Journal of Biogeography

WILEY

Journal of Biogeography

PERSPECTIVE OPEN ACCESS

Understanding Ancient Moose Populations in the Southern Rocky Mountains

William T. T. Taylor[1] | John A. F. Wendt[2] | Jonathan Dombrosky[3,4] | Crystal C'Bearing[5] | Mikayla Costales[1] | Isaac A. Hart[6] | Journey LeBeau[1,5] | Adrian Johnson[1] | Elena Lompe[1] | Russell W. Graham[1] | Chance Ward[7] | Emily Lena Jones[8] | Joshua H. Miller[9]

[1]Museum of Natural History, University of Colorado-Boulder, Boulder, Colorado, USA | [2]Department of Animal and Range Sciences, New Mexico State University, Las Cruces, New Mexico, USA | [3]Crow Canyon Archaeological Center, Cortez, Colorado, USA | [4]Department of Biological Sciences, University of Alabama, Tuscaloosa, Alabama, USA | [5]Tribal Historic Preservation Office, Northern Arapaho Tribe, Riverton, Wyoming, USA | [6]Department of Anthropology, University of Utah, Salt Lake City, Utah, USA | [7]History Colorado, Denver, Colorado, USA | [8]Department of Anthropology, University of New Mexico, Albuquerque, New Mexico, USA | [9]Department of Geosciences, University of Cincinnati, Cincinnati, Ohio, USA

Correspondence: William T. T. Taylor (william.taylor@colorado.edu) | Joshua H. Miller (Josh.Miller@uc.edu)

Received: 21 October 2025 | **Revised:** 21 May 2026 | **Accepted:** 2 June 2026

Keywords: applied archaeozoology | conservation | conservation paleobiology | historical ecology | moose | paleoecology | Rocky Mountains | zooarchaeology

ABSTRACT

Moose (*Alces alces*) are an iconic symbol of contemporary Rocky Mountain ecosystems, and their growing abundance in Colorado and other portions of the Southern Rockies has inspired debate around their regional prehistory prior to their 20th century translocation. The Early Holocene biogeography of moose in North America is poorly characterised, due in part to their life history and logistical obstacles to their archaeozoological and biomolecular identification. Even in areas where moose are well-established today, they are often underrepresented in archaeological assemblages. Here, we assess the premodern presence of moose in the Colorado Rockies, determining that a robust historic record for moose and poor characterisation of the archaeozoological record prior to the 19th century make it scientifically inaccurate to frame moose as 'non-native' within the context of contemporary management.

Location: Rocky Mountains, North America.

Time Period: Holocene (12,000 BP—present).

Taxon: *Alces alces*.

Methods: We conducted a review of moose sightings in historical archives (newspapers, photos, journals, and other written accounts), ethnohistoric sources (stories, songs, oral traditions), and identifications of moose in published archaeozoological assemblages from Colorado and the Southern Rockies.

Results: Findings reveal a clear record for premodern moose presence in the Southern Rockies stretching back to the earliest reliable written accounts, including regular presence of female and juvenile moose, pointing to local reproduction. Archaeological assemblages include a number of premodern moose identifications dating back to the Early Holocene, corroborated by the widespread reference to moose in ethnohistoric sources from Native nations in the Southern Rockies.

Main Conclusions: Historical and ancient data demonstrate that moose have a deep history as part of the faunal communities of the Southern Rockies, including Colorado. As rising moose populations change contemporary wildlife management choices, decision-makers should include careful assessment of cultural and paleoecological datasets and interdisciplinary partnerships to help build effective and accurate management plans for public and private lands.

1 | Introduction

The prehistory of moose (*Alces*) in North America is both poorly understood and politically contentious. During much of the 20th century, moose abundances were low in Colorado, and as early wildlife management activities began, moose were sometimes noted as absent in official census records (Rocky Mountain News 1929). But since the first official reintroduction to the state (North Park) in 1978 and subsequent releases in other areas of Colorado, moose populations have grown steadily (Bergman et al. 2025). As populations have risen, human-moose encounters have also increased (Velez 2025), with some of these interactions turning into moments of conflict, capture, and relocation (Ross 2023).

Moose (*Alces alces*) evolved in Eurasia during the Pleistocene from their parent genus *Cervalces*, also known as the stag-moose or elk-moose (Lister 1993). As a result of their shared evolutionary ancestry, *Alces* and *Cervalces* have remarkably similar postcranial skeletons (Breda 2005). During the Last Glacial Period, *Cervalces scotti* was the largest cervid south of the Laurentide and Cordilleran ice sheets, where it inhabited spruce forests and tundra-edge environments (Schubert et al. 2004). Its distribution extended from the northeast and midwestern United States through much of Canada and Alaska (Churcher and Pinsof 1987). The ice sheets began to recede around 19,000 years ago, but a viable terrestrial corridor connecting Beringia to midcontinental North America likely emerged after ca. 13,500 years ago (Heintzman et al. 2016). Our recent direct radiocarbon dating of a *Cervalces* specimen from the site of Biddle Farm, Illinois (ISM 491749) indicates that this taxon persisted in the American Midwest until at least ca. 13,795–13,606 cal. BP (2 sigma calibrated range, uncalibrated radiocarbon age 11,875 ± 25, UCIAMS 312791). In the postglacial era, *Cervalces* ultimately disappeared while *Alces alces*, the only surviving giant deer species, expanded southward.

The scientific record, however, provides quite poor resolution as to precisely when *Alces* reached lower latitudes in North America. A recent genomic study listed six specimens of ancient *Alces* from lower latitude contexts (< 55° N), three of which were apparently sampled for genomic analysis (Consolidated Concrete, Alberta; North Liberty, Indiana; and Big Bone Lick, Kentucky; see Meiri et al. 2020). Of these, two actually appear to represent *Cervalces* based on our inspection of antler morphology (Consolidated Concrete MM575) and published cranial characters (North Liberty; Gazin 1938). Another specimen (Big Bone Lick) was later inspected by Adrian Lister at the British Museum of Natural History, who confirmed it to be *Bison* (Lister *pers comm*.). Three additional published records of southerly *Alces* with Late Pleistocene or Early Holocene radiocarbon dates are also noted by Meiri et al. (2020). Of these, at least one is referable to *Cervalces*, based on published cranial characters (Lang Farm, Illinois; Schubert et al. 2004). Two other Early Holocene specimens, from SE Alaska and Alberta, could not be located for morphological reassessment at the time of this writing. Interestingly, although DNA extraction did not succeed for other specimens, mitochondrial DNA analysis of the Consolidated Concrete specimen (MM575) grouped this animal with other North American specimens identified as *Alces* (Meiri et al. 2020), despite its *Cervalces*-like antler morphology. Given ambiguity in Early Holocene biogeography of these taxa, reports of 'moose' from Early Holocene faunal assemblages in Colorado and Wyoming (Wheat 1979; Anderson 1968) cannot be confidently assigned to genus (e.g., *Alces* or *Cervalces*).

Moose specimens are rare in later Holocene archaeological sites across North America, even in places where their ancient presence would not be considered controversial. For example, a census of the Alaskan and Canadian Yukon archaeozoological record found that, among dozens of sites that have collectively yielded tens of thousands of analysed specimens, only nine produced published moose identifications, and these often represented less than a tenth of 1% of the Number of Identified Specimens (NISP) recovered from these bone accumulations (Saleeby 2002; Yesner 1989). In fact, most North American archaeological assemblages with meaningful quantities of identified moose remains date only to the most recent centuries, especially those during the Little Ice Age (ca. 14th–19th centuries; e.g., Yesner 1989; Martin 1979; Colburn 1987; Skibo et al. 2004; Kay 1997). The reasons for this scarcity of moose in older assemblages are not clear, but they likely include a combination of ecological factors (low population density and changing geographic distributions in prehistory), cultural factors (low hunting encounter rates, taboos, etc.), taphonomic factors (poor preservation of older materials), and methodological challenges (misidentification or failure to identify isolated occurrences). For these reasons, the interpretation that moose never occurred in Colorado because they are only found in a few ancient Colorado archaeological assemblages (e.g., US National Park Service 2025a) should be reassessed, especially given the uncertainties of preservation in archaeological and paleontological sites as noted above.

Careful archaeozoological comparisons that would identify or exclude moose have rarely been attempted in most lower latitude archaeological contexts. Complete moose skeletons are rarely available for reference in archaeozoological collections in the United States, meaning that scientists often lack the reference material to confidently identify moose remains. Although some morphologically unique elements such as antlers and crania are obvious when they occur (Breda 2005), other elements can be difficult to differentiate from other large ungulates such as elk (*Cervus elaphus*) or even bison (*Bison bison*). Some popular biomolecular tools for taxonomic ID, like Zooarchaeology by Mass Spectrometry (ZooMS), also cannot currently differentiate moose from close relatives (Trolle Jensen et al. 2020).

2 | Study Area

The Southern Rocky Mountains are a large midcontinental mountain range, bounded by the Green and Colorado Rivers on the west and the Great Plains to the east, and separated from the central Rocky Mountains by Wyoming's South Pass and Red Desert. The area rises from moderate elevations (5000 ft) along the Front Range to the highest peaks of the Rockies, reaching elevations over 14,000 ft., and includes a wide range of mountain ecosystems, from foothill prairie and montane

forest to subalpine parkland and alpine tundra. Today, the region hosts a complex patchwork of ecological zones, including riparian and wetland zones that support a growing population of moose, estimated at 3500 individuals in Colorado (Bergman et al. 2025).

Natural resource managers are increasingly concerned about the consequences of growing moose populations for ecosystem health in Rocky Mountain National Park, where recent research has documented changes to the Park's riparian beaver-willow ecosystem (Cooper et al. 2025). Cooper et al. (2025) found that browsing by large cervids (moose and elk [*Cervus elaphus*]) contributed to the decline of tall willow stands, the loss of beaver habitat, and the emergence of a new grassland state dominated by moose and elk. Park staff and others have begun discussing management interventions to reduce herbivore pressure, including expanding exclusionary fencing, reintroducing carnivores, and even culling moose (Cooper et al. 2025). In these discussions, moose are described as non-native to the park, implying that ecological impacts from moose are anthropogenic in origin.

Characterising the limits of a species' native range can be challenging. Although the IUCN definition of a species range excludes instances of 'vagrancy' (IUCN 2001) or temporary roaming beyond a normal territory, recent reviews have demonstrated that vagrancy may often reflect the outer fringe of a growing population and is a key mechanism for colonisation (Veit et al. 2022; Dufour et al. 2024). Moose are often seasonally migratory and young moose, particularly males, are capable of long dispersals of up to hundreds of kilometres (Hoffman et al. 2006), a behaviour sometimes observed for female moose as well (DeCesare et al. 2024). In moose, establishing native range is complicated further by the likely role that human hunting plays in defining and constraining both distributions and population size (Kay 1997).

In recent discourse, moose in Colorado prior to their reintroduction have been presumed to be vagrants. Public communications by park and wildlife officials about moose in Colorado regularly portray confidence surrounding the prehistoric status of moose, such as: 'Experts have concluded they [moose] did not have established populations' (US National Park Service 2025a). However, the inference that moose were not established in Colorado seems based on a superficial look at historic records that were published in the 1970s (Andrews 2011, 416; Armstrong 1972, 306), and a recent internal report that found only a few published archaeological records of moose bones in the vicinity of the park (Brunswig 2015). Given the vagaries of preservation noted earlier, this apparent rarity is unsurprising. The idea that moose were not present in the Southern Rockies in the past has not yet been carefully assessed against the full record of the region.

Management of modern moose populations will be more effective and biologically sound when grounded in empirical evidence. Here, we assess paleontological, archaeozoological, historical, and ethnohistorical evidence related to moose presence in Colorado. Together, data from each of these disciplinary spheres demonstrate that moose populations were established in the Southern Rockies before their 20th century supplementation, with historical data showing male, female, and juvenile moose present across northern and central Colorado. Looking to the deeper past, ethnohistoric and archaeozoological evidence indicates prehistoric moose in Colorado in both the Early and Late Holocene.

3 | Methods

To assess the state of moose in Colorado before their reintroduction, we conducted a literature review for publications of ancient faunal records from archaeological sites for moose in Colorado and the Southern Rockies (including Neotoma Paleoecological Database <https://www.neotomadb.org/>, academic databases including JSTOR/Web of Science, the State of Colorado's COMPASS database, and informal or 'grey' literature). To characterise Indigenous knowledge sources, we assessed published ethnohistoric literature from Native nations with traditional ties to Colorado and the Southern Rockies, along with a summary of Northern Arapaho traditional knowledge and connections to moose gathered and shared by coauthor and Tribal Historic Preservation Officer Crystal C'Bearing. For the historic era (records are available starting in 1859), we searched the Colorado Historic Newspapers Collection <https://www.coloradohistoricnewspapers.org/> for references to 'moose,' excluding keywords related to politics, placenames, mining, and sports that sometimes used this term. We combined this approach with a review of 19th century primary and secondary narrative accounts from early European settlers and visitors to Colorado, along with a search of online historic photo archives, municipal databases and libraries across the Front Range, and biological collections from Colorado in natural history museums with known date and location of collection. For each recorded moose sighting, we noted demographic (age, sex) and abundance information when present, and excluded references that appeared to refer to the same animal or event from different publications (based on time of sighting, demographic of moose sighted, and geographic location).

4 | Results

Published reports from the Southern Rockies suggest a Holocene prehistory for moose (*Alces* and/or *Cervalces*). Our review of the literature uncovered reports of moose at the Jurgens site, near Greeley, CO (ca. 9000 years ago; Figure 1, green star in north-central CO). At Barger Gulch, a Folsom campsite in Middle Park, Colorado, a specimen was identified as either moose or elk by biomolecular analysis (Wetherbee 2022; lower blue star in Figure 1). Possible moose remains (three specimens) have also been identified at the Ute-associated 'Sue site' in North Park dating to ca. 1070–1340 CE (Brunswig 2015; top blue star in Figure 1). Perhaps the most surprising moose identification comes from the site of Lowry Pueblo near Mesa Verde National Park (Figure 1, green star in southwest CO), where moose metapodials were identified by Martin et al. (1936, 1938) in an assemblage likely dating between the Pueblo II and Pueblo III periods (ca. 900–1350 CE).

None of these identifications were accompanied by thorough descriptions of the morphological criteria used, or with clear photos. They should, therefore, be treated with caution and verified through archaeozoological reassessment and supporting techniques like radiocarbon dating, DNA, LC–MS/MS, and other

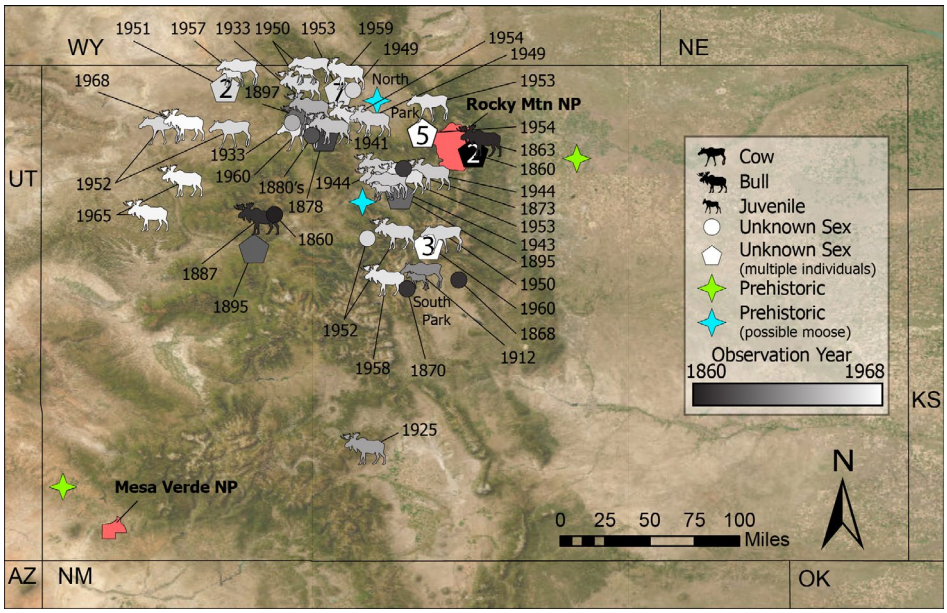

FIGURE 1 | Moose sightings in Colorado from historical (1860–1970) sources, museum collections, and published archaeological identifications. Observations labelled by year and indicated by colour gradient (black to white indicates older to younger, respectively). Red polygons show the boundaries of Rocky Mountain and Mesa Verde National Parks.

methods before they are used to inform wildlife management decisions. Nonetheless, the potential presence of moose in the Southern Rockies across many millennia challenges the prevailing assumption that they were absent prior to the late 20th century, underscoring the need for renewed archaeozoological and molecular investigation.

4.1 | The Indigenous Knowledge Record

Ethnohistories, oral traditions, and other Indigenous knowledge sources indicate that moose have a prehistoric and established presence in most of the Native cultures with ancestral connections to the Southern Rockies. The traditional knowledge record shared here, including Northern Arapaho language, art, material culture, and songs, demonstrates a deep Arapaho connection to moose. In the Arapaho language, the name for moose is *hinenihii*, which translates to 'big man' and refers to the animal's tremendous size. However, the Arapaho language also retains older words for moose including *see'iini3eet*, which refers to the moose's large, flat nose. The presence of older forms of this word within the Arapaho language suggests longstanding interactions with moose across ancestral Arapaho territory, which includes Colorado and large swaths of the Southern Rockies. Moose are present in traditional symbols and Arapaho art (Figure 2). Moose hides, valued for their durability, were traditionally used to make drums for the Eagle Drum Society (Appendix A). Early European writings also chronicle the Arapaho relationship with moose—one writer in 1890, for example, documented an Arapaho song referencing moose (Mooney 1896). Moose were traditionally embedded within Arapaho subsistence systems, contributing to diet, multispecies hunting practices, and the structured seasonal movements of the many Arapaho bands and groups who lived in Colorado.

Moose also appear in the language, stories, and culture of many other communities with ancestral ties to the Southern Rockies. Summer moose hunts are mentioned in mid-19th century oral accounts from the Wind River Range in southern Wyoming (Smith 1985), contradicting the assertion that Shoshone people had not encountered moose until the 20th century (Miller 2024). A 1909 ethnography with Ute people in Whiterocks, Utah (along the border of western Colorado) documented a story about two brothers who hunt and eat a moose (Mason 1910). This and other Ute sources convey serious taboos against moose consumption (Mason 1910) or even interaction (Andrews 2011, 55) that could also have impacted the animal's archaeological frequency, at least in more recent assemblages. Moose were present in the 'ancient order of things' for the Jicarilla Apache of northern New Mexico, as chronicled in the late 19th century (Russell 1898, 259) Jicarilla Apache informants remembered that although 'this animal disappeared in the Rio Grande country, above Santa Fe,' the memory of moose is encoded in the 'hummocky, broken hills along the river, which suggest ... the hump of the moose.' The historical presence and later disappearance of moose is thus remembered in tradition and stories as far south as northern New Mexico.

Ethnohistory and placenames even point to moose in Euroamerican contexts; a study of folklore in Middle Park, Colorado in the 1930s referenced a Native story of moose transformation (Ives 1941). Moose also appear in many older Colorado placenames, including those near Rocky Mountain National Park—early travel records from the 19th century refer to one of the open valleys along the road into Estes Park as 'Moose Park,' and dub an associated topographical feature 'Moose Hill' or 'Moose Park Hill' (Longmont Ledger 1884; Sprague 1922). Topographical features mentioned in these accounts appear to describe what is known today as 'Moose Mountain,' north of Pinewood Springs adjoining Muggins Gulch on the road to Estes Park. Though none of these observations on their own amount to irrefutable proof that moose are native to Colorado, they demonstrate clear familiarity with moose among people of the Southern Rockies.

4.2 | Historic Observations of Moose in Colorado

Anecdotal historic observations of moose in Colorado are sometimes acknowledged during contemporary wildlife discussions, but are usually quickly dismissed. Early narrative accounts pertaining to Colorado are few and far between. Moose are not mentioned in the records of occasional Spanish expeditions that entered into the southernmost reaches of Colorado, nor in the records of the small handful of early expeditions that skirted the edges of the Rockies, such as the expeditions of Zebulon Pike (in 1806) and Stephen Long (in 1819). However, most historic records in Colorado postdate the onset of widespread European settlement with the Colorado Gold Rush of 1859, at which point moose also appear in written accounts. Perhaps most famously, in the 1860s one of the first settlers of the Rocky Mountain Park region, Milton Estes, shot and killed a moose in what is today Estes Park. He speculated that this animal must be 'the first moose that ever wandered so far south' (Estes 1939). Today, Estes' account is sometimes referenced as though it is the only historical instance of moose in the Southern Rockies, paired with the unsubstantiated caveat that moose were 'not established' or similar statements implying impermanence or reproductive inactivity (e.g., US National Park Service 2025a; Miller 2024).

Dated newspaper and photographic data from public archives across Colorado demonstrate that moose were present across the Southern Rockies long before their 1970s reintroduction, contradicting the idea that such sightings were due to isolated dispersal events. Despite Milton Estes' off-the-cuff speculation that his moose was the first in the region around Estes Park (Estes 1939), another source notes 'there are reports of two being killed in this same general country in 1860 and of one on Sweetwater Lake in the White River forest around the same time' (Estes Park Trail 1943). An 1873 summary of the 'wild animals of Middle Park' listed moose among the animals that a trapper had 'either killed or seen in the Park or on the mountains that surround it' (Colorado Miner 1873). A number of similar records appear consistently across the region through the late 19th century (Figure 1; Table 1). In total, our review identified more than 30 published occurrences of moose in newspapers between 1860 and 1970, with these mentions often referencing multiple animals or even groups. Other documents strongly but indirectly implying the presence of moose were excluded from this tally—such as an 1878 writer inviting his English countrymen to 'stalk moose and deer' as they built 'fresh homes on the western slopes of the Colorado mountains' (Tenney 1880). Evaluating the time series of media sightings, we observe that published moose observations occurred regularly from ca. 1860 until the early 1940s, when records of moose became even more frequent (Figure 3). Together, these findings point to the persistent presence of moose across the Colorado Rockies for well over a century prior to their 1978 reintroduction.

Importantly, reports of female moose co-occurring with males and juveniles also make it clear that moose were reproducing locally before their official reintroduction. Despite assertions that the Southern Rockies 'never sustained a breeding population,' cows appeared nearly as often as bulls in historical newspaper reports and photographs, and juveniles accompanied by mothers were reported on multiple occasions during the study period (Table 1, Figures 3 and 4). Adult female moose have stable home ranges, returning to yearling ranges year over year (Cederlund et al. 1987), while moose calves tend to remain near the mothers' home range (Cederlund et al. 1987). Although female moose have also occasionally been documented to conduct long-range travels (DeCesare et al. 2024), cow-and-calf observations are highly likely to reflect a breeding population established within stable home ranges. As one powerful example, a photo of a 1912 hunt of a cow and calf moose (identified in photo archives at the Pike's Peak Library District, Margaretta M. Boas Collection) was not mentioned in any of our surveyed media records (Figure 4). This photo was apparently taken near the Almgren railroad lumber camp near Fairplay, Colorado, where moose are also incorporated into local placenames (e.g., 'Moose Creek'). Almost certainly, this and other similar cow and calf pairs represent locally reproducing moose populations.

Moose encounters were sometimes notable enough to warrant commemoration in newspapers, but the same is true of other native but infrequently-encountered Colorado taxa, such as grizzly bears (*Ursus arctos horribilis*). Our analysed records give strong reason to suspect that many, if not most late 19th and early 20th century moose encounters went undocumented. The earliest accounts of moose came from a small handful of preserved diaries or oral accounts, not from coherent record-keeping (Table 1). Formal tallies of moose sightings were apparently not regularly gathered by wildlife officials in Colorado until the animals' reintroduction, and many moose appear to have been identified in written accounts only after an animal was accidentally killed (e.g., Steamboat Pilot 1941; Wray Gazette 1944; Craig Empire Courier 1950). In 1944, one such moose was confiscated and accessioned to the Denver Museum of Nature and Science from a dismayed elk hunter at Willow Creek (near Grand Lake) along the western boundary of Rocky Mountain National Park (Arctos record: DMNS:Mamm:6745; Wray Gazette 1944). Most tellingly, a series of interviews and notes taken by Division of Wildlife biologist Denney in the area of North Park revealed a large number of moose sightings in the 1950s that were never announced in newspapers at all (Table 1, Denney 1976). If moose sightings such as these often failed to reach newspapers and other archives even as late as the mid-20th century, our assembled record must capture only a fraction of the true abundance of Colorado moose during the 19th and 20th centuries.

4.3 | Contextualising Colorado's Record Across the Rockies

Vagaries of the historical record make it difficult, if not impossible, to translate our time series of observations into reliable moose population estimates. This challenge is also evident from adjoining areas of the American Rockies, where records of moose are similarly scattered and, at times, contradictory. One summary from Utah states that 'occasional sightings of individual moose occurred throughout the first half of the 20th century' (Wolfe et al. 2010, 7). Another focused on Idaho observes that 'few records of moose in Northern Idaho exist prior to 1900' (Toweill and Vecellio 2004, 34). Reviews of Wyoming moose similarly noted that 'few if any moose were believed to exist in the Yellowstone and Jackson Hole areas of Wyoming prior to 1850' (Brimeyer and Thomas 2004) and that 'between 1835 and 1876 no one saw or killed a single moose' (Kay 1997). Despite the confidence of these assertions, they are contradicted by

TABLE 1 | Moose observations in Colorado based on historic sources (newspapers, photos), museum records, and published archaeological identifications. All occurrences are also visualised in Figures 2 and 3.

Source	Location	Year	Sex	Source
Archaeology	Barger Gulch	~10,500 BCE	Unknown (IDs: Moose/elk)	Wetherbee (2022)
Archaeology	Jurgens/Kersey	~7250 BCE	Unknown	Wheat (1979)
Archaeology	Sue (5JA421), North Park	~1070–1340 CE	Unknown (IDs: Possible moose, Moose/elk, Moose/bison)	Brunswig (2015)
Archaeology	Mesa Verde	~1250 CE	Unknown	Martin et al. (1936, 1938)
Journal (secondhand account)	Estes Park	1860	Unknown (x2)	Estes Park Trail (1943)
Newspaper	Sweetwater Lake	1860	Unknown	Colorado Historic Newspapers Collection
Newspaper	Estes Park	1863	Male	Estes (1939)
Journal (secondhand account)	Hall Gulch, Park County	1868	Unknown	Denney (1976)
Journal	South Park	1870	Unknown	Bailey (1944)
Newspaper (narrative account)	Middle Park	1873 or before	Unknown	Colorado Miner (1873)
Newspaper	Steamboat Springs	1878	Unknown (multiple)	Colorado Historic Newspapers Collection
Journal	Sweetwater Lake	1887	Male (skeletal remains)	Bailey (1944)
Newspaper (secondhand account)	Steamboat Springs	1880's	Unknown	Colorado Historic Newspapers Collection
Newspaper	Glenwood Springs	1895	Unknown (multiple)	Colorado Historic Newspapers Collection
Newspaper	Williams Fork	1895	Unknown (multiple)	Colorado Historic Newspapers Collection
Newspaper	Elk River	1897	Male	Colorado Historic Newspapers Collection
Photo archive	Fairplay	1912	Female, Juvenile	Colorado Historic Newspapers Collection
Newspaper	Rio Grande National Forest/San Luis Valley	1925	Male	Colorado Historic Newspapers Collection
Oral account	Routt County	1933	Unknown	Bailey (1944)
Written account (secondhand)	Elk River, Steamboat Springs	1933	Male	Denney (1976)
Newspaper	Steamboat Springs	1941	Male	Colorado Historic Newspapers Collection
Newspaper	Williams Fork/Hot Sulphur Springs	1943	Male, Female, Juvenile	Colorado Historic Newspapers Collection
Newspaper	Troublesome Creek, Hot Sulphur Springs	1944	Male	Colorado Historic Newspapers Collection
Museum specimen	Willow Creek/ Grand Lake	1944	Male	Denver Museum of Nature and Science/ARCTOS

(Continues)

TABLE 1 | (Continued)

Source	Location	Year	Sex	Source
Newspaper	Grizzly Creek/ North Park	1949	Male	Colorado Historic Newspapers Collection
Newspaper	North Fork of North Platte	1949	Unknown	Colorado Historic Newspapers Collection
Newspaper	Snake River	1950	Female	Colorado Historic Newspapers Collection
Newspaper	Hahn's Peak	1950	Male	Colorado Historic Newspapers Collection
Newspaper	Whiskey Park	1950	Female, Juvenile	Colorado Historic Newspapers Collection
Oral account	Fortification Creek	1951/52	Unknown (x2)	Denney (1976)
Newspaper	Willow Lakes, Dillon	1952	Male	Colorado Historic Newspapers Collection
Newspaper	Maybell	1952	Female	Colorado Historic Newspapers Collection
Newspaper	Craig	1952	Female	Colorado Historic Newspapers Collection
Newspaper	Minturn/Holy Cross	1952	Unknown	Colorado Historic Newspapers Collection
Newspaper	Williams Fork/Hot Sulphur Springs	1953	Male	Colorado Historic Newspapers Collection
Oral account	Park Range, North Park	1953/54	Unknown (x7)	Denney (1976)
Oral account	Camp Creek	1953/54	Unknown (x5)	Denney (1976)
Oral account	Porcupine Creek, Gould	1954	Female	Denney (1976)
Oral account	Chedsy Creek	1954	Male	Denney (1976)
Oral account	Little Snake River/Slater	1957/58	Female, Juvenile	Denney (1976)
Oral account	Climax	1958	Male	Denney (1976)
Oral account	Twisty Park, Big Creek	1959	Male	Denney (1976)
Newspaper	Snake River	1960	Unknown (x3)	Colorado Historic Newspapers Collection
Newspaper	Elk River/Steamboat Springs	1960	Female	Colorado Historic Newspapers Collection
Newspaper	Meeker	1965	Male	Colorado Historic Newspapers Collection
Newspaper	Piceance Creek	1965	Male	Colorado Historic Newspapers Collection
Newspaper	Lay	1968	Male	Colorado Historic Newspapers Collection

other, perhaps more careful assessments of the same record: one source notes that moose were observed to be 'quite abundant' in Yellowstone in 1869, and were 'still to be found in fair numbers until at least the mid-1870s' in the region before dwindling due to human activity (Cook et al. 1965; Schladweiler 1974). In Montana, only a handful of early journal accounts mention moose, some commenting on the animals' abundance, and others on their elusivity or scarcity (Schladweiler 1974). Even within a single historic account, the risk of mischaracterisation runs high—when discussing the Lewis and Clark Expedition, Kay (1997) writes that 'Lewis and Clark ... did not personally see a single moose,' even though Lewis wrote 'Reuben Fields wounded a moos [sic] deer this morning near our camp' in his journal on July 7, 1806 (Schladweiler 1974).

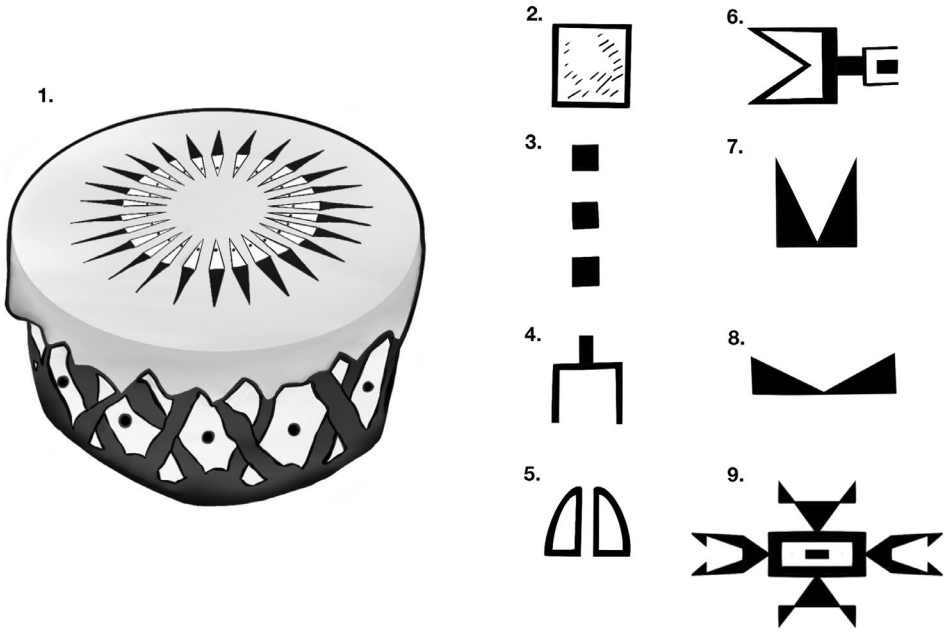

FIGURE 2 | Arapaho objects, symbols and designs linked to moose. (1) Moose hide drum; (2–4) Track designs; (5) Ear design; (6–8) Leg and hoof designs; (9) Animal design (Moose, wolf, or elk). Images modified from Kroeber (1983).

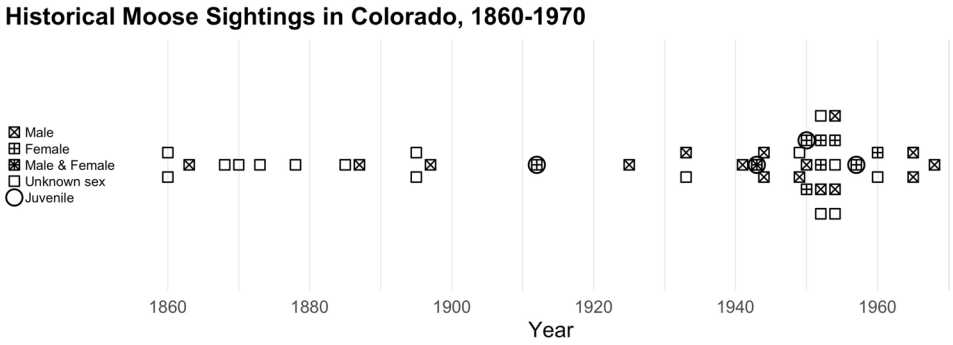

FIGURE 3 | Occurrence timeline of newspaper, dated photos, and diary accounts referencing moose sightings in Colorado. Symbols indicate demographic categories of observed animals (see key in figure).

Although brief periods of legalised hunting for moose were initiated in Montana, Idaho, and Wyoming towards the end of the 19th century, these were soon terminated due to declining encounter rates (DeCesare et al. 2014; Toweill and Vecellio 2004; Brimeyer and Thomas 2004). Early 20th century records in Yellowstone still 'did not include consistent assessments of population status' for moose, with some accounts noting moose as 'fairly common' and others 'a rarity' (Tyers 2006). The first ballpark population estimates for moose in these states were gathered after 1910 as hunting was reinstated (DeCesare et al. 2014; Toweill and Vecellio 2004; Brimeyer and Thomas 2004). Thus, while the Northern Rockies may boast a longer record of formal population records for moose, the contradictory and scattered nature of the early historic record appears to characterise the entire Rocky Mountain region.

4.4 | Changing Narratives, Shifting Baselines

Amid today's rising moose populations, competing narratives have emerged about their place in Colorado and the Southern Rockies, each carrying different implications for management against a backdrop of rapid ecological change. A closer look at the writings of earlier scientists shows that the thinking around moose's status has shifted dramatically over the last century. In the 1940s, some biologists working in the Colorado Rockies considered moose a native taxon that had been 'extirpated except for stragglers' (Hunter and Yeager 1949). In the 1970s, both wildlife biologists and park staff working on moose translocation initially represented their efforts publicly as a 'reintroduction' (Golden Transcript 1973; Duvall and Schoonveld 1988). After some internal discourse and consultation with University of Colorado curator David Armstrong, Rocky Mountain National Park leadership abandoned the plan to reintroduce moose within park boundaries (Andrews 2011; Denney 1976), but Division of Wildlife staff continued to view their efforts as a reintroduction. In a 1976 interview with the Jackson County Star, lead biologist Richard Denney argued that 'the reason moose do not seem to have established a breeding population in Colorado *in recent history* [emphasis added] is that hunting by Indians and trappers and later poaching has kept moose populations down' (Jackson County Star 1976). Official signage aimed at warning hunters of newly reintroduced moose in the area of North Park, along with other public

FIGURE 4 | Adult female and juvenile moose shot by Eric Almgren, a 'tie chopper' (railroad lumber worker) acquiring food for the Almgren tie camp near Fairplay Colorado, dated to ca. 1912. Courtesy of Regional History & Genealogy, Pikes Peak Library District, 001-7513.

FIGURE 5 | Cartoon featured in *Wildlife News* by Colorado Division of Wildlife, February 1978, expressing their view on historical moose presence in Colorado. Reprinted with permission, courtesy of Colorado Parks and Wildlife/Dick Draney.

messaging by the Division of Wildlife in the late 1970s (Figure 5) makes it clear that they viewed the release as a 'reintroduction' of a previously established population. In the decades since, park staff and some biologists have come to see moose instead as 'recently introduced' (Cooper et al. 2025). Our analysis suggests that valid knowledge held by earlier scientists, who were more familiar with the 19th and early 20th century presence of moose in Colorado, has since faded or been displaced, repositioning moose from returning natives to ecological outsiders. This scenario illustrates a variant of shifting baseline syndrome (Pauly 1995) where institutional memory of moose presence faded, causing their resurgence to be misread as an invasion instead of a recovery.

4.5 | Natural Moose Population and Range Expansion

What can we learn about actual moose abundances from pre-1970 records of moose in Colorado, and their notable increase during the 1940s and 1950s (Figure 4)? A rise in newspaper mentions could indicate a wide range of factors, including rising visibility of animals that had long persisted in remote basins, increased human populations, higher rates of recreation, hunting or backcountry travel, changes in media interests and publication rates, or some combination of the above. However, the increase in moose sightings in Colorado in the mid-20th century parallels a near-exponential growth in moose populations in the wider Rockies region in places like Utah and Idaho (Wolfe et al. 2010; Toweill and Vecellio 2004). Colorado wildlife officials recognised this increase and interpreted it as evidence that moose were naturally re-establishing populations in the Southern Rockies prior to their translocation (Denney 1976). These observations, along with the subsequent expansion of moose into additional areas of the Southern Rockies since translocation, suggest that recent range expansion is not an anthropogenic accident but part of a broader natural population change.

5 | Implications

Across the American West, present-day assumptions about species' ecologies are often overturned when the historic and paleoenvironmental records are carefully interrogated, including for large mammals like elk (Lanman et al. 2024). Although elk are currently understood as a native taxon in Rocky Mountain National Park, these animals were, in fact, extirpated from the park in the 19th century under high hunting pressure during the mining boom, and intentionally reintroduced only in 1913 (Frank 2024). Following their reintroduction, the Park has struggled for decades with the absence of the animal's natural predators and downstream ecological effects of high grazing pressure on aspen and willow. Just as with moose, culling plans for elk have been consistently controversial and political, including in the Kawuneechee Valley itself (Frank 2024). Despite these striking similarities in their 19th and 20th century histories, elk have, unlike moose, avoided local designation as non-native in the Southern Rockies.

The debate around moose in the Southern Rockies reveals fundamental issues in using 'native vs. exotic' classifications when considering indigenous species. Efforts by the National Park Service (NPS) to protect Park landscapes from significant changes to contemporary faunas reflect ideology and priorities dating back to the agency's foundation, including the idea of preserving wild and untouched landscapes (Lyman 1998). The National Park Service Management Policies define native species as those that 'have occurred, now occur, or may occur as a result of natural processes,' while exotic species are those occupying areas 'directly or indirectly as the result of deliberate or accidental human activities' (NPS Management Policies 4.4.1.3). This framework assumes that ecosystems are composed of tightly coupled species, bounded spatially within a system that remains in a state of equilibrium. However, Quaternary paleoecology has repeatedly demonstrated that species respond individualistically to environmental change, sometimes resulting in novel assemblages with no modern analogs (Graham 2005; Graham et al. 1996; Williams and Jackson 2007). In postglacial North America, faunal communities have been in near constant flux (e.g., Wendt et al. 2022). When animals such as moose react to a changing landscape that is deeply shaped by both current and prior human influence, Park Service Management Policy definitions can create a false dichotomy between humanity and nature that can be unhelpful in guiding management decisions.

Across the Holocene, presence and abundance for most mammals across the continent was strongly influenced by human activities, including predator removal and habitat modification. Archaeological science and paleoecology clearly demonstrate that Indigenous people played a role in structuring past landscapes in North America, with associated impacts on the range and distribution of many different animal species (e.g., Cole et al. 2024; Jones and Fisher 2023; Roos et al. 2018, 2022; O'Keefe et al. 2023; Lyons et al. 2016). By the time Colorado's parks were founded in the early 20th century, the Southern Rockies had subsequently undergone over two centuries of rapid and dramatic ecological reorganisation, including European settlement, the Columbian Exchange and demographic collapse of Native nations, which left environments deeply altered and destabilised (Jones and Fisher 2023). Consequently, attempting to preserve an early 20th century status quo may have unforeseen negative ecological consequences.

In many national parks and other federally managed landscapes, well-described and well-dated faunal assemblages necessary for understanding ancient wildlife trends are rare. While fossil and subfossil records can provide important historical contexts for managing wildlife populations (e.g., Miller et al. 2021, 2023; Terry 2010), not all records are created equal. Archaeozoological sources and historic records are often low-resolution, capable of identifying a species' presence, but less definitive in documenting their absence. Prehistoric data suffer from complex sampling issues and not all records can address all questions. However, such records also offer critical resources for evaluating historical reference conditions of modern ecosystems, suitable habitat for reintroduced animal populations, and the biological consequences of environmental perturbations (Barnosky et al. 2017; Dietl et al. 2015; Dillon et al. 2022; Kidwell 2015; Lyman 1996, 2016; Tomasovych and Kidwell 2017).

In a static model for ancient ecosystems, gaps in the historical and archaeological records can be easily misinterpreted as 'evidence of absence' and used to justify costly management decisions on federal lands. The case of Olympic National Park (Washington) set a troubling precedent, where mountain goats were released in the 1930s. Despite historical records pointing to an earlier presence for the animals in the region, and only a superficial reckoning with local archaeological evidence, park managers ultimately deemed the animals to be invasive (Lyman 1998). This designation was used to justify a multi-decade effort to eradicate the animals from the park (US National Park Service 2025b). The same pattern has since played out in Rocky Mountain National Park itself, where mountain goats are considered invasive and have been continually removed since translocations to other parts of Colorado in 1948, despite records chronicling their presence in southern Colorado as far back as the 19th century (e.g., Georgetown Courier 1899; Las Animas Leader 1904). These cases demonstrate the peril of static classification systems that depend on separating natural from anthropogenic processes at arbitrary spatial and temporal scales using incomplete historical records. Particularly in a time when climate, land use, and species distributions continue to shift, such simplistic classifications are likely inadequate, and perhaps even adversarial, for managing contemporary ecosystems and biodiversity. Our inability to easily distinguish whether Colorado's historic record of moose represents frequent vagrancy, periods of withdrawal and re-establishment influenced by people and/or climate, or continual low-level persistence, provides a clear reason not to eradicate moose in Rocky Mountain National Park.

Moose face significant challenges across much of North America as they reckon with climate warming, disease, habitat fragmentation, vehicle collisions, and other 21st-century mortality risks (Timmerman and Rodgers 2017). Their local success in the Southern Rockies is just one part of a complex and shifting pattern across the continent, as animal communities respond to rapid environmental change. Public messaging in national parks not only influences human-animal interactions within park boundaries, but also shapes perceptions about wildlife for millions of visitors across the nation and across generations. For wildlife managers responding to increasing moose populations in Rocky Mountain

National Park and elsewhere in Colorado, our results indicate that classifying moose as invasive and pursuing removal on that basis would be scientifically unsupported. Instead, park and wildlife officials should adopt a sustainable approach to management and messaging that acknowledges moose presence before the establishment of federal management regimes and recognises that mammal communities in the Southern Rockies are dynamic, with ranges shifting over decades, centuries, and millennia.

Throughout the Holocene, hunting by Indigenous communities has been an important force structuring the distribution, abundance, and demography of prey species (alongside large carnivores like wolves, cougars, and bears). Today, the absence of human hunters within park boundaries and reduced carnivore presence has released moose and other animals from mortality sources that regulated them for millennia. Scientifically justified efforts to reduce moose impacts might include carnivore restoration or co-management frameworks that include restoring hunting access for Tribes with longstanding ties to the region, as has been proposed for other large mammal populations in national parks, like bison at Glacier (Stevens et al. 2025). Management plans developed through dialogue among scientists, Tribes, and the public are more likely to reflect the full evidentiary record and to sustain public legitimacy over time (Lauber and Knuth 1997). Biogeography, archaeozoology, paleoecology, and Indigenous knowledge offer complementary frameworks for conservation policies that incorporate ecological dynamism and the deep history of human-environment interactions. Cases like Colorado's moose show that these frameworks are urgently needed.

6 | Conclusion

Interdisciplinary data indicate that moose were a part of Colorado's ancient fauna, and are not invasive. Our review of the paleontological, archaeological, historic, and Indigenous records provides evidence that, prior to the 1978 reintroduction, moose were present and had established populations in the Southern Rockies during the 19th and 20th centuries, and likely long before. References to male, female, and juvenile animals in recorded observations likely indicate viable reproducing populations, rather than merely isolated instances of individual dispersals. Moose are scarce and difficult to identify in archaeological and paleontological assemblages, but the archaeozoological literature also includes multiple published moose records within Colorado, dating back millennia. Recognition of moose as part of the native ecology of the region should prompt those making wildlife management decisions at federal and state levels to consider consultation and engagement with paleobiologists, archaeologists, Native leadership, and the public. These consultations will lead to a more complete understanding of the distribution and importance of moose in Colorado ecosystems, and help make stronger specific management strategies informed by deep-time perspectives.

Author Contributions

W.T.T.T., J.A.F.W., J.D., and J.H.M. wrote the manuscript, C.C.'B., M.C., I.A.H., J.L., A.J., E.L., R.W.G., C.W., and E.L.J. contributed original research and figures. All authors contributed to editing and revision.

Acknowledgements

The authors would like to thank Dr. Robert Brunswig (University of Northern Colorado), Jennifer Muskrat Velarde (Jicarilla Apache Nation), the Estes Valley Public Library, the Denver Public Library, Pike's Peak Library District, the Denver Museum of Nature and Science, and the Colorado Historic Newspapers Collection for their special assistance with identifying and accessing key literature, archives, and collections. All relevant permission was obtained for this research—no special permits were required to conduct this work.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All data used in this study are provided within the manuscript text.

References

Anderson, E. 1968. *Fauna of the Little Box Elder Cave, Converse County, Wyoming. The Carnivora* (Series in Earth Sciences 6). University of Colorado Studies.

Andrews, T. 2011. *An Environmental History of the Kawuneeche Valley and the Headwaters of the Colorado River, Rocky Mountain National Park* (RM-CESU Cooperative Agreement Number:H12000040001). Rocky Mountain National Park.

Armstrong, D. M. 1972. *Distribution of Mammals in Colorado*. Museum of Natural History, University of Kansas.

Bailey, A. M. 1944. "Records of Moose in Colorado." *Journal of Mammalogy* 25, no. 2: 192.

Barnosky, A. D., E. A. Hadly, P. Gonzalez, et al. 2017. "Merging Paleobiology With Conservation Biology to Guide the Future of Terrestrial Ecosystems." *Science* 355, no. 6325: eaah4787. https://doi.org/10.1098/rspb.2013.0496.

Bergman, E. J., J. P. Runge, M. C. Fisher, and L. L. Wolfe. 2025. "Management Considerations of Moose Life-History Characteristics in Colorado, USA." *Wildlife Biology* 2025, no. 4: e01310. https://doi.org/10.1002/wlb3.01310.

Breda, M. 2005. "The Morphological Distinction Between the Postcranial Skeleton of Cervalces/Alces and Megaloceros Giganteus and Comparison Between the Two Alceini Genera From the Upper Pliocene–Holocene of Western Europe." *Geobios* 38, no. 2: 151–170.

Brimeyer, D. G., and T. P. Thomas. 2004. "History of Moose Management in Wyoming and Recent Trends in Jackson Hole." *Alces* 40: 133–143.

Brunswig, R. 2015. *Archaeological and Paleontological Evidence for the Prehistoric and Early Historic Presence of Bison (Bison sp.) and Moose (Alces alces)*. Rocky Mountain National Park and the North Central Colorado Rocky Mountains.

Cederlund, G., F. Sandegren, and K. Larsson. 1987. "Summer Movements of Female Moose and Dispersal of Their Offspring." *Journal of Wildlife Management* 51, no. 2: 342.

Churcher, C. S., and J. D. Pinsof. 1987. "Variations in the Antlers of the North American Cervalces (Mammalia: Cervidae): Review of New and Previously Recorded Records." *Journal of Vertebrate Paleontology* 7: 373–397.

Colburn, M. L. 1987. *Faunal Remains Identified From Archaeological Sites in Voyageurs National Park, Minnesota (1986)*. Illinois State Museum Quaternary Studies Program Technical Report 87-323-13.

Cole, K. E., M. Moffatt, B. F. Codding, and J. M. Broughton. 2024. "Human Settlement Density, Not Late Holocene Climate Change,

Influenced Artiodactyla Species Abundance in Northeastern California Faunal Assemblages." *Quaternary International* 689: 43–54.

Colorado Miner (Weekly). 1873. "The Wild Animals of Middle Park." Volume VI, no. 37, January 23.

Cook, C. W., D. E. Folsom, and W. Peterson. 1965. *The Valley of the Upper Yellowstone: An Exploration of the Headwaters of the Yellowstone River in the Year 1869*. Aubrey L. Haines. University of Oklahoma Press.

Cooper, D. J., E. W. Schweiger, J. R. Shaw, et al. 2025. "Rapid Riparian Ecosystem Decline in Rocky Mountain National Park." *Conservation Biology: The Journal of the Society for Conservation Biology* 39: e70053.

Craig Empire Courier. 1950. "Stray Moose Killed During Opening Days of Big Game Season." 59, no. 26.

DeCesare, N. J., C. J. Peterson, J. R. Newby, and R. B. Harris. 2024. "Ecology, Population Dynamics, and Monitoring of Moose in Montana." Final Report for Federal Aid in Wildlife Restoration Grant W-157-R. Montana Fish, Wildlife and Parks, Helena, Montana.

DeCesare, N., T. D. Smucker, R. Garrott, and J. Gude. 2014. "Moose Status and Management in Montana." *Alces* 50 (April): 35–51.

Denney, R. 1976. *A Proposal for the Reintroduction of Moose Into Colorado*. Colorado Division of Wildlife.

Dietl, G. P., S. M. Kidwell, M. Brenner, et al. 2015. "Conservation Paleobiology: Leveraging Knowledge of the Past to Inform Conservation and Restoration." *Annual Review of Earth and Planetary Sciences* 43, no. 1: 79–103. https://doi.org/10.1146/annurev-earth-040610-133349.

Dillon, E. M., J. Q. Pier, J. A. Smith, et al. 2022. "What Is Conservation Paleobiology? Tracking 20 Years of Research and Development." *Frontiers in Ecology and Evolution* 10: 1031483. https://doi.org/10.3389/fevo.2022.1031483.

Dufour, P., A. C. Lees, J. Gilroy, and P.-A. Crochet. 2024. "The Overlooked Importance of Vagrancy in Ecology and Evolution." *Trends in Ecology & Evolution* 39, no. 1: 19–22.

Duvall, A. C., and G. S. Schoonveld. 1988. "Colorado Moose: Reintroduction and Management." *Alces* 24: 188–194.

Estes, M. 1939. "Memoirs of Estes Park." *Colorado Magazine* 16, no. 4: 121–156.

Estes Park Trail, Volume XXIII, Number 1. 1943. "Elk and Deer Census Protects Herds."

Frank, J. J. 2024. *Making Rocky Mountain National Park*. University Press of Kansas.

Gazin, C. L. 1938. "A Cranium of the Extinct Moose, Cervalces, From the Quaternary of Northern Indiana." *American Midland Naturalist* 19, no. 3: 740.

Georgetown Courier. 1899. "New Colorado Animal." 23, no. 21.

Golden Transcript. 1973. "Rocky Mt. Park as Moose Habitat?" 107, no. 8.

Graham, R. W., E. L. Lundelius Jr., M. A. Graham, et al. 1996. "Spatial Response of Mammals to Late Quaternary Environmental Fluctuations." *Science* 272, no. 5268: 1601–1606.

Graham, R. W. 2005. "Quaternary Mammal Communities: Relevance of the Individualistic Response and Non-Analogue Faunas." *Paleontological Society Papers* 11: 141–158.

Heintzman, P. D., D. Froese, J. W. Ives, et al. 2016. "Bison Phylogeography Constrains Dispersal and Viability of the Ice Free Corridor in Western Canada." *Proceedings of the National Academy of Sciences of the United States of America* 113, no. 29: 8057–8063.

Hoffman, J. D., H. H. Genoways, and J. R. Choate. 2006. "Long-Distance Dispersal and Population Trends of Moose in the Central United States." *Alces* 42: 115–131.

Hunter, G. N., and L. E. Yeager. 1949. "Big Game Management in Colorado." *Journal of Wildlife Management* 13, no. 4: 392.

International Union for Conservation of Nature (IUCN). 2001. "IUCN Red List Categories and Criteria: Version 3.1." IUCN Species Survival Commission.

Ives, R. L. 1941. "Folklore of Eastern Middle Park, Colorado." *Journal of American Folk-Lore* 54, no. 211/212: 24.

Jones, E. L., and J. Fisher. 2023. *Questioning Rebound: People and Environmental Change in the Protohistoric and Early Historic Americas*. University of Utah Press.

Kay, C. E. 1997. "Aboriginal Overkill and the Biogeography of Moose in Western North America." *Alces* 33: 141–164.

Kidwell, S. M. 2015. "Biology in the Anthropocene: Challenges and Insights From Young Fossil Records." *Proceedings of the National Academy of Sciences of the United States of America* 112, no. 16: 4922–4929. https://doi.org/10.1073/pnas.1403660112.

Kroeber, A. L. 1983. *The Arapaho*. University of Nebraska Press.

Lanman, R. B., T. J. Batter, and C. J. Mckee. 2024. "Novel Evidence That Elk Were Historically Native to the Sierra Nevada, and Recent Range Expansions Into the Region." *PLoS One* 19, no. 9: e0301665.

Las Animas Leader. 1904. "May Keep Mountain Goat." 32, no. 16.

Lauber, T. B., and B. A. Knuth. 1997. "Fairness in Moose Management Decision-Making: The Citizens' Perspective." *Wildlife Society Bulletin* 25: 776–787.

Lister, A. M. 1993. "Evolution of Mammoths and Moose: The Holarctic Perspective." In *Morphological Change in Quaternary Mammals of North America*, edited by R. A. Martin and A. D. Barnosky, 178–204. Cambridge University Press.

Longmont Ledger. 1884. "Estes Park." 5, no. 44.

Lyman, R. L. 1996. "Applied Zooarchaeology: The Relevance of Faunal Analysis to Wildlife Management." *World Archaeology* 28, no. 1: 110–125. https://doi.org/10.1080/00438243.1996.9980334.

Lyman, R. L. 1998. *White Goats, White Lies: The Abuse of Science in Olympic National Park*. University of Utah Press.

Lyman, R. L. 2016. "A Conservation Paleobiology Perspective on Reintroduction: Concepts, Variables, and Disciplinary Integration." In *Reintroduction of Fish and Wildlife Populations*, edited by D. S. Jachowski, J. J. Millspaugh, P. L. Angermeier, and R. Slotow, 29–51. University of California Press.

Lyons, S. K., K. L. Amatangelo, A. K. Behrensmeyer, et al. 2016. "Holocene Shifts in the Assembly of Plant and Animal Communities Implicate Human Impacts." *Nature* 529, no. 7584: 80–83.

Martin, P. S., C. Lloyd, and A. Spoehr. 1938. "Archaeology of Southwestern Colorado: Archaeological Work in the Ackmen-Lowry Area, Southwestern Colorado." *Publications of the Field Museum of Natural History. Anthropological Series* 23, no. 2: 219–304.

Martin, P. S., L. Roys, and G. von Bonin. 1936. "Archaeology of Southwestern Colorado: Lowry Ruin in Southwestern Colorado, With Reports on Masonry of Lowry Ruin and of the Southwest, and Skeletal Material From the Lowry Area." *Publications of the Field Museum of Natural History. Anthropological Series* 23, no. 1: 1–216.

Martin, T. J. 1979. "Faunal Remains." In *Appendix E in Final Report: Phase II Archaeological Site Examination of the Gros Cap Cemetery Area, Mackinac County, Michigan*. Michigan Technological University Cultural Resource Management Report No. 6, edited by S. R. Martin, 133–148. Houghton.

Mason, J. A. 1910. "Myths of the Uintah Utes." *Journal of American Folk-Lore* 23, no. 89: 299.

Meiri, M., A. Lister, P. Kosintsev, G. Zazula, and I. Barnes. 2020. "Population Dynamics and Range Shifts of Moose (*Alces alces*) During the Late Quaternary." *Journal of Biogeography* 47, no. 10: 2223–2234.

Miller, J. 2024. "Of Moose and Men." *BioGraphic*. https://www.biographic.com/of-moose-and-men/.

Miller, J. H., B. E. Crowley, C. P. Bataille, et al. 2021. "Historical Landscape Use of Migratory Caribou: New Insights From Old Antlers." *Frontiers in Ecology and Evolution* 8. https://doi.org/10.3389/fevo.2020.590837.

Miller, J. H., E. J. Wald, and P. Druckenmiller. 2023. "Shed Female Caribou Antlers Extend Records of Calving Activity on the Arctic National Wildlife Refuge by Millennia." *Frontiers in Ecology and Evolution* 10. https://doi.org/10.3389/fevo.2022.1059456.

Mooney, J. 1896. *The Ghost-Dance Religion and the Sioux Outbreak of 1890*. Government Printing Office, Bureau of Ethnology.

O'Keefe, F. R., R. E. Dunn, E. M. Weitzel, et al. 2023. "Pre-Younger Dryas Megafaunal Extirpation at Rancho La Brea Linked to Fire-Driven State Shift." *Science* 381, no. 6659: eabo3594.

Pauly, D. 1995. "Anecdotes and the Shifting Baseline Syndrome of Fisheries." *Trends in Ecology & Evolution* 10: 430.

Roos, C. I., C. H. Guiterman, E. Q. Margolis, et al. 2022. "Indigenous Fire Management and Cross-Scale Fire-Climate Relationships in the Southwest United States From 1500 to 1900 CE." *Science Advances* 8, no. 49: eabq3221.

Roos, C. I., M. N. Zedeño, K. L. Hollenback, and M. M. Erlick. 2018. "Indigenous Impacts on North American Great Plains Fire Regimes of the Past Millennium." *Proceedings of the National Academy of Sciences of the United States of America* 115, no. 32: 8143–8148.

Ross, T. 2023. "Human-Moose Conflicts Are on the Rise in Colorado. Who Is to Blame—Humans or Moose?" *Colorado Sun*.

Russell, F. 1898. "Myths of the Jicarilla Apaches." *Journal of American Folk-Lore* 11, no. 43: 253.

Saleeby, B. 2002. "Out of Place Bones: Beyond the Study of Prehistoric Subsistence." Arctic Research of the United States 16.

Schladweiler, P. 1974. "Ecology of Shiras Moose in Montana: Big Game Research Projects W-98-R and W-120-R, January 4, 1965-December 31, 1973." Preprint. https://archive.org/details/ecologyofshirasm1974mont/page/n99/mode/2up.

Schubert, B. W., R. W. Graham, H. Gregory McDonald, E. C. Grimm, and T. W. Stafford Jr. 2004. "Latest Pleistocene Paleoecology of Jefferson's Ground Sloth (*Megalonyx jeffersonii*) and Elk-Moose (*Cervalces scotti*) in Northern Illinois." *Quaternary Research* 61, no. 2: 231–240.

Skibo, J. A., T. J. Martin, E. C. Drake, and J. G. Franzen. 2004. "Geta Odena: Grand Island's Post-Contact Occupation at William's Landing." *Midcontinental Journal of Archaeology* 29, no. 2: 167–189.

Smith, B. 1985. "Moose and Their Management on Wind River Indian Reservation, Wyoming." *Alces* 21: 359–391.

Sprague, A. 1922. "The Estes and Rocky Mountain National Parks: An Historical Remembrance." *Estes Park Trail*, November 10.

Stevens, M., K. L. Paul, E. Lunstrum, T. Edmo, and B. Maxwell. 2025. "Rethinking Indigenous Hunting in National Parks." *Annals of the American Association of Geographers* 115, no. 10: 2469–2482.

Tenney, E. P. 1880. *Colorado and Homes in the New West*. Lee and Shepard.

Terry, R. C. 2010. "The Dead Do Not Lie: Using Skeletal Remains for Rapid Assessment of Historical Small-Mammal Community Baselines." *Proceedings of the Royal Society Biological Sciences* 277, no. 1685: 1193–1201.

The Jackson County Star. 1976. "Meetings Discuss Moose Proposal." 43, no. 4.

The Rocky Mountain News (Daily). 1929. "Forests of Colorado Contain 30,958 Deer." 70, no. 244.

The Steamboat Pilot, No. 17. 1941. "Elk Hunter Kills Wounded Moose as It Attacks Him."

Timmerman, H. R., and A. Rodgers. 2017. "The Status and Management of Moose in North America—Circa 2015." *Alces* 53: 1–22.

Tomasovych, A., and S. M. Kidwell. 2017. "Nineteenth-Century Collapse of a Benthic Marine Ecosystem on the Open Continental Shelf." *Proceedings of the Royal Society B* 284: 20170328. https://doi.org/10.1016/j.margeo.2011.10.008.

Toweill, D., and G. Vecellio. 2004. "Shiras Moose in Idaho: Status and Management." *Alces* 40: 33–43.

Trolle Jensen, T. Z., M. Mackie, A. J. Taurozzi, et al. 2020. "The Biomolecular Characterization of a Finger Ring Contextually Dated to the Emergence of the Early Neolithic From Sylthom, Denmark." *Royal Society Open Science* 7, no. 1: 191172.

Tyers, D. B. 2006. "Moose Population History on the Northern Yellowstone Winter Range." *Alces* 42: 133–149.

US National Park Service. 2025a. *Moose Research in Rocky Mountain National Park*. Rocky Mountain National Park. https://www.nps.gov/articles/moose-research-in-rocky-mountain-national-park.htm.

US National Park Service. 2025b. *Mountain Goat Capture and Translocation—Olympic National Park*. US National Park Service. https://www.nps.gov/olym/planyourvisit/mountain-goat-capture-and-translocation.htm.

Veit, R. R., L. L. Manne, L. C. Zawadzki, M. A. Alamo, and I. I. I. Robert William Henry. 2022. "Editorial: Vagrancy, Exploratory Behavior and Colonization by Birds: Escape From Extinction?" *Frontiers in Ecology and Evolution* 10. https://doi.org/10.3389/fevo.2022.960841.

Velez, A. 2025. "A Week of Loose Moose: Agencies Report Moose Sightings on Front Range." *9 News*. https://www.9news.com/article/life/animals/moose-sightings-colorado/73-53373ed2-3e0f-4bd5-9b7c-0d3503ecaec9.

Wendt, J. A. F., D. B. McWethy, C. Widga, and B. N. Shuman. 2022. "Large-Scale Climatic Drivers of Bison Distribution and Abundance in North America Since the Last Glacial Maximum." *Quaternary Science Reviews* 284: 107472.

Wetherbee, S. 2022. *The Zooarchaeology of Barger Gulch: A Folsom Campsite in the Rocky Mountains*. University of Wyoming.

Wheat, J. B. 1979. "Memoir 15: Jurgens Site." *Plains Anthropologist* 24: 1–153.

Williams, J. W., and S. T. Jackson. 2007. "Novel Climates, No-Analog Communities, and Ecological Surprises." *Frontiers in Ecology and the Environment* 5: 475–482.

Wolfe, M. L., K. R. Hersey, and D. C. Stoner. 2010. "A History of Moose Management in Utah." *Alces* 46: 37–52.

Wray Gazette. 1944. "Eckley." Volume XLI, no. 50, October 26.

Yesner, D. R. 1989. "Moose Hunters of the Boreal Forest? A Re-Examination of Subsistence Patterns in the Western Subarctic." *Arctic* 42, no. 2: 97–108.

Appendix A

Traditional Moose-Hide Drums in Arapaho Culture, as Told to Author Crystal C'Bearing by Salem Ynostrosa

The Hand Drum is very important to the Native American tribes around the world. The Drum is made out of wood and moose hide. The wood will be soaked for a few hours till it is soaked enough to bend into a ring shape where it is then bound together so it can dry. Once the drum ring has dried, the two end pieces will be glued together and set to dry. The hide will be scraped of all hair and unwanted material that you do not want on the hide. After the hide is cleaned and resealed, it will be cut into the desired circumference, and extra rawhide lacing will be cut out as well. Once the hide and lacing are cut and ready it will then be stretched around the drum ring and laced up, leaving a little slack giving the hide room to shrink as it dries.

The drum has many different meanings. It is the continuation of life, which is why the drum is in a circular shape – representing the everlasting life cycle. The drum also represents the heartbeat of the people, giving strength to all present to feel the beat of the drum. The drum has the ability to heal someone who may be grieving or going through a hard time in life. So, it is important to continue our native ways of life to hunt for the resources we need from the animals; it is very beneficial for future generations to come.