: entering the sixth mass extinction. *Science Advances* 1(5): e1400253. doi:10.1126/sciadv.1400253
- Channell R, Lomolino MV. 2000a. Dynamic biogeography and conservation of endangered species. *Nature* 403(6765): 84–86. doi:10.1038/47487
- Channell R, Lomolino MV. 2000b. Trajectories to extinction: spatial dynamics of the contraction of geographical ranges. *Journal of Biogeography* 27(1): 169–179. doi:10.1046/j.1365-2699.2000.00382.x
- Cottee-Jones HEW, Mittermeier JC, Redding DW. 2013. The Moluccan woodcock *Scolopax rochussenii* on Obi Island, North Moluccas, Indonesia: a “lost” species is less endangered than expected. *Forktail* 29: 88–93.
- de Lirio EJ, Freitas J, Negrão R, Martinelli G, Peixoto AL. 2018. A hundred years’ tale: rediscovery of *Mollinedia stenophylla* (Monimiaceae) in the Atlantic rainforest, Brazil. *Oryx* 52(3): 437–441. doi:10.1017/S0030605316001654
- Dirzo R, Young HS, Galetti M, Ceballos G, Isaac NJB, Collen B. 2014. Defaunation in the Anthropocene. *Science* 345(6195): 401–406. doi:10.1126/science.1251817
- Ducos P. 1978. La faune de Beisamoun, dans les collections du Musée de Préhistoire de la Vallée du Houleh. Pages 257–268 in Lechevallier M, ed. *Abou Gosh et Beisamoun*. Mémoires et Travaux du Centre de Recherche Préhistorique Français de Jérusalem, No. 2, Paris.
- Eid E, Abu Azam S. 2025. Mammals lost and at risk of extinction in Jordan: historical analysis of constitutions and hunting laws. *Environmental Conservation* 52(1): 41–49. doi:10.1017/S0376892924000328
- Eid E, Ananbeh Y. 2009. Assessment of the release program of the European roe deer *Capreolus capreolus* (Cetartiodactyla: Cervidae) at Ajloun Nature Reserve, Jordan. *Journal of Threatened Taxa* 1(6): 323–326. doi:10.11609/joTT.o2103.323-6
- Eid E, Handal R. 2018. Illegal hunting in Jordan: using social media to assess impacts on wildlife. *Oryx* 52(4): 730–735. doi:10.1017/S0030605316001629
- Eid E, Mallon D. 2021. Wild ungulates in Jordan: past, present, and forthcoming opportunities. *Journal of Threatened Taxa* 13(9): 19338–19351. doi:10.11609/jott.6811.13.9.19338-19351
- Eid E, Abu Baker M, Amr Z. 2020. *National Red Data Book of Mammals in Jordan*. IUCN Regional Office for West Asia, Amman, Jordan. doi:10.2305/IUCN.CH.2020.12.en
- Faure M. 1986. Les Hippopotamidés du Plio-Pléistocène du Levant (Syrie, Liban, Israël). Pages 567–578 in Cauvin J, Sanlaville P, eds. *Préhistoire du Levant*. Centre National de la Recherche Scientifique, Paris.
- Gilpin ME, Soulé ME. 1986. Minimum viable populations: processes of species extinction. Pages 19–34 in Soulé ME, ed. *Conservation Biology: The Science of Scarcity and Diversity*. Sinauer Associates, Sunderland, Massachusetts.
- Henton E, Martin L, Garrard A, Jourdan AL, Thirlwall M, Boles O. 2017. Gazelle seasonal mobility in the Jordanian steppe: the use of dental isotopes and microwear as environmental markers, applied to Epipalaeolithic Kharaneh IV. *Journal of Archaeological Science: Reports* 11: 147–158. doi:10.1016/j.jasrep.2016.11.031
- International Union for Conservation of Nature. 2024. The IUCN Red List of Threatened Species. Version 2024-1. Available at: www.iucnredlist.org (accessed 10 April 2026).
- Long B, Rodríguez JP. 2022. Lost but not forgotten: a new nomenclature to support a call to rediscover and conserve lost species. *Oryx* 56(4): 481–482. doi:10.1017/S0030605322000618
- Loy A, Kranz A, Oleynikov A, Roos A, Savage M, Duplaix N. 2022. *Lutra lutra* (amended version of 2021 assessment). IUCN Red List of Threatened Species 2022. doi:10.2305/IUCN.UK.2022-2.RLTS.T12419A218069689.en
- Mountfort G. 1964. Disappearing wildlife and growing deserts in Jordan. *Oryx* 7(5): 229–232. doi:10.1017/S0030605300003161
- Paglia I, Luber J, de Freitas Mansano V, Freitas L. 2022. A narrowly endemic species of Begoniaceae: rediscovery, distribution and conservation of *Begonia jocolinoi*. *Oryx* 56(6): 935–938. doi:10.1017/S0030605321000740
- Pokines JT, Lister AM, Ames CJH, Nowell A, Cordova CE. 2019. Faunal remains from recent excavations at Shishan Marsh 1 (SM1), a Late Lower Palaeolithic open-air site in the Azraq Basin, Jordan.

- Quaternary Research* 91(2): 768–791. doi:10.1017/qua.2018.113
- Price MD, Makarewicz CA, Chesson MS. 2018. Domestic animal production and consumption at Tall al-Hāndaquq South (Jordan) in the Early Bronze III. *Paléorient* 44(1): 75–92. <https://www.jstor.org/stable/26595357>
- Reuther C, Rifai L, Qarcas M, Abu Baker M, Amr ZS. 2001. Results of an initial field survey for otters (*Lutra lutra*) in Jordan. *IUCN Otter Specialist Group Bulletin* 17(2): 75–79. https://www.iucnsgbull.org/Volume17/Reuther_et_al_2000b.pdf
- Silcock JL, Field AR, Walsh NG, Fensham RJ. 2020. To name those lost: assessing extinction likelihood in the Australian vascular flora. *Oryx* 54(2): 167–177. doi:10.1017/S0030605318001357
- Tchernov E. 1988. The biogeographical history of the southern Levant. Pages 159–250 in Yom-Tov Y, Tchernov E, eds. *The Zoogeography of Israel*. Dr. W. Junk Publishers, Dordrecht.
- Tsahar E, Izhaki I, Lev-Yadun S, Bar-Oz G. 2009. Distribution and extinction of ungulates during the Holocene of the Southern Levant. *PLoS ONE* 4(4): e5316. doi:10.1371/journal.pone.0005316
- Twomey E, Brown JL. 2008. Spotted poison frogs: rediscovery of a lost species and a new genus (Anura: Dendrobatidae) from northwestern Peru. *Herpetologica* 64(1): 121–137. <http://www.jstor.org/stable/25209104>
- Villarroel D, Quintino de Faria JE, Barnes Proença CE. 2014. One new and one long-lost species of *Eugenia* (Myrtaceae) from the Bolivian Cerrado. *Novon* 23(2): 244–249. doi:10.3417/2013040
- von den Driesch A, Boessneck J. 1995. Final report on the zooarchaeological investigation of animal bone finds from Tell Hesban, Jordan. Pages 65–108 in LaBianca OS, von den Driesch A, eds. *Faunal Remains: Taphonomical and Zooarchaeological Studies of the Animal Remains from Tell Hesban and Vicinity*. Hesban 13, Andrews University Press, Berrien Springs, Michigan.
- Watson DM, Davis RA. 2017. Hopeful monsters—In defense of quests to rediscover long-lost species. *Conservation Letters* 10(3): 382–383. doi:10.1111/conl.12386