ABSTRACT

Title of Thesis:	ARCHAEOBOTANICAL LEGACIES: CULTURAL SIGNIFICANCE THROUGH AN INVESTIGATION OF MACROBOTANICALS, MICRORESIDUES, AND ETHNOBOTANICAL DATA AT 12OR0001, HOOSIER NATIONAL FOREST, INDIANA
	Emma Woodruff, Master of Professional Studies in Cultural and Heritage Resource Management, 2024
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Unequal archaeobotanical preservation has wide-reaching impacts on archaeologists' views on what is culturally significant. By looking at the intersections and differences between ethnobotanical, macrobotanical, and microresidue data I examine the information streams that are available to archaeologists tasked with determining regulatory " cultural significance" with regards to plants. This thesis documents the only microresidue research conducted as of this writing for 12Or0001, a site located on Hoosier National Forest in southern Indiana. Preliminary research is vital to beginning any consultation or collaboration process so that informed consent regarding laboratory methods and materials identification can be obtained. The viability of future microresidue studies, and their place in Cultural and Heritage Resource Management, are examined within the framework of existing United States legislation. Future research in ancient starches should include consultation and may aid the recovery of knowledge about traditionally utilized plants that has been lost to Indigenous Peoples over time.

ARCHAEOBOTANICAL LEGACIES:
CULTURAL SIGNIFICANCE THROUGH AN INVESTIGATION OF MACROBOTANICALS, MICRORESIDUES, AND ETHNOBOTANICAL DATA AT 12OR0001, HOOSIER NATIONAL FOREST, INDIANA

by

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Professional Studies
2024

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Acknowledgements

This study would not have been possible without the support of everyone who has patiently put up with me for the past two years. Tesa Villalobos, Heritage Program Manager and Tribal Liaison for Hoosier National Forest (HNF), supported me every time I had to take time off work to digitize catalog cards or catch up on thesis chapters. Jennifer St. Germain, Collections Manager for the Indiana University Museum of Archaeology and Anthropology (IUMAA) provided much-needed logistical support during the data collection stage. And last, but certainly not least, I want to acknowledge the support that Byron de Yampert and Pirate the Kitty have given me. This thesis could not have happened without you!

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American Indian Religious Freedom Act **(AIRFA)**

Archaeological Resources Protection Act **(ARPA)**

Brightfield **(BF)**

Civilian Conservation Corps **(CCC)**

Code of Federal Regulations **(CFR)**

Centimeters Below Surface **(cmbs)**

Cultural and Heritage Resource Management **(CHRM)**

Cesium Chloride **(CsCl)**

Culturally Unaffiliated Human Remains **(CUHR)**

Controlled Unclassified Information **(CUI)**

Darkfield **(DF)**

Indiana Division of Historic Preservation and Archaeology **(DHPA)**

Glenn A. Black Laboratory of Archaeology **(GBL)**

General Land Office **(GLO)**

Indiana University Museum of Archaeology and Anthropology **(IUMAA)**

Intellectual Property **(IP)**

Lithium Metatungstate **(LMT)**

Not Applicable **(N/A)**

Native American Graves Protection and Repatriation Act **(NAGPRA)**

Normal Light **(NL)**

National Historic Preservation Act **(NHPA)**

National Register of Historic Places **(NRHP)**

Revolutions Per Minute **(RPM)**

State Historic Preservation Office **(SHPO)**

Traditional Ecological Knowledge **(TEK)**

Traditional Cultural Place **(TCP)**

Tribal Historic Preservation Office **(THPO)**

United Nations Educational, Scientific, and Cultural Organization **(UNESCO)**

United States Department of Agriculture **(USDA)**

Polarized Light **(POL)**

Cross Polarized Light **(XPOL)**

Chapter 1: Introduction

Preliminary Research Concerns

United States laws and regulations regarding Indigenous America have made strides to bridge the gap between western and indigenous understandings of cultural significance, though claims of legally defensible cultural significance are still most often successful when supported by archaeological and archival evidence. How might unequal preservation of botanical data in the archaeological record shape archaeologists' understandings of culturally significant plants? Originally, I began this thesis with the intent to ask a research question that was more relevant to starch grain analysis and hopefully even identify some plant processing methods. After examining the collected residues, I was not able to identify as many diagnostic morphologies in the potential starch grains as I would have liked (See Figure 8). I decided to broaden my research question and instead consider the role archaeologists have in determining legally defensible interpretations of cultural significance. I used my microresidue results to illustrate how much information can be left out of consideration if even a single information stream is not considered.

I felt that exploring the intersection of cultural and ecosystem behaviors was a direction that fit well with the projects I work on in the Cultural and Heritage Resource Management field. Almost all my professional experience has been spent in the federal government as an archaeologist. I've worked for the National Park Service and the Forest Service and have often encountered what I perceived to be a hard line dividing ecological and cultural concerns. In the spirit of broadening my understanding of culture and ecosystem behavior I chose to investigate botanical preservation through microresidues after learning about proposed palynological research in southern Indiana that is currently in the research design stage. A team of ecological modelers and an archaeologist are interested in researching the environmental makeup of southern Indiana during the protohistoric period. I was intrigued by the non-traditional role archaeology was taking because none of the microbotanicals that were proposed for study came from archaeological sites. I appreciated the ability of archaeology to ask questions without using material culture and I wanted to learn more about the interactions between a culture and the environment.

After a lot of reading, I came across a paper titled: Why are Sustainable Practices Often Elusive? by Crabtree et al that introduced an agent-based model (2022). The model proposed in this paper says that perceived information has a direct correlation to actions taken (Crabtree et al 2022). Oftentimes, unsustainable practices are perpetuated by a failure to consider all information streams affecting a given ecological problem (Crabtree et al 2022). I saw a connection between this model and regulatory use of value-based systems like the "significance" driven National Register of Historic Places because if a site is not considered "important to history" it is more likely to be considered not eligible and subsequently receive fewer federal protections. I think that as archaeologists we have been given a great amount of authority in determining what constitutes as "culturally significant" by cultural resource management laws in the United States. I wanted to explore this topic more to see if there could be useful site information within unanalyzed residues on artifacts.

My research question is explored by examining a 14th century Native American village site, 12Or0001, also called Cox's Woods. The village site is on federal lands managed by Hoosier National Forest and is located on the south bank of Lick Creek approximately one mile south of Paoli in Orange County, Indiana as shown in Figure 2 (Bush 2004: 83, Redmond and McCollough 1993: 103, Redmond 1994:1, USGS 2022). Locational information is intentionally vague as this site is located on Hoosier National Forest, Indiana and protected under federal law. The site is examined through the lenses of three data sets: previously analyzed macrobotanical data, newly examined microresidues, and ethnobotanical data compiled from published sources. A secondary objective of this thesis was successful in determining that published methods for recovering microscopic residues from ceramics were applicable to residue analysis for sherds collected from the Ohio River Valley.

The Cox's Woods site was known to early pioneer settlers and was mentioned in historic records as early as 1876. The residues I studied for this thesis were all collected from ceramic sherds that had been recovered from midden deposits near the palisade wall in the 1990s. I made a conscious choice to avoid testing residues collected from a dwelling and its pit features. I felt that a secondary goal of my research was to determine the suitability of using curated objects for residue analysis, and that questions concerning the dwelling should be asked when collaboration could happen.

Cultural significance is largely subjective, but established definitions that inform federal policies exist in the United States of America. In the context of this thesis "cultural significance" refers to the regulatory definitions of significance used in the National Historic Preservation Act (NHPA) and National Register of Historic Places (NRHP)—such as thresholds of cultural significance that need to be met when evaluating Traditional Cultural Places[1] (TCPs). The National Register Bulletin for Traditional Cultural Places describes "traditional cultural significance" as "significant to their [a traditional community] traditional cultural beliefs, customs, or practices" (NPS 2023: 11).

[1] "Traditional Cultural Place" (TCP), formerly referred to as "Traditional Cultural Property" (TCP) in National Register guidelines until 2022.

All microresidues were collected and examined by the author. Microresidues were recovered from ceramic sherds that have been in curation for three decades at the Indiana University Museum of Archaeology and Anthropology (IUMAA). I aimed to identify appropriate methodologies for future recovery and analysis of microscopic residues at 12Or0001. No microresidue analysis of 12Or0001 had been performed prior to my examination, despite the need having been identified in 2004 by macrobotanical researchers, including Dr. Leslie Bush. I compared Dr. Leslie Bush's data to ethnobotanical data pulled from Daniel Moerman's Native American Ethnobotany (1998) and the USDA's Plant (2023) page. By looking at the intersections and differences between the ethnobotanical, macrobotanical, and microresidue data I hoped to understand the information streams that are available to archaeologists tasked with determining regulatory "cultural significance" with regards to plants.

The productivity of residue analysis at 12Or0001 had to be assessed before a comprehensive understanding of archaeobotanicals and their role at the site could be attained. Without at least a minimal investigation of microresidues at the site, the overarching research question regarding cultural significance would have a limited scope and fail to consider the suite of information that can be yielded from microresidue analysis. If microscopic residues were not considered, the role each of the other two data sets have in shaping understandings of cultural significance would have been skewed. Starches were of particular concern because they are relatively easy to identify, share morphological similarities across species, and have been successfully recovered from artifacts by paleobotanists. Ancient starches are also more susceptible to pre- and post-depositional processes than other environmental residues such as phytoliths or diatoms. This means that the recovery of starches from artifacts can act as a benchmark for how productive additional residue analysis may be at a given site.

I was able to determine that archaeologically diagnostic residues could be recovered from ceramics curated for as long as 30 years. This means that there is an untapped wealth of environmental data stored within repositories throughout the United States. The potential starches observed in this study all appeared to be largely unaltered, which indicates that only the heartiest of starches survived to the present day and that specific processing methods may not be visible at the microscopic level on curated artifacts.

Microresidue research has the potential to increase our knowledge of plants that made up the environment of past peoples. However, it is important to understand and account for modern contaminants that might be recovered alongside archaeological residues. For example, I observed potential paper towel fibers and insect contaminants during my investigation (See Table 2 and Appendix A). Each collection will have different circumstances affecting the preservation of diagnostic residues, so the results from this study do not mean that every collection needs to be assessed for microscopic residues. The acidic soils at the site and the rigorous cleaning protocols at the IUMAA most likely had an impact on the type and quality of potential starch granules I observed. However, the microresidues I observed and photographed will be useful to future residue studies of sites with similar environmental and curatorial circumstances.

The three data sets examined in this thesis are commonly used to support archaeological interpretations of cultural significance and are used to inform scientific interpretations of the precontact environments and human-climate interactions. Research aimed at reframing cultural significance is not new, but it is becoming increasingly relevant to archaeologists tasked with identifying, evaluating, and managing culturally significant places through the application of existing cultural resource management laws in the United States.

Figure 1. Shagbark Hickory, *Carya* sp., nuts (a; left) and bark (b; right) have reported uses including food, fuel, and artifact production (Moerman 1998: 141). Photographed by E. Woodruff in August 2023.

Context for Study

Archaeobotanical research specific to Indiana is sparse, and the vast majority of paleobotanical information has been gleaned from a broader eastern woodland context. The IUMAA has an abundance of unanalyzed objects in curation, many of which were collected during controlled archaeological excavations. This means that the provenience of most items is known, and the curation history has been documented, at least in part, by the museum. Collections at the IUMAA may have untapped potential for microresidue analysis even though most items were not collected with that area of research in mind. Given the huge number of archaeological materials that are retained in federal repositories alone, and the limited processes by which those items can be deaccessioned, it is worth looking at collections through previously underutilized methods. As curation facilities consider deaccessioning collections it may be beneficial for at least some preliminary residue analysis to take place to determine if seemingly innocuous and redundant artifacts in a given collection might hold diagnostic residues. This is especially importance since many repositories do not curate soil samples, which are often used in microresidue research (Pearsall 2015). Establishing broad trends concerning microresidue preservation in curatorial environments will greatly enhance the suitability of specific deaccessioning protocols.

Archaeology is largely preoccupied with material culture because that is often all that physically remains at a site location. Cultural significance definitions should work to embrace information pulled from other fields of study. I only examined residues from ceramics in my project, but other archaeologists have had success in recovering botanical residues from stone tools and groundstone, both of which were recovered from the Cox's Woods site. It would be beneficial to continue assessing the potential of microresidue preservation on different artifact types.

Microresidue analysis has the potential to enhance archaeologists' academic understanding of how Native Americans interacted with their environment. This enhanced understanding is important when crafting successful arguments for the designation of traditional cultural places (TCPs) and for arguments regarding the protection and traditional use of culturally significant plants. By including ethnobotanical information with archaeology and other scientific fields we may be able to find academic justification for traditional cultural practices. This justification may aid tribal nations in ongoing conversations regarding ecological health and land management.

The biggest takeaway I want people to have from my thesis is that cultural significance is relative, and that CRM cannot effectively assess significance unless collaboration and cross-disciplinary conversations occur. Consultation is notably absent from my thesis despite the robust conversations regarding its importance to comprehensive cultural significance studies. The work done for this thesis will be useful in any future attempts to conduct paleobotanical research, specifically at Cox's Woods, and more broadly in the Ohio River Valley. The recovery of archaeologically diagnostic materials from microscopic residues at Cox's Woods suggests that there is an additional data source that has so far been largely ignored by archaeologists working on regulatory projects. The addition of microresidue analysis would help archaeologists to assess the total information potential of a site, which could have an impact on significance determinations for the National Register of Historic Places (particularly under Criterion D).

Thesis Outline

In the following chapter, Chapter 2, I discuss previous research in ancient starch analysis and discuss the role archaeology has to play in environmental reconstruction. I also discuss the recovery of starches from archaeological and curatorial environments. I present potential limitations to the analysis of ancient starches alongside results that can be reliably interpreted from ancient starch recovery. I briefly introduce case studies regarding the underrepresentation of ethnobotanically utilized plants in the archaeobotanical record—one case study is set in the Northern Caribbean and one is set in the Gulf of Florida. I also discuss the reciprocal role that archaeology can take when identifying culturally significant plants that have been lost to Indigenous people over time.

In Chapter 3 I discuss the historical context of 12Or0001 and provide an environmental overview of what is known about the study area. The history of archaeology at 12Or0001 is explored utilizing excavation reports and archival research. The physical layout of the palisaded village site, 12Or0001, is described and the 14th century cultural context is presented for the study area. The environmental history of the unglaciated regions of southern Indiana is also discussed and pulls information from historical records, environmental history, and archaeological data.

In Chapter 4 I describe the methods I used to collect botanical data and microresidues from 12Or0001. Photographs and step-by-step instructions are provided. These instructions have been designed specifically for washed ceramics but are a good framework to begin with when examining other artifact types. The instructions are clearly stated so that consultation and collaboration about laboratory methods can be as transparent as possible. Reasons for choosing the samples examined in this experiment are also explained and justified in this chapter.6

In Chapter 5 I present compiled ethnobotanical information for Indiana, previously published macrobotanical data for the study area, and the results of my microresidue examination of ceramics at 12Or0001. Ethnobotanical information was compiled from published data provided by the United States Department of Agriculture (USDA 2023) and Daniel E. Moerman's book, Native American Ethnobotany (1998). Macrobotanical data was compiled from previous research published by Leslie Bush and pertains specifically to plants recovered from sites considered to be culturally associated with 12Or001 (2004). Microresidues are tentatively identified, and photographs and measurements of residues are provided so that future researchers can perform their own assessments of the results.

Chapter 6 analyzes the results of my microscopic examination and discusses the suitability of decades-long curated items for future microresidue research. Microresidue discussion aims to identify post-collection processes that may impact future analysis of long-curated specimens. The regulatory and legislative implications of the underrepresentation of ethnobotanically utilized plants is discussed in the context of Cultural and Heritage Resource Management (CHRM) in the United States.

In Chapter 7 I conclude my thesis with a discussion of the practical applications of archaeobotanical research and provide suggestions to archaeologists for how to seek broader definitions of cultural significance in the cultural resource management field. This chapter also addresses the role that collaboration and consultation should play in any potential future studies. Final thoughts include a discussion of the outsized role archaeologists have in determining cultural significance.

Chapter 2: Theoretical Background

Previous Research on Archaeological Starches

The earliest work involving the analysis of archaeological starch granules was published in 1982 and discussed the positive identification of 4000-year-old potato starches recovered from preserved tubers (Ugent, Pozorski, and Pozorski 1982). Archaeological starch residues have been recovered and identified from flaked stone, ceramics, bedrock mortars, and feature soils and are well suited to in-tandem macrobotanical analysis (García-Granero et al. 2015). Archaeological starch has also been identified on human dental calculus (Delaney, Alexander, Radini 2023). Archaeological starch analysis is still pursuing its limitations regarding what research questions it can and cannot answer. One major component of identifying the limitations of starch grain analysis is understanding what variables affect archaeological starch preservation and identifying the processes by which foreign starches are introduced to artifacts and archaeological soils in post depositional and curatorial environments (Mercader 2018).

The past two decades have seen an increase in archaeological starch analysis and as a result there is a large body of textbook-style literature that describes morphologies and well-established methodologies relevant to archaeological starches (Henry 2016, Henry 2020, Martson 2014, Pearsall 2015, Perry 2010, Torrence and Barton 2006, Yeung et al. 2015). One problem still affecting the broadscale analysis of archaeological starch residue is the lack of standardized nomenclature and definitions between paleobotanists. Pearsall's 2015 textbook *Paleobotany: A Handbook of Procedures*—and this thesis—uses terms as they are identified in the International Code for Starch Nomenclature (ICSN) (Perry 2011).

There is a need for a starch encyclopedia with photographs and comprehensive descriptions of both modern and archaeological starches (Messner 2011). The published results of previously conducted ancient starch analysis have produced a mostly standardized approach to archaeological starch studies, though methodologies vary slightly based on the specific researcher and a residue's specific taphonomic history (Pearsall 2015). Starch-bearing plant species may have morphological variations based on the time of year they were produced by a plant, individual genetic histories, and post-harvest cultural practices (Messner 2011). This thesis discusses taphonomic processes that may have influenced the presence of archaeological or modern starches on ceramics collected during professional archaeological excavations at 12OR0001 in 1993 and 1994 and the subsequent curation of the collected materials.

Archaeological starch grain analysis is not suitable for the recreation of environmental conditions or cultural preferences for archaeologically dominant starch-bearing plants over less archaeologically visible starch-bearing plants (Mercader et al. 2018, Pearsall 2015). However, starch grain analysis can broaden our understanding of which plant species were utilized by past peoples (Tsafou and García-Granero 2021). Other, more skeptical research demonstrates that archaeological starch modifications thought to be the result of culinary modification processes may be caused by natural processes under specific environmental conditions (Mercader et al. 2018). Soil pH and salt content, among other variables, are known to have an impact on starch preservation in archaeological contexts (Pearsall 2015). Preservation of starch also varies from species to species and must be considered when determining starch extraction and analysis methodologies (Martson 2011). Excavation of materials under conditions that cannot be definitively guaranteed not to have contaminating starches can result in suspect conclusions unless "field archaeologists characterize the starch contamination landscape that is specific to their study area and utilize dedicated excavation tools that can be cleaned frequently with a solvent or starch gelatinizing agent (Mercader at al 2018: 16)". Even attempts to remove contaminant residues with compressed air and several rounds of ultrasonic cleaning cycles are questioned by Mercader et al. (2018). Baselines for the amount and type of naturally occurring residues on museum artifacts are underway and will be vital in future analysis of archaeological starch granules.

Previous research involving archaeological starch granule analysis has resulted in the reported identification of archaeological starch on chipped stone, ground stone, and ceramic artifacts in both tropical and arid environments (Ciofalo, Sinelli, and Hoffman 2019, Duke et al. 2018, Kealhofer et al. 1999, Pearsall et al. 2020, Raviele 2011, Saul et al. 2012, Thoms et al. 2015, Torrence and Barton 2016). Microbotanical analysis is most often performed on artifacts that were collected with the expectation that botanical residue analysis would occur. Residue analysis benefits greatly from having knowledge of all possible post-depositional contaminants, but the vast majority of collected artifacts are not curated with residue analysis in mind. Analysis on survey and museum artifacts are providing a growing body of evidence that certain microscopic residues are heartier than initially thought (Hart 2011, Barton 2007). Huw Barton performed testing on artifacts that had been archived at museums in England and Australia (2007). Barton also examined ethnobotanical samples of two wild yams, *Dioscorea* genus, which had been collected in 1856 and 1928 (2007). The age of the ethnobotanical samples served as a reference for how starch aged over time in a museum environment (2007:1754). Barton concluded that "unmodified native starch and modified, cooked starch granules, may persist on artefacts as an organic residue for scores of years and remain reactive to simple biological stains for more than 100 years (2007: 1760)." Barton's study was optimistic about residue analysis on museum artifacts but cautioned that vigorous cleaning of artifacts inhibits the preservation of archaeological starch

(2007). It is expected that individual collections will vary in cleanliness due to a variation in curation policies, and therefore have differential preservation of archaeological starches.

Limitations in Archaeological Starch Granule Analysis

Human interference with starch can result from botanical resource collection, compound tool preparation, botanical processing, and various cooking methods. Once an artifact bearing starch residue has been discarded, variables affecting starch preservation include plant species, method of human interference (such as grinding or fermenting), and location of disposal (such as a midden or hearth). According to Martson, an artifact that has been subjected to burial is affected by living organisms and individual soil characteristics (2014). Enzymes are likely to affect starch granule morphology and preservation, but a wide array of bacteria and fungi also play a role based on specific burial environments. A soil's texture, moisture content, and pH are also known to affect the preservation of starch granules. Soils with moderate pH, aggregates, clays, and heavy metals have been suspected of contributing to higher levels of starch granule preservation (Johnson and Martson 2020). Soil characteristics that limit the vertical and horizontal transfer of starches through the soil column are expected to limit the possibility of contamination prior to excavation, though passive transfer of starches onto an artifact is unlikely (Martson 2014: 47).

Scientific Approaches vs. Traditional Ecological Knowledge (TEK)

Disparities between plants recovered in archaeological contexts and those plants believed to be important to the lifeways of past peoples is well documented in archaeology (Ciofalo, Sinelli, and Hofman 2019, Jackson et al. 2020, Pearsall et al. 2020). Specifically in the Americas, manioc and acorns are known to have provided a large percentage of overall calories to Indigenous Peoples, but those plants are consistently underrepresented in archaeobotanical studies. Microresidue examinations, specifically analysis of ancient starches on artifacts, has confirmed what ethnobotany has long purported—that these plants were used by past peoples but are not well documented in the macroscopic archaeobotanical record.

North Caribbean Case Study

Ciofalo, Sinelli, and Hofman (2019) investigated microbotanical residues from griddles recovered from three late precolonial sites in the Dominican Republic. Macrobotanicals are rarely preserved in hot and humid environments which means that archaeobotanical studies in the region rely on microresidues. Until the 2000s and 2010s it was presumed that manioc was highly important to precolonial Caribbean peoples. This assumption was largely based on historic accounts written by Europeans (Ciofalo, Sinelli, and Hofman, 2019: 1635). As a direct result of these preconceived notions about which plants were considered important to indigenous peoples, archaeologists had attributed the "presence of microlithic grater chips, shell tools, and clay griddles" as "carrying out a single function" which was processing manioc (Ciofalo, Sinelli, and Hofman, 2019: 1635). Out of the 45 griddles examined in the study, manioc starches were only recovered from 7 of the griddles (1652). Over half of the manioc starch-bearing griddles also had residues from other plants such as maize and chili peppers (Ciofalo, Sinelli, and Hofman, 2019). This case study found that of all microbotanical remains present on the 45 griddles sampled, most starches were from maize. These lower-than-assumed numbers of manioc starch are consistent with other regional microbotanical research conducted by Berman and Pearsall 2000, Berman and Pearsall 2008, and others. The predominance of maize was not documented in European accounts, and archaeologists who relied on these written accounts erred in assuming that griddles were used exclusively to process manioc. It is important to note that archaeologically predominant species should not be interpreted as equivalent to an individual cultural preference. In other words—just because a plant is processed often does not mean that plant is held in higher esteem. Ciofalo, Sinelli, and Hofman explain this by citing niche construction theory which attempts to account for specific environmental cultural adaptations (2019).

Florida Gulf Coastal Wetlands Case Study

Archaeobotanical analysis of the coastal wetlands on Florida's northern peninsular gulf coast is limited because of how harsh the environment is to botanical preservation. Macrobotanical research in the area is even more limited because many of the "most useful coastal wetland forbs do not produce durable seeds or woody tissues and are unlikely to be represented in macrobotanical samples" (Jackson et al. 2020). The preservation of microbotanicals is also hindered by the abrasive nature of sandy soils and highly alkaline soils common to the coastal wetlands region (Jackson et al. 2020: 569). Because of hostile preservation environments, heartier palynological—fossil pollen (phytoliths) and silicate microfossils (sponge spicules) are generally used to interpret past floral environments (Jackson et al. 2020: 573-5). The case study examined in this paragraph analyzed sediment cores from a village shell midden, a marsh near the shell midden, and a hydric hammock near the village plaza (Jackson et al. 2020: 574). Wind-pollinated plants were excluded from analysis due to their large range of dispersal. Bog hemp (*Boehmeria cylindrica*) was a predominant source of pollen fossils recovered from the coastal village site. Bog hemp is a member of the nettle family and has been thoroughly documented as being a source of cloth and cord fiber for precontact communities living within its range (Jackson et al. 2020: 581). The predominance of wapato pollen at the site suggests that its starchy tubers were a reliable source of food. Current zoological observations state that waterfowl are attracted to wapato outcrops, which may have positively reinforced wapato cultivation in the Florida coastal wetlands (Jackson et al. 2020: 582). The only phytoliths recovered were from the palm Family (Arecaceae). Palm trees are believed to be “principal sources of cordage fiber on the Gulf Coast and…the widespread use of palm as a source fiber, dietary carbohydrates, and construction material seems likely” (Jackson et al. 2020: 583). In environments where preservation is not optimal, starch grains and phytoliths can be used to inform archaeobotanical interpretations of the past. Jackson et al. ends their study with the closing note that “microbotanical analyses and biochemical work on targeted archaeological contexts—such as roasting pits, ceramic vessel interiors, and inundated midden deposits—are necessary to further elucidate patterns of ancient plant use…where Indigenous plant use has been understudied by archaeologists” (2020: 584). Jackson et al. also admits that the historical ethnobotany of certain plant species is underdeveloped which severely limits archaeological interpretations of what is and is not a culturally important plant (2020: 581).

Archaeological Contributions to Contemporary Tribal Knowledge

TEK is not always able to answer any and all questions regarding nature-culture interactions. There are documented instances where archaeology has the tools to explore topics that are of interest to contemporary tribal citizens. One example of scientific archaeology aiding in the recovery of traditional knowledge is seen with The Shawnee People and the Shawnee Ancient Pottery Program (Barnes 2016). This program has been spearheaded by the Shawnee Tribe, but involves collaboration with other associated tribal nations, scholars, and tribal citizens (Barnes 2016). The overarching goal of this program is to regain knowledge of ceramic traditions that were lost to tribal members over time due to the rise in popularity of durable metal cookware and the forcible removal of native peoples from their homelands. Archaeologists were able to help Indigenous peoples rediscover clay recipes that were no longer within current tribal knowledge (Barnes 2016). According to then-Second Chief Ben Barnes, species of preferred shellfish, specific clay deposits, and even some designs were reintroduced to the modern-day Shawnee Tribe through collaborative research (Barnes 2016). This pottery project is a testament to the role scientific approaches to archaeology have in informing present-day cultural identities.

Scientific approaches and Traditional Ecological Knowledge (TEK) should work together to explore cultural and environmental questions from multiple angles. By identifying the gaps in information missing from these two knowledge streams collaborative projects can better identify research questions that are of interest to both Indigenous people and scientists. It is also possible that scientific approaches will be able to recover information about commonly used plants in the past that have become underrepresented in present day tribal knowledge. If, for example, a specific species of plant was highly utilized in the past, but due to a nation's removal from their traditional homelands—and that plant's habitat range—a plant could no longer be used, archaeology can help recover information that holds cultural significance to existing tribes.

Conclusion

Microresidue studies have an important role to play in recreating plant use strategies in the past. Precontact and historical use of plants can be an indicator of which plants, if any, were utilized repeatedly over time by a specific group of people. Microscopic analysis is especially useful when investigating areas with poor macrobotanical preservation, or where European accounts are given heavy weight in environmental reconstructions of the Americas in the contact period. Microresidue research can also aid in the recovery of traditional knowledge that has been lost to tribal nations over time.

Chapter 3: Historical Background

Environmental and Cultural History of 12Or0001

12Or0001, also called Cox's Woods, is a 14th century village site located on the south bank of Lick Creek approximately one mile south of Paoli in Orange County, Indiana as seen in Figure 2 (Bush 2004: 83, Redmond and McCollough 1993: 103, Redmond 1994:1, USGS 2022). The village site is located within a D-shaped double concentric earthworks that at one time supported a series of wooden posts or palisades (Redmond 1994). The earthworks at the site are also referred to as a stockade and embankment in various sources and are presumed to have served as a protective barrier for the Cox's Woods village (Redmond and McCoullough 1993). Midden deposits are concentrated within and outside of the earthworks and archaeological excavations have determined that fill around the stockade served as a disposal area for refuse, with the center of the village being mostly devoid of midden deposits except for a few discrete pit features. This would mean that at the time of occupation, refuse was cleared from the village interior and disposed of at the exterior of the village either within or just outside of the stockade walls. Redmond identified the center of the site as a "central plaza" or "public area" that would have served as an activity center during the site's occupation (Redmond 1994: 6).

Cox's Woods lies in the unglaciated Shawnee Hills Natural Region of Southern Indiana and is located where the geologic landscape transitions from the Crawford Uplands to the Escarpment section (Bush 2004: 83). Soils at the site include Elkinsville silt loam, 2 to 6 percent slopes (EepB), Crider silt loam, 6 to 12 percent slopes, eroded (CspC2), and Haymond silt loam, 0 to 2 percent slopes, frequently flooded, brief duration (HcgAH) (NRCS 2023). Vegetation at the site is somewhat unique in the region as it is located within some of the only remaining old growth forests

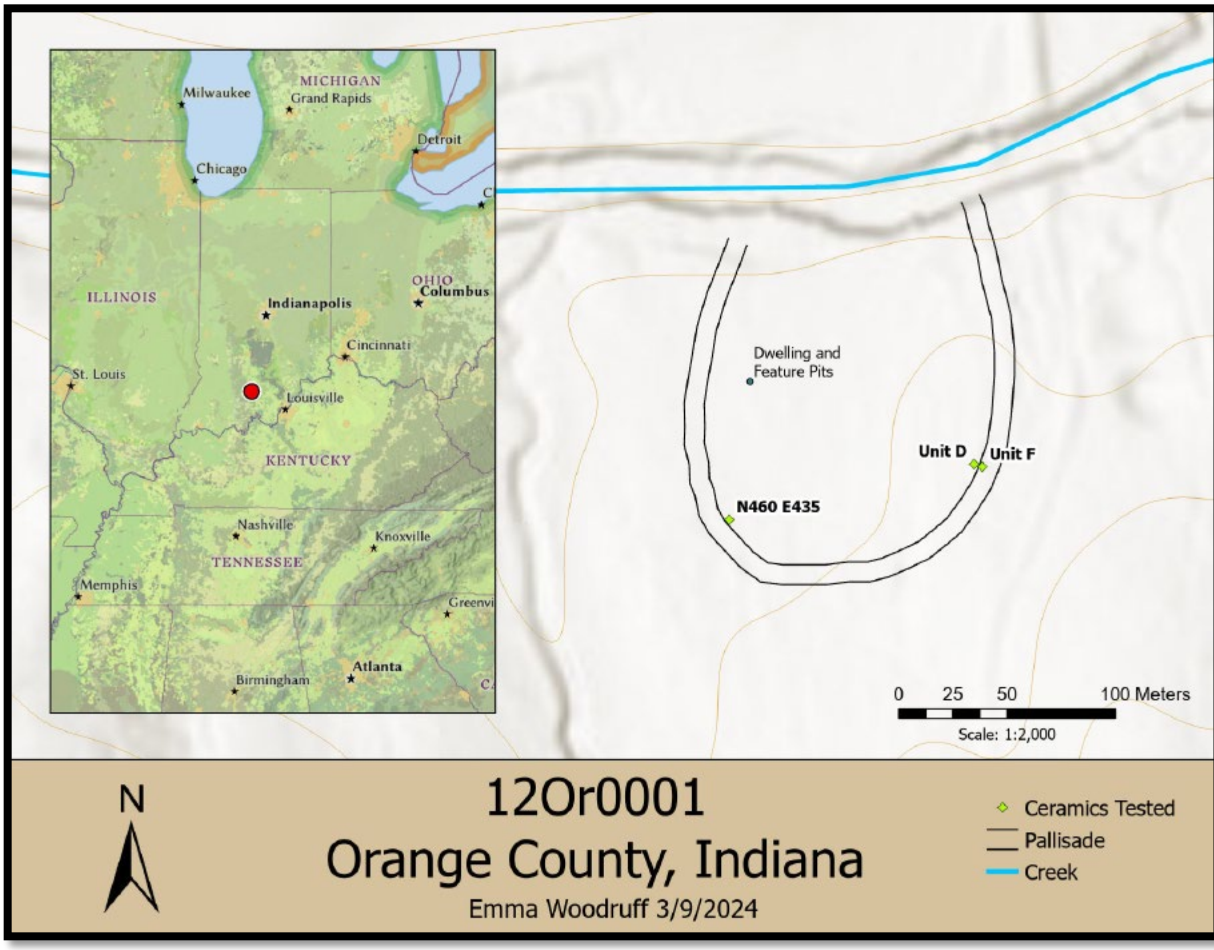


Figure 2. Map of study area created by the author. Locational information is intentionally vague as this site is located on Hoosier National Forest, Indiana and protected under federal law.

in the state and is believed to be largely undisturbed. However, the eastern extent of the site has been subjected to historic era agriculture-related disturbance and subsequent planting of non-native pine by the Civilian Conservation Corps (CCC) in the 1930s. Living trees located within the immediate vicinity of the site include wild plum, beech, hickory, oak, and non-native pine (personal observation, September 2023) (See Figure 3). Animals that would have lived in the immediate area of Cox's Woods in the 14th century includes wild turkey, white-tailed deer, racoons, foxes, squirrels, snakes, frogs, and freshwater shellfish (Jefferies 2008, Redmond 1994).

Unlike other sites that have been attributed to the Oliver Phase, 12Or0001 is located “on the floodplain of Lick Creek, which is a tributary of the Lost River, itself a tributary of the East fork of the White River” (Bush 2004: 83). Other Oliver Phase sites are more commonly located along major rivers rather than within the floodplain of a secondary tributary.

The Oliver Phase is a farming culture, largely defined by a distinct ceramic tradition, located along the East and West Forks of the White River during the Upper Mississippian, also called the Late Woodland, precontact period (Redmond 1994: 1). The Oliver Phase is generally considered to consist of “village dwelling horticulturalists who inhabited Indiana from A.D. 1200 until A.D. 1425 or 1450 A.D. in calendar years” (Bush 2004: 1). Archaeologically speaking, the people who practiced what is called “Oliver” culture are believed to have been the blending of “at least two cultural traditions” that moved into central Indiana “within a few decades of each other” (Bush 2004: 1). Oliver sites are found exclusively within the White River floodplain and were bounded by Oneata cultures to the northwest, Fort Ancient cultures to the southeast, and Mississipian cultures to the south and southwest. Oliver phase sites stand apart from other cultural traditions at the time because they are a blending of other more widespread traditions that existed at the same time. Oliver sites have an array of assemblages that appear to be influenced by the cultural traditions of their neighbors (Bush 2004). It is unclear which modern-day tribes, if any, have ancestral ties to Oliver sites. Today, there are eleven federally recognized American Indian Tribes that consult with the Forest Service on federal projects in Orange County as of the writing of this thesis.

Previous Archaeological Investigations at 12Or0001

12Or0001 was discussed as early as 1876 in the 7th Annual Report of the Indiana Geological Survey (Elrod and McIntire 1876:283-239). However, the site was not registered with the Indiana Division of Historic Preservation and Archaeology (DHPA), which serves as the State Historic Preservation Office (SHPO), until 1975 when it was described as a "potentially important site" (Smith and Brown n.d). Unauthorized excavations performed by "avocational archaeologists from West Baden College" occurred in the 1950s, but all documentation of those excavations have been lost (Redmond and McCullough 1993: 78).

In the early 1990s there were a series of professional excavations led by Redmond, including two Indiana University field schools that took place at 12Or0001. Excavations from March 11 through April 4, 1993 included two 10mx10m magnetometry surveys with a fluxgate gradiometer, and confirmed that portions of the double embankment were undisturbed by excavating a 1mx9m trench across those earthworks. Redmond also completed 40 50cmx50cm test units across the cultivated central and western portions of the site. The residues examined in this thesis were recovered from ceramic sherds excavated from the 1mx9m trench and one 50cmx50cm test unit. Soils were excavated until sterile subsoils were encountered, or to a maximum depth of 50 centimeters below surface (cmbs), meaning that roughly 45 cubic meters of soils were screened through ¼" hardwire mesh in the spring 1993 investigation alone. Tentative results of the spring 1993 excavations were used to determine which areas should be targeted during the first of two field schools. Given that fieldwork for the 1993 field school began just six and a half weeks after the spring excavations ended it is unlikely that archaeologists were able to analyze much, if any, of the collected materials prior to beginning the field school. Additional excavations were conducted by Indiana University archaeological field schools during the summers of 1993 and

1994. These excavations located a house feature and several pits associated with the Oliver occupation of the site (Redmond 1994). Future microresidue research would do well to focus on the house and pit units as they should have a different botanical profile when contrasted with those residues recovered from the village embankment.

In November 1993 a report with findings from the spring 1993 investigation was completed. This report found that "a line of post molds within the inner embankment support the interpretation that the earthen wall complex was constructed as a means of fortification for the village settlement" (Redmond and McCollough 1993: 87). The report also suggested that ceramics were disposed differently from chert in relation to the stockade wall, with ceramics being mostly recovered from "inside" the walls and chert being mostly recovered from "outside" the walls (Redmond and McCollough 1993: 86). Redmond and McCollough proposed that the differential disposal between ceramics and chert was due to ceramic sherds being heavily re-used and considered "less hazardous" than sharp chert debitage and therefore more suitable for disposal within the stockade (Redmond and McCollough 1993: 86). It was also suggested that pottery was disposed of within the stockade wall because it was purposefully swept away from village activity centers and eventually accumulated against the stockade wall which served as a physical barrier that the ceramic sherds could not move beyond.

The magnetometry survey located several anomalies that were attributed to precontact cultural features (Redmond and McCollough 1993: 100). A sample of these anomalies was excavated and found to contain stockade trenches, midden lenses, pottery concentrations, pits, and a stone-lined trench (Redmond 1994: 9). Ceramic sherds were recovered from the site in the highest frequencies, followed by "chert debitage, limestone fragments, and sandstone fire-cracked rock" (Redmond 1994: 19). In total, more than 60,000 ceramic sherds have been recovered over the course of multiple excavations at 12Or0001 (Jennifer St. Germain, personal communication, August 2023). Organic materials were observed in low frequencies at the site, suggesting that a large percentage of floral and faunal remains at the site were not preserved (Redmond 1994: 28). Despite the lackluster preservation of organic materials at the site, flotation samples recovered a wide array of botanical remains from the soils at 12Or0001.

Previous Archaeobotanical Research at 12Or0001

Floral remains recovered in the spring 1993 excavation were analyzed by Leslie Bush and determined to consist of wood charcoal, walnut shell, hickory shell, and both charred and uncharred maize kernels (Redmond and McCoullough 1993). Leslie Bush conducted additional analysis on floral remains from 12Or0001 and other Oliver Phase sites and published the results in 2004. Bush examined 203.25 liters of fill from the Cox's Woods site, and with the aid of flotation an average of 8.19 botanical samples were recovered from each liter of fill representing twenty-eight identifiable plants. Known cultigens such as corn (*Zea mays* L.), bean/persimmon, and tobacco (*Nicotiana* L.) were identified. Additional plants believed to have been utilized at 12Or0001 include chenopodium (*Chenopodium* L.), maygrass (*Phalaris caroliniana* Walt.), and little barley (*Hordeum pusillum* Nutt.) (Bush 2004: 68). Nutshells from hickory (*Carya* Nutt.), the hickory/walnut family (Juglandaceae), acorn (*Quercus* L.), black walnut (*Juglans nigra* L.), hazelnut (*Corylus* L.), and pecan (*Carya illinoinensis* [Wangenh.] K. Koch) were also identified in floatation samples.

Sixteen species of wild plants were identified in soils recovered from 12Or0001 and include blackberry (*Rubus* L.), sumac (*Rhus* L.), purslane (*Portulaca oleracea* L.), pepperweed (*Lepidium* L.), blueberry (*Vaccinium* L.), smartweed (*Polygonum* L.; lenticular), vervain (*Verbena* L.), grass

Figure 3. Recent tornado damage at 12OR0001. Photographs taken by E. Woodruff in September 2023.

family (Poaceae), grape family (Vitaceae), panicum (*Panicum* L.), bedstraw (*Galium* L.), bean/pea family (Fabaceae), black nightshade (*Solanum nigrum* L.), plum/cherry (*Prunus* L.), Chenopodium (*Chenopodium/Amaranthus*), and elderberry (*Sambubus* L.) (Bush 2004: 68-73). The floral remains identified by Bush vary with respect to intra-site location and feature associations, but she did not discuss specific contamination possibilities (Bush 2004: 85). Bush found that interior (within the palisade/stockade walls) features contained "proportionately more fruits and seeds that are themselves edible", whereas the palisade features are more likely to contain plant remains that "were eaten for their greens rather than their seeds" (Bush 2004: 85). Bush suggests that the differences in floral distribution represent distinct discard zones. Processing waste is associated with the stockade, while cooking waste is associated with interior features and living spaces. Though processing waste was recovered in higher frequencies from the stockade it is possible that plant processing was done in the village interior and then inedible waste was disposed of at the stockade walls.

Administrative History of Ceramic Collections at 12Or0001

Noel Justice served as the Curator of Collections during the time in which the 1993 and 1994 excavations were conducted and the collected objects subsequently curated. The artifacts were cleaned, analyzed, and curated at the Glenn A. Black Laboratory of Archaeology (GBL), now called the Indiana University Museum of Archaeology and Anthropology (IUMAA). From 2019 to 2022 all collections recovered from 12Or0001 were stored offsite during construction efforts to combine the GBL with the former Mather's Museum of World Cultures, now managed under a single entity; IUMAA. Ceramic sherds analyzed for this thesis were observed to be stored in individual plastic bags according to their catalog numbers. The bagged artifacts were stored in several cardboard boxes that were housed in a facility that meets standards outlined in 36 CFR Part 79.

Conclusion

The excavations and macrobotanical research described in this chapter represent the breadth of knowledge available regarding archaeobotanicals at 12Or0001. This previously collected data was used to inform methodology and guide the analysis of microresidue results.

Chapter 4: Methods and Data Collection

Sample Selection

This thesis examines microscopic residues recovered from eighteen ceramic sherds that were excavated in the spring of 1993 (see Figure 2). Of the 833 ceramic sherds recovered from Trench 1, which bisected the double embankment at the eastern side of the village, eleven sherds were selected from Units D and F (Redmond and McCullough 1993). Unit D was located on the interior, village side of the palisade and Unit F was located at the center of the palisade berm. A total of 698 ceramic sherds were recovered from the 50cmx50xm test unit (N460 E435) located near the center of the village, and seven of these sherds were selected for starch residue analysis. Those features with the highest densities of macrobotanicals seemed to have much fewer ceramic sherds than less floral-rich areas of the site.

The ceramic sherds were chosen from specific excavations units that were placed at various locations within the village. This was done so that data about starch and microresidue preservation could be compared between those sherds recovered from within the village's perimeter and those recovered from outside the palisade walls. This comparison is considered useful because Redmond and McCullogh proposed that materials were intentionally disposed of either within concentrated locations in the central living spaces, at the perimeters of the village, or outside of the palisade (1993: 84). If there is a notable difference in the amount of starch or other diagnostic microresidues observed between these units, it may be useful in designing future microbotanical studies at palisaded Oliver sites.

Additionally, each of these units had been subjected to flotation analysis, had exact numbers of floral remains documented in an excavation report or other publication, and contained ceramic sherds (Redmond and McCullough 1993, Bush 2004). The units excavated in the spring of 1993 contained few identifiable floral remains and were targeted in an attempt to understand if microresidue analysis has the potential to reveal additional data not already represented in the macrobotanical record.

The ceramics selected for residue analysis were curated as one accession—Accn# 8657 (spring 1993 investigation). A second accession—Accn# 8964 (summer 1994) was digitized in part to assess the potential of future microbotanical analysis at the site's dwelling and associated pit features. Neither accessions' catalog cards were available digitally, so they had to be manually typed into an excel spreadsheet over the course of four visits to the IUMAA archaeology lab (See Figure 4). Specific artifacts selected for analysis were chosen from the digitized catalog after consulting excavation data and other relevant literature.

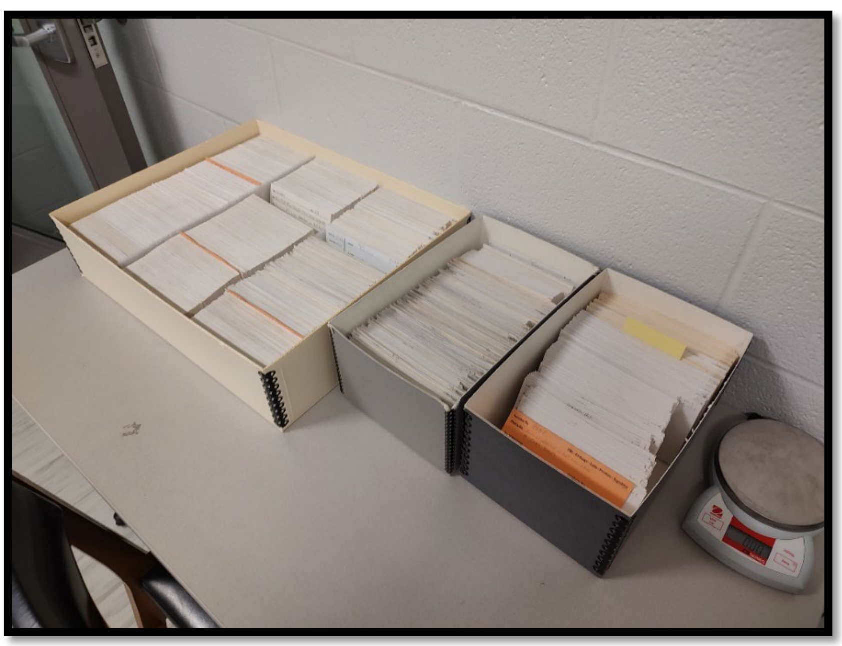


Figure 4. Physical catalog cards consulted for the current investigation. Photo taken by E. Woodruff in 09/2023.

Access to the IUMAA was granted after submitting a research request to the IUMAA Archaeology Collections Manager, Jennifer St. Germain. Residue samples were collected on two separate occasions in July 2023 and August 2023 in the IUMAA's archaeology wet room. All sherds had previously affixed labels and the utmost care was taken to ensure that individual specimens were labeled redundantly in case the sonication procedure damaged the labels. Fortunately, no labels experienced visible degradation which is promising for the viability of future studies (See Figure 5). Given that the sherds tested for this thesis were curated together it is assumed that they received the same treatment post-curation.

Figure 5. Artifact selection and testing process. a) sorting through artifacts to locate ceramics selected for testing, b) 8657/534 after sonication, c) 8657/426 after sonication. Photos taken by E. Woodruff in 09/2023.

Archaeological Starch Extraction Protocol

The archaeological starch extraction protocol designed for this thesis borrows largely from the publications of Henry et al. 2016, Lamb and Loy 2005, Perry 2010, and Pearsall 2015. After the archaeological starch residues were centrifuged at 1000 revolutions per minute (RPM) in an

ONiLAB benchtop centrifuge machine they were stored upright in sealed, labeled centrifuge tubes in a 37-40°F refrigerator. The refrigerator did not contain any food or potential starch contaminants.

Task 1: Sonicate Artifact (See Figures 5 and 6)

1. Prepare a bleach solution that consists of 4 tsp of bleach per quart of room temperature distilled water (CDC 2022). Sterilize all previously cleaned surfaces and tools using bleach solution and a disposable paper towel. When preparing samples in batches it is imperative that all tools and surfaces are sterilized in between samples to prevent contamination. Label both the centrifuge tube body and cap with Sediment 3, the Accession number, and the catalog number of the artifact being tested. Label the top third of the plastic bag with the same information—this will keep the label mostly out of the water and allow a clear view of the artifact during sonication for monitoring purposes.
2. Gently rinse the sherd in distilled water to remove any contaminants. A small metal dish filled with a couple inches of water is a good way to reduce the amount of water required for rinsing—just be sure to keep all samples separate.
3. Put the artifact in a clean bag labeled with Sediment 3, the Accession number, and the catalog number of the artifact. Add enough distilled water to cover the artifact (about 20ml). If processing samples in batches, ensure that the water levels are as similar as possible to one another.
4. Secure the water and artifact filled bag to the suspended clamp. Soak in still water for 5 minutes. While soaking, gently fill the plastic tub with room temperature water and the portable sonicator, taking care to match the water level in the artifact bag to the water level in the tub. There is no need to use distilled water as the tub water never touches the artifact.

5. Sonicate at 50-60Hz for up to 10 minutes with an ultrasonic cleaner. Monitor the artifact and stop sonication if it appears the item is becoming damaged—this is unlikely since very soft or fragile items were removed from consideration for testing. Note how much time the artifact was exposed to sonication. All artifacts for this experiment were exposed to sonification for 10 minutes.
6. Remove the bags from their clips one at a time and sterilize the outside of the bag with the bleach solution. Cut a corner of the bag with sterilized scissors and drain the liquid into a previously labeled 50ml centrifuge tube. If necessary, rinse any remaining material into the tube using distilled water before capping the tube. The artifact may now be removed and set aside to dry.

<u>Task 2: Isolate Starches</u>

7. Let the samples settle undisturbed overnight. Very gently pour or pipet off excess water from the sample until there is only a very small amount of water mixed in with the sample—place this mix into a new tube (Perry 2010).
8. Deflocculation of Sediment 3 samples are not necessary as there is too little soil remaining on washed artifacts for the method to be worthwhile (Perry 2010). However, when extracting starch from sediment samples deflocculation with sodium polymetaphosphate (also called sodium hexametaphosphate or SHMP) is required (Henry et al. 2016, Perry 2010).
9. Arrange the sample centrifuge tubes evenly into the rack, leaving one empty space between samples to prevent accidental splashing (Pearsall 2015: 363). Centrifuge at 1000 RPM for ten minutes (Perry 2010).

a. *If the tube residue is clear, or nearly so, heavy liquid flotation is not necessary. Proceed to **STEP 15**.* All resides recovered were clear or slightly cloudy and did not require heavy liquid flotation.

b. *If sediments are visible, then heavy liquid flotation with Cesium chloride (CsCl) or Lithium Metatungstate (LMT) is recommended (Perry 2010, Pearsall 2015). Proceed to **STEP 10**.* Few sediments were visible in the recovered residues, and it was determined that heavy liquid flotation was not necessary for the samples tested in this experiment.

Task 3: Heavy Liquid Flotation

10. If heavy liquid flotation is required, mix CsCl to a specific gravity of 1.8 g/ml under a fume hood. A ratio of 2.215…(repeating)-parts distilled H_2O to 1-part CsCl will produce this specific gravity, but specific batches should be tested for accuracy. Test the density of the solution by taring a 10ml volumetric flask, adding 10 ml of solution, and weighing it. Make fine adjustments to the solution until the flask weighs 18g. Keep the solution capped until ready to use to prevent changes in density due to evaporation and mix well before use (Pearsall 2015: 364, Perry 2010).
11. Label a new sterilized centrifuge tube with "starch extract" and other tracking information. Keep the tube upright and secure in a rack or other stand.
12. Add 5ml of heavy liquid to the sample with a graduated cylinder, cap, mix gently, and centrifuge for 5 minutes at 2000 RPM. Decant the supernatant from the centrifuged sample into the associated starch extract tube. Repeat this step twice with fresh heavy liquid or until no further starch extract is recovered (Pearsall 2015: 364).

13. Add enough water to each starch extract tube to nearly fill it, cap, mix gently, and centrifuge for 5 minutes at 2000 RPM. Decant the supernatant, leaving ½ cm of nearly clear liquid in the bottom of each tube. Starch granules will be located at the bottom of the tube.
14. Rinse the starch granule extract by adding distilled water, centrifuging for 5 minutes at 2000 RPM, and decanting down to ½ cm of liquid. Repeat this step so that the starch granules are rinsed two times (Pearsall 2015: 364).

Task 4: Prepare Archaeological Starch Slides

15. Cap and store the cloudy starch extract into test tubes if not preparing glass slides immediately.
16. Pipet 1-2 drops of pure glycerol *OR* Congo Red stain onto a dry sanitized slide, add 1-2 pipetted drops of the starch solution, and gently stir with a sanitized metal tool (Pearsall 2015: 369, Lamb and Loy 2005). Starches are easier to differentiate from other residues when Congo Red stain is used, but the dye can obscure diagnostic morphology such as the extinction cross in some cases.
17. Place a cover slip over the prepared sample and seal the edges with clear nail polish (Pearsall 2015: 369). Wait 10 minutes so that the polish can cure and dyes have time to take effect within the sample.

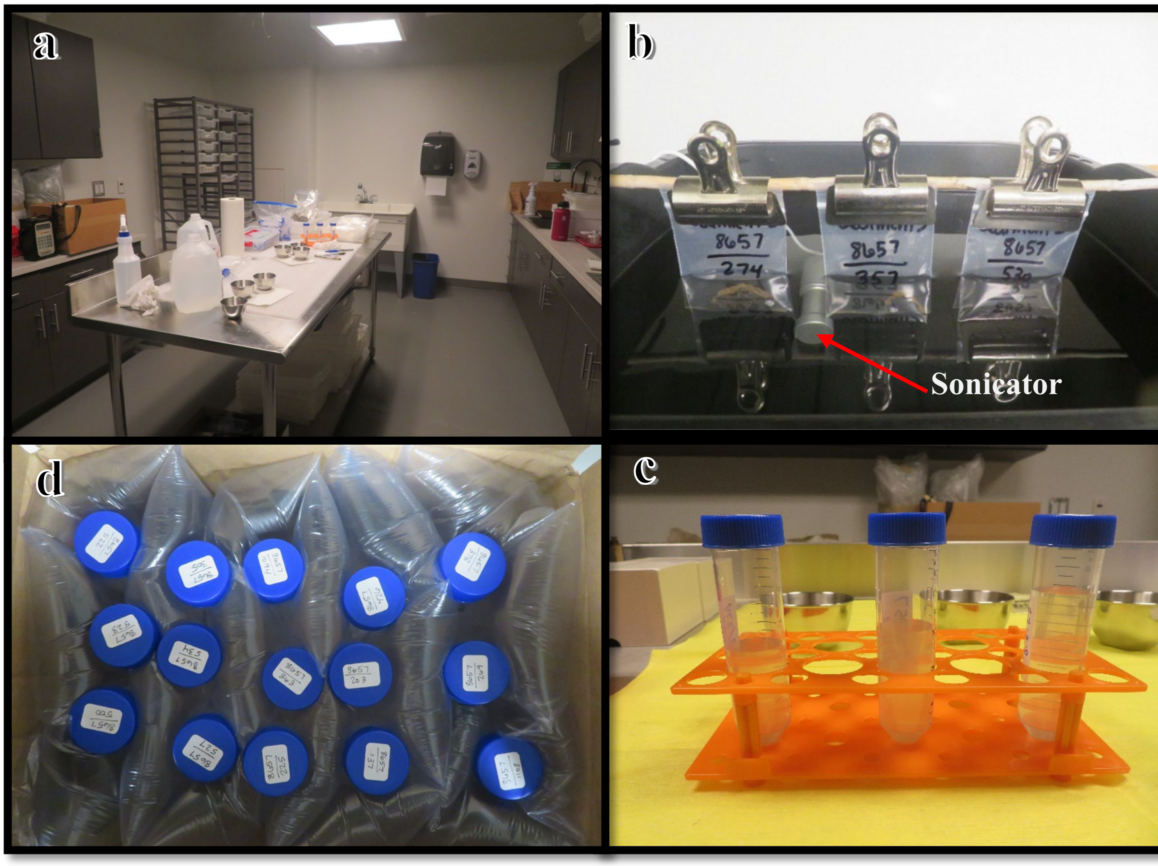


Figure 6. Sonication Methodology. a) The IUMAA archaeology wet lab where archaeological starches were extracted, b) Three artifacts were sonicated at once using a suspension system built out of a plastic tub, bamboo stick, and metal clips, c) After the sonication procedure is complete the residue mixture appears cloudy, d) Residue-filled centrifuge tubes were packaged and transported by the author in an upright position so that potential starches were able to settle towards the bottom of the tube. *Photographs taken by E. Woodruff in July 2023.*

Microscopic Examination

Archaeological sample slides for the 1993 Trench 1 and 50cmx50cm test units were stored for up to six months prior to complete microscopic examination. Each slide was examined using an Amscope Metallurgical Microscope under normal light, polarized light, and cross-polarized light using brightfield (BF), darkfield (DF), and no filters. Slides were examined using 10x eyepieces with 5X, 10X, 20X, and 40X objectives—meaning that materials were magnified 50X, 100X, 200X, and 400X their actual size, respectively.

By examining slides under a variety of lights and filters it was possible to see residues react to each change. Observations were compared to a modern comparative starch slide—Idaho potato (Figure 7)—and published descriptions and photographs of archaeological starches and microresidues. It is important to note that not all starch species look the same, so it was imperative that as many sources were consulted as possible to limit misidentification. Henry's 2020 book, *Handbook for the Analysis of Micro-Particles in Archaeological Samples,* was utilized heavily as it devotes an entire chapter to discussions with figures and photographs of archaeological starches and the residues with which they share morphological similarities. This handbook was also used to determine which other microresidues, if any, could be useful in future microbotanical analysis at the site.

Slides were examined for approximately twenty minutes each in N/S and E/W transect patterns. This thesis experiment examined three slides for each of the ceramic sherds selected which means that a total of fifty-four slides were examined. Any suspected starches or other diagnostic residues were photographed by the author using a 9MP AmScope digital camera that was mounted to the microscope. Residues were also measured in micrometers (μm) by utilizing a calibrated digital measuring tool included in the AmScope camera software. Notes regarding any suspected gelatinized starch , native starch , or damaged starch were documented at the time of examination. Notes were also taken regarding unknown items located during microscopic examination. Every effort was made to photograph microresidues under varying lights and filters and at multiple magnifications for ease of analysis and posterity.

Conclusion

This thesis tests differential preservation of starches and other microresidues based on provenience within an excavated unit/feature and co-occurrence with macrobotanical remains as reported in Redmond and McCullough 1993 and Bush 2004. Sherds of varying design and temper were selected so that a single method of collecting residues could be applied to a variety of clay mixes and vessel types. By applying a single method of residue collection, it was possible to determine if there was an observable difference in an artifact's ability to withstand the residue collection procedure across a variety of clay mixes and vessel types. This information was of secondary importance as it is useful for refining residue collection methodologies, but it is not important to the thesis research question. All ceramic identifications concerning sherd type, decorative features, and temper type were taken directly from the catalog cards and are presumed to have been assigned by Robert McCullough (Redmond 1994: 19).

Chapter 5: Results

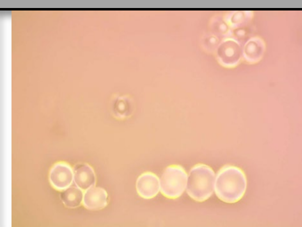
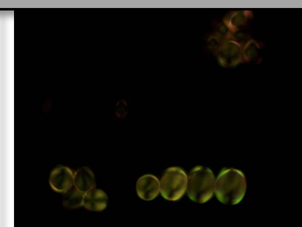
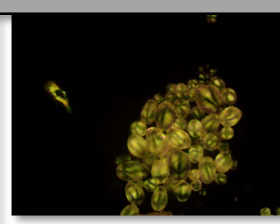
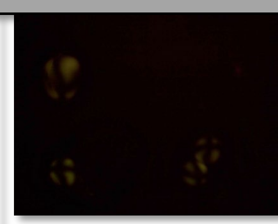
Introduction

Data presented in this chapter includes photographs of microresidues recovered from archaeological ceramic sherds and the measurements of potential starch granules collected by the author (Appendix A-Residue Photographs). Lists of plants native to Indiana were compiled and are shown in Table 2. Data was compiled from published United States Department of Agriculture (USDA; 2023) sources and ethnobotanical information was sourced from David Moerman's Native American Ethnobotany (1998). Plants identified as "culturally significant" by the USDA were noted (2023). The plants listed as culturally significant by the USDA were identified through "interviews with Native Americans, archival research in libraries, cultural museum artifact studies, and field visits to traditional gathering sites" (PLANTS Help n.d., 5). All plant uses were coded by the author using descriptions of ethnobotanical use as identified by David Moerman (1998) and sorted into categories used by the ArchaeoEcology Project (Verhagen et al. 2021) (See Figures 1 and 9).

Microscopic Results

Numerous microresidues were photographed during this experiment, but specific species identification lies outside the scope of this thesis. Out of the eighteen samples examined, only three samples were found to contain residues that possessed morphological similarities to starch (8657/225, 8657/269, and 8657/274) (See Figure 8). Sherd 8657/225 is a punctate rim sherd recovered from Trench 1, Unit D, Level 1. Sherd 8657/269 is a plain rim sherd recovered from

Figure 7. Modern Starch Granules from an Idaho Potato under Normal Light and Bright Field filters (NL/BF). Photographs taken by the author.

Modern Starch Comparative Samples Data Compiled by Emma Woodruff in 2023/2024					
	Species			Photographs by E. Woodruff	
Photo ID#				N/A	N/A
Light Type				NL/BF	XPOL/BF
Total Magnification				400x	400X
Stain				N/A	N/A
Particle diameter range in micrometers (µm)				0.098 to 0.147µm	0.098 to 0.147µm
	Modern Idaho Potato Starch				
Photo ID#				N/A	N/A
Light Type				NL/BF	XPOL/BF
Total Magnification				200x	400X
Stain				N/A	N/A
Particle diameter range in micrometers (µm)				0.028 to 0.111 µm	0.011 to 0.158 µm
	Modern Idaho Potato Starch				

Trench 1, Unit F, Level 3, 30-40cmbs. Sherd 8657/274 is an incised body sherd recovered from a pottery concentration located in Trench 1, Unit F, Level 3, 30-40cmbs. All three sherds with potential starch residues were grit tempered. Potential starch granules measured 0.018 to 0.062 micrometers (µm) in diameter.

Non-starch residues recovered from ceramic sherds at 12Or0001 include possible phytoliths, fungal spores, sponge spicules, and diatoms to name a few. Each of these residues, when identified more narrowly, can provide hints about the environment that Oliver phase peoples experienced in the 1300s C.E.. Potential starches were typically observed as single particles except for one

Figure 8. Potential ancient starches recovered from ceramic sherds at 12Or0001. Photographs taken by the author. Figure continues on the following page.

Microscopic Residues on Ceramic Collections from 12Or0001

Data Compiled by Emma Woodruff in 2023/2024

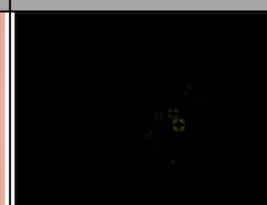
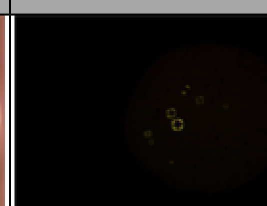
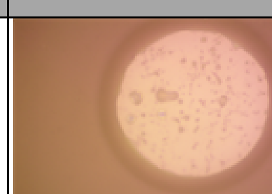
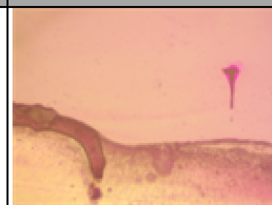
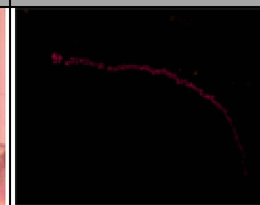
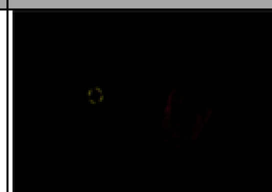
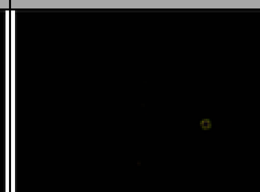
	EMW 2020 Sample #	Accession #	Catalog #	Photographs by E. Woodruff (Photographs are filed as Accn#_Cat#_PhotoID)	
Photo ID#				_0007	_0008
Light Type				NL/BF	XPOL/BF
Total Magnification				200x	400x
Stain				N/A	N/A
Particle diameter range in micrometers (µm)					0.032 to 0.057 µm
	8	8657	225		
Photo ID#				_0009	_0010
Light Type				NL/BF	XPOL/BF
Total Magnification				400x	400x
Stain				N/A	N/A
Particle diameter range in micrometers (µm)					0.018 to 0.055 µm
	8	8657	225		
Photo ID#				_0011	_0012
Light Type				NL/BF	NL/BF
Total Magnification				400x	400x
Stain				N/A	N/A
Particle diameter range in micrometers (µm)					0.037 to 0.062 µm
	8	8657	225		

Photo ID#				_0001	_0005
Light Type				NL/BF	XPOL/BF
Total Magnification				200x	400X
Stain				Congo Red	Congo Red
Particle diameter range in micrometers (µm)					0.012 to 0.050 µm
	15	8657	269		
Photo ID#				_0001	_0002
Light Type				XPOL/BF	XPOL/BF
Total Magnification				400x	400x
Stain				N/A	N/A
Particle diameter range in micrometers (µm)				0.057 µm	0.46 µm
	16	8657	274		

clustered, string-like residue (Photo# 8657_269_0005 see Appendix A). The string-like residue is most likely wood or contamination from a modern paper product (Henry 2020: 121). A possible insect part (Photo# 8657_203_001-002 see Appendix A) was also observed on residue collections from 8657/203 which was most likely introduced to the artifacts at some point in the past three decades after they were curated with the IUMAA.

The sherds that contained the highest diversities of potentially diagnostic archaeological residues were 8567/500 and 8657/426, recovered from first level of N460 E435 and the third level of Trench 1 Unit D, respectively. Residues recovered from 8657/500 include possible spores of plant parasitic fungi, coccoliths, spheroid phytoliths, and charcoal fragments (See Table 1 and Appendix A). Residues recovered from 8657/426 include possible sponge spicules, plant parasitic fungi, cyanobacteria, and phytoliths or pennate diatoms. Select sherds that also exhibited diagnostic residues include 8657/225 (starch, phytoliths), 8657/500 (pollen grains, charcoal, fungal spore), 8657/363 (fungal spore, phytoliths), 8657/1094 (pollen grains, diatoms), 8657/426 (phytoliths, fungal spores, diatoms), and 8657/203 (insect, fungal spore, phytolith). See Table 1 for additional data about individual sherd findings. The potential charcoal residues observed are likely too small to identify down to the level of a specific floral species, and the presence of charcoal residue is somewhat expected since many of the ceramic sherds that underwent testing had visible charring on the interior, exterior, or both sides of the sherd. Though it is possible to collect residues from a single side of an artifact, residues were collected from all sherd surfaces at once, so specific analysis regarding individual vessel function is limited. Studies that are concerned with specific tool functions typically isolate residue studies to a specific part of a tool and combine microresidue and use wear analysis.

Maize , or *Andropogoneae Zea*, was the only macrobotanical species previously identified in the units analyzed for this thesis (Bush 2004). The potential starches recovered during this study appear morphologically similar to published photographs of maize in Corletetti et al. (2015: 53), but definitive starch species identification is beyond the scope of the current study due to the lack of a comprehensive ancient starch comparative collection. The addition of potential future phytolith, diatom, parasitic plant fungi, etc. identification can only add to our understanding of the environmental makeup at 12Or0001. These results and their implications will be discussed further in Chapter 6.

Table 1. Tabularized results of curatorial, macrobotanical, and microbotanical analysis. Catalog numbers highlighted in yellow indicate that potential starch was identified during residue analysis.

Identification Numbers					Provenience			Catalog Card Description (as written)			Co-Occurrence with Macrobotanical Remains: *Redmond and McCullough (1993: 102)*	Co-Occurrence with Macrobotanical Remains: *Redmond and McCullough (1993: Appendix 3)*	Co-Occurrence with Macrobotanical Remains: *Bush (2004: 83-85)*	E. Woodruff Observations (2023)		
EMW 2023 Sample #	**IUMAA Accession #**	**Cat #**	**Spring 1993 FS#**	**N= (only 1 sherd sampled per catalog number)**	**Unit/ Feature**	**Level**	**CM BD**	**Sherd Type**	**Decorative Feature**	**Temper**	**Floral Flotation Samples by Unit?**	**Floral Excavation Artifact Counts by Unit?**	**Floral Flotation Samples by Feature?**	**Sherd and Residue Sample Comments**	**Visual estimate of charring on sherd surface as %**	**Possible Microparticle Identification**
1	8657	500	109	1	N460 E435	level 1	0-18	body	plain	grog	Yes. Abundant charcoal and 2 fragments of maize.	Yes. 1 charcoal fragment.	N/A	visible charcoal on one side of sherd	50%	spores of plant parasitic fungi; chlamydospores specifically (Henry 2020: 82); cocolith (Henry 2020: 137) or spheroid phytolith (Henry 2020: 271), charcoal
2	8657	522	110	1	N460 E435	level 2	18-28	body	plain	limestone and grog	Yes. Abundant charcoal and 2 fragments of maize.	Yes. 1 charcoal fragment.	N/A	small sherd (approximately 1 x 1.5cm)	50%	sponge spicule (Henry 2020: 38)
3	8657	523	110	3	N460 E435	level 2	18-28	body	cordmarked	grog	Yes. Abundant charcoal and 2 fragments of maize.	Yes. 1 charcoal fragment.	N/A	charcoal visible on one side of sherd, but not as pronounced as other sherds	35%	null
4	8657	527	111	4	N460 E435	level 3	28-38	body	fabric marked	grit	Yes. Abundant charcoal and 2 fragments of maize.	Yes. 1 charcoal fragment.	N/A	water after sonication is slightly cloudy	50%	charcoal
5	8657	530	111	2	N460 E435	level 3	28-38	body	incised broadline	grit	Yes. Abundant charcoal and	Yes. 1 charcoal fragment.	N/A	null	50%	null

											2 fragments of maize.					
6	8657	534	111	2	N460 E435	level 3	28-38	body	cordmarked	grog	Yes. Abundant charcoal and 2 fragments of maize.	Yes. 1 charcoal fragment.	N/A	water after sonication is very cloudy and brown	50%	null
7	8657	305	122	1	N460 E435	level 4	38-48	body	plain	grit	Yes. Abundant charcoal and 2 fragments of maize.	Yes. 1 charcoal fragment.	N/A	visible charcoal on one side of sherd; water after sonication is mostly clear	50%	styloids (skinny needle; Henry 2020: 133) or raphides (Henry 2020: 293) or diatom (Henry 2020: 45)
8	8657	225	39	1	trench 1, unit D	level 1	N/A	rim	punctate	grit	Analyzed, but no floral remains reported in 1993.	Yes. 13 charcoal fragments.	N/A	null	0%	potential starch
9	8657	357	74	1	trench 1, unit D	level 2	23-33	body	plain smooth surface	grit	Analyzed, but no floral remains reported in 1993.	Yes. 13 charcoal fragments.	N/A	null	50%	diatom (Henry 2020: 32)
10	8657	363	74	1	trench 1, unit D	level 2	23-33	body	plain smooth surface	grit and limestone	Analyzed, but no floral remains reported in 1993.	Yes. 13 charcoal fragments.	N/A	water after sonication is somewhat cloudy and mostly clear	50%	charcoal, phytolith or styloid (Henry 2020: 133)
11	8657	1094	167	4	trench 1, unit D & E	level 4	45-60	body	cordmarked	grit	Analyzed, but no floral remains reported in 1993.	N/A (Note: 13 charcoal fragments recovered from Unit D and 7 charcoal fragments from Unit E)	N/A	visible charcoal residue on one side of sherd; water after sonication is cloudy and light brown	50%	pollen grains (Henry 2020: 222) or soft wood (Henry 2020: 108)

12	8657	426	95	9	trench 1, unit D	level 3	33-43	body	plain	grit	Analyzed, but no floral remains reported in 1993.	Yes. 13 charcoal fragments.	N/A	visible charcoal residue on one side of sherd; water after sonication is somewhat cloudy	50%	sponge spicule (Henry 2020: 38); spores of plant parasitic fungi; chlamydospores specifically (Henry 2020: 82); cyanobacteria (Henry 2020: 74); phytoliths (Henry 2020: 266) or pennate diatom (Henry 2020: 45)
13	8657	137	19	1	trench 1, unit F	level 1	N/A	rim	cord-wrapped dowel impressed	grit	Analyzed, but no floral remains reported in 1993.	Yes. 9 charcoal fragments.	N/A	visible charcoal residue on one side of sherd; water after sonication is somewhat cloudy	50%	diatom (Henry 2020: 32)/neviculoid diatom (Henry 2020: 48)
14	8657	203	34	6	trench 1, unit F	level 2	20-30	body	cordmarked	grit	Analyzed, but no floral remains reported in 1993.	Yes. 9 charcoal fragments.	N/A	visible charcoal residue on one side of sherd; water after sonication is cloudy and light brown	50%	phytolith, dung spherulite, insect or feather?
15	8657	269	53	1	Trench 1, Unit F	level 3	30-40	rim	plain	grit	Analyzed, but no floral remains reported in 1993.	Yes. 9 charcoal fragments.	N/A	visible charcoal residue on both sides of sherd; water after sonication is somewhat cloudy	75%	potential starch; modern paper product or wood (Henry 2020: 107)

16	8657	274	57	3	trench 1, unit F, pottery concentration #3	level 3	30-40	body	cordmarked	grit	Analyzed, but no floral remains reported in 1993.	Yes. 9 charcoal fragments.	N/A	null	50%	potential starch
17	8657	378	76	12	trench 1, unit F	level 4	40-50	body	cordmarked	grit	Analyzed, but no floral remains reported in 1993.	Yes. 9 charcoal fragments.	N/A	water after sonication is very cloudy and brown	25%	phytolith or styloid (Henry 2020: 133)
18	8657	1108	170	4	trench 1, unit F	level 5	50-64	body	plain	grit	Analyzed, but no floral remains reported in 1993.	Yes. 9 charcoal fragments.	N/A	visible charcoal residue on both sides of sherd; water after sonication is somewhat cloudy	50%	phytolith or styloid (Henry 2020: 133)

Ethnobotanical Results

The ethnobotanical categories described in Table 2 were found in David Moerman's 1998 Native American Ethnobotany and were assigned based on definitions used in the ArchaeoEcology Project (Verhagen et al. 2021). The Medicine category pertains to plants that are "ingested or applied for health reasons" (Verhagen et al. 2021: 5). The Food category pertains to plants "ingested for nutrition including spices" (Verhagen et al. 2021: 5). The Fuel category applies to plants used for "heating, cooking, [or] illumination" (Verhagen et al. 2021: 5). The Artifact category is applied to plants "used to make portable artifacts such as tools, bowls, or utensils" (Verhagen et al. 2021: 5). The Artifact category was interpreted by the author as most appropriate for utilitarian items. The use of artifact in the context of Table 2 is not equivalent to the term as it is commonly used in archaeology. Examples in the Artifact category include plants that are used to create an item such as a basket or pipe. The Ornamental category is applied to plants used for "aesthetic reasons" (Verhagen et al. 2021: 5). Plants used for dyes or non-utilitarian woodcarving would be considered ornamental. This is not to say that items such as baskets or pipes don't have ornamental value. One inherent problem with the ArchaeoEcology Project's use of an Ornamental category is that it assigns aesthetic values where it may be misunderstood or misplaced by archaeologists. The Ornamental category was only used for plants that did not contribute to an identified function, but rather was perceived as decorative. The Housing category is applied to plants "used for timber, thatch, mats, posts, etc." (Verhagen et al. 2021: 5). The Transportation category is applied to plants used to aid movement across land or water. Examples of plants in this category include those used to make canoes or snowshoes. The Trade category is assigned when a plant is used for the purpose of exchanging goods. The Ritual category is applied to plants identified as being used in ceremonial practices. The Other category is applied to plants used for smoking, game pieces, musical instruments, fragrances, and more. The Other category was not included in Verhagen et al. 2021, but it was deemed appropriate for the current analysis as many plants had uses that did not fit neatly into any other category.

Each macrobotanical observed at 12Or0001 (Bush 2004) has several identified ethnobotanical uses. It is important to note that the list of culturally utilized plants in the study area may not be complete, and their ethnobotanical uses may not be complete either. A total of 79 starch bearing plants were identified as having ranges crossing the present-day boundaries of Indiana. Of the 79 starch-bearing species, 20 have been identified as federally recognized "culturally significant plants" important to Indigenous persons in the United States (USDA 2023). Eight "culturally significant plants" were identified in the author's review of Bush's macrobotanical analysis at 12Or0001 (see Table 2). A total of 14% of the forty-two starch-bearing species found at 12Or0001 have been identified by the USDA as "culturally significant plants" (USDA 2023).

Plants cited as culturally significant by the USDA were chosen because those plants represent the knowledge easily accessible on federal government websites—which indicates those plants are more visible on a land management scale and may influence decisions about cultural relevance and significance for federal undertakings. Specific agencies and partner organizations should have additional protected data on culturally significant plants—likely considered Controlled Unclassified Information (CUI) by the United States government—that should be considered during federal undertakings. However, this CUI would only be accessible to those with proper permissions granted by the knowledge holder. This knowledge holder could be an American Indian Tribe, federal agency, or other entity. In the example of CUI held by American Indian Tribes, the privileged knowledge is typically called Traditional Ecological Knowledge (TEK) by archaeologists (Kimmerer 2000 Colwell-Chanthaphonh et al. 2010). However, TEK is more akin to intellectual property (IP) and while like CUI in that the information is protected, TEK and CUI should not be confused with one another. The data made publicly available by the USDA was chosen for this study to demonstrate the limitations that those not “in-the-know” may encounter when researching culturally significant plants. Both the public data included in this study and CUI held by federal agencies are used to evaluate significance and guide implementation strategies in federal undertakings.

Table 2. Ethnobotanical information compiled by the author from USDA 2023 and Moerman 1998. Ethnobotanical data was limited in scope to include only starch bearing plants that may have been located within the study area. Culturally Significant Plants, as identified by the USDA, are highlighted in green.

Starch Bearing Plants in the Study Area

Taxonomic Name	Common Name	Macrobotanicals found at 12Or0001	Ethnobotanical Use
Amphicarpaea bracteata (L.) Fernald	American hogpeanut		Medicine, Food
Andropogoneae Zea	maize	yes	Food, Ritual
Apios americana Medik.	groundnut		Food
Arisaema triphyllum	jack-in-the-pulpit		Medicine
Asimina triloba (L.) Dunal	pawpaw		Food, Artifact
Betula alleghaniensis Britton	yellow birch		Medicine, Food, Artifact, Housing, Transportation, Ritual
Betula nigra L.	river birch		Medicine
Betula papyrifera Marshall	paper birch		Medicine, Food, Fuel, Artifact, Ornamental, Housing, Transportation, Ritual, Other
Betula populifolia Marshall	gray birch		Medicine
Carya illinoinensis (Wangenh.) K. Koch	pecan		Medicine, Food
Carya laciniosa (Michx. f.) G. Don	shellbark hickory	yes	Medicine, Food, Fuel, Artifact, Transportation
Castanea pumila (L.) Mill.	chinquapin		Medicine
Chenopodium berlandieri	chenopod	yes	null
Claytonia virginica	spring beauty		Medicine, Food
Corylus americana Walter	American hazelnut	yes	Medicine, Food, Artifact, Ornamental, Other
Cyperus esculentus	yellow nutsedge		Medicine, Food

Dichanthelium scoparium (Lam.) Gould	velvet panicum	yes	null
Diospyros virginiana L.	common persimmon	yes	Medicine, Food
Fagus grandifolia	beechnut	yes	Medicine, Food, Artifact, Housing, Transportation, Other
Fragaria vesca L.	woodland strawberry		Medicine, Food, Ritual, Other
Fragaria virginiana Duchesne	Virginia strawberry		Medicine, Food, Ritual
Goodyera pubescens (Willd.) R. Br.	downy rattlesnake plantain		Medicine
Helianthus angustifolius L.	swamp sunflower	yes	null
Helianthus annuus L.	common sunflower	yes	Medicine, Food, Housing, Ornamental, Ritual
Helianthus maximiliani Schrad.	Maximilian sunflower	yes	Food
Helianthus mollis Lam.	ashy sunflower	yes	null
Helianthus pauciflorus Nutt.	stiff sunflower	yes	null
Hierochloe hirta (Schrank) Borbás ssp. arctica (J. Presl) G. Weim.	northern sweetgrass		Artifact
Hordeum brachyantherum Nevski	meadow barley	yes	null
Hordeum L.	barley	yes	Medicine, Food, Artifact, Other
Hordeum pusillum Nutt.	little barley	yes	null
Hordeum vulgare L.	common barley	yes	null
Ipomoea pandurata	wild potato		Medicine, Food, Other
Juglans cinerea	Butternut	yes	Medicine, Food, Housing, Ornamental, Other
Juglans nigra L.	black walnut		Medicine, Food, Ornamental
Lilium canadense	Canada Lily		Medicine, Food (starvation)
Malus Mill.	apple		Medicine, Food, Artifact
Medeola virginiana	Indian cucumber		Medicine
Morus alba L.	white mulberry		Medicine, Food
Morus rubra L.	red mulberry		Medicine, Food, Artifact
Nelumbo lutea	water chinquepin		Medicine, Ritual
Nuphar lutea (L.) Sm.	yellow pond-lily		Medicine

Panicum sp.	panicgrass	yes	Medicine, Artifact
Peltandra virginica (L.) Schott	green arrow arum		Medicine, Food
Phalaris arundinacea L.	reed canarygrass		Artifact, Ritual
Phalaris caroliniana	maygrass	yes	null
Polygonatum biflorum	solomon's seal (starch in fall)		Medicine, Food, Other
Polygonum erectum	erect knotweed		Food
Prunus americana Marshall	American plum	yes	Medicine, Food, Artifact, Ornamental, Ritual
Prunus angustifolia Marshall	Chickasaw plum	yes	Food
Prunus serotina Ehrh.	black cherry	yes	Medicine, Food, Artifact, Ornamental
Prunus sp.	wild plums	yes	Medicine, Food, Artifact, Ritual
Prunus virginiana L.	chokecherry	yes	Medicine, Food, Artifact, Ornamental, Housing, Ritual
Quercus bicolor Willd.	swamp white oak	yes	Medicine, Food, Other
Quercus ellipsoidalis E.J. Hill	northern pin oak	yes	Medicine, Food
Quercus lyrata Walter	overcup oak	yes	null
Quercus macrocarpa Michx.	bur oak	yes	Medicine, Food, Ornamental, Other
Quercus michauxii Nutt.	swamp chestnut oak	yes	null
Quercus pagoda Raf.	cherrybark oak	yes	Medicine
Quercus palustris Münchh.	pin oak	yes	Medicine, Artifact
Quercus rubra L.	northern red oak	yes	Medicine, Fuel, Ritual
Quercus shumardii Buckley	Shumard's oak	yes	null
Rhus aromatica Aiton var. aromatica	fragrant sumac	yes	Medicine, Food, Other
Rhus copallinum L.	winged sumac	yes	Medicine, Food, Ornamental, Ritual
Rhus glabra L.	smooth sumac	yes	Medicine, Food, Artifact, Ornamental, Smoke Plant
Rhus typhina L.	staghorn sumac	yes	Medicine, Food, Ornamental
Rubus idaeus L.	American red raspberry		Medicine, Food, Other
Sagittaria cuneata Sheldon	arumleaf arrowhead		Medicine, Food

Sagittaria latifolia Willd.	broadleaf arrowhead		Medicine, Food, Other
Smilax sp.	greenbrier		Medicine
Symplocarpus foetidus	skunk cabbage		Medicine, Food, Other
Trillium sp.	trillium		Medicine
Vaccinium corymbosum L.	highbush blueberry	yes	Food, Trade
Vaccinium oxycoccos L.	small cranberry		Medicine, Food, Trade
Viburnum acerifolium L.	mapleleaf viburnum		Medicine
Viburnum dentatum L.	southern arrowwood		Other
Viburnum opulus L. var. americanum Aiton	American cranberrybush		Medicine, Food, Other
Vitis sp.	grapes	yes	Medicine, Food
Waldsteinia fragarioides	Barren Strawberry		Medicine

Chapter 6: Analysis

Introduction

Analysis of these results will discuss the viability of future microbotanical studies using curated materials from 12Or0001. The experiment described in this thesis was successful in recovering residues from ceramic artifacts that have been in curation for three decades. Close inspection of the residues revealed that diagnostic archaeological residues were recovered in addition to probable modern contaminants. The presence of modern contaminants within residue samples is problematic but does not mean that long-curated artifacts cannot be used in residue studies.

Interpreting Morphological Variation in Archaeological Starches

Once archaeological starch granules are exposed during excavation there is the potential for archaeologists to contaminate the samples. Ideally starch granule analysis has been anticipated during the planning stage of the excavation and common contaminates such as powdered gloves have been avoided. Food residue left on unwashed hands or inconsistent and improper storage methods can introduce foreign starch to an archaeological sample. The risk for foreign starch to be introduced to an archaeological sample continues in perpetuity and care must be taken to minimize contamination. The risk of contamination is greatly reduced after it has been sealed between a slide and cover slide, but slides should be kept clean so the presence of foreign matter to the outside of the slide is limited.

Standard methodologies for analyzing archaeological starches require a microscope with up to 400x magnification, a cross polarizing light filter, and preferably both brightfield (BF) and darkfield (DF) filters (Pearsall 2015). Microscopes that lack any one of these features will not be able to fully showcase starch morphologies and may pose problems in identifying species or taphonomic processes. Additional materials such as a centrifuge, sonicator, and a sterile lab environment are also vital for the extraction of archaeological starches from artifact surfaces (Pearsall 2015).

Stains are particularly useful when identifying native and damaged starch (Barton 2007, Lamb and Loy 2005, Pearsall 2015). Trypan blue, Congo Red, and Lugol's iodine solution are commonly used to enhance the contrast of a residue sample and affects native starch and damaged starches differently based on the specific taphonomic history of that starch (Barton 2007, Lamb and Loy 2005, Pearsall 2015, Henry 2016, Henry 2020). Both native unmodified starch and starches altered by enzymatic decay, gelatinization, and grinding were observed on artifacts that had been collected fifty years prior to undergoing residue analysis (Barton 2007: 1760). The processes by which a starch is altered can be identified by assessing physical characteristics such as granule shape, presence or absence of an extinction cross, and reaction to stains (Barton 2007).

Water, heat, and enzymes are the three main processes by which starches are commonly modified (Martson 2014: 41). These processes occur as the result of both natural processes and human interventions. Pores, vacuoles, and cracks can be indicative of species or taphonomic processes and are visible with the aid of light microscopy and (Martson 2014: 40). Identifying starches down to the genus or species level can be extremely difficult and is best done by a paleobotanist with access to an environmentally relevant comparative collection. Plant starch can vary in size and shape within and between a single plant, the different organs of a single plant, or even the time of year the plant produced the starch (Messner 2011).

Higher water content correlates to discernable characteristics that can be diagnostic of that starch's exposure to heat, and the processes by which a starch was archaeologically modified may be inferred (Barton and Torrence 2015). Time, temperature reached, and starch granule size are all variables affecting the degree to which starches gelatinize (Barton and Torrence 2015, Martson 2014). Especially susceptible to Congo Red stain, gelatinized starch granules have been known to retain diagnostic morphological features that are visible through light microscopy. Boiling requires a high water to starch ratio and is particularly prone to cause starch granules to swell or gelatinize. Water content varies widely in baked and roasted starches, and the morphological variabilities of starches varies accordingly. Waterless forms of cooking such as popping and parching do not usually result in swollen starch granules, but physical evidence of melting after exposure to high temperatures can be observed (Martson 2014: 45). Starch granules that have frozen may burst or show signs of cracking, likely varying based upon the granule's water content at the time of freezing. Birefringence may also be lost after exposure to prolonged frozen temperatures. Starch granules that have experienced exposure to lye or alkali solutions typically gelatinize at lower temperatures than an unaltered granule. Lye and alkaline processing methods, like those used in the preparation of ballpark-style pretzels or ramen noodles, may result in distinctive damage to starch granules (Johnson and Martson 2020). Evidence of enzymatic action on archaeological starch has been hypothesized to indicate fermentation or the use of sprouted grains (Martson 2014: 42).

Enzymes, specifically amylases, alter a starch's appearance by either eroding the granules surface and exhibiting irregular, rough surfaces, or by penetrating the granule and leaving characteristic pits on the granule's surface (Martson 2014: 41). Water can cause a starch granule to swell, increasing the appearance of lamellae, called growth rings in food science, and the overall size of the granule until it has dried (Martson 2014: 41). A starch granule's water content at time of heating and the temperature to which it is heated affects the process of gelatinization. Martson's observations of controlled starch gelatinization can serve as a baseline for investigations targeting the presence of archaeological gelatinization. In starches that have a moderate to high water content at time of heating, the "amorphous regions of the granule swell first and then the crystalline regions melt as the temperature rises" (Martson 2014: 41). Starches with low water content exhibit minimal swelling, with few discernable changes occurring "until the temperature reaches the melting point of the crystalline regions (Martson 2014: 41)." High water content often results in "swelling of the amorphous regions overcomes the structural integrity of the crystalline regions at lower temperatures, before melting can occur, and the starch appears to have burst" (Martson 2014: 41).

All the objects identified as potential starches included a partial extinction cross under cross polarized bright field filters (XPOL/BF) which indicates they are native, or undamaged starches. This means that those specific starches have less interpretable morphology when compared to starch granules that have evidence of gelatinization or surface pitting. Even when heavily processed with traditional methods, native starches remain in modern samples prepared by experimental archaeologists (Raviele 2011).

Post-Curation Contamination

Contamination in the context of this thesis refers specifically to the processes by which modern or non-archaeological residues came into contact with collections from 12Or0001 that are curated at the IUMAA. Artifacts curated at the IUMAA are stored in archival plastic bags. The bagged artifacts are held in cardboard boxes for ease of storage, transportation, and handling. Food and beverages are not permitted within the IUMAA archaeology lab, so it is unlikely that modern starches from food came into direct physical contact with the curated objects. However, modern products such as powdered gloves and paper towels can contain modern starches that may be transferred to artifacts if residue contamination is not considered during handling. Protocols at the IUMAA did not require special handling instructions for artifacts inspected during this thesis. Paper towels were present in the room while residues were being collected but did not come into direct contact with residues. However, paper towels were used to line drying racks that ceramic sherds were placed on after residues were collected. The presence of paper towels at the archaeology lab presents the likelihood that artifacts were exposed to modern starches. Prior to mounting residues, glass microscope slides and cover slips were cleaned thoroughly. Residues from samples 1, 9, 15, and 16 were mounted on slides that had been cleaned with mass-marketed paper towels. After the potential for modern starch contamination was identified the samples preparation methods were changed and synthetic blue fabric was used to clean slides. Fibers from the cloth were observed during microscopic analysis, but retained their bright color and were easily identifiable as modern contaminants.

Two (Samples 15 and 16) of the three residue samples that contained potential starches had been observed within samples that had been prepared with paper towels. Residues from Sample 8 were prepared with synthetic blue cloth. Potential starches observed in Samples 8 and 16 are morphologically identical and it seems likely that the residues recovered from those samples are not from paper towels since they were also found within samples that had not been exposed to paper towels. The potential starches from Samples 8 and 16 did not take up stain and lacked complete extinction crosses. The residues are also much smaller than the modern starches used for comparative analysis. However, discrepancies in size between sample residues and modern starches may be due to the broad range of starch granule sizes between species.

The potential starch recovered from Sample 15 differs in both appearance and reaction to staining with Congo Red dye. The potential starches are packed closely together in a line and appear bright pink under both normal and polarized light. When damaged, starch granules absorb stains like Congo Red which aids in identification. Starch granules can be damaged by grinding, gelatinization, extreme temperatures, exposure to enzymes, or industrial processing. It seems most likely that the potential starch recovered from Sample 15 was from a paper towel or other modern product used during data collection. It should be noted that out of all the residues inspected there was only one of these potential paper towel residues observed. Of particular interest is an object observed in residues from Sample 14. The object is long and appears to have three triangular barbs and a forked edge. This object could be a feather fragment, but it seems more likely that it is from an insect. Though curation facilities monitor for pests it is impossible to entirely prevent insects from entering the facility on items such as shoes or packages.

Non-starchy archaeological residues on ceramic sherds at 12Or0001 and their implications

Though this experiment was designed to optimize collection of archaeological starches, other residues were also recovered during research. Microscopic residues, when positively identified, can reveal information about the natural environment. Residues from 12Or0001 were compared to written descriptions and images compiled by Amanda Henry (2020). Tentative identifications of non-starchy residues include phytoliths, spores from parasitic plant fungi, coccoliths, charcoal, diatoms, cyanobacteria, pollen grains, dung spherulites, styloids, raphids, or spicules (Henry 2020).

Phytoliths, pollen grains, and diatoms are excellent indicators of residues that can be used to understand environmental conditions of the White River Valley during the Late Woodland period. Confident identifications for non-starchy residues are outside the scope of this thesis, but the recovery of what appears to be diagnostic residues are notable for their implications about the viability of future microresidue analysis. These residues, when identified by experts, can inform researchers about specific environmental conditions that may have been experienced by people living at 12Or0001 in the 1300s C.E..

Future Residue Research at 12Or0001

The methods used for this thesis were appropriate for collecting residue samples from cleaned ceramic artifacts but would also be suitable for other material types with some modifications. Several flaked stone tools were observed in the collections from 12Or0001 but were not selected for analysis to preserve potential data. Ceramic sherds recovered from 12Or0001 number in the tens of thousands, whereas identified, formal flaked stone tools number in the dozens. In addition to the abundance of material culture recovered from 12Or0001 there is an unassessed bulk matrix sample that has been retained by IUMAA. Analysis of residues present within the soil sample are expected to be much better preserved than those residues recovered from the artifacts analyzed in this experiment. The soil sample has been minimally handled and has not been exposed to the same contaminants that impacted the reliability of artifact residues examined in this thesis. Recovery of starches from soils is possible, but additional steps are required to adequately separate the starches from sediments (Pearsall 2015). If soil analysis is performed, the recovery of non-starchy residues should also be considered. Fortunately, the additional steps required to process soil samples for starches are also well suited to the recovery of phytoliths (Pearsall 2015).

Collaboration in Palaeobotanical Studies

Palaeobotanical research benefits from historic research in addition to scientific observations and community engagement. However, it is imperative to understand that many written sources regarding pre-contact lifeways are based upon the false assumption that Indigenous peoples had no impact on their surroundings. The so-called wilderness cited by early Europeans was a myth that is perpetuated in historical records written about Indigenous spaces (Deneven 1992, Hayashida 2005). Research aimed at answering questions regarding the role of indigenous peoples in their homelands relies heavily on Euromerican sources like General Land Office (GLO) records and western scientific models of forest successions. These sources are invaluable for answering questions about the ecological past, but they cannot be used in a vacuum.

Evidence from interdisciplinary fields now recognizes that Indigenous peoples throughout the Americas have "…shaped the landscapes they inhabited, a fact often missed by colonial observers who wrote at a time of dramatic population decline and severe social disruption (Hayashida 2005: 45)." It should also be noted that Europeans were foreigners to the spaces they wrote about and had no basis to judge what landscapes were natural or manipulated. Cultural differences also created barriers to complete comprehension of Indigenous practices and motivations. A more objective understanding of past landscapes can be deduced by collaborating with Traditional Ecological Knowledge (TEK) holders and using historical records in conjunction with scientifically collected materials like archaeobotanicals and zooarchaeological specimens. This statement is supported by the large number of plants with ethnobotanical uses that were not found in archaeobotanical studies of 12Or0001 (See Table 2). TEK is broadly defined as the passage of ecological knowledge within a traditional homeland that is facilitated by "folklore and knowledge carriers (Berkes 2000: 1257)." Observed over millennia, indigenous practices have adapted to changing ecosystems. Ongoing research has focused on looking for connections between TEK and western scientific reasoning (Kimmerer 2000, Ford and Martinez 2000). Responsible Indigenous archaeology and TEK studies must recognize that intellectual property and TEK are one and the same (Kottak 1999: 29). Therefore, it is imperative that when approaching Indigenous Nations about archaeological collaborations there is a well-defined outline of what can and cannot be shared, how information is to be used, and how any proposed policy changes are to be credited and compensated.

The research conducted for this thesis was unable to include collaborative approaches, but the gaps in methods produced an understanding of practical applications for a multi-disciplinary approach to archaeology. Future research at 12Or0001 should include those who wish to share ethnobotanical knowledge with researchers. While there is not a definitive descendent tribe who claims ancestry to those who lived at 12Or0001, there are several American Indian Tribes who have traditional homelands in the study area. Given that archaeobotanical studies can only recover a fraction of the materials that would have been utilized by past peoples, it is imperative that Traditional Ecological Knowledge (TEK) be given heavy consideration. Historically, legislation regarding Native Americans has relied heavily on a written record that has been penned by non-Indigenous people. Archaeology and historic records have been given a disproportionate level of authority when compared to TEK. While archaeological investigations and historic records are still required for a well-rounded interpretation of the past, it is only a partial history. Studies regarding items such as starches, pollen, phytoliths, and more cannot be a true reflection of past cultural interactions with the environment without also including ethnobotanical collaboration.

Legislative Applications

Archaeologists are experienced at collaborating with Tribal Historic Preservation Offices (THPOs) on Section 106 compliance projects, but less knowledgeable about including non-archaeologists in cultural research. THPOs are burdened with an overwhelming amount of work and often do not have the infrastructure to facilitate projects that are not tied to a specific regulation. In addition to THPOs, tribes usually have additional government departments that manage natural resources, administrative duties, education, and quality of life. It would be beneficial for future ethnobotanical studies to reach out to Tribal government departments beyond the THPO in what could be considered ethical collaboration, rather than regulatory compliance. However, it should be noted that in the event additional Tribal departments are included in cultural research that a THPO should be consulted prior to initiating contact with those working outside of the THPO.

Current regulations regarding Indigenous culture gives a large amount of authority to written sources which causes an inherent bias in favor of western ideas about cultural affiliation and bounded spaces. The National Historic Preservation Act (NHPA), the Native American Graves Protection and Repatriation Act (NAGPRA), the Archaeological Resources Protection Act (ARPA), and the American Indian Religious Freedom Act (AIRFA) are constrained in scope by the federal system. Fortunately, NAGPRA formally recognizes the needs for oral histories, stories, and tribal knowledge when establishing cultural affiliation. Federal restraints that require boundaries and specific definitions of cultural affiliation are especially notable regarding Traditional Cultural Places (TCP). Bulletin 38 includes guidance specifically on TCPs and is currently being revised. However, no updates are being made on how to identify, document, or evaluate a potential TCP (NPS 2023). A TCP is defined as "a building, structure, object, site, or district that may be listed in (or determined eligible for listing in) the National Register for its significance to a living community because of its association with cultural beliefs, customs, or practices that are rooted in the community's history and that are important in maintaining the community's cultural identity" (NPS 2023; 7). This definition only allows definable, bound spaces to be considered culturally significant under the law.

In her 2004 book, *Boundary Conditions*, Leslie Bush proposed that interactions with botanicals conform just as heavily to cultural traditions as do interactions with human-made artifacts (2004). The connection between a culture and the natural world can be lost in disciplines that rely heavily on specific boundaries and physical evidence, as is the case with archaeology. Much of the physical evidence for past environments and associated cultural behaviors has been lost to time and only survives through knowledge held by communities. Starch granules, phytoliths, and diatoms can most certainly be used to support traditional knowledge, but acceptance of that traditional knowledge is still obstructed by some federal regulations and guidelines.

Recent amendments to federal legislation regarding the Native American Graves Protection and Repatriation Act (NAGPRA) have loosened thresholds for proving cultural affiliation. The Native American Graves Protection and Repatriation Act (NAGPRA) contains both broad and specific information about the identification, management, and repatriation of human remains and associated funerary objects [25 USC § 3001-3013]. Previously, cultural affiliation was largely based on data collected, analyzed, and presented by European American archaeologists preoccupied with material artifacts. Though geographic affiliation could stand in place of cultural affiliation, legal interpretations did not always consider geographic affiliation to be sufficient evidence for repatriation of human remains to a Native American Tribe (Midler 2011). However, this changed when the Culturally Unaffiliated Human Remains (CUHR) section of NAGPRPA was finalized in 2011 (43 CFR § 10.11). Prior to the addition of the CUHR section to NAGPRA in 2011, only federally recognized tribes would have had the legal right to participate in NAGPRA.

Since 2011, non-federally recognized tribes may participate in NAGPRA and request that the control of culturally affiliated human remains be transferred to their control (43 CFR § 10.11). This is a similar process to repatriation under NAGPRA but is described in different terms (repatriation vs. transfer of control) to identify the differences in legal status between federally and non-federally recognized Native American tribes.

Archaeologists are given a large amount of authority in determining cultural significance—a significance that is heavily reliant on interpreting physical evidence and the written word. Altenburg writes that "if significance is relative, non-archaeologists may value places in different ways (2001: 108)." This difference of values is a recurring contributor to misunderstanding TEK applications in non-cultural contexts (Colwell-Chanthaphonh et al. 2010, Drew and Hene 2006). One such example of contradictory values is expressed in the cultural burning practices of the federally unrecognized North Fork Mono Tribe in California. Ron Goode, the Tribal Chairman, is quick to point out that "we [Indigenous Peoples] all do things [cultural burning] a little bit different (Goode 2023, personal communication)". For the North Fork Mono Tribe, cultural burning and prescribed burning are not the same thing because the goal is different. Cultural burning has goals such as clearing trails for humans and animals to escape wildfires or increasing plant production of foodstuffs such as acorns to encourage well-fed species at every trophic level.

TCPs provide the ability for places to be recognized and protected without physical evidence of human activity. There is still a heavy burden of proof required to establish a TCP that typically falls solely on evidence that can be verified by archaeology or documented cultural traditions. In order for a TCP to be considered eligible for listing to the National Register physical boundaries must be defined and supported with evidence. This requirement is especially problematic for places of cultural significance that cover large, ambiguous landscapes or are determined by a nongeographically defined boundary. There is also scant opportunity for places such as plant or animal habitat to be considered a TCP, despite certain plants and animals holding great cultural meaning to some.

Combining protections for cultural and natural resources is an acknowledgment of the inherent interconnectedness of cultural practices and the natural environment. The natural environment is responsible for providing physical items used to create material culture, facilitates food production that supports culinary traditions, and supports the health of individual communities. Unfortunately, culturally driven practices are not always sustainable (especially when the goal is solely wealth as in the case of some furbearing animal harvests, commercial mining, etc.) and laws that aim to combine natural and cultural resource protections seek to honor culture and encourage a healthy environment. The National Environmental Policy Act (NEPA) requires that federal undertakings consider potential impacts to both cultural and natural resources. The 1972 UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage also seeks to safeguard cultural and natural resources from exploitative practices. Problems arise when longstanding cultural traditions are not in line with what is viewed by western science as environmentally responsible. It is important to note that western science is very much a response to the exploitative practices of colonial nations and attempts to correct the overuse of past natural landscapes. A good example of this problem can be seen in conflicts that have risen regarding the rights of Indigenous people to harvest culturally significant plants and animals that are protected by natural resource laws. In cases such as these (i.e. certain fishing methods, harvesting of whales, sea otters, ginseng, etc.) it is becoming more common for cultural traditions to be honored, but these exceptions are often not understood by local law enforcement officers and the general public. This can result in

Indigenous people being harassed by non-Native people who do not understand the complex legal framework that governs the intersection of cultural and natural resources.

Conclusion

At the macrobotanical level 12Or0001 can be viewed much as it is described in the Culture and History Chapter. At the microbotanical—and more broadly microresidue level—the environment at 12Or0001 is less clear due to the preliminary nature of the data that was collected. The ethnobotanical analysis of the site is lacking, though several data sources are available with previously collected information. One issue with this previously collected ethnobotanical information is that the exact methods and motivations behind its compilation are unclear. What is clear is that the ethnobotanical record contains information that is impossible to identify solely through archaeological means. It is therefore of paramount importance that archaeologists work with traditional knowledge holders to bolster claims of cultural significance.

Chapter 7: Conclusion

Microresidue Implications at 12Or0001

Microresidue investigations at 12Or0001 revealed that artifacts stored in curation facilities retain archaeological diagnostic residues for decades after they are collected during controlled excavations. Potential starches were recovered from the palisade embankment, and collaborative microbotanical investigations at higher probability locations should be studied to further explore botanical use at 12Or0001. Ceramic sherds from the dwelling and associated pit features are expected to retain the most archaeologically valuable residues as they were likely deposited during a single event (as with the pits) or during a single occupation of a dwelling. Feature 34, a pit near the dwelling, would be of particular interest for future residue analysis as several macrobotanicals were identified in Bush's floatation analysis of that feature (2004). Those sherds recovered from the palisade embankments were likely reutilized over an extended period, as hypothesized by Redmond (1994), and residues recovered from them are better suited to answer questions about broad, site-wide patterns. The microanalysis conducted during this study can serve as a baseline for identifying residues at 12Or0001. The potential starches observed in this study all appeared to be largely unaltered, which indicates that only the heartiest of starches survived to the present day. This means it is unlikely that plant processing methods can be observed through starches at 12Or0001, and that future investigations would be better served to focus on plant species identification.

Identification of residues from artifacts selected for this experiment was hindered by the lack of readily available comparative collections. The lack of collaboration with paleobotanists and those with ethnobotanical knowledge did not allow for confident residue identification and greatly

Figure 9. *Junglans cinerea,* Butternut a) tree and b) fallen nuts. Macrobotanical remains of Butternut were recovered from 12Or0001 and have identified ethnobotanical uses in the Medicine, Food, Housing, Ornamental, and Other categories. Photographed by E. Woodruff in August 2023.

reduced the ability of the experiment to be course-corrected by those with experience in residue analysis. Archaeological starches can vary in morphology based on their life history and species which makes reliable identification without comparative collections improbable. Any future efforts to investigate ethnobotanical interactions should include collaboration with botanists, ecologists, and most importantly Indigenous knowledge holders. Without this collaborative approach any analysis is increasingly susceptible to inherent bias and may inadvertently ignore significant variables that could affect the results. Despite the limitations in collaboration with this study, conclusive results were obtained that support unequal archaeobotanical preservation at

12Or0001. This study was also able to determine that microresidue studies on artifacts curated from 12Or0001 contain diagnostic archaeological residues that can further inform archaeologists about precontact plant use in the study area. Future residue studies from artifacts at 12Or0001 may be able to answer questions about precontact ecologies in the White River Valley, but it is imperative for those questions to be formed through collaborative work between Indigenous peoples, archaeologists, and ecological scientists.

Cultural Significance as a Regulatory Factor

Within United States legislation cultural significance is especially important to the identification and successful designation of Traditional Cultural Places (TCPs). While the presence of so-called "culturally significant" plants and animals alone cannot be used to designate a TCP boundary, the presence of those plant and animal species can be used to demonstrate the continued importance of a bounded space to the preservation of extant traditional cultural practices (NPS, 2022). Microresidue research can add support to ethnographic information describing the importance of plant and animal species, which will strengthen significance arguments required for the designation of TCPs in the United States.

Identifying a plant as holding "cultural significance" may also have important implications for the legal protections and potential harvesting of plants utilized in traditional cultural practices. Examples of proven traditional cultural practices having an impact on federal regulations and harvesting methods/permits is more often associated with animals—such as with the harvesting of sea otter, salmon, whales, etc by Indigenous people—where that harvesting is expressly forbidden to non-Indigenous peoples (Pevar 2012). These existing hunting regulations demonstrate the impact that identifying cultural significance can have on the preservation of traditional cultural practices. The protection, propagation, and harvesting of traditional cultural plants is just as much a component of cultural resource management as it is natural resources management.

Conclusion

It appears that there is an untapped wealth of archaeobotanical knowledge in assemblages from 12Or0001, and further investigations should be carried out to determine what botanicals may be underrepresented in the archaeological record. Specifically, potential starches should be identified to the species level if possible and pollen, phytoliths, and diatoms, etc. should be identified and evaluated against previously collected environmental data for the Ohio River Valley Region.

Land management agencies, such as the Forest Service, are working to promote the regeneration of native plant species through vegetation management to "historical conditions" that existed prior to recent histories of "fire suppression, pests, diseases, and non-native invasive plants" (Chaveas 2024). Archaeobotanical research at the Cox's Woods site is particularly useful for an endeavor such as this because the site dates to just before the European contact period (1380 C.E) and has the largest variety of plant species of any known Oliver Phase site (Bush 2004). The breadth of plants utilized by peoples living at 12Or0001 is probably broader than what is indicated by macrobotanical analysis alone. The number of ethnobotanical uses identified for plants not labeled "culturally significant" by the USDA is telling of how archaeobotanical studies are underrepresenting the true scope of precontact Indigenous plant use. The identifications made in this study do not provide specific environmental data, but it does indicate that investigating microresidues on museum artifacts has the potential to increase our understanding of human-environment interactions in the past. These ancient interactions, when combined with TEK, may inform current and future climate change management strategies. Moving forward, archaeobotanical research at 12Or0001 should begin with Indigenous collaboration.

It is probable that poor botanical preservation has shaped the way in which archaeologists view culture as belonging to a human-constructed realm rather than a natural one. This failure by many archaeologists to consider natural resources as cultural resources is a byproduct of the field's fixation with material culture. While material culture has its place in archaeology, it should be considered that material artifacts may not hold as much "cultural significance" as does a nearby patch of carefully tended sweetgrass. Ancestral gathering places should be given increased consideration when archaeologists describe past landscapes. Connecting to one's ancestors and traditional cultural practices is well within the scope and abilities of current United States legislation, but archaeologists need to broaden their understanding of cultural significance in order to successfully frame the natural world as a traditional cultural resource.

Appendices

APPENDIX A: Microscopic Residues on Ceramic Collections from 12Or0001

Data Compiled by Emma Woodruff in 2023/2024

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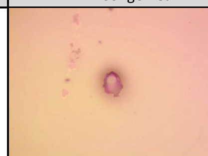
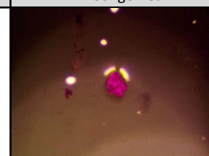
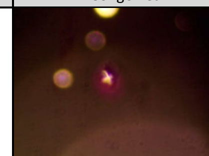
	1	8657	500				
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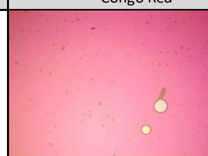
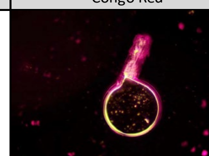
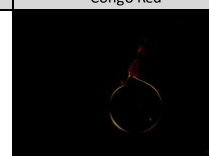
	1	8657	500				
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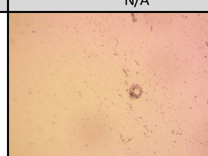
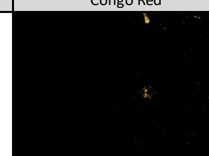
	1	8657	500				
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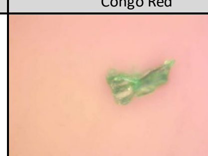
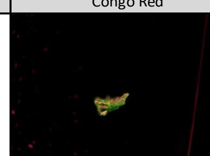
	1	8657	500				
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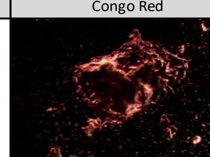
	3	8657	523				

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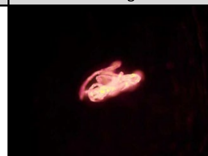
	3	8657	523				
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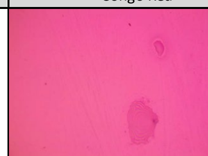
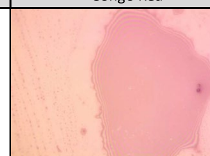
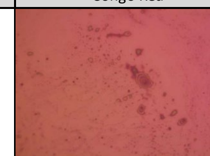
	3	8657	523				
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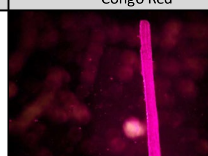
	4	8657	527				
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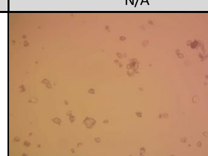
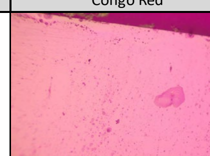
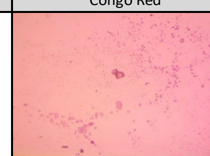
	4	8657	527				
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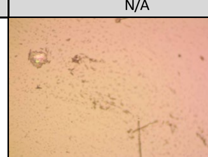
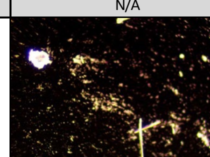
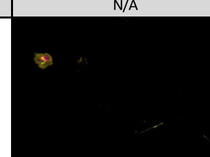
	7	8657	305				

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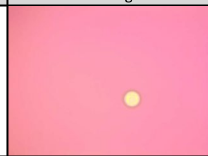
	7	8657	305				
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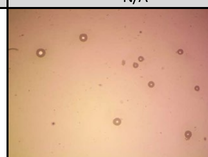
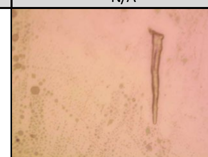
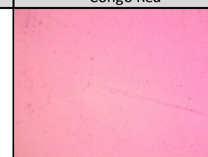
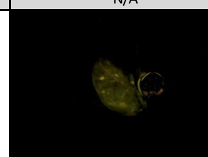
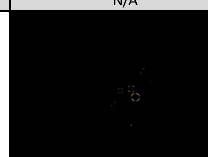
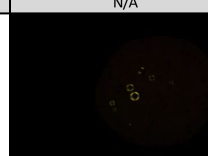
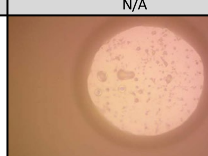
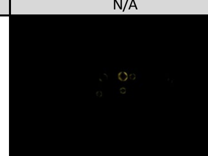
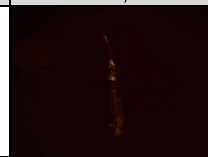
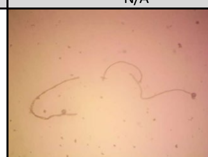
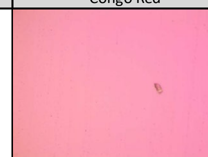
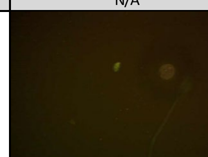
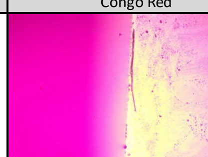
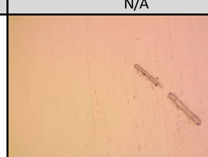
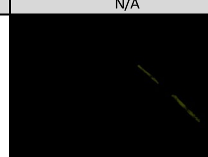
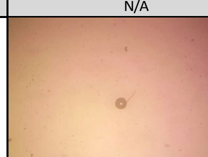
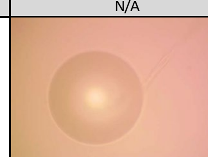
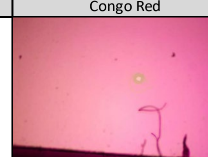
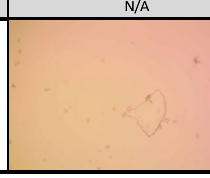
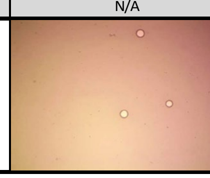
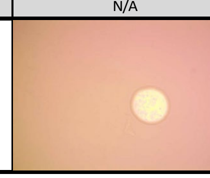
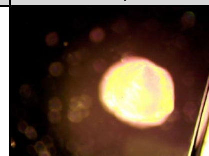
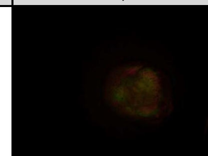
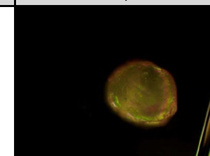
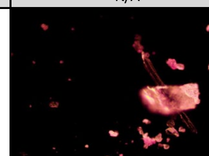
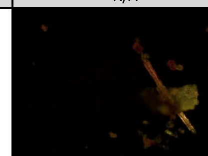
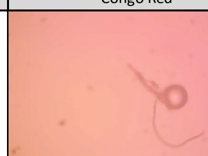
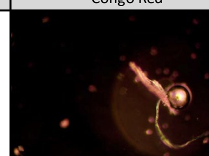
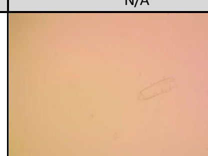
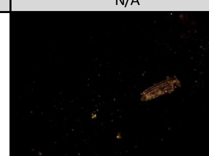
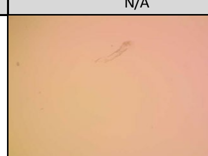
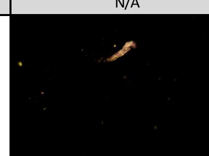
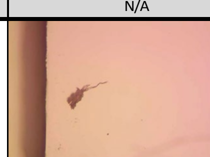
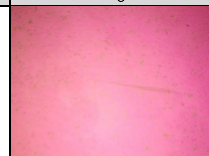
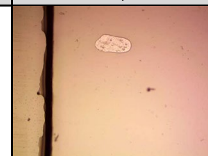
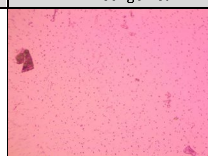
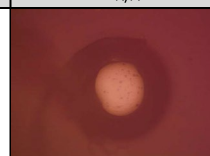
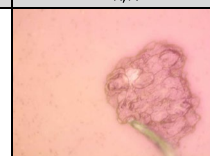
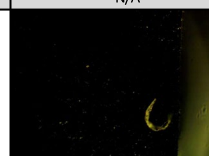
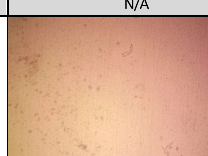
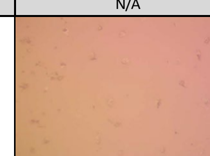
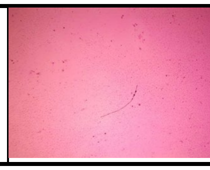
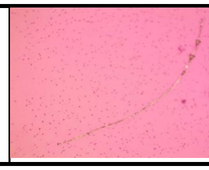
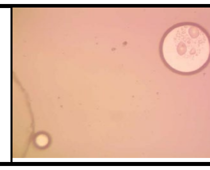
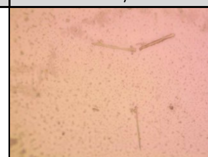
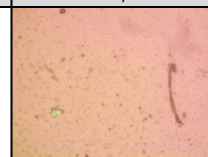
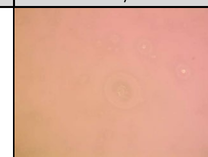
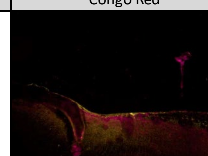
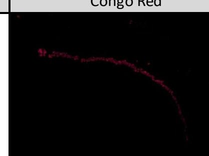
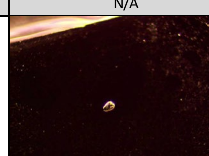
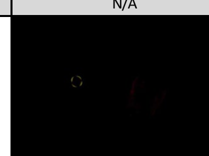
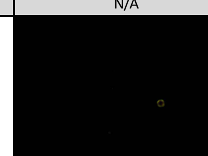
Total Magnification				50x	200x	400x	100x
Stain				N/A	N/A	N/A	Congo Red
	8	8657	225				
Photo ID#				_0005	_0006		
Light Type				NL/BF	XPOL/DF		
Total Magnification				200x	200x		
Stain				N/A	N/A		
	8	8657	225				
Photo ID#				_0007	_0008		
Light Type				NL/BF	XPOL/BF		
Total Magnification				200x	400x		
Stain				N/A	N/A		
	8	8657	225				
Photo ID#				_0009	_0010		
Light Type				NL/BF	XPOL/BF		
Total Magnification				400x	400x		
Stain				N/A	N/A		
	8	8657	225				
Photo ID#				_0011	_0012		
Light Type				NL/BF	NL/BF		
Total Magnification				400x	400x		
Stain				N/A	N/A		
	8	8657	225				
Photo ID#				_0001	_0002	_0003	
Light Type				NL/BF	NL/BF	XPOL/BF	
Total Magnification				400x	400x	400x	
Stain				Congo Red	Congo Red	Congo Red	
	9	8657	357				

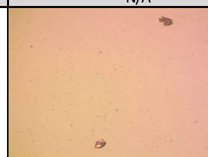
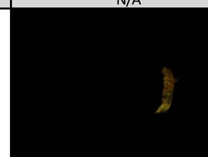
	EMW 2020 Sample #	Accession #	Catalog #	Photographs by E. Woodruff (Photographs are filed as Accn#_Cat#_PhotoID)			
Photo ID#				_0004	_0005	_0006	
Light Type				NL/BF	NL/DF	45POL/BF	
Total Magnification				200x	200x	200x	
Stain				N/A	N/A	Congo Red	
	9	8657	357				
Photo ID#				_0001	_0002	_0003	
Light Type				NL/BF	NL/BF	NL/BF	
Total Magnification				50X	200x	200x	
Stain				N/A	N/A	Congo Red	
	10	8657	363				
Photo ID#				_0004	_0005		
Light Type				NL/BF	XPOL/BF		
Total Magnification				200x	400x		
Stain				N/A	N/A		
	10	8657	363				
Photo ID#				_0006	_0007		
Light Type				NL/BF	NL/BF		
Total Magnification				50x	200x		
Stain				Congo Red	Congo Red		
	10	8657	363				
Photo ID#				_0008	_0009		
Light Type				NL/BF	XPOL/BF		
Total Magnification				200x	200x		
Stain				N/A	N/A		
	10	8657	363				
Photo ID#				_0001	_0002	_0003	
Light Type				NL/BF	NL/BF	NL/BF	
Total Magnification				50x	400x	50x	
Stain				N/A	N/A	Congo Red	
	11	8657	1094				
Photo ID#				_0004	_0005	_0006	
Light Type				NL/BF	NL/BF	NL/BF	
Total Magnification				200x	50x	400x	
Stain				N/A	N/A	N/A	
	11	8657	1094				

	EMW 2020 Sample #	Accession #	Catalog #	Photographs by E. Woodruff (Photographs are filed as Accn#_Cat#_PhotoID)			
Photo ID#				_0001	_0002	_0003	_0004
Light Type				NL/BF	NL/DF	XPOL/BF	XPOL/DF
Total Magnification				100x	100x	100x	100x
Stain				N/A	N/A	N/A	N/A
	12	8657	426				
Photo ID#				_0005	_0006	_0007	
Light Type				NL/BF	NL/DF	XPOL/BF	
Total Magnification				200x	200x	200x	
Stain				N/A	N/A	N/A	
	12	8657	426				
Photo ID#				_0008	_0009		
Light Type				NL/BF	NL/DF		
Total Magnification				100x	100x		
Stain				Congo Red	Congo Red		
	12	8657	426				
Photo ID#				_0010	_0011		
Light Type				NL/BF	NL/DF		
Total Magnification				100x	100x		
Stain				N/A	N/A		
	12	8657	426				
Photo ID#				_0012	_0013		
Light Type				NL/BF	NL/DF		
Total Magnification				100x	100x		
Stain				N/A	N/A		
	12	8657	426				
Photo ID#				_0014	_0015		
Light Type				NL/BF	NL/DF		
Total Magnification				100x	100x		
Stain				N/A	N/A		
	12	8657	426				
Photo ID#				_0016	_0017		
Light Type				NL/BF	NL/DF		
Total Magnification				100x	100x		
Stain				N/A	N/A		
	12	8657	426				

	EMW 2020 Sample #	Accession #	Catalog #	Photographs by E. Woodruff (Photographs are filed as Accn#_Cat#_PhotoID)			
Photo ID				_0018	_0019	_0020	
Light Type				NL/BF	NL/BF	NL/BF	
Total Magnification				50x	50x	50x	
Stain				Congo Red	Congo Red	N/A	
	12	8657	426				
Photo ID#				_0021	_0022	_0023	
Light Type				NL/BF	NL/BF	NL/BF	
Total Magnification				200x	400x	400x	
Stain				Congo Red	N/A	N/A	
	12	8657	426				
Photo ID#				_0001	_0002		
Light Type				NL/BF	XPOL/DF		
Total Magnification				200x	200x		
Stain				N/A	N/A		
	13	8657	137				
Photo ID#				_0003	_0004		
Light Type				NL/BF	NL/DF		
Total Magnification				200x	200x		
Stain				Congo Red	Congo Red		
	13	8657	137				
Photo ID#				_0005			
Light Type				XPOL/BF			
Total Magnification				200x			
Stain				Congo Red			
	13	8657	137				
Photo ID#				_0006	_0007	_0008	_0009
Light Type				NL/BF	NL/BF	NL/BF	NL/BF
Total Magnification				50x	100x	400x	1000x
Stain				N/A	Congo Red	Congo Red	N/A
	13	8657	137				
Photo ID#				_0001	_0002	_0003	_0004
Light Type				NL/BF	NL/BF	NL/BF	XPOL/BF
Total Magnification				50x	200x	100x	1000x
Stain				Congo Red	Congo Red	N/A	N/A

	14	8657	203				

	EMW 2020 Sample #	Accession #	Catalog #	Photographs by E. Woodruff (Photographs are filed as Accn#_Cat#_PhotoID)			
Photo ID#				_0005	_0006	_0007	_0008
Light Type				NL/BF	NL/BF	NL/BF	NL/BF
Total Magnification				50x	400x	400x	1000x
Stain				N/A	N/A	N/A	N/A
	14	8657	203				
Photo ID#				_0009	_0010		
Light Type				NL/BF	NL/BF		
Total Magnification				50x	200x		
Stain				N/A	N/A		
	14	8657	203				
Photo ID#				_0001	_0002	_0003	
Light Type				NL/BF	NL/DF	XPOL/BF	
Total Magnification				200x	200x	200x	
Stain				Congo Red	Congo Red	Congo Red	
	15	8657	269				
Photo ID#				_0004	_0005		
Light Type				XPOL/BF	XPOL/BF		
Total Magnification				400X	400X		
Stain				Congo Red	Congo Red		
	15	8657	269				
Photo ID#				_0003	_0004	_0001	_0002
Light Type				NL/BF	NL/DF	XPOL/BF	XPOL/BF
Total Magnification				400x	100x	400x	400x
Stain				Congo Red	N/A	N/A	N/A
	16	8657	274				
Photo ID#				_0001	_0002	_0003	
Light Type				NL/BF	NL/BF	NL/BF	
Total Magnification				200x	400x	200X	
Stain				Congo Red	N/A	N/A	
	17	8657	378				

	EMW 2020 Sample #	Accession #	Catalog #	Photographs by E. Woodruff (Photographs are filed as Accn#_Cat#_PhotoID)			
Photo ID#				_0004	_0005		
Light Type				NL/BF	XPOL/DF		
Total Magnification				200x	200x		
Stain				N/A	N/A		
	17	8657	378				
Photo ID#				_0006	_0007		
Light Type				NL/BF	XPOL/BF		
Total Magnification				200x	200x		
Stain				N/A	N/A		
	17	8657	378				
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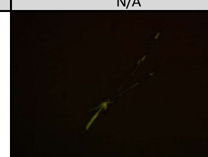
	17	8657	378				
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Stain				Congo Red	Congo Red		
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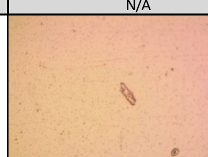
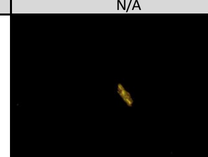
Light Type				NL/BF	XPOL/BF		
Total Magnification				200x	200x		
Stain				N/A	N/A		
	18	8657	1108				
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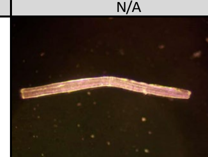
Stain				N/A	N/A	N/A	
	18	8657	1108				
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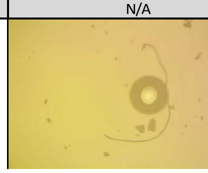
	18	8657	1108				

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