frontiers | Frontiers in Ecology and Evolution

TYPE Brief Research Report
PUBLISHED 21 November 2024
DOI 10.3389/fevo.2024.1487911

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OPEN ACCESS

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RECEIVED 29 August 2024
ACCEPTED 30 October 2024
PUBLISHED 21 November 2024

CITATION
Harrity EJ, Traphagen M, Bethel M, Facka AN, Dax M and Burns E (2024) USA-Mexico border wall impedes wildlife movement. *Front. Ecol. Evol.* 12:1487911.
doi: 10.3389/fevo.2024.1487911

USA-Mexico border wall impedes wildlife movement

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Geopolitical boundaries can present challenges to wildlife conservation because of varying environmental regulations, and increasingly, the existence of border barriers. As of 2024, approximately 1,023 km of border walls (i.e., steel bollard walls 5.5-9.1 m tall with interstitial spaces ≤10 cm) and 169 km of vehicle barriers (i.e., variable steel structures designed to stop vehicles but not pedestrians) exist along the USA-Mexico border. Some small wildlife passages (21.5 x 27.8 cm) were installed in border walls but few other accommodations for wildlife connectivity exist. As such, ecological consequences of border barriers may be severe and documenting the ability of wildlife to traverse these barriers will be essential to conservation efforts. We placed 36 wildlife cameras across 163.5 km of the USA-Mexico border in Arizona, USA and Sonora, MX to evaluate crossing rates through border barriers for 20 terrestrial species. We observed 9,240 wildlife events, including 1,920 successful crossing events. All focal species crossed through vehicle barriers, whereas white-tailed deer, mule deer, American black bear, American badger, wild turkey, and mountain lion appeared unable to cross through interstitial spaces in border walls. Small wildlife passages improved crossing rates for several species, including American badger, collared peccary, coyote, and mountain lion. Yet, small wildlife passages were scarce with only 13 along >130 km of continuous border wall and failed to allow American black bear, deer, and wild turkey to cross. Additional research on the impacts of border barriers and potential mitigation strategies will be critical for effective transboundary conservation.

KEYWORDS

border wall, border barrier, connectivity, wildlife crossing, movement, transboundary conservation

Introduction

The ability to move is crucial for the survival of nearly all wildlife species. Yet, human development has fragmented natural habitats and created barriers to wildlife movement across much of the Earth's surface (Barnosky et al., 2012; Cozzi et al., 2013; Davis et al., 2024). The loss of habitat connectivity and landscape permeability can reduce survival of individuals (Coppola et al., 2021), decrease the viability of populations (Fahrig and

Merriam, 1994; Olson et al., 2009), suppress gene flow (Aspi et al., 2009; Sawaya et al., 2019), and increase extinction risk (Benson et al., 2016; Clobert, 2012; Gilpin, 1986). Hence, maintaining and increasing habitat connectivity and understanding barriers to movement are vital to conservation efforts (Abrahms et al., 2017; Ford et al., 2020; Heller and Zavaleta, 2009).

Conservation efforts across geopolitical boundaries can be hindered by varying environmental regulations and customs (Rick et al., 2004; Thornton and Branch, 2019). Geopolitical boundaries may also act as physical barriers to conservation and wildlife movement because of the growing presence of infrastructure designed to control the movements of humans and goods. Indeed, construction of border barriers has accelerated globally in recent decades with barriers now present in 74 countries (Vallet, 2022). The ecological impacts of such border barriers can be severe as barriers are often long, continuous, and built with minimal accommodations for wildlife due to security concerns (Aspi et al., 2009; Linnell et al., 2016).

The USA-Mexico border exemplifies the recent proliferation of border barriers (Lasky et al., 2011; McCallum et al., 2014). After the passage of the Secure Fence Act in 2006, 1,053 km of border barriers were built, including 570 km of pedestrian border walls and 483 km of vehicle barriers (Isacson, 2023; US Government Accountability Office, 2017, 2023). Pedestrian border walls (hereafter referred to as, "border walls") vary but are typically steel bollard walls, constructed with square carbon steel tubing 15 cm wide and 5.5-9.1 m tall. Interstitial spaces between bollards measure ≤10 cm to stop all human crossings. Vehicle barriers are a variable system of steel posts arranged to stop vehicles but not pedestrians (US Government Accountability Office, 2021). Between 2017 and 2020, the USA replaced most vehicle barriers with border walls and built new walls in previously open areas (all border walls built between 2017 and 2020 were 9.1 m tall). As a result, 1,023 km of border walls and 169 km of vehicle barriers exist along the USA-Mexico border in 2024 (US Government Accountability Office, 2023).

Generally, wildlife movements have not been considered a priority when border barriers have been constructed along the USA-Mexico border. On some federal conservation lands (e.g., National Wildlife Refuges, etc.), small wildlife passages measuring roughly 21.5 x 27.8 cm were added to border walls to facilitate movements of endangered species like ocelots (*Leopardus pardalis*) in south Texas, USA (US Fish and Wildlife Service, 2016). Additionally, floodgates were installed where the border wall crosses arroyos and riverbeds. These gates are opened to accommodate seasonal floods but remain closed most of the year. A settlement in July of 2023 with the Department of Homeland Security will allow select floodgates to remain open longer (Sierra Club v. Biden, 2023), however, most gates remain closed except during high water events. As such, crossing opportunities are limited for wildlife along most of the border wall to the interstitial spaces between bollards, scarce small wildlife passages, and, rarely, open floodgates.

The USA-Mexico border crosses some of the most biologically diverse regions in North America. For example, the Madrean Sky Islands span the USA-Mexico border in southeastern Arizona, USA, and northeastern Sonora, MX. These mountains are recognized as a global biodiversity hotspot and are home to the highest density of bee species in North America (Minckley and Radke, 2021), the highest diversity of mammals, reptiles, and ants in the USA (Warshall, 1994), and one of the highest rates of plant endemism in the USA (McLaughlin, 1994). In its totality, the USA-Mexico border intersects the geographic ranges of 1,077 native animals and bisects important habitat for numerous federally listed species (Peters et al., 2018). Border barriers, especially border walls, may severely limit movements of many of these native animals, including American black bear (*Ursus americanus*), mountain lion (*Puma concolor*), desert bighorn sheep (*Ovis canadensis nelsoni)*, mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and federally listed species such as jaguar (*Panthera onca)*, Sonoran pronghorn (*Antilocapra americana sonoriensis*), and Mexican gray wolf (*Canis lupus baileyi*). Border barriers may hinder recovery efforts for these listed species and threaten other species not currently listed by restricting movement, isolating populations, severing corridors, and limiting gene flow (Chambers et al., 2022; Lasky et al., 2011; Peters et al., 2018).

Presently, land managers and conservation practitioners have insufficient information to manage or mitigate the effects of the USA-Mexico border wall on wildlife populations. Further, the efficacy of small wildlife passages to facilitate movement of wildlife is untested in this region. To address such knowledge gaps, we deployed motion-activated cameras near border barriers along 163.5 km of the USA-Mexico border to: 1) evaluate crossing rates for 20 terrestrial species through border walls and vehicle barriers, and 2) quantify use of the small wildlife passages.

Materials and methods

Field methods

We maintained non-baited, motion-activated cameras (Browning Trail Cameras) at 36 locations spanning 163.5 km of the USA-Mexico border between the Patagonia Mountains in Santa Cruz County, Arizona and the San Bernardino National Wildlife Refuge in Cochise County, Arizona (Figure 1). Three camera locations were in Sonora, MX and 33 locations were in Arizona, USA. We selected camera sites opportunistically across multiple types of border barriers where we were permitted access, could locate a secure mounting structure for the camera with a clear view of the barrier, and could minimize risk of camera theft or disturbance. We maintained 18 cameras facing vehicle barriers, 7 cameras at border walls, and 11 cameras at small wildlife passages (Figures 1, 2). Elevations ranged from 1,140–1,638 m and dominant biotic communities included Madrean evergreen woodlands, plains and great basin grasslands, semidesert grasslands, and Chihuahuan desert-scrub (Brown and Lowe, 1980).

We mounted cameras 1.5–20.0 m from the border barriers and 0.2–1.5 m high based on local conditions (e.g., terrain, vegetation, etc.) to ensure each camera had a clear view of the base of the barrier. We programmed cameras to operate 24 hr/day and capture 20-sec videos with a 1-sec to 30-sec trigger delay to minimize false

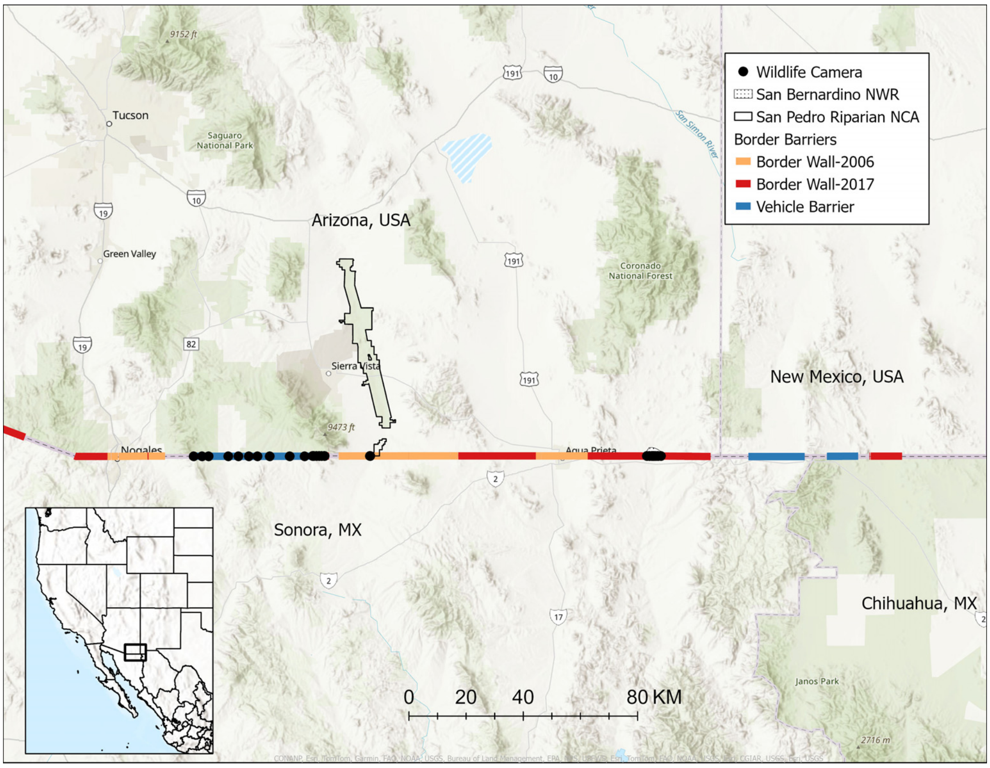

FIGURE 1
We maintained wildlife cameras at 36 locations along 163.5 km of the USA-Mexico border barrier in southern Arizona, USA and northern Sonora, MX between August 2022 and July 2024. Border walls built between 2006-2010 (Border Wall-2006) measure 5.5 m tall and border walls built after 2017 (Border Wall-2017) are 9.1 m tall, both with interstitial spaces between bollards measuring ≤ 10 cm. NCA is National Conservation Area and NWR is National Wildlife Refuge. At the scale of this map, some camera points represent multiple camera locations.

detections. We used video rather than photographs to better document wildlife behaviors near border barriers. We selected longer trigger delays to preserve battery life and storage on memory cards where vegetation caused excessive false triggers (e.g., in areas with dense shrub cover in the camera viewshed, etc.). We considered terrestrial mammals >1 kg as well as wild turkey (*Meleagris gallopavo mexicana)* in our analyses of wildlife crossing rates as we hypothesized such species could be hindered by the interstitial spaces of the border walls (Table 1).

We maintained cameras for 1-23 months between August 2022 and July 2024 and collected memory cards every 4-8 weeks (Supplementary Table S1). Effort varied because of different permitting requirements across land ownership and camera theft. We processed all videos through a multi-step process. First, we sorted all videos into general categories of false triggers (i.e., empty), vehicles, pedestrians, livestock, and wildlife. For terrestrial wildlife >1 kg, we grouped sequential videos of the same species into events, where events began with the first video of an animal and included all subsequent videos within 15 minutes of the initial observation or all videos until a different species occurred (Jones et al., 2020). We then quantified the number of individuals, assigned direction of movement, and categorized behavior relative to the border barrier for each event into three general categories:

- No interaction – animals occur >4 m from, and make no movement towards, the border barrier.
- Successful cross – animals move more than 50% of their body through or under border barrier. We created a threshold of 50% of the body because videos occasionally ended before animals moved 100% of their body through a barrier.
- Interaction without a cross – animals occur within 4 m of the border barrier but do not cross the barrier. We further classified these interactions into the following categories:
  - Move parallel – animals move parallel to the barrier.
  - Deflect – animals approach and turn roughly 90 degrees (parallel) to move along the barrier.
  - Repel – animals approach and turn between 90-180 degrees to move away from the barrier.
  - Move perpendicular – animals move towards or away from the border barrier with at least part of the movement within 4 m of the border barrier.
  - Investigate – animals actively smell or visually search the border barrier.

We assigned only one behavior to each wildlife event and prioritized crossing behaviors. For example, if an animal spent 15 seconds moving parallel and crossed during the final 5 seconds of the event, we categorized this event as a successful cross. For animals we observed in groups, we assigned direction and

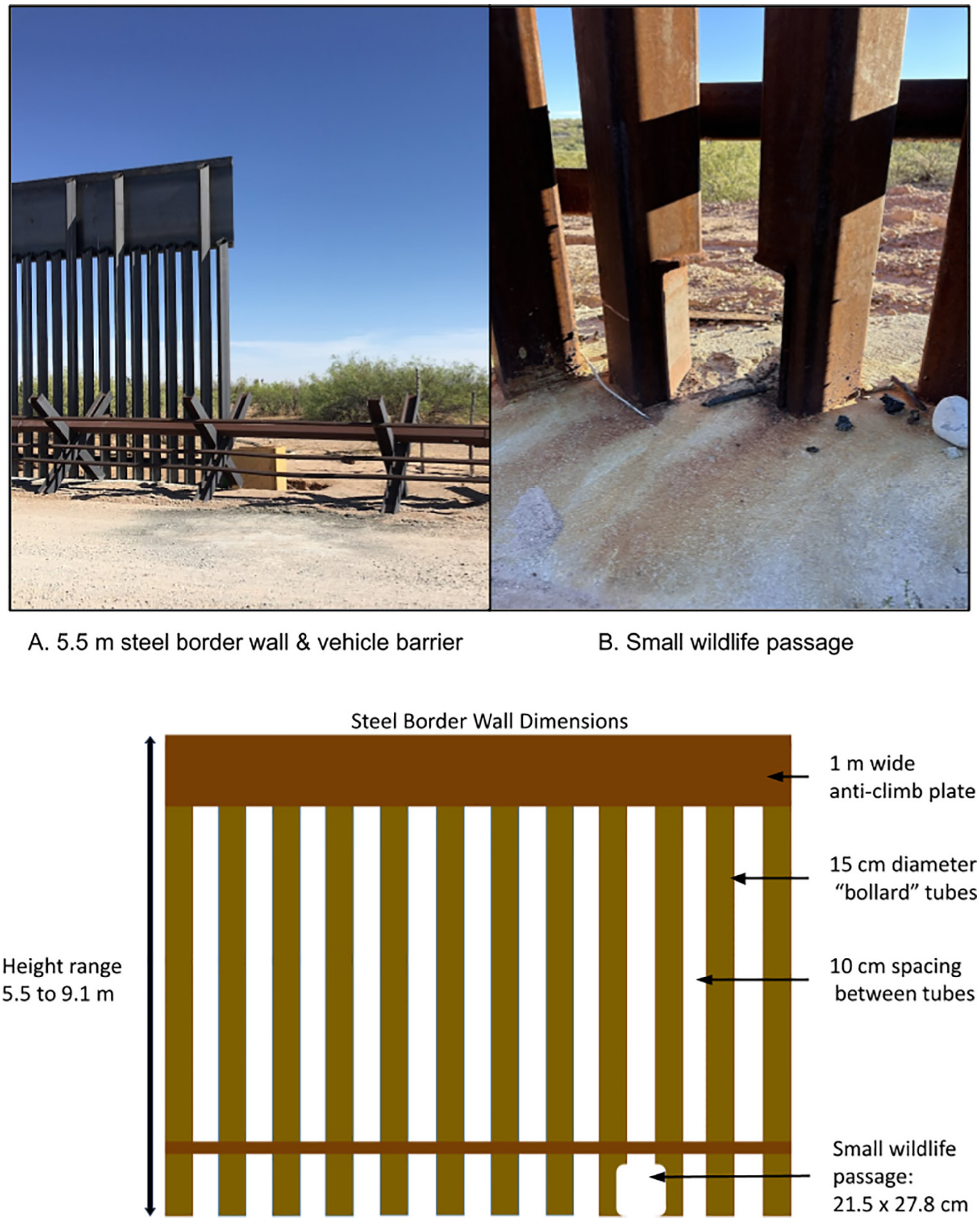

FIGURE 2
Border barriers in our study consisted of vehicle barriers (foreground in **A**), border wall between 5.5-9.1 m tall **(A)**, and small wildlife passages **(B)**.

behavior based on group majority and noted the number of the group that crossed, if any. Finally, we noted the structure through which the animal crossed if appropriate (i.e., small wildlife passage or interstitial spaces between bollards). For vehicles, pedestrians, livestock, and all non-target wildlife species, we identified species but did not assign movement directions or behaviors.

Statistical analyses

For the purposes of this study, we treated all interactions without a cross (e.g., deflect, move parallel, etc.) as a single category and excluded obvious juveniles (i.e., individuals markedly smaller than adults) from our analyses. We calculated crossing rates as the number of crossing events divided by the total number of barrier interactions (i.e., interactions without a cross and successful crosses). We calculated crossing rates separately for each species, camera, and deployment, where a deployment was defined as the dates between successive camera checks. We then averaged crossing rates across all cameras and deployments for each species and barrier type. We calculated wildlife activity rates for each camera as the number of events divided by the number of days a camera was active. We evaluated differences among barrier types in activity rates and average number of crosses per camera trap-day with Kruskal-Wallis (KW) tests because data were not normally distributed. We established a null hypothesis of no difference between groups (e.g., border wall *vs.* vehicle barrier) and rejected this null when alpha values ≤0.05. We used R v4.1.2 (R Core Team, 2021)

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TABLE 1 Number of events for 19 terrestrial mammals and the wild turkey (*Meleagris gallopavo mexicana)* at three types of border barriers across 163.5 km of the USA-Mexico border in Arizona between August 2022 and July 2024.

			Border Wall			Border Wall with Wildlife Passage				Vehicle Barrier		
Common name	Scientific Name	Mass (kg)[a]	No Interaction	Interaction without Cross	Successful Cross	No Interaction	Interaction without Cross	Cross-Wildlife Passage	Cross-Border Wall	No Interaction	Interaction without Cross	Successful Cross
American black bear	*Ursus americanus*	244	11	4	0	2	12	0	0	0	2	8
White-tailed deer	*Odocoileus virginianus*	97	134	67	0	175	75	0	0	451	91	177
Mule deer	*Odocoileus hemionus*	96.5	38	24	0	99	26	0	0	34	13	51
Mountain lion	*Puma concolor*	74.5	2	3	0	12	24	18	0	3	1	3
Javelina	*Pecari tajacu*	28.5	309	49	1	235	142	552	2	57	10	45
Coyote	*Canis latrans*	14	376	65	7	322	120	195	4	387	174	109
Bobcat	*Lynx rufus*	9.5	266	100	15	174	92	48	19	61	17	79
North american porcupine	*Erethizon dorsatum*	9.5	0	0	0	0	0	0	0	5	3	15
American badger	*Taxidea taxus*	8	3	0	0	0	10	1	0	3	5	3
Wild turkey[b]	*Meleagris gallopavo mexicana*	7.3	2	3	0	5	46	0	0	11	4	28
Raccoon	*Procyon lotor*	6.2	134	70	7	282	345	39	26	72	32	49
Gray fox	*Urocyon cinereoargenteus*	5.5	95	39	6	57	105	11	25	164	19	134
White-nosed coati	*Nasua narica*	4.5	1	0	0	2	1	0	0	14	3	6
Virginia opossum	*Didelphis virginiana californica*	4	0	0	0	0	0	0	0	2	1	2
Antelope jackrabbit	*Lepus alleni*	3.7	1	0	0	10	0	0	0	153	17	11
Striped skunk	*Mephitis mephitis*	3.5	68	8	1	51	33	5	15	77	1	16

(Continued)

TABLE 1 Continued

Common name	Scientific Name	Mass (kg)[a]	Border Wall: No Interaction	Border Wall: Interaction without Cross	Border Wall: Successful Cross	Border Wall with Wildlife Passage: No Interaction	Border Wall with Wildlife Passage: Interaction without Cross	Border Wall with Wildlife Passage: Cross-Wildlife Passage	Border Wall with Wildlife Passage: Cross-Border Wall	Vehicle Barrier: No Interaction	Vehicle Barrier: Interaction without Cross	Vehicle Barrier: Successful Cross
Hog-nosed skunk	*Conepatus leuconotus*	2.75	41	2	4	13	13	6	12	21	4	7
Black-tailed jackrabbit	*Lepus californicus*	2.2	122	7	0	6	1	0	6	58	26	5
Hooded skunk	*Mephitis macroura*	1.2	145	18	4	145	65	14	35	106	16	49
Ringtail	*Bassariscus astutus*	1.1	0	0	0	0	8	0	1	13	2	13

No interaction includes all events in which animals occurred >4 m from barriers. Interaction without a cross includes all events in which animals interacted with barriers but did not cross. Successful cross includes all events in which animals moved >50% of their bodies through barriers. At small wildlife passages, we indicate whether animals crossed through the passage or through the interstitial spaces in the border wall near the passage. The table does not include 303 events where we could not determine the species of deer, jackrabbit, or skunk. Mass is the average for adult animals.

[a]Source: animaldiversity.org

[b]We included wild turkey in our analyses because they are primarily terrestrial and frequently attempted to cross through rather than fly over border infrastructure.

for all analyses and plotted all results with the ggplot2 package (Wickham, 2016). We present mean values and use SE to indicate standard error.

Results

We collected 12,780 videos of the 20 focal species, resulting in 9,240 events. Most events (5,225 of 9,240; 56.6%) involved no interaction with border barriers, whereas 22.7% (2,095 of 9,240) of events featured an animal interacting but not crossing, and 20.8% (1,920 of 9,240) of events featured a successful crossing. We documented one fatality of an adult collared peccary that became stuck between bollards in the border wall and subsequently died from exposure. Coyote was the most common species with 1,759 events, followed by collared peccary (n = 1,402), and white-tailed deer (n = 1,170; Table 1). We documented all 20 focal species at vehicle barriers, 90% (18 of 20) at small wildlife passages, and 85% (17 of 20) at border walls. When considering all focal species together, average daily activity (as number of barrier interactions per camera trap-day) varied significantly by barrier type ($KW_2 = 20.7$, p = <0.001) as did the average number of crosses per camera trap-day ($KW_2 = 50.2$, p = <0.001). Specifically, average daily activity was 3.2 times higher near small wildlife passages ($\mu = 0.60$, SE = 0.08) than at border walls ($\mu = 0.19$, SE = 0.03) and the average number of crosses per camera trap-day was 16.7 times greater at small wildlife passages ($\mu = 0.25$, SE = 0.05) than at border walls ($\mu = 0.015$, SE = 0.004; Supplementary Table S1).

Of the focal species we documented at each barrier, 55.6% (10 of 18) crossed through small wildlife passages, 58.8% (10 of 17) crossed through the interstitial spaces in the border wall, and 100% (20 of 20) crossed through the vehicle barrier (Table 1). Within species, crossing rates were consistently highest at vehicle barriers and lowest at border walls (Figure 3). This was evident even for smaller species (e.g., skunk species, bobcat, etc.) that could easily cross through interstitial spaces in the border wall. For example, bobcats showed no physical limitations when crossing through interstitial spaces of border walls but were still 5.1 times more likely to cross through vehicle barriers than border walls (0.82, SE = 0.06 vs 0.16, SE = 0.05). Although many relatively small species were able to cross through all border barriers, we did not observe larger species crossing through border walls. Indeed, white-tailed deer, mule deer, American black bear, American badger, wild turkey, and mountain lion never successfully crossed (crossing rate = 0.0) through interstitial spaces in the border wall but crossed during >50% of events at vehicle barriers (crossing rates of 0.5-0.79).

Small wildlife passages benefited larger-bodied species than we expected. Indeed, the crossing rate of collared peccary (average mass = 28.5 kg) was 24 times greater through small wildlife passages than through interstitial spaces in the border wall (0.38, SE = 0.06 *vs* 0.016, SE = 0.016; Figure 3). Furthermore, mountain lions (average mass = 74.5 kg) never crossed through interstitial spaces in border walls but had a crossing rate of 0.42, SE = 0.12 at small wildlife passages (Figure 3). However, small wildlife passages did not offer any crossing opportunities for white-tailed deer, mule deer, American black bear, or wild turkey, despite many interactions

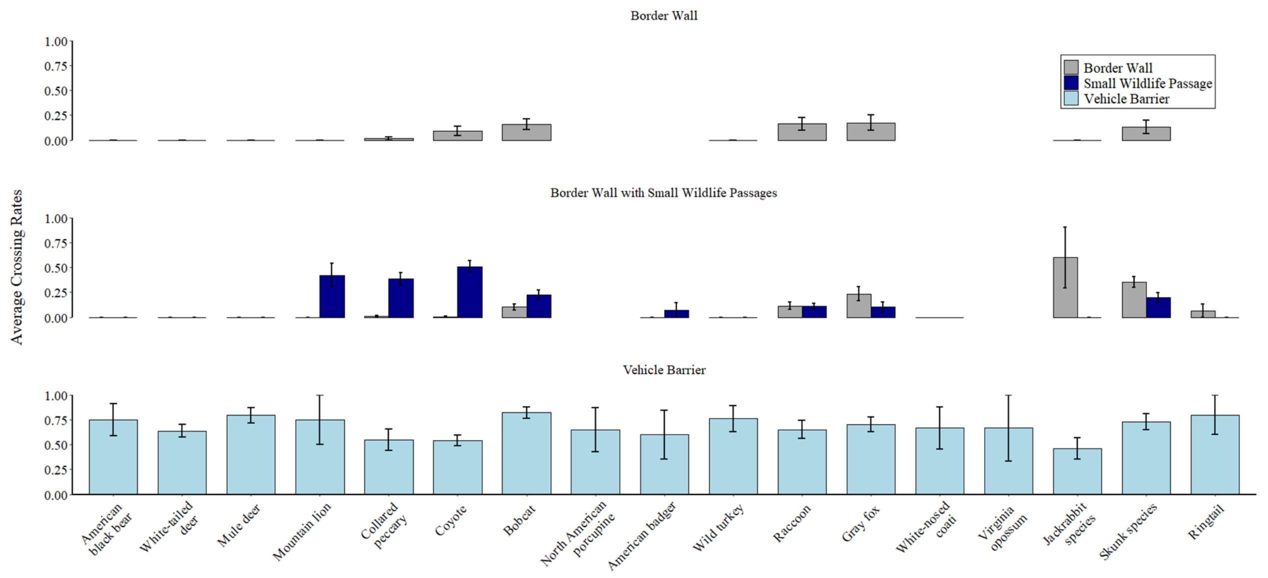

FIGURE 3
Average crossing rates for focal species in our study along 163.5 km of the USA-Mexico border between August 2022-July 2024. We calculated crossing rate as the number of crosses divided by the number of barrier interactions for each species. We averaged crossing rates across all cameras within each barrier type. Species are sorted in descending order by average mass from left to right. We grouped antelope and black-tailed jackrabbits as "Jackrabbit species" and hooded skunk, striped skunk, and hog-nosed skunk as "Skunk species" for sample size considerations. Gaps indicate the species was not observed at the barrier type (e.g., ringtail was not observed on cameras facing border walls without small wildlife passages). For cameras facing small wildlife passages, we categorized crosses as either through the passages or through the interstitial spaces between the bollards adjacent to the passage (indicated as Border Wall crossing rates in the second row). Error bars represent 95% confidence intervals. A library of example videos from this study can be found at https://skyislandalliance.imagerelay.com/fl/4c85eaa9e1c34762be6f476391ec9c30.

from these species near the passages. Smaller species such as gray fox, northern raccoon, and skunks had similar crossing rates through interstitial spaces in the border wall and small wildlife passages. Finally, we did not observe a single crossing event by a human through any border barrier.

Discussion

We present a novel assessment of crossing rates for 20 terrestrial wildlife species through barriers across 163.5 km of the USA-Mexico border. We demonstrate that several large terrestrial species are unable to cross through border walls that now bisect some of the most biodiverse regions of North America and bound approximately 1,023 km of the USA-Mexico border. Moreover, we evaluate for the first time the efficacy of the small wildlife passages and show that they are used frequently by several species. Nevertheless, these small openings are inadequate for large carnivores and ungulates that may have the greatest need to move to find mates, secure resources, or avoid competition. Additional research efforts such as this study are needed to elucidate the ecological consequences of border barriers and potential mitigation strategies.

We observed 10 focal species crossing through the small wildlife passages including two species apparently unable or unwilling to cross through interstitial spaces in the border wall (i.e., mountain lion and American badger) and two species unlikely to cross through interstitial spaces (i.e., collared peccary and coyote). However, only 13 small wildlife passages exist in our study area, with 8 distributed across 6.3 km near the San Bernardino National Wildlife Refuge and 5 distributed across 0.5 km at the San Pedro Riparian National Conservation Area. These clusters of openings are separated by 95 km of continuous border wall, thereby limiting their utility to individuals that do not reside near one of these conservation areas. Moreover, current small wildlife passages measure only 21.5 x 27.8 cm (roughly the size of a piece of A4 printer paper) and provided no crossing opportunities for American black bear, white-tailed deer, mule deer or wild turkey in our study. It is unlikely existing passages would provide crossing opportunities for similarly sized mammals of conservation concern in the area including pronghorn, desert bighorn sheep, jaguar, and Mexican gray wolves. The latter two species are larger than mountain lions and coyotes we observed crossing through the small wildlife passages (De La Torre and Rivero, 2017), and probably would not fit through existing passages. Gaps between constructed sections of border walls remain in some regions of the border (Traphagen, 2021), but the border wall section we monitored is uninterrupted for 130.2 km (Figure 1). Beyond the 13 small wildlife passages, no permanent openings exist for wildlife along this entire stretch of wall. More small wildlife passages should be installed (e.g., every 5-10 m) and different sized passages should be considered to more meaningfully mitigate the impacts of the border wall on wildlife connectivity.

The impacts of the border wall may manifest at multiple levels. At the demographic level, border walls may affect survival and reproductive rates by impeding access to resources and mating opportunities (Cozzi et al., 2013; Hering et al., 2022; Safner et al., 2021). At the population level, border walls may limit dispersal, thereby increasing isolation and decreasing viability of subpopulations (Flesch et al., 2010). For example, American black bears disperse regularly between mountain ranges in the USA and Mexico, and genetic analyses show populations in southeastern Arizona are closely connected with those of northern Sonora, Mexico (Atwood et al., 2011; Gould et al., 2022; Lara-Díaz et al., 2013; Varas et al., 2010). However, our data indicate that the border wall is mostly impermeable for American black bears and will thus hinder their dispersal between the USA and Mexico, where they are listed as federally endangered (SEMARNAT, 2010). Border walls could thus threaten the population viability of American black bears in Mexico. Border walls may also influence community composition and structure by excluding some species but not others from adjacent habitats. For example, many mesocarnivores (e.g., bobcat, gray fox, etc.) had relatively high crossing rates through the border walls, whereas large carnivores were effectively excluded. Finally, climate change is driving the distribution of many species to higher latitudes and elevations (Chen et al., 2011; Thornton and Branch, 2019). The presence of largely impermeable barriers along 1,023 km of the USA-Mexico border may hinder the ability of many species to reach climate refuges, thereby increasing their vulnerability to such changes (Chambers et al., 2022; Davis et al., 2024; Egan et al., 2018).

Other factors associated with the border barriers may influence crossing rates and warrant further research. For example, we considered only the barriers themselves when evaluating crossing rates and use of the small wildlife passages. Border barriers are often accompanied by parallel roads (10-18 m wide in our study area) and a network of access roads with varying levels of law enforcement and maintenance traffic (Sayre and Knight, 2010; US Government Accountability Office, 2021). Moreover, some areas of the USA-Mexico border have high-intensity security lighting that illuminates the barriers (US Government Accountability Office, 2021). We did not include lighting in our analyses because lighting infrastructure has been installed but not activated in our study area. Furthermore, landscape characteristics (e.g., terrain) and vegetation conditions (e.g., vegetation cover adjacent to border barriers) probably affect wildlife occurrence and crossing rates. Future work should evaluate the influence of human activity, additional security infrastructure such as lighting (including for taxonomic groups like birds, bats, and insects that may not be as directly affected by border barriers), and environmental covariates on wildlife crossing rates through border barriers. Additionally, we considered all non-crossing interactions as a single category in our analyses. However, further insights into the impacts of the border barriers could be gained by evaluating non-crossing interactions in greater detail. Finally, we evaluated crossing rates of 20 wildlife species, but many other species may be impacted by border barriers that we could not evaluate because they did not occur in our study area (e.g., peninsular bighorn sheep, Mexican gray wolf, etc.) or because we did not detect them on our cameras, such as desert tortoise (*Gopherus agassizii*), pronghorn, ocelot, jaguar, and ferruginous pygmy owl (*Glaucidium brasilianum*; Flesch et al., 2010). The impacts of border barriers on these species should not be overlooked.

Approximately 1,023 km of the USA-Mexico border (including 63% of the southern border of Arizona) is now bounded by border walls 5.5-9.1 m tall with interstitial spaces between bollards measuring ≤10 cm. Our study is among the first to explicitly evaluate the permeability of these barriers for terrestrial species along the USA-Mexico border. Our results indicate border walls are largely impermeable to many terrestrial mammals, including several federally listed species in the USA and MX. We further demonstrate that existing wildlife passages have the potential to improve crossing rates for some species, but more passages (including larger openings) are needed. Our work may help conservation practitioners and land managers to understand the impacts of current border barriers on wildlife movement and improve design and distribution of wildlife passages. As construction of border barriers accelerates globally, research into the full extent of ecological consequences of these barriers and effective mitigation strategies will be paramount for transboundary conservation efforts throughout the world.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

EJH: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. MT: Conceptualization, Investigation, Methodology, Writing – review & editing. MB: Data curation, Investigation, Writing – review & editing. ANF: Investigation, Formal Analysis, Methodology, Writing – review & editing. MD: Writing – review & editing, Funding acquisition, Resources. EB: Funding acquisition, Resources, Writing – review & editing, Investigation, Methodology, Project administration, Conceptualization.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was completed in compliance with the following permits: US Forest Service Special Use Permit #SUP2349, US Fish & Wildlife Service Permit #SBSUP24-04, Bureau of Land Management Research Permit #20221221, Arizona State Parks and Trails Commercial Rental Permit for Research and Monitoring #2020-00, and the National Park Service Special Use Permit #CORO-0051. Funding was provided by the

Wilburforce Foundation (Grants #SKY12211A and #SKY12311A), Carroll Petrie Foundation (Grants #2022-106 and #2023-132), New York Community Trust (Grant #P21-000540), Clif Family Foundation (Grant #72606543), Brabson Family Foundation, the Wilderness Society, Arizona Community Foundation of Cochise (Grant #31014915), Dr. Scholl Foundation, National Park Service Southwest Border Resource Project Program (Grant #P22AC00512-00), and many individual supporters.

Acknowledgments

Miguel Enriquez Galaz, Oskar Anderson, McKinsey Tighe, Chloe Atkins, Jakelynn Wert, and McKenna Carter assisted with data processing. Bryon Lichtenhan, Brit Rosso, Elizabeth Taylor, John Nametz, and many volunteers assisted with camera maintenance. We received logistical support from San Bernardino National Wildlife Refuge and Cuenca Los Ojos, A.C. Associate editor (M. Di Febbraro) and two reviewers provided valuable feedback to improve a previous version of this manuscript. Charlie Turner provided technical assistance with data management and Dan Morris assisted with adapting MegaDetector for video sorting.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2024.1487911/full#supplementary-material

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