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RESEARCH ARTICLE

Extracting the practices of paleogenomics: A study of ancient DNA labs and research in relation to Native Americans and Indigenous peoples

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Abstract

Objectives: The field of paleogenomics has rapidly grown, influencing a range of scientific fields and drawing notice from the public. In the United States, this work is especially salient for Native Americans, who are frequently the subject of ancient DNA analyses, but are less frequently included as researchers, collaborators, or advisors. This article seeks to deepen our understanding of the current state of paleogenomics so that the field can center Indigenous peoples and their experiences, knowledges, and stakes in the research process.

Materials and Methods: We conducted 31 semi-structured interviews with researchers from three paleogenomics labs located in North America and Europe. We used a responsive interviewing technique where the interview resembled a conversation around a set of questions that could change depending upon the interviewee's answers and experiences. We then employed a theme-based analysis of the interviews.

Results: Through this analysis, we are able to identify practices in the field related to training, the structuring of labs and projects, consent, data control, Ancestor care, and funding that influence various forms of engagement with Indigenous peoples, and which foster or delimit ethical commitments to descendant communities.

Discussion: This research not only elucidates contemporary practices in paleogenomics labs but also identifies specific areas of potential intervention to help researchers work toward ethical and collaborative paleogenomic research with Indigenous peoples. Using these results, researchers and community advocates can work toward reorienting the field of paleogenomics toward ethical research with Indigenous peoples.

KEYWORDS
aDNA, ethical research, Indigenous peoples, Native Americans, paleogenomics

1 | INTRODUCTION

In recent years, paleogenomics has blossomed into a dominant discipline of historical, biological, and cultural analysis—a new "celebrity science" that has frequented the covers of *Nature* and *Science*, captured the public imagination, and provoked impassioned debates by scholars in biological anthropology, archaeology, genetics, science and technology studies, and beyond (Gokcumen & Frachetti, 2020; Jones, 2022; Jones & Bösl, 2021; Källén et al., 2021; Zhang, 2021). At the same time, the extraction of DNA from Indigenous Ancestors[1] and their belongings has incited stinging controversies and debates about the field's practices and ethical commitments.

While some studies have unfolded with the consent and partnership of descendant communities (Cui et al., 2013; Lindo et al., 2017; Malhi & Bader, 2019; Matisoo-Smith, 2019; Severson et al., 2022), many others, arguably the far majority of studies, have not (Cortez et al., 2021; Tsosie et al., 2020). The rapid growth of sequenced ancient genomes—from several dozen to thousands in the last decade (Sedig, 2019)—has led to accusations of a "bone rush" as laboratories have sprinted to find sources of data ahead of their scientific competitors (Fox, 2019), and some with the explicit goal to "industrialize" the processing of remains (Lewis-Kraus, 2019). In some cases, extraction of ancient DNA (aDNA) has been undertaken by "middlemen," operating in countries that do not have clear or uniform legal policies on the rights of the dead (Argüelles et al., 2022; Nieves-Colón et al., 2021). Under the banner of the principles of open science, researchers have argued that genomic data should be widely shared among researchers—an attitude that mirrors long-standing arguments against repatriation of ancestral remains, even as such data remains, in practice, fundamentally inaccessible to Indigenous and descendant communities (Cartney et al., 2022; Fox, 2020; Hudson et al., 2020). Meanwhile, the tradition of individual consent in medical science has failed to translate to questions of the sovereign rights of tribal communities over their genetic heritages (Kowal, 2013; O'Rourke et al., 2005; Tsosie et al., 2019). Some approaches to paleogenomics have been critiqued for contorting and distorting the very notion of indigeneity by reducing it to biology (Blanchard et al., 2019; Kowal et al., 2013; Nicholas, 2016; TallBear, 2013). Paleogenomics, and genomics more broadly, largely continues to be a field *about* Indigenous people rather than a field led *by* Indigenous scientists who work *for* and *with* Indigenous communities (Bader et al., 2021; Bentley et al., 2017; Malhi & Bader, 2015).

As a result of these myriad problems and crises, there has been a flurry of proposed policies, principles, and guidelines (Alpaslan-Roodenberg et al., 2021; Claw et al., 2018; Fleskes et al., 2022; Gibbon, 2020; Handsley-Davis et al., 2020; Hudson et al., 2016; Prendergast & Sawchuk, 2018; Sirak & Sedig, 2019; Wagner et al., 2020). This is a welcome and necessary development. And yet, perhaps because of the immediate need for new standards, few of these discussions have started with an analysis of the everyday culture and on-the-ground practices of paleogenomicists (though see Walker, 2020). Such an approach can reveal the mechanisms that underpin current attitudes and practices in aDNA research, which can make implementation of new recommendations more salient.

Critical ethnographic research can deepen our understanding of the current state of the field. Ethnography is used to not only derive an account of the real-life contemporary context selected for study (in this case, the ethical landscape of aDNA research) (Thomas, 1993), but to also pay close attention to the relations of power, control, and decision making that produce the state of things (Creswell, 2013, p. 94). In particular, our ethnographic research pays critical attention to the indelible connections between knowledge and power by centering Indigenous peoples and their experiences, knowledges, and beliefs, as well as their stakes in research. The final intent, then, is to evaluate, based on ethnographic evidence, questions of scientific values, the nature of relationships, perceptions of accountability, and routine practices that can help identify areas of intervention. Hence, the article's goal is an action-oriented analysis.

This article reports on ethnographic interviews with current and former members of three paleogenomics laboratories. The goal of this work is not to look at the *subject* of paleogenomic research, but the researchers themselves. Focusing particularly on researchers who work with Indigenous ancestral remains, our project sought to explore how scientific practitioners view aDNA, and what socio-cultural, legal, and political issues shape their views. How do researchers in genomic laboratories that study aDNA currently approach perceived and real ethical problems in their work? What are their current policies and practices for, inter alia, consent, consultation, engagement, and collaboration? What structural realities create or limit opportunities to engage Indigenous peoples and other often-marginalized communities? We are particularly interested in illuminating how current practices—voluntary and required—align or not with ethical commitments to diverse stakeholders, and especially Indigenous peoples. To be clear, we are not framing "ethics" broadly here, but specifically in relation to community-based and Indigenous-driven ethical frameworks.

2 | MATERIALS AND METHODS

Our analysis is based on 31 semi-structured interviews conducted by Cortez and Colwell. We employed a responsive interviewing technique (Rubin & Rubin, 2012) where the interview resembled a conversation around a set of questions that could change depending upon the interviewee's answers and experiences, and allowed for us to explore follow-up questions. In using responsive interviewing, we sought to create a non-confrontational and non-hierarchical interview environment and process. Our goal was not to judge the principles, values, or viewpoints of interviewees, but to gain an in-depth understanding of them.

These interviews included 23 main questions, excluding sub questions and follow-up questions. Cortez adjusted how each question was asked based on whether interviewees had direct research experience with Indigenous North American Ancestors. If interviewees did not, Cortez explored interviewees perceptions of these topics. Of the 23 main questions, our team analyzed the following 18 questions:

1. How do you gain access to remains for aDNA analysis for your research projects?
2. Do you seek out tribal consent for your research/Should researchers seek out tribal consent?
3. Do you see a difference between consent, consultation, and collaboration?
4. What kinds of relationships have you entered into with tribal communities?
5. Do you feel you have established reciprocal relationships with the community/ies you work with?
6. What motivates and sustains relationships you have formed with communities?
7. What do you see as the potential merits and demerits of aDNA research?
8. How do you take risk into consideration when deciding whether to undertake an aDNA study?
9. Do you incorporate research questions that are important to the communities?
10. Who do you think currently benefits most from aDNA research?
11. How do you return results to communities?/Do you think researchers should return results to communities?
12. Who owns the data?
13. What would an ethical research project look like from start to finish?
14. What forms of institutional oversight, if any, guide your aDNA research?
15. What kinds of ethics training have you received regarding aDNA research?
16. What protocols do you think labs should have to facilitate working with Indigenous communities?
17. What protocols should Indigenous communities have in place to facilitate working with researchers?
18. Do you believe human remains should be repatriated after study? What should happen to lab derivatives?

These interviews ranged from 45 min to 2 h in length and occurred over Zoom in 2020–2021. We spoke with researchers from three labs located in North America and Europe. We invited the participation of members from these labs in our research because of the varying levels of collaboration in each lab. Members within the three labs represent a range of experience with collaborative research projects with Indigenous communities, including limited collaborative research, increasing commitments to collaborative projects, and, in some cases, full commitments to collaboration and Indigenous-driven research. Thus, researchers within these labs include a broad spectrum of practices in the field of paleogenomics. Interviewees included doctoral students in both the early and late stages of their graduate work, postdoctoral researchers, early career principal investigators (PIs), and PIs with decades of aDNA research experience. While interviewees share the fact that they are members of labs that specialize in aDNA research, not everyone Cortez and Colwell interviewed works with Indigenous Ancestors, nor with a DNA. All 31 interviewees are connected, either currently or formerly, to a paleogenomics lab that conducts research with Indigenous North American Ancestors. Twenty-three of those interviewees (including members of the two labs in North America and the one lab in Europe) have direct research experience with Indigenous North American Ancestors.

Further, interviewees included scientists working in Native North American contexts, as well as in Latin America, Europe, Africa, and Oceania. Interviewees included predominantly non-Indigenous scientists, and scientists who had a range of experiences with Indigenous peoples—including researchers who have never met living individuals and communities who participate in contemporary genomics research, to those who have long-standing engagements with Indigenous peoples and nations who participate in paleogenomic research. The interview questions were directed primarily at research that occurs with Indigenous Ancestors in North America, but also considered perspectives on research in other parts of the world. We have de-identified our interviewees in this writing—which includes the use of gender-neutral pronouns for each person—in order to keep them anonymous. To contextualize responses, we provide general information about academic rank. This also aligns with our goal to not complement or condemn specific labs, but to identify the range of trends across the field.

To identify interviewees for the study, we used nonprobabilistic purposive/judgment sampling, combined with snowball sampling (Bernard, 2000, pp. 176–180; Neuman, 2011, pp. 267–269). The first approach was critical given the nature of study topics and interview questions. Because of the research topic, there is a relatively narrow set of people (scientists) within a specific scientific community (genomicists and paleogenomicists) who hold the kind of knowledge and experience necessary to address the interview questions (Guest, 2014, p. 234). Because our research relies on individuals with specialized knowledge, we also used snowball sampling to identify interviewees (Neuman, 2011, p. 268). We spoke with individuals who had a current or former research affiliation with one of the three paleogenomics laboratories that we identified to participate in our project.

Our work builds upon scholarship that examines the ethics of paleogenomic research (Argüelles et al., 2022; Bader et al., 2021; Bardill, 2014; Bardill et al., 2018; Claw et al., 2017; Cortez et al., 2021; Fox & Hawks, 2019; Tsosie, Bader, et al., 2021), and has sought to establish ethical principles and guidelines for such work (Bader et al., 2021; Handsley-Davis et al., 2020; Wagner et al., 2020). We aim to add to these efforts by contributing an analysis of the context in which this work occurs, as well as an analysis of the perspectives of those scientists who conduct this work. This NSF-funded work includes research on the current ethical landscape of paleogenomics, as well as fostering dialogue oriented toward including Indigenous-led perspectives in this work.

We, the team of researchers on this article, reflect a wide variety of professional contexts, academic disciplines, and personal backgrounds—including geneticists, the four fields of anthropology, and both Indigenous and non-Indigenous scholars—which allow for a range of "readings" of the interviews. We acknowledge that our readings are informed by these positionalities. To address this, we had an initial team of four: the responses to each question were independently analyzed by two team members, and then the two team members compared their analyses; we then compiled the responses into themes and had two team members summarize them; after which, all team members reviewed and edited; finally, the entire leadership team of the project reviewed the article and contributed their interpretations to it. Our analysis draws on all 31 interviews, and directly quotes 23 separate interviews.

We explicitly support efforts to establish ethical and collaborative aDNA research that centers the needs, concerns, and perspectives of those most affected, namely Indigenous peoples and other historically minoritized communities. We work from the position that those who bear the brunt of negative effects of paleogenomic research—and of scientific practices that have a history of exploiting and dispossessing Indigenous peoples of their land, culture, and Ancestors—should be central to how this research proceeds. To this end, we turn the lens of inquiry toward laboratory contexts to identify potential areas of intervention for developing community-based and Indigenous-driven research practices.

A note on terms. The term "Native American" has significant cultural, political, and legal histories within the United States that are distinct from the broader term of "Indigenous" even as many of the histories and structures of violence and oppression (and survivance) may overlap. As such, we use "Native American" and "Indigenous" to acknowledge both the specificity of the contexts in this article as addressed by researchers and the inextricable connections to larger conversations, alliances, and theoretical frameworks. Additionally, we are intentionally capitalizing "Indigenous" and "Ancestors" to reflect these as formal categories of belonging (Meloche et al., 2021; Smith, 1999, pp. 114–115; Younging, 2018).

3 | RESULTS

Our work identifies six broad practices within paleogenomic lab culture that underpin how researchers engage, or not, with Indigenous peoples. While these practices occur within particular labs, they are ultimately a result of structural realities that can determine ethical commitments to descendant communities. These practices are (1) training, (2) hierarchical and siloed approaches to research projects, (3) no oversight on consent, (4) control of data, (5) Ancestor care, and (6) funding. We explore each of these areas below.

3.1 | Training

Responses revealed that scientists have varying degrees of knowledge surrounding Indigenous people, as well as a general lack of training around collaborative research. This lack of knowledge and training has the potential to lead to research that excludes Indigenous participation and approval, resulting in, for example, researchers ignoring tribal knowledge, as well as including objectifying language in publications (see, e.g., Cortez et al., 2021).

Our data show that scientists working with Indigenous aDNA had inconsistent experiences with learning about collaborative practices. In general, the junior researchers were aware that consultation and collaboration is an important component of the work, but at the same time, lacked direct experience with these processes, and lacked training in the theory and methods of successfully implementing them. Many noted that they relied on the reputation of the project's PI, with one postdoctoral scholar who had worked with Indigenous Ancestors answering a question about community perspectives with the response they had been given by their graduate school PI: "I felt like I was just kind of giving away one of [their] answers, but without actually meeting the community." The same postdoctoral scholar stated that they looked forward to the day when they would be the PI and could "actually really go and meet these people. Find out what they're interested in, find out what research questions they're interested in," suggesting that they did not feel like they were able to do this kind of consultation at their present stage of career and training. This calls into question the ability of researchers to conduct adequate consultation later in their careers if they are not instructed on the process early in their careers, or if they are not taught about partnering Nations' social structures and histories.

There appears to be very little extant training focused specifically at aDNA researchers when it comes to collaborative research. Training for collaborative research does exist in many fields, notably within language documentation and archaeological field schools (Genetti & Nash, 2022; Silliman, 2008). At the very least, a set of basic principles, focused specifically on the need to engage with communities would provide parameters for designing training for researchers (Tsosie, Yracheta, et al., 2021). An individual working with a specific community's aDNA should be knowledgeable enough about that community's requirements in order to behave ethically during the research process. Without proper training in how to consult or collaborate with Indigenous Nations, and by relying only on the reputation of the PI, students risk establishing their careers without the experience required to develop and maintain necessary connections. This can lead to mistakes that are harmful to communities and to junior researchers' reputations (Cortez et al., 2021).

Even with the little training reported by interviewees on how exactly to establish collaborative projects, early career scholars are generally excited about collaboration; one graduate student who works with modern DNA reported, "I feel like super invested in these groups, and … I actually really care about these communities. Like, they're not just like, here's just some DNA and analyze it; get a paper out. Like, it's like, that stuff is very interesting, but we want to make sure like we're respecting the communities and their like data." Rather than seeing collaboration—and as part of that process, consent—as hindrances to aDNA work, collaboration is rightly viewed as an ethical part of research.

Notably, in at least one case, a postdoctoral scholar who works with an Indigenous community and their Ancestors was able to collaboratively develop a dissertation project that included intentional engagement at various steps in the process. After discussing multiple visits that they made to an Indigenous community to present initial ideas and provide project updates, they reported that they prefer to take a more active role in sample collection as part of their approach to research. They stated, "I don't like the idea of just being sent like these disembodied teeth to work with them. I'm not a fan of that. It was the same thing for working with the Ancestors in the museum. I really wanted to go and collect the samples I was going to work with from them rather than just sort of like pilfering teeth that were already in the lab." This example demonstrates that though training in collaborative research is not a disciplinary norm, it is possible. This approach was not limited to newer scholars, however; one established PI noted that some of their colleagues ought to work more closely with communities in their research, "I think some of these [lab scientists] need to go out of the lab and get to the community … I mean, they should definitely get out of that … lab."

3.2 | Hierarchy/siloing

During interviews with graduate students and postdoctoral researchers, we were struck by the siloed and hierarchical nature of projects and laboratories. Through our conversations about lab practices and the roles of each interviewee, we found that both laboratories and research projects conducted by lab members are structured hierarchically, resulting in those lower in laboratory hierarchies holding only some knowledge about projects. We found that this often meant that researchers were unaware of ethical standards of the projects, including permissions for sampling, or even from where and how "samples" were obtained. This lack of knowledge created siloed research teams where early career scholars either joined someone else's project to work without full knowledge of ethical standards and consent/permission processes, or they developed their own research project using collections of samples from Ancestors already in a PI's lab where again, these early career scholars may not know anything about the history of consent/permission related to these Ancestors' remains. Given how research projects can function in silos and the hierarchical structure of labs where not everyone has the same access to knowledge related to consent and permission to work with Ancestors, there is great potential for unethical research practices to occur in paleogenomics labs.

One advanced graduate student in a paleogenomics lab explained that in addition to their main dissertation project, they worked on at least two other projects processing samples. When asked about their role on the grant, they explained: "I guess overall for the project, my role is to work under a postdoc. And [they are] teaching me the methods starting from extraction and demineralization to sequencing. So my role really isn't to, I don't consider my role to be like, I think, the most important person that has to know everything about the project. But I have asked if I could take on more of that role, because I don't know really, I don't know anything about the samples themselves. Yeah and so I feel like I am in a black box kind of thing where I'm just working on a project on ancient DNA." This graduate student understood their position in the project as one who performed a job with only the necessary information. As they stated, "If I don't need to know, then why, why tell me, I guess, if I'm at the bottom of the [hierarchy] kind of thing."

Another graduate student in the final year of their program explained that the siloed approach to research projects resulted in them not having all of the information regarding how samples came to be in the possession of the lab, and had concerns about the lack of ethical standards and respect for Ancestors. Rather than bringing in all of the samples themself, they worked with collections that had been brought to the lab by another researcher. They described this researcher as a "sample scout." When asked about how they felt working with samples that the graduate student did not bring to the lab themself, they stated: "Um right now I feel bad. Dirty. Like that's unacceptable. When I started [a number of years ago], I was just like, I just assumed everything was peachy because I was just like, how could [prominent PIs], how would they like, miss anything? Like how would they not dot all their I's or cross all their T's in handling the ethics of these ancient human remains? I just assumed everything was working smoothly … But I now expect that that's not the case after seeing the remains [stored] in the [used food containers]. And you know, things just are missing. [One of the prominent researcher's], like 'Well, what do we have again? I can't remember what's in the lab.' And … I was like, 'I don't know, I thought you had all that documentation, right, but I don't have it.'"

A researcher who completed a PhD in the same paleogenomics lab explained that they were unaware of the consent process of obtaining samples. When asked in the interview if anyone on the project ever had a conversation with them about how researchers obtained the remains, they responded, "No, but I didn't ask. … In some cases, I would go to a conference with a PI, and one of the regional local archaeologists would be there … So, you know, I've gotten some exposure to the archaeologists who, who, like, are not just Westerners coming in and digging. But yeah, no, I, I can't say I know much about the consent process when it happened." The same individual further discussed collaborating with other labs in order to learn the most modern techniques. They noted that as part of one of these projects, they "did some of the, the bone prep in the ancient DNA lab, but [was] very, very removed from the project in general." Such descriptions were common across the labs and interviewees.

One first-year graduate student who at the time of our interview was developing a dissertation project, had recently joined a separate project to help process samples from Ancestors from North America. The graduate student explained that the lab had the necessary permissions to work with those samples, but the student was unable to provide details about the permission process or the approval letter. "It's [someone else in the lab] who had [that] interaction … I don't know anything. I just, they just told me there is authorization because everything that comes [to the lab] has a letter and etc. So I asked [about authorization], [they] said, 'of course there is.' So they got angry when I asked that. They said '…of course there is.' So okay, so there is. But I don't know."

While this seemed to be a shared experience for many early career scholars working in ancient DNA labs, it was not universal, especially when students developed projects that relied on samples obtained by the students themselves. In one lab where the PI had developed long-term collaborative relationships with multiple Indigenous groups, a graduate student was able to build their own research project based on relationships developed by their PI. When describing the process of gaining consent for their project, they said: "I felt like I sort of got, like, mentored or brought into it, because [lab PI] already had this really good long-standing relationship there. So it made it all very comfortable. You know, like, it wasn't like a cold call … [My PI] had a good relationship with the community from past projects. [They] had a good friendship with the community liaisons and the treaty office." The student detailed how they developed their project alongside the community they would eventually work with and thus had knowledge of all aspects of the project, including consent and acquisition of samples.

3.3 | No oversight on consent

These interviews made clear that there are a number of key issues related to research oversight and consent when it comes to aDNA research. One primary challenge is situating aDNA studies within existing institutional research review processes. Unless biological samples from living humans or animals are collected as part of a research project, aDNA research is not considered to fall under the oversight of Institutional Review Boards (IRBs), which are intended to protect living humans. One graduate student reported: "I got IRB for the modern genomic part, the work with the descendant community, but IRB doesn't cover work with Ancestors." A PI observed: "Perhaps consent forms that should be designed for when you're dealing with people's Ancestors, that's another thing that IRB really doesn't do if they're, they care about living participants, but when talking about ancient DNA, that's another thing. It's just like, don't even really even need an IRB for that. No living individuals in the study." Because IRB approval is not required for research that only includes the dead, this model assumes that the impact, and potential harm, of research for individuals and groups exists primarily at the point of sample or data collection. While IRBs do consider breaches of confidentiality and data privacy to be risk factors for research participants, it is significant that IRBs do not consider the potential harm to descendant communities.

As a result, many researchers in aDNA labs—especially those who are not PIs—reported not being aware of whether or not consent had been obtained from descendent communities, or if they assumed it had been obtained, reported not being aware of the specifics surrounding those agreements. As one graduate student noted about their previous lab work "So for any, like, projects I've worked on, it depends on like, what sort of stage I'm brought in at. I think most of the times what I'm, what I end up doing is like lab work. And so, you know, in those cases, I think … that kind of communication in those discussions have already happened." This is also partially a reflection of the many different stages and processes involved in research projects where a single individual may only be responsible for a small part of the analysis (i.e., wet lab work or data analysis) rather than working on the research question as a whole.

Another important element in this discussion is the way that research institutions, including IRBs, funders, and publishers treat consent. Typically, consent is given by an individual for their participation in research. As one former graduate student shared, "When we collected samples from, from people, like living people, that there was, there was like, consent forms, and stuff like that. And I know that we, we definitely collected those and sent them somewhere, or kept them on, on record or something like that." One PI who works primarily with modern DNA saw a distinction between individual consent and consultation at the group level: "I mean, consent, I see it in the context of the Belmont Report, where you approach individuals, and you go over kind of a consent form or something, or the equivalent and have that individual agree to participate in your study. Um, consultation, I see it more as a group thing."

However, as Tsosie et al. (2019) have articulated, individual consent does not address the broader impacts of research on the communities or Tribal Nations that individuals may be a part of. For example, an individual who is a member of a specific Tribal Nation might consent to have their DNA or other biological samples included in a research study, yet, the findings of that study may make claims about their entire tribe or even larger ethno-racial group. As one faculty member who works with both modern and ancient DNA remarked, "We need to make sure when we're talking with you know, a tribal community or a group of Indigenous peoples—you know, whatever they choose to be, I guess, called in a particular situation—we want to make sure that they are, that we're not just talking to one person that doesn't represent the rest of the group." Among other things, this approach highlights the need for knowledge about national, regional, and local norms of tribal or community governance and research protocols.

3.4 | Control of data

Our interviews included questions about the topic of data ownership and control, as well as the difference between Ancestors ("samples") and the lab derivatives and data generated from them. These are critical questions to explore given the implications they have for Indigenous data sovereignty. While there was a general consensus about what should happen to the physical remains of Ancestors (researchers expressed repatriation as an ideal to strive for), what remains less clear is what should happen to the data, who should control the data generated from Ancestors, and how scientists think about lab derivatives (such as DNA extracts and libraries) in terms of ownership and control.

Data ownership was a difficult subject for interviewees to parse. When asked about who owns the data, many interviewees paused to reflect on who, if anyone, technically owns them. While a few had not explicitly thought about the question, other answers ranged from data as either owned or controlled by funding agencies, descendant communities, or researchers who conduct the data analysis.

For at least some researchers, there seems to be a distinction between samples from Ancestors, the raw data generated from samples, and the analysis that arises from the raw data. Each of these may be "owned" or controlled by different entities. A postdoctoral researcher in a non-paleogenomics lab explained, "I would argue that the sequences aren't really owned. I mean, I guess as, if anything, they would belong to the descendant community. I mean, I think any, any analyses where the researcher is doing things to say, look at particular regions of the genome or something, or, you know, build a tree to see how different samples are related to each other, I would say that those are more at that point, those kinds of things belong to the researcher, but that's because the specific, specific analyses they're doing. I mean, I feel like the raw data should belong to whoever is responsible for those samples–so the, the descendant community for example." A postdoctoral researcher who works with aDNA but has never worked with North American Indigenous Ancestors, when prompted on whether they see the data generated from samples as different from the "sample" itself, responded, "It seems different in the fact that it's reproducible. And that it's, it's not like the original thing. So I mean, in the extract you have the, the DNA, which is the original DNA, but then in the library, you know, you do, you do the PCRs, you do like, make millions of copies when there was only a few. And so then the amount of original DNA in a library is, is minuscule basically. And so with the, as soon as, and then you sequence it, and you know, you can sequence it twice. And yes, it, it seems like the further away you get from the real DNA the, the less, I don't know, valuable or important or something it is because it's reproducible, and, yeah."

Outside of the question of who *should* own or control the data is the question of whether an institution, by some standard of their own, has rights to control the data and dictate how and where it is released. A number of interviewees pointed out that it might depend on who paid for the research. A postdoctoral researcher who conducts research with ancient and modern DNA stated: "That depends on who paid for it to be generated … If there was NSF funding involved, by default, the US government owns it." A graduate student who works with contemporary people but not with ancient DNA also believes that whoever paid for the research owns the data. They spoke in the context of a PI's grant paying for the research and explained that just because they had worked with the PI on that dataset did not mean they would be able to access the data if they left the lab. As they explained, they would need to collaborate with the PI on a separate grant in order to access the data again. They continued, "But that's a really good question. Because who owns that DNA? Right. I would say, it's the person whose DNA it is: they own it. And if they don't want their, you know, data, their DNA being used, they have the right … to like, withdraw from the study. Um so they technically own it."

A former graduate student in a paleogenomics lab started to answer the same question about data ownership in a strikingly similar way, before explaining that they initially thought about the question from a financial perspective, but that ultimately data ownership and control comes down to a material transfer agreement: "It all comes to what the … agreement was, if there was an agreement. So like, for me to get a sample from a collaborator who's sending me a sample, even if someone who maybe has passed away, I mean, they would have had consent at some point. We have a material transfer agreement, and then …, the ownership of that data is just explicit in the agreement. So the data is owned by whatever the agreement is… In lieu of an agreement, … I can imagine the descendant groups if they weren't part of the agreement, that they could have ownership over the data too. I don't know; tax-payers might also have ownership over the data." Similarly, a postdoctoral researcher noted the push within the scientific community to make data publicly available. "So the current setup is that once it's, especially when it has been funded by like a public granting [agency] like NSF, or NIH or something like that, it's supposed to be put in a public database that all people have access to … Or if it's not put in a public database, it has to be made available on request. That's kind of the nature of, of data sharing that's going on right now."

At least one postdoctoral researcher, while explaining their experience with tribal members visiting their PI's lab as part of a process to keep the tribe involved in the research, stated that while the researchers are the ones who bring samples back to the lab and conduct research, tribal members have more control. In fact, this postdoctoral researcher explained, the laboratory and the university explicitly do not own the samples. Rather, they house the samples temporarily. This approach of explicitly not owning the samples is one way that the laboratory tries to address power imbalances between researchers and communities. Asked for further explanation regarding university ownership of samples, they explained, "I didn't know this when I started grad school, but like, like, the researchers aren't like, in ownership, it's like, the university I guess, or something. I'm not sure exactly how it works. But, um but like, like, once you collect the sample, it's collected, you bring it back to the lab, you store it, you use it … however you said you would use it … and then like the research project is done or whatever. Um but like in this uh project, um, uh we're talking a lot about, like, um like sample misuse and how some of that misuse has stemmed from people using, like, freezer samples or samples that, like, were collected but never returned or that kind of a thing. So, so I guess so, so there's sort of two pushing reasons to allow like, ownership to remain in the hands of the individuals, and one is to um to like, control that, so that, to prevent that from happening, so like a sort of sample protection base. But then the other side of that is, like we've seen uh how like, like uh part of the, like history of colonial science has been very like, in terms of like power differentials and enacting those power differentials. So like, anything that we can do to, like, shift that balance back to, like, sovereignty of, uh, um, uh is something that I think is very good to do."

While data ownership and control was a topic that many interviewees had considered to some extent, what to do with lab derivatives (including DNA extracts and DNA libraries) was less obvious to researchers. A number of researchers stated that they had not thought of the topic prior to the interview, and very few have spoken with descendant communities and others affected by paleogenomic research about what happens to lab derivatives.

3.5 | Ancestor care

While the ethics of, and best practices for, destructive analysis in paleogenomic research are ongoing questions (Prendergast & Sawchuk, 2018; Sirak & Sedig, 2019), equally important is the question of care for those Ancestors after they arrive at a lab with the intent of destructive analysis. How are Ancestors stored and cared for? Are they treated as Ancestors, or as merely samples? Our interviews demonstrated that Ancestor care is an ongoing issue, and one that was critiqued by early career scholars in particular, which could be part of a generational shift regarding ethical practices. Based on these interviews, we argue that sample care and storage should be more deeply considered by paleogenomics labs and treated just as seriously as every other part of the research process.

As we wrote earlier, in at least one lab, there appeared to be an issue with storing samples and maintaining proper documentation. One graduate student nearing the end of their program, speaking about some of the organizational challenges in their lab, stated that a lack of proper organizational oversight can lead to improperly cared for samples. Without proper organizational structures, they said, "samples get forgotten about, and they just sort of disappear. And then they turn up in [used food containers] with [improper labels] on them. And people are like, 'Who does this belong to? Where's this from? When did we get this?' And that is a hu- a huge problem." Further, the same graduate student, in another instance, found human bones stored in a bag that did not have a sealing mechanism.

A postdoctoral researcher from a different lab also expressed dissatisfaction with the way that remains are stored in one of their former labs. They explained, "I don't like the [way that samples] are stored right now. They're kind of shoved into drawers and I don't think it's particularly, it's not comfortable for me as a researcher to see. Like, I feel like it's like a, I don't know, I don't like it, like a bunch of teeth. And I don't think it's particularly respectful. And like, I would be embarrassed to take a community member in there [the sample storage room] and be like, 'Oh yeah, here's everyone we sampled from,' like, 'look at the desk of drawers of teeth.' Like, that's not good." Another postdoctoral researcher from the same lab described how samples are stored in the aDNA lab. They explained that samples taken inside the aDNA room are stored in opaque boxes so that anyone who does not have permission to see the sample is unable to do so. This practice, explained the postdoctoral researcher, is based on respect for the community that provided consent to view and analyze the sample.

3.6 | Funding

Interviewees broadly acknowledged that money and material resources can foster or limit collaborative relationships with descendant communities. For example, a faculty member who works with aDNA described a project in Latin America, where an archaeologist collaborator had successfully set aside funds to return to a descendant community every year, hiring buses to bring people to a community center to hear a presentation and share in a meal. Along the same lines an interviewee who is in a higher administrative role reported that they simply directed funds to bring descendant community members to their lab. "It's expensive," they said, but "everything being equal … it's nothing compared to the expense of doing the ancient genomes. And it's still really, it's still super important."

However, most other interviewees, especially graduate and recent students, bemoaned the fact that they did not have easy access to funds that would facilitate these types of engagements. One early career scholar, for example, shared a vision for what a deeply collaborative paleogenomic project would look like. Then, when asked what the barriers are to such projects, they immediately brought up funding, explaining that DNA research is expensive and nearly all money is directed to the "hard science part of the work, um, and maybe publication costs." Meanwhile, traveling to meet and collaborate with community members—whether to develop relationships or return results at the completion of a study—requires additional funding.

Interviewees summarized many of the pressures that push against researchers seeking these additional funds for community engagement. A postdoctoral researcher described how early career scholars face "a rush to get things going to get projects going to get funding to get results. You know, whether it's like a doctoral student who's like, I got to be out in five years when my funding expires, or whether it's an early career researcher who's like, I got to get tenure, a postdoc lasts two years for a project. This is like, time constraints." One lab PI who has done collaborative work pointed out that researchers ideally should find money not just for their own travel but to support local collaborators who often must find time away from their jobs and other responsibilities. They also pointed out that it can take several years to develop a good enough relationship *before* the researcher and community members can even apply for a major grant together to begin the real work. Another PI of a paleogenomics lab noted that having guidelines and suggested ways to collaborate attached to funding documents could be useful, "like having some sort of section of the grant, of the NSF, that lays out the ways to actually engage in Indigenous communities, that'd be very helpful."

A graduate student who works primarily with modern DNA and does some work with aDNA noted how the "competition" among labs creates an unequal playing field. The problem starts with the fact that the focus of the field is limited: "because there's not a lot of bones out there for us to test." Then, the biggest labs with the most money can scale up their research programs, conducting more analyses and publishing more, which leads to the acquisition of yet more funding and leading to more inequities. These pressures then may compel the smaller labs to work fast to try to keep up.

In turn, one postdoctoral scholar also focused on how researchers face an array of pressures that encourage them to work in isolation: "Well, if the researchers didn't have to publish, if we weren't so pressured to publish and get grants based off of the data that we were generating, and I could see it how, you know, if the community really had pressing questions that they were finally able to get answers to through ancient DNA, I think that would be great and ideal. That's just not how academia works right now." Even still, this interviewee, a newly appointed postdoc, did once apply for a travel grant, but did not receive it. They bemoaned, "We were kind of out of options, I think. Not, maybe not totally. I maybe could have tried harder, but you probably know how it is. There's only so many grants you can apply for."

Several interviewees asked if funders really do value collaboration with descendant communities. They reported that most of the major funders do not really fund collaborative work, or if they do, they see it as an "add on," with none requiring it. Some did note that funders are in a position of real power and could help encourage researchers in this direction. A lab PI who focuses on modern DNA reflected, "I don't know if it would be within their purview. But it would make sense for them [funders] to demand to ask about, to ask about these concerns. Within the context of the grant itself, first should be a separate page, like it, just like there's a page on, you know, is it called data management, something like that for NSF, already, you know?" A postdoctoral scholar also asked if this might be possible: "I mean, it could be funding agencies, it could be scientific societies, or could be outside institutions." Similarly, another postdoctoral researcher wondered about the role of funding agencies: "I don't know how, like if there's more talk about how funding agencies should be ensuring that collaboration happens and is established."

Most interviewees acknowledged that the current benefits of funding flow almost entirely to researchers. A lab PI and a postdoctoral scholar summarized the benefits in terms of careers, publicity, accolades, and how getting one grant leads to the next. Another postdoctoral researcher confessed that their thesis advisor told them, "there's so much money that went into just the research side of it, but communities see none of that money," and in turn reflected that for communities, "often times the benefits are quite abstract. So if I'm talking about disease, it's helping, you know, understand how diseases evolve better. And that is very, that's a very abstract benefit to a community."

4 | DISCUSSION

While the details of each section are unique to individual labs and researchers, we suggest that these practices are broader issues across the discipline and may resonate with all paleogenomics labs and researchers working with Native Americans, and Indigenous peoples more broadly. Changing paleogenomic lab culture will require an overhaul of lab practices and values. If we wish to shift scientific practices to create a field that is more deeply and meaningfully engaged with Indigenous peoples, then we must shift the structures and individual behaviors that limit Native-led and collaborative research.

This research helps not only elucidate contemporary practices in paleogenomics laboratories but also identifies specific areas of potential intervention. For example, it is especially clear that students in laboratories are not receiving adequate training to work with Indigenous peoples and conduct collaborative methodologies. As one early career scholar reported, "It wasn't really a part of my graduate training. Like we never had an ethics seminar or, you know, we had some discussion of ethics in our courses, but it was never like a thing that was focused on." There are numerous models that could be drawn from, ranging from the Summer internship for Indigenous peoples in Genomics (https://www.singconsortium.org/) to the Institute on Collaborative Language Research (colanginstitute.org). Additionally, paleogenomic programs could be strengthened merely by taking a more intentional approach to ethics training.

Further, it is critical that researchers at all levels are prepared to work with Indigenous Nations. Researchers should be familiar with social and political structures of partnering communities (Arbour & Cook, 2006), even if they are not immersed in community discussions. However, it is not uncommon for scientists to lack deep cultural and basic legal knowledge about the Indigenous peoples they research. This includes the collaborators of paleogenomicists, such as archaeologists, who often vary in their knowledge about American Indian tribes and tribal concerns (Lippert et al., 2022). If paleogenomic researchers lack basic knowledge about tribal histories and structures, they may struggle to understand why it is important to consult with and gain consent from related communities. Researchers need to know governmental structures of communities in order to identify appropriate contacts with whom to initiate consultation. This type of training may not generally be part of existing education, but it is vital to set a foundation for ethical research. However this training occurs, it is important that researchers do not burden Indigenous peoples with training early career scholars. Notably, such training exists in other fields, such as health researchers working in Indigenous communities (Parker et al., 2019)—showing that the lack of training is a choice paleogenomicists, archaeologists, and other researchers are making.

The lack of training for most students and rising researchers is interlinked to other issues identified in this research, such as the siloing of work, which may restrict knowledge about a project to just a handful of researchers. We see this as a complex and nuanced issue given that partnering Indigenous peoples may wish to keep some information limited to just a few partner researchers. While we agree that researchers should respect such requests for confidentiality, there is basic information about a research project and Indigenous history and rights that all participants should be able to access in order to make an informed decision about participation. We argue that all researchers should be made aware of any broad consent and permission processes related to working with Ancestors, even if not every researcher needs detailed knowledge of agreements or has close relationships with individual Indigenous partners.

Also, a likely force in limiting ethics training is the lack of institutional oversight, which leaves each lab and project to derive its own standards of accountability. One negative is that labs and projects are left to their own account. One positive from this lack of standardized or institutionalized accountability is that researchers and communities are relatively free to explore how relationships might best unfold in their particular contexts. Through a deeper exploration of the relationships that do form, we still have yet to learn how such relationships are sustained, how reciprocity is imagined and practiced, how stakeholders are identified, and what models of collaboration are most successful.

As noted, the lack of funders driving responsibilities toward Indigenous communities has hampered efforts to foster more accountability beyond the circle of researchers. And yet models exist here too, such as specific grants like NARCH (Native American Research Centers for Health) from the NIH and IHS where the funds go to the Indigenous Nation and then a subaward goes to the research institution. The NSF has a similar approach with its Build and Broaden program and the Wenner-Gren Foundation has the engaged research grant. There are also voluntary approaches researchers could take to shift power relations, such as having one grant PI be from an Indigenous Nation to funnel a subaward to the Nation and the Indigenous PI, providing shared benefits and greater accountability.

Several respondents noted that the topic of data ownership is problematic, given that communities, researchers, and their institutions may have different expectations about who has access to, controls, or benefits from research results. This extends to intellectual property rights, which is different from data ownership and data sovereignty (Shiva, 2001). In the current disciplinary model, researchers who study the DNA of Ancestors have some legal and intellectual rights to the new knowledge they generate. While this is the de facto position of (most) universities and funding agencies, which assigns the PI the intellectual property rights of the project, researchers may have to make a considerable effort to opt out of this. Indigenous aDNA research requires acknowledging all parties' rights, whether it is through collaborative models (Smith, 2004) or Indigenous data sovereignty models (Tahu Kukutai, 2016).

We are concerned that the norm of open access to data within the scientific community prioritizes commitments to settler science rather than commitments to Indigenous communities. As Tsosie, Yracheta, et al. (2021) note, non-Indigenous scientists' notion of "good science" often requires open access to data (evidenced by Alpaslan-Roodenberg et al., 2021). However, the expectation of open access to data does not always align with the desires of communities who may wish to protect data (Garrison et al., 2019). Further, this ethic of open access not only runs the risk of directly countering Indigenous data sovereignty, but could "act as just another form of colonial dispossession" (Tsosie, Yracheta, et al., 2021). We caution researchers against an uncritical commitment to open access to data as it could directly threaten Indigenous data sovereignty and, and instead encourage researchers to work with descendant communities on this topic. The scientific community at large, including funding agencies and publishers, could also consider nuanced and flexible guidelines of data sharing to ensure researchers are able to prioritize Indigenous communities.

While there is not a definitive answer from interviewees about who "owns" or should own and control data from Ancestors, a similar conversation has taken place elsewhere, especially as it concerns contemporary peoples (Arbour & Cook, 2006; Pullman & Nicholas, 2011; Skloot, 2011). The topic of data control and access is at a critical moment as researchers in genomics and biological anthropology grapple with the implications of scientific principles of ethics that require open access to data. Although a growing number of geneticists and biological anthropologists have argued for Indigenous data sovereignty for at least the last few years, the conversation lags within paleogenomics. When it comes to control over data, data from Ancestors present a set of unique challenges compared to genomics research with living Indigenous peoples. For one, identifying descendant communities with whom to work can be challenging, yet we believe that these challenges make it all the more reason to think carefully about the issue of data control and Indigenous data sovereignty. Further, we wonder what connection there is between lab derivatives, data generated from Ancestors, and the Ancestors themselves, and encourage researchers to think more deeply about lab derivatives as part of the process of transparent research.

An in-depth consideration of the legal context in the United States, Canada, and Europe is outside of the scope of this article, but in general, there is little legal oversight in the United States and Canada when it comes to paleogenomic research with Indigenous Ancestors, including issues of sampling, lab derivatives, and data ownership. What does exist has not always prevented ethical challenges. Even with the implementation of the Native American Graves Protection and Repatriation Act (NAGPRA) in the United States—which requires institutions that receive federal funding to inventory collections, identify the cultural affiliation of funerary objects, objects of cultural patrimony, and Ancestral remains, consult with potential descendant communities, and repatriate objects and Ancestral remains that are deemed "culturally affiliated" by the institution (Fine-Dare, 2002)—there are a number of issues. First, NAGPRA's application is limited to the United States and does not apply to the remains of Ancestors found on privately owned land or held by institutions which do not receive federal funding. Further, even 30 years after the passage of NAGPRA, many institutions remain NAGPRA non-compliant (Angeleti, 2022; Ekdahl, 2020; Jaffe et al., 2023), potentially leaving ancestral remains at the risk of destructive research. Despite updates to the law allowing for the repatriation of Ancestors initially classified as "culturally unaffiliated," many remain housed in institutional collections where researchers may be allowed to sample without permission from or collaboration with descendant communities (Cortez et al., 2021). Additionally, samples collected from Ancestors and sent to researchers, including "legacy" collections from past researchers, often linger in institutions after research is done, especially where there is no agreement for return. Descendant communities may not be aware these samples exist, and thus they may not be included in requests to repatriate the Ancestor's other remains. Researchers working in laboratories with samples from Ancestors and their laboratory derivatives have not commonly considered themselves subject to the conditions of NAGPRA. In Canada, there exists no federal legislation regarding repatriation, and therefore, provinces, museums, and universities have differing policies (Bourgeois, 2021). However, the work of the Truth and Reconciliation Commission and subsequent Calls to Action have spurred professional organizations like the Canadian Museum Association to prioritize repatriation, including the results of research, and collaboration (Danyluk & MacKenzie, 2022; see Bell, 2008; Hanna, 2005 for a discussion of repatriation of ancestral remains in Canada).

We suspect that care and storage practices vary greatly across paleogenomics labs, and that many face issues similar to the ones we described. However, respectful care and storage practices are critical to ethical paleogenomic research. Researchers have begun to provide frameworks for respectful care of Ancestors. To start, the language that researchers use to refer to Ancestors can impact their care (Davis & Krupa, 2022). Treating Ancestors as objects and using objectifying language (such as "specimen") "suggests that Ancestors are things to be collected rather than individuals who require care" (Davis & Krupa, 2022, pp. 20–21). Bader et al. (2021) recommend that researchers "use language that reflects the personhood of Ancestors" (Bader et al., 2021, p. 75). In addition to shifting language, Bader, an Indigenous paleogenomicist, has written elsewhere about her collaborative research with the Metlakatla First Nation. She takes a personal responsibility for samples and data that she collects, and commits to respectful care of the Ancestors. She states that her personal mantra of "no Ancestor left behind" ensures that individual Ancestors are not separated and left in various labs (Bader et al., 2021). One interviewee provided a possible path forward in terms of Ancestor care. They discussed developing a room in collaboration with Indigenous nations dedicated to hosting and caring for Ancestors long term. Such a space would allow the researchers to care for Ancestors' physical well-being in a way that is culturally respectful and informed. In their approach to Ancestor care, the interviewee treats individuals as "Ancestors and not a material sample that's, like, disposable and consumable."

Based on our discussion, we make the following recommendations to shift the field of paleogenomics so that it is oriented toward ethical research with Indigenous peoples:

Area of intervention	Recommendations
Training	• PIs should seek out resources to educate themselves and their lab members on collaborative, ethical research with Indigenous peoples • PIs should ensure that they and their lab members have the necessary knowledge about the social and political structures of partnering communities • PIs should foster a lab culture that empowers early career scholars to inquire about collaboration and ethics
Hierarchy/ siloing	• PIs and project leads should ensure that all research team members are made aware of consent and ethical permissions • PIs should foster a lab culture that empowers early career scholars to inquire about ethical permissions and consent processes
No oversight on consent	• PIs should provide training in ethics • Researchers should obtain community consent to work with Indigenous Ancestors before research begins, regardless of IRB requirements, and ensure this documentation is accessible to all lab members
Control of data	• Researchers should respect and prioritize Indigenous data sovereignty (see Tsosie, Yracheta, et al., 2021) • Before beginning a project, researchers should be aware of any data ownership policies from institutions and funding agencies and discuss these implications with partnering communities • Publishers and funding agencies should consider flexible data sharing policies that respond to ethical standards and challenges of open access
Ancestor care	• PIs and researchers should shift their understanding of the materials they work with from 'samples' to Ancestors who deserve respect and care (Bader et al., 2021; Davis & Krupa, 2022) • PIs and researchers should discuss with partnering communities the curation and potential return of Ancestors' samples, extracts, and other lab derivatives • PIs and researchers should maintain up-to-date inventories and documentation of samples in the lab, such as material transfer agreements
Funding	• Funding agencies should provide funding opportunities for community-collaborative research • Researchers should seek out funding to support collaboration with Indigenous communities, including support to community partners

(Continues)

The research presented here delineates why change in paleogenomics may be difficult and incremental. Much of the work is decontextualized, with most research starting with samples and questions, rather than being rooted in a partnership with a particular community. The structures of training, funding, and disciplinary power all currently tend to work against research that begins with community, responds to community, and is responsible to community. In the current system, those doing the most community-oriented work have not commonly received high profile recognition (fewer *Nature* or *Science* covers), produced fewer research results (because collaboration itself takes time), and thus are less likely to get promoted, build big labs, and have the most students, and so forth (Kowal et al., 2023). As the field now stands, it is notably non-local in its orientations and values. As a result, the most productive interventions that will reorient the field toward communities must not only be at the individual level (e.g., PIs electing to run community-oriented projects, impactful trainings for students, voluntary commitments to consultation), but must be an endeavor recognized by the field as a whole. It must be a disciplinary project.

AUTHOR CONTRIBUTIONS

Amanda Daniela Cortez: Conceptualization (lead); data curation (lead); formal analysis (lead); writing – original draft (lead). **Dorothy Lippert:** Conceptualization (equal); formal analysis (equal); writing – original

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Research data are not shared. Given the ethical standard of anonymity in ethnographic research, and the infeasibility of fully anonymizing interview data, we will not make our interview data available.

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ENDNOTE

[1] We follow Bardill et al. (2018) and define “Ancestors” as “all pre-European–contact individuals in the Americas as well as postcontact deceased Indigenous individuals from infants to elders” (384).

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