Journal of Archaeological Science: Reports 67 (2025) 105359

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Petrographic chert characterization of Suwannee projectile points from Florida and implications for hunter-gatherer mobility during the Younger Dryas

Adam M. Burke *

Center for the Study of the First Americans, Department of Anthropology, Texas A&M University, 4352 TAMU, College Station, TX 77843-4352, USA

ARTICLE INFO

Keywords:
Younger Dryas
Chert
Petrography
Suwannee
Mobility
Provenance
Florida

ABSTRACT

Toolstone provenance studies in the southeastern United States have historically been used to reconstruct past human behavior using a variety of methodological approaches. For over 40 years, the Quarry Cluster Method of chert provenance has been the prevailing method for characterizing Florida cherts with the goal of informing our archaeological understanding of past human landscape use, mobility, and technological organization. While the Quarry Cluster Method is a robust comparative petrographic approach, it has seen only minimal use for late Pleistocene diagnostic artifacts. This study builds upon the initial contributions of the Quarry Cluster Method by presenting the results of new raw-material surveys from northern Florida and southern Georgia, as well as new petrographic descriptions for 265 chert samples from 74 localities in Alabama, Florida and Georgia. These new data are then compared to 163 Younger Dryas-age Suwannee projectile points from three disparate project areas in northern Florida. The results of this chert provenance study shed light on a broad trend of chert conveyance and overlapping landscape use at key localities in northern Florida, most especially in areas that may have provided access to surface water during the arid Younger Dryas. This case study is placed in the broader context of late Pleistocene and early Holocene mobility studies in Florida and the greater Southeast, and a pattern of water-focused landscape use is informed and supported through chert provenance.

1. Introduction

Early models of late Pleistocene hunter-gatherer mobility, subsistence, and technology posited that these populations practiced a highly-mobile big-game hunting-focused lifeway with risk mediated through “high technology” lithic toolkits rather than detailed local landscape knowledge (e.g., Kelly and Todd, 1988). Subsequent research (Anderson, 1990, 1996; Anderson and Hanson, 1988; Anderson et al., 2015; Daniel, 2001; Daniel and Wisenbaker, 1987; Halligan et al., 2023; Hollenbach, 2009; Parish and Burke, 2022; Smallwood, 2012) has shown late Pleistocene hunter-gatherer lifeways in the southeastern United States to be more diverse than suggested by the “high technology” forager model. These studies have focused primarily on technological and theoretical approaches to addressing mobility, with some emphasis on toolstone provenance, to shed light on the magnitude, frequency, and geography, and potential environmental catalysts of hunter-gatherer movement in the remote past.

Using new petrographic data and existing case studies that build on over 40 years of research into the lithic landscapes of the lower Southeast, this paper presents an assessment of Younger Dryas-age Suwannee projectile points from Florida (Austin et al., 2018; Dunbar, 2016; Thulman, 2007; Upchurch et al., 2008). Chert-provenance results indicate that the people who made Suwannee points exploited toolstone in broad conveyance zones that show significant overlap between disparate, centralized occupation areas. A combination of local, nonlocal, and exotic toolstone use is observable, and this pattern is consistent between localities spanning from central Florida through the eastern Florida panhandle. Exotic materials from the distant extremes of these conveyance zones make up only a small portion of the raw-material suite observed in the analyzed artifact assemblages, indicating little past emphasis on high-magnitude mobility. These data tentatively indicate that Suwannee people lived in somewhat restricted territories, that these territories overlapped at key “places” (geographic, subsistence, or cultural), and that Suwannee point makers presumably prioritized other aspects of their livelihood, particularly access to fresh water, over the acquisition of high-quality toolstone.

* Corresponding author.
E-mail address: adamburke@tamu.edu.

https://doi.org/10.1016/j.jasrep.2025.105359
Received 13 May 2025; Received in revised form 30 July 2025; Accepted 12 August 2025
Available online 21 August 2025

1.1. Chert formation and chert-bearing limestones of Florida

The prevailing theory for chert formation on the Southeastern Coastal Plain (including Florida) is explained through diagenetic replacement of parent material by the percolation of silica-rich groundwater (Upchurch et al., 1982:275). Florida cherts began diagenesis with an opal-A catalyst: an unstable and hydrous form of cryptocrystalline silica that originated from the dissolution of siliceous diatoms and sponge spicules. This biogenic opal-A translocated into and through underlying formations, and diagenetically replaced their matrices, thus preserving petrographic features of the pre-alteration parent material (Andrefsky, 2005; Luedtke, 1992; Boggs, 2009:115; Upchurch et al., 1982; Upchurch et al., 2008:1). During this replacement, opal-A underwent maturation to become opal-CT (Weaver and Wise, 1974; Wise and Weaver, 1973). Both opal-A and opal-CT are relatively unstable at ground surface temperature and will mature towards a more stable mineral phase (Upchurch et al., 2008). This maturation process occurs through the dissolution of the opal-A catalyst and subsequent precipitation of opal-CT (Upchurch et al., 2008:17). Opal-CT eventually transforms into quartz, microcrystals begin to grow, and chert nodules form (Nuckles, 1981).

Toolstones derived from silicified parent material and found throughout the lower Southeast are often referred to broadly as "Coastal Plains chert" regardless of their lithology and with limited effort to determine provenance beyond this broad chert "type" (Parish and Burke, 2022). In northern and central Florida, four geologic formations from three epochs make up the vast majority of chert-bearing parent material: Ocala Limestone from the Eocene Epoch (~56–33.9 million years ago [mya]), Suwannee Limestone from the Oligocene Epoch (~34–23.03 mya), and St. Marks Formation and Hawthorn Group formations from the Miocene Epoch (23–5.3 mya) (Austin et al., 2018; Scott, 1988, 2001; Upchurch et al., 2008). The Hawthorn Group, where it still exists today, contains abundant siliceous microfossils, and is proposed as the main contributor of the hydrous Opal-A catalyst that formed the cherts found in Florida's underlying formations (Upchurch et al., 1982) (Fig. 1). Upchurch et al., (2019:42) propose that perimarine and alkaline lakes that existed during the deposition of Hawthorn Group sediments created conditions conducive to the down-profile translocation of silica, and that cherts formed in underlying limestones either "concurrently with the alkaline lakes or… as a result of dissolution of opal and chemical alteration of the clays in the Hawthorn Group and reprecipitation from groundwater in the underlying limestones."

The formation of chert in north and central Florida was restricted to areas that experienced ample interaction with silica-rich water produced by the overlying Hawthorn Group, primarily at or near the permeable boundaries between different formations (Austin, 1997; Upchurch et al., 2008:80; Upchurch et al., 2019). As parent formations retreated or were eroded over time by fluvial or karstic weathering, erosion-resistant chert boulders settled onto the underlying rock in the form of residuum (Upchurch et al., 2019), and similar geomorphic settings and surface lithology have been documented in southern Alabama and Georgia (Goad, 1979; Parish and Burke, 2022: Fig. 12.4) (Fig. 1). In order for cherts to form and then be accessible for use by precontact Indigenous people, a number of diagenetic and erosional stages must occur, and the resulting distribution of accessible chert in Florida is modeled and described by the Quarry Cluster Method.

The process of chert formation and subaerial exposure through subsequent weathering produces a mosaic of chert availability across the southern southeastern Coastal Plain (Fig. 1). The nonuniform distribution and parent lithology of toolstones can be understood as a "lithic landscape": a spatial, geomorphic, and geologic landscape of toolstone resource patches navigated by past peoples much the same way as food

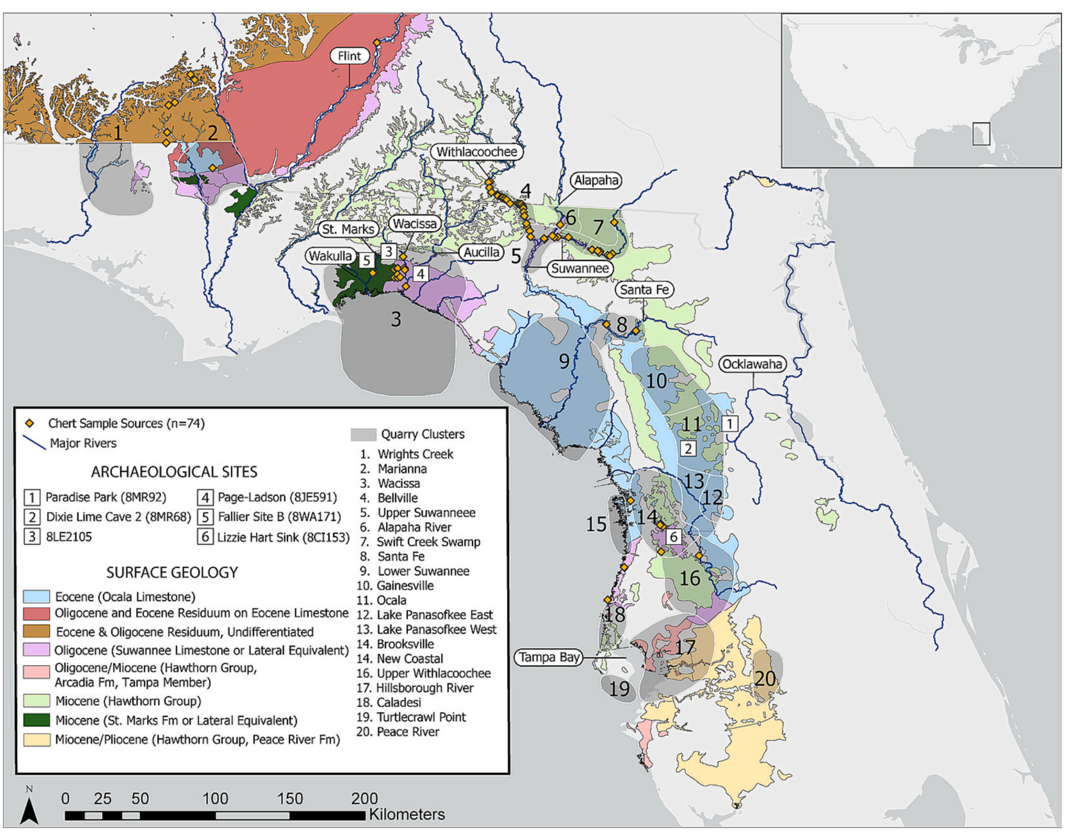

Fig. 1. Map of project area: Rivers and archaeological sites mentioned in the text relative to Florida chert quarry clusters and geologic formations addressed in this study. Quarry cluster data after Austin et al., (2018: Fig. 6.1a) and Lydick and Burke (2020), and geologic data provided by the United States Geological Survey and Florida Geological Survey.

and water resources (Anschuetz et al., 2001; Parish and Burke, 2022:197). The consideration of toolstone sources as generalized and spatially disparate features of the landscape (rather than point-sources) lends itself to spatial analyses, and the southern Coastal Plain is uniquely suited to tracking past human movement using toolstone provenance proxy data. To that end, this study focuses on using the lithic landscape as a means by which to understand past human mobility.

1.2. The quarry cluster method of chert provenance

First introduced in 1982, the Quarry Cluster Method (QCM) of chert provenance continues to evolve and improve as archaeologists, geologists, and paleontologists survey and sample Florida's rich lithic landscape (Austin et al., 2018; Upchurch et al., 2008). The QCM defines areas in Florida where chert is likely to have formed and been available to precontact Indigenous peoples, and relies on georeferenced chert samples to characterize broader areas where chert outcrops have been recorded or are likely to have existed in the past (Fig. 1). Within each quarry cluster, microscopic differences in chert lithology, micropaleontology, and parent material composition are characterized to define specific areas where chert sources have similar, patterned characteristics that set quarry sites in a given quarry cluster apart from other clusters. The QCM is used to ascribe the provenance of a given stone tool to a generalized area rather than to a specific chert boulder or outcrop. This method has been used to successfully pursue nondestructive, discrete raw-material provenance studies for stone tools recovered from archaeological sites in Florida and surroundings states (Austin, 1996, 1997; Austin et al., 2018; Austin and Estabrook, 2000; Burke, 2014; Endonino, 2007; Estabrook and Williams, 1992; Lydick and Burke, 2020; Randazzo, 1972).

While the QCM provides a model for where chert might be located on the landscape, the spatial extents of the north Florida quarry clusters do not necessarily take into account how chert formation and subsequent exposure of chert residuum might impact the spatial distribution of chert. A substantial goal of this research was to test the proposed extents of quarry clusters in northern Florida to determine if chert was indeed present in these locations, and to revise the spatial extent of the quarry clusters if necessary. Consideration of the vertical zone of chert formation (at or between formation boundaries) sheds light on the multiple layers of geologic and geomorphological processes that are prerequisites for precontact chert availability. Diagenetic replacement of chert must occur, which requires a silica source (in this case Hawthorn Group deposits), then these cherts must become exposed (necessitating entire or nearly-entire removal of the Hawthorn Group and underlying Oligocene or Eocene limestones). While the Miocene-aged formations necessary for chert formation in underlying deposits are mapped throughout Florida and Georgia (Fig. 1), these formations must be significantly eroded for any cherts to be expose and accessible to past people. Erosional processes are the only means by which chert residuum is exposed, and as such, we should expect some variation in the geomorphological setting of different quarry clusters depending on what sort of erosional processes dominate in a given region. We might also expect that Quaternary processes, such as sea-level rise and sedimentary deposition, will differentially impact some geomorphic settings, obscuring chert residuum that may now be inundated or buried (Austin et al., 2018; Burke, 2014; Burke and Smith, 2023; Halligan, 2020a; Smith, 2020; Upchurch et al., 2008). Thus, there is room for improvement of the QCM based on field observations of the geomorphological contexts where cherts are presently found, and particularly for chert exposures that show evidence of past human toolstone procurement.

The QCM is the only systematic means of evaluating chert provenance in Florida, but it has not been extensively applied to late Pleistocene hunter-gather assemblages, and has only rarely been applied to any archaeological collections in northern Florida (Austin, 2006; Austin and Mitchell, 2010; Bridgeman Sweeney, 2013; Burke, 2014; Daniel and Wisenbaker, 1987; Halligan et al., 2023; Pevny et al., 2012; Smith, 2023). Thus, little reliable data exists regarding the mobility and toolstone procurement patterns of late Pleistocene hunter-gathers in Florida. To address this shortcoming, raw-material surveys were conducted in northern Florida and southern Georgia to map and sample toolstone outcrops in previously-unsurveyed areas (Lydick and Burke, 2020). Chert and silicified coral samples collected on these surveys were petrographically characterized and compared (in combination with georeferenced samples and published data from other researchers) to an assemblage of Younger Dryas-age (~12,900–11,700 calendar years before present [cal yr BP]) Suwannee projectile points from numerous archaeological localities in northern Florida. (Bullen, 1975; Dunbar, 2016; Dunbar and Vojnovski, 2007; Farr, 2006; Pevny et al., 2018; Smith, 2020). The results of this research shed new light on hunter-gatherer landscape use, mobility, and interaction in Florida during the Younger Dryas.

1.3. Proposed age for Suwannee projectile points

Suwannee projectile points, a highly-variable, often asymmetrical, basally-ground and occasionally spatulate-bladed lanceolate form ranging from straight-sided to waisted (Fig. 2), remain undated by direct radiometric means but are generally agreed upon by Florida archaeologists to date to the Younger Dryas (~12,900–11,700 cal yr BP), and more specifically after Clovis and before Bolen (Anderson et al., 2015; Bullen, 1975; Farr, 2006; Dunbar, 2016; Faught and Pevny, 2019; Pevny et al., 2018; Smith, 2020; Thulman, 2007). Clovis is also undated in Florida, but is dated elsewhere in North America to ~ 13,050–12,770 cal yr BP (Waters et al., 2020) (but see also Hemmings, 2004). The age of Bolen points in Florida is better understood, and Pevny et al., (2018:233) place them confidently between ~ 11,400–11,100 cal yr BP (and potentially as young as 10,500 cal yr BP) using radiocarbon ages from multiple stratified sites. While Suwannee points are regularly recovered from ambiguous/mixed stratigraphic contexts in some association with Bolen points (Daniel and Wisenbaker, 1987; Rink et al., 2012; Thulman, 2006; Tesar and Jones, 2004), this relationship is one of geological and spatial association, rather than temporal (Balsillie et al., 2006; Dunbar et al., 2004; Dunbar and Vojnovski, 2007; Dunbar, 2007; Thulman, 2012).

Four localities in Florida help to shed light on the potential stratigraphic and temporal relationship between Clovis, Suwannee, and Bolen projectile points (Fig. 1). At Paradise Park (8MR92) near Silver Springs in central Florida, Neill (1958:42) reported slight vertical separation between a fluted Clovis-like projectile point and a Suwannee-like point (1958: Pl.3). Later attempts to relocate the potential late Pleistocene archaeological deposits at this site were unsuccessful (Faught and

Fig. 2. Typical Suwannee projectile points from Florida showing variation in symmetry, lateral margins, basal treatment, and blade shape.

Thulman, 2003; Hemmings, 1975). From Dixie Lime Cave 2 (8MR68), also in central Florida, Bullen and Benson report an unfluted, basally-ground lanceolate point that was "too thick and crudely made for a Clovis point" (1956:162). This artifact, which compares favorably in shape to a Suwannee point (Bullen and Benson, 1956: Fig. 3), was recovered ~ 0.5 m (meters) below a Bolen point in the same small solution hole (approximately 2 m wide and 2 m deep) that was completely excavated during initial fieldwork. Excavations at 8LE2105, at the base of the Cody Escarpment in north Florida, yielded the recovery of a Suwannee point preform from a stratum underlying a multi-component Bolen site (Faught et al., 2003; Goodwin et al., 2014). Lastly, a Suwannee point was recently recovered from within the Unit 5 soil at Page-Ladson, which dates from ~ 12,600–11,400 cal yr BP (Halligan et al., 2016; Halligan, 2020, 2024; Webb and Dunbar, 2006). These four sites place Suwannee projectile points as younger than Clovis and older than Bolen. Given the known ages for Clovis and Bolen, Suwannee points would date to the Younger Dryas.

2. Materials and methods

2.1. Raw-material survey

In addition to sampling previously recorded chert quarries (both terrestrial and underwater), over 300 km (km) of riverine toolstone surveys were conducted on the Alapaha, Aucilla, Santa Fe, St. Marks, Suwannee, Wacissa, and Withlacoochee Rivers (Fig. 1). These surveys were accomplished mostly using canoes during drought conditions that prohibited the use of motorized boat, and provided valuable data on the varied geomorphological contexts of Florida and Georgia's lithic landscapes. Many prolifically-exploited chert quarries in north Florida and southern Georgia can be found in shoal contexts in these rivers, and their availability for past people likely varied seasonally and temporally according to hydrologic condition (Halligan et al., 2023; Lydick and Burke, 2020). While these quarries are now usually inundated, they were likely subaerially exposed during the Younger Dryas, and would have remained accessible perhaps as late as the middle Holocene (when waters stabilized to near modern levels), when they were eventually drowned as a result of rising sea and aquifer levels (Halligan, 2013, 2020; Joy, 2019; Thulman, 2009). Additionally, these chert exposures would have occasionally been accessible during drought conditions even after the middle Holocene.

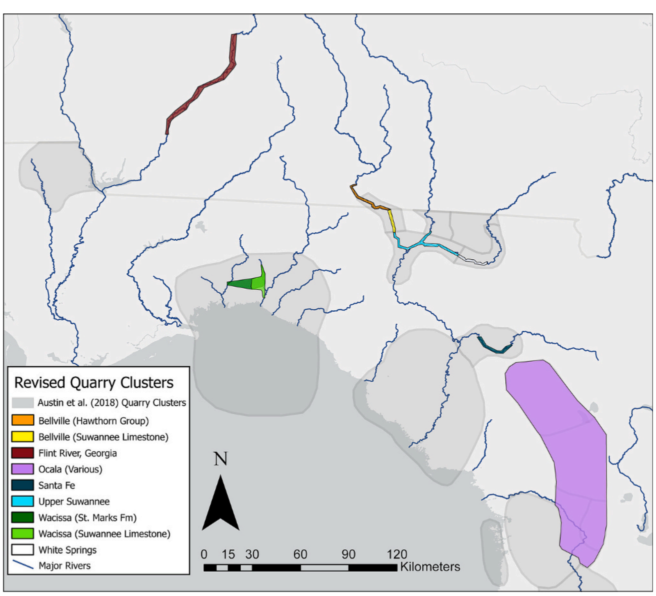

Fig. 3. Proposed reduced quarry cluster areas for north Florida and southern Georgia based on toolstone availability and lithology. The Wacissa, Bellville, Upper Suwannee, White Springs, and Santa Fe Quarry Clusters are modified to reflect the availability of chert observed during surveys. The nearest availability of Flint River chert (relative to the analyzed archaeological assemblages) is displayed as a potential new cluster in Georgia. Ocala chert was not ascribed to individual quarry clusters beyond Ocala chert observed in the Santa Fe Quarry Cluster (but see also Endonino (2007)).

2.2. Comparative toolstone assemblage

The comparative toolstone assemblage compiled for this project consists of 265 samples from 74 localities in Florida, Georgia, and Alabama, representing a subsample of the nearly 1,300 toolstone samples collected during raw-material surveys and laboratory research between 2016 and 2021 (Lydick and Burke, 2020) (Fig. 1; Table 1). These surveys were conducted to map and sample Oligocene-age Suwannee Limestone and Miocene-age Hawthorn Group and St. Marks Formation chert-bearing lithologies in north Florida. Survey areas were selected using the predictions of the QCM and focused on previously unsurveyed but high-probability regions of southern Georgia and north and central Florida with high densities of late Pleistocene and early Holocene archaeological sites nearby (Anderson et al., 2015; Dunbar, 1991; Halligan et al., 2023; Smith et al., 2022; Thulman, 2006a, 2019; Upchurch et al., 2008). When possible, riverine surveys were conducted during drought conditions to maximize the visibility of inundated chert quarries (Lydick and Burke, 2020).

Fieldwork resulted in the intensive representative sampling of 22 substantial chert and silicified coral quarries and extensive representative sampling of numerous smaller geological and archaeological localities (Fig. 1). A "quarry" is defined for this study as a locality that contains both chert exposures and evidence of precontact exploitation, such as the presence of debitage. Not all outcrops are quarries, but all quarries have outcrops. Samples from the 22 intensively-sampled quarries represent 56 % (n = 147) of the 265 chert samples used in this project, and the remaining 45 % (n = 118) samples came from a combination of the extensive sampling and the contribution of georeferenced samples from other researchers.

These surveys also helped to constrain the spatial extent of the Wacissa, Bellville, Upper Suwannee, White Springs, and Santa Fe Quarry Clusters based on the geomorphological contexts and exposed lithologies where chert was found. For these six quarry clusters, new revised boundaries are proposed that conform to the spatial distribution of chert observed during fieldwork (Fig. 3). While these revised clusters constrain where we model accessible chert exposures, they are only contemporary refinements to the QCM in previously-unsurveyed regions. The consideration of geomorphological context used in this study can be broadly applied to other quarry clusters in Florida to provide revised spatial extents that more accurately reflect chert availability. It is anticipated that future work will further refine our understanding of Florida's lithic landscape, and the data presented here are meant to represent a first step towards discrete provenance in north Florida

Table 1
Chert samples analyzed in this study by area.

Quarry Cluster	Number of Samples	Number of Sites
Wacissa	73	13
Brooksville*	25	5
White Springs	27	7
Bellville (Suwannee)	25	5
Bellville (Hawthorn Group)	30	16
Upper Suwannee	48	10
Santa Fe	13	5
Marianna and Alabama*	7	7
New Coastal	4	2
Upper Withlacoochee*	3	1
Swift Creek Swamp	1	1
Flint River Georgia*	9	2

[*] Indicates Some or All Samples Provided by Other Researchers.

(Austin et al., 2018; Upchurch et al., 2008).

2.3. Archaeological sample

The Suwannee points used in this study came from multiple repositories, including state, federal, museum, and private collections. The vast majority of the projectile points were recovered as surface finds from palimpsest contexts both inundated and terrestrial, and thus lack stratigraphic and geochronological control. Provenience for the assemblage varies from piece-plotted coordinates at professionally-excavated archaeological sites to generalized locational data, such as a section of a particular river, portion of a plowed field, or a state county. To that end, site-level, river-section-level, and county-level provenience are used to allow for the comparison of artifacts from different repositories and collections. In total, 163 Suwannee projectile points from 10 generalized locations, including 15 localities, were analyzed for this study (Fig. 4).

2.4. Petrographic methods

Chert comparators and artifacts were subjected to petrographic analysis with a Dino-Lite digital microscope between magnifications of 20X to 200X and generally under polarized light to reduce glare on polished chert and weathered artifact surfaces. To standardize the analyzed area of each chert sample, a combination of thick-sections and their waste billets were used, each with a maximum area of 27 mm (mm) by 46 mm. The only exception to this approach was for samples of Flint River chert (n = 9 samples from two localities near Albany, Georgia), which were analyzed as hand samples with a maximum dimension of less than 6 cm. Using thick-sections and billets allowed for characterizing the geological samples in both translucent and opaque views, while also maintaining a uniformly small area that is similar in size to a small projectile point. When possible, all thick-sections and billets were prepared to preserve an external, cortical surface on one edge of the slide/billet to allow for insight into the weathering, staining, patination, and desilicification patterns of various Florida toolstones (Burke, 2014; Hurst and Kelly, 1961; Kelly and Hurst, 1956; Luedtke, 1992; Purdy and Clark, 1987; Shepherd, 1972). These weathering processes commonly impact artifacts recovered from inundated contexts at Florida's many submerged archaeological sites (Dunbar et al., 2005; Faught, 2002, 2004; Hemmings, 1999; Smith, 2023; Thulman, 2006a).

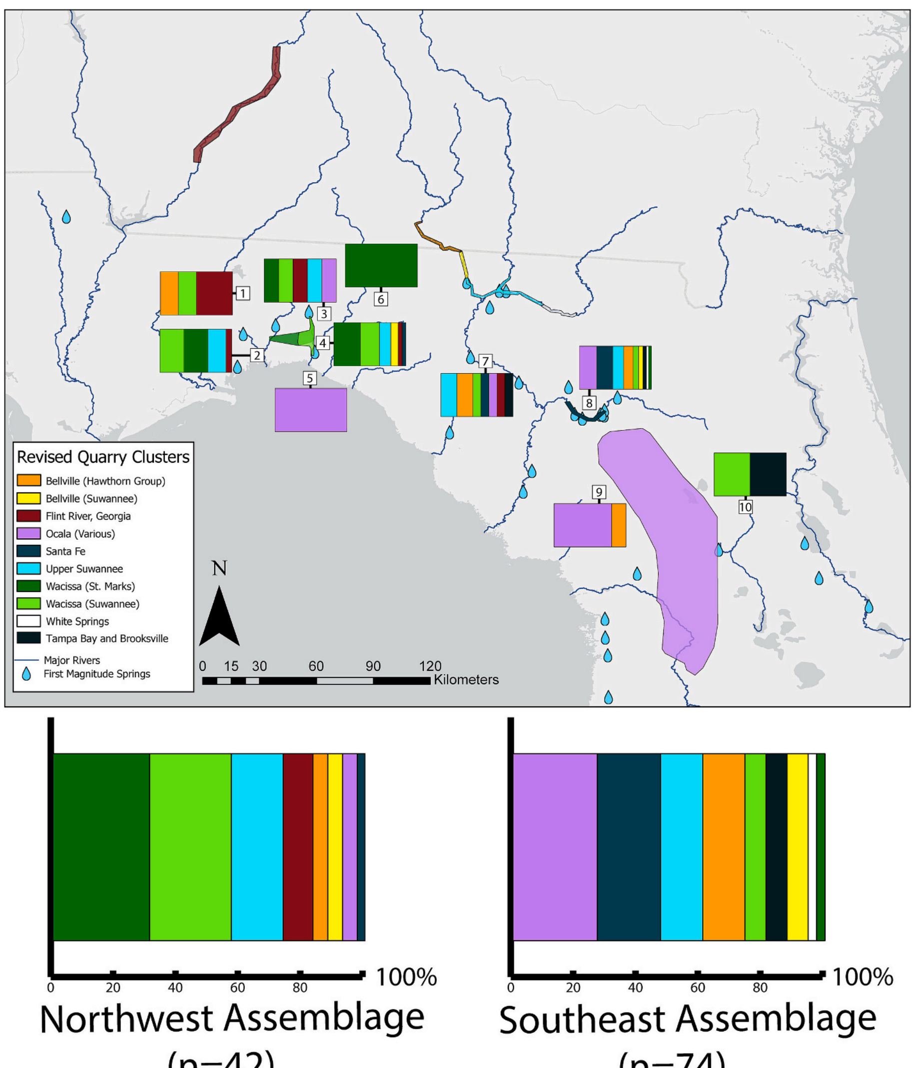

Fig. 4. Locations of study area relative to the revised quarry clusters and first magnitude springs showing localities that produced Suwannee points and the ratios of toolstone types identified at each. Each bar chart represents 100 % of the successfully ascribed projectile points from each locality. Suwannee localities and number of successfully-ascribed points: 1) Leon County (two localities, n = 4); 2) Wakulla River (two localities, n = 12); 3) Wacissa River (two localities; n = 5); 4) Aucilla River (three localities; n = 19); 5) Ontolo (8JE1577) (one locality; n = 1); 6) Taylor County (one locality; n = 1); 7) Luraville area (one area; n = 9); 8) Santa Fe River (one locality; n = 67); 9) Alachua County area (one locality; n = 5); 10) Ocklawaha River (one locality; n = 2).

Petrographic and micropaleontological data collected from the projectile points were compared directly with the georeferenced chert samples to determine the provenance of the toolstone on which the points were made. Raw-materials were identified first to the formation level, then to individual quarry clusters if possible. Published petrographic data for lithologies in Florida outside the study areas were used to aid in provenance determinations for artifacts discovered to be made on raw-materials not contained within the comparative toolstone assemblage. Ascriptions to Ocala Limestone chert from central Florida and Miocene-age Tampa chert from the Tampa Bay region were made with the aid of published chert descriptions (Austin et al., 2018; Endonino, 2007; Upchurch et al., 2008). Weathering, staining, and/or patination were observed on nearly all artifacts, though these taphonomic characteristics does not regularly present a barrier to petrographic analysis, and in some cases actually improves the visibility of traits, akin to staining a microscope slide.

3. Results

3.1. Constraining the vertical zone of chert formation in northern Florida and southern Georgia and implications for the quarry cluster method

While reports or field observations pertaining to the potential vertical zone of chert formation do not exist for all areas of Florida, several key locations visited for this research shed light on where cherts initially formed. The presence of cherts in the Withlacoochee, Suwannee, and Alapaha Rivers, for example, is the result of fluvial erosion of the Cody Escarpment, which exposed cherts from both the Hawthorn Group and the Suwannee Limestone as the rivers downcut through the escarpment (Fig. 1). Hawthorn Group cherts and silicified corals are reported upriver and up-profile from Suwannee Limestone cherts, which are only exposed below the Miocene/Oligocene boundary. Hawthorn Group cherts and corals appear constrained to the basal portion of their formation, and Suwannee Limestone chert appears constrained to the upper portion of their formation (Lydick and Burke, 2020).

This pattern is mirrored in the Wacissa Quarry Cluster, where Suwannee Limestone chert and St. Marks Formation chert are concentrated along the present formation boundary that runs longitudinally through the central portion of the cluster as mapped by Austin et al (2018) (Fig. 1). Cherts in the Wacissa Quarry Cluster appear to be settling onto the underlying Suwannee Limestone as both the Suwannee Limestone and St. Marks Formation experience fluvial erosion and karstic weathering. Only one example of bedded (non-residual) St. Marks Formation chert was observed from this quarry cluster (from Fallier Site B (8WA171)), and it was found exposed in the channel of the St. Marks River, which flows through (and downcuts into) the St. Marks Formation. It appears that St. Marks Formation chert is constrained to the basal portions of the formation and Suwannee Limestone chert appears constrained to the upper portions of the formation.

This model is also supported in the Santa Fe Quarry Cluster, where the Suwannee Limestone is absent, but residual Suwannee Limestone chert is found mixed with Ocala Limestone chert that has settled onto the underlying Ocala Limestone (Fig. 1). In this case, it appears that Suwannee Limestone chert is constrained to the lower portions of the now-absent formation and Ocala Limestone chert is constrained to the upper portion of the formation. Endonino (2007) reported that the Gainesville and Ocala Quarry Clusters are dominated by Ocala Limestone chert with minor, spatially-disparate residual cherts from the overlying Hawthorn Group. In the Brooksville Quarry Cluster, at Lizzie Hart Sink (8CI153), Suwannee Limestone chert boulders are exposed along the rim and colluvial slopes of a large sinkhole, with Ocala Limestone and Ocala Limestone chert present at the bottom. In each of these cases, the chert lithologies are mixed, indicating that both parent materials were silicified and subsequently comingled as residuum on underlying older formations.

Chert exposures in the banks and shoals of the Withlacoochee, Suwannee, and Alapaha Rivers provide the best direct support for a model of chert formation at or near the contacts of limestone formations, and the Wacissa, Santa Fe, Gainesville, Ocala, and Brooskville Quarry Clusters show how this chert formation processes might be expressed in areas that lack substantial downcutting of chert-bearing formations by fluvial processes. While the erosional forces of the Withlacoochee, Suwannee, and Alapaha Rivers have served to expose and aggregate chert, quarry clusters in Florida that are dominated by karstic weathering (rather than fluvial erosion) (Upchurch et al., 2019), such as the Wacissa and Brooksville Quarry Clusters, have toolstone resources distributed much more broadly. In either case, the presence of cherts of more than one geologic age in each of these chert-bearing regions adds complexity to our understanding of the lithic landscapes of Florida and Georgia, but allows for an enhanced understanding of chert formation beyond the coarse scale of typical geologic mapping (Huddleston, 1993; Scott, 1988, 2001).

Based on the combination of the modeled vertical zone of chert formation and the distribution of chert observed in this study, spatial revisions for the Wacissa, Bellville, Upper Suwannee, White Springs, and Santa Fe Quarry Clusters are warranted, and a new cluster is proposed for the Flint River in Georgia (Goad, 1979) (Fig. 3). These revisions can be incorporated into the existing QCM framework, and help to reduce the spatial extent of chert availability proposed by that method. These revisions also pay particular attention to the parent lithology of the cherts found within the newly-revised quarry clusters. Where mixed lithologies are present but spatially patterned with limited overlap, the quarry cluster is divided to account for where a given toolstone is available (the Wacissa and Bellville Quarry Clusters, for example) while maintaining the original name of the cluster to avoid confusion and to maintain consistency with the QCM (Austin et al., 2018; Lydick and Burke, 2020; Upchurch et al., 2008) (Fig. 3).

3.2. Physical geography of north Florida and south Georgia's lithic landscapes

Ground-truthing of the spatial extents for chert availability predicted by the QCM revealed three distinct geomorphological settings that, in some cases, are helpful for reducing the total area where chert outcrops might be expected in a given quarry cluster (Fig. 5; Table 2). These three settings are: Type 1) boulder fields of chert residuum on low-lying epikarst dissected, in places, by spring-fed rivers (Fig. 5a); Type 2) residual boulders in shoals and colluvium exposed by rivers that downcut through the chert-bearing formations that make up the Cody Escarpment (Fig. 5d); and Type 3) boulder fields of chert residuum on upland epikarst (Fig. 5g). While each of these contexts and their associated geomorphic processes result in the exposure of toolstone that can be exploited by humans, the spatial extent and means of erosion had far-reaching impacts on when and how past peoples were able to acquire chert resources in Florida (Upchurch et al., 2008).

The Wacissa (both the St Marks Formation and Suwannee Limestone chert-bearing portions) and Santa Fe Quarry Clusters, Type 1 settings, are low-lying landscapes marked by low-energy, spring-fed rivers. The geomorphic context of cherts in these settings is best understood as broad fields of residual boulders that settled and accumulated onto the eroding epikarst by the dissolution and erosion of overlying deposits (Fig. 5a-c) (Upchurch et al., 2019). These boulder fields were subsequently and intermittently buried and exposed by Quaternary fluvial and aeolian processes, but would have been available for use by people throughout the late Pleistocene and early Holocene (Burke and Smith, 2023; Halligan et al., 2023; Smith, 2020; Thulman, 2009). In addition to abundant toolstone resources, the Wacissa and Santa Fe Quarry Clusters would have provided humans with access to surface water and the plants and animals that grew and aggregated around it, resulting in areas of resource convergence that would have been appealing to past foragers (Daniel, 2001; Dunbar, 1991; Hollenbach, 2009; Thulman, 2009).

The Bellville (both the Hawthorn Group and Suwannee Limestone

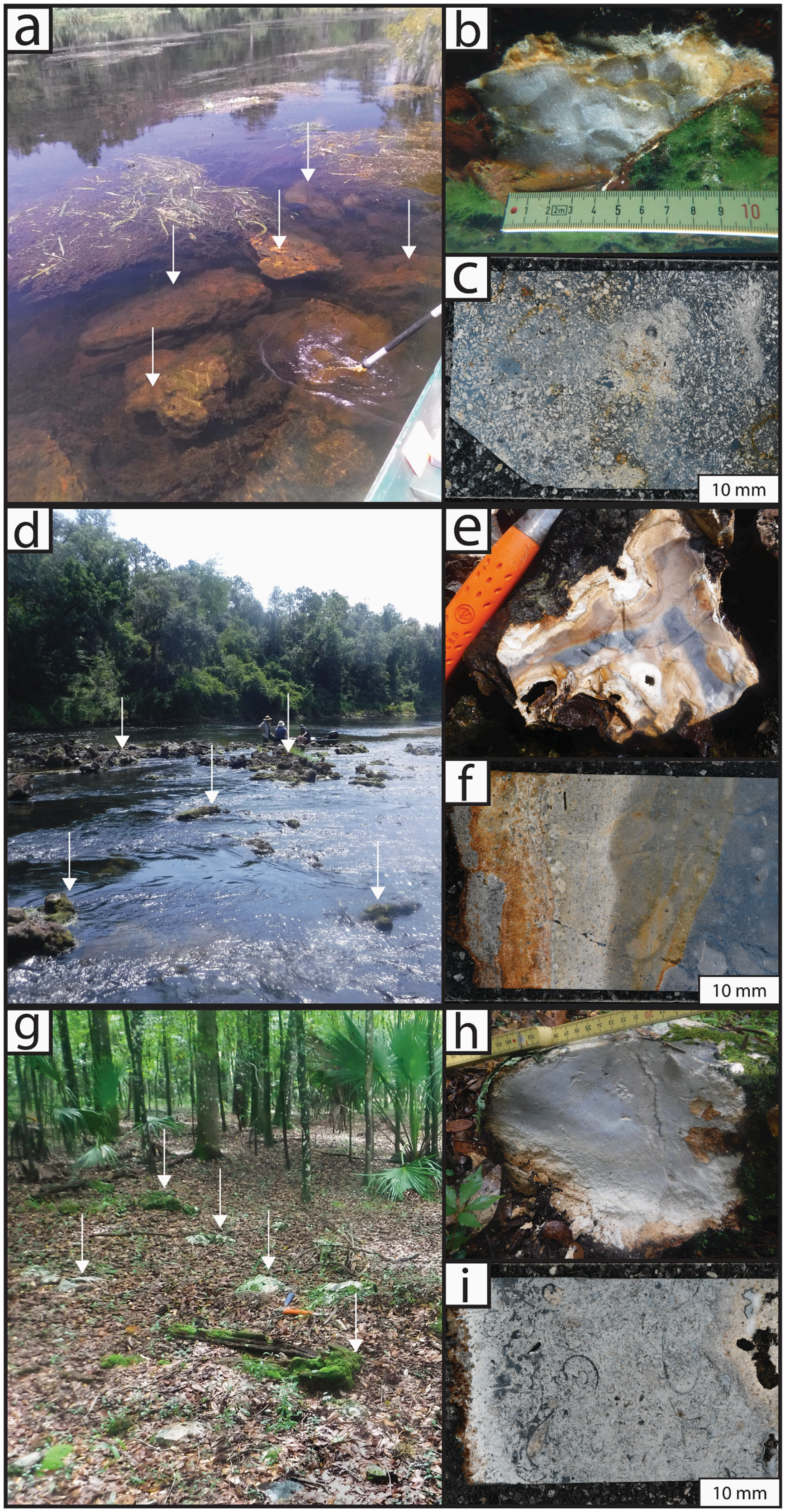

Fig. 5. Three observed chert-bearing geomorphological contexts (white arrows indicate individual chert boulders) and examples of the petrographic variation inherent in Florida cherts; a) Chert boulder field of residuum on low-lying epikarst dissected by the Wacissa River in the Wacissa Quarry Cluster; b) Suwannee chert from the Wacissa Quarry Cluster in hand-sample and in thick-section (c); d) Residual chert boulders in shoals and colluvium exposed by the Withlacoochee River in the Upper Suwannee Quarry Cluster; e) Suwannee chert from the Upper Suwannee Quarry Cluster in hand-sample and in thick-section (f); g) Chert boulder field of residuum on upland epikarst in the Brooksville Quarry Cluster; h) Suwannee chert from the Brooksville Quarry Cluster in hand-sample and in thick-section (i).

Table 2
Geological and geomorphological contexts of quarry clusters surveyed for this work.

Quarry Cluster	Chert-Bearing Formations and Residuum	Geomorphological Context
Wacissa	Suwannee Limestone; St. Marks Formation	Inundated in Wacissa, Aucilla, and St. Marks Rivers and associated low-lying swamps
Bellville	Suwannee Limestone; Hawthorn Group (Chert and Coral)	Constrained to the bed and shoals of the Withlacoochee River
Upper Suwannee	Suwannee Limestone; Hawthorn Group	Constrained to the bed and shoals of the Suwannee River and its tributaries
White Springs	Suwannee Limestone; Hawthorn Group (Chert and Coral)	Constrained to the bed and shoals of the Suwannee River and its tributaries
Santa Fe	Suwannee Limestone; Ocala Limestone	Constrained to the Santa Fe River and surrounding low-lying floodplain
Brooksville	Suwannee Limestone; Ocala Limestone	Various terrestrial contexts including in and near caves and sinkholes

chert-bearing portions), Upper Suwannee, and White Springs Quarry Clusters, Type 2 settings, are prolific sources of cherts and silicified corals. Toolstones in these quarry clusters appear to be constrained to the courses of the Suwannee, Alapaha, and Withlacoochee Rivers (and their immediate tributaries), largely limited to residual deposits in shoals and riverbank colluvium where high-energy fluvial activity is the predominate erosive force (Fig. 5d-f). In these quarry clusters, rivers are actively downcutting through the chert-bearing formations of the Cody Escarpment (both the Hawthorn Group and Suwannee Limestone) and aggregating erosion-resistant cobbles and boulders of toolstone in rocky shoals surrounded by steep cliffs of limestone and stabilized levees (Lydick and Burke, 2020; Upchurch et al., 2019). Chert is widely available and easy to access in these quarry clusters, though variation in hydrologic conditions certainly impacted availability during times of high precipitation. While it is unclear if the Suwannee, Alapaha, and Withlacoochee Rivers were flowing intermittently or in a manner similar to their modern conditions during the terminal Pleistocene, freshwater springs are common in this area and were likely present during the Younger Dryas (Dunbar, 1991; Thulman, 2009) (Fig. 4). Given the broad and substantial upstream catchments of the Alapaha and Withlacoochee Rivers, it is possible that flowing water in the Suwannee River's channel was largely restricted to below its confluence with the Alapaha and Withlacoochee Rivers. The Suwannee River, in contrast, has a rather restricted upstream catchment associated with Okefenokee Swamp, which does not appear to have reached modern conditions until the middle Holocene (Fair-Page and Cohen, 1990).

The Brooksville Quarry Cluster in central Florida, a Type 3 setting, is marked by boulder fields of chert residuum on upland epikarst (in this case, the Brooksville Ridge) produced by the weathering of the Suwannee and Ocala Limestones (Fig. 5g-i) (Upchurch et al., 2008; Upchurch et al., 2019). Suwannee Limestone chert makes up the majority of the available toolstone, but usable package-sizes of Ocala Limestone chert are also present. The Gainesville, Ocala, Lake Panasoffkee East, and Lake Panasoffkee West Quarry Clusters are found in a similar geomorphic context, and these clusters are dominated by Ocala Limestone chert with minor amounts of residual Suwannee Limestone chert in the southern clusters and Hawthorn Group chert near the northernmost cluster (Austin et al., 2018; Endonino, 2007). The Brooksville Quarry Cluster was surveyed and sampled to provide a distant outlier source of Suwannee Limestone chert for comparison with Suwannee Limestone chert from the Wacissa, Bellville, Upper Suwannee, White Springs, and Santa Fe Quarry Clusters.

Variation in the geomorphological settings of these quarry clusters impacts raw-material availability in northern Florida and southern Georgia: toolstone is abundant but spatially constrained in some places (Wacissa, Bellville, Upper Suwannee, White Springs, and Santa Fe Quarry Clusters), and abundant but diffusely distributed in others (Brooksville, Gainesville, Ocala, Lake Panasoffkee East, and Lake Panasoffkee West Quarry Clusters). In either case, chert availability can be treated as a constant when *within* a quarry cluster, but there are spatial gaps *between* clusters. Considering clusters as disparate patch resources may be a useful heuristic for exploring variation within and between quarry clusters. Additionally, Type 1 and Type 2 settings like the Wacissa, Bellville, Upper Suwannee, White Springs, and Santa Fe Quarry Clusters likely contained accessible surface water (in the form of springs and ponds associated with modern first magnitude springs in the lowlands of Florida's Tertiary karst) during the arid Younger Dryas (Dunbar, 1991; Halligan et al., 2016; Halligan et al., 2023; Scott et al., 2002; Scott et al., 2004; Thulman, 2009; Willard et al., 2007).

3.3. *Summarized petrographic characterizations of cherts from northern Florida, southern Georgia, and southern Alabama*

Efforts to map, sample, and analyze toolstone resources have resulted in a renewed understanding of the petrographic variation present in cherts in north Florida and southern Georgia. This is not surprising, given that numerous and varied diagenetically-altered parent formations make up the rich lithic landscapes of the lower Southeast (Barlow et al., 2022; Daniel, 2001; Daniel and Wisenbaker, 1987; Goad, 1979; Goodyear and Charles, 1984; Goodyear and Wilkenson, 2014). This work builds on the QCM in a number of ways, particularly in northern Florida, which was not intensively or representatively sampled during the original development of the method (Austin et al., 2018; Upchurch et al., 2008). Detailed petrographic characterization of the cherts encountered during raw-material surveys are reported in Table 3 and the Supplemental Material.

From these petrographic data, several trends were observed that help to characterize cherts in a way that is meaningful for chert provenance in the study area. Petrographic differences in parent-material texture reflect differences in the original depositional environment of the chert-bearing formation (Dunham, 1962). Variation in micropaleontological content reveals biofacies, and visual traits related to the diagenetic replacement of the parent limestone shed light on regional and localized patterns in the original formation of the chert (Bryan, 1991; Nuckles, 1981). Taken together, these traits can be used to readily differentiate not only between cherts from different geologic formations, but also cherts from different deposits of a single formation (Austin et al., 2018; Upchurch et al., 2008) (Table 3).

The micropaleontology and preserved trace fossils found in Miocene-aged cherts from northern Florida and southern Georgia (from both the Hawthorn Group and St. Marks Formation) do not compare favorably with those published and described from the Tampa Bay area (Austin et al., 2018; Upchurch et al., 2008). Additionally, marked differences exist in the texture and trace fossils observed between St. Marks Formation chert from the Wacissa Quarry Cluster (preserved, striated algal mats coupled with occasional rounded grains and rare and isolated *Archaias*) and Hawthorn Group chert from the Bellville Quarry Cluster (sponge spicules, branching unsilicified structures, and abundant iron oxide speckling). It is therefore possible to tell the difference between Miocene-aged chert from the Tampa Bay area and northern Florida/southern Georgia, and also possible to tell the difference between Miocene-aged cherts from the Wacissa and Bellville Quarry Clusters in northern Florida and southern Georgia.

Additionally, clear differences were observed in the rock texture, micropaleontological suite, and diagenetic characteristics of Suwannee Limestone cherts from the Wacissa, Bellville, Upper Suwannee, White Springs, Santa Fe, and Brooksville Quarry Clusters. The presence of abundant angular grains, coralite fragments, and non-*Lepidocyclina* Orbitoididae foraminifera (single-celled calcareous planktonic organisms) make Suwannee Limestone chert from the Wacissa Quarry Cluster distinct in comparison to other quarry clusters. Suwannee Limestone cherts from the Bellville, Upper Suwannee, White Springs, and Santa Fe

Table 3
Petrographic characterizations for geological comparators used in this study.

Quarry Cluster	Chert Lithology	Petrographic Description
Wacissa	**Suwannee Limestone**	Abundant Miliolidae, common Orbitoididae (but not *Lepidocyclina* sp.), occasional *Fallotella* sp. (formerly *Dictyoconus*) foraminifera, and occasional fragmentary *Rotalia.* Occasional corallite fragments, and a foraminiferal grainstone/hashed foraminiferal grainstone fabric composed of small angular grains punctuated by occasional large, rectangular grain inclusions (possibly shell fragments of larger biota or poorly-preserved corallite fragments) (Upchurch et al., 2008). Suwannee Limestone Chert from the Lower Aucilla has prominent and angular opaline inclusions, regularly in the form of a breccia; this grey-blue to black chert also contains abundant very fine white nonsilicified inclusions, white chalcedonic inclusions, and dendritic manganese inclusions along pre-silicification fractures.
	St. Marks Formation	Glassy and well-replaced mudstone, but striated algal mats are regularly preserved (and occasionally poorly-silicified). Microgranular quartz fabrics are common. Rounded grains, when present, are widely spaced and any groupings of grains are also widely spaced. Rare and isolated *Archaias* and Soritids.
Bellville	**Suwannee Limestone**	Clear grainstone texture composed of small rounded grains, the smallest observed in any of the Suwannee Limestone chert analyzed for this study. Grains tend to be oval in shape, often overlap, and are occasionally ringed/banded with chalcedony. This texture seems to be the result of dramatic reworking of the parent material prior to lithification, and this is supported by the rarity of intact microfossils in this quarry cluster.
	Hawthorn Group	Occasional Soritids, abundant sponge spicules, common branching unsilicified structures that are 1–2 mm in diameter and produce a crisscross, almost crazed pattern, common and abundant iron oxide speckling, and abundant spotty un-silicified to poorly-silicified carbonate inclusions contained within a glassy, microgranular mudstone.
Upper Suwannee	**Suwannee Limestone**	Very well-silicified, which obscures texture. Mudstone textures are common, as are sandy/gritty matrixes where the chert seems cemented. This chert tends to break across around grains rather than through them, and is marked by occasional iron-oxide speckling and ubiquitous but widely spaced secondary porosity (pitting), resulting in a speckled white to gray chert. Gastropod fragments are rare, and this chert may represent a lithified foraminiferal hash.
	Hawthorn Group	Blue hue and very glassy; devoid of microfossils and visible rock texture; clearly in a gravel/secondary context in small clasts up profile and in tributaries of the Suwannee River.
White Springs	**Suwannee Limestone**	Contains more *Fallotella* sp. (formerly *Dictyoconus*) foraminifera than other clusters; abundant Miliolids preserve in a wackestone to grainstone texture. Most internally-varied grainsize (within-sample) observed in Suwannee Limestone chert, with grains ranging from small to large present in relatively equal abundance. Fragments of echinoderm plates are abundant, and gastropod shell fragments tend to be relatively small and linear. Silicified coral is present throughout this quarry cluster, though it is most often found in small, weathered clasts in secondary/gravel deposits.
Santa Fe	**Suwannee Limestone**	Absence of *Follotella* sp. (formerly *Dictyoconus)* fossils and few gastropod shell fragments in an otherwise highly fossiliferous (Miliolids) toolstone; grainstone to packstone texture with larger and more widely spaced grains than other clusters; void-filling chalcedony ringing many of the grains; chert ranges from well- to poorly-replaced, and secondary porosity is common but larger and less regular than observed in the Upper Suwannee Quarry Cluster.
	Ocala Limestone	Pecten molds unobserved; *Lepidocyclina* fossils are common, but not as abundant or as large as those in other Ocala Limestone cherts; high abundance of *Nummulites*, sometimes nearly bedded/stacked.
*** Brooksville**	**Suwannee Limestone**	Widely spaced and small grains with diffuse edges present a veinous pattern; Miliolids common and large; gastropod shell inclusions tend to be large and not fully replaced/incorporated into the chert with clear quartz growth; round fine-grained and silicious carbonate enclusions are common; manganese dendrites and void from their erosion also common; chalcedonic veins formed in old fractures also observed.
	Ocala Limestone	Fine-grained, mudstone to grainstone texture; *Nummulites* observed but widely spaced; *Nummulities* and *Lepidocyclina* are well-preserved and show internal equatorial chambers in cross-section.
*** Marianna and Alabama**	**Ocala Limestone**	Abundant but widely-spaced *Nummulites* that are often quite well-preserved; mudstone to packstone texture; *Lepidocyclina* present but rather rare and can be quite large and well-preserved; secondary porosity is iron-stained, like a bloodstone; cherts range from pink to brown to white.
***Flint River, Georgia**	**Ocala Limestone**	*Lepidocyclina* present but rare and widely spaced compared to other Ocala Limestone cherts; *Nummulites* abundant and larger than observed in other Ocala Limestone cherts with excellently-preserved cross-sections; mudstone to wackestone; contains abundant linear inclusions and is very well-replaced; common brown to tan color; occasional Bryozoa.

* Representative Outliers.

Quarry Clusters are readily differentiated from one another based on texture, but variation was also observed in the fossil suite and post-diagenetic features (Upchurch et al., 2008).

The Bellville Quarry Cluster is marked by small, round to ovular grains that often appear to overlap and are occasionally ringed or banded with chalcedony in a matrix that generally lacks well-preserved microfossils, whereas the grainstone texture of Suwannee Limestone chert from the Santa Fe Quarry Cluster has much larger and more widely spaced grains that are commonly ringed with void-filling chalcedony, which is also present in the space between grains, coupled with an abundance of Miliolid and absence of *Fallotella* sp. (formerly *Dictyoconus*) formanifera, a marker fossil for the Suwannee Limestone. The grainstone texture of Suwannee Limestone chert from the White Springs Quarry Cluster is poorly sorted, and has the greatest within-sample variation of grain sizes observed in Suwannee Limestone chert, with both small and large grains present in relative abundance. The White Springs Quarry Cluster also has abundant *Fallotella* sp. foraminifera, the most observed from any quarry cluster. The Upper Suwannee Quarry Cluster contains very well-replaced Suwannee Limestone chert that is marked by sandy and gritty matrices that appear to be foraminiferal hashes, though the texture of the parent limestone is commonly obliterated by silcification. This quarry cluster is marked by distinct and ubiquitous secondary porosity and pitting, which results in a speckled appearance, and chert from here is well-cemented and often breaks around rather than through grains. Suwannee Limestone chert from the Brooksville Quarry Cluster is differentiated from that found in the northern Florida quarry clusters by the presence of widely spaced but small grains with diffuse edges that present a veinous pattern, as well as visible chalcedonic infilling along old, pre-silicification fractures and large, widely spaced Miliolid foraminifera.

Endonino (2007) has described in detail Eocene-age Ocala Limestone cherts from the Gainesville, Ocala, Lake Panasoffkee East, and Lake Panasoffkee West Quarry Clusters. This study does not aim to differentiate Ocala Limestone cherts between these four clusters, but rather to differentiate between chert found in the central Florida Ocala Limestone deposits and those from deposits in northwest Florida and southwestern Georgia (Fig. 1). Ocala Limestone chert from the Santa Fe Quarry Cluster is marked by a high abundance of *Nummulites* and the common presence of *Lepidocyclina* foraminifera in such aggregate density that they appear bedded/stacked. *Lepidcyclcina* foraminifera are less common in Ocala

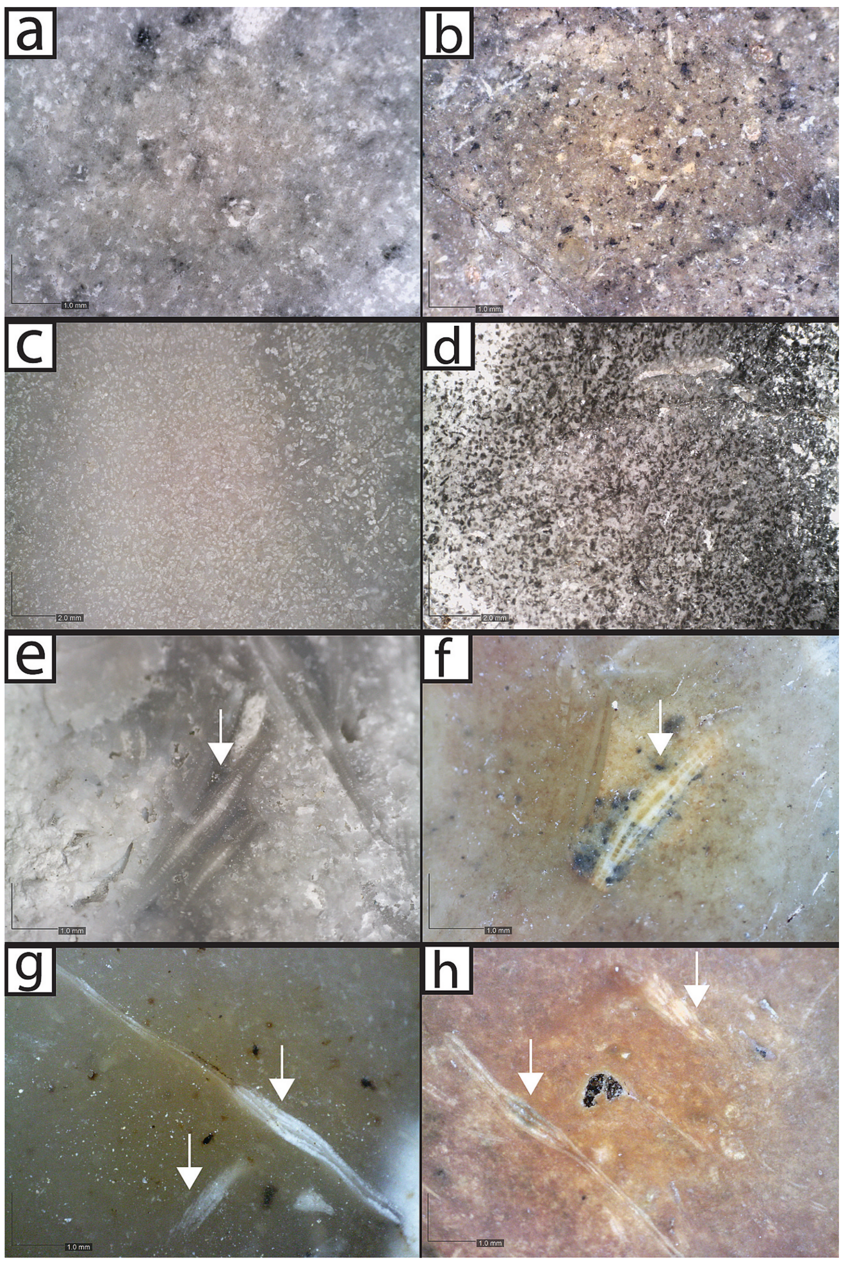

Fig. 6. Photomicrographs of successful chert provenance ascriptions and white arrows pointing to key features: a) Suwannee Limestone chert from the Upper Suwannee Quarry Cluster showing obliterated and cemented grainstone texture and abundant secondary porosity and b) a Suwannee projectile point from the Santa Fe River; c) Suwannee Limestone chert from the Bellville Quarry Cluster showing a clear grainstone texture with small, rounded, and overlapping grains and d) a Suwannee projectile point from the Aucilla River; e) Ocala Limestone chert from central Florida showing abundant and well-preserved *Lepidocylcina* foraminfera and f) a Suwannee projectile point from the Santa Fe River; g) Flint River chert from Albany, Georgia showing well-preserved large *Nummulites* foraminfera and bryozoan and h) A Suwannee projectile point from the Suwannee River at the Luraville Area.

chert from the Santa Fe Quarry Cluster than in the Ocala-bearing clusters to the south, and the abundance of *Nummulites* in chert from this cluster is the most observed to date in any Ocala Limestone chert (Endonino, 2007).

Ocala Limestone chert from northwest Florida and southwestern Georgia are dramatically different when compared to each other as well as to those from central Florida. Ocala Limestone chert from the Marianna Quarry Cluster and related Alabama sources are marked by abundant and often well-preserved *Nummulites* foraminifera. *Lepidocyclina* foraminifera in these cherts are quite large but rare and remarkably well-preserved with clear equatorial chambers. Iron-stained secondary porosity is abundant in these cherts, almost resembling a bloodstone at times. No cherts from the Marianna Quarry Cluster and related Alabama sources were observed in the artifact assemblages analyzed for this project.

Ocala Limestone chert from the Flint River Quarry Cluster is also quite petrographically distinct. *Lepidocyclina* are present but rare, widely spaced, and very poorly preserved compared to other Ocala Limestone cherts. *Nummulites* are abundant, widely-spaced, larger, and excellently preserved with distinct parallel cross-sections in comparison to those observed in other Ocala Limestone cherts. Small linear inclusions (of unknown origin) are also very common, and occasional Bryozoa, that, when present, are abundant and distinct. Ocala Limestone chert from the Flint River Quarry Cluster, particularly due to its *Nummulites* and Bryozoa fossil inclusions, is quite petrographically distinct when compared to other Ocala Limestone cherts.

3.4. Suwannee point provenance determinations

Of the 163 Suwannee points analyzed, 125 (76 %) could be confidently identified to an individual quarry cluster using microscopy (Fig. 6). Points with raw-material that could only be identified to parent lithology (but not to quarry cluster) or that could not be identified at all were removed from further consideration. While this approach might limit our understanding of the totality of past toolstone acquisition and mobility, it limits us only to what we might say confidently based on direct comparison with geological control samples. Future sampling and analysis of new chert sources will undoubtedly modify these interpretations and improve our data resolution.

Toolstone diversity for the analyzed Suwannee points is presented at the scale of three aggregate assemblages (the Northwest Assemblage [NWA], the Southeast Assemblage [SEA], and the Luraville Area) (Fig. 4).

3.5. Northwest assemblage

The NWA Suwannee point assemblage (Fig. 7) is composed of projectile points west of the Suwannee River: Leon County, the Wakulla River, the Wacissa River, the Aucilla River, Ontolo (8JE1577), and Taylor County (Fig. 4). This assemblage consists of 24 projectile points (57 % of the assemblage) made on cherts that are local to the Wacissa Quarry Cluster, with the remainder of the toolstone seemingly coming from greater than 70 km away, and a maximum procurement distance of ~ 150 km represented by only 2 projectile points (5.% of the assemblage). The next most common source area, the Upper Suwannee and Bellville Quarry Clusters, produced 11 (or 26 %) of the points in the NWA. The maximum extent of procurement in the NWA is bracketed by Flint River chert from the northwest (~140 km away, represented by four projectile points, or 10 % of the assemblage) and chert from the Ocala Limestone chert-bearing central Florida clusters and the Santa Fe Quarry Cluster to the east (~130 km away, represented by three points or 7 % of the assemblage). Straight-line distance between the nearest potential source of Flint River chert and the nearest source of Ocala Limestone chert provides a conservative maximum catchment distance estimate of ~ 250 km.

3.6. Southeast assemblage

The SEA Suwannee point assemblage (Fig. 8) is composed of projectile points from east of the Suwannee River: The Santa Fe River, Alachua County, and the Ocklawaha River (Fig. 4). This assemblage consists of 35 projectile points (47 % of the assemblage) made on cherts that are local to the Santa Fe River, including both the Santa Fe Quarry Cluster and the Ocala Limestone chert-bearing clusters directly to the south of the Santa Fe River and between the Alachua County and Ocklawaha River localities. The remaining sources in the assemblage come from greater than 50 km away, with a maximum procurement distance of ~ 200–230 km represented by only five projectile points, or 7 % of the assemblage. The next most common source area, the Upper Suwannee and Bellville Quarry Clusters, produced 25 projectile points (34 % of the assemblage). The maximum extent of procurement in the SEA is bracketed by the Wacissa Quarry Cluster to the west (~130–200 km away, represented by seven points, or 10 % of the assemblage) and the Tampa-chert bearing clusters to the south (~200–230 km away). Straight-line distance between the nearest portion of the Bellville Quarry Cluster to the north of the SEA and the Tampa-chert bearing clusters to the south provides a conservative maximum catchment distance estimate of ~ 300 km.

3.7. Luraville area

The Luraville Area, located ~ 80 km east of the center of the NWA and ~ 60 km northwest of the SEA, produced nine successfully-ascribed Suwannee points (Fig. 9). At Luraville, 44 % (n = 4) of the Suwannee points are made on chert from the Upper Suwannee and Hawthorn Group chert-bearing Bellville Quarry Clusters, and the remaining 56 % (n = 5) are each from separate, disparate sources to the west, northwest, east, and southeast. Although there are only nine Suwannee points at Luraville, seven different toolstone sources are represented. Of particular note is the presence of both Flint River chert (11 % (n = 1) of the assemblage) from ~ 170 km northwest and Tampa chert from the Tampa Bay region from ~ 230 km south in the same assemblage. These two source areas, from the extreme ends of the NWA and the SEA, are only represented together at Luraville, despite the presence of Flint River chert throughout the NWA and the presence of Tampa chert throughout the SEA. The remaining 33 % (n = 3) of the assemblage comes from the Santa Fe Quarry Cluster (~60 km away) and Ocala Limestone chert-bearing clusters (~70 km away) to the southeast, and the Wacissa Quarry Cluster (~80 km away) to the west. Straight-line distance between the nearest source of Flint River chert to the northwest and the nearest source of Tampa chert to the south provides a straight-line conservative maximum catchment distance of ~ 400 km. The Luraville Area appears to represent an overlap between the toolstones found in the NWA and SEA.

4. Discussion

Two distinct but overlapping chert conveyance zones are visible for Suwannee point makers, apparently situated relative to the Aucilla River and Santa Fe River regions of northern Florida and bracketed by toolstone and water sources on the margins of the conveyance zones (Fig. 10). In this interpretation, the Suwannee River and its major tributaries represent an overlapping area in subsistence rounds that is reflected in the two large conveyance zones. Supporting this notion is the fact that both the NWA and the SEA have materials from the Upper Suwannee and Bellville Quarry Clusters, chert-bearing clusters that are geographically between the localities that produced the analyzed artifacts (Fig. 4).

Cherts from both Bellville and Upper Suwannee Quarry Clusters make up 26 % (n = 11) of the total Suwannee point assemblage from the NWA and 34 % (n = 25) of the total Suwannee point assemblage for the SEA, a difference that is not statistically significant (Chi-square = 0.722,

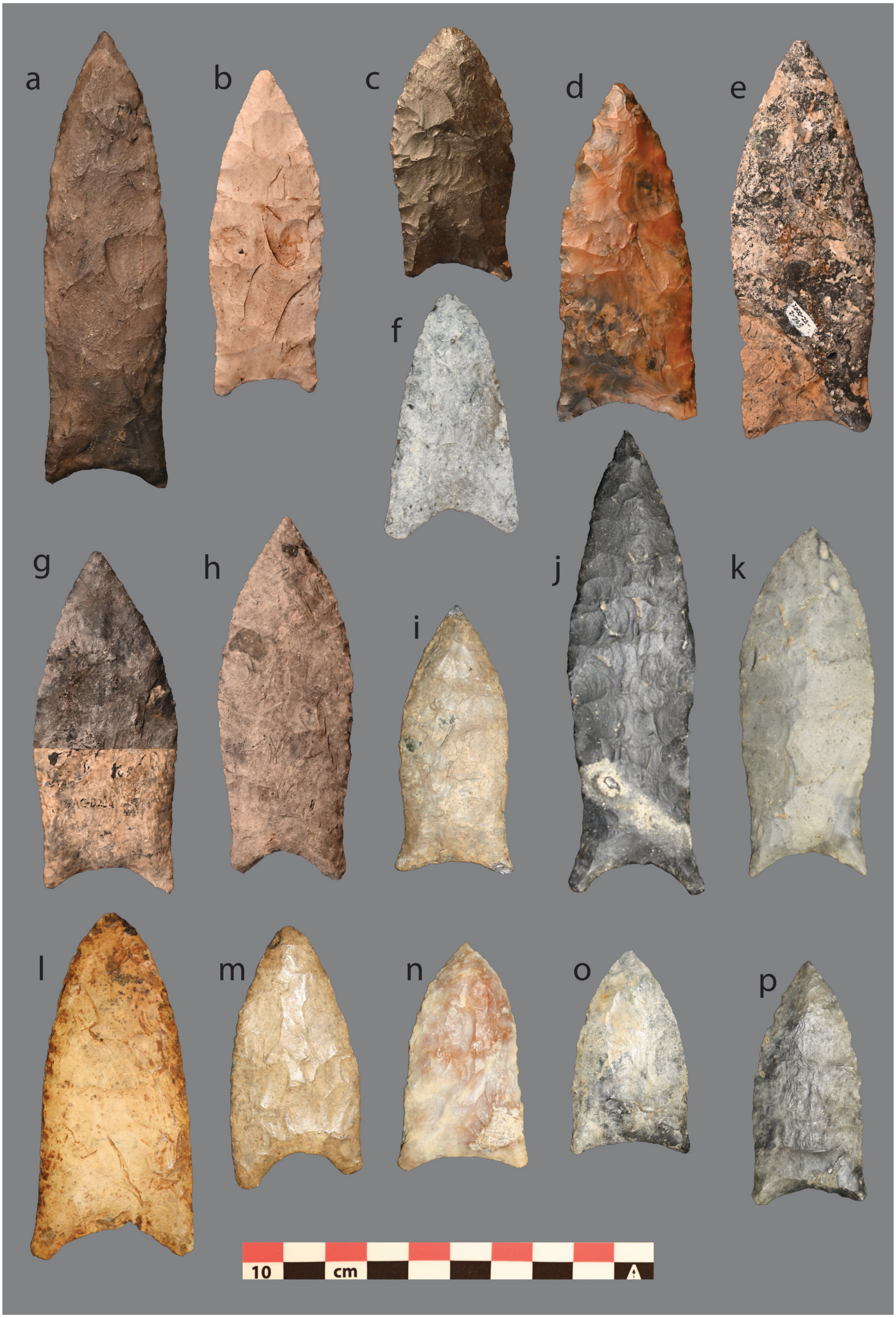

Fig. 7. Suwannee projectile points from the Northwest Assemblage (NWA) by area: a-f) Lower Aucilla River; g-i) Wacissa River; j, k, p) Wakulla River; l, m) Lake Jackson Basin; n) Taylor County; o) Ontolo (8JE1577), made on six different raw materials: a) Suwannee chert from the Bellville Quarry Cluster; b, g, n, p) St. Marks chert from the Wacissa Quarry Cluster; c, d, e, j, k) Suwannee chert from the Wacissa Quarry Cluster; f, h, m) Flint River chert from Georgia; i, o) Ocala chert from central Florida; l) Hawthorn Group chert from the Bellville Quarry Cluster.

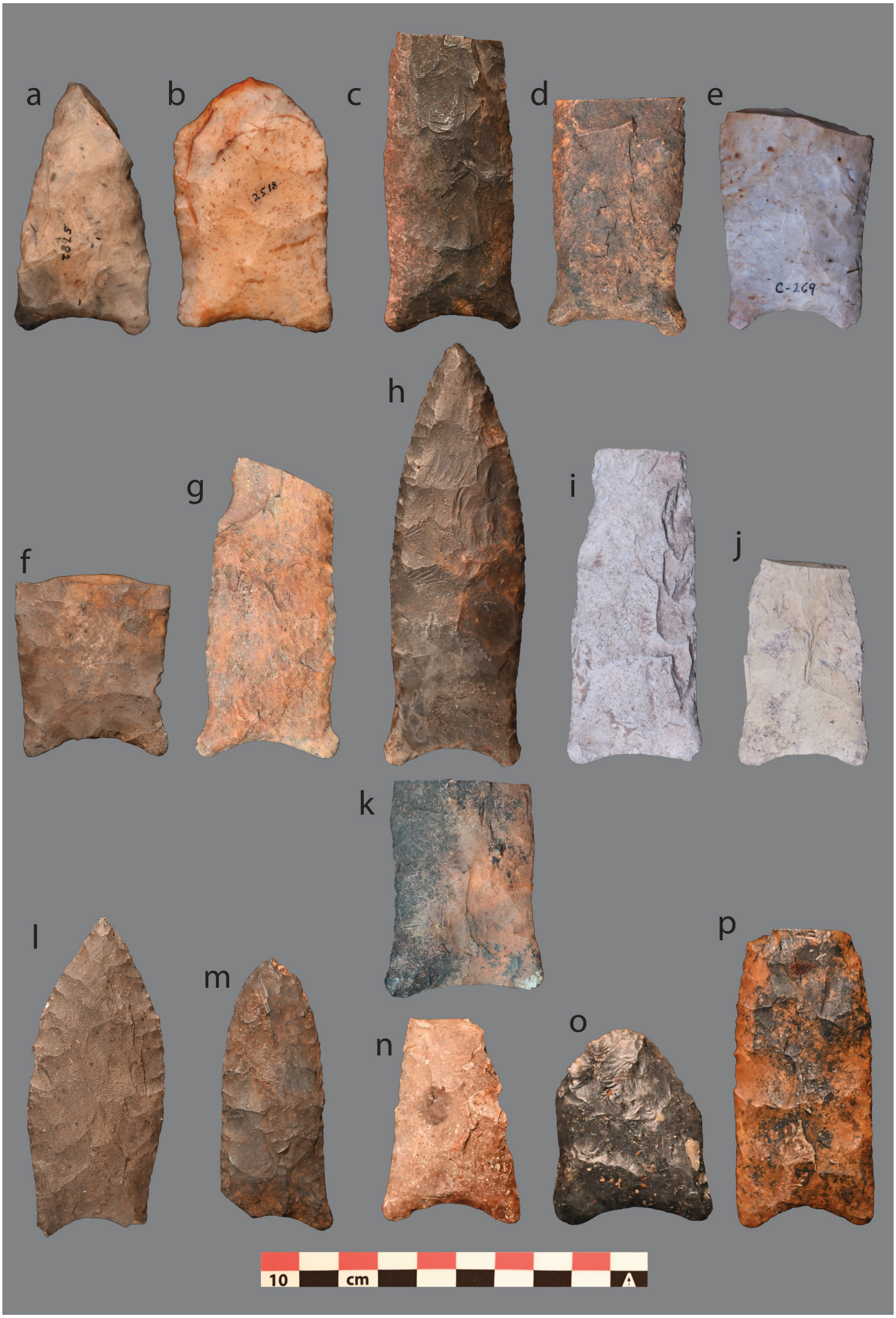

Fig. 8. Suwannee projectile points from the Souhtheast Assemblage (SEA), all recovered from the Santa Fe River, and made on seven different raw materials: a-e) Ocala chert from central Florida; f, g) Suwannee chert from the Santa Fe Quarry Cluster; h) Suwannee chert from the White Springs Quarry Cluster; i, j) Suwannee chert from the Upper Suwannee Quarry Cluster; k) Hawthorn Group chert from the Bellville Quarry Cluster; l, m) Suwannee chert from the Bellville Quarry Cluster; n) Tampa chert from the southern Florida; o) St. Marks chert from the Wacissa Quarry Cluster; p) Suwannee chert from the Wacissa Quarry Cluster.

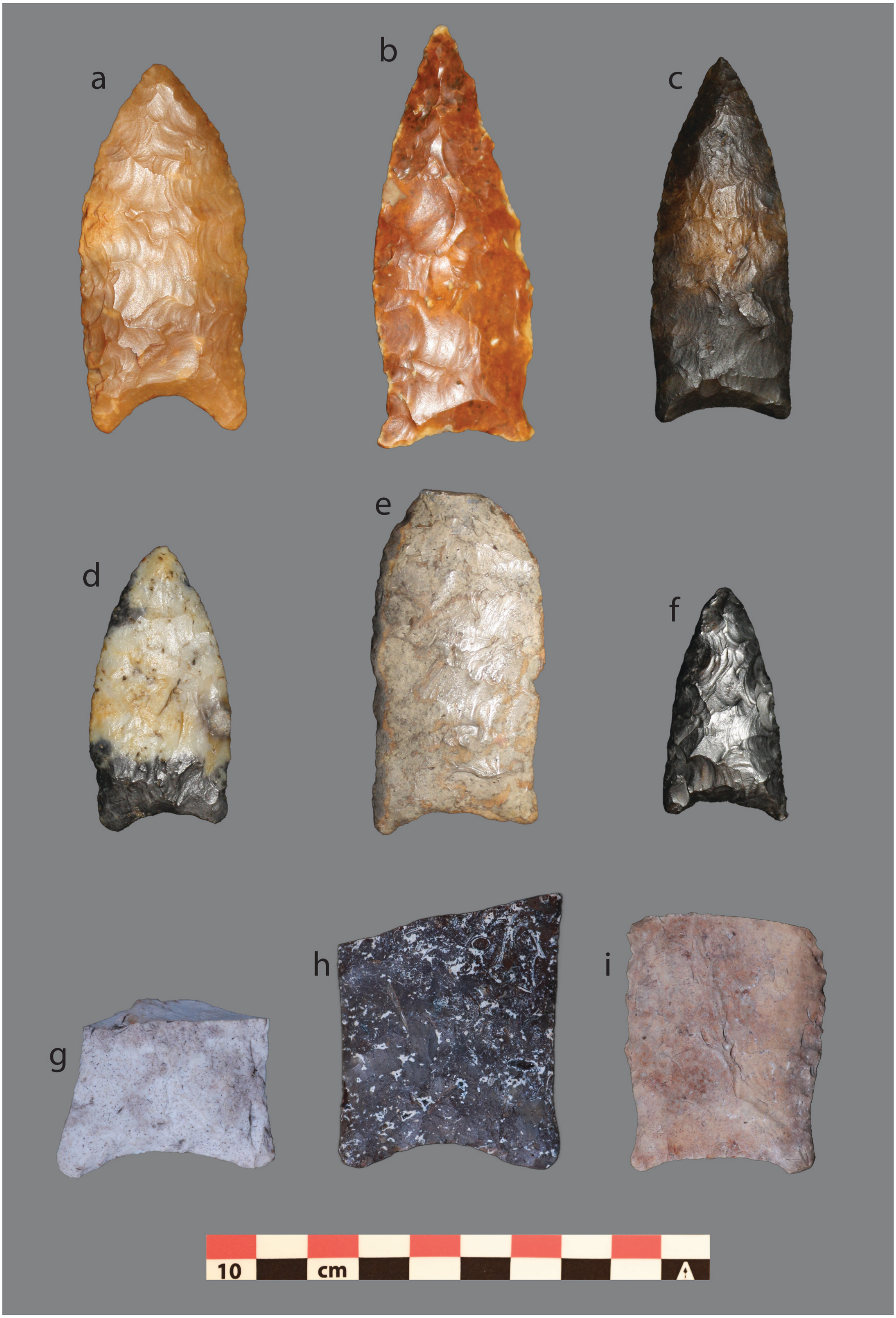

Fig. 9. Suwannee projectile points from the Luraville Area, made on seven different raw materials: a, i) Hawthorn Group chert from the Bellville Quarry Cluster; b) Flint River chert from Georgia; d) Suwannee Chert from the Santa Fe Quarry Cluster; e) Ocala chert from central Florida; f) Suwannee chert from the Wacissa Quarry Cluster; g, c) Suwannee chert from the Upper Suwannee Quarry Cluster; h) Tampa chert from southern Florida.

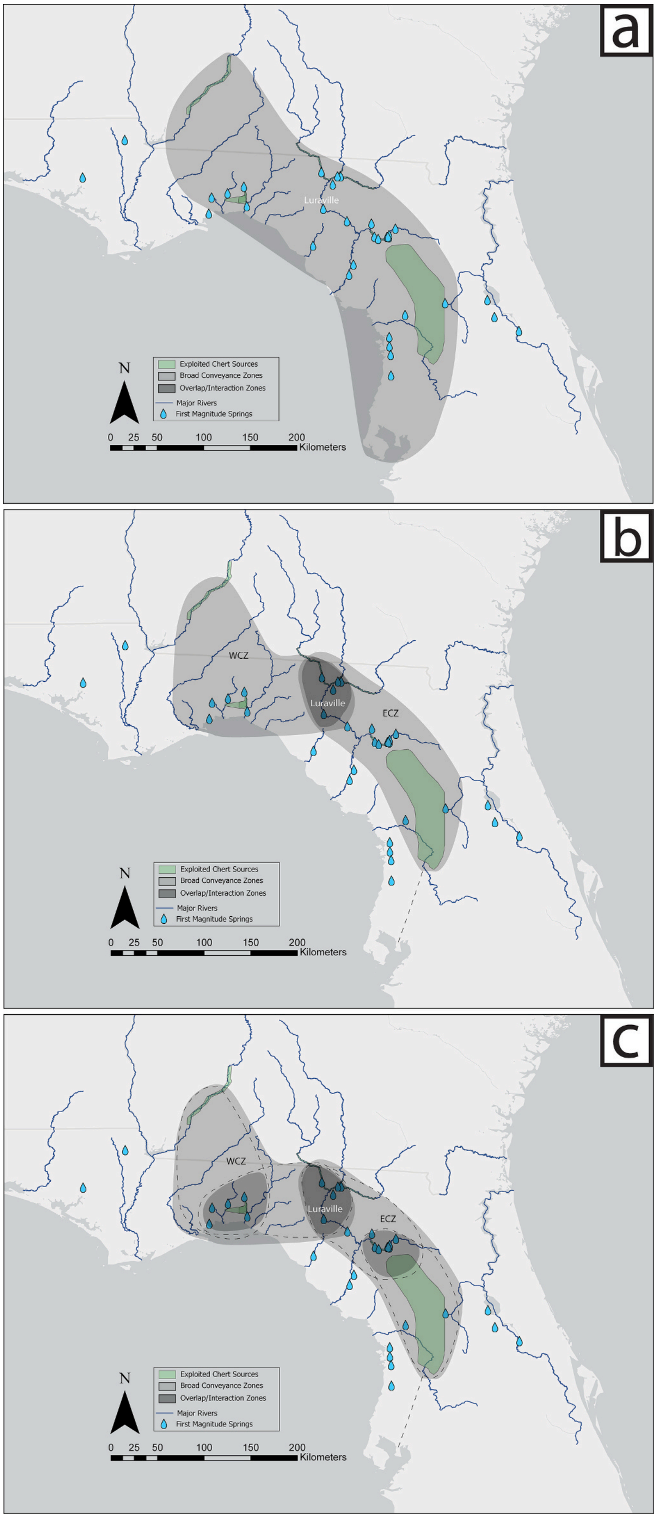

Fig. 10. Three proposed Suwannee point maker toolstone conveyance zones in northern Florida and southern Georgia: a) Scenario 1, a single large conveyance zone; b) Scenario 2, two smaller conveyance zones overlapping in the Luraville Area; c) Scenario 3, four small conveyance zones that overlap in the vicinity of the Aucilla River, the Luraville Area, and in the vicinity of the Santa Fe River. Areas of overlap and/or interaction contain first-magnitude springs and sources of toolstone in proximity.

$p = 0.3955$), even with considering two SEA ascriptions to the White Springs Quarry Cluster (Chi-square = 1.289, $p = 0.2562$). In contrast, only 7 % (n = 3) of NWA Suwannee points came from sources local to the SEA (cherts from the Santa Fe Quarry Cluster and various central Florida Ocala Limestone chert-bearing clusters), and 10 % (n = 7) of the SEA Suwannee points came from sources local to the NWA (St. Marks Formation and Suwannee Limestone cherts from the Wacissa Quarry Cluster).

While there is certainly some direct spatial overlap between the toolstone assemblages, it is minimal, and the vast majority of the similarity between the two conveyance zones is represented by the use of chert from the centrally-located Bellville and Upper Suwannee Quarry Clusters (Fig. 3), rather than by longer-distance transport of cherts between the central portions of the NWA and SEA, which are ~ 130 km apart. In contrast, the Wacissa Quarry Cluster is ~ 75–80 km away from both the Bellville and Upper Suwannee Quarry Clusters, and the Santa Fe Quarry Cluster is between ~ 60–80 km away.

In addition to the above patterns, the maximum ascription-distance also warrants discussion. While much of the chert used by Suwannee people appears to have been locally procured, the greatest range of ascriptions from both conveyance zones is between ~ 150–200 km in straight-line distance (n = 7). A Suwannee point made on Ocala Limestone chert was recovered from the Wacissa River (n = 1), Suwannee Limestone chert from the Wacissa Quarry Cluster made it as far as the Ocklawaha River (n = 1), and chert from the Tampa Bay region can be found as far north as the Ocklawaha River, the Luraville Area in and near the Suwannee River, and the Santa Fe River (n = 5). While these ascriptions provide concrete data on the possible upward magnitude of Suwannee mobility, they represent only 4 % of the successfully-ascribed artifacts and are a small but intriguing part of Suwannee landscape use.

While long distance procurement of toolstone (150 km or greater) is somewhat rare among this Suwannee point sample, it has been observed in both the NWA and SEA, in relatively equivalent proportions. Of particular note is that Flint River chert and Tampa chert, exotic sources in their respective conveyance zones, are only found together at Luraville, which is ~ 30 km south of the Upper Suwannee Quarry Cluster, (where both the NWA and SEA overlap) and centrally located between the two conveyance zones. Within this scheme, the Luraville Area provides additional insight into the zone of interaction between the NWA and the SEA. This area is between quarry clusters, and shows a clear combination of two different toolstone procurement patterns. Three possible scenarios might be used to explain this pattern.

4.1. Scenario 1

The first scenario posits that Luraville represents an aggregate of one large conveyance zone, reflective of the full scale of mobility by one group of Suwannee point makers (Fig. 10a). The people who deposited Suwannee points near Luraville traveled in a range that included Tampa Bay area, the Santa Fe River area, the Suwannee River, the Aucilla River area, and the Flint River area (a distance of nearly 500 km between geographic extremes). Additionally, their movement would have happened quickly enough that Flint River chert and Tampa Bay chert would be represented in the same active lithic toolkit. This scenario also assumes that all the Suwannee points from the Luraville Area are coeval and were deposited by a single traveling group.

4.2. Scenario 2

The next two proposed scenarios assume that all the Suwannee points analyzed in this study are of roughly the same age but represent concurrent activities on the landscape by different but related groups of people. The second scenario is that Luraville reflects the convergence of two Suwannee conveyance zones: one spanning from the Flint River in Georgia to the Suwannee River in Florida by way of the Aucilla River region (the Western Conveyance Zone [WCZ] and the other spanning from Tampa Bay to the Suwannee River by way of the Santa Fe River region (the Eastern Conveyance Zone [ECZ]) (Fig. 10b). The Flint River-to-Aucilla River-to-Suwannee River (between Luraville and the Upper Suwannee Quarry Cluster) catchment would span ~ 200 km, and the Tampa Bay-to-Santa Fe River-to-Suwannee River (between Luraville and the Upper Suwannee Quarry Cluster) catchment would span ~ 270 km. This scenario is further supported not only by the abundance of chert from the Upper Suwannee and Bellville Quarry Clusters that circulated in the WCZ and ECZ, but also by the presence of overlapping exotic toolstones from the extremes of both conveyance zones at Luraville, as well as the presence of other raw-materials from both the Wacissa and Santa Fe Quarry Clusters. Though coarse, the procurement patterns observed in this study align well with this proposed scenario.

4.3. Scenario 3

The third proposed scenario for the observed pattern is that the Aucilla River and Santa Fe River areas represent central locations for subsistence rounds, as both of these areas are thought to have had predictable and accessible surface water in the form of springs and ponds during the arid Younger Dryas (Dunbar, 1991; Halligan, 2020b; Thulman, 2009). In the case of the WCZ, chert provenance informs a pattern of northwest/southeast movement between the Flint River and the Wacissa Quarry Cluster, as well as northeast/southwest movement between that cluster and the Suwannee and Withlacoochee Rivers. In the case of the ECZ, chert provenance informs a pattern of north/south movement between Tampa Bay and the Santa Fe Quarry Cluster, as well as northwest/southeast movement between that cluster and the Suwannee and Withlacoochee Rivers.

Four smaller conveyance zones can be recognized in this third scenario, nested within the larger zones described in the second scenario (Fig. 10c). It is suggested that the Aucilla River region, the Santa Fe River region, and the Luraville Area all represent similar social environments and resource patches. In each of the three areas, first-magnitude springs are abundant on the modern landscape (Halligan et al., 2023; Scott et al., 2002; Scott et al., 2004; Thulman, 2009). The modern presence of first magnitude springs is a good proxy for past freshwater availability, because these springs tend to have deep conduits that would have contained water despite the suppression of the Floridan aquifer during the Younger Dryas due to lower sea-levels and limited precipitation (Anderson and Sassaman, 2012; Balsillie and Donoghue, 2004; Dunbar, 2002, 2016; Halligan et al., 2016; Joy, 2019; Thulman, 2009:268). This hypothesis could be tested through further provenance studies of Suwannee points from the Tampa Bay and Flint River regions to see what toolstones occur at the extreme ends of WCZ and ECZ, and by modeling the proximity of archaeological sites on the margins of these conveyance zones to sources of potable water.

Ancillary support for this scenario is also provided by the seemingly minimal exploitation of the White Springs Quarry Cluster, which is ~ 20 km upstream from the nearest first magnitude spring and mostly constrained to the channel of the Suwannee River. In contrast, the Hawthorn Group chert-bearing portion of the Bellville Quarry Cluster, constrained to the channel of the Withlacoochee River, is also ~ 20 km upstream of the nearest first magnitude spring, yet appears to have been intensively exploited. The main difference between these two examples is that the upstream catchment of the Withlacoochee River is significantly larger than that of the Suwannee River, and thus the Withlacoochee River may have served as a more reliable source of surface water during times of aridity. Additional geochronological work may help to further refine our understanding of the Quaternary history of these rivers, and perhaps support a model of past human movement that centers on access to reliable and potable surface water.

4.4. Scenario discussion

Only the first scenario helps to explain the small amount of Wacissa Quarry Cluster chert found in the interior of the SEA, as well as the small amount of Santa Fe Quarry cluster chert found in the interior of the NWA. Alternatively, if the Upper Suwannee and Bellville Quarry Clusters, and the Luraville Area, represent overlapping landscape use between different but related groups, perhaps exchange between conspecifics can account for the presence of exotic and nonlocal toolstones overlapping in one area (Goodyear, 1989; Meltzer, 1989; Speth et al., 2013). Without the consideration of aggregation and exchange, the Luraville Area is a small, highly-varied assemblage that represents a nearly ~ 500 km conveyance zone, more than double the average of the maximum ascription distances observed in the NWA and SEA. The consideration of exchange opens the door for down-the-line trade nested in human movement, which would help to explain the presence of Flint River chert and Tampa chert at Luraville, as well as the presence of materials local to both the WCZ and the ECZ.

While, the seasonal occupation of spring-rich areas embedded in a broad geographic subsistence round cannot be ruled out, we might expect less emphasis on local toolstone use if a group was engaging in high-magnitude, short-interval movements. The intensive use of local toolstone observed in both the NWA and SEA, coupled with the abundance of artifacts and pattern of using the Upper Suwannee and Bellville Quarry Clusters shows repeated and overlapping landscape use. Additionally, the relative dearth of exotic toolstones in these assemblages testifies to a minimal amount of high-magnitude movement as far as we can detect with chert provenance. The Suwannee point made on Tampa chert recovered from the Luraville Area represents the longest-distance ascription in this study, exceeding the next longest ascription by ~ 30 km. It is an interesting coincidence that a centrally located site with the greatest toolstone diversity relative to assemblage size also has the longest-distance provenance ascription observed.

4.5. Theoretical context

The data presented here support a long theoretical tradition in Florida archaeology that emphasizes the use of lowland Tertiary karst regions by late Pleistocene hunter-gatherers (and now-extinct Pleistocene fauna) for the purpose of accessing potable water. Areas with dramatic lowland relief in the form of sinkholes, karst windows, and spring conduits would have always provided the highest probability for exposed surface water due to their penetration into the Floridan Aquifer (Dunbar, 1991; Dunbar and Waller, 1983; Halligan, 2013; Neill, 1964; Thulman, 2007, 2009; Waller and Dunbar, 1977; Webb, 1974). The abundance of diagnostic late Pleistocene artifacts recovered from these low-lying karstic patches, particularly in the Aucilla, Santa Fe, and Tampa Bay regions, is well document, as is the relative dearth of artifacts from that time period outside of these regions (Austin et al., 2018; Dunbar, 1991: Fig. 7, 2016; Faught and Pevny, 2019; Thulman, 2006b). Chert provenance data from the WCZ and ECZ regions demonstrate that Younger Dryas hunter-gatherers moved between these patches, and that the presence of water (rather than chert) was likely the governing principal of these movements. In each of the quarry clusters, toolstone is present in large quantities, and because the material abundance is high, and the quality relatively consistent, there is no need for chert procurement to be a primary driver of mobility (Andrefsky, 1994). Groups were not occupying a single patch, but rather maintained some degree of mobility, and provenance data reflects toolstone procurement that was embedded in movement between patches containing first-magnitude springs (Binford, 1979).

It is clear that hunter-gatherers in Florida during the Younger Dryas were quite regularly crossing modern drainages, though not all of the waterbodies we recognize today were flowing then (Dunbar, 1991, 2006; Halligan, 2013; Halligan et al., 2016; Thulman, 2009). Using chert provenance, we can see that toolstones from the Flint River and Suwannee River watersheds make it to the area of the Aucilla Basin, and cherts from the Tampa Bay region and the upper reaches of the Suwannee River watershed makes it to the Santa Fe River area. While the Santa Fe River is today a major tributary of the Suwannee River, the presence of exotic chert from the Tampa Bay area in the SEA indicates that cross-drainage mobility occurred during the Younger Dryas. The Upper Suwannee and Bellville Quarry Clusters appear to have been included in two distinct but overlapping conveyance zones that met near the Suwannee River (in the Luraville Area) from both the east and west. Both of these conveyance zones show that while groups are more intensively occupying the first magnitude spring-rich regions of the modern Aucilla and Santa Fe Rivers, there was clear movement of toolstone (and thus people) across multiple drainages throughout north and central Florida. These findings are in contrast to prevailing models for human mobility in the early Holocene Southeast that posit limited movement between drainages (Anderson and Hanson, 1988) and reliance on high-quality toolstone (Daniel, 2001), but are not divergent from mobility patterns proposed for late Pleistocene peoples (Anderson et al., 2015).

The conveyance and aggregation/overlap zones presented here are not dissimilar from those described elsewhere in the southeast. Using reflectance spectroscopy on cherts from Tennessee and surrounding states, Parish (2018, 2025) proposed periodic macroband aggregation in the Lower Tennessee River Valley during the late Pleistocene and early Holocene as an explanation for overlapping chert conveyance zones with majority use of local toolstone and some importation of exotics. Using the same methodological approach on diagnostic projectile points from the Big Sandy Site (1LI573) in northern Alabama, Barlow et al., (2020:12-13) demonstrated a preference for local toolstones and a decrease in mobility over time from the late Pleistocene into the Holocene. This pattern was also observed at Harney Flats near Tampa Bay, though no exotic cherts are reported from either the Suwannee or Bolen assemblage, and only cherts local to the site were used (Austin, 2006; Daniel and Wisenbaker, 1987:169). This is of particular import, because some Suwannee points analyzed in this study from as far north as the Luraville Area were found to be made on Tampa Bay chert. It is interesting that the pattern observed in the SEA is not mirrored in the Harney Flats assemblage.

Daniel (2001), in a reevaluation of Anderson and Hanson's (1988) macroband settlement model for the early Holocene in the Savannah River Valley, also proposed broad macroband territories in the Carolinas that were centered on high-quality toolstone, included cross-drainage movement, and had aggregation areas that did not contain toolstone. In support of this model, Daniel proposed that "lithic assemblages from possible aggregation sites might be recognized as having more stone types from different distinct sources and directions as compared to surrounding assemblages" (Daniel, 2001:258). For the Carolinas, this pattern holds for Clovis (Daniel and Goodyear, 2018), but is difficult to observe in the Younger Dryas due to a perceived post-Clovis population crash in this region of the Southeast (Anderson et al., 2011; Goodyear et al., 2023).

The Luraville Area appears to conform with Daniel's (2001) proposal, and thus may represent either an aggregation area, or an area of conveyance zone overlap. To that end, the second and third scenarios presented above seem to be the most feasible explanation for hunter-gatherer mobility in Florida during the Younger Dryas, and the third scenario is supported by other published case studies from the greater Southeast. It appears that late Pleistocene hunter-gatherers in Florida organized their geographic movement around reliable sources of water; we are merely able to observe these movements using toolstone provenance.

5. Conclusion

While chert provenance studies are currently the only direct method by which to gauge late Pleistocene human mobility in Florida, toolstone procurement cannot be implicated as the sole reason for movement between resource patches during the Younger Dryas. Florida's lithic landscape contained abundant and easily-accessible chert sources in numerous disparate patches that also likely contained sources of fresh water. Environmental reconstruction of the arid late Pleistocene supports an interpretation of human mobility in Florida that is centered on the acquisition of reliable water, rather than centered on the procurement of high-quality toolstone (Dunbar, 1991; Smallwood, 2012; Thulman, 2009). Aggregation areas, like the Aucilla River and Santa Fe River regions provide case studies demonstrating that well-developed karst landscapes with ample first-magnitude springs were a desirable location for human occupation during the arid Younger Dryas in the Southeast. At 30 km from the nearest sources of chert, the Luraville Area sheds light on the margins of two broader chert conveyance zones that overlap not only at the chert-and-water-rich Bellville and Upper Suwannee Quarry Clusters, but also some distance away from accessible toolstone. Future research focused on the extreme margins of the WCZ and the ECZ will improve our understanding of landscape use by Younger Dryas populations in Florida, and allow for an evaluation of the role that water played in the subsistence and settlement strategy of Suwannee point makers. Additionally, this research highlights the importance of dedicated raw-material surveys and the necessity for regional provenance models and methods, like Florida's Quarry Cluster Method, that provide regionally-tailored comparative datasets related to the geographic area of interest (Parish and Burke, 2022; Upchurch et al., 2008).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

I sincerely thank Drs. Michael Waters, Jessi Halligan, Bryan Tomlin, and David Carlson for comments on earlier drafts of this paper, and Dr. Ryan Parish, one anonymous reviewer, and the editorial reviewer for their thoughtful reviews of this manuscript. I greatly appreciate the Silver River Museum, the Florida Bureau of Archaeological Research, the Florida Museum of Natural History, and Osceola National Forest for access to their collections and for providing institutional support, most especially Scott Mitchell, Marie Prentice, and Drs. Andrea Torvinen and Neill Wallis. The Aucilla and Citrus Wildlife Management Areas allowed access for sampling of terrestrial quarries. I am exceptionally thankful to Christopher Lydick for his assistance and logistical support with the riverine surveys, as well as to Dr. Morgan Smith, Dr. Jon Bryan, Eddie Green, Joe Davis, Dr. Sunshine Thomas, Eric Jones, Analise Hollingshead, Nicholas Bentley, Jordan Pratt, Sydney O'Brien, C. Cameron Walker, Wyatt Taylor, Zachary Newell, Austin Cross, Taylor Bethell, Andrew J. Van Slyke, Chris Williams, and Joe Davis for field support. I am grateful for the training in the Quarry Cluster Method provided to me by Drs. Sam Upchurch and Robert Austin, and to Sarah Price and Drs. James Dunbar and Jon Endonino for generously sharing hand samples that were included in this research. Thank you also to Dr. Lou Hill and the Means Family for providing access to their collections. Lastly, a hearty thanks to American Canoe Adventures in White Springs, Florida for facilitating our riverine surveys. All errors in this manuscript are my own.

Funding: This work was supported by the Lewis and Clark Fund for Exploration and Field Research through the American Philosophical Society, the William V. Sliter Research Award through the Cushman Foundation for Foraminiferal Research, Inc., the Roy J. Shlemon Student Field Geoarchaeology Fund, the Texas A&M Department of Anthropology, and the North Star Archaeological Research Fund.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

org/10.1016/j.jasrep.2025.105359.

Data availability

Data will be made available on request.

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