COMPASS **(2024)** Volume 4, Issue 1, Pages 4−17

The Canine Surrogacy Approach: Applications for studying North American pre-colonial diets

by Faith Boser

Studying human diets through isotopic signatures can come with multiple challenges, primarily the availability and feasibility of utilizing human tissues, such as bone, teeth, hair, or coprolites. This may be due to preservation issues, the destructive nature of the analysis, ethics, or legislature. To mitigate these issues, it has become increasingly popular for researchers to utilize tissues from animals. In order for this method to be used successfully, an animal that would have consumed a diet similar to that of its human companions must be utilized. Due to the close relationship between humans and dogs in many past cultures worldwide, a method called the Canine Surrogacy Approach (CSA) has proved successful in many regions where dogs were known to have subsisted on human foods. This method is useful for colonized regions, as the archaeological remains of Indigenous people are often only subjected to bioarchaeological analysis if descendant groups grant explicit permission. This paper highlights and discusses the usefulness of this method in North America with reference to ethnographic and ethnohistoric accounts of dog provisioning. Three case studies are presented, which exhibit the applications of the CSA in different regions of the United States and Canada. Each case study approaches the CSA in different ways, showcasing the various applications of this method utilizing a variety of bioarchaeological remains. In closing, the usefulness of applying the CSA method in future studies of the dispersal of maize in the period before colonization in Canada is emphasized.

The study of human diets through isotopic signatures obtained from human tissues such as bone, teeth, hair, or coprolites is not always possible. This may be due to preservation issues, the destructive nature of the analysis, ethics, or legislature. Rather, it has become increasingly popular for researchers to utilize tissues from fauna, specifically dogs, as evidence for reconstructing human diets. Due to the close relationship between humans and dogs in various cultures worldwide and the likelihood that this close relationship included owners feeding their dogs similar diets, this method, termed the Canine Surrogacy Approach (CSA), has proved successful in studying human diets in many contexts. This method is particularly valuable in North America, as the remains of Indigenous people are often only subjected to bioarchaeological analysis if descendant groups grant explicit permission. This is in accordance with NAGPRA (North American Graves Protection and Repatriation Act) legislation in the United States. Although not part of legislation in Canada, it is not considered ethical practice to work with Indigenous human remains unless explicit permission is granted. By examining various North American case studies, the utility of the CSA is emphasized, and its limitations are explored. Examining ethnographic and ethnohistoric sources from North America helps shed light on variations in dog provisioning throughout a broad geographic and cultural landscape that is useful for interpreting isotopic results. The discussion of the limitations and successes of the CSA is useful when determining

Faith Boser is an MA Student at the University of Alberta (Department of Anthropology, 13–15 HM Tory Building, Edmonton, Alberta, T6G 2H4 [fboser@ualberta.ca]).

the best practices for this method to be utilized in future studies of pre-colonial and peri-colonial subsistence strategies in North America.

The Canine Surrogacy Approach

Research that utilized dog tissues to infer human diets was first published by Burleigh and Brothwell (1978). This project provided evidence for the consumption of maize in pre-contact Peru using bone collagen and hair samples, which led the authors to suggest that humans were cultivating and eating maize. The first publication to make use of the CSA as it is known today was that of Noe-Nygaard (1988), which focused on reconstructing diets of coastal and inland sites dating to the Neolithic and Mesolithic in Denmark using human and dog tissues for stable isotope analyses. However, the CSA approach was most clearly demonstrated in the work by Cannon et al. (1999) on dog remains from the pre-colonial coastal site of Namu in British Columbia.

Guiry (2012) explains that the CSA is a theoretical framework that utilizes dog tissues in place of human tissues, with the results being used as an analogy for coeval human diets. In utilizing “analogical inferences,” the results of the dog proxy data are evaluated for their relevance to assessing human diets, where some results are more important to help answer these questions than others (Guiry 2012:352). Guiry (2012) emphasized the complexities of this type of analogical reasoning. Dogs may be used as analogs due to their supposed metabolic and biochemical affinity to humans. However, differences created by factors of environment, culture, and behaviour still need to be considered.

This method has been particularly useful in colonized continents such as the Americas, where ethical concerns regarding the treatment of human remains are much greater. Guiry (2013) stated that at the time of publication, the only studies that emphasized the use of CSA due to ethical or cultural reasons were those conducted in the Americas. In the United States, under NAGPRA, the cultural affiliation of the remains of Indigenous people recovered during excavation must be determined, and permission to utilize the remains for research needs to be granted by the affiliated descendant community (Ubelaker 2011). In Canada, there is no federal legislation akin to NAGPRA. Rather, in 1992, guidelines were established regarding repatriation and cooperative partnerships between Indigenous groups and researchers in a Task Force Report on Museums and First Peoples (Cybulski 2011). Furthermore, under the United Nations Declaration on the Rights of Indigenous Peoples Act (UNDRIP), archaeologists seek to collaborate with descendant communities and receive permission before conducting research involving human remains (Department of Justice Canada 2021).

On top of ethical considerations regarding the sampling of human tissues, researchers must consider the destructive nature of this process. Furthermore, there are situations where human remains are not uncovered, have not survived depositional processes, or are insufficiently preserved for isotopic analyses. In some cases, both dog and human remains are subjected to stable isotope studies to obtain a greater picture of the diet, especially when human sample sizes are small (Guiry 2013).

Human and Dog Relationships in Pre-Colonial and Early Colonial North America

Dogs held multiple roles within Indigenous societies throughout North America before colonization. They were seen as work animals, protectors, companions, spiritual beings, and in some cases, subsistence sources (Wilson 1924; Mandelbaum 1979; Callahan 1997; Bethke 2020). Due to their important role within human communities, they have been thought of as good proxies for studying the diets of their human owners, particularly when the study of human tissues cannot occur. Although we may not know the exact relationship humans in North America had with their dogs thousands of years ago, examining ethnographic and ethnohistorical sources provides insights closer to the truth than otherwise. The following section highlights a few ethnohistoric accounts of human-dog relationships and provisioning strategies utilized by North American Indigenous groups. These accounts do not represent how all Indigenous groups treated their dogs. Rather these ethnohistories provide a general idea of dog provisioning that will better inform data interpretations when utilizing the CSA.

Ethnohistoric Accounts of Provisioning

Buffalo Bird Woman provided one of the most well-known ethnohistoric accounts of indigenous dogs. She communicated the role that dogs played within Hidatsa society to Gilbert Wilson in AD 1914. Buffalo Bird Woman described that dogs were raised and cared for by women, who trained the dogs to become draft animals (Wilson 1924). She provided insight into what the dogs were provisioned with. As puppies, dogs were first given boiled cuts of meat from any available animal. Once they matured, the women began to feed them boiled corn (Wilson 1924). Any food considered spoiled or unwanted was often fed to the dogs, as well as any parts of the bison that were left after butchery. In times of plenty, when too many bison were killed, not all the meat could be carried home. Buffalo Bird Woman further stated, "the next day after the killing anyone who wished meat for his dogs could go to the place where the carcasses were butchered and get the cast-away pieces" (Wilson 1924:202). She also indicated that during famine, people did their best to continue to care for their dogs by provisioning them with discarded bones (Wilson 1924).

Jesuit accounts of groups also provide some insight into what dogs were given for subsistence. An AD 1634 account of the Montagnais (now known as the Innu) in the French colony of New France, documented by Paul Le Jeune, described what was not fed to dogs. Specifically, Le Jeune indicated that certain bones from beavers, female porcupines and other animals trapped in nets, such as birds, were not fed to dogs. This was due to the belief that these animals would become elusive if fed to dogs. Instead, their bones were collected and preserved (Le Jeune 2000). Le Jeune's Innu informant explains these beliefs, stating:

> Before the beaver is completely dead…its soul comes to visit the cabin of the man who kills it, and looks very carefully to see what is done with his bones. If they have been given to the dogs, the other beavers would be warned, and so they would make themselves difficult to catch. (Le Jeune 2000:27).

Another account mentions similar practices where the bones are disposed of by burning them, throwing them into the river or burying them (Jesuits and Thwaites 1896). Le Jeune (2000) stated that, unlike the Innu, another group he observed, the Iroquois, did not adhere to these practices, as beaver remains were fed to the dogs. These few accounts demonstrate the various ways and reasons that dogs may have subsisted upon slightly different or very similar diets to their human owners. These ethnohistories also show variations in belief systems related to provisioning dogs between the Indigenous groups in North America. One must bear this in mind when planning on using the CSA in their research, as differing cultural beliefs may impact the usefulness of the CSA method, and consult ethnographic and ethnohistoric records when possible.

Case Studies on the Canine Surrogacy Approach in North America

Due to the limitations of this paper, only three case studies will be discussed. They all deal with utilizing dogs as proxies for identifying the consumption of maize by their human owners, as the movement of this cultivar through North American trade networks as a subsistence crop is a popular research topic. All of the case studies represent different uses of the CSA. The first paper by Glencross and colleagues (2022) utilized stable carbon and nitrogen isotope analyses of dog remains compared to non-domesticates and human isotope values. The paper by Edwards, Walde, and Katzenberg (2016) utilized stable carbon and nitrogen isotope analyses of dog and bison remains and lacks human values for comparison. The final paper, by Witt and colleagues (2021), utilized dog coprolites to reconstruct human diets rather than skeletal tissues, allowing them to analyze macro remains, DNA, and stable isotopes. Many other papers have utilized the CSA approach in reconstructing the diets of humans in North America (e.g., Cannon et al. 1999; Rick et al. 2011; Guiry and Grimes 2013; West and France 2015; Edwards et al. 2017; Fisher 2019; Semanko and Ramos 2022), but will not be discussed here to limit the paper's length.

"Estimating Ancient Huron-Wendat Diet in Southern Ontario Using Stable Isotopes from Dogs" by Glencross et al. (2022)

This research aimed to examine human diets in five Huron-Wendat villages dating from AD 1300 to 1650 in southern and central Ontario using dogs as proxies. All of the villages date to a period when the three sister crops (maize, beans, and squash) were known to be vital to the Huron-Wendat diet. The village sites were chosen based on the prevalence of dog remains uncovered during excavations (Glencross et al. 2022). These sites include the villages of Robb (AD 1330–1370), Jean-Baptiste Lainé (AD 1530–1590), Seed-Barker (AD 1530–1560), Ball (AD 1585–1610), and Ossossané (AD 1636–1640). Ossuaries were located near four of the five sites, and human remains were already subjected to isotopic analyses as part of another research project. A total of 45 canids were sampled, with 42 elements being from dogs (Canis familiaris) and the remaining three from foxes (Urocyon cinereoargenteus) (Glenncross et al. 2022). The archaeological fox remains were included as a reference point for wild canid diets. Carbon and nitrogen isotope analyses were conducted on bone collagen and apatite on each of the canid elements. The authors also incorporated known isotope values of archaeological specimens derived from previous research, including fish, birds, and various terrestrial animals, to obtain baseline values for the environments surrounding the village sites (Glenncross et al., 2022). The $\delta 13C$ values indicate that the dogs and foxes from the southern village sites were likely consuming maize, as do the mice values (fig. 1). The $\delta 13C$ values from the northern sites indicate that most dogs were consuming maize, other than three dogs from the Ball site (fig. 2). Based on this data, the authors suggest that the dogs from these sites were

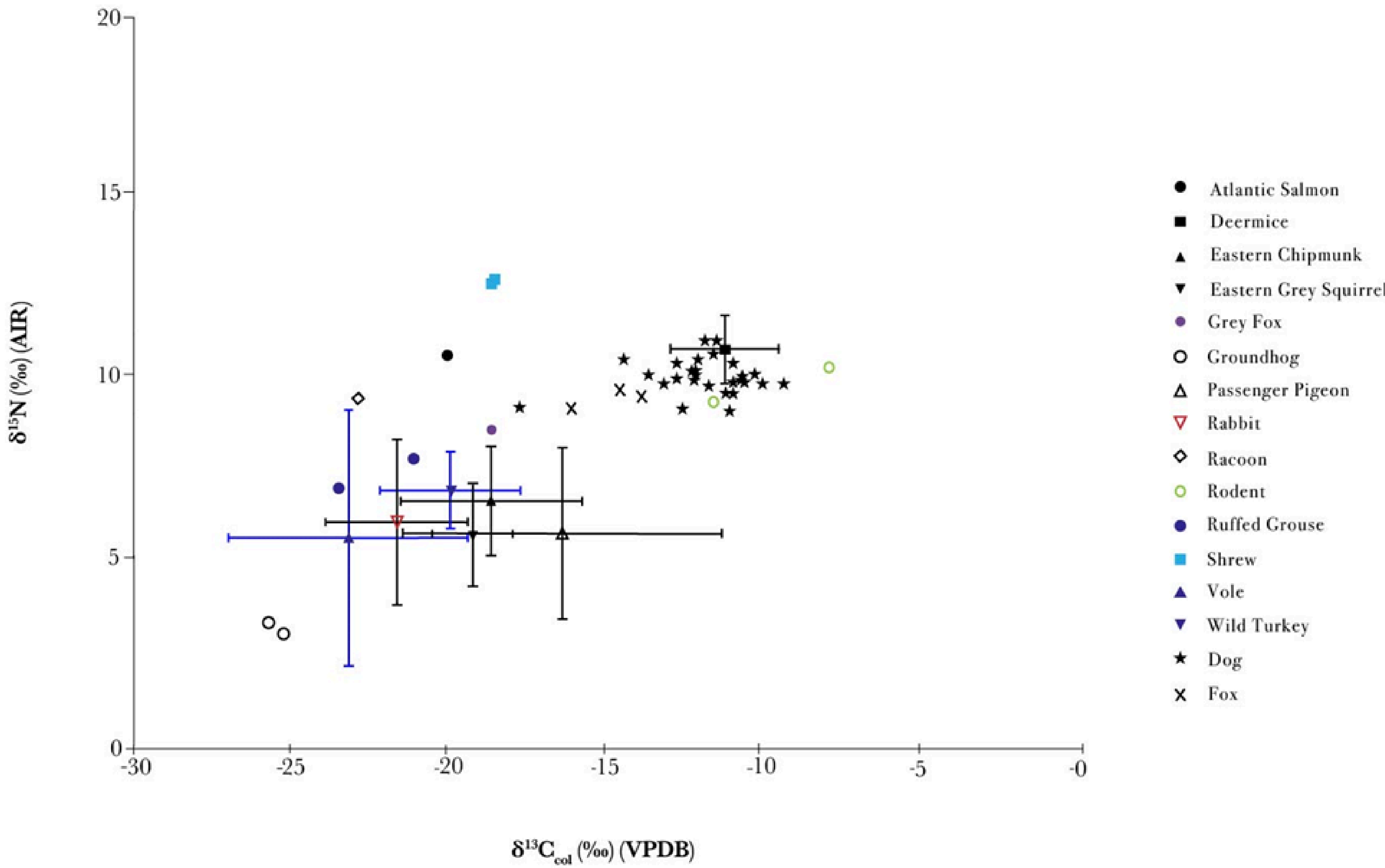

Figure 1. Results of δ13C and δ15N derived from bone collagen of individual southern Iroquoian village canid specimens, alongside the mean and standard deviations of wild animals from the region (Adapted by the author from Figure 3 in Glencross et al. 2022).

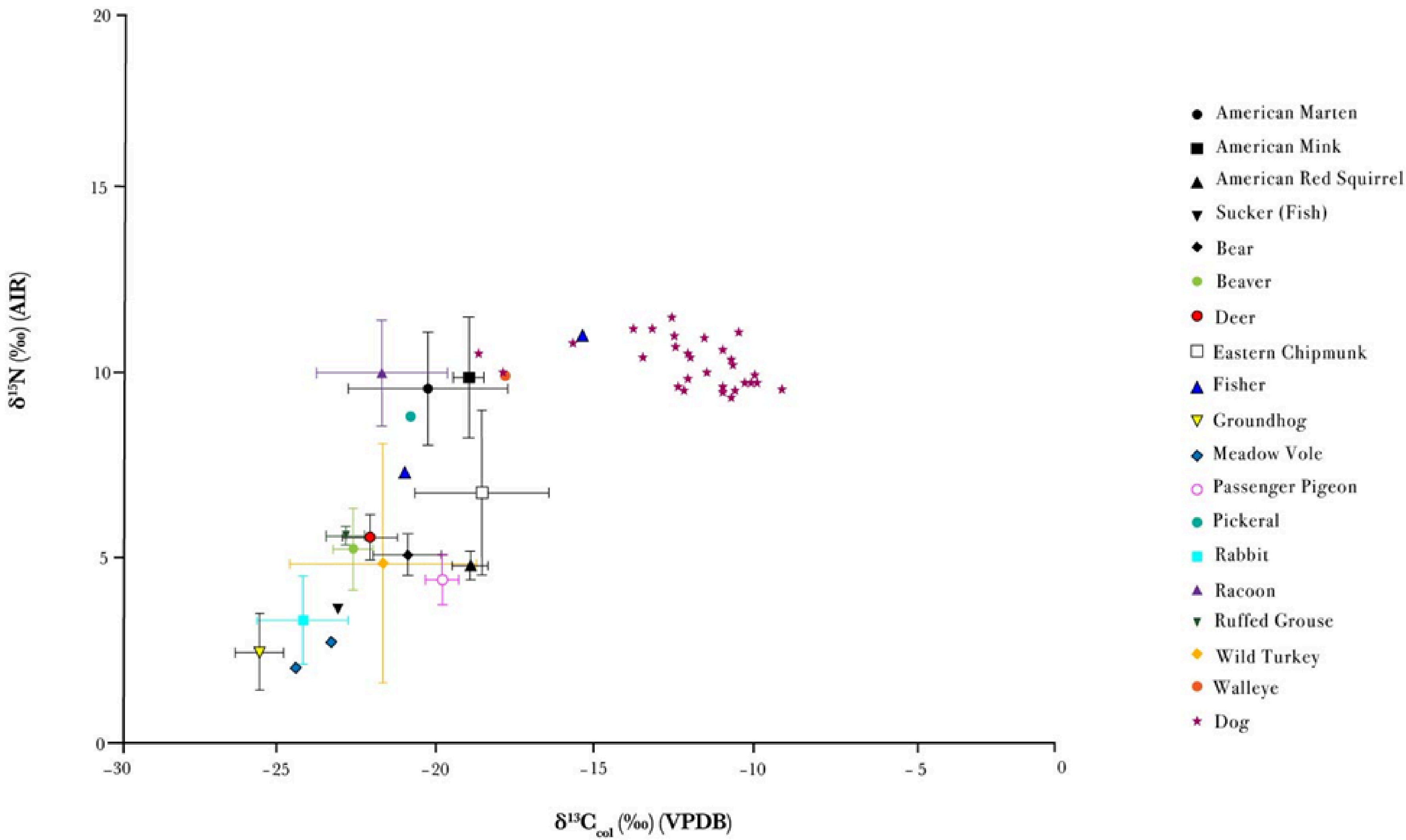

Figure 2. Results of δ13C and δ15N derived from bone collagen of individual northern Iroquoian village canid specimens, alongside the mean and standard deviations of wild animals from the region (Adapted by the author from Figure 4 in Glencross et al. 2022).

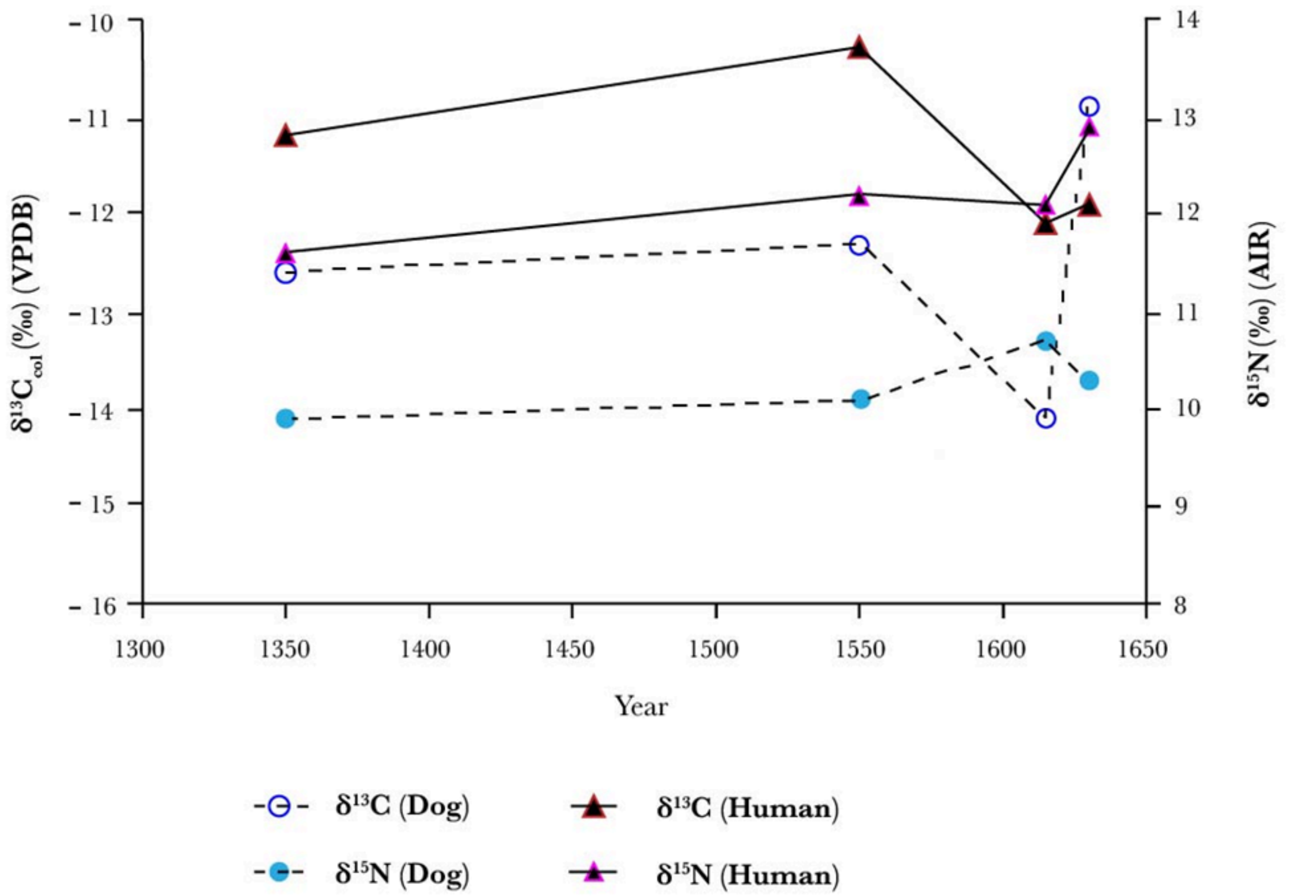

Figure 3. Comparison of human and dog mean δ13C and δ15N values over time (Adapted by the author from Figure 9 in Glencross et al. 2022).

consuming maize as a significant proportion of their diets, either through eating animals who had eaten maize, consuming maize in human and animal waste, or by directly eating maize (Glenncross et al. 2022:7). To determine how significant maize was in the dogs' diets, the authors utilized δ13C values obtained from bone apatite, which indicate the amount of δ13C obtained from protein, carbohydrates, and lipids. The results indicated that the dogs had a diet comprising C3 proteins and C4 carbohydrates. Meaning the carbohydrate portion of their diet came from C4 plants, which in this case most likely represents maize. The authors specified that six of the dogs from the sample consumed higher levels of animal protein, suggesting dietary differences that may stem from different provisioning and hunting activities (Glenncross et al. 2022). Stable nitrogen isotope values for the sampled dogs were quite high (fig. 1 and fig. 2) compared to the non-domesticates. The authors explain that these high values are indicative of a significant proportion of the dogs' diets being composed of fish, possibly obtained through provisioning (Glenncross et al. 2022).

The authors compared the δ13C and δ15N values between the five village sites and the previously obtained human values. There was considerably more variability in the δ13C values between each site than δ15N. The values from the Ball site canids exhibit the most variability between each period of occupation. These values indicate lower proportions of maize in the diet over time than other sites. The data from the

Ossossané site exhibited the most substantial levels of average δ13C of all of the sites. These levels were notably higher than the Ball site, indicating much more maize was consumed at Ossossané, despite both of the sites dating to a similar time period. The authors further compared the data by looking at contextual differences by comparing δ13C and δ15N values from dogs recovered from middens and those recovered from longhouse contexts. They found that the mean δ15N values between the midden and longhouse contexts differed significantly (Glenncross et al. 2022), indicating that dogs living in longhouses were being provisioned with higher-trophic level protein. The authors suggest that the δ13C values imply that dogs from both contexts had a diet largely based on C4 plants (directly or indirectly). Most dogs found in association with longhouses were from the Ball site, which had much higher δ15N values, likely reflecting that these dogs were consuming more fish. Comparing the dog δ13C and δ15N values to the previously published human values shows relatively similar carbon isotope values when examined through time, demonstrating that humans and dogs were eating similar carbohydrate sources (fig. 3). Based on these results, the authors indicate that dogs can successfully be used as proxies for the presence of maize in human diets at these sites, but that the complexities of diet at these sites needs to be studied further.

"Searching for Evidence of Maize Consumption at Cluny: Stable Carbon and Nitrogen Isotope Analysis of Dog and Bison Bone Collagen" by Edwards, Walde, and Katzenberg (2016)

This research is centred on determining if maize was being consumed at the Cluny village site in Alberta, dating from AD 1400 to 1750. The fortified village is the type site for the One Gun phase. The Cluny village and other designated One Gun sites share similarities with Plains village sites found elsewhere on the northern Plains, where maize was a substantial part of their subsistence. However, the authors state that maize consumption and horticulture are not known to have occurred in this region of the Plains. No artifacts associated with horticulture, such as scapula hoes, have been uncovered at the site, and plant remains have also not been found. Due to the fortifications at the site and the foreign pottery styles, it has been assumed that the site represents the movement of a foreign group into Blackfoot territory. The authors hope that reconstructing human diets through the stable isotope analysis of canids from the site will provide evidence, or lack thereof, of maize consumption at Cluny, which will provide greater insight into the possible relationship the site had to other more southern and eastern Plains village sites.

Edwards, Walde, and Katzenberg (2016) evaluated δ13C and δ15N values from the collagen samples of eleven dog elements and ten bison elements. Only nine dog elements were utilized for the results since the others were contaminated or had poor collagen preservation. The mean values for the δ13C from the bison samples were -19.1 0.3‰ and 6.7 0.3‰ for the δ15N values. The mean for the δ13C obtained from the dog samples were -18.50.3‰ and 100.4‰ for the δ15N values. The results show that the dogs' diets primarily consisted of C3 plants. This indicates that the dogs were not consuming maize (a C4 plant) and had slightly higher mean carbon isotope ratios due to their consumption of bison, which were eating C3 grasses. The stable nitrogen isotope values further indicate that the dogs consumed bison (fig. 4). The authors assume that the dogs were subsisting

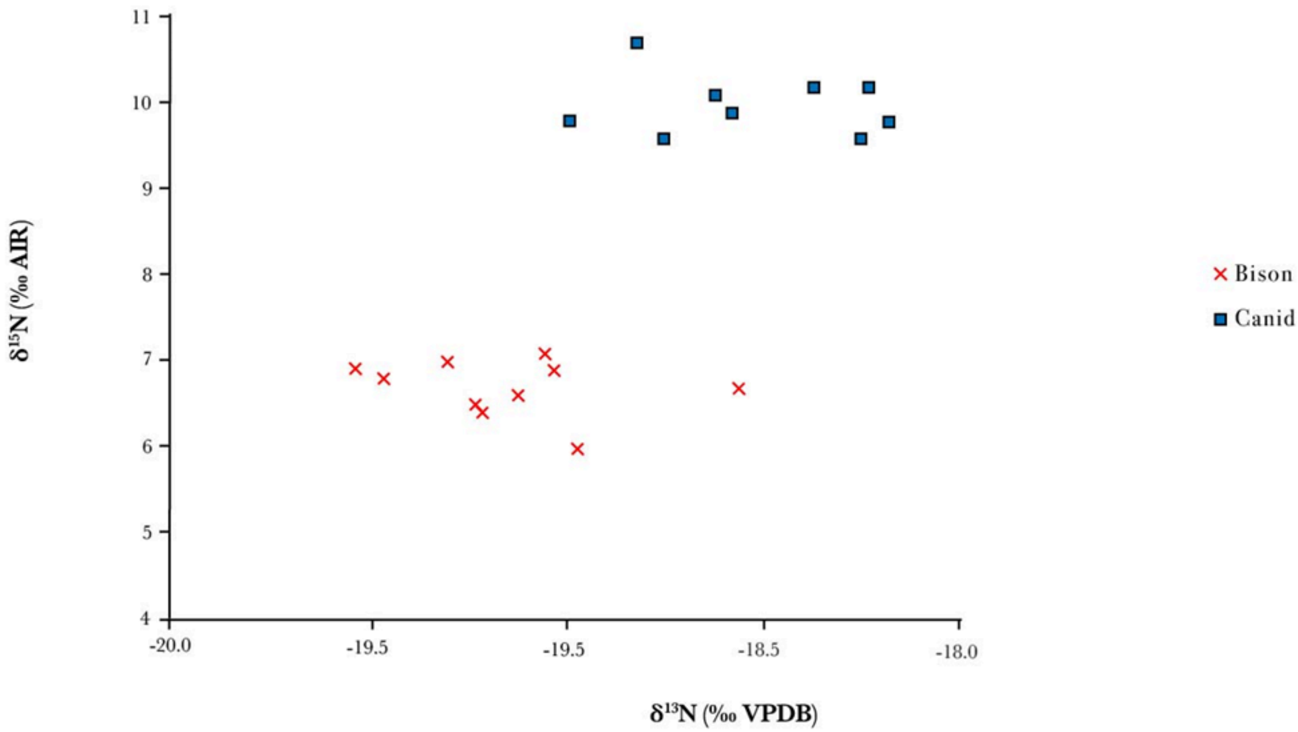

Figure 4. δ13C and δ15N values of dogs and bison from the Cluny village site (Adapted by the author from figure 3 in Edwards, Walde, and Katzenberg 2016).

on similar diets as their human owners, meaning the human inhabitants of the site were likely not eating maize as well. The stable isotope results and the lack of evidence of maize consumption at the site suggest that the assumed foreigners occupying Cluny had adopted a local subsistence strategy consisting primarily of bison (Edwards, Walde, and Katzenberg 2016).

"Integrative Analysis of DNA, Macroscopic Remains and Stable Isotopes of Dog Coprolites to Reconstruct Community Diet" by Witt et al. (2021)

The authors of this paper utilized dog coprolites rather than skeletal elements, as the previous two papers had. Stable isotope analyses of dog coprolites, as well as macrobotanical and DNA analyses, were utilized to better understand human diets from sites dating to the Late Woodland period (ca. AD 600–900) in the Mississippi River flood plain in southern Illinois, an area that the authors refer to as the American Bottom. People in the area subsisted on both cultivated domesticates and wild plants. A population boom near the end of the Late Woodland period brought many cultural and subsistence changes with the rise of Cahokia, which included the introduction and cultivation of maize (Witt et al. 2021). The coprolites come from the site Janey B. Goode, of which 150 were uncovered, in addition to the remains of over 100 dogs.

The authors identified the coprolites as the remains of dog feces. This was determined by looking at the colour of the inside of the coprolites, which was white, reflecting the consumption of bone. Additionally, the microbiome of the coprolites was a 43% match to the modern dog fecal microbiome. Macro-remains found in eight of the eleven coprolites consisted of fish scales, vertebrae, and bird bone fragments. Some of the fish scales were identified as gar (Lepisosteus sp.), and some fish bones were identified as bullhead (Ameirus sp.). No plant macro remains were recovered. DNA analyses were conducted on eleven coprolites, nine of which provided identifiable results, including 24 taxa that were likely part of the diet (Witt et al. 2021). The most significant species consisted of local fish, waterfowl, walnuts, and tentatively little barley, which have also been recovered archaeologically. Not all coprolites could provide usable stable carbon and nitrogen isotope data due to their lack of inorganic material. The values that were obtained yielded a mean δ13C value of -18 3.23‰ and a mean δ15N value of 6.53 0.53‰. The stable isotope values were plotted against values obtained from archaeological human and dog remains from the region (fig. 5). These analyses indicate that many dogs' diets consisted of fish (with low δ15N and high δ13C), terrestrial mammals, C3 plants, and possibly C4 plants like maize, although maize DNA was not present in the coprolites. The authors suggest that the maize DNA may have been destroyed during nixtamalization. The coprolites may predate the introduction of maize, or maize was only consumed variably. Another surprising result of these analyses was the lack of deer macro remains or DNA (Witt et al. 2021).

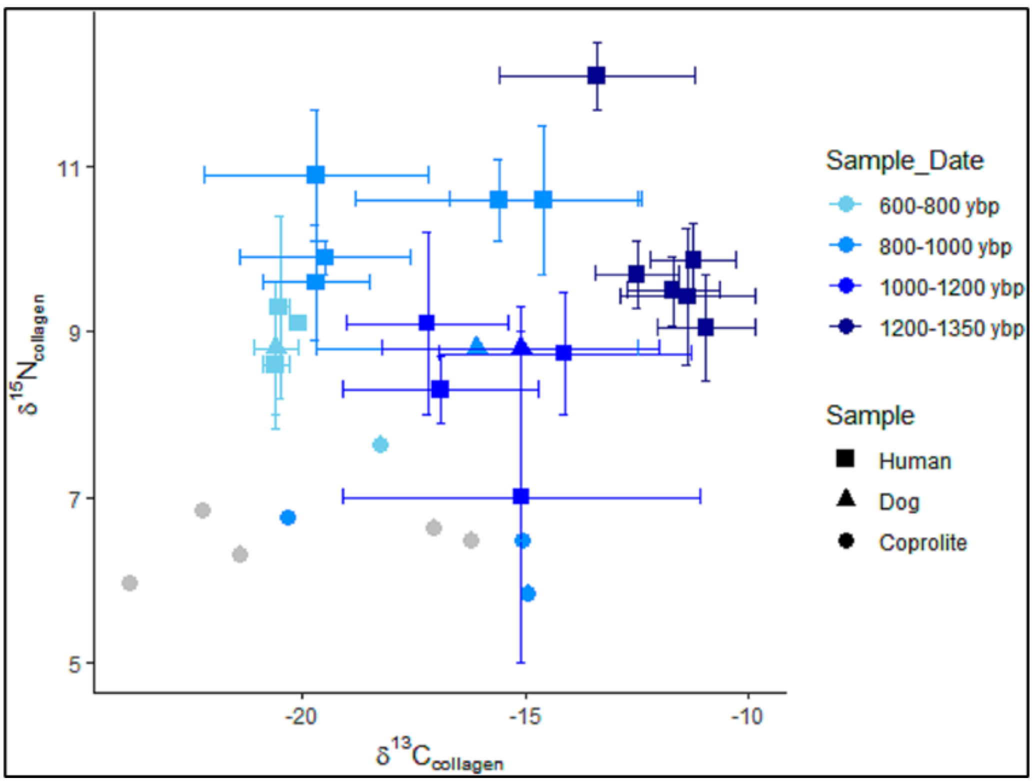

Figure 5. δ13C and δ15N values from coprolites, alongside bone collagen values derived from dogs and humans from Mississippian and Late Woodland assemblages of the American Bottom. The authors indicate that the grey dots are samples with an undetermined age, and points without an error bar represent individuals, rather than populations (Witt et al. 2021; image licenced under Creative Commons 4.0 International Contributions Licence https://creativecommons.org/licenses/by/4.0/).

The authors indicate that there is evidence that humans in the region regularly consumed deer, so they assumed that the dogs would have as well. These results may reflect the occasional provisioning of dogs with deer since these coprolites only provide a limited snapshot of the diet. Despite this type of analysis providing limited insight into the dogs' diets rather than the diet as a whole, it is still a helpful demonstration of this method using biological material other than bone and still sets a baseline for further inquiries into diet at this site.

Considerations and Limitations of the Canine Surrogacy Approach

The CSA has proved helpful for reconstructing human diets in many cases, but it has its limitations, and it is not a straightforward approach as many factors must be considered. The accuracy of this method is reliant on many situationally dependent factors. The results of these studies can only provide insight into a portion of the human diet, as dog diets cannot be considered direct reflections of the diets of their caretakers. They are only analogies for the diets of humans (Guiry 2012). Various behavioural, cultural, and biological differences create distinctions between human and dog diets. For this method to provide the most accurate results, one must keep in mind the accurate identification of domestic canids (Guiry 2012). In cases when DNA analysis cannot be conducted, morphologically differentiating between wild and domestic canids can be difficult with only the postcranial skeleton. Regarding morphometrics, dogs can be more easily differentiated from wild canids based on cranial and mandibular morphologies (Fisher 2019). These differentiations are further complicated by interbreeding between dogs and wild canids. Recent research by Losey et al. (2022) highlights the difficulties associated with differentiating dogs from wild canids, specifically on the northern Plains, due to the lack of reliable reference samples and large variation in canids. This area of research requires further work to reliably identify larger domestic canids in the archaeological record without the use of DNA analysis.

As indicated in the previous sections, it is evident in both the ethnographic record and archaeological analyses that dog diets were variable both within the same communities and between different cultural groups. To mediate issues related to different cultural practices related to dog provisioning in precolonial North America, it is best to examine the ethnohistoric record for information regarding how an associated group may have fed their dogs. Although depending on the time disparity between the site being examined and the ethnohistoric record, this method also has limitations. These practices may not be accurate for every community within the same cultural group, but they can provide a starting point for interpreting the results of isotope analyses. Guiry (2012) highlights issues related to differences in the cultural treatment of dogs, such as provisioning dogs differently depending on their breed and societal role. He mentions the dogs kept by the Coast Salish in British Columbia, who were fed a diet of primarily salmon and bred for the use of their hair for blankets (Guiry 2012: 365). One must also consider the changing importance of dogs within society, such as the case of dogs as work animals on the Great Plains who carried loads as pack animals or pulled travois (Wilson 1924; Mendelbaum 1979; Bozell 1988). Since they had such a vital role within the group, they were highly prized for their strength and ability to lessen the load of the group (Bethke 2020). With the eventual adoption of the horse, dogs were replaced and were no longer the primary work animals, lessening their societal and spiritual significance (Bethke 2020; Bozell 1988). One must also keep in mind social differences between those who provision the dogs, as some dogs may have had a sole owner and provisioner who may have access to different foods depending on their social status.

Dogs may have also been traded between groups, possibly from a group with vastly different subsistence sources (Guiry 2012). If a traded dog had died not long after being relocated, their isotope signatures would likely not yet reflect the diet of their new owners (Guiry 2012). One must then be wary of any extreme differences between the isotopes of the canids in the sample. This would be most problematic if dogs were traded from an agricultural village where they could consume maize to a hunter-gatherer group lacking maize agriculture or if coastal groups were trading dogs with inland groups. Guiry (2012) suggests that this issue may be mediated by using strontium isotope analysis to determine the animal's mobility. One must also consider issues related to sample size in the case of outliers and reference available subsistence data for comparison.

Many uses of the CSA in North America examine the presence of maize in the diet. Guiry (2012) emphasizes considerations of the local ecology when seeking to answer a research question involving the consumption of maize. This method is most accurate if C3 plants dominate the natural environment, and the dogs consumed enough maize in their diet that a C4 signature reflects this consumption. There is a possibility that maize was consumed by the community the dogs belonged to. Still, if they were not provisioned with enough maize, it may not be reflected isotopically. In cases such as this, searching for the consumption of maize in the form of starch residues and macrobotanical remains, if possible, would be beneficial.

Discussion and Conclusion

As demonstrated in the case studies above, the utilization of the CSA to reconstruct human diets has become more popular in recent years, especially in North America. The three case studies focused on different regions in North America. These studies demonstrate different situations, contexts, and the utilization of different approaches to gain insight into human diets by canine proxy. Even if the authors were unsuccessful in finding evidence of the consumption of a certain subsistence product, such as the lack of maize in the case of Edwards, Walde, and Katzenberg (2016), our understanding of the usefulness of the CSA is furthered, and insights into diet are still achieved. In the case of Edwards, Walde, and Katzenberg (2016), maize may have been present in the form of trade goods, but it is clear that the dogs did not consume enough of it if there was any present to be reflected isotopically. If anything, insight into the dogs' diets is gained, and greater insight into the relationship between humans and dogs at the site is established. Glencross et al. (2022) and Witt et al. (2021) had access to human tissues to compare the reliability of the isotopic results of the canid tissues. This will not be possible in all regions of North America, especially in cases when the CSA approach is being utilized due to the inability to sample human tissues. Nevertheless, these instances provide information regarding the reliability of dog proxies in these regions, which can help inform future studies using the CSA. Despite the limitations of the CSA method, if one is aware of the considerations, this method is valuable for better understanding past human diets. As demonstrated above, the results of this method are more reliable when paired with other forms of data, such as isotopic analysis of wild fauna, as well as other subsistence remains in the form of faunal and botanical remains.

Although domesticated canids are not direct human correlates, examining dogs' diets through stable isotope analysis can provide meaningful glimpses into human diets in certain circumstances. In places such as Canada, the United States, and other colonized countries where human tissue sampling is not always conducted, dog tissues can be utilized to gain insights that might not otherwise be achieved. The CSA is not as straightforward as one might think, as it requires diligence and consideration of many factors to establish a reliable dataset and interpretation. The CSA has been utilized more frequently in recent years as scholars have come to understand its applications and limitations better. As demonstrated in the case studies discussed, this method is especially useful in establishing subsistence changes, such as the introduction of maize to the diet. This method could prove useful in establishing the timing of maize dispersal in other regions of North America, particularly in Canadian prairies. Regions where maize might have been consumed in larger quantities have the most potential for significant results, such as southern Manitoba (Robert J. Losey, personal communication, March 15, 2023). This is an area where the practice of pre-colonial maize horticulture is well established and canid remains are prevalent (Boyd et al. 2006; Nicholson 1990, 1991). As more research using the CSA is conducted, more insights into the effectiveness of this method in certain regions and contexts can be established. Research into the reliability and usefulness of this method in studying human diets can lead to less reliance on the destructive sampling of human tissues while also providing information on the relationship between humans and animals.

References Cited

Bethke, Brandi. 2020. Dog days to horse days: the introduction of the horse and its impact on human-dog relationships among the Blackfoot. In *Dogs: archaeology beyond domestication*. Brandi Bethke and Amanda Burtt, eds. Pp. 163–185. Gainesville: University Press of Florida. https://doi.org/10.5744/florida/9780813066363.003.0007.

Boyd, M., C. Surette, and B. A. Nicholson. 2006. Archaeobotanical evidence of prehistoric maize (*Zea Mays*) consumption at the northern edge of the Great Plains. *Journal of Archaeological Science* 33(8): 1129–1140. https://doi.org/10.1016/j.jas.2005.12.003.

Bozell, John R. 1988. Changes in the role of the dog in protohistoric-historic Pawnee culture. *Plains Anthropologist* 33(119):95–111. https://doi.org/10.1080/2052546.1988.11909431.

Burleigh, Richard, and Don Brothwell. 1978. Studies on Amerindian dogs, 1: carbon isotopes in relation to maize in the diet of domestic dogs from early Peru and Ecuador. *Journal of Archaeological Science* 5(4):355–362. https://doi.org/10.1016/0305-4403(78)90054-7.

Callahan, Ruth 1997. Domestication of dogs and their use on the Great Plains. *Nebraska Anthropologist* 103. https://digitalcommons.unl.edu/nebanthro/103.

Cannon, Aubrey, Henry P. Schwarcz, and Martin Knyf. 1999. Marine-based subsistence trends and the stable isotope analysis of dog bones from Namu, British Columbia. *Journal of Archaeological Science* 26(4):399–407. https://doi.org/10.1006/jasc.1998.0341.

Cybulski, Jerome S. 2011. Canada. In *The Routledge handbook of archaeological human remains and legislation*. Nicholas Marquez-Grant and Linda Fibiger, eds. Pp. 525–530. New York: Routledge.

Department of Justice Canada. 2021. *United Nations Declaration on the Rights of Indigenous Peoples Act*. https://www.justice.gc.ca/eng/declaration/about-apropos.pdf.

Edwards, Kim, Dale Allen Walde, and M. Anne Katzenberg. 2016. Searching for evidence of maize consumption at Cluny: stable carbon and nitrogen isotope analysis of dog and bison bone collagen. *Canadian Journal of Archaeology / Journal Canadien d'Archéologie* 40(2):319–331.

Edwards, Richard W., Robert J. Jeske, and Joan Brenner Coltrain. 2017. Preliminary evidence for the efficacy of the canine surrogacy approach in the Great Lakes. *Journal of Archaeological Science: Reports* 13: 516–525. https://doi.org/10.1016/j.jasrep.2017.05.008.

Fisher, Abigail E. 2019. When is a wolf a dog? Combined geometric morphometrics and stable isotope analyses for differentiating wild from domestic canids on the Northern Plains. *Plains Anthropologist* 64(252):316–349. https://doi.org/10.1080/00320447.2018.1548064.

Glencross, Bonnie, Gary Warrick, Taylor Smith, and Tracy L. Prowse. 2022. Estimating ancient Huron-Wendat diet in southern Ontario using stable isotopes from dogs. *Journal of Archaeological Science: Reports* 41:103324. https://doi.org/10.1016/j.jasrep.2021.103324.

Guiry, Eric J. 2012. Dogs as analogs in stable isotope-based human paleodietary reconstructions: a review and considerations for future use. *Journal of Archaeological Method and Theory* 19(3):351–376. https://doi.org/10.1007/s10816-011-9118-z.

———. 2013. A canine surrogacy approach to human paleodietary bone chemistry: past development and future directions. *Archaeological and Anthropological Sciences* 5(3):275–286. https://doi.org/10.1007/s12520-013-0133-8.

Guiry, Eric J., and Vaughn Grimes. 2013. Domestic dog (*Canis familiaris*) diets among coastal Late Archaic groups of northeastern North America: a case study for the canine surrogacy approach. *Journal of Anthropological Archaeology* 32(4):732–745. https://doi.org/10.1016/j.jaa.2013.04.005.

Jesuits, and Reuben G. Thwaites. 1896. *The Jesuit relations and allied documents; travels and explorations of the Jesuit missionaries in New France, 1610–1791; the original French, Latin, and Italian texts, with English translations and notes.* Letters from missions (North America). Cleveland: Burrows Bros. Co. https://catalog.hathitrust.org/Record/000833013.

Le Jeune, Paul. 2000. Paul Le Jeune winters with Mestigoit's band, 1633–1634. In *The Jesuit relations: natives and missionaries in seventeenth-century North America*. Allan Greer, ed. Pp. 21–26. New York: Bedford/St. Martin's.

Losey, Robert J., Abby G. Drake, Patricia E. Ralrick, Christopher N. Jass, Angela R. Lieverse, Megan Bieraugle, Rebecca Christenson, and Karin Steuber. 2022. Dogs and wolves on the northern plains: a look from beyond the site in Alberta. *Journal of Archaeological Science* 148:105690. https://doi.org/10.1016/j.jas.2022.105690.

Mandelbaum, David G. 1979. *The Plains Cree: an ethnographic, historical, and comparative study*. Canadian Plains Studies, no. 9. Regina: Canadian Plains Research Center.

Nicholson, B. A. 1990. Ceramic affiliations and the case for incipient horticulture in southwestern Manitoba. *Canadian Journal of Archaeology* 14:33–59.

Nicholson, B. A. 1991. Modeling a horticultural complex in south-central Manitoba during the Late Prehistoric Period—The Vickers focus. *Midcontinental Journal of Archaeology* 16(2):163–188.

Noe-Nygaard, N. 1988. $\delta^{13}C$-values of dog bones reveal the nature of changes in man's food resources at the Mesolithic-Neolithic transition, Denmark. *Chemical Geology: Isotope Geoscience Section* 73(1):87–96. https://doi.org/10.1016/0168-9622(88)90023-1.

Rick, Torben C., Brendan J. Culleton, Carley B. Smith, John R. Johnson, and Douglas J. Kennett. 2011. Stable isotope analysis of dog, fox, and human diets at a Late Holocene Chumash Village (CA-SRI-2) on Santa Rosa Island, California. *Journal of Archaeological Science* 38(6):1385–1393. https://doi.org/10.1016/j.jas.2011.02.008.

Semanko, Amanda, and Frank C. Ramos. 2022. Teaching an old dog new tricks: implications for isotopic studies of southwest dogs. *KIVA* 88(3):327–346. https://doi.org/10.1080/00231940.2022.2036911.

Ubelaker, Douglas H. 2011. United States of America. In *The Routledge handbook of archaeological human remains and legislation.* Nicholas Marquez-Grant and Linda Fibiger, eds. Pp. 533–540. New York: Routledge.

West, Catherine F., and Christine A. France. 2015. Human and canid dietary relationships: comparative stable isotope analysis from the Kodiak Archipelago, Alaska. *Journal of Ethnobiology* 35(3):519–535. https://doi.org/10.2993/etbi-35-03-519-535.1.

Wilson, Gilbert L. 1924. *The horse and the dog in Hidatsa culture*, vol. 15, part 2 of *Anthropological papers of the American Museum of Natural History*. New York: American Museum of Natural History.

Witt, Kelsey E., Karthik Yarlagadda, Julie M. Allen, Alyssa C. Bader, Mary L. Simon, Steven R. Kuehn, Kelly S. Swanson, et al. 2021. Integrative analysis of DNA, macroscopic remains and stable isotopes of dog coprolites to reconstruct community diet. *Scientific Reports* 11(1):3113. https://doi.org/10.1038/s41598-021-82362-6.