A Multiscalar Consideration of the Athabascan Migration

Briana N. Doering, Julie A. Esdale, Joshua D. Reuther, and Senna D. Catenacci

Genetic and linguistic evidence suggests that, after living in the Subarctic for thousands of years, Northern Athabascans began migrating to the American Southwest around 1,000 years ago. Anthropologists have proposed that this partial out-migration and several associated in situ behavioral changes were the result of a massive volcanic eruption that decimated regional caribou herds. However, regional populations appear to increase around the time of these changes, a demographic shift that may have led to increased territoriality, resource stress, and specialization. Building on existing syntheses of cultural dynamics in the region, analyses of excavated materials, and landscape data from Alaska and Yukon, this research shows that the Athabascan transition represented a gradual shift toward resource specialization in both salmon and caribou with an overall increase in diet breadth, indicating a behavioral transition that is more consistent with gradual demographic change. Further, this behavioral shift was already in motion at the time of the volcanic eruption circa 1150 cal BP and suggests that the ultimate migration from the area was the result of demographic pressures. In sum, this research elaborates on the complex dynamics of resilience and adaptation in hunter-gatherer groups and provides a testable model for explaining past migrations.

Keywords: migration, North American archaeology, Athabascan, human behavioral ecology, geochemistry, isotopic analysis, lithic analysis, geospatial analysis, landscape archaeology, environmental archaeology

Después de vivir miles de años en el sub-ártico, evidencia lingüística y genética sugiere que hace aproximadamente 1.000 años, los Atabascanos del Norte migraban al sur oeste de los Estados Unidos. Antropólogos han surgido que esta migración, y varias transiciones conductuales in situ asociadas, fueron causados por una erupción volcánica que diezmó manadas de caribú. Sin embargo, después de esta erupción, parece que populaciones regionales se aumentó al mismo tiempo que esta transición, un cambio demográfico que pudo haber llevado un aumento en la territorialidad, la demanda de recursos, y la especialización económica. Basándose en las síntesis existentes de las dinámicas culturales en la región, analices de materiales excavados, y los paisajes de Alaska y el Yukón, esta investigación muestra que la transición Atabascana representó un cambio hacia una especialización en la recolección de salmón y la caza del caribú. Este cambio estaba asociado con un aumento general en la amplitud de la dieta, indicando una transición conductual que está más coherente con un cambio demográfico gradual. Además, esta transición conductual ya hubiera comenzado antes que la erupción volcánica en 1150 cal BP, lo cual sugiere que la inmigración al suroeste era causada por presión demográfica y no la erupción volcánica. En suma, esta investigación elabora las dinámicas complejas de resiliencia y adaptación en grupos cazadores-recolectores y proporciona un modelo comprobable para explicar otras migraciones prehistóricas.

Palabras clave: migración, arqueología norteamericana, Atabascanos, ecología del comportamiento humana, geoquímica, análisis isotópicos, análisis lítico, análisis geoespacial, arqueología del paisaje, arqueología ambiental

Athabascan linguistic and human population genetic evidence indicates that a group of Northern Athabascans migrated from the western Subarctic through the Great Plains and into the western continental United States approximately 1,000 years ago (Derry 1975; Dixon 1985; Ives 1990; Malhi et al. 2008; Seymour 2012a, 2012b). This partial migration

Briana N. Doering (doeringb@umich.edu, corresponding author) and **Senna D. Catenacci** ■ Museum of Anthropological Archaeology, University of Michigan, 3010 School of Education, 610 East University Avenue, Ann Arbor, MI 48109, USA
Julie A. Esdale ■ Center for Environmental Management of Military Lands, Colorado State University, Directorate of Public Works, 1046 Marks Street, #4500, Ft. Wainwright, AK 99703-4500, USA
Joshua D. Reuther ■ University of Alaska Museum of the North, 1962 Yukon Drive, Fairbanks, AK 99775, USA

American Antiquity 85(3), 2020, pp. 470–491

doi:10.1017/aaq.2020.34

followed several thousand years of behavioral consistency in central Alaska and Yukon (Dixon 1985; Esdale 2009; Potter 2008, 2016). Anthropologists have proposed that a catastrophic volcanic eruption around 1150 cal BP ultimately led to several coincident in situ behavioral changes and an associated migration (Derry 1975; Hare et al. 2012; Mullen 2012; Workman 1979). Conversely, an overall increase in the number of sites in the region (see below) suggests that the population may have expanded around the time of these changes, a demographic shift that may have led to intensified territoriality and resource stress. The research presented here represents one of the first attempts to evaluate both potential causes of this migration—volcanism versus demographic stress—with data spanning Northern Athabascan territory on both sides of the U.S.-Canada border (Mullen 2012:42).

Migrations are social processes that provide critical insights into human decision making, adaptation, and resilience (Cabana and Clark 2011). While past migration is now conceived of as an inherently collective social process resulting from a suite of push and pull factors (Anthony 1990, 1997), explanations of the Athabascan migration remain largely based in environmental variables (Kristensen, Andrews et al. 2019; Mullen 2012). Yet Athabascans and Arctic peoples more generally are impressively impervious to episodes of prolonged ecological degradation due to their complex social networks and flexible technological systems honed over millennia of survival in these dynamic environments (Berkes and Jolly 2001; Gordon 2012; Ives 1990). Moreover, scholars have recently called into question the extent and severity of ash-induced ecological failure that archaeologists have linked to the Athabascan migration (Gordon 2012; Letts et al. 2012), demanding a reexamination of the migration process and its potential cause(s).

The research presented here builds on existing syntheses of cultural dynamics in the region, excavated materials, and landscape data from Alaska and Canada to evaluate whether this migration and associated behavioral changes were most likely caused by (1) a massive volcanic eruption and presumed ecological collapse and/or (2) increased territoriality associated with a gradual population increase. We evaluated this multiscalar dataset, comprising excavated remains from five components spanning circa 2000–500 cal BP and location and site size data from 198 radiocarbon-dated components recovered in both Alaska and Yukon spanning 6000–100 cal BP (Figure 1) within a theoretical model drawn from predictions based in human behavioral ecology and ethnographic analogy.

Background

According to linguistic data, Athabascan people occupied the interior of Alaska and Yukon for at least 2,000 years and perhaps longer than 5,000 years (Dumond 2010; Kari 2010; Vajda 2010) before a significant number of Dene (Athabascans) migrated hundreds of miles south toward the Northwest Coast, the Great Plains region, and the Southwest through the Rocky Mountains and surrounding plains (Ives 1990, 2003; Seymour 2012a). For thousands of years before this migration, denizens of central Alaska and Yukon maintained a highly mobile, caribou-based subsistence system centered in the upland ecological zones of the region (ca. 600 masl), identified archaeologically as the Northern Archaic Tradition (Anderson 1968; Esdale 2008; Potter 2008). Archaeologists have recovered consistent evidence for atlatls and stone-tipped darts, notched projectile points, caribou-based subsistence, and residential mobility at small upland hunting camps associated with the Northern Archaic throughout this interior region, spanning approximately 7000–2000 cal BP (Blong 2016; Bowyer 2011; Dixon et al. 2005; Esdale 2009; Graf and Bigelow 2011; Hare et al. 2012; Potter 2008).

Archaeologists have identified material evidence from between 1,000 and 2,000 years ago for the Athabascan transition, which represented a departure in subsistence, mobility, and technology across central Alaska and Yukon (Dixon 1985; Hare et al. 2012; Holmes 2008; Potter 2008; Shinkwin 1979). Specifically, the Athabascan transition is associated with increased diet breadth, indicated both by increased use of fish and small game represented in faunal assemblages and by increased use of lowland ecological zones that have fewer caribou (Holmes

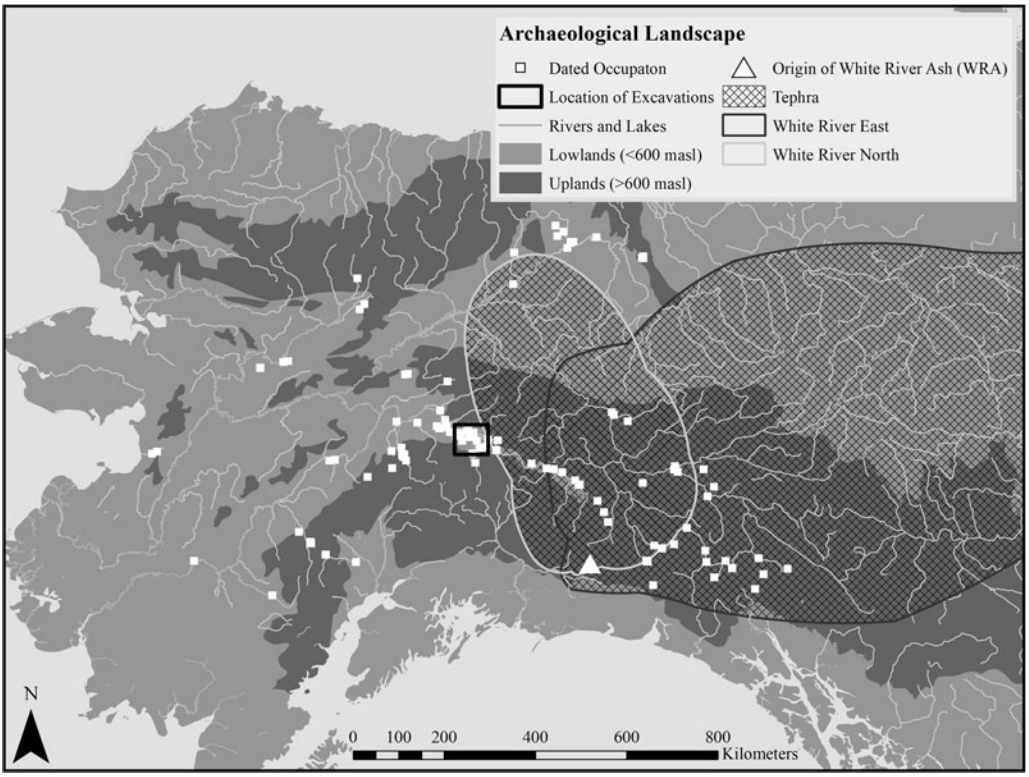

Figure 1. Study area depicting locations of sites, ecological zones, and distribution of White River Ash north and east.

2008; Perry 1983; Potter 2008; Shinkwin 1979). Additionally, the first semisubterranean house pits and ceramic materials are associated with this period, which suggest decreased mobility (Shinkwin 1979). Regarding technology, archaeologists have asserted that stone tools, particularly microblades, were replaced by bone and metal tools around 1000 cal BP (Carlson 2012; Hare et al. 2012; Holmes 2008; Potter 2008), and ice patch finds from Yukon provide limited evidence for a transition to bow and arrow technology that may be related to increased diet breadth (Angelbeck and Cameron 2014; Bettinger 2013; Hare et al. 2012) and/or increased territoriality (Maschner and Mason 2013). In sum, archaeologists have argued that the Athabascan transition comprised increased diet breadth, reduced mobility, and use of bone and metal tools.

Apachean and Navajo technological terms and archaeological assemblages provide the opportunity to link Subarctic behavioral changes with the greater Dene (Athabascan) diaspora. Southern Dene speakers show linguistic ties with their Northern counterparts that indicate that the use of bow and arrow technology, copper, and ceramics preceded the Athabascan migration south (Ives 2010; Wilson 2019). Importantly, ancestral Apachean and Navajo assemblages contain both ceramics and bow and arrow technology as early as 750 cal BP (Hill 2012; Ives et al. 2014; Seymour 2013) and may also include microblade technology (Dykeman and Roebuck 2012:154). Identifying the timing of these technological developments and the diaspora as a whole remains complicated by the similarity of Dene (Athabascan) culture, mobility, and subsistence to that of other groups in the American Plains and Southwest as well as the Dene (Athabascan) proclivity to accept material culture and ceremonial life from neighboring societies (Ives et al. 2014:619; Seymour 2012b). Nevertheless, these Southern Dene linguistic and archaeological data provide greater context for the Athabascan behavioral transition and migration.

A number of anthropologists have linked changed Athabascan behaviors and migration to a large volcanic eruption circa 1150 cal BP that deposited ash from southeast Alaska to Greenland (Clague et al. 1995; Derry 1975; Fast 2008; Kristensen, Andrews et al. 2019; Kristensen, Hare et al. 2019; Mullen 2012; Workman 1979). Indeed, ecologists have associated this event, referred to as the White River Ash east event, with widespread paleoecological changes in the regions' lacustrine and terrestrial ecosystems (Hughes et al. 2013; Kuhn et al. 2010; Lacourse and Gajewski 2000). Notably, caribou genetic data indicate a possible caribou population replacement event in central Yukon at the time of the White River Ash (Kuhn et al. 2010), and archaeologists have recently employed evidence of shifting trade networks to argue that decreased caribou populations led to a temporary abandonment of the affected region that ultimately resulted in migration as displaced groups sought improved upland hunting venues (Kristensen, Andrews et al. 2019; Kristensen, Hare et al. 2019).

Ecologists have linked this caribou population decline to the ash event in part because mid- to late Holocene (6000–100 cal BP) environmental reconstructions show no evidence for other significant environmental disruptors (Kaufman et al. 2016), though the relationship between the White River Ash east and regional caribou populations remains equivocal (Letts et al. 2012). Alternatively, archaeologists have considered an earlier White River Ash event that occurred circa 1625 cal BP (Lynch et al. 2018; Reuther et al. 2019) as a possible cause for migration from central Alaska and Yukon to the Pacific Northwest (Ives 2003; Mullen 2012). However, this ashfall was considerably smaller than the White River Ash east, was patchily distributed, and has not been correlated with any ecological changes in the region (Reuther et al. 2019). Therefore, we will consider the pace of the Athabascan transition between 500 and 2,000 years ago to evaluate how this earlier volcanic event may have contributed to technological, subsistence, and mobility changes, including migration, though the White River Ash east is the primary focus of this investigation.

The temporal correlation between an inferred ecological decline and behavioral shifts has led archaeologists to suggest a causal relationship. Indeed, a regional decrease in caribou populations could have been catastrophic to the highly mobile caribou hunters associated with the Northern Archaic Tradition. Oral historic evidence suggests a link between volcanism and the first use of copper tools in the region (Moodie et al. 1992), and radiocarbon-dated ice patch finds show chronological links between the White River Ash east and a rapid transition to bow and arrow technology (Dixon et al. 2005; Hare et al. 2012). However, additional genetic research on neighboring caribou populations has called into question a Yukon caribou population replacement episode due to issues of sampling and temporal scale (Letts et al. 2012). Additionally, critics charge that this explanation is largely circumstantial, does not address issues of scale, and fails to accommodate the complex adaptive social dynamics of Western Subarctic peoples that have made them resilient to environmental perturbations (Gordon 2012; Holmes 2008; Potter 2008), particularly caribou population crashes (Burch 2012). Further, ecological studies following recent volcanic eruptions in similar ecosystems show that succession is highly heterogeneous across large regions and that salmonid, lichen, and mammal rehabilitation can occur within two to three decades after a volcanic event (Blackman et al. 2018; Crisafulli et al. 2018; Nelson et al. 2018), during which time Athabascans could have temporarily employed established fallback strategies, such as increased diet breadth. Combined, these critiques have provoked recent reexaminations of Athabascan behavior that argue that the eruption had only subtle effects on trade in south-central Yukon and did not provoke an adaptive behavioral response throughout the broader Northern Athabascan region (Kristensen, Andrews et al. 2019; Kristensen, Hare et al. 2019). Additional research is needed to contextualize the broader regional response to volcanic activity during the late Holocene.

Archaeological data from the region show another important change at this critical interval:

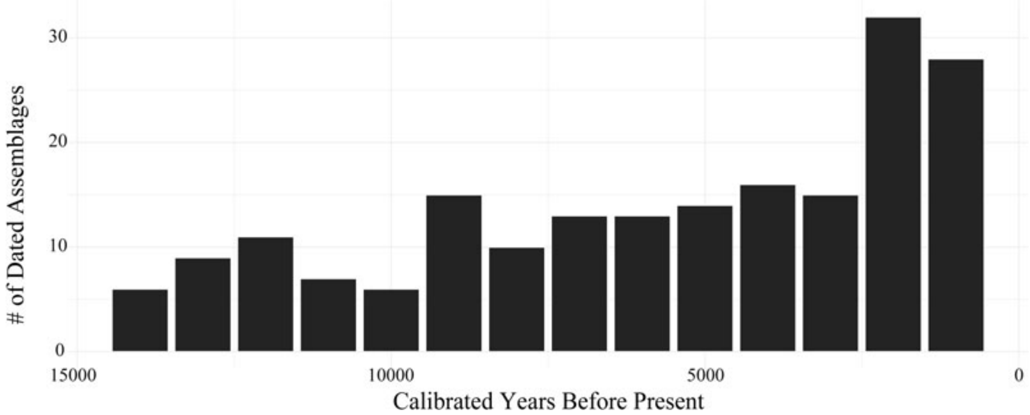

Figure 2. Radiocarbon-dated assemblages from central Alaska and Yukon.

the number of sites from circa 2000–100 cal BP is nearly twice that of the total for the preceding 4,000 years (6000–2000 cal BP; Figure 2), and average site size also increased significantly (ADNR Office of History and Archaeology 2019; Martindale et al. 2016; Mullen 2012). These concomitant increases suggest that an important demographic shift took place between 3000 and 1000 cal BP. While such a late increase in overall number of sites might be associated with survey or taphonomic bias, research in this region has been focused on occupations related to the initial colonization of the Americas (~12,000 cal BP), and this research bias likely negates taphonomic effects (Anderson et al. 2019; Surovell and Brantingham 2007). The number of sites increased before the White River Ash east event and remained consistent after the event, suggesting an alternative explanation for settlement patterning and other behavioral changes: population growth. An increase in the number of sites and site size (represented here by diameter) could signify an overall increase in population facilitated by stable climatic conditions and/or endogamous local group growth kinship systems (Ives 1990:113). Alternatively, the Thule emergence across the Northern Arctic may have displaced Athabascans from the Northwest Coast of Alaska to the interior, a potential explanation suggested by archaeological and linguistic data (Esdale 2008:8; Krauss and Golla 1981). Therefore, it appears that populations increased, either through in situ growth, in-migration, or replacement, and associated social shifts may have contributed to the Athabascan migration.

Analytical Framework

Migrations represent the culmination of individual responses to adaptive pressures that ultimately result in the permanent displacement of entire communities. Slobodkin (1968) and Colson (1979) suggested that the key to explaining adaptive decisions, such as migration, lies in understanding and explaining the penultimate responses to adaptive pressure(s). Here, we will consider social and environmental catalysts of the Athabascan transition as a way of inferring how certain push and pull factors ultimately contributed to the Athabascan migration. The choices that Athabascans made circa 2000–500 cal BP can be evaluated within the framework of human behavioral ecology to reconstruct how individual decisions made in response to social and/or environmental factors culminated in a systemic change in Athabascan behavior and, ultimately, migration (Winterhalder 2001).

Human behavioral ecology draws on optimization and game theoretic models to build predictions about the fitness-related trade-offs that individuals face in variable environmental and social circumstances (Bird and Codding 2008; Winterhalder and Smith 1992). Within this paradigm, optimal foraging theory offers the diet breadth model to predict subsistence decisions under shifting resource availability (Bettinger et al. 2015). Specifically, the diet breadth model provides a framework for predicting the adaptive response of foragers to changed resource availability. Frequently, foragers will broaden their diet to include lower-ranked resources that were previously ignored when higher-ranked resources are no longer available (Winterhalder et al. 1999). In the Subarctic, caribou are a high-ranked resource, and salmonids and other fish are considered lower-ranked unless they are intensively pursued in larger quantities due to the relationship between processing time and biomass (Tremayne and Winterhalder 2017). Therefore, this framework offers the possibility to explain the documented increase in diet breadth that occurred during the Athabascan transition.

Economic and ecological models also offer predictions for land use decisions based on resource availability that can be used to explain subsistence and mobility changes associated with the Athabascan transition (Dyson-Hudson and Smith 1978; Nonaka and Holme 2007). Specifically, agent-based and ecological models suggest that foragers pursue a strategy of high mobility and generalized subsistence when resources are sparse and unpredictable. Conversely, foragers pursue a territorial strategy of specialized resource use when resources are predictable, dense, and patchily distributed and the cost of defending predictable resources is outweighed by the benefits of controlling them. It may be difficult to conceive of territoriality occurring in such a vast landscape with a relatively low population density. However, this Subarctic ecosystem presents a unique resource scheduling conflict in two top-ranked resources, salmon and caribou, which are both available for only a few weeks in the late summer and early fall at predictable lowland and upland locations, respectively. Additionally, evidence for territoriality in both the protohistoric period and the ethnographic present supports territoriality associated with this resource scheduling conflict in this region (Blong 2016; Burch 2012:39; Sharp and Sharp 2015).

If a significant caribou population decrease associated with volcanic activity disrupted the Northern Archaic subsistence strategy, ethnohistoric data and predictions from ecological models suggest that Athabascans would pursue a strategy of high mobility and generalized subsistence that incorporated lower-ranked resources, such as fish, or would potentially move to a new region with more abundant terrestrial resources (Nonaka and Holme 2007; Tremayne and Winterhalder 2017; VanStone 1974:52). Therefore, subsistence use at all sites should be oriented around a wide range of available resources, such as moose, sheep, fish, and small game (i.e., furbearers and waterfowl), reflecting increased diet breadth. In technological assemblages, this generalized and highly mobile subsistence strategy would be associated with a general lack of intersite variability and homogeneous lithic tool reduction patterning across sites (Binford 1980). Further, assemblages should contain traded exotic materials, such as obsidian and copper, representing links to the broader social network (Dyson-Hudson and Smith 1978:26). At a landscape level, a transition to generalized diet breadth would result in a decrease in the number of upland sites and an increase in the number of lowland sites and lowland site size as subsistence focus shifted from caribou to lower-ranked resources. Finally, this generalized subsistence and land use strategy should be unified and only visible after the White River Ash east event.

In contrast, if Athabascan behavioral changes are linked to a population increase, the ecological models presented above suggest internal pressures on resource availability that would result in a gradual shift to increased resource specialization and territoriality (Dyson-Hudson and Smith 1978; Potter 2007). While overall diet breadth would increase, territoriality would necessitate the intensification of specific upland and lowland resources to increase the utility of lower-ranked resources, such as fish, and offset the cost of defending these predictable and abundant resources. Such specialization would yield heterogeneous technological assemblages suited to specific subsistence pursuits and faunal assemblages that are dominated by ecologically specific and potentially lower-ranked resources, such as fish in lowland faunal assemblages. Settlement patterning would reflect resource specialization and increased territoriality through an overall increase in the number of sites in both upland and lowland ecological settings, with an overall increase in site size as occupations grow longer, signifying increased territorial investment. Finally, gradual demographic change would likely be associated with an equally gradual change in behavior rather than a rapid, unified behavioral response.

Methods

To evaluate the dynamic process of the Athabascan transition and subsequent migration, we carried out a multiscalar evaluation of data collected through archaeological investigations. This approach unites data from regional and site scales to effectively evaluate the environmental and demographic factors that contributed to the Athabascan transition and migration.

Technological Analysis

The analysis of tools and toolmaking debris, or debitage, is standard in North American archaeology and critical to understanding the late Holocene transition in Athabascan technology. Indeed, the analysis of raw material type and debitage phase has the potential to show reduction strategies and has larger implications for mobility and land use strategy (Andrefsky 1994, 2005; Surovell 2009). Further, comprehensive debitage analyses of lithic assemblages have provided key information on subsistence and mobility across the Subarctic (Esdale 2009; Holmes et al. 2018; Rasic and Andrefsky 2001). Charcoal associated with archaeological occupations was recovered from four Alaskan archaeological sites with a total of five late Holocene components and was radiocarbon dated at the National Ocean Sciences Accelerator Mass Spectrometry lab with accelerator mass spectrometry radiocarbon dating, unless otherwise noted. Resulting dates were calibrated to 2σ using Calib 7.1 and reported following standard conventions (Stuiver and Polach 1977; Stuiver and Reimer 1993; Stuiver et al. 2019).

Associated excavated materials were analyzed at the University of Michigan Museum of Anthropological Archaeology following standard methods for morphological and functional analysis of lithic remains (Andrefsky 2005; Esdale 2009). First, all artifacts were weighed, and material types were assessed through comparisons of tool stone types found in local drainages. Second, tools and tool fragments were distinguished from debitage, or lithic material with an intact platform, identifiable bulb of percussion, and terminating edge. Only complete pieces of debitage, tools, and tool fragments are considered here. Tools and tool fragments were analyzed in comparison with established Northern Archaic and Athabascan tool types and distinguished into six broad technological categories: uniface, biface, burin, blade, microblade, and expedient tool. Debitage was assigned a size class on a base 2 scale, beginning at 1 cm^2. Next, these pieces were assessed individually for presence of cortex, heat treatment, and use-wear. Finally, each piece was assigned one of 13 production phase categories (Andrefsky 2001; Odell 2000). General production phase categories distinguished between early reduction, bifacial reduction, unifacial reduction, and microblade reduction. Early reduction flakes were further separated into primary decortication (>50% cortex), secondary decortication (10%–50% cortex), and interior flakes (0%–10% cortex). Debitage related to bifacial reduction was separated into early thinning, late thinning, alternate, edge preparation, and bifacial pressure flakes. Microblade reduction debitage was distinguished into core face rejuvenation flakes, platform rejuvenation flakes, linear flakes, and core tablets. This functional analysis of debitage in combination for statistical tests allows for the production strategy to be assessed as part of overall site use strategy.

Geochemical Analysis

Isotopic chemistry has revolutionized archaeologists' ability to measure and track diet and mobility in the past. The compound-specific isotope analysis of fatty acids in ceramic residue analysis has recently been applied to Arctic hearth residues due to the excellent preservation of fatty acids, particularly in acidic soils (Buonasera et al. 2015; Choy et al. 2016). This approach can successfully discriminate between a variety of faunal sources through dietary mixing models and gas chromatography mass spectrometry analysis (Buonasera et al. 2015; Choy et al. 2016; Craig et al. 2011; Kedrowski et al. 2009). Further, compound-specific isotope analysis can correct for deposition/preservation bias and provide a more accurate understanding of the relative importance of dietary items, such as fish, whose remains preserve poorly or are lost using standard sampling methods (Colley 1990; Grayson 1984).

Fatty acids from four hearths within three archaeological contexts all dated to the late Holocene were analyzed following standard methods for compound-specific isotope analysis to reconstruct the dietary items processed in these contexts. Approximately 1 g of soil was collected from hearths with characteristic black and/or greasy appearance associated with calcine and/or burned bone fragments. Control soils from nonhearth contexts at both sites were also collected. Fatty acid methyl esters from hearth soils were extracted with dichloromethane following a modified Bligh-Dyer technique standard in hearth residue analysis (Buonasera et al. 2015), with an appropriate amount of nonadecanoic acid serving as an internal standard (Supplemental Text 1). The resulting fatty acid methyl esters were analyzed at the University of Michigan on a Shimadzu GCMS-QP2010 with a gas chromatograph that contains a 30 m long DB-5 column with a 0.25 mm ID and a quadrupole mass spectrometer capable of unit mass resolution. This analysis confirmed the presence of C16:0 and C18:0 fatty acids and measured the relative proportion of each within the sample. Aliquots of each sample were then submitted to the University of California, Davis, Stable Isotope Facility for compound-specific isotope analysis via gas chromatography/combustion/isotopic ratio mass spectrometry. Compounds were analyzed on a TRACE 1310 Gas Chromatograph coupled to a Thermo Scientific MAT 253 isotopic ratio mass spectrometer through a GC IsoLink II combustion interface. Samples were injected, splitless, on a DB-5 ms column (60 m × 0.25 mm OD, 0.5 mm film thickness, constant flow 1.4 mL/min). Once separated, fatty acid methyl esters were quantitatively converted to CO_2 with a NiO/CuO catalyst at 1,000°C, dried, and introduced to the isotopic ratio mass spectrometer. Provisional isotopic ratio mass spectrometer values were corrected both based on working standards composed of fatty acid methyl esters calibrated against National Institute of Standards and Technology standard reference materials and for isotopic contribution of methanol, with a resulting standard deviation of $\pm 0.11‰$ or better. Fatty acid methyl ester sample $\delta^{13}C$ values are expressed in per mill (‰) ratios of ^{13}C to ^{12}C relative to the ratio for the standard reference, Vienna Pee Dee Belemnite.

Previous research has shown that the isotopic values of C16:0 and C18:0 in terrestrial and aquatic fauna are significantly different and suitable for stable isotope mixing models (Choy et al. 2016). Therefore, isotopic contributions of various fauna were estimated via $\delta^{13}C$ isotopic values of C16:0 and C18:0 using background compound-specific isotope data collected from Subarctic fauna and corrected postindustrial carbon (Buonasera et al. 2015; Choy et al. 2016; Taché and Craig 2015). SIAR version 4.2 (Parnell and Jackson 2013), an open-source package in R, was used to estimate relative contributions of potential dietary resources, and its Bayesian statistical framework incorporates uncertainty in modeling different food groups, making it ideal for estimating relative contributions of dietary items in hearth remains.

Landscape Analysis

Landscape approaches serve to unite disparate data and explore larger patterns across regional ecological use, integrating human experiences with environmental data through spatial relatedness. The complex record of Subarctic archaeological research conducted through academic, tribal, and industrial interests, among others, has resulted in varying levels of site assessment that can be integrated at a landscape level, particularly when sites have not been excavated at a large scale (Kintigh 2006). Moreover, a landscape-level analysis provides an opportunity to synthesize regional trends and better investigate causal explanations premised on resource availability, such as those presented here, and Alaskan and Canadian archaeologists have successfully used geospatial analyses to elaborate mobility and subsistence dynamics at several periods of Subarctic history including the

Athabascan transition (Kristensen, Andrews et al. 2019; Mullen 2012; Potter 2008).

Several difficulties and potential ethical issues arise from the inclusion of geospatial databases, including issues of analytical scale, the accuracy of various dating techniques, and permissions. Therefore, records and associated reports from the Alaska Heritage Resource Survey database (ADNR Office of History and Archaeology 2019) and the Canadian Archaeological Radiocarbon Database (Martindale et al. 2016) were carefully screened to mitigate research, discovery, and taphonomic bias (Surovell and Brantingham 2007; complete references available in Supplemental Table 1). Site location and associated radiocarbon dates were recorded for all occupations within the study area, defined by ethnohistoric linguistic boundaries (Krauss et al. 2011). The region considered is vast, but archaeologists have aggressively surveyed and radiocarbon dated sites across this region in part because of their potential significance to the colonization of the Americas. Radiocarbon dates for each component at all occupations were calibrated using Calib 7.1 (Stuiver and Reimer 1993; Stuiver et al. 2019:1), and approximate site sizes were attributed based on field notes and landform size using topographic maps of the region (U.S. Geological Survey 2017). Ice patch finds and other ephemeral occupation contexts were not considered in this analysis, but occupations that were relatively dated using tephras or stratigraphic position were included if they were bracketed by radiocarbon-dated contexts. Finally, hydrologic features for the study area were aggregated from the Alaska Department of Natural Resources and Parks Canada at a resolution of 1:1,000,000 (ADNR Information Resource Management 1998; Natural Resources Canada 2019), and upland and lowland zones were drawn based on ecoregion data hosted by the Environmental Protection Agency (Commission for Environmental Cooperation 1997; Gallant et al. 1995). Ecological zones (e.g., upland and lowland) were defined based on modern climate, vegetation, hydrology, terrain, and elevation (Gallant et al. 1995) and are consistent with definitions used in previous studies of settlement patterning in the region (Blong 2016; Potter 2008; Wygal 2010).

Occupations were grouped into three time periods approximately corresponding to reconstructed culture-historic periods: 6000–2000 cal BP, 2000–1150 cal BP (pre–White River Ash east), and 1150–100 cal BP (post–White River Ash east; Esdale 2008; Holmes 2008; Potter 2008). These periods are of varying lengths but have comparable numbers of radiocarbon-dated occupations and reflect relatively consistent cultural intervals. For each site, the ecological zone was recorded along with the distance to the nearest lake and the nearest river. Data from each of these periods were compared on counts of sites in different ecological zones, average distance to rivers and lakes, and average site size to identify and evaluate any significant shifts in site size and placement during the Athabascan transition. Several statistical tests were applied to the resulting dataset. A two-tailed Student's *t*-test was applied to understand differences in site size and distances throughout the period of interest. When appropriate, these data were corrected for right-hand skew through log normalization. A two-tailed Fisher's exact test was applied to overall counts of sites to determine whether significant differences existed in site number and distribution at different periods. The results of this analysis will be considered below.

Results

Artifactual Analysis

Tools, tool fragments, and tool debris recovered from five components at four sites in two different ecological settings were compared to assess patterns in technology use, specialization, and production between 2000 and 500 cal BP (Table 1; Figure 3). All five components are associated with summer or early fall use, and they span the period before (Caribou Knob, Clearview, Delta Creek, Klein site Upper Locus) and after (Klein site Lower Locus) the White River Ash east event. Further, these sites were selected for analysis because they are outside the White River Ash east deposit but proximal to the affected area and, thus, should show how this event led to behavioral changes in the immediate vicinity of the ashfall extent.

Table 1. Debitage Phase and Raw Material Counts by Site and Ecological Setting.

Site/Locus	Ecological Setting	Core Preparation	Early Bifacial	Late Bifacial	Microblade Reduction	Unifacial Reduction	Exotic Material	Local Material	Total
Caribou Nob	Lowland	45	161	355	2	3	16	434	566
Klein site, Lower	Lowland	15	8	16	3	2	5	33	44
Klein site, Upper	Lowland	34	44	109	16	0	7	192	203
Clearview	Upland	144	520	662	85	11	8	1,312	1,422
Delta Creek	Upland	2	12	13	0	0	1	24	27

Technological Assemblages and Radiocarbon Chronology. Two components from sites located in upland ecological zones were evaluated here: Clearview (XMH-1303) and Delta Creek (XBD-110). A technological analysis of Clearview, dated to 1540 ± 30 BP (NOSAMS OS-130785; wood charcoal) and calibrated to 1370–1520 cal BP, yielded 1,477 diagnostic lithic artifacts, including 55 tools, tool fragments, and cores, made of at least 13 raw material types. Delta Creek, dated to 1560 ± 60 BP (NOSAMS OS-140923; wood charcoal) and calibrated to 1400–1530 cal BP, yielded 27 diagnostic lithic artifacts made of at least four raw material types. Calibrated radiocarbon dates indicate that both of the sites predate the White River Ash east event. Faunal remains were limited from these sites, potentially due to

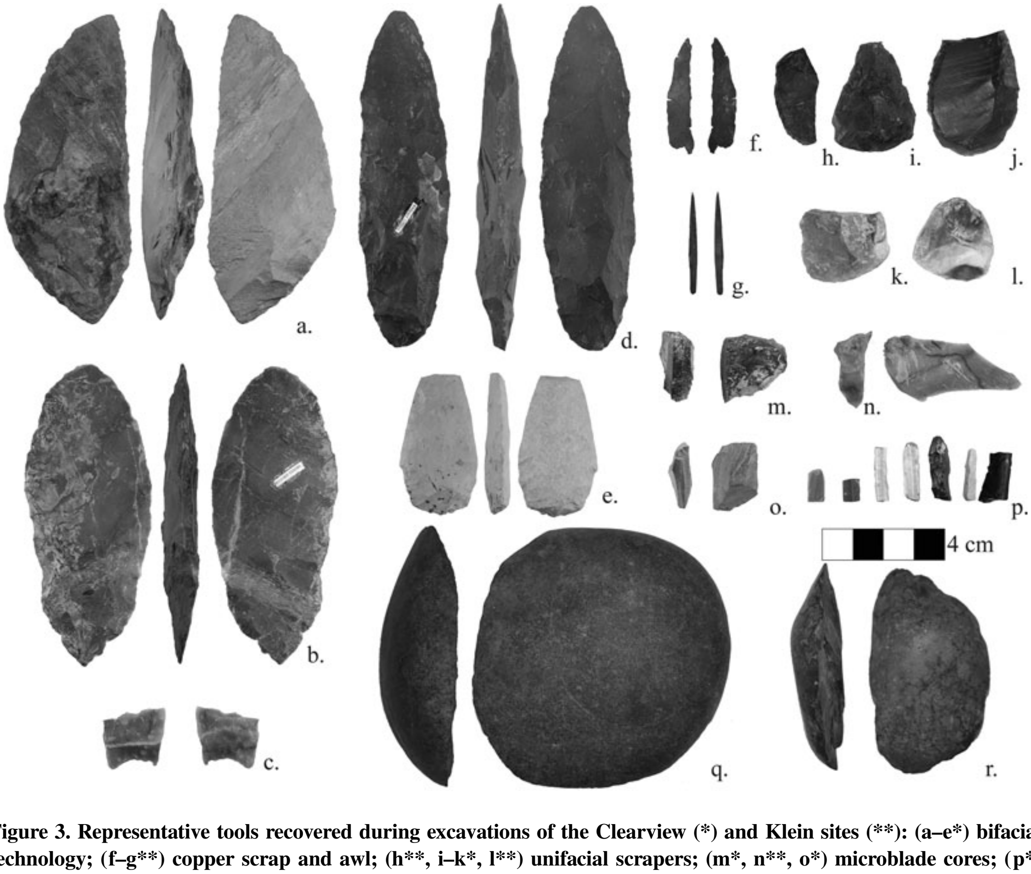

Figure 3. Representative tools recovered during excavations of the Clearview (*) and Klein sites (**): (a–e*) bifacial technology; (f–g) copper scrap and awl; (h**, i–k*, l**) unifacial scrapers; (m*, n**, o*) microblade cores; (p*) microblades; (q–r**) expedient tools. (Clearview artifact photos courtesy of Whitney McLaren.)**

poor preservation associated with boreal soils (Ping et al. 2008), and no bone technology was recovered during excavations.

Three components from two sites located in lowland ecological zones were also evaluated: Caribou Knob (XMH-917) and both the Upper and Lower Loci at the Klein site (XBD-362). Caribou Knob, dated to 1,420 ± 40 BP (Beta-271226; wood charcoal) and calibrated to 1280–1390 cal BP, yielded 568 diagnostic lithic artifacts made of at least seven raw materials, including one expedient scraper and one unifacial scraper fragment. The Upper Locus of the Klein site was dated to 1256 ± 38 BP (AA88629; wood charcoal; $\delta^{13}C = -23.1‰$; Reuther 2013:21), has a calibrated age of 1080–1160 cal BP ($p = 0.22$) and 1170–1280 cal BP ($p = 0.78$), and yielded 209 diagnostic artifacts, including a copper awl, three expedient tools, two unifacial scraper fragments, and at least 11 raw materials. The Lower Locus of the Klein site was dated to 560 ± 20 BP (Beta-40143; wood charcoal; $\delta^{13}C = -24.0‰$), calibrated to 520–560 cal BP ($p = 0.52$) and 600–630 cal BP ($p = 0.48$), and yielded 44 diagnostic artifacts, including one microblade core fragment, one unifacial scraper, one expedient flake knife, and at least six raw materials. According to the calibrated radiocarbon dates presented above, Caribou Knob and likely the Klein site Upper Locus predate the White River Ash east event, while the Klein site Lower Locus postdates this event. Though faunal material was present in all three assemblages, no evidence for osseous technology was recovered, contrasting results of previous excavations at lowland sites (e.g., Dixthada) that recovered osseous technology (Shinkwin 1979).

Production Strategies and Ecological Setting. A detailed investigation of raw material use and reduction strategies from artifacts from these five components revealed significant differences between upland and lowland ecological zones during the Athabascan transition. Results of a Fisher's exact test show that exotic raw materials, such as obsidian and copper, were significantly more frequent in lowland ecological zones ($p < 0.01$). Further, exotic materials were twice as abundant in overall count at lowland sites and four times as abundant by weight. Three copper artifacts were recovered during excavations at the Klein site Upper Locus, including one awl and two pieces of scrap, and the delamination cracks on each of these are consistent with cold hammering (Cooper 2007:123; Franklin et al. 1981). Though exotic materials, obsidian specifically, were found in all assemblages, they were more abundant in components found in the lowland ecological zone.

All assemblages showed evidence for initial core reduction and bifacial tool production. Moreover, unifacial, microblade, and expedient technologies were recovered from all assemblages except for Delta Creek. A Fisher's exact test on the overall count of artifacts related to microblade and bifacial reduction showed that microblade reduction was significantly more common in upland ecological zones ($p < 0.01$). Additionally, upland sites had significantly higher quantities of debris related to early bifacial reduction according to a Fisher's exact test ($p < 0.01$), while lowland sites had more expedient tools and debris related to initial core reduction ($p < 0.01$). These results indicate that tool production strategies were distinct in upland and lowland ecological settings during the Athabascan transition.

Compound-Specific Isotope Analysis of Hearth Fatty Acids

Hearths were identified based on soil discoloration, abundance of charcoal or charcoal flecking, and presence of fragmentary and calcined bone. Further, carbon isotope ratios showed that hearth soils were significantly different from control soils at all occupations (Table 2). The results of an unpaired Student's t-test showed that Caribou Knob control and hearth $\delta^{13}C$ values of C16:0 and C18:0 were significantly different ($t = 4.55$, $p = 0.01$; and $t = 1.78$, $p = 0.01$, respectively). Similarly, control and hearth $\delta^{13}C$ values from the Klein site also varied significantly in C16:0 ($t = 2.97$; $p = 0.02$) and C18:0 ($t = 14.67$; $p < 0.01$).

Hearth soils at Caribou Knob and both loci at the Klein site contained a significant quantity of extractable fatty acids (FAs), identifiable by their FA methyl ester mass spectra (Figure 4). Long-chain saturated FAs (C14:0–C26:0) were the most abundant constituents, with hexadecenoic

Table 2. Results of Compound-Specific Isotopic Analysis of Fatty Acid Methyl Esters Extracted from Hearth Remains.

Site/Locus	Sample ID	Feature	Lipid Concentration (μg/mg)	δ^{13}C16:0 (‰)	δ^{13}C18:0 (‰)
Caribou Knob	2019-2-ck261	Control	0.11	−32.03	−31.13
Caribou Knob	2019-5-ck261	Control	0.19	−31.63	−31.48
Caribou Knob	2019-2-ck9	CK F1	0.36	−32.99	−31.92
Caribou Knob	2019-4-ck10	CK F1	0.47	−32.74	−31.49
Caribou Knob	2019-5-ck10	CK F1	0.13	−32.58	−31.53
Caribou Knob	2019-6-ck9	CK F1	0.18	−32.55	−31.58
Klein site	2019-5-AEHOZ	Control	0.11	−29.64	−29.95
Klein site	2019-6-AEHOZ	Control	0.05	−29.53	−29.67
Klein site, Lower	2019-4-ks315	KS F2014-1	0.10	−32.19	−31.13
Klein site, Lower	2019-4-ks354	KS F2014-1	0.09	−31.32	−31.11
Klein site, Lower	2019-5-ks315	KS F2014-1	0.29	−32.39	−31.11
Klein site, Upper	2019-4-ks624	KS F2018-3	0.10	−31.08	−31.02
Klein site, Upper	2019-6-ks624	KS F2018-3	0.05	−31.12	−31.06
Klein site, Upper	2019-4-ks656	KS F2018-5	0.13	−30.52	−31.04
Klein site, Upper	2019-5-ks656	KS F2018-5	0.11	−30.61	−30.88
Klein site, Upper	2019-6-ks656	KS F2018-5	0.04	−30.46	−30.96

acid (C16:0) more abundant than octadecanoic acid (C18:0). Unsaturated FAs were also identified, including C16:1, C18:1, and C18:2. We did not identify any FAs used as marine biomarkers, such as isoprenoid FAs (4,8,12-trimethyltridecanoic, pristanic, or phytanic acid), long-chain ω-(o-alkylphenyl)alkanoic acids, or dihydroxy FAs (Buonasera et al. 2015; Choy et al. 2016; Heron et al. 2010; Taché and Craig 2015).

The results of a Bayesian analysis of faunal contribution to hearth isotopic data show that a mix of faunal resources were used at Caribou Knob and both loci of the Klein site (Figure 5), occupations that span circa 1300 cal BP to around 500 cal BP. A mixing model estimated the relative probability of terrestrial, freshwater, and marine resources within hearth soils (Figure 6; Choy et al. 2016; Taché and Craig 2015). This model showed that the majority (>50%) of fats found in hearth materials could be attributed to freshwater resources in all three contexts and that lacustrine resources were supplemented by terrestrial and marine resources. This indicates that freshwater fish were of central importance in these three occupations spanning the late Holocene.

Landscape Analysis

A total of 79 archaeological components were occupied before 2000 cal BP, and a total of 119 components were occupied after 2000 cal BP (Table 3; Supplemental Table 1). Of these, 61 occupations predate the White River Ash east event, and 58 postdate this event, according to the median probabilities of calibrated radiocarbon dates. Occupation size and ecological information reveal significant differences in spatial patterning across these periods of Subarctic history that will be considered in detail below.

Pre- and Post-2000 cal BP. The results of a two-tailed Student's t-test show that no significant difference exists in overall site size during the pre- and post-2000 cal BP periods ($t = -0.21; p = 0.84$). Additionally, no significant differences exist between these periods in average site size in either the uplands ($t = 0.28$; $p = 0.78$) or the lowlands ($t = -1.17$; $p = 0.25$). However, upland sites are significantly larger in diameter than lowland sites during both the pre-2000 cal BP period ($t = -2.66$; $p = 0.01$) and the post-2000 cal BP period ($t = 2.16$; $p = 0.03$). Pre-2000 cal BP upland site diameters are 68 m larger than lowland sites, on average, and post-2000 cal BP upland site diameters are an average of 17 m larger than lowland sites.

Site patterning was also evaluated for differences in site placement relevant to lakes and rivers and for overall number of sites in lowland and upland locales to ascertain resource and landscape use at different periods in the past. The results of two-tailed Student's t-test show no

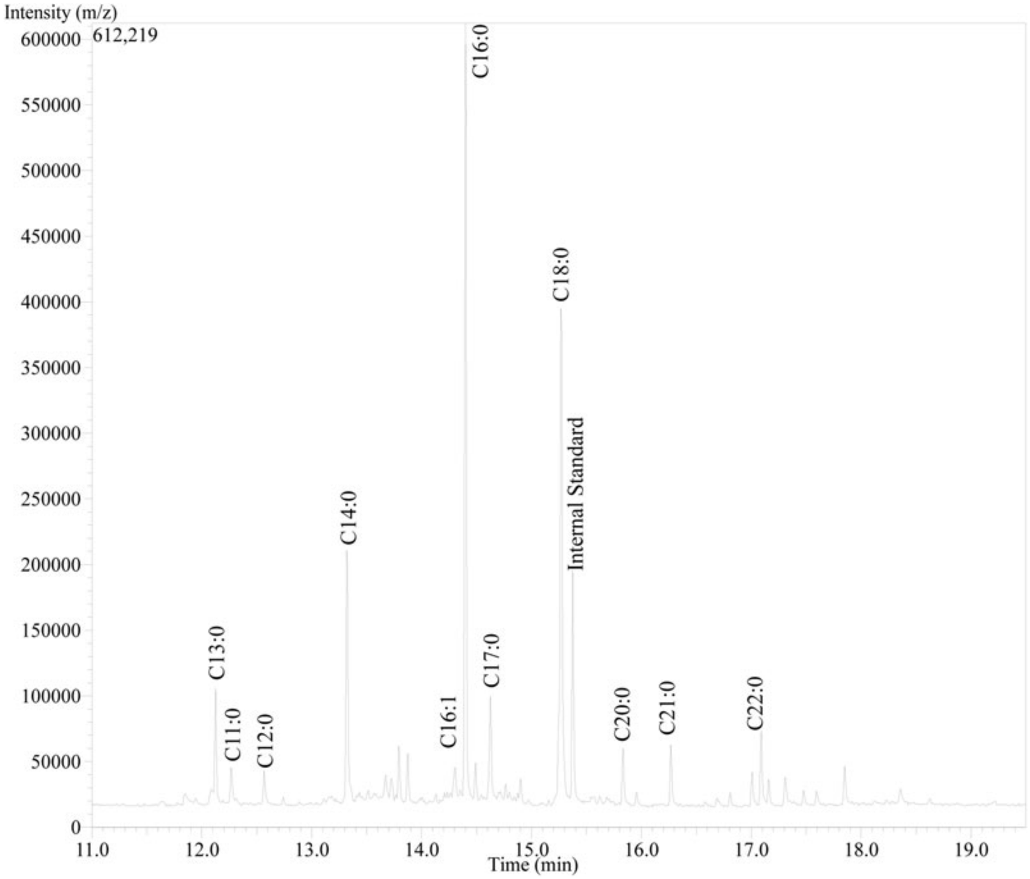

Figure 4. Representative chromatogram derived from Klein site Upper Locus hearth fatty acid methyl esters.

significant difference in proximity to rivers during the pre- and post-2000 cal BP periods ($t = 0.5$; $p = 0.61$). Contrastingly, the results of a t-test show that post-2000 cal BP occupations were significantly closer to lakes than pre-2000 cal BP sites ($t = 2.04$; $p = 0.04$). On average, pre-2000 cal BP occupations were 2.4 km closer to lakes than post-2000 cal BP sites. Finally, the results of a Fisher's exact test show that the distribution of sites was significantly different during the pre- and post-2000 cal BP periods ($p < 0.01$), with significantly more upland sites than lowland sites during the pre-2000 cal BP period and an even distribution during the post-2000 cal BP period.

Pre– versus Post–White River Ash East. Results were further divided into pre– and post–White River Ash east to ascertain landscape use patterns during the last 2,000 years of Northern Athabascan history. A two-tailed Student's t-test showed no significant difference in overall site diameter before and after the White River Ash east event ($t = -0.85$; $p = 0.4$), nor was there a significant difference between site diameters in either upland ($t = 1.5$; $p = 0.12$) or lowland ($t = 0.07$; $p = 0.95$) occupations before and after the White River Ash east event. However, the same test showed that upland site diameters were significantly larger than lowland site diameters before the White River Ash east event ($t = 2.16$; $p = 0.03$) but not after the event ($t = 0.95$; $p = 0.48$). During the pre–White River Ash east period, upland site diameters were 43 m larger on average.

Patterns in site placement relative to rivers and lakes as well as overall sites present in upland and lowland locations were assessed to document landscape patterning before and after the White

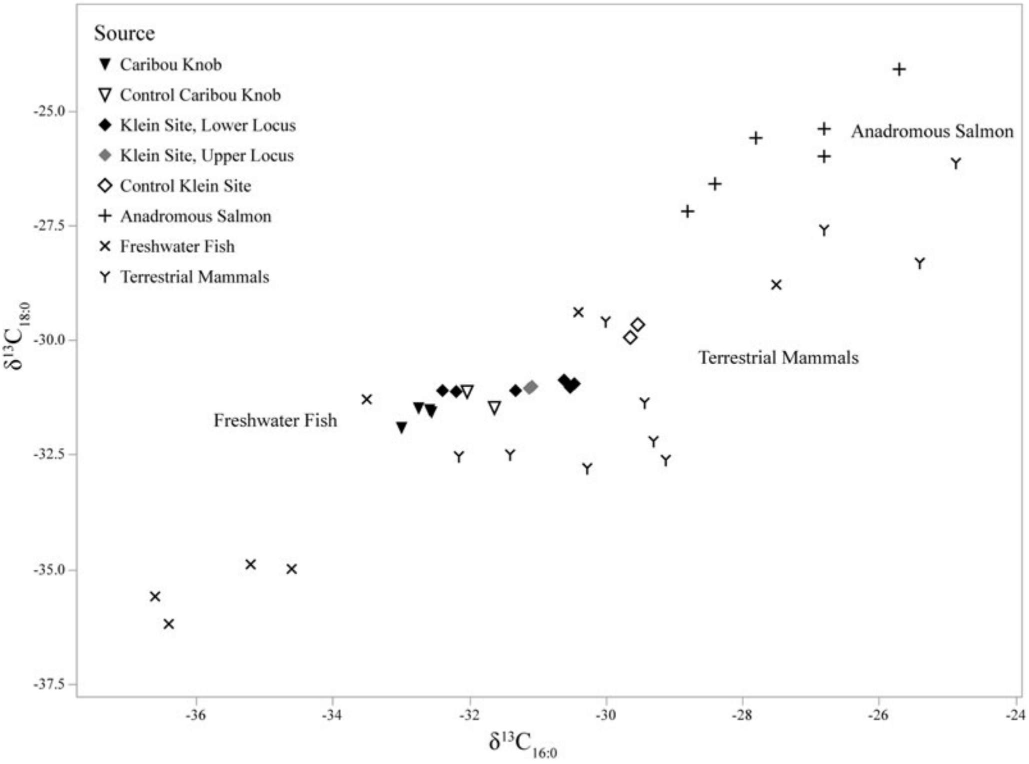

Figure 5. **δ^{13}C16:0 and δ^{13}C18:0 values of lipids from Caribou Knob and Klein site hearth residues.**

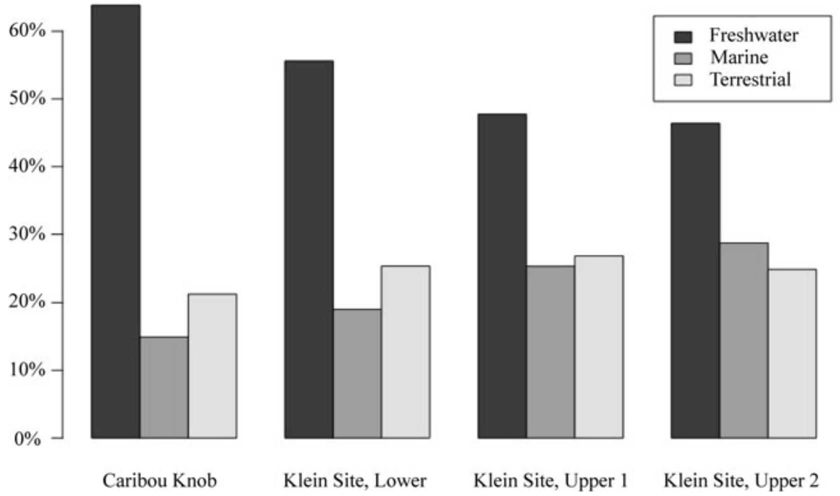

Figure 6. **Relative abundance of terrestrial, freshwater, and marine (anadromous) fauna in hearth remains.**

River Ash east event. The results of a two-tailed Student's *t*-test showed that post–White River Ash east occupations were significantly closer to rivers than pre–White River Ash east sites ($t = -2.67$; $p < 0.01$), at 1.4 km closer on average. In contrast, no significant difference was found

Table 3. Relationship between Overall Number of Occupations, Site Size, and Placement of Mid- to Late Holocene Sites in Central Alaska and Yukon.

	Mid-Holocene	Late Holocene	Pre-1000 cal BP	Post-1000 cal BP
# of occupations	79	119	61	58
Ecological Zone				
# in uplands	56	56	29	27
# in lowlands	23	63	32	31
Proximity to Water Features				
Mean site distance to nearest lake (km)	11.9	9.3	7.3	9.5
Mean site distance to nearest river (km)	1.3	1.9	2.5	1.2
Average Site Size				
Mean site diameter (m)	163	159	163	157
Mean diameter of sites in uplands (m)	182	168	186	158
Mean diameter of sites in lowlands (m)	114	151	143	156

in lake proximity pre– and post–White River Ash east ($t = -0.49$; $p = 0.63$). Finally, a Fisher's exact test showed no significant difference in upland and lowland site distribution between these two periods ($p = 1.0$).

Discussion

The results have several implications for the Athabascan transition, associated behavioral changes, and the ultimate migration south. Specifically, these results indicate that behavior gradually changed to become more specialized between 1800 and 1200 cal BP, reflecting predictions associated with a pronounced demographic change rather than rapid ecological deterioration. Moreover, the results suggest that the timing of this change is inconsistent with an adaptive response to either White River Ash event, further indicating that the Athabascan migration resulted from gradual demographic shifts.

Transition to a Specialized Subsistence Economy

Generally, the results from subsistence and technological analyses show greater specialization based on ecological zone and are consistent with an overall increase in diet breadth associated with the broader Athabascan transition. Artifacts recovered from five components located in both upland and lowland ecological contexts reveal several significant, location-specific uses of technology and strategies for technological production. First, lowland sites yielded much higher quantities of exotic material such as obsidian and copper. Further, expedient tools were recovered in significantly higher quantities from occupations in lowland ecological zones, as was debitage associated with late-stage bifacial reduction. In contrast, sites located in upland ecological zones exhibited significantly more microblades and early bifacial reduction than lowland occupations. These results indicate that technology was structured around resource availability and associated with specific upland and lowland subsistence pursuits, suggesting that bifacial reduction began in the uplands and reduced bifaces were transported for further reduction, use, and modification in the lowlands, where expedient tools, exotic materials, and, potentially, osseous tools were curated (Shinkwin 1979). Previous research has shown limited ecological specialization within Northern Archaic assemblages, with bifacial reduction in the uplands and microblade reduction in the lowlands (Potter 2008; Wygal 2010). The technological data presented here illustrate greater ecological specialization in raw material, reduction strategy, and use among Athabascan assemblages, indicating a technological transition between 1800 and 1200 cal BP. Additional research focused on reduction sequence, chronology, and location from occupations spanning the period and region of interest could further articulate the nature and timing of this technological change and would likely reveal greater nuance in Northern Archaic technological organization. In sum, these technological results suggest an increase in specialization relative to current understandings of the Northern Archaic that is consistent with increased populations and territoriality suggested by the diet breadth and economic defensibility models.

Results from a compound-specific isotope analysis of fatty acid methyl esters from hearth contexts also suggest that diet breadth increased during the Athabascan transition, consistent with previous research (Holmes 2008; Potter 2008), but with subsistence use specialized based on ecological context. Specifically, the dietary mixing model presented here showed that freshwater resources likely predominated in all three lowland occupations. Probability distributions indicate a specialized use of freshwater resources in these lowland settings, indicating that this lower-ranked resource was intensified even though higher-ranked resources, such as caribou, were locally available (Broughton 1994). Future geochemical research on upland hearth remains could elaborate on these findings.

The analysis of landscape data is also consistent with the results from hearth remains and previous research that suggests increased use of lowland ecological zones circa 2000–1000 cal BP (Potter 2008). Starting circa 2,000 years ago, the overall number of sites as well as the number of lowland sites significantly increased, reflecting changes in subsistence suggested by archaeological and ethnohistoric data. Additionally, upland site size remained the same, while lowland site size increased significantly relative to upland site size. Both the increase in lowland sites and the increase in lowland site size indicate the greater importance of this ecological zone after 2,000 years ago. Upland site size and count remain consistent throughout this period, indicating that these sites maintained their importance within a subsistence system increasingly specialized to upland and lowland resources. This suggests that late summer and early fall resource scheduling conflicts and increased population size were resolved by committing to an increasingly specialized subsistence system.

A Gradual Change

Evidence from technology, subsistence, and landscape use presented above indicates that the behavioral changes associated with the Athabascan transition were gradual, occurred between 1800 and 1200 cal BP, and were unrelated to volcanic-induced environmental degradation. The results of the technological analysis above suggest that assemblages vary more with location than with age. Evidence for microblade production was recovered both from Clearview, one of the earliest occupations considered here, and from the Lower Locus at the Klein site, which was occupied around 1,000 years later and well after the White River Ash east event. Archaeologists have previously suggested that microblade use ended around the time of this event and atlatl and dart technology was replaced by bow and arrow technology based on data from Yukon ice patches (Hare et al. 2012; Holmes 2008; Potter 2008). Yet, the excavation evidence presented here demonstrates that microblade production continued for at least 600 more years in central Alaska and shows no indication of bow and arrow technology. The introduction of copper technology in this region has also been associated with the White River Ash east (Cooper 2007; Hare et al. 2012; Moodie et al. 1992). However, results from the Upper Locus of the Klein site suggest that copper technology was already present in the region circa 1250 cal BP, well before the White River Ash east, though the copper materials recovered show evidence of cold hammering, indicating that hot working, characteristic of Athabascan copper work, occurred later in the region (Franklin et al. 1981). These results indicate that technological transitions were gradual and well under way by the time of the White River Ash east event, a conclusion supported by recent research in the region (Grund and Huzurbazar 2018; Kristensen, Hare et al. 2019).

The geochemical results presented above also point toward a transition in behavior that spanned the late Holocene. Hearths from occupations spanning 1300 cal BP to 500 cal BP all showed similar patterns in subsistence use according to the isotopic composition of fatty acids extracted from those soils. This indicates that fish were an important resource from at least 1300 cal BP. Additionally, the lack of definitive bow and arrow technology in assemblages through 500 cal BP indicates that overall increases in diet breadth were unrelated to a transition to bow and arrow technology and is consistent with previous research showing that increased diet breadth preceded the introduction of bow and arrow technology to the region (Kristensen, Andrews et al. 2019:787). These results suggest that geoarchaeologists could apply an analysis of fatty acid methyl esters to identify dietary trends during the Northern Archaic, which remain poorly understood due to poor preservation environments. Such results may reveal a wide diet breadth at even earlier periods in Subarctic history (Holmes 1975:101).

Results of the landscape analysis show evidence for gradual changes during the Athabascan period from 2,000 years BP to the protohistoric period circa 100 years BP and a significant departure from the previous period, suggesting a prolonged interval of behavioral change and a broad window for the timing of the Athabascan migration. Before and after the White River Ash east circa 1150 cal BP, we observe no significant changes in number of sites and no changes in upland site size. This indicates that upland resources were pursued similarly during the last 2,000 years of Athabascan history. However, after 1,000 years ago, lowland sites were significantly larger, and occupations were significantly closer to rivers, suggesting that commitment to lowland resources and particularly riverine resources such as fish had increased by this time. These changes in landscape use may be related to a general lowland expansion and increased specialization that spanned the late Holocene or may simply represent preservation bias associated with meandering braided rivers common to the region (Anderson et al. 2019).

Recent research has reemphasized the importance of understanding the complex Northern Athabascan social landscape, with a network of traded exotic raw materials that collectively spans northwest Alaska to southern Alberta and beyond (Kristensen, Andrews et al. 2019; Kristensen, Hare et al. 2019). This research concludes that neighboring Athabascan and non-Athabascan groups shared their territories with southern Yukon Athabascans for a brief time following the White River Ash east before these affected Athabascans either returned or moved farther south, toward Alberta and the Great Plains, and adopted bow and arrow technology from coastal, non-Athabascan groups. However, the results presented here suggest that Northern Athabascans adapted to increased population pressure with increased territoriality, which provides a more parsimonious explanation for a gradual decrease in interactions among Northern Athabascans and increased interactions between Yukon Athabascans and neighboring groups represented by obsidian and clinker sourcing studies (Dyson-Hudson and Smith 1978; Kristensen, Andrews et al. 2019; Kristensen, Hare et al. 2019). Further, the sudden adoption of bow and arrow technology is frequently associated with increased territoriality and likelihood of interpersonal conflict, providing a tangible trigger for the adoption of this technology represented in Yukon ice patch assemblages (Maschner and Mason 2013). Together, the data from this multiscalar analysis indicate that trade network dynamics in Yukon reflect broader changes to the social landscape related to increased territoriality and population size.

Athabascan Behavior and Migration

Combined, this multiscalar dataset suggests that a gradual increase in population that began in the region around 2,000 years BP led to the behavioral changes that constitute the Athabascan transition and are intimately linked to the Athabascan migration. Consistency within Dene (Athabascan) terminology for ceramic, copper, and bow and arrow technology indicates that this technological transition was inherent to the process of the Athabascan migration (Colson 1979; Ives 2010; Wilson 2019). Results from a multiscalar dataset comprising subsistence, mobility, and technology point to a gradual change that resulted from regional resource stress caused by population pressure, not by a rapid environmental change.

Population pressure may have resulted from an in situ population increase, facilitated by endogamous local group growth kinship systems documented in northern Canadian Dene (Ives 1990) and/or stable climatic conditions (Kaufman et al. 2016). Alternatively, this regional population increase may have been triggered by coastal in-migration. Research that targets the margins of Northern Athabascan geography can speak to the broader Athabascan interaction sphere and chart the timing and homogeneity of cultural and behavioral shifts, as recent Yukon raw material sourcing studies have shown (Kristensen, Andrews et al. 2019; Kristensen, Hare et al. 2019). Linguistic data also suggest that western Alaska may represent the origin of the Athabascan diaspora, rather than central Yukon (Wilson 2019). Together, these recent efforts show that the Athabascan migration was a complex social process related to important behavioral changes in the region that culminated around 1,000 years ago.

Conclusion

This multiscalar approach suggests that the Athabascan transition and subsequent migration were gradual and socially mediated, with important consequences for our understanding of Subarctic cultural systems and hunter-gatherer behavior more generally. The synthesized data presented above suggest that social and demographic factors, possibly augmented by environmental stress, caused the Athabascan migration and associated behavioral changes. Site use, as indicated by location, technology, and subsistence evidence, and broader patterns in landscape use suggest that resource use was broader overall after 2000 cal BP. However, comparisons of artifactual, landscape, and geochemical data between upland and lowland sites show specialization by ecological zone, with large upland camps focused on caribou and large lowland camps targeting fish, contrasting expectations for environmental stress based in human behavioral ecology and ethnographic analysis. Additionally, variations in site and land use also suggest that this change was relatively slow, indicating that prolonged demographic shifts ultimately resulted in adaptation and migration, rather than the rapid ecological fallout associated with volcanic activity in the region.

The results of this analysis contribute to our understanding of late Holocene hunter-gatherer behavior in several dimensions. First, data from excavations showed the prolonged use of microblade technology through the White River Ash east event and document some of the earliest copper artifact use and manufacture in this region. Second, these results emphasize the feasibility of residue analysis of hearths from late Holocene occupations in the region, particularly where remains are too fragmentary or poorly preserved for a traditional faunal analysis. Third, the landscape analysis presented here highlights the utility of uniting results from diverse field research endeavors collected at different scales, such as cultural resource management, academic, and government projects, in the interest of explicating regional behavioral trends. Finally, this research highlights the potential of evaluating past episodes of hunter-gatherer behavior change and migration in social and environmental terms using predictions drawn from human behavioral ecology. Future research on central Alaskan and Yukon occupations spanning the Holocene can expand on these findings to further refine our understanding of Subarctic culture, migration, and hunter-gatherer behavior at many periods in the past.

Acknowledgments. The research presented here was funded by the National Science Foundation (award #1830705), the Wenner-Gren Foundation (grant #9754), the National Geographic Foundation (award #HJER1517), and the University of Michigan Museum of Anthropological Archaeology. U.S. Army Garrison Alaska provided access to sites on Fort Wainwright under Archaeological Resources Protection Act Permit 2016-001. Brian Stewart, John Speth, and Raven Garvey offered guiding questions and critical suggestions during the research design and interpretation phases of this project. Tammy Buonasera provided lab guidance that allowed us to present the isotopic results here. Jordan Dalton and Jennifer Larios provided Spanish translation assistance. Sam Coffman, Scott Shirar, and Fawn Carter provided collections access at the University of Alaska Museum of the North and aided in excavations at the Klein site. Kate Yeske, Whitney McLaren, Heather Hardy, Angela Gore, John Blong, Kristin Cimmerer, Emma Creamer, Angie Feak, Emma Jones, Annika Reibentisch, and Xinglin Wang contributed to data collection and analysis in the field and/or lab.

Data Availability Statement. The data considered in this article are housed in Deep Blue, a data repository hosted by the University of Michigan, with the exception of specific site location data.

Supplemental Materials. For supplementary material accompanying this article, visit https://doi.org/10.1017/aaq.2020.34.

Supplemental Text 1. Fatty Acid Methyl Ester Extraction Protocol.

Supplemental Table 1. Calibrated Radiocarbon Dates and Landscape Data Considered in Spatial Analysis.

References Cited

ADNR (Alaska Department of Natural Resources) Information Resource Management
1998 Alaska Hydrography, 1:1,000,000. Unpublished vector digital data.

ADNR (Alaska Department of Natural Resources) Office of History and Archaeology
2019 The Alaska Heritage Resources Survey Portal. Electronic document, https://dnr.alaska.gov/ohasecurity/portal, accessed January 15, 2019.

Anderson, Douglas D.
1968 A Stone Age Campsite at the Gateway to America. *Scientific American* 218(6):24–33.

Anderson, Shelby L., and Thomas Brown, and Justin Junge, and Jonathan Duelks
2019 Demographic Fluctuations and the Emergence of Arctic Maritime Adaptations. *Journal of Anthropological Archaeology* 56:101100.

Andrefsky, William, Jr.
1994 Raw-Material Availability and the Organization of Technology. *American Antiquity* 59:21–34.

Andrefsky, William, Jr. (editor)
2001 *Lithic Debitage: Context, Form, Meaning*. University of Utah Press, Salt Lake City.

Andrefsky, William, Jr.
2005 *Lithics: Macroscopic Approaches to Analysis*. 2nd ed. Cambridge Manuals in Archaeology. Cambridge University Press, Cambridge.

Angelbeck, Bill, and Ian Cameron
2014 The Faustian Bargain of Technological Change: Evaluating the Socioeconomic Effects of the Bow and Arrow Transition in the Coast Salish Past. *Journal of Anthropological Archaeology* 36:93–109.

Anthony, David W.
1990 Migration in Archeology: The Baby and the Bathwater. *American Anthropologist* 92:895–914.
1997 Prehistoric Migration as Social Process. In *Migrations and Invasions in Archaeological Explanation*, edited by John Chapman and Helena Hamerow, pp. 21–32. Archaeopress, Oxford.

Berkes, Fikret, and Dyanna Jolly
2001 Adapting to Climate Change: Social-Ecological Resilience in a Canadian Western Arctic Community. *Conservation Ecology* 5(2):18.

Bettinger, Robert L.
2013 Effects of the Bow on Social Organization in Western North America. *Evolutionary Anthropology* 22:118–123.

Bettinger, Robert L., Raven Garvey, and Shannon Tushingham
2015 *Hunter-Gatherers: Archaeological and Evolutionary Theory*. Springer, Boston.

Binford, Lewis R.
1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45:4–20.

Bird, Douglas W., and Brian F. Codding
2008 Human Behavioral Ecology and the Use of Ancient Landscapes. In *Handbook of Landscape Archaeology*, edited by Bruno David and Julian Thomas, pp. 396–408. Left Coast Press, Walnut Creek, California.

Blackman, Tara E., Charles M. Crisafulli, and Shannon M. Claeson
2018 Characteristics of a New Rainbow Trout Population: Spirit Lake, Mount St. Helens Volcano, 2000–2015. In *Ecological Responses at Mount St. Helens: Revisited 35 Years after the 1980 Eruption*, edited by Charles M. Crisafulli and Virginia H. Dale, pp. 251–267. Springer, New York.

Blong, John Christian
2016 Prehistoric Landscape Use in the Central Alaska Range. PhD dissertation, Department of Anthropology, Texas A&M University, College Station.

Bowyer, Vandy E.
2011 *Caribou Hunting at Ice Patches: Seasonal Mobility and Long-Term Land-Use in the Southwest Yukon*. University of Alberta, Edmonton, Alberta, Canada.

Broughton, Jack M.
1994 Late Holocene Resource Intensification in the Sacramento Valley, California: The Vertebrate Evidence. *Journal of Archaeological Science* 21:501–514.

Buonasera, Tammy Y., Andrew H. Tremayne, Christyann M. Darwent, Jelmer W. Eerkens, and Owen K. Mason
2015 Lipid Biomarkers and Compound Specific δ^{13}C Analysis Indicate Early Development of a Dual-Economic System for the Arctic Small Tool Tradition in Northern Alaska. *Journal of Archaeological Science* 61:129–138.

Burch, Ernest S.
2012 *Caribou Herds of Northwest Alaska, 1850–2000*. University of Alaska Press, Fairbanks.

Cabana, Graciela S., and Jeffery J. Clark
2011 *Rethinking Anthropological Perspectives on Migration*. University Press of Florida, Gainesville.

Carlson, Roy L.
2012 Issues in Athabaskan Prehistory. In *From the Land of Ever Winter to the American Southwest: Athapaskan Migrations, Mobility, and Ethnogenesis*, edited by Deni Seymour, pp. 410–425. University of Utah Press, Salt Lake City.

Choy, Kyungcheol, Ben A. Potter, Holly J. McKinney, Joshua D. Reuther, Shiway W. Wang, and Matthew J. Wooller
2016 Chemical Profiling of Ancient Hearths Reveals Recurrent Salmon Use in Ice Age Beringia. *Proceedings of the National Academy of Sciences of the United States of America* 113:9757–9762.

Clague, John J., S. G. Evans, V. N. Rampton, and G. J. Woodsworth
1995 Improved Age Estimates for the White River and Bridge River Tephras, Western Canada. *Canadian Journal of Earth Sciences* 32:1172–1179.

Colley Sarah M.
1990 The Analysis and Interpretation of Archaeological Fish Remains. *Archaeological Method and Theory* 2:207–253.

Colson Elizabeth
1979 In Good Years and In Bad: Food Strategies of Self-Reliant Societies. *Journal of Anthropological Research* 35(1):18–29.

Commission for Environmental Cooperation
1997 *Ecological Regions of North America: Toward a Common Perspective*. Commission for Environmental Cooperation, Montreal, Quebec, Canada.

Cooper, H. Kory
2007 The Anthropology of Native Copper Technology

and Social Complexity in Alaska and the Yukon Territory: An Analysis Using Archaeology, Archaeometry, and Ethnohistory. PhD dissertation, Department of Anthropology, University of Alberta, Edmonton, Alberta, Canada.

Craig Oliver E., Val J. Steele, Anders Fischer, Sönke Hartz, Søren H. Andersen, Paul Donohoe, Aikaterini Glykou, Hayley Saul, D. Martin Jones, and Eva Koch
2011 Ancient lipids reveal continuity in culinary practices across the transition to agriculture in Northern Europe. *Proceedings of the National Academy of Sciences* 108:17910–17915.

Crisafulli, Charles M., Robert R. Parmenter, Tara E. Blackman, and James A. MacMahon
2018 Mammal Community Assembly during Primary Succession on the Pumice Plain at the Mount St. Helens Volcano (1983–2015). In *Ecological Responses at Mount St. Helens: Revisited 35 Years after the 1980 Eruption*, edited by Charles M. Crisafulli and Virginia H. Dale, pp. 269–303. Springer, New York.

Derry, David E.
1975 Later Athapaskan Prehistory: A Migration Hypothesis. *Western Canadian Journal of Anthropology* 5(3–4):134–147.

Dixon, E. James
1985 Cultural Chronology of Central Interior Alaska. *Arctic Anthropology* 22(1):47–66.

Dixon, E. James, William F. Manley, and Craig M. Lee
2005 The Emerging Archaeology of Glaciers and Ice Patches: Examples from Alaska's Wrangell–St. Elias National Park and Preserve. *American Antiquity* 70:129–143.

Dumond, Don
2010 The Dene Arrival in Alaska. In *The Dene-Yeniseian Connection*, edited by James Kari and Ben A. Potter, pp. 335–346. Anthropological Papers, New Series 5(1–2). Department of Anthropology, University of Alaska, Fairbanks.

Dykeman, Douglas D., and Paul Roebuck
2012 Navajo Emergence in Dinétah: Social Imaginary and Archaeology. In *From the Land of Ever Winter to the American Southwest: Athapaskan Migrations, Mobility, and Ethnogenesis*, edited by Deni Seymour, pp. 150–181. University of Utah Press, Salt Lake City.

Dyson-Hudson, Rada, and Eric A. Smith
1978 Human Territoriality: An Ecological Reassessment. *American Anthropologist* 80:21–41.

Esdale, Julie A.
2008 A Current Synthesis of the Northern Archaic. *Arctic Anthropology* 45(2):3–38.
2009 Lithic Production Sequences and Toolkit Variability: Examples from the Middle Holocene, Northwest Alaska. PhD dissertation, Department of Anthropology, Brown University, Providence, Rhode Island.

Fast, Phyllis Ann
2008 The Volcano in Athabascan Oral Narratives. *Alaska Journal of Anthropology* 6(1–2):131–140.

Franklin, U. M., E. Badone, R. Gotthardt, and B. Yorga
1981 *An Examination of Prehistoric Copper Technology and Copper Sources in Western Arctic and Subarctic North America*. Mercury Series. National Museums of Canada, Ottawa.

Gallant, Alisa L., Emily F. Binnian, James M. Omernik, and Mark B. Shasby
1995 *Ecoregions of Alaska*. U.S. Geological Survey Professional Paper 1567. Electronic document, https://pubs.usgs.gov/pp/1567/report.pdf, accessed January 1, 2019.

Gordon, Bryan
2012 The White River Ash Fall: Migration Trigger or Localized Event? *Revista de Arqueología Americana* 30:91–102.

Graf, Kelly E., and Nancy H. Bigelow
2011 Human Response to Climate during the Younger Dryas Chronozone in Central Alaska. *Quaternary International* 242:434–451.

Grayson Donald K.
1984 *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas*. Academic Press, Orlando, Florida.

Grund, Brigid S., and Snehalata V. Huzurbazar
2018 Radiocarbon Dating of Technological Transitions: The Late Holocene Shift from Atlatl to Bow in Northwestern Subarctic Canada. *American Antiquity* 83:148–162.

Hare, P. Gregory, Christian D. Thomas, Timothy N. Topper, and Ruth M. Gotthardt
2012 The Archaeology of Yukon Ice Patches: New Artifacts, Observations, and Insights. *Arctic* 65:118–135.

Heron, Carl, Gørill Nilsen, Ben Stern, Oliver Craig, and Camilla Nordby
2010 Application of Lipid Biomarker Analysis to Evaluate the Function of "Slab-Lined Pits" in Arctic Norway. *Journal of Archaeological Science* 37:2188–2197.

Hill, David V.
2012 Variation in the Production of Ceramics by Athapaskans in the Western United States. In *From the Land of Ever Winter to the American Southwest: Athapaskan Migrations, Mobility, and Ethnogenesis*, edited by Deni Seymour, pp. 225–240. University of Utah Press, Salt Lake City.

Holmes, Charles E.
1975 A Northern Athapaskan Environment System in Diachronic Perspective. *Western Canadian Journal of Anthropology* 5(3–4):92–124.
2008 The Taiga Period: Holocene Archaeology of the Northern Boreal Forest, Alaska. *Alaska Journal of Anthropology* 6(1–2):69–81.

Holmes, Charles E., Joshua D. Reuther, Jacob S. Adams, Peter M. Bowers, and Allison Little
2018 The Erodaway Site: Lithic Technological Variability at a Late Glacial Subalpine Camp in the Central Alaska Range. *Alaska Journal of Anthropology* 16(1):44–70.

Hughes, Paul D. M., Gunnar Mallon, Alastair D. Brown, H. J. Essex, J. D. Stanford, and S. Hotes
2013 The Impact of High Tephra Loading on Late-Holocene Carbon Accumulation and Vegetation Succession in Peatland Communities. *Quaternary Science Reviews* 67:160–175.

Ives, John W.
1990 *A Theory of Northern Athapaskan Prehistory*. Westview Press, Boulder, Colorado.
2003 Alberta, Athapaskans and Apachean Origins. In *Archaeology in Alberta: A View from the New Millennium*, edited by Jack W. Brink and John F. Dormaar, pp. 256–289. Archaeological Society of Alberta, Medicine Hat, Alberta, Canada.
2010 Dene-Yeniseian, Migration, and Prehistory. In *The Dene-Yeniseian Connection*, edited by James Kari and Ben A. Potter, pp. 324–334. Anthropological Papers, New Series 5(1–2). Department of Anthropology, University of Alaska, Fairbanks.

Ives, John W., Duane G. Froese, Joel C. Janetski, Fiona Brock, and Christopher Bronk Ramsey

2014 A High Resolution Chronology for Steward's Promontory Culture Collections, Promontory Point, Utah. *American Antiquity* 79:616–637.

Kari, James

2010 The Concept of Geolinguistic Conservatism in Na-Dene Prehistory. In *The Dene-Yeniseian Connection: Bridging Asia and North America*, edited by James Kari and Benjamin A. Potter, pp. 194–222. Anthropological Papers, New Series 5(1–2). Department of Anthropology, University of Alaska, Fairbanks.

Kaufman, Darrell S., Yarrow L. Axford, Andrew C. G. Henderson, Nicholas P. McKay, W. Wyatt Oswald, Casey Saenger, R. Scott Anderson, Hannah L. Bailey, Benjamin Clegg, Konrad Gajewski, Feng Sheng Hu, Miriam C. Jones, Charly Massa, Cody C. Routson, Al Werner, Matthew J. Wooller, and Zicheng Yu

2016 Holocene Climate Changes in Eastern Beringia (NW North America)—A Systematic Review of Multi-proxy Evidence. *Quaternary Science Reviews* 147:312–339.

Kedrowski, Brant L., Barbara A. Crass, Jeffery A. Behm, Jonathan C. Luetke, Angela L. Nichols, Alyssa M. Moreck, and Charles E. Holmes

2009 GC-MS Analysis of Fatty Acids from Ancient Hearth Residues at the Swan Point Archaeological Site. *Archaeometry* 51:110–122.

Kintigh, Keith

2006 The Promise and Challenge of Archaeological Data Integration. *American Antiquity* 71:567–578.

Krauss, Michael, and Victor K. Golla

1981 Northern Athabascan Languages. In *Handbook of North American Indians*, Vol. 6, edited by June Helm, pp. 67–85. Smithsonian Institution, Washington, DC.

Krauss, Michael, Gary Holton, Jim Kerr, and Colin West

2011 *Indigenous Peoples and Languages of Alaska*. Alaska Native Language Center, Fairbanks; University of Alaska Anchorage Institute of Social and Economic Research, Anchorage.

Kristensen, Todd J., Thomas D. Andrews, Glen MacKay, Ruth Gotthardt, Sean C. Lynch, John M. Duke, Andrew J. Locock, and John W. Ives

2019 Identifying and Sourcing Pyrometamorphic Artifacts: Clinker in Subarctic North America and the Hunter-Gatherer Response to a Late Holocene Volcanic Eruption. *Journal of Archaeological Science: Reports* 23:773–790.

Kristensen, Todd J., P. Gregory Hare, Ruth M. Gotthardt, Norman A. Easton, John W. Ives, Robert J. Speakman, and Jeffrey T. Rasic

2019 The Movement of Obsidian in Subarctic Canada: Holocene Social Relationships and Human Responses to a Large-Scale Volcanic Eruption. *Journal of Anthropological Archaeology* 56: 10114.

Kuhn, Tyler S., Keri A. McFarlane, Pamela Groves, Arne Ø. Mooers, and Beth Shapiro

2010 Modern and Ancient DNA Reveal Recent Partial Replacement of Caribou in the Southwest Yukon. *Molecular Ecology* 19:1312–1323.

Lacourse, Terri, and Konrad Gajewski

2000 Late Quaternary Vegetation History of Sulphur Lake, Southwest Yukon Territory, Canada. *Arctic* 51:27–35.

Letts, Brandon, Tara L. Fulton, Mathias Stiller, Thomas D. Andrews, Glen MacKay, Richard Popko, and Beth Shapiro

2012 Ancient DNA Reveals Genetic Continuity in Mountain Woodland Caribou of the Mackenzie and Selwyn Mountains, Northwest Territories, Canada. *Arctic* 65:80–94.

Lynch, Joshua J., T. Goebel, Kelly Graf, Jeffrey T. Rasic, and Steven C. Kuehn

2018 Archaeology of the Uppermost Tanana Basin: Results of a Survey of the Nabsena and Chisana Rivers, East-Central Alaska. *Alaska Journal of Anthropology* 16 (1):21–43.

Malhi, Ripan S., Anjelica Gonzalez-Oliver, Kari Britt Schroeder, Brian M. Kemp, Jonathan A. Greenberg, Solomon Z. Dobrowski, David Glen Smith, Andres Resendez, Tatiana Karafet, Michael Hammer, Stephen Zegura, and Tatiana Brovko

2008 Distribution of Y Chromosomes among Native North Americans: A Study of Athapaskan Population History. *American Journal of Physical Anthropology* 137:412–424.

Martindale, Andrew, Richard E. Morlan, Matthew W. Betts, Michael Blake, Konrad Gajewski, Michelle A. Chaput, Andrew Mason, and Pierre M. Vermeersch

2016 Canadian Archaeological Radiocarbon Database. CARD 2.0. Electronic document, https://www.canadianarchaeology.ca/, accessed January 15, 2019.

Maschner, Herbert, and Owen K. Mason

2013 The Bow and Arrow in Northern North America. *Evolutionary Anthropology* 22:133–138.

Moodie, D. Wayne, A. J. W. Catchpole, and Kerry Abel

1992 Northern Athapaskan Oral Traditions and the White River Volcano. *Ethnohistory* 39:148–171.

Mullen, Patrick O.

2012 An Archaeological Test of the Effects of the White River Ash Eruptions. *Arctic Anthropology* 49(1):35–44.

Natural Resources Canada

2019 Lakes, Rivers, and Glaciers in Canada. Unpublished vector digital data, CanVec.

Nelson, Peter R., Bruce McCune, Tim Wheeler, Linda H. Geiser, and Charles M. Crisafulli

2018 Lichen Community Development along a Volcanic Disturbance Gradient at Mount St. Helens. In *Ecological Responses at Mount St. Helens: Revisited 35 Years after the 1980 Eruption*, edited by Charles M. Crisafulli and Virginia H. Dale, pp. 185–198. Springer, New York.

Nonaka, Etsuko, and Petter Holme

2007 Agent-Based Model Approach to Optimal Foraging in Heterogeneous Landscapes: Effects of Patch Clumpiness. *Ecography* 30:777–788.

Odell, George H.

2000 Stone Tool Research at the End of the Millennium: Procurement and Technology. *Journal of Archaeological Research* 8:269–331.

Parnell, Andrew C., and Andrew L. Jackson

2013 SIAR: Stable Isotopic Analysis in R. Electronic document, https://cran.r-project.org/web/packages/siar/index.html, accessed August 1, 2019.

Perry, Richard J.

1983 Proto-Athapaskan Culture: The Use of Ethnographic Reconstruction. *American Ethnologist* 10:715–733.

Ping, C. L., G. J. Michaelson, J. M. Kimble, V. E. Romanovsky, Y. L. Shur, D. K. Swanson, and D. A. Walker

2008 Cryogenesis and Soil Formation along a Bioclimate Gradient in Arctic North America. *Journal of Geophysical Research: Biogeosciences* 113(G3):G03S12.

Potter, Ben A.

2007 Models of Faunal Processing and Economy in Early

Holocene Interior Alaska. *Environmental Archaeology* 12:3–23.

2008 Exploratory Models of Intersite Variability in Mid to Late Holocene Central Alaska. *Arctic* 61:407–425.

2016 Holocene Prehistory of the Northwestern Subarctic. In *The Oxford Handbook of the Prehistoric Arctic*, edited by T. Max Friesen and Owen K. Mason, pp. 537–562. Oxford University Press, New York.

Rasic, Jeffrey T., and William Andrefsky, Jr.

2001 Alaskan Blade Cores as Specialized Components of Mobile Toolkits: Assessing Design Parameters and Toolkit Organization through Debitage Analysis. In *Lithic Debitage: Context, Form, Meaning*, edited by William Andrefsky Jr., pp. 61–79. University of Utah Press, Salt Lake City.

Reuther, Joshua D.

2013 Late Glacial and Early Holocene Geoarchaeology and Terrestrial Paleoecology in the Lowlands of the Middle Tanana Valley, Subarctic Alaska. PhD dissertation, Department of Anthropology, University of Arizona, Tucson.

Reuther, Joshua D., Ben A. Potter, Sam Coffman, Holly Smith, and Nancy Bigelow

2019 Revisiting the Timing of the Northern Lobe of the White River Ash Volcanic Event in Eastern Alaska and Western Yukon. *Radiocarbon* 62:169–188.

Seymour, Deni J.

2012a Gateways for Athabascan Migration to the American Southwest. *Plains Anthropologist* 57:149–161.

2012b Isolating a Pre-differentiation Athabascan Assemblage in the Southern Southwest. In *From the Land of Ever Winter to the American Southwest: Athapaskan Migrations, Mobility, and Ethnogenesis*, edited by Deni Seymour, pp. 90–123. University of Utah Press, Salt Lake City.

2013 Platform Cache Encampments: Implications for Mobility Strategies and the Earliest Ancestral Apaches. *Journal of Field Archaeology* 38:161–172.

Sharp, Henry S., and Karyn Sharp

2015 *Hunting Caribou: Subsistence Hunting along the Northern Edge of the Boreal Forest*. University of Nebraska Press, Lincoln.

Shinkwin, Anne D.

1979 *Dakah De'nin's Village and the Dixthada Site: A Contribution to Northern Athapaskan Prehistory*. Musée National de l'Homme, Collection Mercure, Commission Archéologique du Canada, Publications d'Archéologie, Dossier Ottawa 91. University of Ottawa Press, Ottawa, Ontario, Canada.

Slobodkin Lawrence B.

1968 Toward a Predictive Theory of Evolution. In *Population Biology and Evolution*, edited by Richard C. Lewontin, pp. 187–205. University of Syracuse Press, Syracuse, New York.

Stuiver, Minze, and Henry Polach

1977 Discussion: Reporting of ^{14}C Data. *Radiocarbon* 19:355–363.

Stuiver, Minze, and Paula J. Reimer

1993 Extended ^{14}C Data Base and Revised CALIB 3.0 ^{14}C Age Calibration Program. *Radiocarbon* 35:215–230.

Stuiver, Minze, Paula J. Reimer, and Ron W. Reimer

2019 CALIB 7.1. Electronic document, http://calib.org/calib/, accessed January 1, 2019.

Surovell, Todd A.

2009 *Toward a Behavioral Ecology of Lithic Technology: Cases from Paleoindian Archaeology*. University of Arizona Press, Tucson.

Surovell, Todd A., and P. Jeffrey Brantingham

2007 A Note on the Use of Temporal Frequency Distributions in Studies of Prehistoric Demography. *Journal of Archaeological Science* 34:1868–1877.

Taché, Karine, and Oliver E. Craig

2015 Cooperative Harvesting of Aquatic Resources and the Beginning of Pottery Production in North-Eastern North America. *Antiquity* 89:177–190.

Tremayne, Andrew H., and Bruce Winterhalder

2017 Large Mammal Biomass Predicts the Changing Distribution of Hunter-Gatherer Settlements in Mid-Late Holocene Alaska. *Journal of Anthropological Archaeology* 45:81–97.

U.S. Geological Survey

2017 *US Topo: Maps for America*. Electronic document, http://www.usgs.gov/core-science-systems/national-geospatial-program/us-topo-maps-america, accessed January 15, 2019.

Vajda, Edward J.

2010 Yeniseian, Na-Dene, and Historical Linguistics. In *The Dene-Yeniseian Connection*, edited by James Kari and Ben A. Potter, pp. 100–118. Anthropological Papers, New Series 5(1–2). Department of Anthropology, University of Alaska, Fairbanks.

VanStone, James W.

1974 *Athapaskan Adaptations: Hunters and Fishermen of the Subarctic Forests*. Aldine, Chicago.

Wilson, Joseph A. P.

2019 Archery, Metal, and Ceramics, Oh My! Late Holocene Technology Words in Proto-Athabaskan. Paper presented at the Society for the Study of the Indigenous Languages of the Americas Annual Meeting, New York.

Winterhalder, Bruce

2001 The Behavioural Ecology of Hunter Gatherers. In *Hunter-Gatherers: An Interdisciplinary Perspective*, edited by Catherine Panter-Brick, Robert H. Layton, and Peter Rowley-Conwy, pp. 12–38. Biosocial Society Symposium Series 13. Cambridge University Press, Cambridge.

Winterhalder, Bruce, Flora Lu, and Bram Tucker

1999 Risk-Sensitive Adaptive Tactics: Models and Evidence from Subsistence Studies in Biology and Anthropology. *Journal of Archaeological Research* 7:301–348.

Winterhalder, Bruce, and Eric A. Smith

1992 Evolutionary Ecology and the Social Sciences. In *Evolutionary Ecology and Human Behavior*, edited by Eric A. Smith and Bruce Winterhalder, pp. 3–23. Aldine de Gruyter, Hawthorne, New York.

Workman, William B.

1979 The Significance of Volcanism in the Prehistory of Subarctic Northwest North America. In *Volcanic Activity and Human Ecology*, edited by Payson D. Sheets and Donald K. Grayson, pp. 339–371. Academic Press, New York.

Wygal, Brian T.

2010 Prehistoric Upland Tool Production in the Central Alaska Range. *Alaska Journal of Anthropology* 8(1):107–119.

Submitted November 19, 2019; Revised March 27, 2020; Accepted March 28, 2020