Submitted/PI: [redacted]

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PROGRAM ANNOUNCEMENT/SOLICITATION NO./DUE DATE: **NSF 23-531**

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TITLE OF PROPOSED PROJECT
Doctoral Dissertation Research: Assessing Support for Human-Caused Extinction of Pleistocene Horses in the Radiocarbon Record

SHOW LETTER OF INTENT ID IF APPLICABLE

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 38,125	12 months	06/01/2025	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
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- ■ COLLABORATIVE STATUS: Non-Collaborative
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CERTIFICATION PAGE

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By electronically signing and submitting this proposal, the Authorized Organizational Representative (AOR) is: (1) certifying that statements made herein are true and complete to the best of the individual's knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this proposal. Further, the proposer is hereby providing certifications regarding conflict of interest, flood hazard insurance, responsible and ethical conduct of research, organizational support, and safe and inclusive working environments for off-campus or off-site research, as set forth in the NSF Proposal & Award Policies & Procedures Guide (PAPPG). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section §1001).

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Certification Regarding Organizational Support

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that there is organizational support for the proposal as required by Section 526 of the America COMPETES Reauthorization Act of 2010. This support extends to the portion of the proposal developed to satisfy the Broader Impacts Review Criterion as well as the Intellectual Merit Review Criterion, and any additional review criteria specified in the solicitation. Organizational support will be made available, as described in the proposal, in order to address the broader impacts and intellectual merit activities to be undertaken.

Certification Regarding Dual Use Research of Concern

By electronically signing the certification pages, the Authorized Organizational Representative is certifying that the organization will be or is in compliance with all aspects of the United States Government Policy for Institutional Oversight of Life Sciences Dual Use Research of Concern.

Certification Requirement Specified in the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Section 223(a)(1) (42 USC 6605(a)(1))

By electronically signing the Certification Pages, the Authorized Organizational Representative is certifying that each individual employed by the organization and identified on the proposal as senior/key personnel has been made aware of the certification requirements identified in the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Section 223(a)(1) (42 U.S.C § 6605(a)(1)).

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE		SIGNATURE	DATE
NAME [redacted]		**Electronic Signature**	**Mar 26 2025 11:03 AM**
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PROJECT SUMMARY

Overview

The cause of the loss of 38 genera of megafauna in North America at the end of the last ice age has been the cause of considerable anthropological, paleontological, and ecological debate. One of these taxa, the North American Pleistocene horses (Equini, or the combined genera of *Equus* and *Harringtonhippus*) have featured centrally in megafaunal extinction debates. Pleistocene Equini specimens are not as well dated as other key megafauna taxa, which has made advances in research about their extinction challenging. Using radiocarbon dating and stable isotope paleoecology, we seek to address the following overarching question: given our understanding of Paleoindian prey choice, the radiocarbon record, and horse paleoecology, is there evidence for human contribution to the extinction of Pleistocene horses in North America? Published radiocarbon dates for Equini indicate that humans and horses shared the landscape in North America for a period of time. However, the low number of dates has forestalled the establishment of a terminal date for Equini in North America. We aim to generate more direct radiocarbon dates on horses from the terminal Pleistocene. This will increase the robustness of the estimates of extinction timing and our understanding of the temporal overlap of horses and Paleoindian groups. With new radiocarbon dates, we will be able to develop a chronology for the timing of their continent-wide extirpation. Using stable isotope analysis of terminal Pleistocene horse remains, we will look at change over time leading up to extinction to map the possibilities of extinction due to dietary restriction and inter-specific competition. More radiocarbon dates using modern pretreatment methods on both new and previously dated specimens will test this overlap so horse exploitation can be assessed with confidence. The models used to estimate extinction timing and population dynamics prior to extinction will be tested with multiple ‘tiers’ of radiocarbon dates, where dates run using differing pretreatment methods will be grouped and modelled separately to assess how the model results change based on the reliability of the radiocarbon data input. This will influence archaeologists’ understanding of the radiocarbon record and address concerns related to the quality of the radiocarbon dates with which we rely on to draw conclusions.

Intellectual Merit

This interdisciplinary project has implications for both the megafaunal extinction debate and archaeologists’ understanding and interpretation of radiocarbon dates on bone collagen. By studying human and horse interaction in North America at the end of the last ice age, our understanding of this relationship is broadened. Using this extinction timing question as an exemplification, this research also addresses the reliability of results achieved through different types of radiocarbon pretreatment processes. The results of this study will be important to scholars in many different STEM disciplines including Biology, Earth and Planetary Sciences, and Environmental Sciences, as well as Anthropology.

Broader Impacts

The role of humans in late Pleistocene extinctions is a topic with wide scientific significance, in part due to parallels with modern anthropogenic climate change and extinctions. Modelling the extinction of a particular taxon rather than a suite of them will not only provide new insight into Pleistocene extinction, but it will also provide evidence for how a taxon supposedly resistant to extinction or extirpation can go extinct in a relatively short amount of time. In light of present-day rapid climate change and anthropogenically-caused extinctions, the study of past extinctions provides insight into the reasons why some species are more vulnerable to extinction than others. Results will be broadly disseminated, both in scientific publications and through outreach to public audiences.

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*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

PROJECT DESCRIPTION

Introduction

Much has been written about the causes for and process of megafaunal extinction at the end of the last ice age, particularly in North America, where 38 genera went extinct shortly before the beginning of the Younger Dryas at 12,800 cal. BP. Despite this history, however, the causes and condition of this extinction event remain debated. The research proposed here will track this extinction event through the trajectory of aims of one megafauna taxon, the terminal Pleistocene Equini — North American horses — using radiocarbon dating and stable isotope paleoecology. In so doing, the co-PI will address the following overarching question: given our understanding of prey choice, the radiocarbon record, and horse paleoecology, is there evidence for human contribution to the extinction of Pleistocene horses in North America? This question encompasses three specific aims: establishing an estimated time of extinction of Equini, analyzing the reliability of radiocarbon dating techniques in extinction models, and tracking palaeoecological change in Equini through the terminal Pleistocene. In analyzing existing data and data gathered through this project in tandem, this project will determine the efficacy of radiocarbon dating pretreatment and establish an extinction date for an important taxon that shared the landscape with humans. The co-PI will interpret these results within a broader archaeological context based on principles of behavioral ecology and prey choice modelling, to explore evidence surrounding the relationship between Paleoindian groups and Pleistocene horses.

Pleistocene Extinctions and the North American Radiocarbon Record

Megafaunal Extinction. This extinction event was size-selective, affecting terrestrial mammals with an adult body mass of > 44 kg. In North America, the extinction occurred over a few hundred years and was largely synchronous (Broughton & Weitzel, 2018; Faith & Surovell, 2009; Owen-Smith, 1999). Considerable debate has continued since the 1960s about the role (or lack thereof) of humans in the extinction of these species (Martin & Wright, 1967; Martin, Paul S., 1984). Though all contributors to this debate have heavily relied on climate data, ecological modelling, and paleontological and archaeological evidence to make their claims, much of this debate has focused on chronological coincidences of climate change, human arrival, and megafaunal extinction, with the youngest recorded date of species occurrence, or the last appearance date, being a critical component of these arguments (Dehasque et al., 2021; McFarlane, 1999; Surovell et al., 2016).

To unravel the uncertainty behind megafauna extinctions, it is crucial to identify broad patterns in megafaunal extinction and on an individual-species level (Finlayson et al., 2012; Meltzer, 2020; Wolverton et al., 2009). However, all arguments in the megafaunal extinction debate are currently being made using limited evidence, particularly those that include fauna that are not well dated (Nagaoka et al., 2018; Pelton et al., 2022). Because of this, we cannot robustly analyze patterns in the archaeological/paleontological record without more in-depth work on the individual genera that became extinct or extirpated from the North American continent. This work includes the analysis of life-histories and the creation of better chronologies leading up to extinction (Grayson et al., 2021; Meltzer, 2020; Wolfe & Broughton, 2021).

Pleistocene Equini. Horses are one of several taxa that evolved in the Americas tens of millions of years ago, and survived innumerable climatic shifts, only to go rapidly and abruptly extinct just prior to the Holocene (Barrón-Ortiz et al., 2019; Buck & Bard, 2007). Horses are considerably less well dated than other megafaunal taxa, likely because they occur infrequently in human occupation levels at archaeological sites (Grayson & Meltzer, 2015). Combined with the uncertainty in the timing of humans' late Pleistocene arrival in the Americas, this makes assessment of human effect on megafaunal extinction challenging. Because of this, horses have long been featured in arguments for climate-induced extinction of megafauna given the lack of evidence for human hunting of horses in North America and poor representation of specimens that date from the period of human arrival in the Americas (Dale Guthrie, 2006; Grayson, 2007; Grayson & Meltzer, 2003).

Despite the lack of dates, horses are common in terminal Pleistocene deposits from the North American continent, and human hunting of equids in the eastern hemisphere throughout the late Quaternary is well documented (Feyfant et al., 2015; Hoffecker et al., 2010; Olsen, 1989; W. Taylor et al., 2020). Additionally, horses are a common taxon in paleontological and archaeological sites from the Central Russian Plain to western Beringia (Leonardi et al., 2018). Though this may not indicate that human hunting directly led to the extirpation of horses in North America, it does have implications for human/horse paleoecology while sharing a landscape. Additionally, it is worth considering that horses were a primary source of food in Eurasia during the late Pleistocene (Hoffecker et al., 2010; Soffer, 1985), and this may suggest that the first peoples to arrive in North America were proficient horse hunters. However, this behavior would not necessarily have belonged to hunters outside of Beringia.

Previous studies (Byers & Ugan, 2005; Cannon & Meltzer, 2004; Grayson & Meltzer, 2015) have largely excluded horses from Paleoindian diet because of the dearth of kill sites and the broad acceptance that humans and horses did not overlap significantly in the western hemisphere. Given our understanding of horse hunting in Eurasia and the unresolved nature of the megafaunal extinction debate, human involvement in the extirpation of Equini from North America is possible, but it needs to be tested. Based on the taxon's wide range (Rubenstein et al., 2016), flexible diet (Schoenecker et al., 2016), and survival in Eurasia, North American horses are not a prime candidate for extinction by environmental change alone. Despite this, their presence in terminal Pleistocene geologic deposits, and the role that they have played in the megafaunal extinction debate, relatively little is known about horse extinction in the Americas at the end of the last ice age.

Environmental change would be at play here. Climate instability between the Bølling-Allerød and the Younger Dryas likely caused significant changes to the abundance of graze and browse in North and South America, limiting the food resources shared among bison, horse, camel, and mammoth (Graham & Lundelius, 1984). This climate-based extinction model is supported by a recent study showing dietary stress on equid populations at the end of the Pleistocene, while bison were affected little by the change in graze availability (Barrón-Ortiz et al., 2019). Throughout the North American continent, megafauna appear to have suffered from the terminal Pleistocene climate in a see-saw pattern, with horses being no exception (Meltzer, 2020; Stewart et al., 2021).

Analyses of horses' dietary niches during the late Pleistocene have shown that horses had considerable dietary flexibility despite their dramatic range reduction (Schwartz-Narbonne et al., 2019). Further, stable isotope studies indicate that equids were mixed feeders throughout the western hemisphere (Pérez-Crespo et al., 2018), a testament to the dietary flexibility that is observed today in extant equids, evidenced by their considerable historic range throughout Eurasia (Fages et al., 2019; Leonardi et al., 2018). This is further supported by the persistence of caballine horses in Eurasia through the terminal Pleistocene to the present, despite noted population bottlenecks just prior to the Holocene (Leonardi et al. 2018). It is unresolved why horses experienced different fates in different hemispheres, although one must also consider that in contrast to Europe and Asia, humans were a very new, very recent predator in eastern Beringia and farther south, potentially altering the predator-prey dynamic considerably, a dynamic which did not occur in Eurasia, where there were millions of years of coevolution between horses and humans (Martin & Steadman, 1999; Smith et al., 2016, 2019).

Recent discoveries of horse kill and butchering sites at Wally's Beach, Alberta (Kooyman et al., 2001, 2006; Waters et al., 2015), and at Bluefish Caves, Yukon Territory (Bourgeon & Burke, 2021), have yielded the only direct evidence of human exploitation of horse in North America. Many more known sites have been implicated as possibly holding similar evidence, but they have yet to be fully explored for evidence of human-horse interaction (e.g. Haury et al., 1975; Hemmings, 2008; Yohe & Bamforth, 2013). If humans and horses overlapped on a continental scale for hundreds to thousands of years before the disappearance of the horse, this overlap has significant implications for the human prey choice models at the end of the Pleistocene and therefore, potentially, the causes for extinction.

Given all of this, human involvement in the extirpation of Equini from North America is possible, but remains a hypothesis in need to testing. The research proposed here addresses the above issues by using three different methods. It will produce much-needed new radiocarbon dates to generate a better chronology of horse extinction in North America; it will conduct a palaeoecological analysis of the species; and it will test whether or not the estimated extirpation timing of horses in North America is robust by using the best radiocarbon dating of bones and teeth. This research focuses on the temporal and geographic proximity of horses and studied Paleoindian groups and offers a palaeoecological assessment of the Equini based on molecular evidence.

Research Design

By generating an approximate extinction date and date range, examining the differences in model results caused by laboratory chemical preparation procedures, and looking at palaeoecological change over time, this proposed research will generate new information on Pleistocene Equini and consider these variables in context of the megafaunal extinction debate. This is important because it emphasizes an archaeological perspective on extinction modelling, especially as scientists address the vulnerability today of species that may have appeared unaffected to extinction pressures. This will provide a dialog about the inclusion of species that are included in extinction models and how radiocarbon dating techniques can affect results.

Ethics and the destructive analysis of horse remains. The reintroduction of the modern horse *Equus caballus* into the Americas with the arrival of European colonizers in the 15th century was nothing short of prodigious. While Spanish horses were initially used for the suppression of indigenous peoples, these same horses quickly became integral to Native Americans' lifestyles, power, and resistance (Kelekna, 2009; Mitchell, 2015). Eurasian domestic and then feral horses spread through the North American continent before 1600 CE, often outpacing European conquest (W. T. T. Taylor et al., 2023). Shortly after their arrival on the continent, horses and horsemanship became embedded in many indigenous cultures as sacred (Mitchell 2015). In many of these indigenous cultures, particularly on the Northern Plains, traditional knowledge and indigenous knowledge argues that Pleistocene horses never faced extinction and have had relationships with these cultures for time immemorial (Collin, 2017). In our investigation of Pleistocene horse extinction, the co-PI will consider these Indigenous perspectives when selecting our specimens for sampling.

Both because horses are currently considered by some to be sacred animals and because archaeological/paleontological remains are a finite resource, the authors recognize that these museum resources should be treated with respect. The research proposed here is inherently destructive and will cause permanent damage to the museum specimens involved in this study. Museums balance their responsibility for preserving samples for future generations and the protection of non-renewable resources with their mission to be knowledge generating institutions accessible to the public and to researchers (Internationaler Museumsrat, 2017; *NPS Museum Handbook, Part III - Museums & Collections (U.S. National Park Service)*, n.d.).

While the destructive sampling and study of human remains is well discussed and regulated, the destructive sampling of zooarchaeological material is regulated to a much smaller extent. Zooarchaeological remains can provide a plethora of valuable information that must be weighed against the cost of destructive sampling. Zooarchaeological material cannot be replenished and therefore sampling to a minimal degree is preferable. Responsible zooarchaeological sampling includes collaboration, having a sampling strategy, keeping track of your sample information, obtaining appropriate permissions, strategizing what you sample, taking only what you need, and providing a shared record of your research (Pálsdóttir et al., 2019). This study plans to adhere to these principles.

Behavioral ecology. The conclusions that will be drawn about human/horse interactions will be based on a behavioral ecology framework. These principles will be used in two ways concerning diet. The first will be informed by the outcomes of the extinction timing estimates. Using behavioral ecology logic, what we know about human diet, and the prey choice model, the co-PI will draw conclusions about the human hunting of horses based on evidence for their shared presence on the landscape. Based on the body mass of horses, evidence for their procurement in Eurasia as well the two North American sites, and record of other megafaunal hunting by Paleoindians, it is assumed that horses would be hunted upon encounter, as explained through ecological observation and ethnographic analogy (Bird & O'Connell, 2006; Jones, 2004; Surovell & Waguespack, 2009). Whether or not this behavior would have contributed to the extinction of the horse in North America is affected by encounter rate, though even a small additional negative force on horse populations could push the animals to a tipping point or across a biological threshold if horses were under stress already (Botero et al., 2015; Ripple et al., 2016).

This research will also employ behavioral ecology is to explain the behavior of the horses themselves. Using the stable isotope record to examine the 'health' of the species leading to extinction is based on the logic that horses will optimize their diet to the landscape they are occupying. If a species is experiencing dietary stress, behavioral ecology argues that it will still optimize its diet despite the resource depression or degradation (Broughton, 1994; Charnov et al., 1976; Nagaoka, 2002). However, as dietary stress increases, a species will consume on average an increasingly less optimal diet, which may be visible in stable isotope value change over time (Pilaar Birch, 2013). Horses prefer grasses to browse (Barrón-Ortiz et al., 2019; Menard et al., 2002) and if horses incorporate more browse into their diets at the end of the Pleistocene, this would likely be visible in their bone collagen stable isotope values that would record dietary stress. This may be visible if the proportion of 'heavy-value' **C_4** grasses decreased in the diet over time and 'lighter' valued forage increased, particularly with the so-called 'canopy effect' of increasing tree cover driving lighter values (Allen et al., 2017; Bonafini et al., 2013). Though this is unlikely to be traceable with a small sample size, this research will incorporate newly-generated values with previously published data.

Radiocarbon dating techniques. Direct absolute dating of megafaunal remains is key to understanding the extinction timing of these genera. The reliability of the dating technique chosen for this task is crucial for the production of accurate extinction timing estimates. Since the inception of radiocarbon dating, the physics of ^{14}C measurement and chemical processing techniques have improved over time, increasing the precision and accuracy of dates. Today, though it is common practice in all accredited radiocarbon laboratories to prepare bone samples for collagen analysis, these pretreatment processes vary widely among laboratories. Considerable work has shown that chemical pretreatment techniques affect the ^{14}C dates of specimens and therefore the conclusions that we draw about them (Brock, Higham, Ditchfield, et al., 2010; Devièse et al., 2018; Fiedel et al., 2013). Collagen produces the most accurate ^{14}C dates, when special care is taken to remove exogenous carbon (Stafford et al., 1990, 1991). Dates on XAD-2 resin purified collagen isolated from bone collagen are widely recognized to be the most reliable form of pretreatment (Fiedel et al., 2013; Herrando-Pérez, 2021), because it chemically separates amino acids in collagen from humates and other contaminants (Stafford et al., 1988).

The co-PI will use this XAD-purification method in our research to ensure that the highest quality dates and stable isotope values are obtained. This is necessary for establishing accurate extinction dates and identifying palaeoecological indicators in the horse bone record. This method was developed by Stafford and colleagues in the 1980's (Stafford et al., 1988) and uses hydrolysis and the hydrophobic resin XAD-2 to chemically separate contaminating humates from collagen-derived amino acids. This intensive pretreatment process is especially helpful for radiocarbon dating late Pleistocene bone that has experienced over 13,000 years of contamination during burial (Stafford, 2014).

However, XAD pretreatment is not widespread and commercial laboratories instead rely on either direct dating of gelatin or ultrafiltration techniques to remove humic acids (Brock et al., 2007; Higham et al., 2006). Though this is often effective in producing an accurate radiocarbon date, highly contaminated specimens cannot be fully purified without the removal of chemically bonded humates (Stafford et al., 1988). This is especially true for conclusions made about radiocarbon dates on late Pleistocene aged bone (Devièse et al., 2018). Because accurate dating is essential for unravelling the causes of late Pleistocene megafaunal extinction, the co-PI will use this pretreatment method for this project to produce new dates on terminal Pleistocene horse specimens. This research aims to compare the reliability of XAD pretreated ^{14}C dates to other types of pretreatment in extinction timing models. This will assess the changes in model outcome that occur from using different quality data.

Stable isotope analysis. Using stable isotope analyses is a powerful tool for assessing the paleoecology of individuals and groups. Using stable isotope geochemistry, we can develop a diet profile from an individual's remains, including protein and carbohydrate sources (Froehle et al., 2010), trophic level (DeNiro & Epstein, 1981), and the percentage of C_3 and C_4 plants consumed by an individual (DeNiro and Epstein, 1978). Stable isotope ratios from vertebrate remains reflect the animal's diet, including protein and carbohydrate sources and the relative reliance on plants with different photosynthetic pathways, as well as other aspects of their ecology such as trophic level (see review in Shipley & Matich, 2020). Additionally, because diet is tied to environment, stable isotope geochemistry can be used to infer the environment in which the individual lived (e.g., Bowen et al., 2005). C_3, C_4, and CAM plants are defined by their photosynthetic pathway and how the plants fractionate CO_2 and its stable carbon isotopes (Farquhar et al., 1989). Because of their different photosynthetic pathways, the incorporation of CO_2 into plant biomass is differentiated among C_3 C_4 and CAM plants, which have unique ranges of $\delta^{13}C$ values (Farquhar et al., 1989). Examples of C_3 plants are trees, shrubs, and temperate environment grasses; C_4 plants as grasses in hotter, more arid climates, (Lee-Thorp et al., 1989) and succulents (Griffiths, 1992) within the CAM group. Different tissue types and different isotopic systems reflect different aspects of diet and environment. Bone collagen records the $\delta^{15}N$ and $\delta^{13}C$ values of protein in an organism's diet (Froehle et al., 2010; Sealy et al., 2014). Environmental conditions have been shown to have a significant effect on $\delta^{15}N$ values as well, where hot, xeric environments elevate the $\delta^{15}N$ values of the organisms living in them relative to cool hydric environs (Cormie & Schwarcz, 1996; Hartman, 2011). Carbon and nitrogen values reflect diet and physiological stress, which are indicators of whether or not a species may be struggling biologically (Ballutaud et al., 2022). The co-PI will compare our new stable isotope data with those previously published along with their associated radiocarbon dates. The co-PI will collect and vet these data in similar ways to the radiocarbon dataset. This is crucial for getting accurate values that are representative of horse paleoecology. This research will identify patterns in the data preceding extinction.

Preliminary data

For her Master's project at UNM, the co-PI aggregated and analyzed published radiocarbon dates on horse specimens from the terminal Pleistocene in North America. Using the available data, the co-PI and her committee noted a substantial lack of dated horse specimens from south of the coalesced Laurentide and Cordilleran ice sheets in North America as compared to the number of dated horse specimens from Beringia. A statistical analysis of these data revealed that there are numerous radiocarbon dates on horses from both regions that show significant temporal overlap with humans on the continent. This has prompted further investigation of this timeline, accounting for issues with the accurate radiocarbon dating of Pleistocene bone. Already, the co-PI is working with local museums and has, as of fall 2024, radiocarbon dated, conducted stable isotope analysis, and amino acid analysis on two horse specimens from New Mexican cave sites. They yielded the following terminal Pleistocene dates: 12,930 ±30 and 11,740 ±30 (UCIAMS 298793 and UCIAMS 298794). Based on the stable isotope evidence, the younger dating individual had a notably higher stable nitrogen and stable carbon values than the older dating individual. The amino acid analysis on these two specimens and several others of varying degrees of preservation quality showed a clear correlation between the amount of hydroxyproline and the fossil's ability to yield sufficient collagen to date. These preliminary analyses and data show that there is work to be done on fleshing out the radiocarbon record of Pleistocene horses in North America as well as the wealth of molecular information that can be achieved in this pursuit.

Research Questions and Predictions (Table 1.)

Extinction timing. The first question directly addresses our lack of knowledge about Equini extinction timing. Though simple, this question is crucial to our understanding of extinction causes because timing is the foundation for all other data. Further, as behavioral ecology principles state that high-ranked resources should be taken upon encounter, establishing the duration that humans and horses shared the landscape is essential for drawing conclusions about the Paleoindian groups that could have included horses in their diet. This is most readily achieved through radiocarbon dating of bone collagen. In this research, the co-PI will estimate an extinction date or dates and compare those times to established Paleoindian technocomplexes through an analysis of new and published radiocarbon dates. Primary question 1: **Based on radiocarbon evidence, when did the Tribe Equini go extinct in North America?** Hypothesis: The extinction times of *Equus* and *Harringtonhippus* will post-date the emergence of some Paleoindian technocomplexes in North America. The co-PI is choosing to compare the timing of horse extinction to published date range estimates of Paleoindian technocomplexes that have well established age ranges south of the ice sheets. This estimate of extinction timing and the chronology of radiocarbon dates are prerequisites for drawing conclusions about extinction causes and associated evidence.

Work is needed to demonstrate the reliability of previous radiocarbon dates on bone and therefore the results of models that employ them. Because of the importance of reliable dates in the execution of extinction models that use radiocarbon, this research is focusing on radiocarbon dating preparatory techniques in two ways. First, the co-PI will use the most comprehensive pretreatment process on the samples that are included in the project (XAD-2 purification). This will ensure that the dates generated in this study will be inherently accurate. Then, the co-PI will gather data on pretreatment methods and results from other horse dates for comparison. This work will include specimens that have been dated by previous workers as part of a redating focus to ensure the accuracy of the extinction timing models to address the following question: **does the XAD-2 pretreatment method change the dates of horse specimens that have also been dated using different chemical methods?** With new dates using the most comprehensive pretreatment technique and previously run dates also using XAD-2, this research can compare how extinction estimates differ using different pretreatment methods on previously published samples and our own sub-samples using different techniques. With this in mind, this research will address the second sub-question: **how does the reliability of a radiocarbon date affect the outcome of summed probability distributions models and the Calibration-Resampled Inverse-Weighted McInerny Method? Are the results appreciably different?** The co-PI will do this by separating new and published radiocarbon dates into tiers by our assessment of reliability based on pretreatment and running the models of interest with each set of data and comparing the outcomes for horse extinction timing given our new influx of dates.

Horse paleoecology. Our second primary question seeks to address extinction causality from a paleoecological perspective. The terminal Pleistocene is characterized by rapid global climate change and ecosystem turnover, which tested the adaptability and flexibility of species on the landscape. Research has shown that Pleistocene horses are primarily grazers, with their ecological niche conserved to present day (Barrón-Ortiz et al., 2019; Leonardi et al., 2018). Identifying a palaeoecological shift away from grazing would indicate that Pleistocene horses were consuming less than optimal diets and were therefore under dietary stress. This investigation will question conclusions about horse extinction causes by looking directly at evidence for environmental stress. Primary Question 2: **Prior to the extinction of late Pleistocene horses on the North American continent, is there evidence for a dietary shift that would indicate its species were under stresses unrelated to and independent of human hunting?**

Hypothesis: Leading up to extinction, there will be a detectable shift in Equini paleoecology that is indicative of non-hunting related stress. This will help establish the health of the species that humans encountered during the terminal Pleistocene and what pressures horses were experiencing simultaneously.

Data Collection and Analytical Methods

New samples. This investigation will use museum specimens from archaeological, paleontological, biological, and geological collections to draw conclusions about horse extinction and the effect of radiocarbon preparatory techniques. The research will include approximately 55 new ^{14}C dates on bone collagen, 5-10 of which will be re-dates of previously dated specimens. An additional 10 samples will be selected and subsampled for chemical preparation using ultrafiltration, a very common, though possibly less accurate form of pretreatment. These will function as direct comparisons between XAD prep and ultrafiltration prep. This research is interested in previously dated specimens to assess the difference that XAD pretreatment makes on dating collagen. The co-PI will select these specimens based on their previously published ages, age ranges, and the pretreatment technique that was used. Any pretreatment process that was used besides ultrafiltration, XAD, or single amino acid is of particular interest, as with dates that have large standard deviations and/or date from the early Holocene. In total, the co-PI will request at least 65 specimens because a certain percentage of specimens will fail to yield collagen due to poor chemical preservation, insufficient size, or both. The authors are allowing that approximately 15 specimens may not be dateable. See Figure 1 for a graphic on the breakdown of these specimens/samples over laboratories and analyses.

This investigation is limited to horses that have been identified as *Equus* and *Harringtonhippus* because of their comparability to modern horses and because of the unresolved nature of the equid phylogeny. The new dates and stable isotope values generated here will be from specimens found in North America south of late glacial maxima for the coalesced Laurentide and Cordilleran ice sheets. All samples that will be included in this analysis are currently housed at accredited museums in the United States or Canada. These collections are a variety of paleontological, geological, biological, and archaeological materials. For this research, the co-PI will submit destructive analysis research requests to each museum that houses specimens that are of interest for sampling. Each request will be reviewed by a committee from the given institution.

The co-PI will sample the museum specimens using a steel jeweler's saw or diamond tipped Dremel blade that is the appropriate size and shape for best preserving the integrity of the specimen. The blade will be changed after each fossil to prevent cross-contamination. Each sample will weigh approximately 1g. The co-PI will photograph the specimen both before and after sampling. A small amount of material from each sample will be analyzed by Fourier transform infrared (FTIR) spectroscopy in the Center for Stable Isotopes at the University of New Mexico. FTIR is a minimally destructive technique that provides an estimate on the collagen preservation of a specimen and is frequently used as a precursor to other molecular analyses of bone (Berthomieu & Hienerwadel, 2009). This information is not only valuable for determining if a specimen should be sampled further, but also why a specimen may or may not be preserved enough to yield collagen (Trayler et al., 2024). If the estimated collagen yield is sufficient, the co-PI will proceed with radiocarbon and stable isotope pretreatments. The co-PI will take photos during the chemical processing in addition to laboratory records to document the behavior of the samples throughout the process.

The co-PI will assess the accuracy of stable isotope and ^{14}C results by using their reported C/N ratios, %N on bone (Brock, Higham, & Ramsey, 2010). After the radiocarbon and stable isotope analyses are completed, the co-PI will send 10 selected samples to the Molecular Facility at the UC-Davis Genome Center for quantitative amino acid analysis. This will provide information on the direct causes for success and failure of samples during radiocarbon/stable isotope sample prep. Amino acid analysis is a powerful tool for comparing hard evidence for preservation at the protein level to proxy evidence for bone preservation, such as FTIR, C/N ratios, %N, and the physical appearance of the prepared collagen. Amino acid analysis of several specimens will help us understand and test the quality of the radiocarbon dates and stable isotope values are received.

Previously analyzed samples. The published radiocarbon dates will be gathered from databases such as the Canadian Radiocarbon Database, the Digital Archaeological Record, Neotoma, and other peer-reviewed sources. These data will be vetted for accuracy based on the quality of the radiocarbon prep process, what tissues were dated, and the instrumentation used. Namely, there is currently a database that has been created by Dr. Salvador Herrando-Perez et al. that has aggregated a considerable number of radiocarbon dates on Pleistocene aged bone, including information on the prep technique that was used on them. This database, likely to be formally launched this year, will be a key resource in locating radiocarbon dates on horses and the techniques used for ^{14}C dating.

Bone pretreatment procedures. The co-PI for this research will primarily use the Center for Stable Isotopes at the University of New Mexico for the preparation of samples whose pretreated collagen will be combusted to CO_2 and the gas sent for graphitization and dating at the W. M. Keck Carbon Cycle Accelerator Mass Spectrometer (KCCAMS) Facility at the University of California – Irvine for ^{14}C dating. The co-PI has stable isotope and radiocarbon prep procedure experience at the Paleoecology Laboratory at Iowa State University and the KCCAMS facility at the University of California – Irvine. The UNM Center for Stable Isotopes (CSI) has its own collagen XAD preparation protocol, which the co-PI will use to prepare the samples. The ultrafiltration protocols at CSI are based on those developed at KCCAMS, at the Oxford Radiocarbon Accelerator Unit (Brock, Higham, & Ramsey, 2010), and the XAD methods by Stafford (Stafford et al. 1988, Stafford 2014). The collagen preparation comprises physical cleaning, demineralization, and isolation techniques developed by Longin (1971). The co-PI will follow these procedures by demineralizing the bone with an acid-base-acid process, gelatinization, eliminating humic acids with sodium hydroxide, hydrolyzing the collagen, and purifying the resulting amino acid hydrolyzate with XAD-2 resin before drying and combustion. The co-PI will prepare and analyze several samples using both ultrafiltration and XAD to compare the results. The co-PI will send a sample of ~5 specimens for amino acid analysis to assess preservation.

The co-PI will prepare a selected portion of samples in the Higham Lab within the Department of Evolutionary Anthropology in the Faculty of Life Sciences at the University of Vienna, Austria. This is a state-of-the-art radiocarbon preparatory facility and is connected to the accelerator mass spectrometer at the University of Vienna. Dr. Thomas Higham, the laboratory director, has given the co-PI permission to prepare samples using XAD-2 pretreatment and extract and date both collagen-derived amino acids and humates from these samples. The ^{14}C measurements and isotope analyses will be done at the University of Vienna Mass Spectrometry Centre. The authors have decided to split the radiocarbon and stable isotope prep and analyses between the Center for Stable Isotopes and the Higham Laboratory for three reasons. The first being that the Higham Laboratory is one of the best equipped laboratories in the world for purifying and extracting collagen from late Pleistocene-aged specimens. More difficult specimens that may have failed at CSI can be taken and retried at the Higham Laboratory. The second reason is the experimental mission of the Higham Laboratory where they can extract and date very small amounts of collagen. The third reason is based on the scientific principle of replicability and the unique opportunity that the use of multiple laboratories gives to make sure that the results are checked and replicable. Additionally, collaboration between different laboratories broadens connections, the dispersal of results, and opportunities for improvement.

Extinction timing modelling. The data, both newly generated and collected from previous studies, will be separated into groups based on radiocarbon pretreatment type (eg., XAD, ultrafiltration, single amino acid, unfiltered collagen, bone apatite, whole bone, etc.) and run in models in multiple tiers.

To examine the distribution of radiocarbon dates in Pleistocene horses, our newly generated radiocarbon dates will be compiled with previously published radiocarbon dates in a kernel density estimate distribution model to visually observe the change in frequency over time. As taphonomic and diagenetic losses increase as time moves toward the 55ka limit of radiocarbon dating, this distribution provides a heuristic to gauge the taphonomic bias that is being captured in the population of radiocarbon dates on horses. These kernel density estimates are a type of summed probability distribution and will be compared using Kolmogorov–Smirnov tests. Summed probability distributions (SPDs) take a set of established distributions and 'stacks' them to create a composite distribution over a given time window. The most common archaeological use of SPDs is the aggregation of calibrated radiocarbon date probability distributions. They have been used as a metric for population change over time since the early 2000s, with the assumption that frequency of dates reflects an increased number of actors on the landscape (Kelly et al., 2025; Williams, 2012). This is based on the idea that more humans on the landscape equates to a higher probability of being radiocarbon dated by scientists in the future. In other words, SPDs use the "date as data" approach (Rick, 1987). Though SPDs are subject to strong biases because of preservation and sampling, they do provide a perspective on relative rises and falls of population, particularly near the end of a record.

SPDs can be powerful when examining patterns later in their time range, such as initial decline dates, which are important for teasing out the causes of end-Pleistocene megafaunal extinctions (Pelton et al., 2022). The co-PI will calibrate, aggregate, and analyze the late Pleistocene radiocarbon dates presented here using the rcarbon package in R (Crema & Bevan, 2021). The rcarbon package uses the same calibration as OxCal (Ramsey et al., 2010) along the IntCal20 curve (Reimer et al., 2020) and produces a probability density for each date and accompanying 2σ range. To further minimize the artificial wiggles in the SPD caused by variations in the calibration curve, the co-PI will transform these data into a calibrated Kernel Density Estimate (cKDE) (Brown, 2017). An example of this using the co-PI's master's project work is displayed in Figure 2. This process uses Monte Carlo simulation to randomly sample calendar dates from within each defined bin. In this analysis, the results are drawn into a cKDE envelope and then recalibrated into a resulting distribution, which ultimately is a smoothed version of the original SPD. These distributions can then be compared to how radiocarbon date frequency varies predictably and naturally over time and space (Surovell & Pelton, 2016).

The co-PI will also put these data into the Calibration-Resampled Inverse-Weighted McInerny (CRIWM) method, an extinction timing model that accounts for the Signor-Lipps Effect (Raup, 1986) that estimates the last appearance date of a species. These analyses will be done in the R coding language using the package Rextinct (Herrando-Pérez & Saltré, 2024). The CRIWM is based on previous, well-recognized extinction timing models: the Gaussian-Resampled Inverse-Weighted McInerny (Bradshaw et al., 2012) and the original McInerny et al. (2006) method. These models attempt to ameliorate the Signor-Lipps effect — the fact that it's essentially impossible to ever find the first or last specimen of a species and determine the absolute extinction date, a time invisible in the paleontological record (Raup, 1986). These models use the frequency, distribution, and margin-of-error on dates to model an estimated extinction date beyond just the last recovered specimen and are considered to have high model accuracy (Saltré et al., 2015).

The recently developed CRIWM method, developed and described by Salvador Herrando-Perez and Frédérik Saltré, models extinction timing using calibrated radiocarbon date distributions instead of the Gaussian distributions associated with uncalibrated radiocarbon dates. This improves the accuracy of these extinction-date estimates because it emphasizes the peaks and dips of the date probability within calibrated distribution rather than just the center-of-the-error term. This method defines extinction timing as the date when the probability of the existence of a given species is low enough for the researcher to consider it extinct. This is an arbitrary value defined by the researcher. The co-PI intends to run and discuss multiple probability cutoffs between p=0.001 to p=1.0. This is calculated by randomly sampling one value from the distribution of each dated sample to create a time series of resampled ages, calculating extinction time as the year in which the probability of finding a new fossil falls beneath the set cutoff, and then repeating these steps 10,000 times to create an estimate of extinction timing with error.

Palaeoecological assessment. The stable isotopes of carbon and nitrogen are measured on a subsample of the same chemical fraction used for AMS ^{14}C dating. With these data, the co-PI will examine horse dietary changes over time. Today, the average $\delta^{13}C$ value of a C_3 plant globally is -25‰, though the range is from -20 to -37‰, while C_4 plants have average $\delta^{13}C$ values ~9.7‰ (Kohn, 2010) and CAMS plants average -18‰ (Gilman & Edwards, 2020). The $\delta^{13}C_{apatite}$ and $\delta^{13}C_{collagen}$ values for bone can provide estimates of the relative amount of C_3 vs. C_4 plants that made up an individual's diet when computed in a linear mixing model (Froehle et al., 2010; Kellner & Schoeninger, 2007). The observed dietary C_4 contribution will be quantified based on collagen using a simple two-factor mixing model described in Fry (2006). The proportion of C_4 plants in the horses' diets will be determined from the bone collagen results using the following equation:

$$1: \% C_4 = (\delta^{13}C_{Sample} - \delta^{13}C_{C3})/(\delta^{13}C_{C3} - \delta^{13}C_{C4})$$

Using this metric as well as placing trend lines through our data, this research will look at changes in carbon and nitrogen values over time to draw conclusions about horse dietary stress. The observed trends in our data will be compared to known environmental changes during the terminal Pleistocene and available palaeoecological records for North America.

Conclusion

To our knowledge, this is the first research project to comprehensively address North American late Pleistocene horse extinction from an archaeological viewpoint and the first to look specifically at horse extinction in North America outside of Beringia using radiocarbon. Our work will yield new data on an understudied group — Equini — that despite being well understood in Eurasia archaeological record, have yet to be appreciated in reference to Paleoindian peoples and their diet/landscape interactions. Broadening our understanding of horses in North America will add to our archaeological conception of the importance of Equini globally. This project also addresses important discrepancies in the laboratory procedures that determine the radiocarbon results on which we rely so heavily as archaeologists. By understanding how model results are affected by radiocarbon dating chemistry, archaeologists will be better informed about possible problems in their conclusions. This research is relevant to debates in multiple fields, including megafaunal extinctions, the peopling of the Americas, and modern climate change.

BROADER IMPACTS

The human role in Pleistocene extinctions is a topic with wide scientific significance, in part due to parallels with modern anthropogenic climate change and extinctions. The fate of Equini and its temporal overlap with late Pleistocene humans is a key component of the debate. This research will provide important contextual information on the extinction of mammalian species in light of human-caused ecosystem change while producing new information on molecular archaeology methods. Modelling the extinction of a particular taxon rather than a suite of taxa will not only provide new insight into Pleistocene extinctions, but will also provide evidence for how taxa thought to be resistant to extinction can go extinct in a relatively short amount of time. This project will support the doctoral training of a woman in science. In this project, questions about horse extinction and extirpation will be studied using museum collections, a type of research that is under-represented in archaeological research, despite its utility. In light of present-day rapid climate change and anthropogenically-caused extinctions, the study of past extinctions provides insight into the reasons why some species are more vulnerable to extinctions than others. In current extinction models, Pleistocene horses would have been low on the list of species likely to die out because the family Equidae evolved in North America and has over a 50-million-year presence in the Americas. Results will be broadly disseminated in scientific publications.

Table 1. Research questions

Question	Method	Analytical Approach
Primary question 1: Based on radiocarbon evidence, when did the Tribe of horses, Equini, go extinct in North America?	Direct AMS radiocarbon dating of Pleistocene Equini specimens using XAD-2 resin purification of collagen hydrolyzates.	Modelling of published and vetted radiocarbon dates on late Pleistocene Equini using composite kernel density estimates and the Calibration-Resampled Inverse-Weighted McInerny Method model
Sub-question 1: How does the reliability of a radiocarbon date affect the outcome of summed probability models and the Calibration-Resampled Inverse-Weighted McInerny Method?	Creation of five tiers of radiocarbon dates on late Pleistocene horse material from both newly dated fossils and previously published radiocarbon dates	Kolmogorov–Smirnov test to compare summed distribution models and multiple runs of the Calibration-Resampled Inverse-Weighted McInerny Method model
Sub-question 2: Does XAD-2 dating change the age of previously dated youngest-dated Pleistocene horse specimens and fossils with latest Pleistocene (11-15 ka RC ages?	Direct AMS radiocarbon dating of Pleistocene Equini specimens using XAD-2 purification from bone collagen and additional dating of the extracted contaminants	Comparison of calibrated date distributions of previously published versus new dates on the same material and acknowledgement of offset from dated contaminants
Primary Question 2: Is there evidence for a palaeoecological shift for ~~the genus~~ Equini prior to extinction in North America and which would indicate that the species was under environmental stress independent of human hunting?	Direct $\delta^{13}C$ and $\delta^{15}N$ stable isotope analysis of Pleistocene Equini specimens using XAD-2 purification of bone collagen	Placing new and previously vetted, published stable isotope data into a time series using corresponding radiocarbon dates and comparing patterns in the North American data to data from Eurasia

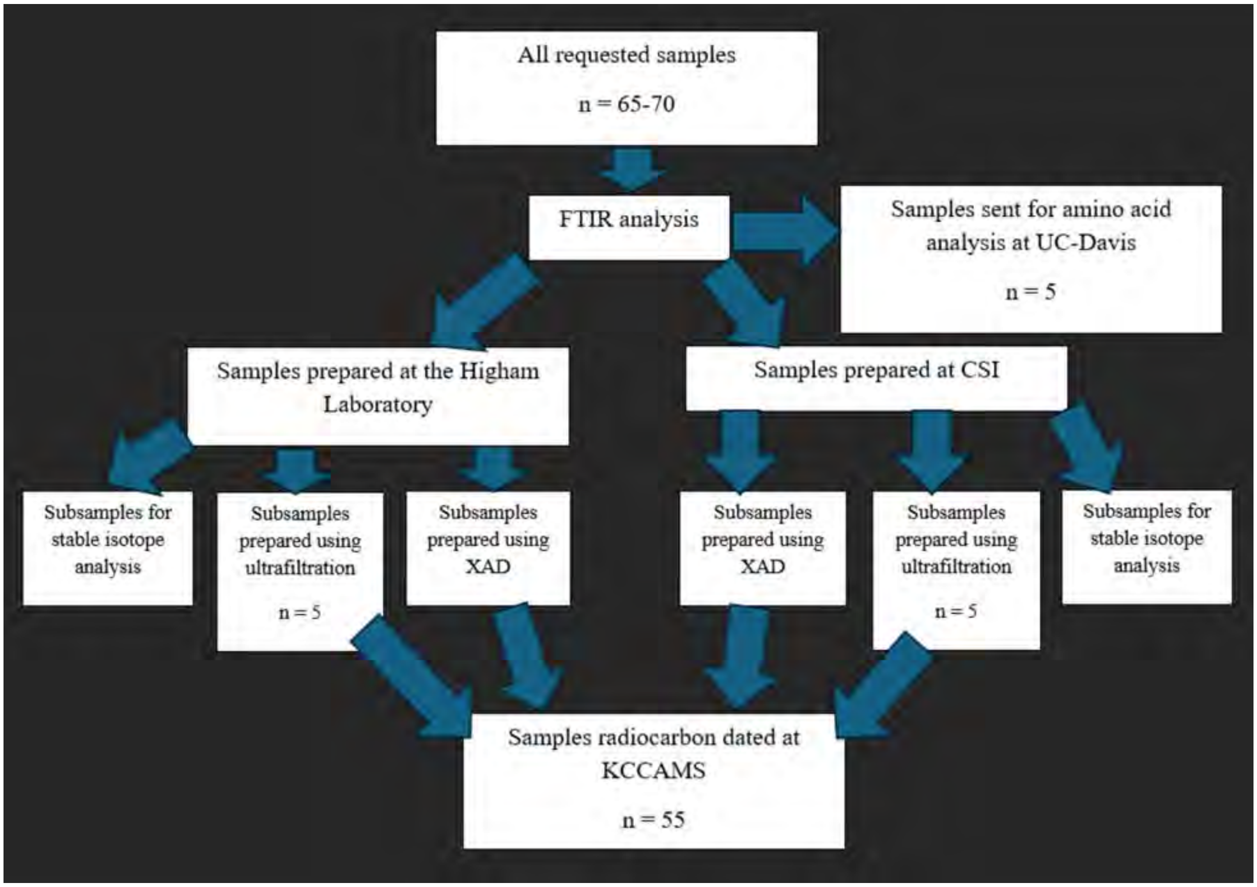

Figure 1. Planned path of samples in the proposed research.

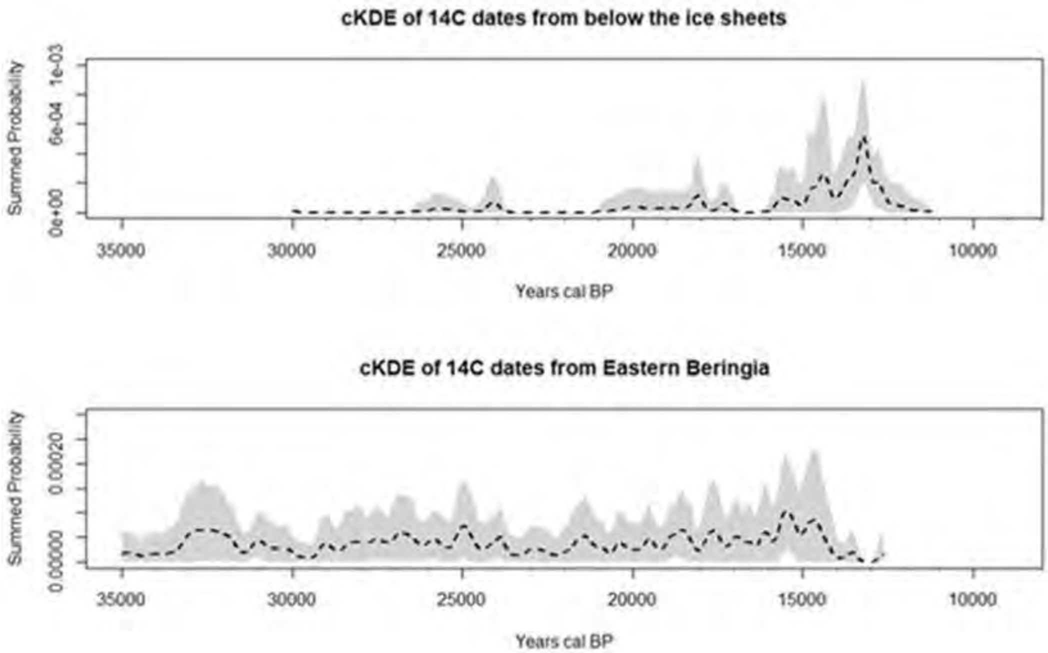

Figure 2. Composite kernel density estimates from the co-PI's previous work on the distribution of horse dates during the terminal Pleistocene.

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Submitted/PI: [redacted]

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION University of New Mexico	FOR NSF USE ONLY			
	PROPOSAL NO. 2530104	DURATION (months)		
		Proposed	Granted	
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR [redacted]	AWARD NO.			

A. SENIOR/KEY PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior/ Key Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1.					
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.0			0	
7. ( ) TOTAL SENIOR/KEY PERSONNEL (1 - 6)	0.0			0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.0			0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.0			0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				3,230	
2. INTERNATIONAL				4,400	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				8,270	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				9,100	
TOTAL OTHER DIRECT COSTS				17,370	
H. TOTAL DIRECT COSTS (A THROUGH G)				25,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Modified Total Direct Cost (Rate: 52.5, Base:25000)					
TOTAL INDIRECT COSTS (F&A)				13,125	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				38,125	
K. FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				38,125	

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $		
PI/PD NAME Emily Jones	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* Glenna Doctor	Date Checked	Date Of Rate Sheet	Initials - ORG

*ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Submitted/PI: [redacted]

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION University of New Mexico				FOR NSF USE ONLY PROPOSAL NO. 2530104	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR [redacted]				AWARD NO.		
A. SENIOR/KEY PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior/ Key Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1.						
2.						
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)						
7. ( ) TOTAL SENIOR/KEY PERSONNEL (1 - 6)	0.0			0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.0			0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.0			0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				0		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				3,230		
2. INTERNATIONAL				4,400		
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $ 0						
2. TRAVEL 0						
3. SUBSISTENCE 0						
4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				8,270		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				9,100		
TOTAL OTHER DIRECT COSTS				17,370		
H. TOTAL DIRECT COSTS (A THROUGH G)				25,000		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				13,125		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				38,125		
K. FEE				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				38,125		
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME Emily Jones				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* Glenna Doctor				Date Checked	Date Of Rate Sheet	Initials - ORG

*ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

UNIVERSITY OF NEW MEXICO
BUDGET JUSTIFICATION

E. TRAVEL

Domestic: A total of $3,230 is requested to support three trips to museums within the United States, such as the Nebraska State Museum, the University of Arizona Paleonological Collections, and the CU-Boulder Museum of Natural History. The estimated costs include airfare ($500), lodging ($176/night x 2 nights = $352), and Per diem ($75 x 3 days = $225).

International: A total of $4,400 is requested to support travel to perform fieldwork in Vienna, Austria. The graduate student will perform this field work in coordination with the Higham Laboratory at the University of Vienna. The estimated cost is based on official state rates and Google Flight searches and includes airfare ($900) and lodging + Per diem ($250 a day x 14 days = $3,500).

Total Travel: $7,630

G. OTHER DIRECT COSTS

Lab Supplies: We request $8,270 to cover the following supplies:
Collagen Sample Preparation at the Center for Stable Isotopes – XAD radiocarbon prep at $205 x 28 units at the total cost of $6,150
Collagen Sample Preparation at the Center for Stable Isotopes – Ultrafiltration radiocarbon prep at $190 x 10 units for $1,900
Collagen XAD Sample Prep at the University of Vienna at $42 x 15 units at the total of $639
Total Lab Supplies: $8,270

Service: Funds are requested for the following listed analysis:
KCCAMS graphitization and C14 measurement at the cost of $135 x 53 units = 7,155
CSI IRMS Measurement at the cost of $15 x 28 units = $420
CSI FTIR Measurement at the cost of $5 x 53 units = $265
Vienna Mass Spectrometry Centre IRMS Measurement at the cost of $24 x 15 units = $360
UC-Davis Molecular Structure Facility Amino Acid Analysis at the cost of $121 x 5 units = $605
Total Service: $8,805

Postage: We include $295 in postage fees.

H. TOTAL DIRECT COSTS (A-G)
Total $25,000

I. INDIRECT COSTS
Indirect Costs are assessed according to the University of New Mexico's Negotiated Indirect Cost Rate Agreement with DHHS, dated March 9, 2022 including predetermined and provisional rates, which can be accessed at: https://osp.unm.edu/resources/unmrateagreement.pdf. Per the University's negotiated rate agreement, the overhead rate on the project will be 52.5% of a modified total direct cost base for On-Campus Organized Research Programs.
Total $13,125

J. TOTAL AMOUNT REQUESTED (H+I)
Total $38,125

FACILITIES AND OTHER RESOURCES

Sample acquisition: Samples for this research will be acquired from accredited museums in the United States and Canada. The co-PI is in contact with staff at the Nebraska State Museum, the Royal Museum of Alberta, the UTEP Biological Collections, the CU-Boulder Natural History Museum, the University of Arizona Paleontology Collections, and the New Mexico Museum of Natural History and Science. She has been approved in the past for destructive analysis at three of these institutions. The co-PI will plan on making trips to at least four of these institutions to examine specimens in person and sample them. Specimens may be sent from museums to the University of New Mecxico (UNM) for sampling.

Using standard zooarchaeological and museum practices, the co-PI will sample specimens using a diamond tipped Dremel tool with either a saw blade or boring end. These will be provided by the co-PI. The Dremel tips will be switched out for clean tips between each sample to minimize potential contamination. The tips will be cleaned at the Center for Stable Isotopes on the UNM campus. Each sample will be stored in a borosilicate glass vial, provided by small personal grants received by the co-PI. Samples and specimens will be kept in the UNM Zooarchaeology Laboratory (https://anthropology.unm.edu/research/research-labs/lab/zooarchaeology-lab.html) while they await further processing.

Center for Stable Isotopes (CSI): The co-PI will conduct FTIR, radiocarbon/stable isotope prep to the combustion stage, and IRMS analysis at CSI (https://csi.unm.edu/center-stable-isotopes). As one of the largest stable isotope centers (607 sq. ft.) in the U.S. in terms of instrumentation and cutting-edge analytical capabilities, the Center for Stable Isotopes (CSI) collaborates with approximately 50 universities and research institutions throughout the world on their research. The CSI laboratories have four newly constructed climate-controlled rooms equipped with seven isotope ratio mass spectrometers, one quadrupole gas chromatograph mass spectrometer (GC-MS) system, and laboratory space for processing a variety of samples for isotope analysis.

Higham Laboratory, University of Vienna: The co-PI will conduct radiocarbon/stable isotope prep to the combustion stage at the Higham Laboratory (https://highamlab.univie.ac.at/). This laboratory is based in the Department of Evolutionary Anthropology in the Faculty of Life Sciences and is a new state-of-the-art climate controlled facility. It undertakes rigorous radiocarbon pretreatment chemistry on challenging samples from around the world up to 50,000 BP. IRMS will be done on these samples at the University of Vienna Mass Spectrometry Centre, which includes a variety of instruments for molecular and isotopic measurements (https://msc.univie.ac.at/instruments/).

W. M. Keck Carbon Cycle Accelerator Mass Spectrometer Facility (KCCAMS): After the samples have completed pretreatment, the co-PI will send them as CO_2 gas inside of sealed glass combustion tubes to KCCAMS for graphitization and ^{14}C, %C, %N, $\delta^{13}C$, and $\delta^{15}N$ meausrements. KCCAMS is considered to be one of the best mass spectrometry facilities in the world and frequently returns analytical error ranges of tens of years on Pleistocene aged samples (https://sites.ps.uci.edu/kccams/).

Molecular Structure Facility: The Molecular Structure Facility is part of the UC-Davis Gemone Center and provides amino acid analysis and proteomics services (https://msf.ucdavis.edu/amino-acid-analysis). The facility operates Three Hitachi (L-8800, L-8800a, L-8900) amino acid analyzers that use ion-exchange chromatography and a "post-column" ninhydrin reaction detection system. The co-PI will send this facilty small (less than 100mg) whole bone samples for this analysis.

IDENTIFYING INFORMATION:

NAME: [redacted]

ORCID iD: [redacted]

POSITION TITLE: [redacted]

PRIMARY ORGANIZATION AND LOCATION: University of New Mexico, Department of Anthropology, Albuquerque, New Mexico, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
[redacted]	[redacted]	[redacted]	Anthropology
			Anthropology
			Anthropology
			Anthropology

Appointments and Positions

[redacted]

Products

Products Most Closely Related to the Proposed Project

[redacted]

[redacted]

Other Significant Products, Whether or Not Related to the Proposed Project

[redacted]

Certification:

I certify that the information provided is current, accurate, and complete. This includes but is not limited to current, pending, and other support (both foreign and domestic) as defined in 42 U.S.C. § 6605.

I also certify that, at the time of submission, I am not a party to a malign foreign talent recruitment program.

Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by [redacted] in SciENcv on 2025-03-24 13:32:29

IDENTIFYING INFORMATION:

NAME: [redacted]

ORCID iD: [redacted]

POSITION TITLE: [redacted]

PRIMARY ORGANIZATION AND LOCATION: University of New Mexico, Albuquerque, New Mexico, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
[redacted]	[redacted]	[redacted]	Anthropology Anthropology

Appointments and Positions

[redacted]

Products

Products Most Closely Related to the Proposed Project

[redacted]

Other Significant Products, Whether or Not Related to the Proposed Project

Certification:

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I also certify that, at the time of submission, I am not a party to a malign foreign talent recruitment program.

Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by [redacted] in SciENcv on 2025-03-12 15:47:02

Other Personnel Biographical Information

Data Not Available

CURRENT AND PENDING (OTHER) SUPPORT INFORMATION

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person.

*NAME: [redacted]

PERSISTENT IDENTIFIER (PID) OF THE SENIOR/KEY PERSON: [redacted]

*POSITION TITLE: [redacted]

*ORGANIZATION AND LOCATION: University of New Mexico, Albuquerque, New Mexico, United States

Proposals/Active Projects

***Proposal/Active Project Title:** Doctoral Dissertation Research: Process of Faunal Domestication

***Status of Support:** Current

Proposal/Award Number: 2203297

***Source of Support:** National Science Foundation

***Primary Place of Performance:** Albuquerque, NM

***Proposal/Active Project Start Date: (MM/YYYY):** 05/2022

***Proposal/Active Project End Date: (MM/YYYY):** 05/2024

***Total Anticipated Proposal/Project Amount:** $9,080

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2022	0.01
2023	0.01

***Overall Objectives:** Doctoral dissertation research support for graduate student [redacted]

***Statement of Potential Overlap:** None

***Proposal/Active Project Title:** Collaborative Research: Horses and Human Societies in the American West

***Status of Support:** Current

Proposal/Award Number: 1949304

***Source of Support:** National Science Foundation

***Primary Place of Performance:** Albuquerque, NM

***Proposal/Active Project Start Date: (MM/YYYY):** 06/2020

***Proposal/Active Project End Date: (MM/YYYY):** 05/2023

***Total Anticipated Proposal/Project Amount:** $39,394

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2020	0.25
2021	0.5
2022	0.5
2023	0.25

***Overall Objectives:** Investigation of the reintroduction and spread of the horse in the historic North American West

***Statement of Potential Overlap:** none

***Proposal/Active Project Title:** Horse stories: new perspectives on horses in North America

***Status of Support:** Pending

Proposal/Award Number:

***Source of Support:** National Endowment for the Humanities

***Primary Place of Performance:** New Mexico

***Proposal/Active Project Start Date: (MM/YYYY):** 02/2026

***Proposal/Active Project End Date: (MM/YYYY):** 02/2029

***Total Anticipated Proposal/Project Amount:** $39,962

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2027	1
2028	1
2029	1

***Overall Objectives:** Creation of a book manuscript focused on Indigenous stories about horses

***Statement of Potential Overlap:** None (this project deals with horses in the recent past and today).

***Proposal/Active Project Title:** American Bees: the introduction of the European honeybee and its impact on human-pollinator interaction webs in protohistoric North America

***Status of Support:** Pending

Proposal/Award Number:

***Source of Support:** Guggenheim Foundation

***Primary Place of Performance:** Albuquerque, New Mexico

***Proposal/Active Project Start Date: (MM/YYYY):** 07/2025

***Proposal/Active Project End Date: (MM/YYYY):** 06/2026

***Total Anticipated Proposal/Project Amount:** $30,000

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2026	8

***Overall Objectives:** Archival research on the introduction of the European honeybee

***Statement of Potential Overlap:** none

***Proposal/Active Project Title:** This proposal

***Status of Support:** Pending

Proposal/Award Number:

***Source of Support:** National Science Foundation

***Primary Place of Performance:** Albuquerque, New Mexico

***Proposal/Active Project Start Date: (MM/YYYY):** 06/2025

***Proposal/Active Project End Date: (MM/YYYY):** 05/2026

***Total Anticipated Proposal/Project Amount:** $38,125

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2026	1

***Overall Objectives:** Supervisor of doctoral research performed by [redacted]

***Statement of Potential Overlap:** None

Certification:

I certify that the information provided is current, accurate, and complete. This includes but is not limited to current, pending, and other support (both foreign and domestic) as defined in 42 U.S.C. § 6605.

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Certified by [redacted] *in SciENcv on 2025-03-24 14:14:05*

CURRENT AND PENDING (OTHER) SUPPORT INFORMATION

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person.

*NAME: [redacted]

PERSISTENT IDENTIFIER (PID) OF THE SENIOR/KEY PERSON: [redacted]

*POSITION TITLE: [redacted]

*ORGANIZATION AND LOCATION: University of New Mexico, Albuquerque, New Mexico, United States

Proposals/Active Projects

***Proposal/Active Project Title:** Assessing Support for Human-Caused Extinction of Pleistocene Horses in the Radiocarbon Record

***Status of Support:** Pending

Proposal/Award Number:

***Source of Support:** HEAS Seed Grant

***Primary Place of Performance:** Higham Laboratory, University of Vienna

***Proposal/Active Project Start Date: (MM/YYYY):** 10/2025

***Proposal/Active Project End Date: (MM/YYYY):** 07/2026

***Total Anticipated Proposal/Project Amount:** $3,242

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2026	2

***Overall Objectives:** A HEAS Seed Grant is designed to provide support for students working on their research in laboratories at the University of Vienna. This grant would support the co-PI for room and board in Vienna during her time working in the Higham Laboratory.

***Statement of Potential Overlap:** None.

***Proposal/Active Project Title:** Assessing the timing of Pleistocene horse extinction in the Southwest and their overlap with Paleoindians

***Status of Support:** Pending

Proposal/Award Number:

***Source of Support:** UNM Center for Regional Studies Project Fellowship

***Primary Place of Performance:** University of New Mexico

***Proposal/Active Project Start Date: (MM/YYYY):** 08/2025

***Proposal/Active Project End Date: (MM/YYYY):** 05/2026

***Total Anticipated Proposal/Project Amount:** $6,000

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2025	1
2026	1

***Overall Objectives:** Receive funding for dissertation travel/research expenses, produce a presentation based on how dissertation relates to the American Southwest region.

***Statement of Potential Overlap:** None.

***Proposal/Active Project Title:** Assessing the timing of Pleistocene horse extinction in the Southwest and their overlap with Paleoindians

***Status of Support:** Pending

Proposal/Award Number:

***Source of Support:** Frank C. Hibben Trust and The Maxwell Museum of Anthropology

***Primary Place of Performance:** University of New Mexico

***Proposal/Active Project Start Date: (MM/YYYY):** 08/2025

***Proposal/Active Project End Date: (MM/YYYY):** 05/2026

***Total Anticipated Proposal/Project Amount:** $16,000

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2025	1
2026	1

***Overall Objectives:** The Hibben Foundation provides a stipend during the school year for advanced graduate students conducting research in the American Southwest.

***Statement of Potential Overlap:** None.

***Proposal/Active Project Title:** UNM Anthropology Graduate Student Grants

***Status of Support:** Pending

Proposal/Award Number:

***Source of Support:** University of New Mexico Dept. of Anthropology

***Primary Place of Performance:** University of New Mexico

***Proposal/Active Project Start Date: (MM/YYYY):** 04/2025

***Proposal/Active Project End Date: (MM/YYYY):** 10/2025

***Total Anticipated Proposal/Project Amount:** $3,000

*** Person Months per budget period Devoted to the Proposal/Active Project:**

Year	Person Months
2025	1

***Overall Objectives:** Receive a small grant for research/travel expenses related to dissertation.

***Statement of Potential Overlap:** None.

Certification:

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I also certify that, at the time of submission, I am not a party to a malign foreign talent recruitment program.

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Certified by [redacted] *in SciENcv on 2025-03-24 12:16:10*

Submitted/PI: [redacted]

Table 1

1	Your Name:	Your Organizational Affiliation(s), last 12 mo	Last Active Date
	[redacted]	University of New Mexico	

Table 2

2	Name:	Type of Relationship	Optional (email, Department)	Last Active Date
R	[redacted]	Family		

Table 3

3	Advisor/Advisee Name:	Organizational Affiliation	Optional (email, Department)
G	[redacted]	University of Washington	
G		University of Washington	
T		University of Colorado-Boulder	
T		Pacific Northwest National Laboratory	
T		Adams State University	
T		Crow Canyon Archaeological Center	
T		Universidade do Algarve	
T		University of Bergen	
T		Bureau of Land Management	
T		Office of Archaeological Studies, New Mexico	
T		Maxwell Museum of Anthropology	
T		University of New Mexico	
T		University of New Mexico	

Table 4

4	Name:	Organizational Affiliation	Optional (email, Department)	Last Active Date
C	[redacted]	Sacramento State University		02/01/23
C		University of Oklahoma		11/01/24
C		University of Oklahoma		11/01/24
C		University of Colorado-Boulder		05/01/25
C		New Mexico Consortium		10/01/24
C		University of New Mexico		04/01/25
A		Universidad de Cantabria		06/01/23
A		American Center for Mongolian Studies		02/01/23

A	[redacted]	University of Colorado-Boulder		02/01/25
C	[redacted]	Pacific Northwest National Laboratories		04/01/25
A	[redacted]	Pacific Northwest National Laboratories		04/01/25
A	[redacted]	Crow Canyon Archaeological Center		07/01/24
A	[redacted]	University of New Mexico		02/01/23
A	[redacted]	Maxwell Museum of Anthropology		04/01/25
A	[redacted]	University of New Mexico		07/01/22
A	[redacted]	University of New Mexico		04/01/25
A	[redacted]	Universidade do Algarve, Faro, Portugal		04/01/25
A	[redacted]	University of Wyoming		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	University of Oxford		
A	[redacted]	University of Michigan		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	American University of Central Asia		
A	[redacted]	McGill University		
A	[redacted]	University of Sydney		
A	[redacted]	Curtin University		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	Max Planck Institute for the Science of Human History		
A	[redacted]	unknown		
A	[redacted]	Brigham Young University		
A	[redacted]	Bureau of Land Management		
A	[redacted]	Northwest University, Xi'An, Shaanxi, China		
A	[redacted]	University of Cape Town		
A	[redacted]	University of Colorado-Boulder		
A	[redacted]	Université Paul Sabatier		
A	[redacted]	Université Paul Sabatier		
A	[redacted]	University of Utah		
A	[redacted]	unknown		
A	[redacted]	University of New Mexico		

A	[redacted]	Universidad de Cantabria		
A	[redacted]	Universidad Tecnológica Nacional, San Rafael, Argentina		
A	[redacted]	Universidad Tecnológica Nacional, San Rafael, Argentina		
A	[redacted]	Universidad Nacional de la Patagonia Austral		
A	[redacted]	University of Arizona		
A	[redacted]	University of Wyoming		
A	[redacted]	Silpakorn University, Bangkok, Thailand		
A	[redacted]	University of Washington		
A	[redacted]	University of Pennsylvania		
A	[redacted]	Thailand Natural History Museum, Pathum Thani, Thailand		
A	[redacted]	University of Otago, New Zealand		
A	[redacted]	University of Washington		
A	[redacted]	Mahasarakham University, Thailand		
A	[redacted]	University College London		
A	[redacted]	University College London		
A	[redacted]	Henan University, China		
A	[redacted]	Henan Provincial Institute of Cultural Heritage and Archaeology		
A	[redacted]	Henan Museum		
A	[redacted]	Henan Provincial Institute of Cultural Heritage and Archaeology		
A	[redacted]	University of Science and Technology of China		
A	[redacted]	Harvard University		
A	[redacted]	Santa Fe Institute		
A	[redacted]	South Ural State University, Russia		
A	[redacted]	Ulaanbaatar University, Mongolia		
A	[redacted]	National Museum of Mongolia		
A	[redacted]	National Museum of Mongolia		
A	[redacted]	Morrison Designs		
A	[redacted]	Tufts University		
A	[redacted]	Colorado State University		
A	[redacted]	Universidade do Algarve, Faro, Portugal		
A	[redacted]	Universidade do Algarve, Faro, Portugal		
A	[redacted]	Rochester Institute of Technology		
A	[redacted]	University of North Carolina-Wilmington		

A	[redacted]	University of West Bohemia, Czech Republic		
A		University of Louisville		
A		University of New Mexico		
A		University of New Mexico		
A		University of New Mexico		
A		University of California-Los Angeles		
A		University of New Mexico		
A		University of New Mexico		
A		Harvard University		
A		Centre for Anthropobiology and Genomics of Toulouse		
A		Oglala Lakota, Pine Ridge Reservation		
A		Comanche Nation		
A		Oglala Lakota, Pine Ridge Reservation		
A		Oglala Lakota, Pine Ridge Reservation		
A		Oglala Lakota, Pine Ridge Reservation		
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A		Oglala Lakota, Pine Ridge Reservation		
A		Oglala Lakota, Pine Ridge Reservation		
A		History Colorado		
A		Pueblo of Acoma		
A	[redacted]	Centre for Anthropobiology and Genomics of Toulouse		
A		Centre for Anthropobiology and Genomics of Toulouse		
A		Centre for Anthropobiology and Genomics of Toulouse		
A		Centre for Anthropobiology and Genomics of Toulouse		
A		Centre for Anthropobiology and Genomics of Toulouse		
A		Centre for Anthropobiology and Genomics of Toulouse		
A		Centre for Anthropobiology and Genomics of Toulouse		
A		Centre for Anthropobiology and Genomics of Toulouse		
A		Alaska Pacific University		
A		Kentucky Archaeological Survey, Western Kentucky University		
A		W.S. Webb Museum of Anthropology, University of Kentucky		
A		Conservation and Evolutionary Genetics Group, Estación		

		Biológica de Doñana (EBD-CSIC)		
A	[redacted]	Laboratorio de Paleontologia y Paleobiologia, Instituto Andaluz del Patrimonio Historico		
A		Université Paris-Saclay		
A		Musée de l'Armée, Hotel des Invalides		
A		Musée de l'Armée, Hotel des Invalides		
A		Musée de l'Armée, Hotel des Invalides		
A		The Royal Danish Academy		
A		University of California Santa Cruz		
A		University of Southampton		
A		Institute for Anthropological Research		
A		CNRS		
A		Faculty of History, University of Oxford		
A		Genoscope, Institut de biologie Francois Jacob, CEA, CNRS, Université d'Evry		
A		Genoscope, Institut de biologie Francois Jacob, CEA, CNRS, Université d'Evry		
A		Taif University		
A		Princess Nourah bint Abdulrahman University		
A		Zoology Department, College of Science, King Saud University		
A		University of Zagreb		
A		University of Zagreb		
A		University of Edinburgh		
A		Max Planck Institute for the Science of Human History		
A		Archeological Consultant		
A	[redacted]	Texas A & M		
A		SWCA		
A		University of Arizona		
A		University of Colorado-Boulder		
A		University of Colorado-Boulder		
A		Adams State University		
A		Royal Alberta Museum		
A		University of Colorado-Boulder		
A		University of California, Santa Cruz		
A		Univeristy of California, Irvine		
A		Dartmoor Hill Pony Association		
A		Dartmoor Hill Pony Association		

A	[redacted]	University of Exeter		
A	[redacted]	Sul Ross State University		
A	[redacted]	Florida Department of Health		
A	[redacted]	Swedish University of Agricultural Sciences		
A	[redacted]	Xeni Gwet'in First Nations Government		
A	[redacted]	McCrory Wildlife Services Ltd.		
A	[redacted]	Swedish University of Agricultural Sciences		
A	[redacted]	KU Leuven		
A	[redacted]	Plateforme GeT-PlaGe - Génome et Transcriptome		
A	[redacted]	Plateforme GeT-PlaGe - Génome et Transcriptome		
A	[redacted]	Plateforme GeT-PlaGe - Génome et Transcriptome		
A	[redacted]	Université Paris-Saclay		
A	[redacted]	University of Oklahoma		
A	[redacted]	University of Oklahoma		
A	[redacted]	University of New Mexico		
A	[redacted]	Pueblo de San Ildefonso		
A	[redacted]	University of Colorado-Boulder		
A	[redacted]	University of Colorado-Boulder		
A	[redacted]	Southern Methodist University		
A	[redacted]	CONICET		
A	[redacted]	CONICET		
A	[redacted]	CONICET		
A	[redacted]	University of York		
A	[redacted]	University of York		
A	[redacted]	University of York		
A	[redacted]	University of York		
A	[redacted]	University of York		
A	[redacted]	Centre for Anthropobiology and Genomics of Toulouse		

Table 5

5	Name:	Organizational Affiliation	Journal/Collection	Last Active Date
B	[redacted]	Yale University	Journal of Archaeological Science: Reports	
B	[redacted]	University of Tulsa	Journal of Archaeological Science: Reports	
E	[redacted]	University of Rhode Island	Journal of Archaeological Science: Reports	

Table 1

1	Your Name:	Your Organizational Affiliation(s), last 12 mo	Last Active Date
	[redacted]	University of New Mexico	

Table 2

2	Name:	Type of Relationship	Optional (email, Department)	Last Active Date

Table 3

3	Advisor/Advisee Name:	Organizational Affiliation	Optional (email, Department)
G	[redacted]	University of New Mexico	Anthropology

Table 4

4	Name:	Organizational Affiliation	Optional (email, Department)	Last Active Date
A	[redacted]	University of New Mexico	Anthropology	
A	[redacted]	Pacific Northwest National Laboratories		
A	[redacted]	University of New Mexico	Anthropology	
A	[redacted]	National Science Museum, Thailand		

Table 5

5	Name:	Organizational Affiliation	Journal/Collection	Last Active Date

[redacted]
Synergistic Activities
24 March 2025

- 2024 recipient of the Newcomb Cleveland Prize (for best paper published in *Science*) from American Association for the Advancement of Science (AAAS)
- Service to local community as a subject expert in the archaeology of central and northern New Mexico, including interviews for film industry; lectures for local avocational organizations such as the Albuquerque Archaeological Society, Friends of Tijeras Pueblo, and Friends of Coronado State Historic Site; and archaeological training/education for landholders
- Board member for the Gallina Research Institute for Indigenous Technology (GRIIT), 2021 – Present
- Panelist for numerous grant review panels, including IIE's Fulbright Scholar Program Peer Review Panel (2018, 2019, 2020), Fulbright Student National Screening Panel (2018, 2019), and National Science Foundation's Graduate Research Fellowship Program Panel (2022)
- Service to professional community through peer reviews for funding agencies, professional journals, and presses; member of the *Journal of Archaeological Science: Reports* editorial board, 2014 – present; member of the University of New Mexico Press committee, 2019 – present.

Name: [redacted]
Position Title: PhD Student
Primary Organization and Location: University of New Mexico, Albuquerque, NM

Synergistic Activities:

1. Development of Non-parametric Statistics in Archeology course (in progress)
2. Development of course material in an Archaeology methods lab (currently teaching)
3. Participation in the NSF funded interdisciplinary Museum Research Traineeship at the University of New Mexico
4. Volunteer note taker for meetings of the ARID Institute at the University of New Mexico
5. Public presentations of research findings at the New Mexico Museum of Natural History and Science

DATA MANAGEMENT PLAN

Roles and responsibilities

The data produced in this project are both physical and digital. During the research, the co-PI will request to destructively sample museum specimens, create physical samples from these specimens, photograph specimens and samples, process these samples for chemical and molecular data, and analyze these data digitally. The co-PI will manage the data so that it is available to all participating during the research and available to the public and other researchers in perpetuity after the research's completion. The co-PI and the UNM Libraries' Data Curation Librarian will supervise and ensure proper adherence to this plan.

The specimens received via mail will remain in their original packaging within the Zooarchaeology Laboratory in the Anthropology Annex at the University of New Mexico (https://anthropology.unm.edu/research/research-labs/lab/zooarchaeology-lab.html) during their time before and after sampling. Before the samples are taken/sent to the laboratory for processing, these 1g samples will be kept in borosilicate glass vials also in the Zooarchaeology Laboratory. A portion of each sample will be archived in case the prep needs to be redone for any reason during the research. These archived samples will be kept in the Zooarchaeology Laboratory.

Expected data

This research will produce photographs of museum specimens and their associated samples, laboratory notes and records, FTIR analysis results, IRMS (stable isotope) analysis results, AMS (radiocarbon dating) results, amino acid analysis results, R script, and R input files. The photos will be of every specimen and every sample prior to processing and the estimated size of these image files is 3-4GB (n=200, as .JPEG). We estimate that the tabular files used in this study will not exceed 2GB of total space. The computer analysis and modelling done by the co-PI on these data will create R Markdown files, estimated to be no more than 1GB total. To budget for enough space, we believe that the entirety of this research will take less than 15GB.

Period of data retention

The co-PI will retain sole rights over the research results until all results have been published in peer-reviewed journals or until a period of 12 months after the completion of this DDRIG grant funding. Each published article will include relevant data in the form of an appendix, table, or supplementary data section. During this research, the image and tabular laboratory analysis data will be stored locally in UNM's OneDrive so that the data can be accessed by the PI, co-PI, and other interested parties with permission. UNM's OneDrive is backed up daily and accessible via the internet. The R markdown files and their associated data files, which will include all new molecular data and the previously published data that we will use in our analyses, will be kept in a version-controlled GitHub repository with a permissive license.

Data format and dissemination

The data from FTIR, stable isotope, radiocarbon, and amino acid analyses will be tabular in nature and will be stored and used in a non-proprietary format such as .CSV. The README files containing the results of these analyses will include information on the individual runs, the laboratories and instruments involved, and the standards/blanks included in the analyses. The co-PI will adhere to guidelines produced by Archaeology Data Services and Digital Antiquity The files in the GitHub repository will include

README files according to GitHub's guidance: https://docs.github.com/en/repositories/managing-your-repositorys-settings-and-features/customizing-your-repository/about-readmes. These will include metadata on the authors, licensing, funding, publication, type, date, and use of the data. The highest quality of metadata standards will be ensured using the standards of peer-reviewed journals and relevant repositories.

Data storage and preservation of access

For long-term storage, the tabular FTIR, stable isotope, radiocarbon, and amino acid data, direct from the utilized laboratories, will be held in the Dryad open data publishing database, using UNM's subscription to the service for a minimum of 10 years. Additionally, a copy of the R Markdown scripts and their associated files will also be housed in Dryad along with the image files. The authors will give permission for the files to be public domain. README files for the data will be produced according to Dryad guidance: https://datadryad.org/best_practices. For researchers and the public who may wish to replicate the computer modelling and analyses, a copy of the R Markdown scripts and their associated files will be kept on previously mentioned same GitHub repository. Once the data is published in Dryad, a DOI will be produced that can be used to cite and data. The location of these data will be made known through any publication produced from this research.

Submitted/PI: [redacted]

DEPARTMENT OF ANTHROPOLOGY
MSC01 1040
1 University of New Mexico
Albuquerque, NM 87131

To: NSF Archaeology Program
From: [redacted]

By signing below, I affirm that I have read the proposal, and that, barring unforeseen circumstances, the student will be prepared to undertake the research within 12 months of the submission window. I agree to be available during the performance of the research in order to relay information and communications from NSF to the student.

Signed: [redacted]

Organization: University of New Mexico

Date: 24 March 2025

DEPARTMENT OF ANTHROPOLOGY
MSC01 1040
1 University of New Mexico
Albuquerque, NM 87131

March 9, 2025

To: National Science Foundation
From: [redacted]

If the proposal submitted by [redacted] entitled "Assessing Support for Human-Caused Extinction of Pleistocene Horses in the Radiocarbon Record" is selected for funding by NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description or the Facilities, Equipment and Other Resources section of the proposal.

[redacted]

universität wien

Submitted/PI: [redacted]

Department of Evolutionary Anthropology

[redacted]

Thursday, 6th March 2025

Letter of support for your NSF proposal

To Whom It May Concern:

I am writing concerning a proposal submitted by [redacted] entitled "Assessing Support for Human-Caused Extinction of Pleistocene Horses in the Radiocarbon Record". If this proposal is selected for funding by NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description or the Facilities, Equipment and Other Resources section of the proposal.

Yours sincerely,

[redacted]

UCI

UNIVERSITY OF CALIFORNIA, IRVINE

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

EARTH SYSTEM SCIENCE DEPARTMENT

[redacted]

March 22 2025

To: NSF Archaeology Program

If the proposal submitted by [redacted] entitled "Assessing Support for Human-Caused Extinction of Pleistocene Horses in the Radiocarbon Record" is selected for funding by NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description or the Facilities, Equipment and Other Resources section of the proposal.

Organization: Keck AMS lab, Earth System Science Dept, University of California Irvine

[redacted]

LIST OF SUGGESTED REVIEWERS

[redacted]

List of Reviewers Not to Include

Data Not Available