PEAT, HEATH, AND CEREAL: INVESTIGATING CONTRIBUTIONS OF NONHUMAN COMMUNITIES TO THE POIESIS OF PICTLAND THROUGH MICROBOTANICAL AND MICROALGAE RESIDUES

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Chapter 1: Exploring the Poiesis of Pictland (Plants, Algae and People)

How are aspects of human social organization, such as agriculture, settlement patterns, and routes of movement influenced by the non-human communities of northern coastal landscapes? These landscapes are highly dynamic and coastal societies interact with both aquatic and terrestrial ecological zones forming complex patterns of human-environment relationships. The focus of this dissertation is to understand human–environment relationships through the lens of human-plant and human-algae relations in northern coastal environments. Using the Picts as a cultural case study, my research targets durable microscopic residues (e.g., phytoliths and diatom frustules) representing plants and algae from archaeological soils, artifacts, and dental surfaces to trace human-plant and human-algae relationships that territorialized Pictland. To fully investigate the everyday settlement landscapes in coastal environments, I advocate for a relational approach which emphasizes the interconnectedness of terrestrial and aquatic ecological zones through an emphasis on ecological indicator species (e.g., aquatic – algae, terrestrial – asters, wetlands – reeds). By targeting a range of topographic zones (e.g., coastal, lowlands and uplands), I explore the spectrum of human-environment relations across Pictland to examine the active roles of nonhuman communities (e.g., plants) in the poiesis and maintenance of human communities.

Coastal ecological networks are complex, biologically diverse, and dynamic. Furthermore, our understanding of how past human societies operated within these networks is often highly fragmented (e.g., terrestrial/aquatic, nature/culture). Archaeological approaches to coastal landscapes are generally conducted from terrestrial perspectives, and aquatic components are not always incorporated into our understanding of human-environmental relationships (Benjamin et al. 2014). This terrestrial-centric approach is problematic because it fails to sufficiently address how coastal societies interact with land, water, and the realms in-between (e.g., estuaries). Coastal environments are key places for human settlements in the past and present, and understanding human-environment relationships in past coastal settlements is important to frame our contemporary experiences of dwelling within coastal landscapes. Fishing grounds, ports, watercraft landing sites, and coastal dwellings represent key components of human life in coastal environments but are often challenging to identify and interpret from the archaeological record (Benjamin et al. 2014; Crouch 2010; Cummings 2009; Ilves 2009, 2004; King and Robinson 2019).

To examine how past human societies in coastal zones structured and managed their lifeways, I have focused my investigation on the Picts, a group of people who dwelled within the first millennium of what is now Scotland. I aim to examine how nonhuman communities (e.g., plants and algae) contributed to Pictish foodways, social organization, and land use within their coastal landscape. The highly complex and dynamic nature of northern coastal environments presents a variety of pathways, opportunities and tempos of movement and interaction. To tease apart these complex relationships, I trace human-plant and human-algae relations emplaced within Pictish archaeological contexts (e.g., house platforms, enclosure ditch fills, and pot sherds). My research broadly explores how aspects of Pictish social organization (e.g., agricultural practices) influenced by nonhuman communities. To address this question I examine use of space and land use within Pictland using a relations-as-metaphysics approach following Latour (1999), Deleuze (1988, 1990), Deleuze and Guattari (2004), and Harris (2021). I structure my investigations into two themes: use of space and land use.

To address use of space, I explore how coastal people design their architecture relationally with local plant communities available (e.g., heathlands) and tease out how the Picts structured their settlements and established relationships between their settlements (e.g., how did upland settlements interact with nearby lowland settlements?). I also address several related questions. Which plant communities contribute more to human settlement than others? Were specific local plant communities prioritized for resources or were plant communities outside of the immediate local zone sought (e.g., wetland plants)? What might various patterns of local and distant Pictish-plant/algae relationships tell us about how northern coastal peoples engaged with various non-human communities? Overall, placemaking is examined through spatial patterning of soil sample assemblages interpreted as indices of activity areas in Pictish sites and used to identify the prominence of specific ecological indicators (e.g., coastal/wetland versus upland). Soil samples were procured from intact settlement deposits (e.g., floor layers) predominately using a horizontal sampling strategy to examine the use of space at each site. Very little is known about the function of Pictish settlements, particularly regarding daily lifeways (Noble and Evans 2022:52) and this research improves the resolution of Pictish dwelling practices (e.g., architectural traditions). Prior expectations for use of plants in the assemblages, based on contemporary vegetation, included arboreal (e.g., wood), agricultural crops (e.g., cereal inflorescences), heathland plants (e.g., heathers and asters), and wetland plants (e.g., reeds and sedges).

The address land use, I focus on the spatial patterns of Pictish-environment relationships in relation to topography using three zones: coastal (i.e., within the coastal zone, sea level – 350 m), upland (~350 m – 700 m), and lowland (< 350 m) areas. This theme assesses the variability of human-plant/algae relationships represented in the microbotanical and microalgae assemblages of each site and topographic zone to understand human-environment patterns across Pictland. I investigate the degree of human-aquatic interaction through presence/absence and ubiquity of aquatic ecological indicator species (e.g., marine diatoms, wetland reeds) to understand if the Picts living at inland sites (upland and lowland) interacted frequently with aquatic zones (i.e., the seascape – as evidenced by marine diatoms) or, if coastal communities established stronger relationships with aquatic environments (e.g., as evidenced by wetland plant phytoliths).

Overall, I aim to understand how human-environment relationships were consistent or divergent across Pictland. Were the Picts living on the coast more 'coastal' than the Picts living further inland? Or were all Picts connected with aquatic communities (among other ecological communities– e.g., heathlands) to some degree? The ubiquity of specific ecological indicator species (plant and algae) retrieved outside of their expected ecological niche zones will also be examined to assess movement if possible. Soil samples and residues procured from dental and artifact surfaces will be used to assess the contributions of plant and algae communities to foodways across Pictland (e.g., human foodways, domestic animal foodways). Based on the wider literature, it is expected that plant and algae signatures will, for the most part, match their immediate ecological signatures (e.g., coastal plants and algae in coastal sites).

The layout of this dissertation begins with a theoretical grounding in relational archaeological approaches to human-environment investigations (Chapter 2). I discuss conventional approaches to human-environment relationships (e.g., Historical Ecology) and relevant aspects including the nature/culture dualism (among other ontological dualisms) and the tendency toward anthropocentric approaches in environmental archaeology. I present a relational approach (i.e., relations-as-metaphysics) to human-environment relationships in Pictland, emphasizing the contributions of non-human communities (e.g., plants) to the poiesis of Pictland. Poiesis is defined as the creation or genesis of something such as an entity or network of entities that did not previously exist and is constantly in a state of becoming (Pauketat and Alt 2018:75).

Following this theoretical grounding, in Chapter 3 I discuss our current knowledge of the Picts, what we know about their settlements, architectural practices, trade, and material culture through archaeological research programs (e.g., Northern Picts Project). I situate my research on human-environment relationships in Pictland, building upon recent macro- and microbotanical research (e.g., wood charcoal and pollen) that addresses human-environmental relationships. Here, I describe how such studies lay the groundwork for research using phytolith, starch grain, diatom, and chrysophyte residues embedded in Pictish archaeological contexts. I outline how human-plant and human-algae relations can be traced in Pictland, before introducing the methodological approaches I pursued to retrieve microbotanical and microalgae residues.

Chapter 4 describes my methodological approaches, including sampling strategies for soil samples (e.g., floor layers), dental surface residues, artifact residues, and extraction techniques. Laboratory processes for soil samples and secondary analyses are also included in this chapter (and further detailed in **Appendix A**). Overall, the aim of this chapter is to ground the reader in standard paleoethnobotanical research methods to understand the microbotanical and micro-algae residues targeted in this research. I present sampling strategies to retrieve these microresidues; laboratory processes for the extraction, isolation, and identification of microremains; and secondary analyses (such as ubiquity and richness) for tabulating and interpreting identified taxa.

Chapter 5 presents the results of microbotanical and micro-algae analyses and is divided into four major parts: 1) phytoliths, 2) starch grains, 3) micro-algae (diatoms and chrysophytes), and 4) results based on sampling contexts (e.g., soil, artifacts, teeth). In Part 1 I outline the key phytolith morphotypes recovered from Pictish archaeological sites. These siliceous microstructures represent plant materials that decayed *in situ* and are used to address the two themes of my dissertation (i.e., use of space and land use). In Part 2, I discuss the second botanical proxy, starch grains. Procured from artifact and dental surface residues, starch grains are used in this dissertation to examine agriculture, animal feeding regimes, cooking, foraging, and storage. Starch grains uniquely provide evidence of cooking based on the damage patterns of the grains and the residues from this research are assessed to understand Pictish foodways, though not a major theme of this dissertation. In Part 3, microalgae, such as diatom frustules and chrysophycean cysts recovered from soil and residue samples are situated within the broader archaeological and environmental fields of scholarship. These Kingdom Protista proxies are less common than Kingdom Plantae residues in archaeological research. Representing the semi-aquatic and aquatic components of Pictish environmental interactions, micro-algae are used to examine architecture (e.g., turf walls) and degree of aquatic interaction. Finally, Part 4 collates the microbotanical and micro-algae evidence regarding sampling context: soil, artifacts, and teeth (human and animal). The results demonstrate the success of this sampling strategy, which retrieved a high number of microbotanical and micro-algae residues across all contexts and sites studied.

Following the theoretical, methodological, and results chapters of my investigation, I discuss each of the major themes as individual discussion chapters (Chapters 6 & 7). These chapters translate the quantitative results into qualitative understanding of how nonhuman communities contributed to the poiesis of Pictish settlements and rhythms of life in the first millennium. Chapter 6 examines use of space using microresidues to assess activity areas in and around Pictish fortified enclosures (e.g., roundhouse floors, working space areas, and enclosure ditch fills). Pot sherd residues are also examined here to understand plant contributions to Pictish foodways (e.g., cereal communities). Chapter 7 casts a broader geographic net and uses site-level data to trace human-plant and human-algae relationships across three topographic zones (lowland, upland, and coastal). This chapter investigates patterns of human-environment relationships to assess if the Picts had similar or divergent patterns of relationships with nonhumans across Pictland. Microresidues retrieved the teeth of from domestic livestock are used in this section to examine animal feeding traditions across Pictland (e.g., pastoralism practices and transhumance).

I broadly summarize my results in Chapter 8, and compare these findings with nearby regions. Here, I situate the Pictish model of human-environment relationships within broader narratives of human-environment relationships in the early Medieval period, through a comparison of archaeological evidence from Anglo-Saxon England and early Medieval Ireland. This final chapter also outlines suggestions for future research and revisits my theoretical toolkit to discuss the merits and shortcomings of a relations-as-metaphysics approach to evaluate human-environment relationships.

This research contributes to broader studies focused on environmental archaeology and paleoethnobotany in northern Europe. I examine how nonhuman communities were active participants in the poiesis of Pictish settlements in varying topographic contexts and evaluate the patterns of human-plant/algae relationships across Pictland for consistent and divergent practices. Aquatic and semi-aquatic environmental evidence recovered from Pictish sites (e.g., algae, sedges, and reeds) are used in this dissertation as proxies to examine the strength of human interaction and relationships with aquatic environments (e.g., wetlands) following the examples set by several scholars (Bjerck and Zangrando 2016; Grauer 2020; Strang 2010) who emphasize the importance of evaluating both the terrestrial and aquatic elements of past human-environmental relationships in coastal landscapes.

Research on organic materials (i.e., plant remains) in northern coastal environments is often limited due to preservation difficulties, but, microbotanical residues present exciting opportunities to illuminate lifeways in these dynamic environments. Methodologically, paleoethnobotanical research has yet to prioritize assessments of both terrestrial and aquatic environments in tandem; therefore, this dissertation will contribute to establishing a baseline for such studies within Europe. Given the significant ecological diversity and rate of destruction of environmental records due to climate change, in addition to eroding coastlines and sea level rise, coastal research is at a critical point. This study provides a timely contribution to understanding relationships between nonhuman communities and human communities in a dynamic northern coastal setting.

Chapter 2: Understanding Human-Environment Relations

To understand how the Picts established relationships with non-human communities across coastal, lowland, and upland contexts, I ground my theoretical toolkit in relational approaches. Archaeological approaches to human-environment interactions and relationships have emphasized the complex entanglement of humans and our environment to varying degrees, drawing from a spectrum of theoretical models. Human-animal, human-plant, and other human-non-human relations are an essential part of our experiences as humans. Understanding how these relationships were formed, maintained, disrupted, and dissolved in the past is important for contextualizing and orienting our place in nature in the present and in the future (Crellin et al. 2021; Morell-Hart 2020). However, the intricacies of these relationships are often obscured in established environmental anthropological theories that typically focus on large scale (spatial and temporal) human-environment interactions.

Some well-established theoretical approaches that have emerged out of environmental anthropology include cultural ecology, historical ecology, human ecodynamics and systems theory approaches (Carleton and Collard 2020; Contreras 2016; Thompson 2013). These theoretical approaches have improved archaeological interpretation and anthropological understanding of how humans adapt to environmental conditions and form social structures within their environments. However, many of these approaches continue to juxtapose humans and the environment, often treating the environment as the container within which human communities are situated. Some approaches, such as Historical Ecology, Human Ecology, General Systems Theory, and Human Ecodynamics (Fitzhugh et al. 2019:1083), work toward eliminating problematic dualisms (e.g., nature/culture) and highlight the role of humans as active players within the environment (i.e., shaping the environment and adapting to it). But such approaches rarely work toward untangling the complexities of the environments in question, nor do they foreground contributions of non-human communities (e.g., plants)– long-standing issues within the social sciences that need to be amended to expand our investigations of human-environment relationships (Kopnina and Shoreman-Ouimet 2017:5). In prior studies, relational approaches have been used to refocus environmental anthropological and archaeological narratives by removing the nature/culture dualism and elevating non-human entities to a higher plane of consideration (Harris 2013:175; Pauketat and Alt 2018; Watts 2013:13). Such efforts illuminate how non-human entities, such as plants, contribute to and are influenced by human communities.

This chapter is broken down into three parts. In Part 1, I address established theoretical approaches to environmental archaeology and discuss the limitations of relying on these approaches to human-environment interactions. I outline how each of these approaches is operationalized in archaeology and consider how these approaches address the nature/culture dualism. I continue a critique of established theoretical approaches by discussing how large-scale theoretical paradigms can gloss over the intricacies of human-environment relationships; for example, by overlooking the active roles of non-human communities. Understanding that plants, and other non-humans, can play active roles in the formation and maintenance of human communities does not necessarily adhere to environmental determinism, nor does it negate the capacity for human agency (Morell-Hart 2020:149; Williamson 2010); instead, this allows us to acknowledge that humans are one-of-many with agency in their ecological network (Costello 2017:192, 2021:153; McKerracher 2018:8; Williamson 2010).

In Part 2, I suggest that relational approaches can be used to address the limitations of conventional human-environment interaction approaches discussed in Part 1. I outline relational approaches, focusing on work by Latour (1999), Deleuze (1988, 1990), Deleuze and Guattari (2004), and Harris (2021), and examine how they have been pursued in archaeological research. In Part 3, I tie the discussions from Part 1 (i.e., established approaches to human-environment interactions) to my research in Pictland. I incorporate information from prior approaches to human-plant relationships in Pictland which have largely interpreted plant residues (macrobotanical remains and pollen) either as components of socio-economic strategies (e.g., agricultural crops, wood species preferred for fuel) or as environmental background contexts (e.g., degree of woodland coverage). For example, grasses and other 'wild' taxa (e.g., weeds) can be dismissed when recovered in the archaeological record because they are characterized as part of 'nature' and this negates the active roles of nondomesticated plant taxa. I apply the relational theoretical approach described in Part 2 and identify three key agents/actants involved in my research on dwelling in Pictland: humans, plants, and algae. I conclude with a discussion on how this relational theoretical framework will be used to interpret the microbotanical and micro-algae data, the strengths, and limitations of this framework in Pictish settings, and advocate for relational approaches elsewhere in archaeological research.

Part 1 – Human-Environment Interaction in Archaeology

In archaeological contexts, human-environment interactions are studied to understand how people in the past grew, stored, and cooked their food, fed their animals, built their dwellings, and interacted with various ecological niche zones. Such studies often draw on evidence of human practices (e.g., resource use) that modified and maintained these environments and created their landscapes (Balascio and Wickler 2018:155–156; Denham 2010; Fleming 2006; Rosenzweig and Marston 2018). Investigations of human-environmental relationships have become increasingly popular within archaeological research, with one literature review by Carleton and Collard (2020:114) estimating an increase in papers focused on human-environment interactions growing from less than 10 papers per year before the 1970s to approximately 300 papers per year since 2010. This increased focus is thought to reflect the growing acknowledgment and concern for anthropogenic climate change (Carleton and Collard 2020; Contreras 2016) and the desire to situate archaeological data within this discourse.

To examine human-environment interactions in the past, archaeologists use a variety of evidence, such as zooarchaeological remains (e.g., animal bones), pollen, seeds, wood charcoal and soil sequences to understand the connections between environmental and cultural changes. A number of theoretical approaches stemming from the fields of environmental anthropology and biology are then used to interpret archaeological, biological, geological, etc. data. These theoretical approaches have been discussed by Contreras (2016) who helpfully categorized archaeological investigations of human-environment interactions into three “strands”: (1) investigations of the structuring effects of environments on their human inhabitants, (2) analyses of human impacts on environments, and (3) studies of mutually constitutive human-environment interactions (Contreras 2016:5). The first strand refers to approaches centred on “environmental determinism” and “environmental possiblism,” which have been widely criticized as over-simplistic because they imply that environmental influence fully explains the choices and adaptations of past humans, ignoring the potential for human agency (Denham 2010).

Environmental determinism has recently been re-evaluated by several scholars who argue that claiming environmental factors affect human communities living within it is not inherently flawed (Arponen et al. 2019; Outram and Bogaard 2019). If humans are viewed as biological players, subject to biological needs and conditions, then certainly such needs are framed by environmental affordances and thresholds (Arponen et al. 2019:4). The central problem with environmental determinism is when the environment is exclusively underlined as the cause of social and cultural change. Such monocausal models of human-environment interaction do not account for the dynamic interplay of cultural, social, and political histories that are also entangled with environmental histories (Riede 2019:18). Here, the standard critique against environmental determinism points to a deterministic model of human behavior where humans are denied individual agency (Outram and Bogaard 2019:2). However, environmental determinism need not be one-sided, and efforts to understand the co-occurrence of environmental change with social changes (e.g., epidemics) have been suggested to avoid unilinear deterministic models (Arponen et al. 2019:9).

Outram and Bogaard (2019:47) point to an example by Dennell (1983:7) who describes environmental constraints on the viability of Norse settlement in Greenland. The pastoral and hunting subsistence framework of Norse settlers was deeply impacted by the environmental thresholds of Greenland, and the Little Ice Age compounded the limited viability of this strategy. However, Inuit settlements in Greenland demonstrate another viable subsistence model that did not consist of pastoralism but relied on hunting and fishing as the predominant subsistence strategy. Dennell suggests that Norse settlers could have adapted and continued to live in Greenland but “their cultural preferences were rigid” and instead of adapting the Norse settlements were abandoned. Through this example, environmental factors can be traced to understand how the environment limited the viability of Norse cultural practices (i.e., pastoralism) but it was not the environment alone that determined this result (as evidenced by the viability of Inuit communities).

The second strand arose out of the criticism for such environmentally deterministic models as anthropogenic influences on the environment began to be more widely accepted in anthropology, environmental sciences and related disciplines, and broader public discourse. Theoretical approaches within this strand include later Cultural Ecology and Historical Ecology. Several examples draw from Steward's conception of cultural ecology (1955) which influenced settlement pattern studies such as Willey's (1953) Virú Valley Survey and the Basin of Mexico Survey by Sanders et al. (1979) (in Contreras 2016:5). Archaeological investigations framed through historical ecology are typically interdisciplinary as they use a range of evidence from the social sciences, humanities, ecology, and biology to understand human-environment relations over time (e.g., Balée 1998, 2006; Crumley 1994; Fitzhugh et al. 2019:1080; Scholl et al. 2012).

My own research most closely aligns with the third and most recent strand. Studies of mutually constitutive human-environment interactions have gained popularity more recently as archaeologists and paleoenvironmental scientists work closely together, integrating human effects on the environment, and environmental influence on humans. Human Ecodynamics is included in this strand. Several recent examples have used human ecodynamics to investigate long-term human-environment relationships, focusing on the co-evolution of human and non-human systems such as the economic productivity of foodways (e.g., fisheries) (e.g., Dufeu 2018). Such approaches often integrate paleoenvironmental datasets with archaeological data (Fitzhugh et al. 2019:1082; Tallavaara and Pesonen 2020).

While I agree with the overall trajectory of these last theoretical strands, there are two significant hurdles that arise when following these well-established theoretical approaches. The first is the continued juxtaposition of humans and their environment (Denham 2010; Pálsson 1996). This stems from the nature/culture dualism, introduced to Western ontologies after the

European Enlightenment which sought to elevate and set humans apart from other entities (e.g., plants, animals) (Brück 2019: 13; Cipolla 2019: 616; Crellin et al. 2021:37; Descola 2013; Fitzhugh et al. 2019:1078; Grauer 2020; Ingold 2000; Sundberg 2014; Watts 2013:3; Weismantel 2018). Efforts to dissolve the nature/culture dualism have increased in recent years within archaeological research (e.g., Brück 2001; Fuglestvedt 2014; Grauer 2020; McNiven 2010) and this work suggests that some scholars are beginning to reach a consensus regarding the inappropriate pervasiveness of Western worldviews, particularly in studies of past peoples who likely did not conform to this nature/culture dualism. However, truly eliminating the nature/culture dualism is incredibly challenging in practice, as terminology and archaeological methodologies are entangled within Western ontologies. A profound shift in thinking and practice to address this entanglement (i.e., the ability to not break up natural and cultural elements) has yet to be fully realized and alternatively some approaches aim to integrate cultural and natural components to blur the edges of these elements (e.g., Human Ecodynamics).

The second hurdle is an inherent emphasis on large-scale or long-term approaches; for example, historical ecology approaches that examine human responses to climate change, and catastrophic events (e.g., Fitzpatrick and Keegan 2007; McGovern 1981, Yeakel et al. 2014). This emphasis can be useful, and these established approaches have made significant contributions toward our understanding of the complexity of human-environment interactions, such as long-term human-environment investigations of Cahokia (e.g., Briere and Gajewski 2023), Pacific Northwest Indigenous communities (Cannon et al. 2011; Moss and Cannon 2011; Morin et al. 2021), and Pueblo settlements in the Mesa Verde region (Varien et al. 2007). However, such investigations are typically connected to archaeological methodologies designed to examine large-scale phenomena, rather than focusing on how relationships are established, maintained, disrupted, and concluded between humans and non-humans at smaller spatial and shorter temporal scales. Following examples set by Albert et al. (2000), Morell-Hart et al. (2014), Zarillo et al. (2008), I argue that focusing on the small-scale creates more compelling engagement with what it means to be human and to dwell within complex entangled environments, rather than developing an anthropocentric understanding of such engagements, where humans simply use non-human resources to live.

Many of the well-established theoretical models in environmental archaeology address the nature/culture dualism (to varying degrees) including Cultural Ecology, Historical Ecology, General Systems Theory, Human Ecology, Agency models, Landscape models, and Human Ecodynamics. However, each of these theoretical models approach the nature/culture dualism differently and each present variable strengths and limitations. Cultural Ecology, established in the early 20th century by Julian Steward (1938, 1955) argued that culture, rather than biology, is the underlying mechanism that humans use to adapt to their environment (Renfrew and Bahn 2018:26). Within Cultural Ecology the nature/culture dualism is perpetuated despite attempts to examine the interplay between the two. Within archaeological research, the use of Cultural Ecology theory is applied to archaeological material remains to understand how culture evolution/adaptation was related to environment. For example, in a study by Whitaker, Rosenthal and Brandy (2019) Cultural Ecology is applied to interpret variable zooarchaeological representation of elk, pronghorn, and deer in Late Holocene Californian archaeological sites. The variability in quantity of elk, pronghorn, and deer remains were interpreted to indicate the effects of social circumscription caused by human population increase in the Late Holocene. This population increase was argued to have restricted human movement which resulted in deer becoming the preferred game as deer are more readily found closer to human settlements

(Whitaker, Rosenthal and Brandy 2019). Here it is argued that the social dynamics of an increased human population resulted in a change in hunting practices, and this aligns with understanding culture as the underlying mechanism for this change.

Historical Ecology attempts to push the model of Cultural Ecology further by focusing on long-term interactions, to understand how humans adapt to and shape the environment as the primary agents of ecological change and how this often results in landscape transformations (Balée and Erickson 2006; Crumley 1994; Thompson 2013:2). Historical Ecology also operates on multiple spatial scales though a focus on 'landscape,' acknowledging that various spatial scales (e.g., regional, local) need to be linked together to understand landscape changes. Similarly, to Cultural Ecology, the nature/culture dualism persists here but in a long-term perspective and multi-scalar spatial perspective. Historical ecology often aims to reconstruct an ecological 'baseline' (i.e., nature) and then assesses how humans impacted this baseline, which suggests that humans are understood as interloping agents of change within environments rather than part of the ecological system. Historical Ecology is widely used in archaeological investigations of human-environment interactions and has much to contribute to discussions regarding the importance of archaeology's role in collecting environmental data from the Anthropocene to understand our contemporary and future environments. This approach is particularly strong in coastal environments that examine long-term human impacts on marine animal populations (e.g., Cannon 2001; Erlandson and Rick 2008; McKechnie and Wigen 2011; Milner 2013). Like Cultural Ecology, Historical Ecology is interested in the interplay between nature and culture but is not concerned with erasing this dualism.

With Cultural Ecology and Historical Ecology, it appears that an overcorrection was made from earlier concepts like environmental determinism. Cultural Ecology made a monumental impact on anthropological thought as it was the first to argue that culture, not biology, was responsible for human adaptations to their environments. Other theoretical approaches, like Historical Ecology, were formed out of Cultural Ecology to build upon this significant ontological shift. However, Historical Ecology maintained many western ontological dualisms while expanding theoretical discourse. The current scholarly and public dialogue is turning toward the inclusion of ontologies situated outside of the Western Enlightenment paradigm and highlights the need for some of these environmental approaches to broaden their perspectives (i.e., remove these dualisms) (Crellin et al. 2021).

Human Ecology is the study of the interrelationships between human populations with their environments and suggests that human-environment interactions are shaped by cultural characteristics (Schutkowski 2010). This approach addresses the nature/culture dualism by integrating these entities and focuses on biocultural adaptions of human communities. Such studies often focus on population dynamics, subsistence strategies, and resource allocation (Schutkowski 2010). Human Ecology approaches are multi-scalar ranging from household to global assessments of human-environment interactions. Humans are central agents within this approach, and although it allows for the integration of methodologies from biology, physics, and social sciences (Butzer 1982) the contributions and active roles of nonhuman communities are not centered in Human Ecology.

General Systems Theory (GST), developed by Ludwig von Bertalanffy (1969) and strongly advocated by Kent Flannery (1965, 1967, 1968) was one of the first theoretical approaches to reduce the nature/culture dualism. GST aims to incorporate both natural and social sciences to understand the underlying systems that formulate complex networks of entities (Trigger 2006:419–420). GST therefore does not directly perpetuate the many ontological dualisms pervasive in human-environment interaction research (e.g., nature/culture, subject/object, mind/body, etc.), as it instead suggests that systems are formed through the collection of various entities (i.e., cultural and environmental / ‘natural’). This systematic, and often mathematical, approach to archaeological materials was successful in creating a multitude of explanations for causal relationships between key variables and outcomes and pushed archaeologists to be more inclusive in their considerations of which entities can be considered as key agents within a system. Although GST is useful for identifying changes in systems it has been critiqued for its inability to explain these changes in detail, resulting in more general explanations of causality (McGlade 1995:116; Trigger 2006:422).

Agency and Agent Based models are closely related to GST and are used “to simulate the behavior of complex systems” in environmental archaeology to model interactions between humans and environment over time and compare such models with archaeological data (Fitzhugh et al. 2019:1086; Perry and O’Sullivan 2018). Agent Based models have been used to emphasize the complex agents which contributed to the rise of modern hominins and the disappearance of Neanderthals during the late Pleistocene (Barton et al. 2011) and to understand the rise and fall patterns of communities and social systems (Fitzhugh et al. 2019; Kohler et al. 2012). These models consider the active roles (i.e., agency) of humans and other entities within socio-natural systems, and thus integrate natural and cultural components. However, such approaches typically rely on enormous datasets to create these models (Perry and O’Sullivan 2018:814) and may not be suitable for small-scale investigations.

Landscape, place, and space approaches address how past people existed within their landscapes and layers these investigations with social meaning (David and Thomas 2008:38). These models are human-centric and often focus on experiential qualities of living in the landscape (e.g., phenomenology), arguing that “landscape is an entity that exists by virtue of its being perceived, experienced, and contextualized by people” (Ashmore and Knapp 1999). Various ‘scapes’ have been investigated using these approaches including ‘spiritscapes’ (David et al. 2005; McNiven 2003), ‘seascapes’ (McNiven 2008), and ‘ceremonial landscapes’ (Ashmore 2008). Landscape frameworks harness a spectrum of data including GIS, paleoethnobotanical residues, DNA, and faunal remains (David and Thomas 2008). The landscape is understood as an active agent, and these approaches nod to the interrelatedness of humans within these landscapes to work toward addressing nature/culture dualism (Ashmore and Knapp 1999:20; Tilley 1994). However, these approaches typically aim to understand how landscapes were constructed and conceptualized by human communities, rather than to investigate how nonhuman communities contributed to human settlements.

Human Ecodynamics enters this discourse with the claim that there are only socio-natural systems (i.e., no ‘environment’) and human-environmental relationships refer to the co-evolution of natural and socio-historical processes (McGlade 1995:120). Human Ecodynamics suggests that the boundaries between nature and culture can be erased by emphasizing that ‘environment’ cannot be defined independently from humans. The ‘socio-natural systems’ are understood as complex, and contain non-linear interactions, meaning a small change in one variable may have disproportionate effects on other variables or even the whole system (McGlade 1995:121). This theoretical approach sidesteps the nature/culture dualism with the goal of investigating combined socio-natural systems. Even so, we can see it is challenging for scholars to avoid binary divisions (e.g., social/natural, human/non-human) when discussing human-environment relationships as it is necessary to delineate the component parts under study. Despite the ability for human ecodynamics approaches to combine social and natural components into one system, such approaches continue to focus on a long-term understanding of human-ecosystem relationships and do not center the active roles of non-human communities. It is essential to consider the roles and agency of non-humans and their complex relationships with human communities because this continues to break apart arbitrary divisions such as nature/culture and creates new ways to understand our world (e.g., understanding the world where humans are one-of-many). How then, can one investigate these human-environment relationships at smaller-scales, regarding both spatial and temporal scales, and how can we elevate our consideration of non-human agency?

Part 2 - Relational Approaches to Human-Environment Relationships in Pictland

To reorient these large-scale approaches to a smaller scale some researchers have proposed a ‘downscaling’ method to alter the resolution of paleoenvironmental data to the human level (e.g., Contreras et al. 2018) while others have attempted to integrate these enormous environmental datasets with perspectives that account for human agency (e.g., Widlok et al. 2012). While these efforts are certainly needed for existing datasets, attempts to ‘fix’ large-scale data to answer smaller-scale questions is flawed because these large-scale data cannot be appropriately applied to smaller-resolutions. For example, in coastal archaeology, relative sea level (RSL) curves are often used to identify paleoshorelines. These are highly variable locations on a seasonal basis let alone on a temporal scale of tens of thousands of years, which RSL curves are designed to reflect as they rely on glacial data (Stright 1986:347**)**. Large-scale environmental datasets, like RSL curves, are an epistemological inheritance in environmental archaeology as many of the methodological approaches produce long-term and large-scale datasets that are unsuitable for small-scale investigations (e.g., site level). In the example of pollen, this environmental proxy provides a broad geographic perspective of plant pollen present at a regional scale, and when examined at the site scale it can be challenging to use these data to interpret plants present at a specific site because pollen travels hundreds of kilometres on the wind. Although some studies have pursued such analyses in Mesoamerica (e.g., McNeil 2012, 2021). Instead of attempting to pare down large-scale approaches and datasets, environmental archaeological research can restructure our investigations to examine the complexities of human–non–human relations which make up the world using relational approaches (Crellin et al. 2021: 6). These 'relational' approaches have emerged out of dissatisfaction with the established theoretical approaches outlined in Part 1 and here I turn to a discussion on relational archaeology.

This theoretical pivot is required if we truly want to chip away at problematic dualisms such as nature/culture, pursue small-scale or multi-scalar approaches, and consider the contributions of non-human entities. Relational approaches allow archaeologists to home in on the particulars of how humans established relationships with non-human entities and argue that we can better understand humans, animals, plants, objects, structures, landscapes, and seascapes if the interpretive emphasis is focused on the connections between these entities. This contrasts with Enlightenment thinking which would categorize each as a bounded individual entity (Crellin et al. 2021:7). Relational approaches and ontologies are not new, as many Indigenous and non-Western societies have demonstrated in oral histories, ethnographic accounts, and theories (Atalay 2008; Cipolla 2019; Montgomery 2021; Wall Kimmerer 2020**).** However, the application of relational ontologies in archaeological practice is relatively novel as the major foundations of these ontologies lie outside of Western thought, and historically archaeology has operated within Western ontologies.

Relational approaches can be categorized into three broad paradigms: relations as epistemology, relations as methodology, and relations-as-metaphysics (Harris 2021:16).

Relations as epistemology "involves a conscious awareness in the world of one's position and activity in the world as a reciprocal and relational being" (Harrison-Buck and Hendon 2018b:10). This form of relational approach relies on historical and ethnographic data to connect this model appropriately to people who position themselves and engage with the world relationally. This model can be seen in archaeological investigations of personhood where personhood is understood as fundamentally relational (e.g., Fowler 2016; Harrison-Buck and Hendon 2018a; Watts 2013).

Relations as methodology moves away from an emphasis on past people's understanding of relations and focuses on identifying and tracing relations in the material record. For example, Ian Hodder's concept of entanglement (2012, 2016) is situated within methodological approaches to relations (Harris 2021:17–18). Hodder's entanglement aims to investigate how humans and things become connected and entangled and categorizes these entanglements using a spectrum of strength associations (e.g., weak or strong) (Hodder 2012:107). The opposition between humans and things are methodologically maintained in this approach to relations but does not necessarily adhere to binary ontological divisions. Instead, as seen with other approaches (e.g., Human Ecodynamics) the nature/culture dualism is bypassed to a degree, as the component parts are inherently connected.

Relations-as-metaphysics aspires to reject problematic dualisms (e.g., people and things) and argues that the world is fundamentally relational. This category of relational approaches is linked to symmetrical archaeology, the work of Bruno Latour (e.g., 1993), Actor-Network Theory (ANT), and new materialisms (Harris 2021:19–20). Critical to my discussion on relations is Latour's definition of entities (1999) which is centered on the ability of an entity to affect the world (i.e., agency). Agency, in a Latourian perspective, is a quality of relationships that emerges from connections between entities within a network. Relational archaeologies, such as symmetrical archaeology, draw upon this definition of agency to construct relational approaches that emphasize relations-as-metaphysics and consider the agency of non-human entities (Latour 1993; Meskell 2004; Pauketat and Alt 2018:72). New materialist approaches develop the approach of symmetrical archaeology further, by suggesting relations are constantly in a state of becoming. In these new materialist approaches, assemblages are the result of distinct historical actions that can be identified and traced (DeLanda 2006; Harris 2021:20). Such approaches aim to understand how people in the past engaged with the world relationally, but the relations as epistemology claim is not necessary – we do not need to know that people understood the world relationally to pursue a relations-as-metaphysics approach (Harris 2021) although this has been discussed as a significant critique of relational approaches (see below, Cipolla 2019).

My research fits within this category of relations-as-metaphysics by viewing the world as inherently relational. This perspective allows for an investigation of how humans related to non-humans in the past and is inclusive of the role of non-humans (Harris 2021:21). This approach involves three metaphysical claims: relations are relations of affect, relations are relations of difference, and objects and relations emerge together in a continual process of becoming (Harris 2021:22–24). The first claim, relations are relations of affect, underlines the capacity of entities to affect and be affected (Clough 2009; Deleuze 1988, 1990; Harris 2021:22; Massumi 2002, 2015; Spinoza 1996), with the essential understanding that "one body cannot affect another without being affected in turn" (Bird David 2018:29; Harris 2021:22). For example, a dog running across a lawn tearing up grass in the process is an example of affect, and doing so results in the dog's paws becoming dirty another example of affect. Understanding the two-way essence of affect allows for an examination of the links between physical properties and experiential qualities (Harris 2021:22). Using a plant community example, an oak tree bears an abundant crop of acorns one year and this has an effect on human and non-human animal communities that rely on acorns as food. In this way the oak tree is affecting the food stores for various animal communities and this in turn affects the oak tree by creating multiple avenues for seed dispersal. By focusing on affect in this way, we can acknowledge the influence of non-human entities on human communities and vice-versa. Another example of this two-way essence of affect has been described by Pollan who outlines maize as the keystone species of the industrial food chain in the United States (2007).

The second metaphysical claim, relations are relations of difference, underlines relations are relations of affect by acknowledging that relations make a difference. In the oak tree example, the production of a bumper crop of acorns strengthens the connections between the tree and non-tree communities that collect acorns for sustenance. This oak becomes an essential provider for its community by increasing human and non-human animal sustenance and therefore their energy and capacity for particular forms of action (Deleuze 1988, 1990; Harris 2021:23).

The third metaphysical claim, objects and relations emerge together in a continual process of becoming, means relations do not belong to things, and are not contained by things, they exist in flux, emerging with the things they relate (Harris 2021:24; Viveiros de Castro 2013). Relations therefore cannot exist outside of their complex networks which Deleuze and Guattari term assemblages, where humans are one-of-many and therefore do not have an elevated status, in an absolute sense, above non-humans (Deleuze and Guattari 2004; Crellin 2021:120).

Applying these claims under a relations-as-metaphysics theoretical approach can be operationalized by understanding an archaeological context as an 'emplacement of a suite of relations.' This follows an excellent example set by Pauketat and Alt (2018) where the roles of people, materials, and landscape are investigated in regard to the development of Cahokia and Mississippian lifeways, arguing that specific historical processes functioned through relational connections in the landscape between humans, mud, shell, water, and maize. I aim to follow this example by examining the roles of people, plant communities, and algae communities in the development of Pictish settlements.

Pauketat and Alt (2018) trace the movement and qualities of maize and shells (among other materials) to understand the agency of these non-human entities and their role in the creation of Cahokia and other Mississippian places (2018:73). In their consideration of the maize plant, they describe the affective qualities of maize on humans as this plant "draws water and nutrients from the earth and grows skyward with the aid of the sun, rain, and human beings to finally produce nourishing grain…Mississippians traveled daily between water bodies and agricultural plots, relying intimately on both mollusks and maize for their energy and growth" (Pauketat and Alt 2018:76–77). In this example we see an entanglement of maize, mollusks, and Mississippians within the landscape (and aquatic-scapes) in a form of territorialization that connects place, humans and non-humans within which Cahokia emerges. Pauketat and Alt use a 'genealogical consideration' "to trace the potential relations among water, mollusks, corn, mud, and fire to judge how they mediated and territorialized social relations," requiring an enormous dataset to develop such an interpretation.

Within my research on Pictland, I would not be able to mirror such a project as my dataset pales in comparison to the quantity of excavated materials and research on Cahokia. Instead, I follow the relational framework used by Pauketat and Alt (2018) to trace the movement and qualities of plants and algae. I investigate human-environment relationships and interpret the potential relations among non-humans (plants, algae, animals, and pots) and humans. This approach allows me to understand how these non-human entities affected settlements, architecture, and movement. Such an approach may help to interpret unusual plant and algae residues present at Pictish sites, such as deposits of seaweed found in inland settlements (e.g., Rhynie, Niehaus 2021).

Two significant critiques have been argued for relational approaches. The first critique concerns the de-centering of humans as a major component of relational approaches. It is argued that if we pursue a nonanthropocentric approach, our investigations are pushed too far out of anthropological inquiry into a posthumanist perspective (Alberti 2016:168; Witmore 2014). However, I would argue that by elevating the status of non-humans into a higher plane of consideration (therefore de-centering humans) does not remove humans from our approach altogether, but just lends the opportunity to understand and investigate the active roles of nonhuman communities (Morell-Hart 2020:125; Olsen 2012:29). The second critique is a lack of consideration for how relations-as-metaphysics relates to the human worldviews in the past (Cipolla 2019). This is rarely considered in such approaches and may create significant problems within the relations-as-metaphysics framework, particularly in text-aided and historical societies (Cipolla 2019:622). Applying a relations-as-metaphysics approach when historical evidence suggests past people did not conceptualize their world as relational runs the risk of misrepresenting local worldviews and creating a universal ontology (Cipolla 2019:622). Furthermore, these approaches need to address and give credit to Indigenous knowledge to avoid replicating or appropriating Indigenous relational ontologies in relational approaches (Cipolla 2019:622; Cipolla, Quinn and Levy 2019; Todd 2016).

As the Picts are temporally situated at the confluence of the late Iron Age and Early Medieval Period, the primary textual sources are extremely limited and are largely written from outsider perspectives. Therefore, I suggest that the application of a relations-as-metaphysics approach is appropriate in this case because we do not know how these people conceived their place in the universe (i.e., within 'nature'). Although the Picts were one of the first people in the British Isles to become Christianized, they still lived well before the establishment of Enlightenment thought (e.g., the implementation of the nature/culture dualism). Therefore, to understand how these people related to plants and algae I suggest the relations-as-metaphysics approach is appropriate.

Part 3 - Human-Environment Relationships in Pictland

By following a relations-as-metaphysics theoretical approach, with a new materialist turn similar to the examination of Cahokia by Pauketat and Alt (2018), I investigate how nonhuman communities contributed to the poiesis and maintenance of Pictland by tracing how people engaged relationally with non-humans. This is done by tracing the movement (i.e., ecological indicator species) and qualities of plants and algae through the retrieval of microresidues present at Pictish sites. Specifically, I focus on the relationships between human communities, plant communities, algae communities (Chapters 6 and 7), and to a lesser degree touch on the relationships between human and animal communities (e.g., domestic livestock, Chapter 7). This theoretical approach requires microremain analysis (Chapter 5) as it treats microbotanical and micro-algae residues as material remains of relational assemblages emplaced at each site. These assemblages are understood as emplacements of relations and are used to trace relations within Pictish settlements.

Identifying Contributions of Non-human Communities to Pictish Settlements

To address how coastal people design their architecture in relation to local plant communities, I examine the plant and algae remains at Pictish archaeological sites and interpret these remains relationally. For example, at Cairnmore a lack of post holes surrounding an intact floor layer suggested that this building, located beside the outer rampart wall and entrance to the bivallate fort, was perhaps built of turf. However, this was an example of evidence from absence. The micro-algae residues (i.e., chrysophytes and diatoms) recovered across the floor showed higher values around the edge of the floor layer. This pattern, accompanied by the lack of post-holes, supported the turf-wall theory as the high levels of chrysophytes point to materials from peat bog environments (Prado and Noble 2022).

If we examine the chrysophyte residues relationally, we can trace an interaction between humans and peat bog environments (where chrysophytes live). Chrysophytes are part of the peat bog ecosystem, one of many non-human entities, that forms dense root mats which humans have historically used for many purposes due to the physical qualities and experiential characteristics present in turf. The physical properties of peat (e.g., wet, dense, organic) and functional qualities (e.g., insulation) connected humans to peat bogs for a variety of purposes; notably, as a location of architectural and fuel resources (Bathurst et al. 2010; van Hoof and van Dijken 2008**).** In this interpretation, chrysophytes are part of a group of providers within peat bog environments, from which humans gather architectural and fuel materials for quickly building efficient and warm shelters within Pictland. Peat turf has also been recorded as a fertilizer and an alternative fuel source in northern regions where firewood is scarce (Johnson 1866). Peat is excellent at absorbing water and is therefore a functional entity when acquired for insulation qualities.

Evidence from this research suggests that peat was a central agent for creating shelter for animal and human dwellings (see Chapter 6), and humans collected peat (likely at various tempos – seasonally, daily) and relied upon it for their shelters (and possibly for fuel) where food (e.g., cereals) were processed, cooked, and consumed. Peat then can be understood as a crucial agent that contributed to the poiesis of settlements as this nonhuman entity mediated the ability for humans to live within the uplands, and furthermore, such findings potentially point to a preference for turf walled huts. Following this approach, it can be argued that peat bogs (and other peat producing communities such as upland fens) were crucial agents in human-environment relationships and directly contributed to the territorialization of Pictland.

Addressing Ontological Dualisms and Terminology

Although tethered to constrictive terminology and methodologies which perpetuate ontological dualisms to a degree this approach aims to 1) foreground the contributions and active roles of nonhuman communities to human communities, 2) account for aquatic, terrestrial and in-between (e.g., semi-aquatic) non-human contributions to human settlements, 3) metaphysically reject the nature/culture dualism (i.e., understand nature/culture as interconnected), and 4) approach human-environment interaction at a small-scale. Such an approach can significantly contribute to the development of relational approaches as very few studies have emphasized human-plant relations in this way and certainly there is a substantial lacuna in research on human-algae relations.

This approach also addresses an important hurdle in coastal archaeological research: terrestrial/aquatic dualism. As Pictland is situated within Scotland, a coastal nation where one can never be further than ~65 kilometers from the coast (Marine Scotland 2022), the terrestrial/aquatic dualism is important to address. This dualism is yet another remnant of Enlightenment thought and Cartesian divisions of reality and is distinctly problematic when studying coastal societies that meaningfully engage with both land and sea (among other aquatic environs). However, as previously noted, it is difficult to shake this dualism's terminology. In the absence of true alternatives, within this dissertation I maintain binary language such as human/non-human and terrestrial/aquatic. Despite this binary phrasing, I persistently couple such phrases to demonstrate the interconnectedness and blurred boundaries between these binary categorizations. Archaeological sites within the coastal zone are found within a spectrum of inundation and can be fully submerged, newly submerged, intertidal, newly terrestrial, and fully terrestrial. Submerged sites may be classified as fully submerged, meaning they are believed to have always been submerged since forming the "site" (e.g., shipwreck or marine hunting ground), or newly submerged, meaning they have become submerged after site formation due to environmental changes over time (e.g., sea level rise). Intertidal sites may have been intentionally designed as intertidal (e.g., fish weirs) or have become intertidal (again due to environmental changes). Most coastal sites studied within archaeological investigations are terrestrial sites (i.e., site that are currently in the terrestrial zone), which has created several issues within coastal archaeological research. By fracturing the coastal zone, which is inherently both terrestrial and aquatic, we overlook the relational aspects of the coastal zone as places of connection, resources, and cosmologies (Crouch 2010; Cummings 2009; Farr 2006; King and Robinson 2019; Robinson 2013; Wickham-Jones 2019:80). Archaeological research within the coastal zone rarely synthesizes data from the terrestrial coast, the intertidal area, and underwater zones which further partitions our concept of dwelling in the coastal zone.

I advocate for a relational approach that examines human-plant and human-algae relationships, softens ontological dualisms such as the terrestrial/aquatic distinction, and pursues an assessment of the active roles of plant and algae communities on human communities. Given the methodological approach (outlined in Chapter 4), this study will only address one side of the relational coin, as the data cannot be used to address human impacts on plant and algae communities (e.g., long-term effects). Although nature/culture and terrestrial/aquatic dualisms are perpetuated to a degree through the use of binary terminology my investigation of human-environment relationships within Pictland aims to emphasize the interconnectedness between these elements and blur the boundaries between these elemental components. Methodologically this is pursued by structuring the sampling strategy of this research to span terrestrial, aquatic, and in-between environments (e.g., assessed through microbotanical and microalgae residues) and human/nonhuman communities. (e.g., assessed through microbotanical and microalgae residues retrieved from a spectrum of human settlement contexts).

Understanding Non-Human Agency in Pictland

What is surprising is that amidst a forest of relational archaeological approaches centered on investigations of non-human ‘animal’ agency there is a dearth of investigations on non-human ‘plant’ agency, and again no discussions (to my knowledge) on the agency of algae. We know from ethnobotanical studies that plants have been considered to have agency (e.g., Wall Kimmerer 2020) yet archaeological approaches rarely center the agency of plants and algae on past human communities, with rare exceptions (e.g., Ardren 2020; Grauer 2020; Morell-Hart 2020). Plants certainly have affective qualities; they feed, heal, shelter, warm, and sustain humans and non-humans alike. This is demonstrated throughout the Anthropocene through the human use of plants as foods, medicines, building materials, fuel, and ritual materials. Of course, plant communities have agency and affect human communities. I contribute to the discussion of non-human agency through this project which considers plant and algae relations, and the contributions of these non-human communities to human settlements, architecture, and movement.

We do not know and likely will never fully understand Pictish epistemologies and ontologies. We do not have reliable textual evidence (e.g., from a cultural insider perspective) from this period, therefore it is challenging to argue that applying a relations-as-metaphysics approach glosses over the nuances of how these people related to their world. This limitation comes from side-stepping an emphasis on worldview in a relations-as-metaphysics approach. However, I have suggested that in the case of the Picts, this approach is appropriate because they lived well before the Enlightenment period when the nature/culture dualism was widespread within Western Europe. Furthermore, we do not necessarily need confirmation that people in the past understood the world as relational to use a relations-as-metaphysics approach (Harris 2021); although, this has been noted as a critique of relational approaches by Cipolla (2019).

Tracing Relations Across Pictland

Complicating ‘humanist’ divisions such as nature/culture, person/object, and terrestrial/aquatic helps to develop our understanding of human engagement with the world outside of constrictive Enlightenment ontologies. This allows archaeologists to re-engage with investigations of human-environment relationships in new ways; for example, by considering the role of plants and algae in the poiesis of human communities at different scales. In archaeological practice, pursuing a relations-as-metaphysics approach consists of first acknowledging the world as inherently relational. My approach however is only one half of a relational approach, as the scope and methodology of this research does not include broad human impacts on nonhuman communities. I investigate the contributions and influences of plants from the perspective of human communities and not the influences of humans on plant and other nonhuman communities (e.g., transformations of the landscape). Therefore, this relational study aims to investigate the physical properties, functional expressions, and experiential qualities of relations captured within an archaeological site (the emplacement of a suite of relations) to examine relations as affect and relations as difference. Finally, the relations identified in the archaeological record can be traced to understand the complex interplay of historical processes between humans and non-humans and how plants and algae (as nonhuman communities) contributed to human (i.e., Pictish) settlement, architecture, use of space, and land use in northern coastal landscapes.

In a coastal landscape context, a relational approach is useful for avoiding the terrestrial centric bias present in coastal archaeology because an understanding of coastal landscapes as relational is necessarily inclusive of aquatic, terrestrial and in-between (e.g., intertidal) ecological zones. A relational approach to coastal landscapes therefore provides the opportunity to include the spectrum of environments in our investigations of human-environment relationships in coastal landscapes. I do this through the recovery of aquatic and terrestrial proxies (i.e., plant and algae residues) to elevate our understanding of human-environment interactions in northern coastal environments at a smaller scale (e.g., site) than conventional approaches to human-environment relationships allow.

This approach builds upon the foundational research on Pictish settlement which argues that fortified enclosures and settlements both established and reinforced new and emergent cultural identities in northern Britain (Noble and Evans 2019:26). I contribute to this foundational research by investigating the roles of plant and algae communities in creating, transforming, and maintaining (i.e., affecting) lifeways. This relational framework complicates problematic Western divisions of nature/culture and terrestrial/aquatic, and instead emphasizes the dynamic and continuously changing relational processes that occurred between humans, plants, algae, and animals. Therefore, this theoretical approach uncovers new ways to think about human-environment relationships that are more inclusive of non-human agents and elevates the status of plants and algae for our consideration in the establishment and evolution of Pictland.

Chapter 3: A Relational Approach to Pictland

Historical and archaeological research on the Picts, the inhabitants of what is now known as Scotland during the first millennium AD, has steadily grown in recent decades through research programs such as the Northern Picts and the Comparative Kingship projects led by the University of Aberdeen. Such research has improved our understanding of these enigmatic communities, often termed a "lost people of Europe." These projects have contributed to our knowledge of settlement traditions, foodways, and overall chronology of the period through the expansion of archaeological excavations and innovative archaeological science approaches. These studies have begun to suggest a more complex picture of these people than previously believed, rather than a marginalized people on the outskirts of other societies. We now know the Picts lived in large, fortified settlements (e.g., Tap o'Noth), were connected to long distance trade routes (e.g., Byzantium to Rhynie), and constructed a variety of settlement forms (e.g., coastal promontory forts, wheelhouses, roundhouses, hillforts, and ringforts).

Research focused on how the Picts related to their environment, however, is rare, with only a handful of studies to date (e.g., Jones et al. 2021; Niehaus 2021). The lack of research is partially attributable to the taphonomic challenges within Scotland's environment. Significant degrees of rainfall result in highly acidic soil conditions, which often inhibit the preservation of organic residues (e.g., plant matter); therefore, without unique preservation events (e.g., charring, mineralization, waterlogging, etc.) organic matter is rarely preserved in Scotland's archaeological contexts. This has limited our understanding of plant use, with only rare occurrences of macrobotanical remains (e.g., charred cereal grains) and some pollen analyses (Jones et al. 2021; Niehaus 2021; Ramsay 2019). Charring is one of the most common pathways for the preservation of macrobotanical remains in northern temperate environments, alongside waterlogging; mineralization, desiccation, and freezing are not typical pathways of macrobotanical preservation in these environments. Certainly, these paleoethnobotanical analyses have made meaningful contributions to our understanding of Pictish environment (e.g., Jones et al. 2021). However, such analyses encounter multiple challenges in regard to taphonomy and depositional uncertainty (e.g., mixed contexts – from historical and modern ploughing). This makes it difficult to understand how humans interacted with and were influenced by plant and algae communities within the coastal landscapes of Pictland.

In this chapter, I outline what we know about Pictland and its environment. This review highlights the need for investigations focused on everyday lifeways, to push our understanding of these people further. Everyday lifeways are tied to my central research question: how are aspects of human social organization influenced by nonhuman communities in northern coastal landscapes? For example, how did plant and algae communities affect human social organization, settlement patterns, decision making and cultural practices? By investigating the plants that were central players at fortified settlements, I identify and trace the relations between humans and non-human communities (i.e., plants and algae) to better understand the chronology of Pictland and aspects of daily life. Such quotidian lifeways include how humans structured their settlements and moved throughout Pictland, in addition to how humans design their architecture relationally with local plant communities, and how human-environment relationships are consistent or divergent across Pictland (i.e., in lowland, upland and coastal contexts).

In this chapter I summarize our archaeological knowledge of Pictland by identifying the first of the major players pertinent to this doctoral project the Picts themselves. Following the relations-as-metaphysics approach, in this chapter I begin to identify what we already know about the relations established between the Picts and various plant species (e.g., heather, sedges, grasses) and algae communities (e.g., freshwater, brackish, saltwater). These relations contributed to the poiesis and territorialization of Pictland. First, I investigate what we know about the Pictish people through foundational archaeological research and projects on Pictland. Following this, I summarize what we know about Pictish-plant relationships to assess our current knowledge of human-environment relationships. To conclude this chapter, I briefly outline the major themes used to narrow the scope of my interpretation (use of space, and land use) and briefly present my initial hypotheses and expectations for Pictish-plant and Pictish-algae relations captured within settlement contexts. This review is directed toward contextualizing my five primary thesis questions: 1) How were aspects of Pictish social organization (e.g., agriculture) influenced by nonhuman communities (i.e., plants and algae)? 2) How did the Picts design their architecture relationally with local plant communities? 3) Which human-plant/algae activities were practiced in Pictish settlements? 4) How were human-environment relationships consistent or divergent across Pictland? 5) How did the Picts structure relationships between their settlements (e.g., uplands – lowlands)?

The Archaeology of the Picts

The first documentary record of the Picts comes from a Latin panegyric (*Panegyrici Latini 8.20.4–5*, AD 297) (Noble et al. 2018). Within this panegyric is a mention of the *Picti*, a term meaning "painted people." This mention is used to establish the beginning of the Pictish period AD ~300, culminating in end of the period with the rise of the kingdom of Alba around AD 900

(Noble and Evans 2022:250–251). Later historical sources (e.g., the Venerable Bede and Gildas) are also largely written from a cultural outsider perspective and record events that involved the Picts hundreds of years later. Etic misunderstandings, the degradation of historical memory and intent are additional problems that arise with reliance on the fragmentary historical record (Halsall 2013) to understand the creation and evolution of Pictland (Evans 2019); therefore, archaeological research, as a discipline that investigates past lifeways through material evidence recovered directly from archaeological contexts is well positioned to investigate the daily lifeways of the Picts.

Antiquarian investigations began in the 1800s with James MacDonald and Hugh Young, (Noble and Evans 2019). These antiquarian efforts focused on prominent (i.e., archaeologically visible) fortification remains, and although these efforts would not necessarily be recognized as standard archaeological practice today, they were effective at creating early records of several notable sites such as Burghead, Tap o'Noth and Mither Tap. Key findings from antiquarian investigations are limited (Noble 2019b:3) and mostly identified and delineated elements of fortified enclosures such as Burghead's rampart walls (e.g., MacDonald 1863; Young 1890, 1891, 1893).

A formal first wave of systematic archaeological research on the Picts occurred in the late 20th century with excavations carried out by Leslie Alcock (Alcock et al. 1989), Alan Small (1969), Ian Ralston (1980, 1987), Anna Ritchie (1977), and Colvein Greig (1970, 1971, 1972). The main objective of these research projects was to identify more sites such as fortified settlements and cemeteries, and this research produced useful typologies and dating evidence for Pictish sites. Aerial archaeological surveys conducted from the 1970s – 1990s also contributed to the identification of sites during this phase of archaeological research (Greig 1994; Mitchell et al.

2020:21), expanding the numbers of cropmark sites identified in Scotland (Maxwell 1978; Noble and Evans 2022:34); although, it is extremely challenging to distinguish between Pictish and non-Pictish sites through cropmarks alone.

Early excavations of Pictish sites were typically smaller in scale (e.g., keyhole excavations) and created a strong foundation of research on Pictland for more recent research programs such as the Northern Picts project (under Gordon Noble) the Hillforts of Strathdon project (under Murray Cook), and the Comparative Kingship project (under Gordon Noble, Tim Mighall, Patrick Gleeson, and Derek Hamilton). These recent projects expanded to large-scale excavations spanning multiple field seasons. Excavations at Portmahomack, a monastery complex, spanned fourteen field seasons and yielded key findings in terms of our understanding of early Christianity in Pictland including architectural traditions such as a vallum enclosure (i.e., Roman style rampart/earthwork) and direct evidence of various crafting practices such as vellum working (Carver 2016; Noble 2019b:4,145). Recent projects have focused more on understanding the development of enclosed fortifications and are beginning to turn toward understanding what the lives of the Picts might have been like. However, the character of these communities is somewhat elusive because of the lack of preservation of organic remains, due to highly acidic soil conditions, and variable degrees of disturbance from modern communities (e.g., agricultural intrusions such as ploughing) (Driscoll et al. 2011:263; Noble et al. 2020a:320, 328).

A large degree of Pictish material culture has not survived in the archaeological record as a substantial number of artifacts was made of organic materials such as wood and other plant matter (e.g., thatch). However, evidence of metal working, and other specialized crafts (e.g., glass making) have survived. Metal working evidence such as crucible fragments, iron blooms, clay and stone moulds, and items of personal adornment have been recovered at Rhynie, Cairnmore and Tap o'Noth (Clements and Gooder 2010; Noble et al. 2020b). Sporadic finds of hoards, such as the Norrie's Law and Gaulcross hoards have also included remarkable examples of craft skill, including brooches and pins with Pictish symbols (Noble et al. 2019a). Other material culture remains from Pictish sites include pottery and ceramic sherds, amber and glass beads, spindle whorls, stone tools, and game pieces (Gondek and Noble 2011:4; Noble et al. 2015:7). These artifacts suggest a highly skilled and artistically inclined society, involved in many different craft forms. These finds are substantial evidence that the Picts were capable carpenters, textile artisans (e.g., spinners and weavers), smiths, and potters.

Pictish material culture is perhaps most famously represented by the symbol stone monuments (Noble 2019b:3; Noble et al. 2013:1138). The symbols carved into stone slabs and erected throughout the landscape have yet to be fully understood, despite much scholarly attention (Samson 1992; Forsyth 1997; Lee et al. 2010; Noble, Goldberg and Hamilton 2019:110–133) – one prevailing theory argues that the symbols are a non-alphabetic writing system (Noble et al. 2018). Apart from the fortified settlement remains the symbol stones are the most readily visible remains of the Pictish people and certainly the most celebrated. The symbols upon the stones include depictions of animals, material objects such as mirrors, probable historic events such as processions, and more abstract designs such as the z-rod, v-rod, and double disc designs (Henderson and Henderson 2004:167; Noble 2019b:3; Noble et al. 2020a:260). Targeted archaeological research on symbol stones is challenging, as new stones may be found at random, including the recent recovery of a stone seemingly used as a paving stone at the entrance of a fortified enclosure at Broomend of Crichie (Noble and Evans 2022). The Rhynie Environs project is the only excavation program that has focused on the relationship between symbol stone monuments and the immediate landscape (Gondek and Noble 2011:24). This innovative project used a strip and map evaluative excavation method and was successful at identifying interior enclosures surrounding the Craw Stane symbol stone (Gondek and Noble 2012:2).

Overall, archaeological investigations of Pictish fortified structures have provided the bulk of archaeological knowledge about the Picts. The recent archaeological projects such as the RCAHMS survey project '*In the Shadow of Bennachie'*, the Northern Picts project, and the Comparative Kingship project have made significant contributions through the expansion of the scale and frequency of archaeological excavations in Pictland. These studies have provided a monumental recovery of archaeological evidence to better understand the layout and chronology of fortified settlements (e.g., Noble and Evans 2019, 2022; RCAHMS 2007). Advances in archaeological science have also been essential in recent projects, including the use of LiDAR to target settlements that are less archaeologically visible such as Tap o'Noth (Noble and Evans 2020:66). There is certainly room for other novel archaeological approaches to improve our assessment of Pictish sites to better understand the evolution of settlements and the nuances of life in Pictland.

In spite of this body of research, spanning several decades, archaeological understandings of Pictish lifeways are still limited. We know that these people inhabited large, fortified settlements in various zones of the landscape including hilltops, coastlines, and valleys. Fortified enclosures were especially prolific in the 5th – 6th centuries AD (Noble 2019b:7) and the Picts were capable of sourcing substantial quantities of building materials and constructing impressive wooden and stone structures. Within these settlements are indications of elite power structures as evidenced through the remains of metal working activities and monumental building programs that required substantial labour investment and well-coordinated efforts of large communities (Alcock

1988:29; Noble et al. 2013:1140; Noble et al. 2017:23). There is also evidence of long-distance trade connections, suggested through material culture remains from the continent including the most northerly recovered remains of Late Roman Amphora in Europe, at Tap o'Noth and Rhynie (Gondek and Noble 2011:25; Noble et al. 2016:52; Noble and Evans 2022:67,100,137). Despite these achievements of recent excavation programs, narratives surrounding daily life and activities within settlements have yet to be fully realized. This dissertation begins to assess Pictish lifeways through several central research questions. For example, 1) How were aspects of social organization influenced by nonhuman communities? 2) How did the Picts design their architecture relationally with local plant communities? And 3) Which human-plant/algae activities were practiced in Pictish settlements?

Several prominent archaeological excavations within the past two decades have focused on how Pictish sites, such as Burghead, Tap o'Noth, Rhynie, and Portmahomack contributed to our understanding of how these sites were situated within the broader (elite) landscape; however, human-environmental relationships were not the central focus. This lacuna in research is partly due to the poor preservation of biological remains, a considerable hurdle for archaeological investigations across Scotland. However, some information about human-environment relationships can be extrapolated from the wider picture of Pictish settlement archaeology through careful assessment of site reports, monographs, and grey literature.

Although our understanding of the geography of Pictland is not fully complete, there is some consensus regarding several major kingdoms, such as Fortriu and Ce. Once thought to be located in southern Pictland, foundational research by Alex Woolf (2006) has changed this perspective to consider Fortriu as the central kingdom and one that was likely situated further north. This argument dramatically shifted the conception of Pictland and its landscape from the southern borderlands to the Moray Firth. Pictish settlements have been found across Scotland from Orkney and Shetland, the Highlands (e.g., Caithness), northeastern Scotland (e.g., Aberdeenshire) and southern Scotland. In regard to ecological niches, these settlements were situated within upland (e.g., hillforts), lowland (e.g., ring forts), coastal (e.g., promontory forts), and other aquatic environments (e.g., lacustrine – crannogs). While settlement evidence has been identified across a vast geographic area and ecological zones, we do not understand why these people selected such a range of settlement areas and how these settlements related to one another. How did hillforts relate to lowland ringforts? How did settlement change over time? Why did the Picts choose to live in both crannogs and hillforts? How did small scale buildings (e.g., households) operate within larger complexes? What can architectural details tell us about how the Picts interacted with their environment? Uncovering such details would amplify our perception of these enigmatic people and illuminate several unknowns of daily life in Pictland including aspects of Pictish dwellings (e.g., architectural preferences, fuel use, agricultural practices).

Pictish–Plant Relationships

Wooden palisades, timber ramparts, stone and turf walls are several of the architectural aspects of Pictish fortified settlements that index human-environment relationships. Large postholes and intact fragments of ramparts at several sites suggest large amounts of timber were required for constructing fortified enclosures (RCAHMS 2007). For example, the timber required for the lowland enclosure at Rhynie has been estimated to be a minimum of one hundred and eighty oak trees (Noble et al. 2016:50). This information primarily comes from wood charcoal analysis. Although often recovered in small quantities (relative to wood charcoal remains from other regions with better organic preservation, e.g., England), recent wood charcoal analyses at multiple Pictish sites suggest some initial patterns of wood preferences for fuel and architecture (Niehaus 2021). Firewood selection appears to have been a mix of deadwood and felled wood for fuel and was largely harvested following regional availability, varying between sites. However, birch (*Betula* sp.) was the highest taxon represented in hearth contexts followed by hazel (*Corylus* sp.), Willow / Poplar (*Salix* sp., and *Populus* sp.), alder (*Alnus* sp.), oak (*Quercus* sp.), and Ericaceae species (Niehaus 2021). Across the sites studied in Niehaus' research, oak appears to have been consistently preferred for construction over any other wood taxon. Wood charcoal has therefore contributed to our understanding of arboreal communities in Pictland particularly in regard to fuel use/selection and building materials.

As previously mentioned, macrobotanical analysis is limited in Pictish archaeological contexts due to a lack of robust preservation of these residues. Some carbonised seeds and other macroremains (apart from wood charcoal) have been recovered from such sites, although in trace amounts. These residues include seeds from 'wild' plant taxa including mustard (*Brassica* sp.), sedges (*Carex* sp.), ribwort plantain (*Plantago lanceolata*), docks (*Rumex* sp.), crowberry (*Empetrum nigrum*) and grasses (Poaceae) which are often dismissed as 'natural environment' indicators. Evidence of agricultural crops is also limited and includes barley (*Hordeum* sp.), oat (*Avena* sp.), emmer wheat (*Triticum dicoccum*) and flax (*Linum usitatissimum*). This assemblage of crop species is not unexpected as these taxa were commonly grown in early Medieval Ireland and Anglo-Saxon England as well (McCormick 2014; McKerracher 2018; Niehaus 2021:45). A surprising outlier in the macrobotanical record is the presence of fucoid seaweed, including a deposit of 251 pieces recovered from a stone socket at Rhynie (Niehaus 2021). Overall, the macrobotanical residues provide very narrow lines of evidence for understanding human-environment interaction, and due to their trace amounts these proxies do not provide enough data to robustly interpret use of space and land use in Pictland.

Pollen analysis has also contributed to our understanding of Pictish-environment relationships, although again in limited instances with one prolific example that targeted the Craw Stane Complex at Rhynie (Jones et al. 2021). Pollen analysis has suggested that oak was the most common building material at fortified enclosures (Dickson and Dickson 2000:130) which agrees with the findings of Niehaus (2021). Hazel was also well represented in the pollen record and is well known in the British Isles and Ireland as a building material used for wattle and daub, fencing, and other architectural features. Notably, hazel rods can be coppiced sustainably over the life of the hazel tree (Carver 2019:17). In the analysis by Jones et al. (2021), a large number of arboreal and herbaceous taxa are listed including species not identified through wood charcoal analysis by Ramsay (2018, 2019) and Niehaus (2021). The palynological analysis by Jones and colleagues added species such as pine (*Pinus* sp.), ash (*Fraxinus* sp.), elm (*Ulmus* sp.), sphagnum moss (*Sphagnum* sp.), bulrush (*Typha* sp.), nettle (*Urtica* sp.), horsetail (*Equisetum* sp.), asters (Asteraceae), and ferns (*Pteridium* sp).

This analysis aimed to better understand the chronology of plant community change in the Strathbogie valley and the sites situated there during the late Iron Age through the Medieval period (i.e., Rhynie, Cairnmore and Tap o'Noth). Jones et al. (2021) suggest that the Pictish communities within the valley would have used local woodland resources (e.g., birch trees) and focused on growing cereal crops (e.g., barley). The abandonment of the site around the sixth century AD is signalled in the pollen record, as there is a marked a recovery in quantities of tree taxa pollen, increased instances of erosion and burning in the valley, and a slight decline in cereal production, suggesting a period of economic decline. Pollen analysis has provided a substantial list of taxa that were present in the Strathbogie valley during this period; however, pollen analysis cannot be used to understand spatial activities at the site level due to the ability for pollen grains to travel long distances through the air. Certainly, pollen is able to confirm the presence of agricultural activity in the general area of the site, which greatly contributes to our understanding of land use; however, pollen analysis is not common for Pictish sites and the research by Jones et al. (2021) is an exceptional case study.

Wood charcoal, carbonized seeds, and pollen remains have indeed made noteworthy contributions to our understanding of the overall assemblage of plants and plant communities present in Pictland. Using the theoretical toolkit presented in chapter 2, I suggest that the existing macrobotanical and pollen evidence points to sustained relationships with forest communities for fuel (e.g., birch) and architecture (e.g., oak), in addition to maintaining and sustaining cereal plant production, likely for food. These two prongs of human-plant interaction evidence are interesting as each influences the other, as seen in the pollen evidence. A reliance on forest communities for wood (both deadwood and felled) resulted, at least in the upper Strathbogie valley, in a decline in tree cover, and increases in cereal pollen (until the site was abandoned) indicate a period of agricultural intensification (Jones et al. 2021). The brief relational story here is one of reducing forest cover and increasing cereal production. However, I do not think that these data are sufficient to provide a detailed overview of human-plant relations in Pictland. This is largely due to the scarcity of the macrobotanical evidence and the distribution concerns regarding pollen analysis (i.e., large spatial distribution range). Furthermore, the standard approach to environmental archaeology for understanding past human-environment relationships does not consistently address the interconnectedness of human and nonhuman communities. For example, approaches in the British Isles often use socio-economic perspectives to understand human-plant relationships (Williamson 2010:135). Because of this standard approach, considerable pieces of the puzzle are missing or are dismissed in our interpretations. In paleoethnobotanical research it often becomes common practice to count and then dismiss the weeds, grasses, and other ‘wild’ taxa because they are part of 'nature' and therefore do not significantly contribute to ‘culture’.

Relational approaches more readily include overlooked plant communities like weeds, and this is important if we want to deepen our understanding of human-environment relationships in the past. In northern coastal environments this is especially critical as paleoethnobotanical residues are typically more limited than in other regions and we therefore cannot afford to dismiss ‘non-anthropogenic’ plants in favour of overrepresenting plants that deemed ‘significant’ to human communities. By elevating the status of all plants (necessarily as players within the relational network) for consideration in paleoethnobotanical approaches, we can shift away from a limited focus on specific ‘anthropological’ plant categories (e.g., arboreal and agricultural) toward a more nuanced and vibrant interpretation inclusive of a broader spectrum of plant communities.

Phytolith, starch grain, and micro-algae analyses complement existing paleoethnobotanical data as these remains are more secure in regard to taphonomic preservation and/or depositional contexts. Using an appropriate toolkit of sampling strategies and analyses, multiple contexts (e.g., house floors, ditch fills, hearths, etc.) can be better understood than through macrobotanical and pollen residue analyses. Although the taxonomic identification level of phytoliths and starch grains is limited within this northern coastal context (e.g., high clade levels, as in the case of grasses) the identifications from wood charcoal, carbonized seeds, and pollen can provide a broad list of possible taxa available at Pictish sites.

Pictish–Algae Relationships

Existing scholarship on Pictish–algae relations is even more limited than what we know about Pictish–plant relationships, with limited instances of seaweed recovered from Pictish sites. The most notable example is the previously mentioned deposit of fucoid seaweed retrieved from the Craw Stane enclosure at Rhynie, which lies 50km inland (Jones et al. 2021). Hypotheses for the use of seaweed at Rhynie include fertiliser (McKenzie 2007), food (for humans and/or animals), flux substance for metalworking (Niehaus 2021:46; Sebire 2013), or for medicinal, ritual, or other unknown purposes. Smaller deposits of seaweed have also been retrieved from Cairnmore and Dundadd (Lane and Campbell 2000; Niehaus 2021:46). Algae belong to Kingdom Protista rather than Kingdom Plantae and while both algae and plants are eukaryotic (i.e., cells contain a nucleus) and produce energy through photosynthesis, algae do not have many structures found in plants (e.g., stems, leaves, and true roots). The lack of these structures likely further contributes to the invisibility of algae in the archaeological record, as there are few physical structures that can preserve in the macroscopic archaeological record unlike plants (e.g., seeds).

Micro-algae such as diatoms and chrysophytes are composed of biogenic silica, and the morphology of their silicious cell walls can be taxonomically diagnostic (Pearsall 2015:253; Piperno 2006; Smol and Stoermer 2010; Stone and Yost 2020). Microscopic algae are often present in archaeological samples targeting phytoliths and other microbotanical structures, as diatom frustules and chrysophycean cysts. However, these microscopic residues are rarely examined with microbotanical residues in archaeological investigations (e.g., Vuorela et al. 1996). Other types of multi-proxy archaeological approaches, often termed “piggy-back” approaches, have targeted phytoliths, starch grains, calcareous spherulites and other microscopic residues together (Canti and Nicosia 2018:32; Portillo and Albert 2011), but micro-algae are seldom integrated into these studies (Stone and Yost 2020:23). There is a reluctance toward focusing on micro-algae in archaeological investigations despite the capacity of these proxies to contribute information about specific aquatic and semi-aquatic contexts (Juggins and Cameron 2010; Mannion 1987; Smol and Stoermer 2010:3).

In northern coastal contexts such as Pictland, micro-algae analysis can greatly improve our understanding of movement through the landscape, seascape, and other aquatic zones. Accurate identification of diatom frustules can be challenging as diatoms are the most diverse protists (Spaulding et al. 2022; Stone and Yost 2020:23). However, this presents interdisciplinary opportunities for paleoethnobotanists and microbiologists (among other specialists) to work together in environmental archaeology research to aid future identification (Prado and Noble 2022). Similar to interpreting environmental indicator species through phytolith analysis, the identification of micro-algae taxa retrieved from outside of their environmental context can signal deliberate transportation of algae to the site. For example, the recovery of oceanic micro-algae at a hillfort could signal movement from the coastal zone to the upland zone. Although understanding the depositional context of micro-remains can be challenging in archaeological investigations, all contexts studied in this dissertation appear to be stable (i.e., no evidence of vertical movement).

Defining Human-Environment Relations in Pictland

While archaeological investigations in Pictland in recent years have greatly contributed to our understanding of the Picts, particularly in refining our understanding of their fortified enclosures, identifying more settlements and individual dwellings, and tracing genetic relationships of humans and livestock there is a notable lacuna in our understanding of everyday settlement landscapes (Czere et al. 2021; Morez et al. 2023; Noble and Evans 2019, 2022:52).

This dissertation contributes toward filling the gap in our knowledge through an investigation of human-environment relationships that aims to trace the network of human-plant/algae relationships and to investigate how these agents contributed to the poiesis of settlements through the establishment, maintenance, disruption, and conclusion of relations between Pictish communities and non-human communities. These objectives are methodologically pursued through site-scale paleoethnobotanical investigations of features, architecture, artifacts, and teeth. I focus on ten sites in Pictland (Figure 3.1) to answer research questions focused on how nonhuman communities influenced aspects of human social organization; how nonhumans played active roles in the creation of architectural traditions and settlement activities; and how these nonhuman communities helped build relationships between settlements. In this study I investigate three coastal sites (Burghead, Dunnicaer, and Lundin Links), four upland sites (Cairnmore, Croftgowan, Mither Tap, and Tap o'Noth), and three lowland sites (Balbinny, Craig Rock and Rhynie). By including a number of different zones, I examine the patterns of human-plant and human-algae relationships across Pictland where settlements were established to trace consistent or divergent relationships.

Burghead

Famously known for its bull statues, Burghead is one of the largest Pictish settlements and was likely a power centre of Fortiu (Noble and Evans 2022:63). Radiocarbon dates suggest that the site was in use from the 7th – 8th centuries AD which situates Burghead toward the end of the Pictish period. Large timber ramparts outlined the upper and lower citadels and smaller rectangular and horse-shoe shaped buildings as evidenced by floor layers have been identified at Burghead (Figure 3.2). The function of these smaller buildings has not been determined as little macroscopic evidence survives that attests to their structural components and use of space is difficult to interpret without such evidence. Microbotanical and micro-algae residues then, are poised to make substantial contributions toward understanding the use of space within these smaller buildings at Burghead, and the overall use of space within the upper and lower citadels more broadly.

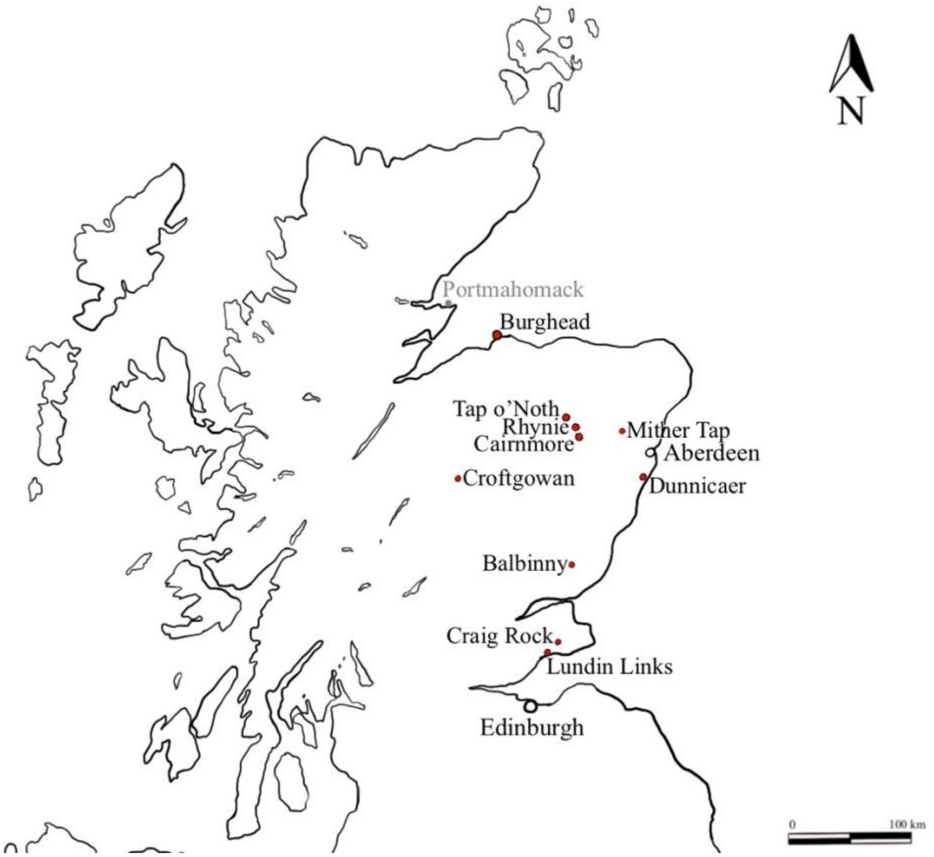


Figure 3.1 Map of Pictish sites investigated in this study (red) and contemporary cities (white).

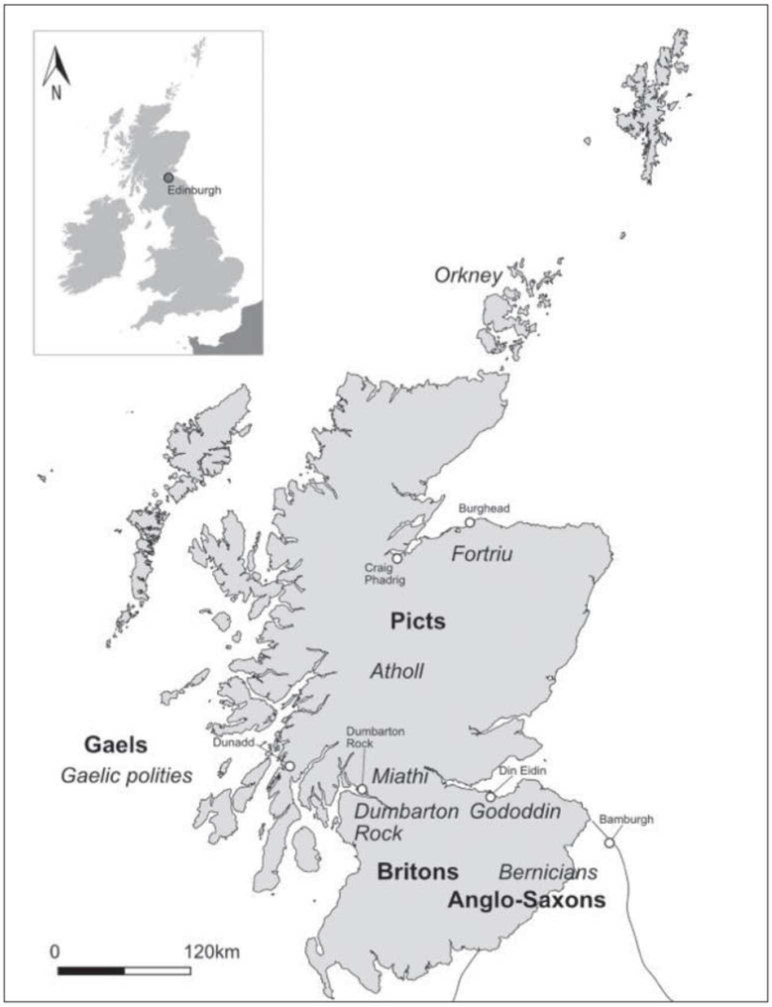


Figure 3.2 Map of Pictland illustrating Pictish power centers and neighbours in the early 7th century (Noble and Evans 2022:17).

Figure 3.3 (Top) Aerial view of modern Burghead. (Bottom) Reconstruction of Burghead Coastal Promontory Fort (Reconstruction by Dr. Alice Watterson – University of Dundee) (University of Aberdeen – Northern Picts)

Rhynie

Rhynie is one of the three sites within this study located in the Upper Strathbogie Valley, (alongside Cairnmore and Tap o'Noth) and is dated from the 4th – 6th centuries AD (Noble and Evans 2022:99). This lowland settlement consists of a settlement enclosure known as the Craw Stane Complex and a nearby cemetery. Rhynie is notable for its association with several symbol stones, most notably the Craw Stane and the Rhynie Man (Figure 3.3) and is representative of a non-hilltop elite center within Pictland (Jones et al. 2021; Noble and Evans 2022:99; Noble et al. 2019b). The Rhynie Environs Archaeological Project (REAP) led by the University of Aberdeen delineated interior buildings within the Craw Stane Complex and retrieved evidence for metal working (e.g., crucible moulds) and long-distance trade (e.g., Byzantine glass). This evidence points to Rhynie's elite status (Noble and Evans 2019:113). Botanical and algae residues have been recovered from archaeological investigations at Rhynie including pollen (e.g., cereal) and an unusual deposit of fucoid seaweed. This seaweed deposit is unusual as Rhynie is an inland site. In this study, human-environment relationships are examined through microbotanical residues of pottery sherds retrieved from REAP excavations (n=3).

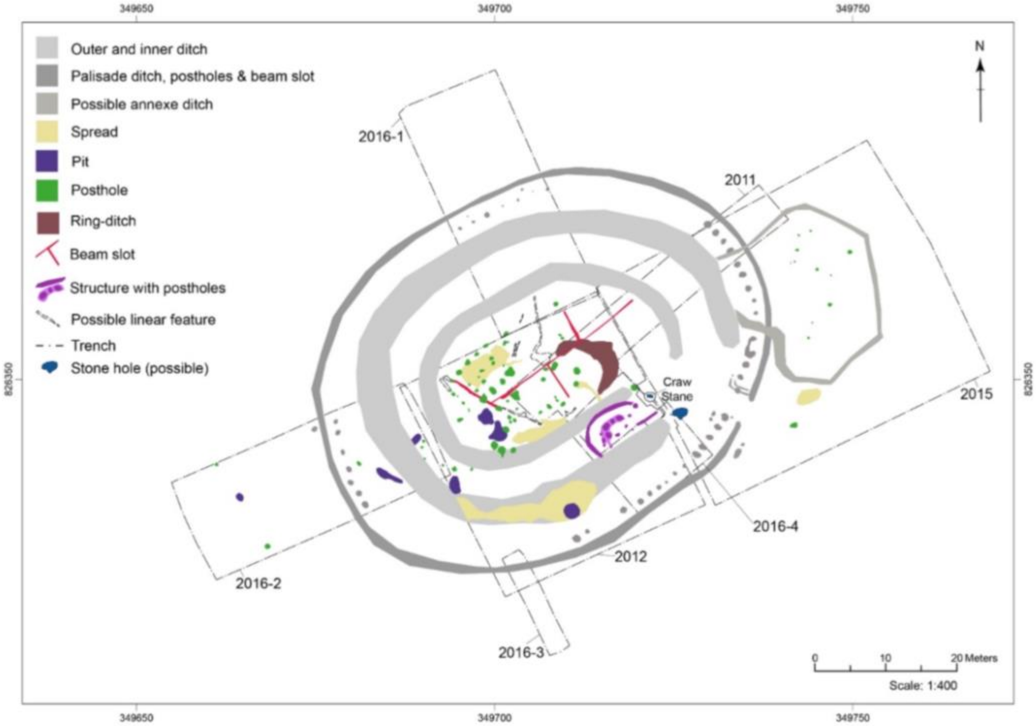


Fig. 5 Plan of 2016 Trenches 1-4

Figure 3.4 2016 Excavations at Rhynie – Craw Stane Complex. (Top left) Aerial view of excavation trenches. (Top right) The Craw Stane symbol stone (Tap o'Noth hillfort behind). (Bottom) Craw Stane excavation diagram (Noble et al. 2016:6,12,14).

Balbinny

Balbinny is a small lowland enclosed settlement in southern Pictland dated from the 5th – 6th centuries AD (Noble and Evans 2022:101; Noble and O'Driscoll 2023). Much of the archaeological remains at this site have been impacted by historical and modern ploughing, due to its location in the fertile lowlands (Noble and O'Driscoll 2023). Therefore, little is known about this site to date. Excavations in 2020 and 2021 revealed internal and external features of this settlement including floor layers, a round house, large oval structures, and part of a souterrean within the enclosure (Noble et al. 2021:3). This study assesses human-environment relationships (e.g., crop processing activities) through soil samples from the enclosing ditch fill (n=15).

Craig Rock

Craig Rock is characterized as a 'nuclear' hillfort, a defensive form of enclosure located on hilltops. Dated to the 6th century AD, this site has not been extensively excavated and similar to Balbinny we do not know a great deal about this settlement's role within Pictland (Hinckley 2023 p. comm). Excavations in 2019 revealed segments of large ramparts, midden deposits, sub-rectangular building remains, and a variety of artifacts including crucibles, sharpening stones, a spindle whorl, and an ingot mould (Noble, O'Driscoll and Hinckley 2020). In this study, human-environment relationships are investigated through microbotanical, and microalgae residues extracted from zooarchaeological dental remains recovered during excavation by the Northern Picts project (n=6).

Tap o'Noth

One of the oldest sites in this study is Tap o'Noth (Fig. 3.4), an upland hillfort dated from the 2nd–6th centuries AD (Noble and O'Driscoll 2022). This hillfort is one of three important Pictish sites identified in the Upper Strathbogie valley and overlooks the lowland elite enclosure at Rhynie. Tap o'Noth features a vitrified Iron Age fort at the summit of the hill and the lower fort features hundreds of hut platforms (identified using LiDAR), which suggests Tap o'Noth may have been a vital site of assembly or seasonal gathering place (Noble and Evans 2022:67). Significant finds at Tap o'Noth include pottery, items of personal adornment (e.g., beads) and metalworking evidence (e.g., clay mould fragments). Multiple contexts and methodological approaches are pursued to investigate human-environment relationships in this study including soil sampling of a hut floor (n=14), animal dental residues (n=3), and pot sherd residues (n=3).

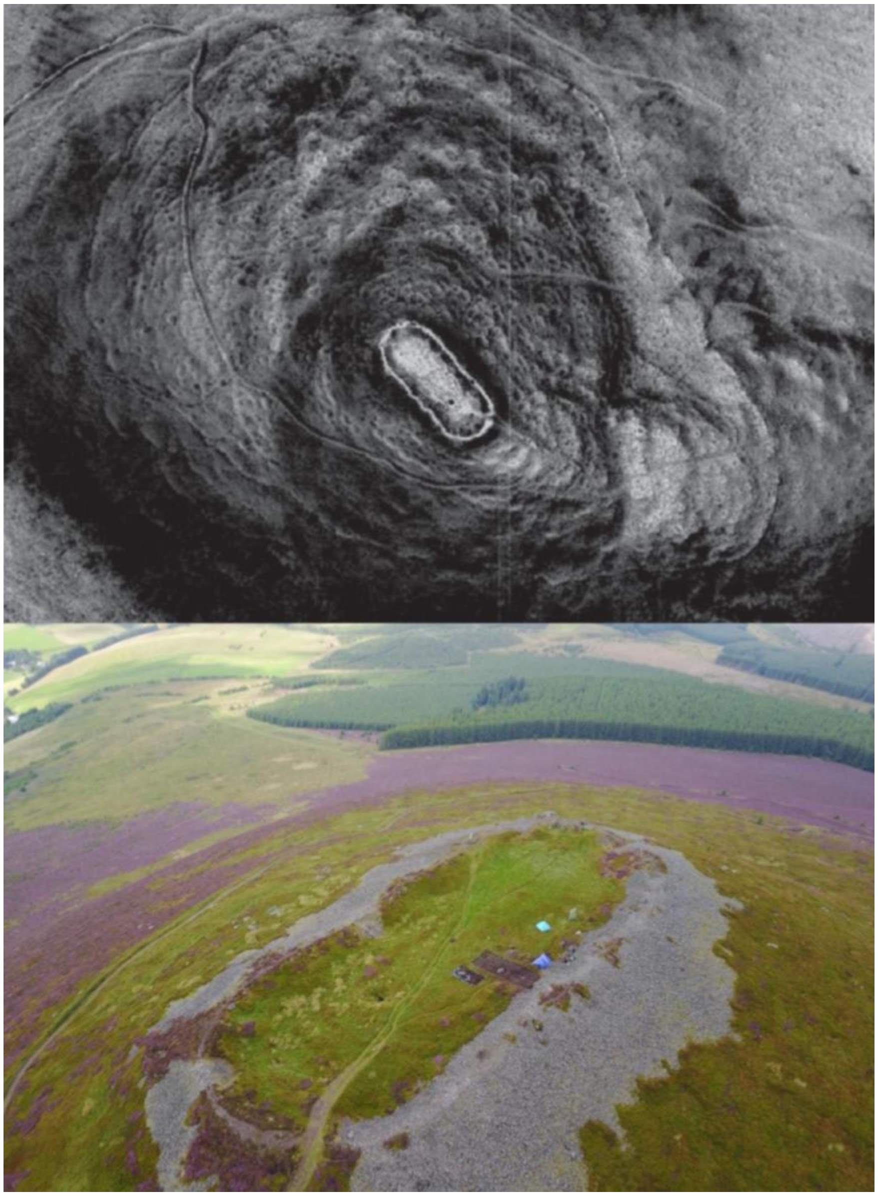


Figure 3.5 Aerial views of Tap o'Noth. (Top) LiDAR image showing 800> house platforms and remains of Iron Age vitrified fort at summit (Noble and Evans 2022:100). (Bottom) View from summit with excavation trench (Noble et al. 2017).

Cairnmore

The third and final of the three important sites located in the Upper Strathbogie Valley and assessed in this study is Cairnmore, a small upland ringfort enclosure. Dated from the 4th – 7th centuries AD, Cairnmore is characterised as a bivallate enclosure and is often discussed in connection to both Rhynie (the Craw Stane complex) and Tap o'Noth (Noble and Evans 2022:116). Excavations at Cairnmore have revealed monumental fortifications including double ramparts built of stone and timber, and several internal buildings. Considerable truncation of the archaeological record is present at Cairnmore due to agricultural activities; however, the collapse of the outer rampart wall resulted in the fortuitous survival of a house floor layer located just outside of the enclosure. In this study, human-environment relationships are assessed through soil sampling of this intact floor layer located beside the entrance to the enclosure (n=21).

Mither Tap

Mither Tap is a complex citadel hillfort situated upon a craggy granitic tor (Fig. 3.5). The main phase of occupation dated from the 7th – 8th centuries AD and the fort is made up of a small upper citadel, internal settlement platforms, and an elaborate well with a series of descending stone steps. Excavations at Mither Tap have uncovered extensive middens, metalworking evidence, and small assemblages of locally produced pottery (Noble and Evans 2022:106–107; Noble et al. 2019a). In this study, human-environment relationships at Mither Tap are investigated through microbotanical and microalgae residues retrieved from animal dental surfaces (n=6) and pot sherds (n=2).

Figure 3.6 (Top) Aerial view of Mither Tap summit. (Bottom) Well structure (Noble et al. 2019c:1,15).

Dunnicaer

The coastal promontory fort of Dunnicaer (Fig 3.6) is one of the earliest fortified enclosures in Pictland, dated from the 2nd/3rd – 4th/5th centuries AD. The fort is proposed to have set the example for later coastal promontory forts such as Burghead (Noble and Evans 2022:238). Mediterranean and Roman imports, such as glass and ceramics (e.g., Roman Samian Ware) have been recovered during excavations at this coastal fort, and several symbol stones are associated with this site (Noble and Evans 2022:49,246). Individual structures have been identified through excavation of Dunnicaer, some featuring central hearths. However, agricultural efforts have severely impacted the preservation of archaeological deposits at this site. Coastal erosion has also significantly impacted the archaeological record at Dunnicaer as this promontory fort is presently situated upon a sea stack, a coastal land formation which resembles a tower of rock emerging from the ocean. Dunnicaer was likely constructed when this stack was still part of a larger connected landform but has since become a sea stack due to coastal erosion (Noble and Evans 2022:95). Due to the scarcity of the archaeological record at Dunnicaer, this study targets pot sherds (n=3) to assess human-environment interaction.

Figure 3.7 (Top) Aerial View of Excavations at Dunnicaer (Northern Picts Project). (Bottom) Reconstruction of Dunnicaer coastal promontory fort (Dr. Alice Watterson).

Croftgowan

Croftgowan is the largest cemetery in northern Pictland and consists of over 40 identified barrows (Mitchell and Noble 2017; Mitchell 2020:111–115; Noble and Evans 2022:204). Located in the Cairngorms National Park, this cemetery site has been historically associated with human remains, items of personal adornment (e.g., buckles) and weaponry (e.g., sword blades). Recent excavations in 2021 identified two round barrows and one square barrow. Human remains in Pictland are exceedingly rare, as the acidic soils often prevent the preservation of biological remains, and during the 2021 excavations human remains within these barrows were limited to skull fragments and enamel caps of an individual's teeth (Noble and Evans 2022:204). These enamel caps and teeth embedded within an individual's upper palette were sampled to understand human-environment relationships (e.g., foodways) at Croftgowan (n=2).

Lundin Links

Lundin Links is the second cemetery site targeted in this study. Located near the coastal village of Lower Largo, this cemetery was discovered after storm erosion in the 1960s revealed six round cairns and unusual monuments that were covered by coastal dunes (Noble and Evans 2022:199). Dated to the 5th-6th centuries AD, Lundin Links represents the southernmost site within this study (Fig. 3.6). Individuals from this cemetery site have been analyzed for Sr/O isotopic analysis which revealed an absence of direct common female ancestors within this cemetery. This finding suggests exchanges of female individuals between communities during the Pictish period (Morez et al. 2023). Microbotanical samples were procured from four molars (four individuals) to investigate human-environmental relationships at Lundin Links (n=4). It is important to note that microbotanical and micro-algae residues from dental surfaces represent meals eaten before death and are not reflective of long-term food consumption.

Tracing Relations in Pictland

Within a relational approach (i.e., relations-as-metaphysics) it is understood that Pictland was inherently relational with relations defined according to three claims outlined in the previous chapter: relations are relations of affect, relations are relations of difference, and objects and relations emerge together in a continual process of becoming. Regarding affect, I ask how were the Picts influenced by plants/algae (i.e., what plants/algae contributed to settlements and how)? This line of questioning helps to understand everyday life by investigating the presence/absence (of algae), frequency, and distribution of specific residues of plants and algae at Pictish settlements, which remain as echoes of past relations. How these relationships changed or remained consistent over time connects to the maintenance, disruption, and conclusion of these relations. These patterns can also be investigated to interpret the physical and experiential qualities that create the two-way essence of affect and how relations make a difference. This approach entails identifying the affective qualities of plant/algae communities, meaning the "lines of force" plant bodies press into human bodies and change the capacity for human bodies to act (Harris 2021:22). For example, these affective qualities could include the production of urushiol by some plant species such as poison ivy (*Toxicodendron* sp.) or trichomes (small stinging hairs) as seen in stinging nettle (*Urtica dioica*) which typically produces an allergic skin reaction in human bodies. This affects the individual human body and may result in several effects on these plant communities (e.g., human avoidance of plant community or decision to remove plants from their location). In this example, we can trace both physical (e.g., urushiol, trichomes) and experiential qualities (e.g., rash inducing, deterrence/avoidance) of human-plant relations. Lastly, relations emerge with the things they relate and cannot exist outside of their complex networks. In Pictland, I understand this claim similarly to Pauketat and Alt (2018) where each archaeological context (e.g., site) is considered as an emplacement of a suite of relations (i.e., assemblage). Each assemblage contains evidence of past relations that connected place, humans, and non-humans to form Pictland.

By comparing these suites of relations from each site, I aim to uncover human-plant relations across northern Pictland to better understand how northern coastal people establish, maintain, and conclude relationships with plant and algae communities, and how these relationships influence human communities. This objective is broad; therefore, to narrow down the scope of this investigation I focus on two key themes: use of space and land use.

Use of Space

To investigate the use of space, I target activity areas and architectural features to understand how plants and algae contributed to these components of everyday life in Pictland in chapter 6. For example, I investigate how coastal people designed their architecture in relation to local plant communities (e.g., forests) and how they structured their settlements. Were local plant communities prioritized (i.e., have stronger relationships) due to proximity to settlement location, or were plant communities outside of the immediate local zone sought (e.g., wetland plants)? What might more distant relations suggest about Pictish-plant and Pictish-algae relationships? Methodologically, use of space is examined through spatial patterning of soil samples containing phytolith, diatom and chrysophyte assemblages to examine activity areas within settlements and the relative prominence of ecological indicators (e.g., wetland versus heathland phytoliths). Using a relational toolkit, the presence/absence, frequency and ubiquity of plant and micro-algae taxa are used to trace relations in Pictland.

Coastal settlements, such as Burghead, may have been more strategic at structuring their space due to often cliff-side locations (e.g., Dunottar) and what appear to be substantial economies (indexed by large, fortified settlements). Wider literature suggests that coastal lands proximal to the sea and estuaries were especially valued. Therefore, it is expected that relatively large quantities of marine algae and coastal plants (e.g., reeds) will be represented at coastal sites. In this project, I examine use of space at coastal sites within the upper citadel at the coastal promontory fort of Burghead (Moray, Scotland).

Upland settlements, such as the Tap o'Noth hillfort, were certainly structured (as evidenced by hierarchical portioning of space by fortification walls) but had plenty of room available for continuous growth if needed. These settlements often feature centrally located large meeting areas/open spaces with smaller units for housing typically radiating outwards from the centre. To understand use of space in upland settlements, I focus on the smaller units to better understand use of space in the daily life of Picts at a small scale. This is partially reflective of the excavation areas available for sampling but also because earlier investigations of hillforts focused on the central spaces (i.e., large meeting areas). It is expected that arboreal plants (e.g., wood residues), upland grasses/shrubs (e.g., heather), and agricultural crops (e.g., barley) will feature prominently. One might assume that algae would be less prominent in upland sites due to the greater distance from our typical conceptions of aquatic environments such as wetlands which are commonly associated with flat, lowland contexts. However, diatoms and chrysophytes are also present in semi-aquatic, terrestrial and sub-aerial environments; therefore, microalgae can be recovered from a wide range of environments, including blanket peatlands in alpine environments (Bai et al. 2018).

Settlements within the upland zone such as Tap o'Noth and Mither Tap provide exceptional contexts to understand the range of preferences for use of space in Pictland as only specific plant taxa and algae can thrive in the uplands. Furthermore, at Tap o'Noth new LiDAR evidence has identified an unprecedented amount of house platforms within the lower fort (estimated 800) which makes this hillfort an exceptional example of concentrated settlement in northern Britain (Noble and Evans 2022:66). At present, the character of upland settlement is unknown and microbotanical/algae analysis may help us to understand if these upland settlements were related to more specialised and/or seasonal occupations. For example, agricultural processing residues such as elongate dendritic phytoliths may be able to help us understand the use of space and seasonality within the house platforms surrounding Tap o'Noth.

Similar to upland settlements, lowland settlements may be less structured in response to broader affordances of space in lowland areas. Lowlands, unfortunately, present the lowest degree of available data due to substantial disruption by agricultural ploughing and historic/modern settlements. Plant expectations for lowland sites included a heavy emphasis on agricultural cultivars (e.g., wheat), lowland plants and algae (e.g., lacustrine/riverine diatoms) and wetland plants (e.g., sedges). This is because wetlands and agricultural production are typically associated with lowland environments, although wet environments such as bogs, mires, and fens also exist in non-lowland contexts (Keddy 2013). Regarding agricultural cultivars, lowland environments have historically been targeted due to their productivity potential (fertile soils, warmer climate), while uplands have been categorized as "marginal arable land" (Costello 2021)

Only a few lowland sites such as Balbinny and Craig Rock are investigated in this dissertation, largely because of the lack of secure contexts required for microbotanical sampling at these lowland sites due to modern interventions. The small lowland enclosure settlement at Balbinny is dated to the 5th – 6th century AD and points to a time during the Pictish period when the consolidation of resources may have begun. Recent excavations by the University of Aberdeen began in 2017 to better understand the chronology and activities at Balbinny and these excavations were successful at identifying floor deposits within the interior of the enclosure and part of a souterrain (Noble, O'Driscoll and Masson-MacLean 2021). Soil samples taken from the enclosure's ditch fill will help to interpret the use of space and the chronology of activities at Balbinny.

Overall, early medieval architecture and use of space is notably difficult to trace in northern Britain. However, intact floor layers and other preserved archaeological features allow for the targeted deployment of paleoethnobotanical approaches that use microbotanical and micro-algae residues to illuminate the character of early medieval settlement and use of space in Pictland. In this dissertation, I make use of such approaches to identify more ephemeral construction techniques, such as turf walling, evidence of roofing materials, and various activity areas (e.g., food processing/storage).

Land Use and Relations in Pictland

The theme of land use assesses movement, seasonality, and agricultural regimes within the broader geographic range of Pictland. I focus my investigations on the variability of Pictish-plant/algae relationships encapsulated in the microbotanical/algae assemblages from settlements (addressed in chapters 7 and 8). This research presents a multi-scalar understanding of relations, as use of space targeted the site scale, and this theme builds upon the small-scale data to understand movement and broader geographic land use. For example, were inland sites (upland

and lowland) more, or less, in contact with the coast (e.g., as evidenced by marine diatoms)? Did coastal settlements show greater evidence for human interaction with wetlands (e.g., as evidenced by wetland plant phytoliths) in comparison to inland settlements? Overall, were the Picts living on the coast more 'coastal' than those living further inland? Or were all Picts connected with the seascape to some degree? Land use and aquatic zone use are examined through the presence and ubiquity of diatoms/microalgae to assess seasonality and the degree of aquatic interaction at coastal, upland, and lowland sites. The relative prominence of particular ecological indicator species (plants and algae) retrieved outside of their ecological niche zone is used to assess movement within Pictland.

Coastal sites, like Burghead, are likely to have the strongest evidence of seascape interaction due to their proximity to the seascape, providing readily available resources for human settlement and lifeways such as food (e.g., fish, shellfish, seaweed) and fuel (e.g., driftwood). Soil samples from Burghead's upper citadel and dental residues from animal teeth (e.g., sheep/goat, cattle, pig, and horse) address movement and aquatic interaction at coastal sites. Microbotanical and algae residues targeted within these contexts are used to interpret aquatic/terrestrial interaction and seasonality regarding animal care (i.e., watering and pasturing regimes) to better understand land use in coastal settlements. Based on the wider literature, it is expected that wetland and coastal plants will dominate the microbotanical assemblage (e.g., bulrushes and reeds) alongside agricultural plants such as barley and wheat. Historical accounts have pointed to the practices of wetland grazing of domestic livestock and the cultivation of barley and wheat as a major focus of agricultural production in coastal areas around the North Sea region (Amiaud et al. 1998; McKerracher 2018; McKerracher and Hamerow 2022). Given the later chronology of Burghead, this may be the only context where beans or other legumes are identified if Pictland follows the general pattern observed in southern Britain such as Anglo-Saxon England where crop diversification begins in the 7th–8th centuries with the uptake of flax and pea agricultural production (Banham 2014; McCormick 2014; Niehaus 2021:45).

Within upland settlements, land use may differ from practices in the coastal zone as specific resources may have been less readily available within the immediate upland environment of these settlements. Therefore, distinct evidence of movement from various niche zones that contrast with upland environmental affordances could be signaled in the microbotanical/algae record. For example, diatom frustules retrieved from wall residues can address how aquatic resources (e.g., wetland turf) were procured at settlement sites (Bathurst et al. 2010), and can potentially illuminate seasonal occupation patterns (e.g., through freshwater diatom frustules that signal presence in aquatic environments during specific seasons). Plant expectations based on the wider literature include upland plants such as heather and a dearth of wetland plants (e.g., sedges). Heather is a characteristic plant of Scottish upland environments and often dominates hillslopes alongside bog mosses, purple moorgrass (*Molinia caerulea*) and cross-leaved heath (*Erica tetralix*) (Lusby and Wright 1996:13).

As lowland contexts are few in this dissertation and subject to higher degrees of modern disturbance than coastal and upland contexts, it is difficult to hypothesize the expectations for lowland settlements. It could be expected that given the ideal landscape for agricultural production a high degree of evidence for farming and food processing would be present at lowland sites. Aquatic evidence may also be more diverse, reflecting lacustrine, riverine, marshland, and bog aquatic environments. Indeed, a higher diversity of plants overall may be observed including heathland plants, ericaceous shrubs (e.g., heather, bilberry), agricultural crops (e.g., barley, oat), wetland plants (e.g., horsetail, reeds), and trees (e.g., rowan). Within lowland settlements microbotanical and microalgae assemblages are compared with pollen evidence from Jones et al. (2021) and the signatures from coastal and upland environments to better understand the overall character of land use (e.g., movement and agriculture) in Pictland.

Microbotanical and micro-algae assemblages from Pictish sites are assessed for ecological indicator species to better understand human interaction with various ecological niche zones and overall land use. Through a relational approach I trace the network of relations between the Picts and ecological niche zones to identify which of these communities had ties to human lifeways. For example, did the Picts across various settlements (coastal, upland, and lowland) relate strongly with peat bog environments (i.e., as evidenced through high ubiquity of peat residues – chrysophytes and sedge phytoliths) for fuel and architectural qualities (e.g., as seen at Cairnmore)? By tracing relations between ecological niche zones, through the retrieval and identification of environmental indicator species within archaeological contexts, we can better understand how the Picts in coastal, upland, and lowland environments similarly or divergently interacted with diverse environments. From there, we can better hypothesize why different environments were selected for settlement, how these settlements related to each other, and what life was like within settlements and more broadly throughout Pictland.

Chapter 4: Microbotanical Approaches to Relations in Pictland

In this dissertation research, I draw from established protocols in paleoethnobotany and employ two primary methodologies to recover plant and algae microresidues: soil sampling and residue washing of artifacts and dental surfaces. Paleoethnobotanical approaches allow archaeologists to examine past environments, landscape modification, foodways, fuel use, architecture, rituals, and medicinal practices through the identification of recovered plant remains (Hastorf 1999; Morehart and Morell-Hart 2015; Pearsall 2015; Wright 2010). Archaeological research in the British Isles and Ireland has predominately targeted macrobotanical residues which typically consist of seeds and wood charcoal (Britton and Huntley 2011; de Moulins 2007:385; Lodwick 2019; van der Veen et al. 2007, 2013). Microbotanical residues, such as phytoliths and starch grains, have yet to be fully pursued in this region apart from pollen analysis, which is becoming increasingly common (Dumayne 1993; Edwards 2018; Groves et al. 2012).

Overall, paleoethnobotanical residues are exceptional proxies for human and plant elements to corroborate and complement other lines of landscape and human-environmental relationship evidence (e.g., faunal remains). Within the British Isles and Ireland, however, macrobotanical preservation is often inhibited by acidic soil conditions. Therefore, microbotanical remains such as phytoliths and starch grains offer further evidence to fill gaps in our understanding of past human-plant relationships in this region. Such evidence can also serve to corroborate and to challenge our interpretations of macrobotanical remains (Boyadijian et al. 2007; Mackay et al. 2020; Robertson and Roy 2019:13; Wright 2010:55).

Another method employed in my research is the identification of micro algae. Micro-algae residues are not fully integrated into paleoethnobotanical research, because algae are technically not considered plants as they lack stomata, xylem and phloem components of terrestrial plants. Furthermore, there are very few diatom specialists within archaeological research (Battarbee 1988; Juggins and Cameron 2010:519; Weiner 2010:23). As my research is situated within coastal landscapes and micro-algae residues have been recovered alongside phytoliths and starch grains in the archaeological samples for this project (Prado and Noble 2022), I have taken the opportunity to examine these micro-algae residues in tandem with the microbotanical assemblages. Within the context of this research, micro-algae can be divided into two types — diatom frustules and chrysophycean cysts. Diatoms are microscopic algae that thrive in most aquatic and semi-aquatic environments. Like phytoliths, diatoms are largely made up of biogenic silica, and their silica skeletons called frustules remain long past the lifespan of the diatom itself (Smol and Stoermer 2010:3). The form of the diatom frustule can be taxonomically diagnostic, and this is particularly useful as diatoms are exceptional biological monitors, meaning they are ecologically sensitive and specific species thrive within specific environments (e.g., related to aquatic pH and salinity) (Julius and Theriot 2010:8; Smol and Stoermer 2010:3). Chrysophytes are single-celled golden-brown algae that are typically present in freshwater environments (Weiner 2010:37). Similar to diatoms, these proxies reflect specific aquatic environments, often peat-bogs and other semi-aquatic environments. Together these micro-algae proxies represent a spectrum of watery environmental contexts from subaerial to deep water zones.

This chapter will summarize the paleoethnobotanical approaches and outline sampling strategies, laboratory processes, and analytical techniques used in this research. Part 1 summarizes and explains why I have chosen phytolith, starch grain, and micro-algae as proxies to examine Pictish-environment relationships. Part 2 details my sampling strategies for soil, artifact, and dental contexts. Part 3 explains the laboratory processes required after sampling, largely focused on the extraction of phytoliths from soil samples. Part 4 outlines the process of microscopic analysis and tabulation, as well as secondary analysis of the results (e.g., calculation of ubiquity). In my conclusion, I reiterate how the overall approach is used to collect a subsection of residues which reflect each site's assemblage of relations and how these data contribute to our understanding of dwelling within Pictland.

Part 1 – Microresidue Analysis in Pictland

Paleoethnobotanical approaches provide evidence related to a variety of human-environment relationships including agricultural practices, construction materials, food storage, tool use, plant processing technologies, foraging, pastoralism, ritual practices, and burial traditions (Barton 2007; Fairbairn 2010; Mosler and Hobson 2018:13; Pearsall 2007, 2015; Rowe and Kershaw 2010; Twiss 2007; Wright 2010). However, each paleoethnobotanical approach retrieves different data, so it is important to choose the appropriate methodology to best answer research questions (Pearsall 2015; Rowe and Kershaw 2010:108; Wright 2010:54). Paleoethnobotanical approaches that target microbotanical residues are also well suited to recover other types of microresidues such as diatoms and chrysophytes (Prado and Noble 2022).

This research examines how the Picts, as primarily coastal people, managed their foodways, social organization, and interactions with non-human communities within the landscapes and seascapes of Pictland. I have summarized the variety of paleoethnobotanical assessments I use in this project in **Table 4.1**. Overall, I have used two approaches: soil sampling and residue washing of artifacts and dental surfaces. These approaches were successful in retrieving the desired counts of phytoliths, starch grains, and diatom frustules in most samples and did not show any indication of modern contamination (e.g., contaminant taxa such as maize – *Zea mays*).

Table 4.1. Project Themes and Research Framework

	Examines	Toolkit / Assessment	Sample Type	Proxies
Use of Space	Activity areas Architecture Fuel use	- Spatial Patterning - Relative prominence of ecological indicators and activities	Soil	Phytoliths Diatoms
Foodways	Agriculture Animal husbandry Cooking Foraging Trade of foreign taxa Storage	- Relative taxonomic evenness between site assemblages - Relative prominence of particular taxa types - Presence and ubiquity of foreign plants	Soil Artifact residues Dental residues	Phytoliths Starch grains
Land/Sea Use	Movement Seasonality Degree of aquatic interaction	- Presence and ubiquity of diatoms/microalgae - Relative prominence of ecological indicator species	Soil Artifact residues Dental residues	Phytoliths Diatoms

Phytoliths

Phytoliths are siliceous microstructures created by the vascular system of many plants when silica is absorbed from the earth and groundwater and deposited in the plant's cell walls. After the plant dies and decays, the phytoliths are re-deposited into the soil. As phytoliths are composed of silica, they are inorganic, extremely durable, and can survive long-term in a well-preserved state. The morphology of phytoliths can be diagnostic at a variety of taxonomic levels, allowing paleoethnobotanists to interpret past plant communities and environmental contexts. As phytoliths are deposited into the soil through a decay-in-place model, their depositional context is more secure than pollen remains which are primarily circulated through the air and can thus be representative of plant communities hundreds of kilometers distant from a site.

Within Scotland, and northern Europe more broadly, it is expected that grass family (Poaceae), sedge family (Cyperaceae), aster family (Asteraceae), and possibly heather family (Ericaceae) will be represented, based on previous archaeobotanical studies in Scotland and microbotanical studies in Europe (Dal Corso et al. 2018; Jones et al. 2021; Niehaus 2021; Powers et al. 1989; Ramsay 2019). The grass family is known as one of the highest producers of phytoliths, and therefore it is expected that the majority of the phytolith assemblage will reflect various subfamilies including Panicoideae, Pooideae, Arundinoideae, and possibly Chlorideae. Panicoideae grasses characteristically thrive in dry environments (i.e., xerophytic), while Pooideae grasses thrive in temperate environments and typically consist of pasture and cereal grasses (e.g., barley – *Hordeum vulgare*). Given the temperate climate of Scotland, even within warmer periods of the Medieval era, it is expected that Pooideae grasses, such as barley, will be well represented at Pictish sites based on previous archaeobotanical research in Scotland and broader research in the British Isles and Ireland (Niehaus 2021; Ramsay 2019; McKerracher and Hamerow 2022; Oosthuizen 2013; O'Sullivan et al. 2014). Grass family plants are represented through elongate, bilobate, polylobate, bulliform, and trapeziform phytolith morphotypes (Fig. 4.1). Elongate dendritic and papillae morphotypes also represent the grass family of plants, but specifically relate to inflorescence bracts (i.e., the plant part which houses cereal grains). The retrieval of grass phytoliths can provide direct evidence for cereal agriculture, which for many

Pictish sites has been suspected (i.e., through pollen analysis) but remained unproven due to a lack of macrobotanical preservation.

The *Arundinoideae* and *Chlorideae* subfamilies of grasses are represented by bulliform phytolith morphotypes, and these include grass plants such as reeds (*Phragmites australis*). Together with sedge (Cyperaceae) morphotypes, bulliform morphotypes can indicate wetland environments. Given the northern latitude and temperate environment of Scotland, it is expected that the *Arundinoideae* subfamily would be represented by bulliform morphotypes rather than the *Chlorideae* subfamily which thrives in warmer to tropical environments. Sedge plants, which often thrive in areas with wet and inundated soils (e.g., wetlands), are represented in the phytolith record as cone morphotypes (Fig. 4.2**)**. Both sedges and grasses are classified as monocotyledonous plants, meaning they germinate with a single embryonic leaf. Within the context of Scotland grasses and sedges are found within several ecological niche zones, including grasslands and wetlands.

Plants that germinate with two embryonic leaves are known as dicotyledonous plants (or dicots) and two families are expected to be representative of dicots within this study: Asteraceae and Ericaceae. The aster family (Asteraceae) is represented through opaque perforated plate phytoliths, and heather family (Ericaceae) forms also appear to resemble these perforated plate morphotypes (Carnelli et al. 2004). Research on phytolith production in the Ericaceae family is limited (e.g., Bujan 2013; Thorn 2006), and further investigations should focus on identifying diagnostic morphotypes for this family of plants. This would be especially useful for northern European phytolith research as this family of plants is well represented in temperate European environments and within Scotland specifically (e.g., *Calluna vulgaris*) (Prado and Noble 2022).

Lastly, tabular, spheroid, and hair cell morphotypes are indicators of dicot (e.g., cleavers – *Galium aparine*) and arboreal plants (e.g., oak – *Quercus ithaburensis*) (Albert et al. 1999; Danu et al. 2020:7; Delhon et al. 2020:232; Hart 2007). However, within northern Europe these forms are not taxonomically diagnostic. Overall, the representation of dicotyledonous morphotypes is expected to be less than monocotyledonous morphotypes as a general pattern previously observed in archaeological investigations (Carnelli et al. 2004; Dal Corso et al. 2017:15; Tsartsidou et al. 2007). Delhon et al. (2020:235) notes that several studies have concluded that dicot phytolith production in temperate areas appears to be limited to leaves and woody plant parts (e.g., Kondo et al. 1994; Alexandre et al. 1997; Albert and Weiner 2001). Within this dissertation the relative recovery rate of dicots was not calculated as dicot phytoliths were extremely scarce (e.g.,

There are some limitations to phytolith analysis. The first is that not all plants produce diagnostic phytoliths, nor indeed phytolith forms (Ball et al. 2016:42). The production of phytoliths is dependent upon the silica uptake by the plant, which varies across environments and plant taxa (Wright 2010:40). Furthermore, microbotanical reference collections, which are essential for accurate identification of phytoliths and other microbotanical residues (Wright 2010:50) are rare, and most existing reference collections are not focused on northern temperate environments. To fill this lacuna, as part of this doctoral project I compiled my own reference collection for phytoliths and starch grains which is open access online (macmicrobot.omeka.net). Reference or comparative collections are created by processing plant matter to mimic natural biodegradation so the microstructures can be identified microscopically. This can be done relatively quickly and easily by grinding plant matter using a pestle and mortar, adding a small amount of ultrapure water, and pipetting this plant/water mixture onto a microscope slide. In some cases, this fresh preparation may not be sufficient and plant matter can instead be ashed using a muffle furnace at 500 degrees Celsius for 5 hours (Morell-Hart 2019a). This ash, filled with concentrated phytoliths, is then collected using a pipette to be placed in sterile containers or directly mounted on microscope slides.

Starch Grains

Starches are part of the energy storage system of many plants and in archaeological research can be used as proxies to investigate the diets of humans and animals (Haslam 2006; Loy 1994; Pearsall 2015:341; Torrence and Barton 2006). Like phytoliths, starch grains have distinctive morphological characteristics and can be taxonomically diagnostic. Furthermore, some taphonomic processes such as boiling, cutting and grinding can be interpreted through changes to starch grain morphology (Henry et al. 2009; Torrence and Barton 2006). Starch grains are identified through a variety of morphological characteristics including grain shape, location of the hilum, presence/absence of lamellae, shape of extinction cross, wall type (e.g., single wall), facets, surface texture, presence/absence of fissures, and composition (e.g., single grain or composite) (Fig. 4.3). Grain shape can include lenticular, polygonal/polyhedral, spheroid, reniform, conical/triangular, ovoid, ellipsoid, spherical, sub-spherical, and compound forms (Ahituv and Henry 2022). It is essential to rotate starch grains to perceive their 3D shape, as relying on the plan-view (i.e., 2D) creates the potential for misidentification as a starch grain may appear spherical in plan-view, but when rotated appears compressed, meaning it is actually a lenticular form. Determining the location of the hilum and shape of the extinction cross, essential for accurate identifications, requires the use of cross-polarized light. The extinction cross is a feature of starch grains created when the growth of the grain is terminated. This feature typically reesembles a cross or x-shape at varying angularities which helps with taxonomic identification. For example, the angularity of cereal grain (Pooideae) extinction crosses are 90 degrees and resemble a plus sign (+). In comparison, Fabaceae extinction crosses have bent arms and often have more than four arms due to longitudinal fissures typical of these plant Family (Henry et al. 2009).

Within this study, starch grains were extracted from dental and artifact surfaces to better understand Pictish foodways and animal care. Given the historical record from the British Isles and Ireland it is expected that most starch grains will be reflective of cereal agriculture including barley, oats, and wheat (i.e., Pooideae starch grains) (McCormick 2014; McCormick et al. 2011; McKerracher 2018; McKerracher and Hamerow 2022; Moffett 2011; Murphy 2010; Oosthuizen 2013; O'Sullivan et al. 2014; Van der Veen and Jones 2006). Cereal grains are represented in the starch record as lenticular forms. Lenticular, literally meaning lentil-like, grains are typically circular to sub-spherical (or oval) in plan-view (i.e., from above), and biconvex in side-view. Legumes such as beans, peas, and other members of the Fabaceae family are also recorded as common foodstuffs in the Medieval period (Treasure and Church 2016); however, macrobotanical evidence of these plants is rarely preserved (Treasure and Church 2016). Starch grains from Fabaceae typically have a very distinctive reniform or kidney shape and a bold longitudinal fissure. Underground storage organs (USOs) such as horseradish (*Armoracia rusticana)*, parsnip (*Pastinaca sativa)* and cattail (*Typha latifolia*) tubers can also be identified using starch grain analysis, as these plant parts often produce conical or triangular starch grains with an eccentric (e.g., off-centre) hilum and extinction cross (Cagnato et al. 2021). Overall, starch grain analysis provides information about the use of ceramic vessels and dietary regimes (animal and human) and is particularly useful for identifying plants and plant parts which rarely preserve in the macrobotanical record such as legumes and underground storage organs.

Diatoms and Chrysophytes

Diatoms, like phytoliths, are microfossils composed of biogenic silica and the morphology of these silicious cell walls can be taxonomically diagnostic (Battarbee 1988; Smol and Stoermer 2010; Stone and Yost 2020). Microscopic algae are often present in archaeological samples that target phytoliths and other microbotanical structures. However, these microscopic residues are rarely examined together in archaeological investigations given the lack of regional-specific studies of these proxies and the perceived difficulty to accurately identify these residues (Battarbee 1988; Stone and Yost 2020). Other types of multi-proxy archaeological approaches, often termed “piggy-back” approaches, have targeted phytoliths and starch grains in tandem (Canti and Nicosia 2018:32; Portillo and Albert 2011), but diatoms and other micro-algae are rarely incorporated into these studies beyond a count of specimens present in archaeological samples (Stone and Yost 2020:23). This hesitancy toward targeting diatoms and other micro-algae specimens in archaeological investigations is presumably a response to the skill required for accurate identification of these silicious microstructures as diatom species are incredibly diverse (Battarbee 1988; Stone and Yost 2020:23). However, similar to starch grains and phytoliths, diatoms can provide detailed information about environmental contexts when retrieved from *in situ* archaeological deposits (Juggins and Cameron 2010; Mannion 1987; Smol and Stoermer 2010:3). The presence of diatom residues (i.e., frustules) allows archaeologists to investigate the aquatic and semi-aquatic components of human-environment relationships, such as the collection and movement of aquatic and semi-aquatic resources (e.g., turf, drinking water, clay, etc.) (Beneš et al. 2022; Flower 2006; Hill et al. 2019; Juggins and Cameron 2010; Prado and Noble 2022; Rippon et al. 2000).

Diatoms are identified through the morphology of their silicious cell walls known as frustules which can be taxonomically diagnostic (Julius and Theriot 2010:8; Weiner 2010:26). Diatoms are typically classified into two categories: pennales (also known as pennates) or centrales (also known as 'centrics') (Fig. 4.5). Within this project I use the terms pennate and centric. The pennate form consists of the diatom valve symmetrically composed along a "plane," creating a canoe-like shape in plan-view, whereas the centric form develops radially from a central point (Julius and Theriot 2010:10). Within these two categories we can further identify diatom frustules through the presence/absence, and form of the raphid. The raphid or raphe structure is a slit-like opening within the diatom valve structure which is typically used to attach diatom cells within a colony or to a substrate surface (Weiner 2010:26). Diatoms with raphe structures have the ability to move, whereas diatoms without this structure float within water. The inclusion of the raphe structure for taxonomic identification results in three broad classes of diatoms: radially symmetric, raphid pennate, and araphid pennate (i.e., without a raphid) (Julius and Theriot 2010:10). In terms of mobility, diatoms can be classified as either 'benthic' (meaning they live attached to a substrate - with a raphe structure) or 'plankton' (floating in water - without a raphe structure) diatoms. Benthic diatoms are known to live within a spectrum of specific ecological microhabitats and include epipelic (attached to mud), epipsammic (attached to sand), epilithic (attached to rocks), rheophilic (within flowing water), and aerophilic (within subaqueous environments) habitats, to name a few (Weiner 2010:27).

The accurate taxonomic identification of diatoms is important if we want to understand the specific environmental context of archaeological deposits. However, documenting simple presence/absence of diatom frustules within deposits can also be useful when accompanied by other micro-algae and microbotanical remains (Prado and Noble 2022). Diatoms have been used to examine mud brick construction techniques within the Nile valley of Egypt (Flower 2006), to identify the function of a pit feature in the Tehuacan Valley of Mexico (Neely et al. 1995), and to interpret the wall structure of early historic houses in Iceland (Bathurst et al. 2010).

Chrysophytes are single-celled golden-brown algae typically found in freshwater systems, and like diatoms they can be used to examine specific aquatic environmental contexts (Weiner 2010:37). These micro-algae range from 2 to 30 microns and typically are spherical or balloon-shaped. Archaeological investigations have yet to prioritize the extraction and identification of chrysophytes in microarchaeological research, although these proxies can be useful as environmental indicators of wet and inundated environments alongside diatoms. Chrysophytes have been used in archaeological investigations to reconstruct paleoenvironments (e.g., Bonomo et al. 2009) and to understand long-term environmental changes, including changes triggered by human practices (Dumont et al. 1999; Tóth et al. 2019).

Part 2 – Sampling at Different Scales: Site to Sample Type

Sampling strategies for this thesis targeted botanical residues across soils and artifacts at three types of sites, while also adventitiously incorporating diatom and chrysophyte residues. Building a nuanced sampling strategy to appropriately pursue a project’s research questions is of paramount importance, as recovery of paleoethnobotanical data is determined by the choice of sampling strategy (D’Alpoim Guedes and Spengler 2015:77; Pearsall 2015:28; Wright 2010:42). Phytoliths, diatoms, and chrysophytes were retrieved simultaneously, while starch grains were targeted separately as they did not appear to preserve within soils. The lack of starch grains was assessed through quick preliminary tests of soil prior to chemical processing, which did not indicate any starch grains were present in the samples. This lack of preserved starch likely reflects the acidic soil environment (Prado and Noble 2022; Noble and Evans 2022:190), however, more comprehensive research is required to verify this hypothesis for Pictish contexts.

Sites were selected based on availability (i.e., active excavation projects) and significance. Regarding availability, all of the sites sampled were accessed through collaboration with the Northern Picts project. This project operates through the University of Aberdeen and broadly aims to expand the visibility and understanding of Pictish sites in Scotland. The sites sampled for this doctoral research include the most well-known sites from this period in Scotland: the coastal promontory fort of Burghead; the hillforts of Tap o'Noth, Mither Tap, Craig Rock, and Cairnmore; the lowland royal complex of Rhynie; and a circular enclosure complex at Balbinny.

Sampling strategies used in this project can be divided into two major categories: soil sampling and surface residue sampling. Soil sampling was further divided into horizontal blanket sampling and vertical column sampling, with the majority of this sampling strategy focused on the horizontal strategy. Phytoliths were the key proxy targeted in the soil sampling strategy, while starch grains were the key proxies for the surface residue sampling. Each strategy was employed to answer specific questions and to accommodate the archaeological deposits encountered at each site (see Figures 4.2 and 4.3 for detailed breakdown).

For example, excavations at Balbinny did not uncover any intact floor layers but did encounter a stratified ditch fill deposit. This deposit was well suited for vertical sampling which allows for plant use over time to be investigated. Vertical sampling requires a minimum deposit depth of 0.3 m (D'Alpoim Guedes and Spengler 2015:88) and most Pictish deposits do not reach this depth requirement, so the ditch fill at Balbinny provided an opportunity to test both vertical and horizontal microbotanical sampling methods. Vertical sampling strategies attempt to collect a chronology of plants across multiple soil horizons at an archaeological site within a smaller spatial context (Pearsall 2015:76). Samples were taken from archaeological soils from the earliest (or lowest) horizon and were consecutively taken moving upward toward the modern level to prevent cross-contamination (following methods outlined by Pearsall 2015:275).

The majority of soil sampling employed a horizontal sampling strategy and targeted intact floor layers (e.g., at Cairnmore and Tap o'Noth) to examine architectural details, use of space, activity areas, and foodways. Areas without intact floor layers (i.e., undetermined deposits) were also tested at Burghead, again to examine use of space and activities areas and with the overall aim of improving our understanding of the function of Pictish fortified enclosures. Floor areas were sampled by establishing a 1 m x 1 m grid over the deposit and a "pinch" sampling method was employed for each unit within the grid, meaning small pinches of soil (~20g each) were taken using a clean trowel from across each unit to create a composite sample from each unit (i.e., lot – taken across a single level unless stated otherwise [e.g., vertical sampling]). Each sample amounted to approximately 200 grams from each unit and when available "outside" or "natural" context samples were taken as well. Samples were placed in fresh plastic ziplock soil sample bags and double bagged for transportation. This horizontal blanket sampling approach is best suited to collect a higher diversity of plants present within an archaeological site as it maximizes the amount of residues recovered by taking samples from throughout a specific context (Lennstrom and Hastorf 1992:206, 211; Pearsall 2015:74).

Table 4.2. Sample contexts in this study. Burghead (H) – horizontal sampling, (V) – vertical sampling. Animal teeth abbreviations: C – Cattle, S/G – Sheep/Goat, P – Pig, and H – Horse. Breakdown of animal teeth contexts in Table 4.3.

	Soil		Pot Sherds		Animal Teeth				Human Teeth	
	# of samples	# of contexts	# of samples	# of contexts	C	S/G	P	H	# of samples	# of individuals
Balbinny	15	1								
Burghead	12 (H) 7 (V)	1 7			2	2	2	1		
Cairnmore	21	1								
Craig Rock					1	1	2	0		
Croftgowan									2	1
Dunnicaer			3	3						
Lundin Links									4	4
Mither Tap			2	1	2	2	2	0		
Rhynie			3	3						
Tap o'Noth	14	2	3	3	1	0	0	2		
TOTAL	**69**	**12**	**11**	10	**6**	**5**	**6**	**3**	**6**	5

Table 4.3. Sample contexts for animal teeth. Minimum number of individuals was not quantified due to small sample size and difficulty identifying molars sampled (i.e., unclear if molar was right or left).

	Cattle		Sheep / Goat		Pig		Horse	
	# of samples	# of contexts	# of samples	# of contexts	# of samples	# of contexts	# of samples	# of contexts
		context		*context*		*context*		*context*
Burghead	2	2	2	2	2	2	1	1
		24020 *24036*		*24035* *24047*		*24011* *24012*		*24034*
Craig Rock	1	1	1	1	2	1	0	
		T5-506		*T2-2003*		*T2-2002*		
Mither Tap	2	1	2	1	2	1	0	
		1005-SE		*1005-SE*		*1005-SE*		
Tap o'Noth	1	1	0		0		2	1
		16011						*16011*

Surface residue samples employed a three-wash process upon artifact and dental surfaces. This process has been successfully used in archaeological investigations of early hominin diets (Boyadjian, C.H.C. et al. 2007; Henry et al. 2011; Lalueza Fox and Pérez-Pérez 1994; Scott Cummings and Magennis 1997) and domestic animal diets (Middleton and Rovner 1994; Weber and Price 2015). The three-layer wash process consists of a dry wash, a wet wash, and a sonicated wash which effectively extracts adhering residues from the outermost to the innermost surface. The first wash (dry) is performed by gently brushing off the outer layer of soil adhering to an artifact or dental surface into a petri dish using a gloved hand (sterile, nitrile powder-free gloves are used) (Hart 2011:3246; Pearsall 2015:360). The second wash (wet) follows the same process with the addition of ultrapure water, which again is collected into a petri dish and then pipetted into a sample tube (e.g., 50mL centrifuge tube). The third and final step is the sonication wash which allows the microbotanical (and micro-algae) residues adhering to the cracks and grooves of an artifact or dental surface to be released (Barton 2007:1752; Hart 2011:3247; Pearsall 2015:360). Using a handheld sonication device, the artifact or dental crown is exposed to sonication while being partially submerged in ultrapure water. For ceramic sherds, ultrapure water can be carefully added to the convex sherd surface and the sonicator tip can be submerged in this water (Berubé et al. 2020; Morell-Hart 2015; Morell-Hart et al. 2014, 2019; Pearsall et al., 2004:427). Dental sonication involves holding a tooth by the root and submerging the crown into a petri dish with ultrapure water, while holding the sonicator near to the submerged tooth’s surface. In larger artifacts, like quern stones, plastic wrap may be used to portion off part of the artifact for sampling. Optimal duration of sonication time is approximately five minutes (Pearsall 2015:360). Once the sonication is finished, the distilled water from the sonication wash is pipetted out of the petri dish and into a sterile container (e.g., 20 mL centrifuge tube). In some cases, archived artifacts might be the only available surfaces for microbotanical residue sampling; therefore, additional control samples may be beneficial to gauge contamination (Hart 2011). For example, if a mandible fragment with embedded molars is being sampled, the bone area where it was likely handled without gloves can be sampled for comparison with the dental surface extractions.

Part 3 – Laboratory Processes

Soil samples were processed at the McMaster Paleoethnobotanical Research Facility (MPERF) where they were processed using MPERF protocols for extracting phytoliths from sediments and soils (Piperno 2006; Morell-Hart 2018) (See Appendix A). This process involves soil sterilization, deflocculating samples in water, dividing soils into A/B and S fractions, clay removal, microwave chemical digestion, and flotation of phytoliths. For the Pictish contexts, processing took an average of twenty-six days for batches of approximately 20 samples.

As the samples were collected from a foreign country (i.e., outside of Canada), the soil samples were first sterilized in a muffle furnace at 200 degrees Celsius for six hours to remove the risk of soil-borne contamination. The samples were then transferred to 1000mL beakers, and 2 Tbsp of sodium bicarbonate was added. Beakers were filled with hot water and stirred every 15 minutes to break up clumps of soil. Next, the samples were divided into sand (S), larger soils (D), and fine/coarse soils (A/B) using U.S.A. Standard Testing sieves No. 35, No. 60, No. 270, and base pan. S fractions were collected from sieve No. 270 into 50mL centrifuge tubes, and A/B fractions from the base pan were each transferred to a 1000mL beaker. These A/B fractions required a clay removal step and so the samples were stirred, allowed to sit for one hour, slowly poured off the upper 400mL, re-added hot water, then repeated until the water was clear of suspended clay for all samples. Once clear, the A/B samples were transferred to 50mL centrifuge tubes (Appendix A).

Samples were centrifuged for 5 minutes at 1000rpm to concentrate the sample at the base of the centrifuge tube, and excess water was poured off, leaving a damp soil plug in the tube. Ten grams of each soil plug was weighed into 600mL beakers for the chemical digestion process. To this soil was added 3mL of hydrochloric acid (10% aqueous solution), 5mL of nitric acid (68 – 70% aqueous solution) and 1mL of hydrogen peroxide (30% aqueous solution). Once all three chemicals were added, samples were transferred to microwave vessel tubes and heated in the MARS 6 microwave digestion system for 130 minutes at 180 degrees Celsius for 55 minutes (plus 22 minutes ramp time to reach 180 ℃). Samples were allowed to sit in the microwave overnight after processing, then transferred from microwave tubes into 50mL centrifuge tubes and centrifuged at 3000rpm for five minutes. The chemical supernatant from each tube was poured off, then samples were subject to two rinses using ultra-pure water.

Following chemical digestion and rinsing, the samples were floated using heavy liquid (sodium polytungstate solution). This solution was added to each 50mL centrifuge tube sample, agitated, then centrifuged for five minutes at 1000rpm to allow phytoliths to rise to the surface of the tube. Phytoliths were extracted using a pipet to skim the surface of each sample and transferred to a 15mL centrifuge tube. This process was repeated for two extractions total from each sample. The samples were then isolated from the heavy liquid by filling the 15mL tube with ultra-pure water, centrifuging for 10 minutes at 1000 rpm and then pouring off the supernatant. This process was repeated for a total of three washes until the sample was clear. After the final pour-off, approximately 3mL of acetone was added to the sample, centrifuged for 10 minutes at 1500rpm, and poured off. Samples were uncapped, covered with parafilm, and placed under a fume hood for one week to dry completely. Once dry, the samples were mounted onto glass microscope slides using a pipet, covered with 1–3 drops of immersion oil and a glass coverslip.

The surface residue samples did not require further laboratory processing past the sampling process. This is one of the advantages to surface residue sampling as it is a quick extraction process and typically does not require harsh chemicals before microscopic analysis. Some paleoethnobotanists find it useful to centrifuge the samples to concentrate them at the base of the centrifuge tube and to pour off the ultrapure water (Pearsall 2015:360; Perry 2001). I did not find that this step was necessary for my samples and instead focused on pipetting from the bottom of the tube where soil and starch grains had settled, which was sufficient to mount samples onto a microwave slide in the ultrapure water.

Part 4 – Identification, Tabulation and Analysis of Microresidues

Identification of microresidues in each sample extraction was conducted at the MPERF using a Zeiss microscope for transmitted light microscopy (200x, 400x, and 630x magnifications). Each divided soil sample (A/B and S fraction) was mounted onto a microscope slide and thoroughly scanned for diagnostic phytoliths, starch grains, diatom frustules, and chrysophytes. Phytolith morphotypes (e.g., Poaceae bilobates) were counted to a minimum of 200 counts per sample (combined A/B and S fractions) following recommended practice (Albert et al. 1999; Albert and Weiner 2001; Pearsall 2015).

Phytolith morphotypes were described using the International Code for Phytolith Nomenclature (ICPN) 1.0 and 2.0 when possible (Madella et al. 2005; Neumann et al. 2019). Starch grains were described following Ahituv and Henry (2022), Piperno and Dillehay (2008), Torrence and Barton (2006), and Yang and Perry (2013). Grass phytoliths (Arundinoideae, Chlorideae, Panicoideae and Pooideae subfamilies) were identified following Albert et al. (2008), Ball et al. (1999), Barboni and Bremond (2009), Dal Corso et al. (2017), Fahmy (2008), Fredlund and Tieszen (1994), Lancelotti and Madella (2012), Madella (2007), Novello and Barboni (2015), Neumann et al. (2009), Piperno (2006), Portillo and Albert (2011), Portillo et al. (2006), Rosen (1992), Stromberg et al. (2007), and Twiss et al. (1969). Sedge phytoliths were identified following Ollendorf (1992). Dicotyledonous phytoliths were identified following Garnier et al. (2013), Neumann et al. (2009), Piperno (2006), Portillo and Albert (2011), and Stromberg et al. (2007). Lenticular cereal starch grains were identified following Hart (2011), Henry et al. (2009), Yang and Perry (2013), Micro-algae such as diatoms and chrysophytes were counted separately (although synchronously) from the phytoliths and starch grains, and were described and tentatively identified using ICPN 2.0, Jüttner et al. (2022), Spaulding et al. (2022), and Stone and Yost (2020).

All tabulation and secondary analyses were carried out using Excel, including the pivot table function. Each specimen was tabulated with morphological information, such morphotype (e.g., lenticular starch grain), size (e.g., 20 microns), lamellae (e.g., present or absent), hilum (e.g., centric or eccentric), extinction cross (straight), fissures (e.g., longitudinal), and cooking damage (e.g., present – blurred extinction cross) Secondary analyses included calculating 1) the relative prominence of ecological indicators (e.g., wetland taxa), 2) the relative prominence of human activities (e.g., grain processing), 3) the ubiquity of major plant groups (e.g., monocots and dicots) and micro-algae, and 4) the richness of plant taxa within sample contexts. Procedures and results of each specific analysis are detailed in the following chapters.

Summary of Analytical Techniques

Although microbotanical and micro-algae analyses are understudied in northern temperate regions, these approaches can provide robust data to interpret architectural features, foodways, use of space, activity areas, movement, and seasonality related to archaeological sites. Such approaches are especially valuable in environments where organic preservation is rare and macrobotanical analysis is extremely limited. The findings from this project suggest that microbotanical analysis is a very useful technique for archaeological sites and contexts where settlement remains are sparse and difficult to interpret, as is the case for early medieval Scotland.

Microbotanical residues can be used to interpret architectural details otherwise lacking direct evidence such as the character of the materials used for flooring or roofs (e.g., Cairnmore) (Prado and Noble 2022). These residues are also useful to confirm the presence or absence of cereal agriculture through cereal inflorescence bract phytoliths (e.g., at all sites sampled). The recovery of microbotanical and micro-algae from archaeological deposits is not always straightforward, as taphonomic processes affect individual specimens and contamination during excavation can complicate assemblages (Shillito 2013:76); however, most of the residue signatures in the project suggest that the sampling contexts were not significantly disturbed post-abandonment nor during the excavation process. Microbotanical analysis was successful in retrieving the desired counts of phytoliths and starch grains across the sampling areas. As I describe in the next several chapters, this methodology proved effective in providing new data to interpret fortified settlements and the wider landscape of Pictland. Micro-algae analysis is still in its infancy within archaeological practice; however, this proxy proved valuable to better characterize Pictish-environment relationships by including aquatic and semi-aquatic environments.

Chapter 5: Microresidue Results: Phytoliths, Starch Grains, Diatoms, and Chrysophytes

Paleoethnobotanical approaches retrieve direct evidence of past human-plant relationships from archaeological contexts, and this dissertation presents a novel case study which targeted microbotanical and microalgae residues across Pictland. In this study, I examined over 100 contexts (n= 106) which covered 10 sites and included artifacts such as pot sherds (n= 11), occupation soil layers (n= 71), human teeth (n= 6), and animal teeth (n= 23). Approximately fourteen species represent the minimum number of plant taxa recovered. Microbotanical and microalgae residues were successfully retrieved from all sites studied. These findings demonstrates that paleoethnobotanical methodologies are effective at Pictish sites where macrobotanical remains (such as seeds) are limited in the archaeological record (Pearsall 2015:253; Piperno 2006:1; Shillito 2013:72).

This chapter presents the results from the paleoethnobotanical analyses described in Chapter 4 and is divided into five main parts. Part 1 focuses on phytoliths recovered predominantly through soil samples across a spectrum of archaeological contexts at Pictish sites (e.g., hearths, floor layers, ditch fills). Phytolith results are discussed using two biological categories: monocotyledonous plants (e.g., grasses) and dicotyledonous plants (e.g., asters), to describe various plant communities more clearly such as grasslands and heathlands. Part 2 describes the results of starch grain analysis from dental and pot sherd residue contexts and includes starch grains from cereals, geophytes, and unidentified/tentatively identified taxa. Part 3 characterizes the microalgae residues: diatoms and chrysophytes and provides tentative identifications as no diatom expert was available for confirmation of taxonomic identification. Part 4 provides a breakdown of results in connection to depositional contexts (i.e., soil, teeth, and artifacts). Part 5 briefly outlines the secondary analyses used to synthesize and describe the data: relative prominence of ecological indicators, relative prominence of human activities, ubiquity of important plants, presence/absence of micro-algae, and richness of plant taxa within sample contexts.

I provide a quick overview of my results and types of samples in Table 5.1. In rare instances, other types of microremains were recovered in trace quantities alongside the targeted microremains. Parasites, hair follicles and feather barbules were photographed but were not considered for contribution toward this study. One interesting case, a feather barbule, was retrieved from the dental wash of a horse from the lower citadel at Burghead. This potentially suggests post depositional inclusions as the lower citadel is notable for its significant deposit of zooarchaeological remains. Broadly, however, the results suggest that the Picts established relationships with both domesticated plants (e.g., barley and oat crops) and wild plant communities such as heathlands (e.g., Asteraceae, Ericaceae), grasslands (e.g., Poaceae), forests, peatlands (e.g., chrysophytes), and marshlands (e.g., Arundinoideae, Cyperaceae).

Table 5.1 Plant Taxa Recovered through Microbotanical Analysis. Numbers in brackets represent tentative identifications (cf.).

Taxon	**Type of Microremain**		**Total Count**	**Type of Sample**			
	Phyto	Starch		Sediment	Pots	Human Teeth	Animal Teeth
Asteraceae sp.	71		71	X			
Asteraceae sp. / Ericaceae sp.	13		13	X			
Cyperaceae sp.	95		95	X			
Poaceae (TOTAL)	917	30 (30)	966 (21)				
Poaceae Arundinoideae	13		13	X			X
Poaceae Chlorideae	2		2				X
Poaceae Panicoideae	304		304	X	X	X	X
Unknown Poaceae	275		275	X	X	X	X
Poaceae Pooideae	323	18 (9)	360 (9)	X	X	X	X
Pooideae – *Hordeum* sp.		11 (9)	11 (9)		X	X	X
Pooideae – *Avena* sp.		1 (12)	1 (12)		X	X	X
Unident Arboreal	40	2	42	X			X
Unident Geophyte		(2)	(2)			X	X
Unident cf. *Quercus*		(1)	(1)			X	
Unident Unident	225	32	246	X	X	X	X
TOTALS	1361	97	1458	1203	58	22	173

Part 1 – Phytoliths

Phytoliths were targeted to examine activity areas, architecture, agriculture, animal feeding regimes, and movement. These siliceous microbotanical residues were primarily recovered from soil samples of intact features identified during archaeological excavations of Pictish sites (Table 5.1). Phytoliths were also recovered from dental and pot sherd residues although in trace quantities. Some phytoliths appeared partially dissolved or weathered which likely reflects the acidic soil conditions, and these degraded phytoliths were not counted (i.e., did not contribute to this data). Many of the degraded phytoliths were of the elongate entire (Poaceae) and scutiform (unidentified taxa) morphotypes.

Monocotyledonous plant taxa, which germinate with a single embryonic leaf (typical of grasses), were the most represented in all samples, and phytoliths from the monocot grass family (Poaceae) had the highest total counts across all soil contexts. This is unsurprising as the grass family is known as one of the highest producers of phytoliths (Delhon 2010; Delhon et al. 2020:231; Morell-Hart 2019b:236; Twiss 1992). Within the Poaceae family, the subfamilies Panicoideae (characteristically xerophytic – thriving in dry environments, e.g., needle grass – *Stipa capensis*) (Morell-Hart 2019b:236) and Pooideae (characteristically temperate – consisting of pasture and cereal grasses, e.g., barley – *Hordeum sp.*) are the most prominent, with rarer occurrences of Arundinoideae and cf. Chlorideae subfamilies (as evidenced by bulliform morphotypes, e.g., common reed – *Phragmites australis*). It is important to note that there is a substantial degree of morphotype overlap within the grass subfamilies; however, genus-level identification is not necessary for nuanced reconstructions of past grassland communities (Piperno 2006:33).

Overall, the grass family is represented through bilobate, cylindrical polylobate, trapeziform sinuate, and elongate entire morphotypes (Figure 5.1). Phytoliths representative of cereal inflorescence bracts (i.e., elongate dendritic and papillae phytoliths) were also recovered in highly variable quantities (Figure 5.1D–E). Elongate dendritic phytoliths were recovered from 50% of the sites studied and in 100% of the sites studied through soil sampling. The identification of these phytoliths verifies the presence of cereal inflorescences and supports other evidence of crop processing activities (e.g., threshing/winnowing) at Balbinny, Burghead, Cairnmore, Mither Tap, and Tap o'Noth. Elongate dendritic phytoliths can be identified to the species level if recovered in articulated forms or using morphometric analysis (Ball et al. 1996, 1999, 2009, 2016, Rosen 1992). Morphometric analysis was not pursued for this investigation as starch grain analysis allowed for more nuanced identification of cereal starch grains which are more easily identifiable without technical software. Rondel morphotypes also contribute to our understanding of cereal production in Pictland (albeit to a lesser degree than elongate dendritic phytoliths) as they are also produced in the inflorescence bracts, culms, and leaves of cereal grasses (Piperno 2006:32). The recovery of Pooideae phytoliths in this study suggests the Picts cultivated and processed cereal grasses (Pooideae) as part of their agricultural practices and processed these cereals within their settlements (see Chapters 6 and 7). Panicoideae phytoliths point to grass species which thrive in drier environments (e.g., needlegrass) which may have been used for thatching, flooring, and domestic animal pastures (see Chapter 6 and 7).

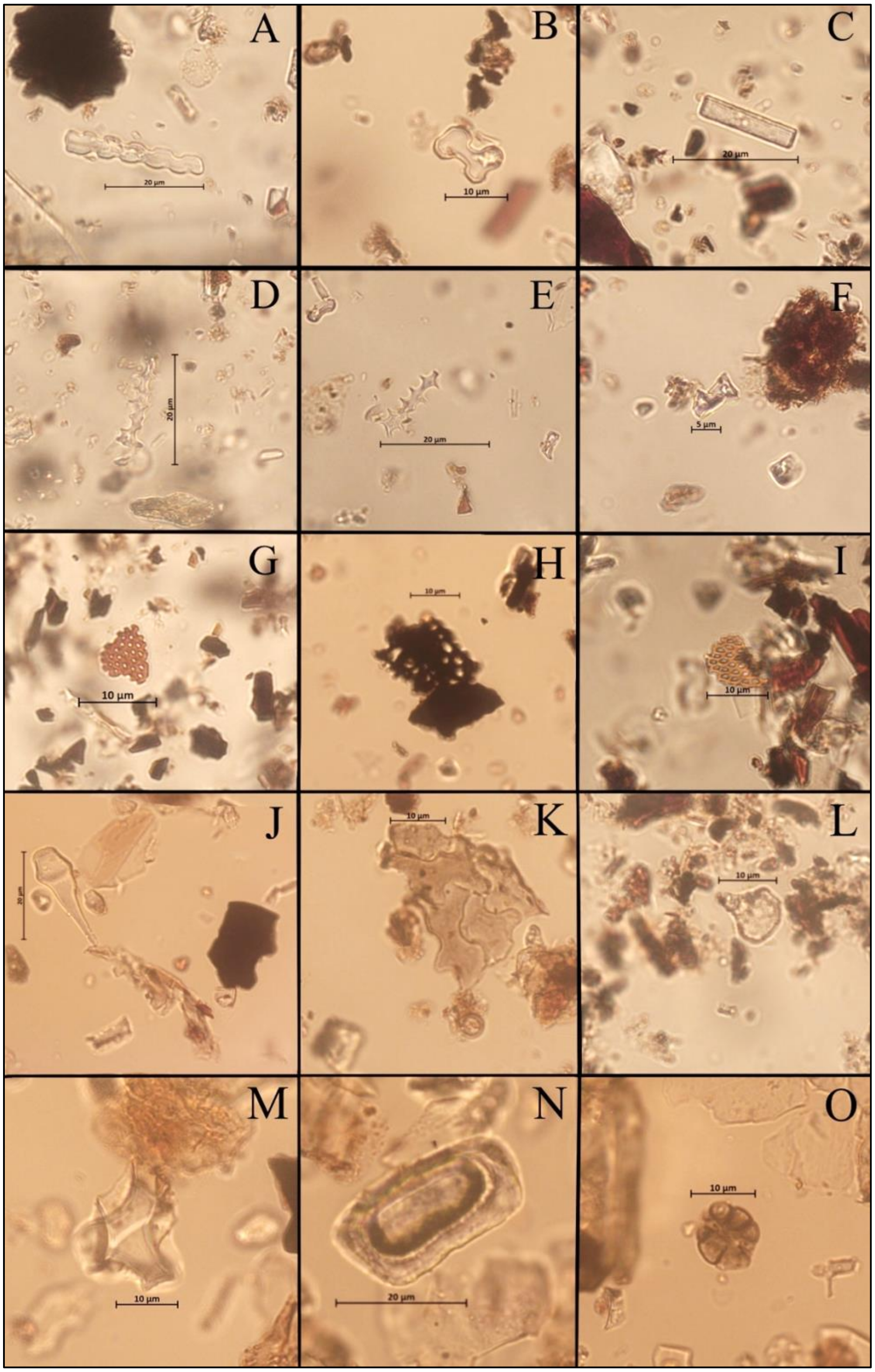
Cone-shaped phytoliths were occasionally identified, indicating the presence of sedge family (Cyperaceae) taxa (Carnelli et al. 2004:51; Morris et al. 2009; Ollendorf 1992). These cones were the most important morphotype for identifying sedges in Pictish archaeological contexts. However, infrequent acicular phytoliths morphotypes were present within the Cairnmore samples which appeared very similar to morphotypes present in common club-rush (*Schoenoplectus lacustris*) (Fig. 5.1F) and contributed to sedge tabulation (i.e., alongside cone phytoliths). The presence of sedges can be used to infer interaction with wetland ecological niche zones as these plants thrive in areas with wet and inundated soils. Modern communities of sedges in Scotland are found in a wide spectrum of wet environments including wet heaths, mires, blanket and raised bogs, acidic moorlands, the margins of ponds and lakes, fens, saltmarshes, and swamps (to name a few) (Preston et al. 2002). Although species identification is not possible through phytolith analysis, key Cyperaceae species may include pendulous sedge (*Carex pendula*) which is native to the British Isles and has been used for making rope and mats (Milliken and Bridgewater 2004: 108).

Dicotyledonous morphotypes (representing plants that germinate with two embryonic leaves) such as opaque perforated plates, spheroid, tabular, jigsaw, facetate, hair cell, and stomata phytoliths were retrieved (Fig. 5.1G–O). Opaque perforated plates were prominent at Tap o'Noth and Cairnmore, indicating residues from the aster family of plants (Asteraceae). However, some of these perforated plate morphotypes also resemble morphotypes from the heather family (Ericaceae) identified by Carnelli et al. (2004), and others appear similar to vascular tissues, potentially from tubers (Morell-Hart p.comm 2022). Research on phytolith production in the Ericaceae family is limited (e.g., Bujan 2013; Thorn 2006), and further investigations should focus on identifying diagnostic morphotypes for this family of plants. This research would be especially useful for northern European phytolith studies as this family of plants is well represented in temperate European environments and within Scotland specifically (e.g., *Calluna vulgaris*). Although phytolith analysis is limited to identification at the family level for Asteraceae and Ericaceae plants, key species likely include heather (Ericaceae) and a variety of Asteraceae species such as burdock, dandelion, yarrow, and daisy. These species were used for spectrum of applications that are well attested by historical and folk sources, including as bedding materials, dyes, medicinal ingredients, and for crafting (e.g., basketry).

Tabular, spheroid, hair cell, and jigsaw morphotypes were counted as dicot specimens following Albert et el. (1999), Danu et al. (2020:7), and Delhon et al. (2020:232). Arboreal phytoliths such as facetate and conifer morphotypes were recovered in trace quantities (Figure 5.1M–N). Overall, dicotyledonous morphotypes were less represented than monocotyledonous morphotypes; however, this follows the general pattern observed in archaeological investigations (Carnelli et al. 2004; Dal Corso et al. 2017:15; Tsartsidou et al. 2007). These morphotypes potentially represent local conifers (e.g., pine) used by the Picts for fuel or as building materials (Milliken and Bridgewater 2004).

Table 5.2 Breakdown of Samples for Dissertation. S - soil sample, D - dental extraction sample, A - artifact extraction sample. BHF – Burghead, DUNC – Dunnicaer, LL – Lundin Links, ToN – Tap o'Noth, CM – Cairnmore, MTap – Mither Tap, CG – Croftgowan, REAP – Rhynie, BAL – Balbinny, CR – Craig Rock. Detailed breakdown of contexts and species are outlined in Tables 4.2 and 4.3.

Coastal					**Upland**					**Lowland**				
	S	D	A	Total		S	D	A	Total		S	D	A	Total
BHF	19	7	0	26	ToN	14	3	3	20	REAP	0	0	3	3
DUNC	0	0	3	3	CM	21	0	0	21	BAL	15	0	0	15
LL		4		4	MTap	0	6	2	8	CR	0	4	0	4
					CG		2		2					
Total	19	11	3	33		35	11	5	51		15	4	3	22


A
20 µm
B
10 µm
C
20 µm
D
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E
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F
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G
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H
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J
20 µm
K
10 µm
L
10 µm
M
10 µm
N
20 µm
O
10 µm

Figure 5.1 Common phytolith morphotypes retrieved from Pictish Sites (400x). (A) Cylindrical polylobate –Panicoideae, (B) bilobate –Panicoideae, (C) elongate entire – Poaceae, (D – E) elongate dendritic [inflorescence bract] –Pooideae, (F) cones – Cyperaceae, (G) opaque perforated plate – Asteraceae/Ericaceae, (H) opaque perforated plate – Asteraceae, (I) vascular tissue, possibly from a tuber, (J) hair cell – Dicot, (K) jigsaw – epidermal tissue, Dicot, (L) bulliform – Arundindoideae, (M) facetate – Arboreal, (N) conifer morphotype – Arboreal, (O) stomata – Dicot, cf. *Calluna vulgaris*.

Part 2 – Starch Grains

Starch grains were recovered exclusively from teeth and artifact surfaces, as any starch residues that may have been present within the soil samples would have been burned away during chemical digestion processing for phytoliths. However, small amounts of soil from the Cairnmore samples were briefly scanned for starch grains before processing and no starch grains were identified during microscopic analysis. Given the highly acidic soil conditions, it is probable that starch grains might not preserve in most soil contexts. This is further supported by a lack of starch grains retrieved in dry wash samples, which represent the external layers of artifact and dental residues. Starch grains were recovered using the three-layer wash method outlined in Chapter 4, and targeted Pictish human teeth (n= 6**;** 5 individuals) from Lundin Links (n=4) and Croftgowan (n=1), pottery sherds (n= 11; 10 pots) from Mither Tap (n=1), Tap o'Noth (n=3), Rhynie (n=3), and Dunnicaer (n=3), and animal teeth (n=23; 15 minimum individuals) from Burghead (2 cattle, 2 sheep/goat, 2 pig, 1 horse), Tap o'Noth (1 cattle,1 horse), Mither Tap

(1 cattle, 1 sheep/goat, 1 pig), and Craig Rock (1 cattle, 1 sheep/goat, 1 pig) (Tables 4.2, 4.3, 5.2).

Cereal type starch grains (Pooideae) such as oat (*Avena* sp.), barley (*Hordeum vulgare*), and possibly emmer wheat (*Triticum dicoccum*) were the most frequently represented in this study (Fig. 5.2). These starch grains are lenticular in form, appearing circular to sub-circular (i.e., oval) in plane-view (view from above) and bi-convex in side-view (Fig. 5.2: 2A–B). Oat starch grains are often also polyhedral in form (Fig. 5.2: 1A-B). Several starch grains (18% of total recovered) were too damaged for accurate identification; however, in some cases a tentative identification could be made (marked as *cf.*). Cereals were ubiquitous economic taxa identified in this study and were likely the main agricultural component of the Pictish economy. The microbotanical evidence suggests cereal inflorescences were processed (i.e., threshed and winnowed) within fortified enclosures and likely near individual dwellings (see Chapters 6 and 7).

Non-cereal starch grains were present in rare quantities, and tentative identifications of these non-cereal taxa include acorn (*Quercus sp.*), and unidentified geophytes (e.g., tuber, rhizome, or other underground storage organ) (Fig. 5.2: 4A–B). The possible acorn starch grain was triangular in form; however, it is also likely that this example is a transitory starch grain (not diagnostic) and could have been originated from several starch producing plants. Unidentified geophytes included ellipsoid and pyriform starch grains with eccentric hila – all diagnostic characteristics of underground storage organs, tubers, and rhizomes. Surprisingly, no legume starches were recovered. Legumes (Fabaceae), such as peas and beans, are known to have been grown and consumed in southern Britain and in Ireland during the Pictish period (Treasure and Church 2016). However, this study did not identify any evidence for the production or consumption of legumes within Pictland. Unidentified geophyte and cf. acorn starch grains may point to economic practices such as foraging. Evidence for foraging wild plant foods in Scotland can be traced back to the Neolithic period as evidenced by macrobotanical remains such as hazelnut shells, cherry stones, and seeds from berries (e.g., raspberry) (Dickson and Dickson 2000).

Various indicators of starch damage from cooking were observed in approximately 26% of starch grains retrieved from pot sherd residue contexts and 28% of starch grains retrieved from human teeth contexts. These percentages do not include starches that were too damaged for identification; however, such starches could also have been cooked but were too damaged to identify taxon or cooking damage. Therefore, I suggest these results represent a minimum estimation of cooking evidence. Cooking damage includes blurred or blown extinction crosses (Henry et al. 2009) (Fig. 5.3). Such damage was not always consistent across starch grains within samples (i.e., mixed contexts with both damaged and undamaged starch grains).

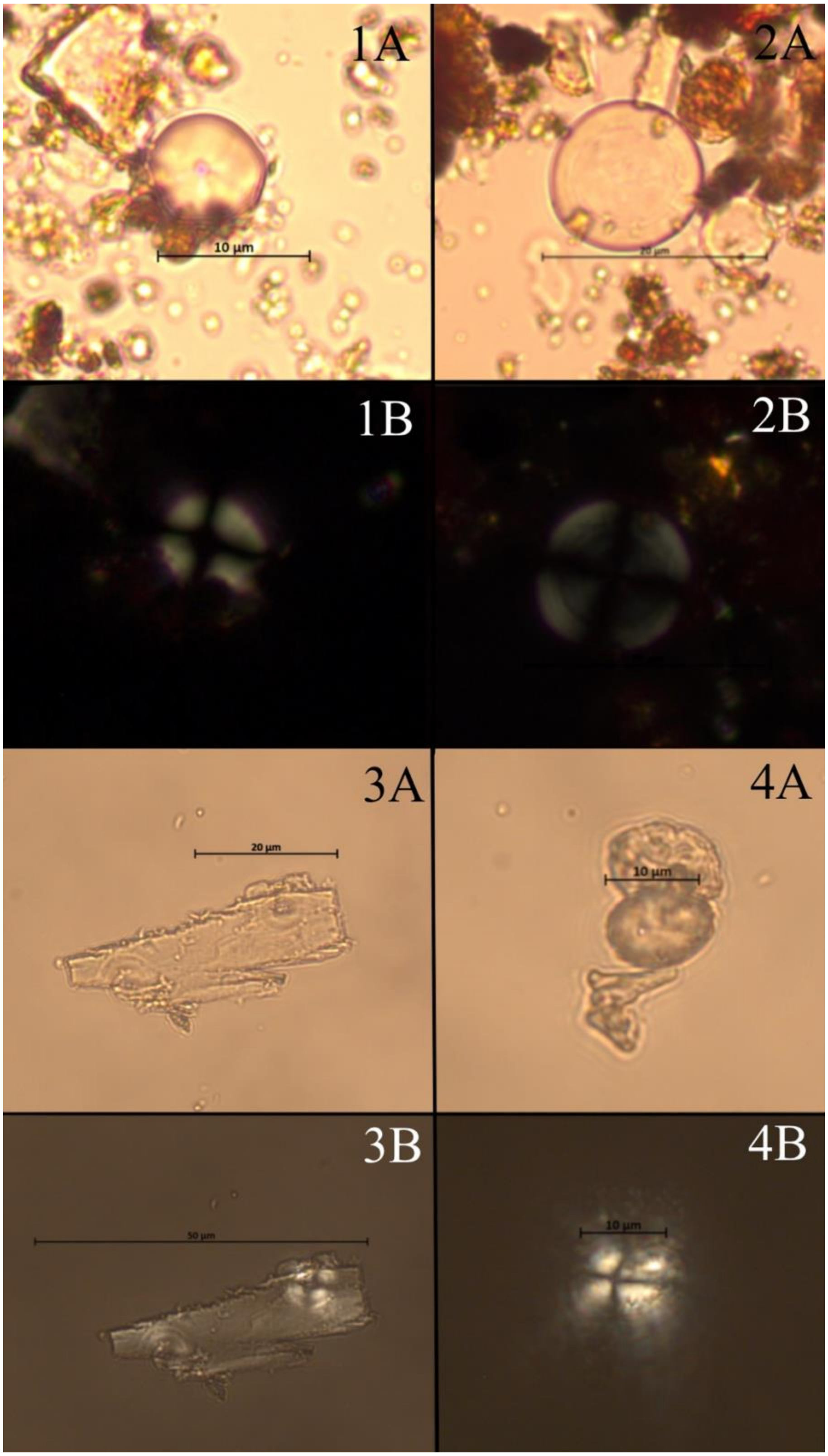
1A
10 µm
2A
20 µm
1B
2B
3A
20 µm
4A
10 µm
3B
50 µm
4B
10 µm

Figure 5.2 Notable starch grain morphotypes from Pictish sites (400–630x). (1A-B) lenticular with pressure facets – *Avena*, (2A-B) lenticular – *Hordeum*, (3A-B) softwood fiber – Arboreal, (4A-B) ellipsoid – Unidentified Geophyte.

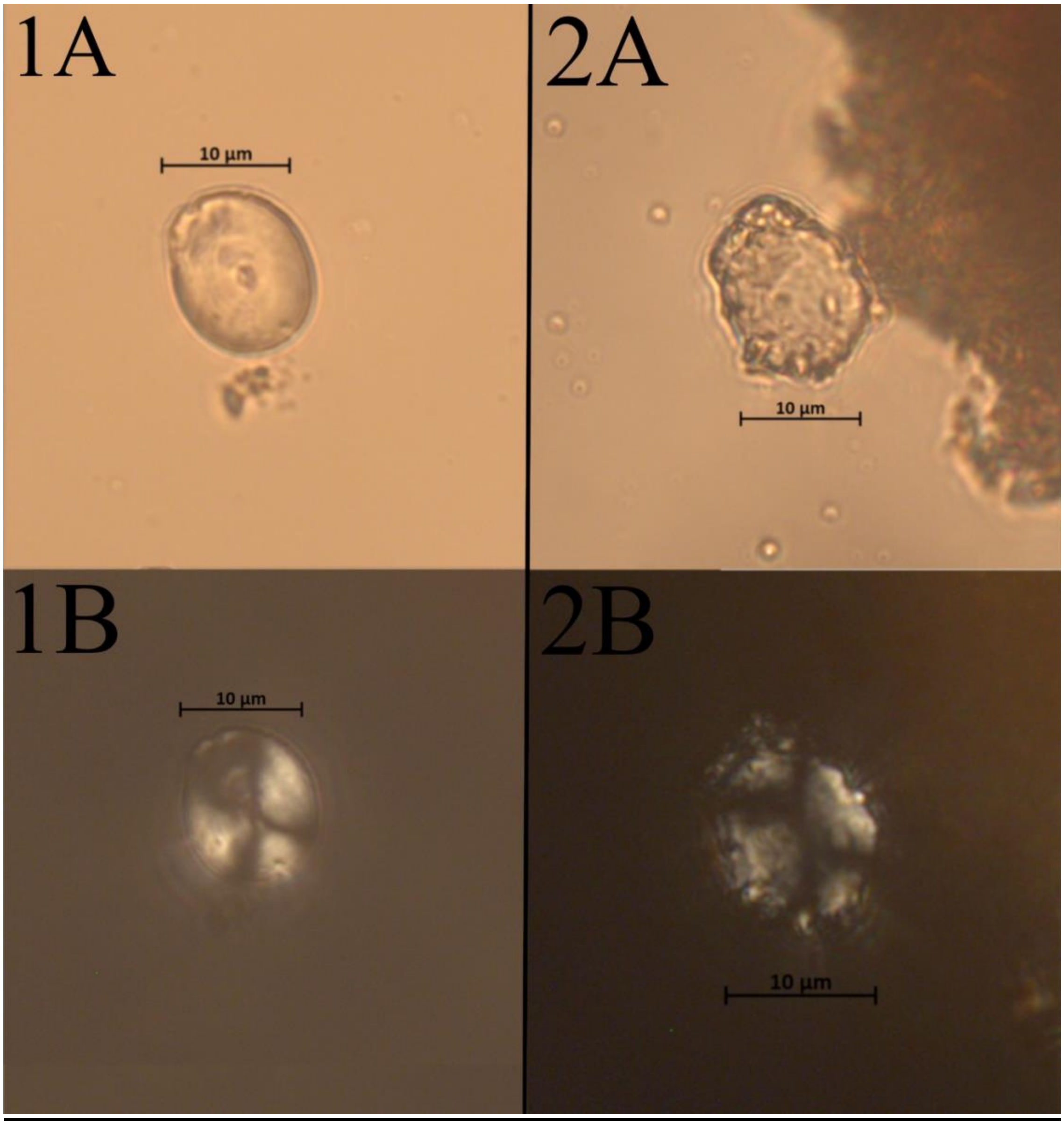

Figure 5.3 Cereal-type starch grains with cooking damage – blurry extinction crosses and rugose surface (right) (400x). Although 2B has an extinction cross that is consistent with Fabaceae, this grain was lenticular in form (i.e., cereal type).

Part 3 – Microalgae: Diatoms and Chrysophytes

Diatom frustules and chrysophytes were present in most of the samples in soil, teeth, and artifact contexts and were counted synchronously alongside phytoliths and starch grains in each sample (Table 5.3). These aquatic microstructures are essential for indexing interactions with semi-aquatic and aquatic environments. Accurate identification of diatom frustules can be challenging as diatoms are the most diverse protists (Spaulding et al. 2022; Stone and Yost 2020:23); however, this presents interdisciplinary opportunities for paleoethnobotanists and microbiologists (among other specialists) to work together on environmental archaeology research to aid future identification. Within the samples, tentative identifications were assigned for complete diatoms with redundant morphotypes (Figure 5.4) following Jüttner et al. (2022), Spaulding et al. (2022), Stone and Yost (2020) and Denys (1991). Chrysophytes retrieved in these samples largely consisted of small spherical forms and stomatocysts with smooth and rugose ornamentation. Round chrysophyte specimens appear similar to the *C. pseudodiachloros* and *C. elegans* forms recovered from peat bogs by Cambra (2010) in Spain. However, verification from diatomists is needed to fully confirm these identifications. Interestingly, no diatoms or chrysophytes were recovered from human teeth. Such residues might be present as post depositional contamination or may be indicative of aquatic food consumption (e.g., seaweed). However, as of yet no studies have examined microalgae residues present on human teeth.

Many plant taxa contributed to the Pictish economy, and this study has retrieved evidence for a variety of plant and algae communities used for architecture (e.g., peat turf) and foodways (e.g., cereals), Turf was collected to form well-insulated and waterproof roundhouse walls which supported roofs thatched with heather, asters, and grasses (see Chapter 6). Cereals, such as barley and oats, were cultivated, stored, and cooked to feed the Picts and their domestic livestock (see Chapter 7). Furthermore, these foodways were likely supplemented by foraged plant foods such as tubers, nuts, and berries.

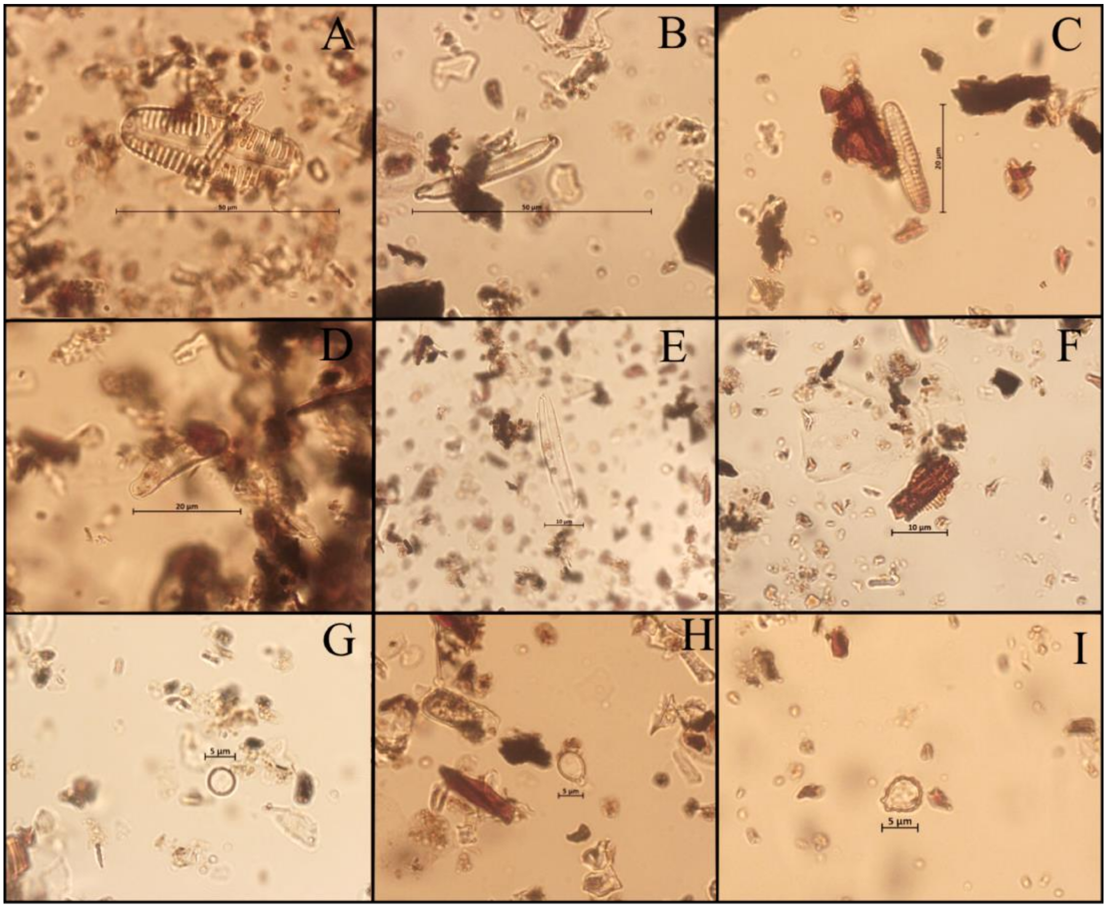

Figure 5.4 Diatoms and chrysophytes commonly retrieved in this study (viewed at 400x). All identifications are unverified by a diatomist (A) cf. *Achnanthidium* sp., (B) cf. *Hanzschia* sp., (C) cf. *Pinnularia* sp., (D) cf. *Eunotia* sp., (E) cf. *Pinnularia* sp., (F) burnt fragment of cf. *Navicula* sp., (G – I) chrysophycean cysts.

Table 5.3 Presence/Absence of Microalgae in Pictish Archaeological Contexts

Morphotype	Total Count	Soil	Pots	Human Teeth	Animal Teeth
Diatom	443	X	X		X
Chrysophytes	8355	X	X		X

Part 4 – Depositional Contexts (Soil, Teeth, and Artifacts)

To investigate human-environment relationships and the influence of plants and algae on Pictish social organization multiple depositional contexts were targeted to maximize the recovery of plant taxa: soil, teeth (animal and human) and artifacts (i.e., pot sherds). These human-environment relationships are outlined in **Table 5.4** which highlights ecological indicators recovered from each site, potential agricultural evidence from Pooideae microremains, presence/absence of diatoms and chrysophytes, and plant species richness (minimum taxa).

Table 5.4 Ecological Indicators, Agricultural Evidence, Presence/Absence of Microalgae, and Plant Species Richness in this Study. Arranged according to topographic zone and earliest to latest. Minimum total number of plant species recovered from combined sites: N= 3. Site acronyms: REAP – Rhynie, BAL – Balbinny, CR – Craig Rock, ToN – Tap o'Noth, CM – Cairnmore, MTAP – Mither Tap, CG – Croftgowan, DUNC – Dunnicaer, LL – Lundin Links, and BHF – Burghead

Site	**Location**	**Period**	**Ecological Indicators**	**Potential Agricultural Evidence (Pooideae)**	**Diatoms**	**Chrysophytes**	**Plant Species Richness (Minimum taxa)**
REAP	Lowland	4th – 6th AD	Grassland	Consumption & Storage	Absent	Absent	5
BAL	Lowland	5th – 6th AD	Grassland, Wetland, Heathland, Forest	Processing	Present	Present	7
CR	Lowland	6th AD	Grassland	Animal feed	Present	Present	6
ToN	Upland	2nd – 6th AD	Grassland, Heathland, Wetland, Forest	Processing, Consumption, Animal feed	Present	Present	11
CM	Upland	4th – 7th AD	Grassland, Heathland, Wetland, Forest	Processing	Present	Present	7
MTAP	Upland	7th – 8th AD	Grassland	Processing, Consumption, Storage	Present	Present	6
CG	Upland	~8th AD	Grassland	Consumption	Absent	Absent	5
DUNC	Coastal	~2nd – 5th AD	Grassland	Consumption & Storage	Absent	Absent	3
LL	Coastal	5th–7th AD	Grassland, Forest	Consumption	Absent	Absent	4
BHF	Coastal	7th – 8th AD	Heathland, Grassland, Wetland, Forest	Processing, Animal feed	Present	Present	9

Soil

Soil samples were taken and processed according to the methodologies outlined in Chapter 4. Horizontal sampling was the main strategy, to investigate the use of space, architectural preferences, and activity areas within Pictish fortified enclosures. These samples were taken from a suspected working space at Burghead upper citadel (n= 12, 3 x 4 grid of 1m x 1m units, context layer 19055), a Tap o'Noth house platform floor (n= 14, 3 x 5 grid of 1m x 2m units, context layers 16002 and 16005), and an intact house floor at Cairnmore (n=21) (4 x 7 grid of 1m x 1m units, context layer 17001**)**. Vertical sampling was taken in two instances to better understand the chronology, use of space, and land use at Balbinny (n=15, across one soil fill – context layer 2002, sampled using arbitrary 5cm intervals) and Burghead (n= 7, across 7 distinct soil layers: 19053, 19052, 19030, 19029, 19028, 19027, and 19008**).** In most cases, vertical sampling is not possible in Pictish contexts as the minimum depth requirement is seldom met (> 30 cm); however, the Balbinny enclosure trench and an excavation trench in the upper citadel at Burghead reached 0.84m and approximately 1.5m deep respectively.

In all strategies and contexts, grasses (Poaceae) were the most well represented. The representation among Poaceae subfamilies across sites are however markedly different. Unknown Poaceae and Panicoideae subfamilies each made up approximately 25% of the total assemblage at Balbinny, Tap o'Noth and Cairnmore. This suggests strong relationships with drier grassland environments dominated by Panicoideae grasses. Comparatively, the signature at Burghead has a high representation of Pooideae subfamily species (cereal grains), followed by Unknown Poaceae and low numbers of Panicoideae subfamily species. This finding suggests a stronger relationship at Burghead with grasslands which have higher moisture requirements and lower temperature requirements (typical of C3 pathway grasses). Within the Pooideae subfamily, cereal inflorescence bract indicators (i.e., elongate dendritic morphotype) were recovered at every site using soil sampling, with the highest representation at Burghead upper citadel (3%). Cereal inflorescence bracts were not identified to the species level although this may be possible with morphometric software (Ball et al. 1996, 2016). Given the context, macrobotanical evidence and later historical evidence (Dickson and Dickson 2000; Niehaus 2021; Ramsay 2019), it is likely that most of these inflorescence bracts are representative of barley and oat.

Non-grass species were represented across all soil samples, notably Asteraceae, Asteraceae/Ericaceae, and Cyperaceae. Cairnmore and Tap o'Noth house platforms had the highest representation of Asteraceae and Asteraceae/Ericaceae, although this representation is still comparatively low (<10%). This suggests that aster and ericaceous species (e.g., heather) were used to supplement house activities in upland environments, such as using them for thatching and bedding. This is possibly due to the availability of these species as modern uplands are covered with heather, asters (e.g., hawkfoot) and other species within these subfamilies. Cyperaceae (sedges) had low representation but were also present across all soil sampling contexts, although Cyperaceae was found in slightly higher quantities at Tap o'Noth and Balbinny. This finding may indicate wetter environments at these sites, which is also supported by the presence of both diatoms and chrysophytes.

Most unidentified species in soil contexts were interpreted as dicotyledonous plants as the phytolith morphotypes representing these species (e.g., spheroid) are known to originate from non-monocotyledonous plant taxa. Production and depositional biases are expected to skew the representation of dicot species at archaeological sites (Carnelli et al. 2004; Dal Corso et al. 2017:15; Tsartsidou et al. 2007) which to an extent explains the low representation at Pictish sites. Facetate forms indicative of wood residues were occasionally retrieved and rare instances of conifer phytoliths were also identified (Figure 5.1M–N). This finding may indicate remains from past structures (e.g., wooden fences, ramparts) or fuel use (e.g., firewood).

The retrieval of micro-algae is important for understanding the microbotanical record within soil contexts at Pictish sites. Chrysophytes were well represented across sites with high amounts at Cairnmore, Balbinny and Tap o'Noth. Within the house floor contexts at Cairnmore and Tap o'Noth, the horizontal representation of chrysophytes, coupled with diatoms, suggests the use of turf for house walls (see Chapter 6). Diatoms were also recovered alongside chrysophytes and phytoliths and the tentative identifications for the recovered diatom frustules suggest freshwater and subaerial (i.e., semi-aquatic terrestrial) aquatic contexts (Figure 5.4). This finding may indicate the environmental context of past peatlands (e.g., bogs) the Picts targeted for turf building materials.

Teeth

Using the three-layer wash process described in Chapter 4, microbotanical and microalgae residues were retrieved from animal (n= 20 samples, MNI= 5 cattle, 4 sheep/goat, 4 pig, 2 horse) and human dental surfaces (n= 6, 5 individuals) (Figures 5.5 and 5.6) **Table 5.4**. One deer (*Cervid*) mandible retrieved from excavations at Burghead in 2021 was also sampled to examine wild animal foodways. All sampling contexts contained high numbers of cereal microremains which suggest an emphasis on cereal agriculture for plant-based sustenance in Pictland.

Six human dental contexts were sampled from two sites: Croftgowan (n=2, 1 individual) and Lundin Links (n=4, 4 individuals). These teeth were exceptionally fragile, and a dry wash was not possible; therefore, only wet, and sonicated washes were pursued. In some cases (MB-22-LL-3 and MB-22-LL-4), to maintain the integrity of the teeth, only a sonicated wash was possible due to fragility of the tooth. Across both sites 18 starches were recovered, with most identified as barley (*Hordeum vulgare*). Oat (*Avena sp*.) (n=2) and two non-cereal starch grains were also retrieved. The non-cereal grains are likely non-diagnostic forms from 1) a geophyte (e.g., tuber), 2) a nut (e.g., acorn – *Quercus sp.*), or 3) are transitory starch. Over half of the retrieved starch grains from human teeth showed evidence of cooking through the identification of swollen grains, uncharacteristically rugose surfaces, blurry extinction crosses, and wrinkled/pitted hila (Figure 5.3). Only two grains appeared to be uncooked/raw. Very few phytoliths (all Poaceae) were retrieved from Croftgowan dental residues and these likely reflect post-depositional background (i.e., soil contaminant). Cereal residues from human teeth reflect meals eaten shortly before death and suggest that barley and oats were a central component of Pictish food, potentially indicating a meal of pottage, stew, oatmeal/cakes, or bread.

Animal teeth residues represent complementary data for Pictish human foodways and provide information about animal care (e.g., feeding regimes), movement (e.g., pasturing), and seasonality. Again, samples were taken using the three-layer wash process from intact teeth within mandibles and individual molars from pig (*Sus scrofa*), cattle (*Bos taurus*), sheep/goat (*Caprinae sp.*), horse (*Equus*), and deer (*Cervus*) (Figure 5.6). The breakdown of samples from animal teeth and minimum number of individuals is detailed in Tables 4.2 and 4.3. These zooarchaeological specimens were procured from four sites: Burghead, Craig Rock, Mither Tap and Tap o'Noth.

Across faunal species, phytoliths, starch grains, diatoms, and chrysophytes were recovered. Interestingly, microbotanical and microalgae signatures differed more by site than by species (see Chapter 7, Figures 7.2, 7.3, 7.4, and 7.5). Animals at Burghead, for example have higher values of diatoms and both Panicoideae and Arundinoideae grasses (e.g., reeds). This suggests that animals at Burghead were likely grazed within the nearby coastal grasslands in areas with mixed grass communities including those that 1) thrived in cool, moist environments (Arundinoideae), or 2) thrived in warmer, drier environments (Panicoideae). Pigs at Burghead show evidence of being occasionally given oat feed supplements, as evidenced through cf. *Avena* polyhedral starch grains retrieved from dental surfaces (Fig. 5.2 1A–B). Other evidence of cereal supplementation for animal feed can be seen at Tap o'Noth, where residues from horse and cattle teeth have a unique signature, with oat, barley, and arboreal starch grains. This potentially suggests that before end of life these animals were supplemented almost exclusively with cereals. The remaining sites where animal teeth were targeted for microbotanical analysis, Craig Rock and Mither Tap, indicate that sheep/goat, pigs, and cattle at these locations were largely grass-fed, with occasional supplementation of cereals, specifically for sheep/goats, and cattle.

Figure 5.5 Pict teeth (human) sampled for microbotanical residues – Lundin Links

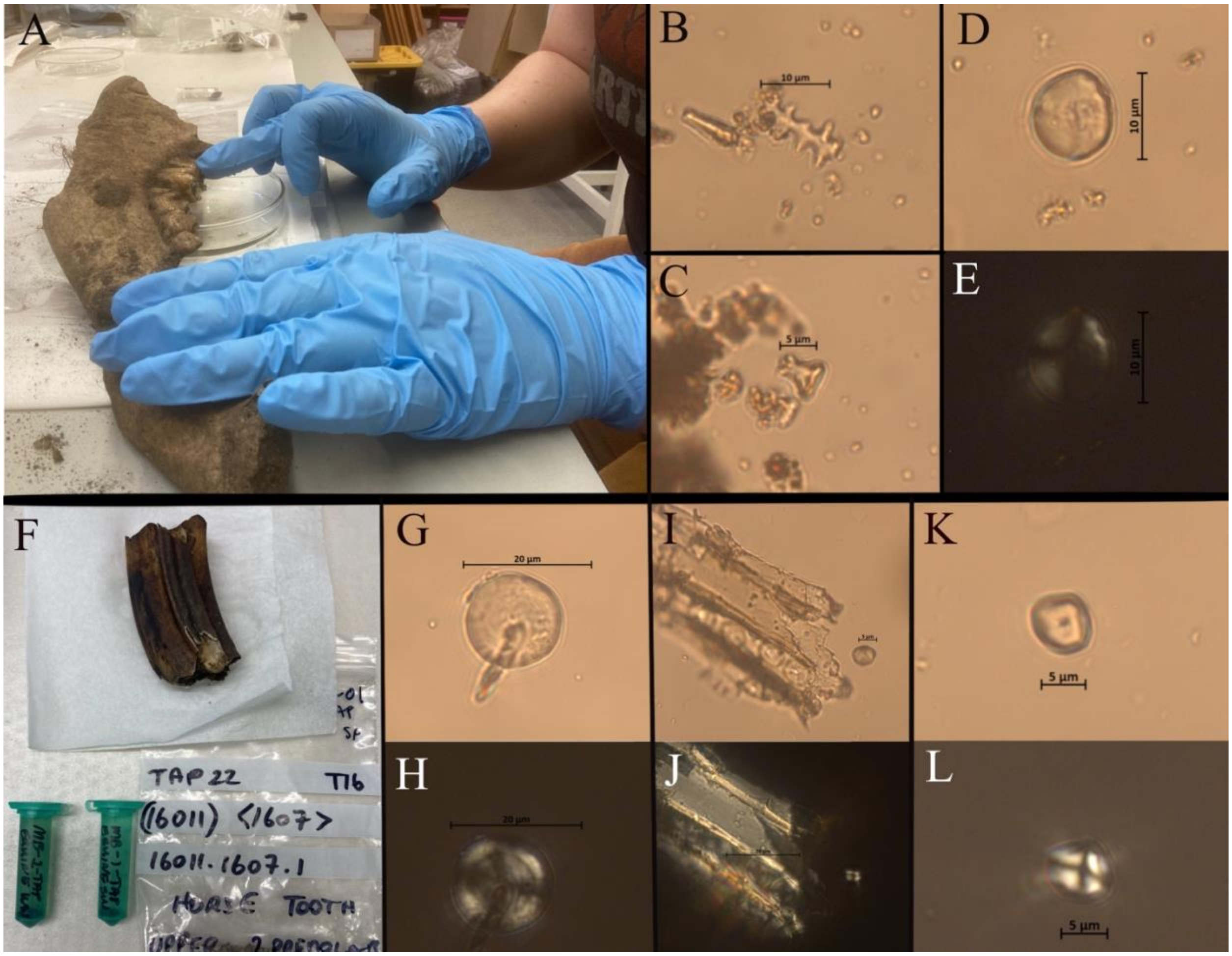

Figure 5.6 Animal teeth sampled for microbotanical analysis and microbotanical residues retrieved. (A) Cervid mandible from Burghead lower citadel and (B–E) microbotanical residues from sampling. (B) elongate dendritic phytolith (cereal inflorescence bract), (C) rondel phytolith, (D–E) lenticular starch grain (Pooideae). (F) Equus tooth from Tap o’Noth and (G–L) microbotanical residues from sampling. (G–H) lenticular starch grain (Pooideae), (I–J) softwood fiber, (K–L) polyhedral starch grain (cf. *Avena*).

Artifacts

Eleven pot sherds from Rhynie (n=3), Mither Tap (n=2), Tap o’Noth (n=3), and Dunnicaer (n=3) were targeted for microbotanical residues (Figure 5.7) **Table 5.4**. These pot sherds were made locally by hand and such artifacts are rarely recovered from Pictish archaeological sites (Noble and Evans 2022:85). Most pot sherds tested contained phytoliths and starch grains largely from cereals such as barley and oats. Only one pot sherd from Rhynie (MB-22_REAP-2) was considered 'empty' as no microbotanical residues were recovered from the washes. Cooking damage was present across pot sherd contexts and was typically accompanied by almost equal amounts of undamaged starch grains. This suggests that pots were used for both storage and cooking/eating rather than for singular purposes, or that starches did not experience damage during processing, or that starchy foods were not fully processed, or that "raw" ingredients were mixed in. Mither Tap and Tap o'Noth pot sherds also contained chrysophytes, and diatoms were recovered from Mither Tap pot sherds exclusively. Given the rare occurrences and similar signatures from other contexts, I believe this suggests post depositional contamination from the surrounding soil. Microalgae residues were largely recovered from the wet wash (66% of samples with microalgae), and to a lesser degree from the sonicated wash (33%). Grass type phytoliths were also present within the pot sherd residues, also likely present because of post-depositional contamination. These grass phytoliths were mostly retrieved from the wet wash (52% samples with grass phytoliths present) and sonicated wash (42%). Only 2 of the 11 total pot sherds in this study were suitable for a dry wash (i.e., sampled directly after excavation). For most of these pot sherds then, I suggest the wet washes (i.e., preliminary washes) likely contained trapped post-depositional residues that would have been removed during a dry wash (i.e., grass phytoliths and microalgae).

One sherd from the Rhynie assemblage (MB-22_REAP-3) contained over 50 uncooked starch grains that appeared to be either barley and/or emmer wheat (Figure 5.8). This was the highest quantity of starch grains retrieved across contexts in this study and is unsurprising given the high-status of this site. The presence of barley in the microbotanical record corroborates macrobotanical and palynological evidence from this site which identified and cereal grains (e.g., barley) and cereal type pollen grains at Rhynie's Craw Stane complex (Jones et al. 2021; Niehaus 2021; Ramsay 2019).

Artifact residues are one of the two direct lines of evidence for Pictish food consumption and cooking processes, alongside residues from human teeth. Given the consistent presence of oats and barley within pot sherd and human teeth residues, one of the main plant-based meals in Pictland was likely pottage or porridge. Pottage is a thick soup which features a cereal grain as a main component, often accompanied by other ingredients such as meat, legumes, and/or vegetables (e.g., cabbage). In medieval England and Ireland, pottage was claimed to be a food of the lower class, children, and the sick in connection with its simplicity and a nutritious character (Kelly 1997; O'Sullivan et al. 2014:74).

Figure 5.7 Pot sherds sampled for microbotanical residues – Mither Tap

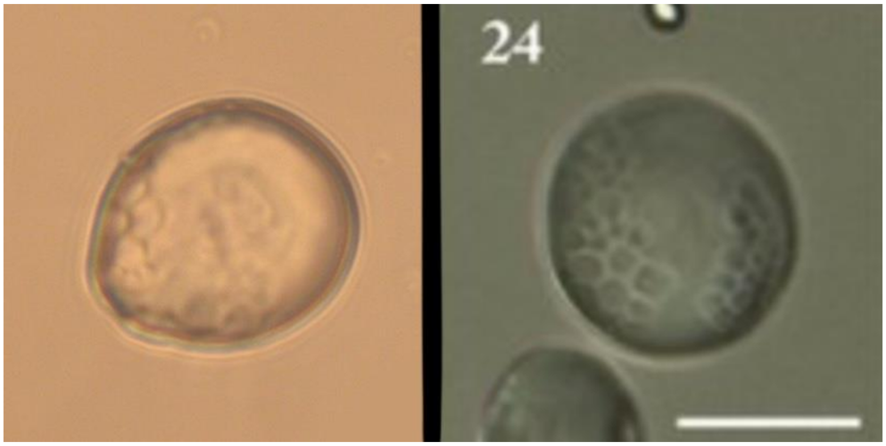

Figure 5.8 (Left) cf. Emmer wheat starch from Rhynie pot sherd (REAP–3). (Right) Modern reference example showing distinctive dimpling on surface of emmer starch grain (Yang and Perry 2013).

Part 5 – Secondary Analyses: Ecological Indicators, Human Activities, and Species Richness

Secondary analyses grant further insight into the raw data presented above to address the central research questions of this dissertation. Relative prominence of ecological indicators, assessed through ubiquity is connected to the questions 4) How were human-environment relationships consistent or divergent across Pictland, and 5) How did the Picts structure relationships between their settlements? Relative prominence of human activities tracked through spatial concentrations of activity indicators relates to questions 1) How were aspects of Pictish social organization influenced by nonhuman communities, 2) How did the Picts design their architecture relationally with local plant communities, 3) Which human-plant/algae activities were practiced in Pictish settlements, and 4 (above). Measures of ubiquity, presence/absence, and species richness are used to tease apart human-plant/algae entanglements at each site and across all sites studied. These secondary analyses are used in chapters 6 and 7 to trace human-plant/algae relations across Pictland.

Relative Prominence of Ecological Indicators

The relative prominence of ecological indicators (wetland taxa, grasslands, heathlands/fen/mire, etc.), as assessed through ubiquity is outlined in **Table 5.4**. Relative prominence examines the representation of ecological indicators identified within a site's microbotanical assemblage (measured through the presence of ecological indicator taxa). Similar approaches have been used for environmental reconstructions of grasslands and forests using phytolith analysis to identify the relationship of C3 and C4 grasses (e.g., Fredlund et al. 1985; Lewis 1981) and tree cover density (e.g., Bremond et al. 2008). These approaches hinge on the identification of 'key indicator species' which point to distinct plant communities (e.g., reeds – wetlands) (Pearsall 2015:319). In this study grasslands, wetlands, heathlands, and forests were identified through the recovery phytoliths, starch grains, and micro-algae.

Grasslands were the most prominent ecological plant community represented in this analysis, with evidence of grassland relationships present across all sites studied. Again, this is unsurprising given that grasses are well known for their high production of phytoliths and diagnostic starch grains. Forests were the second-most represented ecological community recovered from 50% of the sites studied. Forests are represented in the microbotanical record through facetate phytoliths and softwood starch grain fibers. Through the macrobotanical record (e.g., wood charcoal), we know that the Picts relied on forests for building materials and fuel with a strong preference for oak and birch respectively (Niehaus 2021); therefore, the relationships with forests likely exceed the 50% ubiquity identified in this study as wood residues have been recovered from the vast majority of Pictish sites (e.g., wood charcoal, postholes, preserved wattle fencing). Heathlands and wetlands were both indicated at 40% of the sites studied and were recovered exclusively from soil samples (100%). These characterizations will be further discussed in Chapter 7.

Relative Prominence of Human Activities (e.g., grain processing/agriculture).

Similar to the relative prominence of ecological indicators, the relative prominence of human activities can be interpreted using the data from this study, assessed through the presence of activity indicators (e.g., elongate dendritic phytoliths). The prominence of activities is measured spatially through the identification of areas with higher concentrations of indicator morphotypes. For example, within the working space area at Burghead's upper citadel, higher concentrations of elongate dendritic phytoliths were recovered close to the dressed stone feature on the eastern side of the floor layer. These concentrations are notably higher in comparison to other sampling areas across the same context (see Figure 6.4). Such approaches to use of space have been successful for archaeological investigations in southern Jordan (Portillo et al. 2009), of a seventeenth century site in Virginia, U.S.A. (Sullivan and Kealhofer 2004), and for a Neolithic village in Northern Greece (Tsartsidou et al. 2009), to name a few. Architectural and crop processing activities were highlighted in this study and are further discussed in Chapter 6. Generally, the phytolith and micro-algae evidence in this study contributes to our understanding of Pictish architecture (e.g., use of turf), use of space within individual houses (e.g., cooking areas), and agricultural evidence/activities (e.g., crop processing) through the identification of distinct concentrations of indicator morphotypes that are comparatively higher than in other proximal sample contexts. For example, at Cairnmore, the relative prominence of chrysophytes were higher along the edges of the floor layer, which suggests the use of turf for the walls of the roundhouse located just outside the outer rampart wall. As noted in **Table 5.4**, agricultural evidence from this study can be divided into several subcategories: processing, consumption, storage, and animal feed.

Relative Frequency of Plant Taxa

The ubiquity of plants is outlined in **Table 5.5**. Measuring the ubiquity of plants and micro-algae allows us to understand the presence patterns of specific taxa across proveniences by counting the occurrences of a taxon within a sampling population (Hastorf 1999:59). This is a helpful measurement that allows us to understand how frequently plants are represented across multiple contexts and prevents an overestimation of plant representation which can occur if we only focus on quantity. For example, if quantity is the major focus to understand the representation of cereal grains at a site, a cache of 100 grains found in one provenance can greatly skew our interpretations to overestimate the value of cereal grains at said site.

The grasses, especially subfamilies Panicoideae, Unknown Poaceae, and Pooideae, were ubiquitous across sampling contexts (i.e., soil, pots, human teeth, and animal teeth). Again, this is unsurprising given the well documented high production values of diagnostic microbotanical residues produced in the grass family. Specifically, barley and oats were retrieved from pots, human teeth, and animal teeth contexts. Although the ubiquity values for oats and barley are rather low (8 – 10%), they are likely to be ubiquitous up to the Pooideae value. This discrepancy may be due to the fact that in many cases, the specific taxon for Pooideae specimens could not be determined based on the elongate dendritic phytolith alone, or because cereal-type starch grains were too damaged for genus level identification. Such issues are known complications encountered in macrobotanical and microbotanical datasets (Morell-Hart 2019b).

Table 5.5 Ubiquity of major plant taxa by site and sample provenance. (S) – Soil, (D) Animal dental surface, (D*) Human dental surface, (P) Pot sherd. Arranged by alphabetical order of plant family (Pooideae subdivided by genus with highest ubiquity). Site abbreviations: BAL – Balbinny, BHF – Burghead, CM – Cairnmore, CG – Croftgowan, CR – Craig Rock, DUNC – Dunnicaer, LL – Lundin Links, MTAP – Mither Tap, REAP – Rhynie, and ToN – Tap o'Noth.

	Lowland			Upland				Coastal			
Taxon	BAL (S)	CR (D)	REAP (P)	CG (D*)	CM (S)	MTap (D,P)	ToN (S,D,P)	BHF (S,D)	DUNC (P)	LL (D*)	TOTALS /106
Asteraceae	13/15	0/4	0/3	0/2	20/21	0/6, 0/2	14/14, 0/3, 0/3	1/19, 0/7	0/3	0/4	48/106
Asteraceae/Ericaceae	0/15	0/4	0/3	0/2	0/21	0/6, 0/2	10/14, 0/3, 0/3	0/19, 0/7	0/3	0/4	10/106
Cyperaceae	15/15	0/4	0/3	0/2	19/21	0/6, 0/2	13/14, 0/3, 0/3	13/19, 0/7	0/3	0/4	60/106
Poaceae	15/15	3/4	0/3	1/2	21/21	5/6, 2/2	14/14, 1/3, 2/3	19/19, 7/7	0/3	0/4	89/106
Panicoideae	15/15	3/4	1/3	1/2	21/21	2/6, 1/2	14/14, 1/3, 2/3	19/19, 7/7	1/3	0/4	91/106
Pooideae	15/15	3/4	2/3	2/2	21/21	4/6, 2/2	14/14, 2/3, 3/3	19/19, 7/7	1/3	1(1)/4	98/106
Hordeum	0/15	(2)/4	2/3	2/2	0/21	0/6, 1/2	0/14, (1)/3, 2/3	0/19, 0/7	0/3	1/4	11/106
Avena	0/15	0/4	1/3	2/2	0/21	0/6, 2/2	0/14, (2)/3, 1/3	0/19, (1)/7	0/3	0/4	9/106

Relative Frequency of Micro-algae

I focused on the relative frequency (i.e., presence/absence) of diatoms and chrysophytes to broadly understand aquatic and semi-aquatic relationships present at fortified settlements. Tentative identifications have been assigned for common morphotypes to begin to understand with which specific aquatic environments the Picts may have established relationships at each site. Diatoms and chrysophytes were equally represented at 60% of the sites studied, with diatoms and chrysophytes always occurring together. This may also indicate sampling bias, as only at Dunnicaer, Rhynie, Lundin Links, and Croft Gowan were micro-algae absent. These sites were only targeted for artifact and dental residues. Soil samples consistently retrieved the highest counts of micro-algae, and I suggest that the absence of soil samples at these four sites explains the low counts of microalgae at Dunnicaer, Rhynie, Lundin Links and Croft Gowan.

Richness of Plant Taxa within Sample Contexts.

The richness of plant taxa is outlined in the final column of Table 5.3 (Plant species richness – Minimum taxa). Overall, the measurement of plant taxa richness points to the sampling methodologies. Sites which were subject to multiple approaches (i.e., soil, pot sherd, and dental residue analyses) had higher richness values than those that only focused on one approach. Tap o'Noth had the highest species richness (n=11) and this was the only site where soil, pot sherd, and animal teeth residues were examined. Soil analysis was especially effective for extracting a wide range of plant taxa, as Burghead, Balbinny and Cairnmore also had higher richness signatures than sites that were not targeted for soil analysis. Sites which were studied using solely residue analysis of artifacts and teeth recovered a minimum of 4.8 taxa on average, versus a minimum of 8.5 taxa on average for sites that targeted soil. Dunnicaer had the lowest plant richness. However, this finding is likely related to preservation challenges, as there were residues present, but most were too damaged for accurate identification. Broadly, taxonomic richness appears to be more a function of sample type and numbers of samples taken, than related to patterns of human activity at any one site. For this reason, I do not rely on measurements of taxonomic richness to make further arguments.

Broad Summary of Results

The results from microbotanical and microalgae analyses have provided direct evidence for Pictish architectural traditions (e.g., turf walled structures), agricultural practices (e.g., cereal intensive cultivation), human food consumption (e.g., cooking and consumption evidence), animal feeding regimes (e.g., pasturing and cereal grain supplements), and interaction with various ecological zones (e.g., wetlands, heathlands and grasslands). This paleoethnobotanical approach was successful at retrieving a variety of microresidues at each site, and these proxies shed light on human-plant/algae relationships across Pictland.

This evidence is further examined in Chapters 6 and 7 to address the broad research questions of this dissertation. Chapter 6 examines use of space to answer thesis questions 1, 2, and 3 which broadly investigate how the Picts structured their settlements in relation to local plant communities. Chapter 7 builds upon this architectural and activity area focus and traces the network of relations between humans, plant and algae communities to answer thesis questions 4 and 5. These thesis questions consider the broader patterns of human-plant/algae relations to understand if such relationships were homogenous or diverse across Pictland.

Chapter 6: Plant and Algae Contributions to Pictish Communities

This chapter focuses on understanding how fortified settlements are structured at the site level and how plants contributed the poiesis and maintenance of Pictland. Here I examine how the Picts designed their settlements relationally with local plant communities and investigate the organization of space. This chapter is largely based on the results from sites studied using the soil sampling approach, detailed in Chapter 4, and highlights activity areas and architectural traditions. Soil studies were limited to Balbinny, Burghead (upper citadel), Cairnmore and Tap o'Noth—results from other analyses are discussed in Chapters 5 and 6. To investigate how settlements emerged through relational connections between humans and non-human communities (i.e., plant and algae communities) I identify the network of relations emplaced at each site, particularly within contexts from which soil samples were taken: house floors, occupation layers, and a ditch fill.

I focus on architecture in the following section. Specific plant and algae communities that contributed to architectural traditions are identified and are foregrounded to investigate their contributions to use of space at these settlements. These relational suites from Burghead, Tap o'Noth, Cairnmore, and Balbinny are studied independently (site level) and are later compared for a regional understanding (intersite) to determine if engagements with space were consistent or divergent across Pictland (see Chapter 7).

Broadly, this chapter draws on the results summarized in the previous chapter to address human-environment relationships. Through this interpretive process, we are able to better understand the contributions of non-human communities to the poiesis of Pictish settlements and lifeways.

Activity Areas

Several recent studies using paleoethnobotanical approaches have demonstrated the capabilities of microbotanical analysis to illuminate past landscapes, foodways, and spatial activities (e.g., Borderie et al. 2020; Dal Corso et al. 2017; Juhola et al. 2019; Wade et al. 2021). Microbotanical assessments of floor layers have proven successful for the identification of plant resources from storage areas, ovens, hearths, and sleeping areas (Rosen 2005). However, such assessments are not common in northern European archaeological contexts, and this study is the first to target microbotanical residues of house floors in Scotland. Within northern British archaeological contexts, highly acidic soil conditions, along with later land use (Ralston 1997; Hunter 2007:48–50; Noble et al. 2020:328), often inhibit the preservation of macrobotanical remains, floors, artifacts, and structural remains, leading to poor understanding of settlement and early landscape use. These limitations are particularly evident for early medieval Scotland where our knowledge of activity areas and architectural traditions is notably scarce (Ralston 1997:24; Noble et al. 2020:320,327–328) (Prado and Noble 2022).

In this section I assess phytoliths, diatom frustules, and chrysophytes procured from house floor layers (Cairnmore and Tap o'Noth), unidentified occupation layers (Burghead, upper citadel), and a ditch fill (Balbinny). The results from the analysis of sampled soils suggest that the Picts established relationships with peatlands, heathlands, grasslands, and forests to create their settlements, and carried out agricultural processing activities within and around fortified enclosures. Other features such as bedding areas were not identified in this study, although bedding activity has been described in the broader literature (e.g., Cabanes et al. 2010, Henry et al. 2004; Portillo et al. 2009). Agricultural activities had the most prominent signatures identified within this study and therefore are a particular focus of this discussion. In the subsections below, I focus on house floors at Cairnmore and Tap o'Noth, occupation layers at Burghead, and a ditch fill at Balbinny to address elements of plant contributions to architecture and daily life in connection to primary thesis questions 1, 2 and 3.

House Floors at Cairnmore and Tap o'Noth

Intact house floor features were targeted for phytolith analysis through soil sampling at Cairnmore and Tap o'Noth. Both sites are situated within the Upper Strathbogie Valley which also includes two sites that did not undergo soil sampling protocols: the high status early medieval enclosure Rhynie, and more distantly the hillfort Mither Tap. One of the objectives of this research is to better understand how the settlements within Pictland operated in relation to one another. This objective also fits into broader research goals by the Northern Picts and Comparative Kingship projects to better understand the settlements within the Upper Strathbogie Valley specifically (Jones et al. 2021; Noble et al. 2013).

The Cairnmore house floor appeared to form part of a circular roundhouse structure located just outside of the outermost rampart wall (Figure 6.1). Half of the floor layer was truncated by a later stone wall and only half of the floor was accessible for soil sampling (Chapter 3, Fig. 3.8). A small number of artifacts were recovered from the floor layer, including a fragment of a shale brooch and a small iron object. Three pit features were present within the floor layer, potentially representing hearths (Noble et al. 2022). Macrobotanical remains included charcoal fragments of oak and birch, and charred plant seeds such as black mustard (*Brassica nigra*), ribwort plantain (*Plantago lanceolata*) and sedges (*Carex* sp.) (Niehaus 2021). These findings were interpreted as evidence for wet woodland and grassland vegetation (Niehaus 2021:27). No structural features such as postholes or evidence of roofing were preserved to give any indication of the appearance or form of the building. Radiocarbon dating suggests the floor layer is of 5th – 6th century AD date, contemporary with the 5th – 7th century AD ringfort of Cairnmore (Prado and Noble 2022).

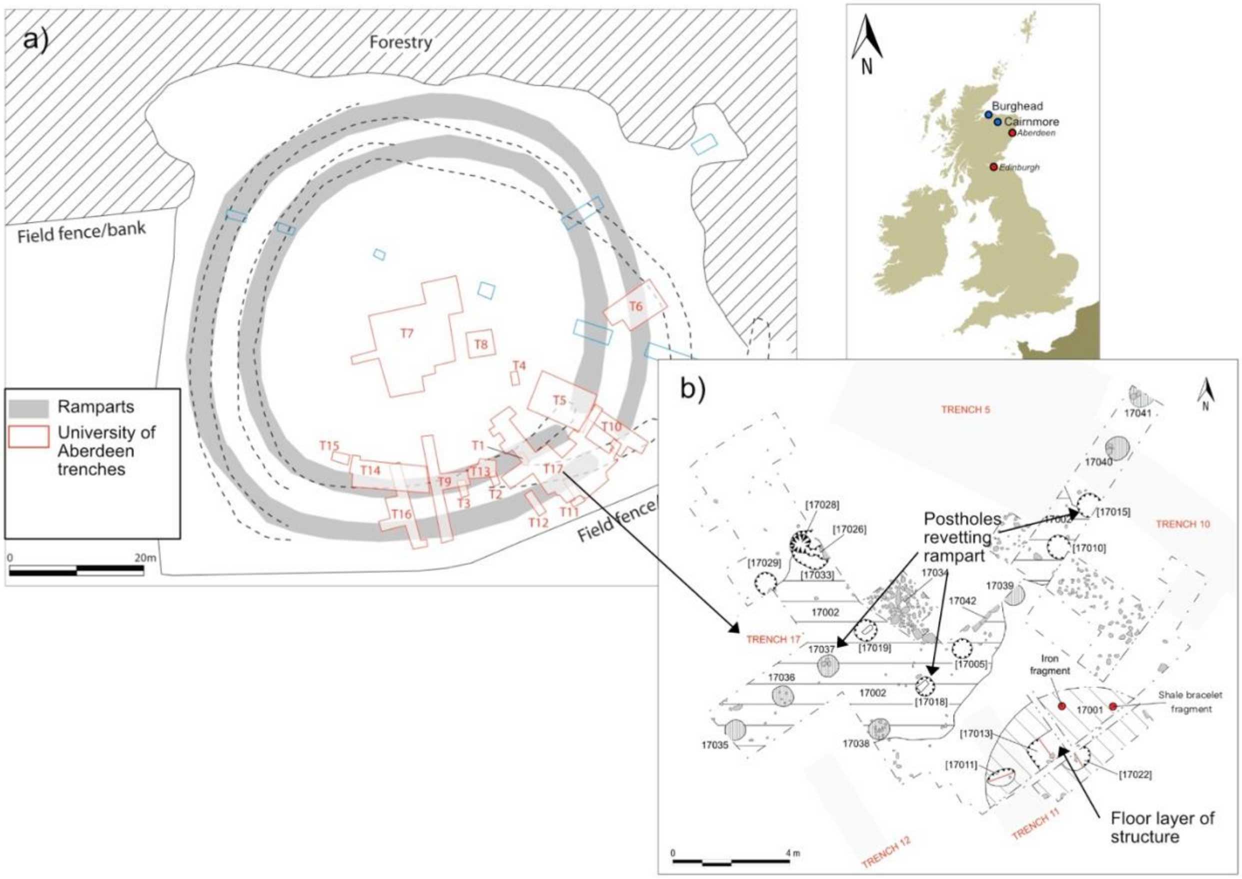

Figure 6.1 a) Cairnmore enclosure excavation areas and b) location of roundhouse floor (Prado and Noble 2022).

Across the mire, the Tap o'Noth house platform targeted for soil sampling also lacked architectural evidence aside from the floor layer itself. House platforms were identified at Tap o'Noth hillfort using LiDAR which identified an estimated 800 platforms within the lower fort (Noble and Evans 2022). The chronology and relatedness of these platforms has yet to be investigated, and microbotanical sampling targeted one of the platform floors to begin to assess activities within these structures. This house platform (T16 – House 3) was oval in form and a single hearth was situated approximately center-west within the structure. Nearby were two other house platforms which were sampled for microbotanical analysis but are not a part of this study. Samples have been taken for radiocarbon dating of this floor layer, including bulk soil samples, hearth fill, and animal teeth. Dating from previous field seasons returned 3rd–6th century AD dates, and the house floor examined in this study is suspected to be contemporaneous with these dates.

The microbotanical assemblages from the Cairnmore (Figure 6.2) and Tap o'Noth (Figure 6.3) house floors did not strongly indicate the division of space for specific activities such as cooking, crop processing, or sleeping/bedding. Furthermore, small concentrations of cereal inflorescence bract morphotypes were present across both floors. This spatial representation of elongate dendritic morphotypes within these house floors suggests that food processing was likely carried out in the vicinity of these structures. As these morphotypes were recovered in trace quantities across the house floor surfaces threshing/winnowing was likely not carried out within the structures but could have been tracked into the structures from nearby processing areas.

Grass inflorescences are typically formed in the later summer or early autumn and robust phytolith evidence of these plant parts are usually represented through articulated multicellular structures (Delhon et al. 2020). Such an example was exclusively recovered in this study from Burghead's upper citadel (Figure 6.4), which very tentatively indicates a place of cereal grain storage. Without morphometric analysis it is challenging to interpret the taxa represented by elongate dendritic morphotypes, especially because most of these phytoliths were fragmented and therefore were difficult to confidently match with reference examples in the *McMaster Microbotanical Research Database* and elsewhere. However, given the macrobotanical and starch grain evidence, the most likely taxonomic identification is barley.

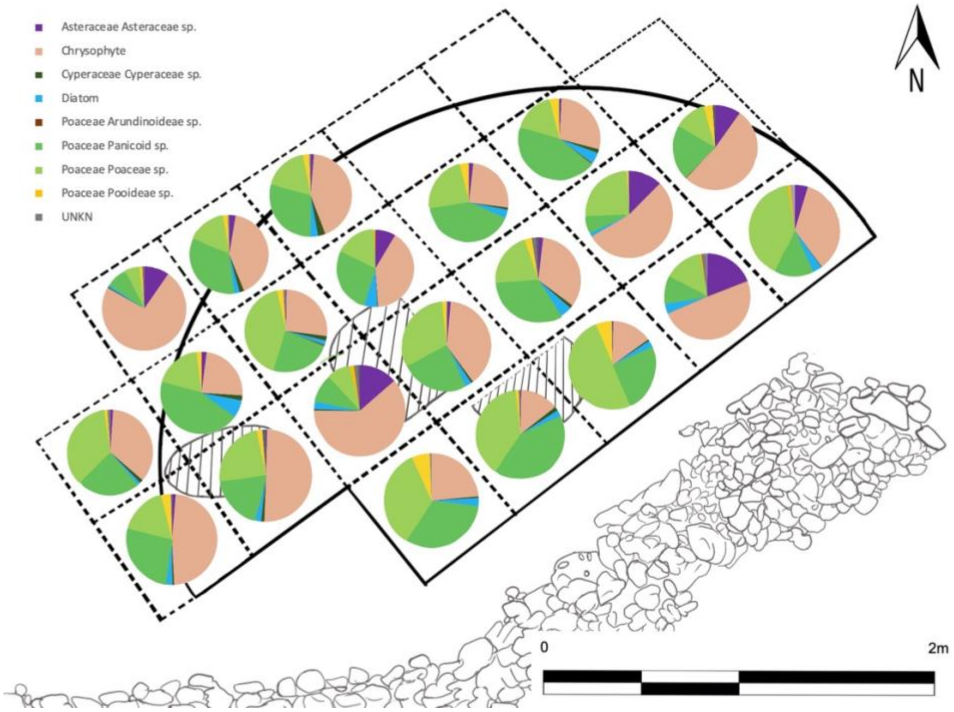

Figure 6.2 Microbotanical and micro-algae spatial representation across the roundhouse floor at Cairnmore (Prado and Noble 2022)

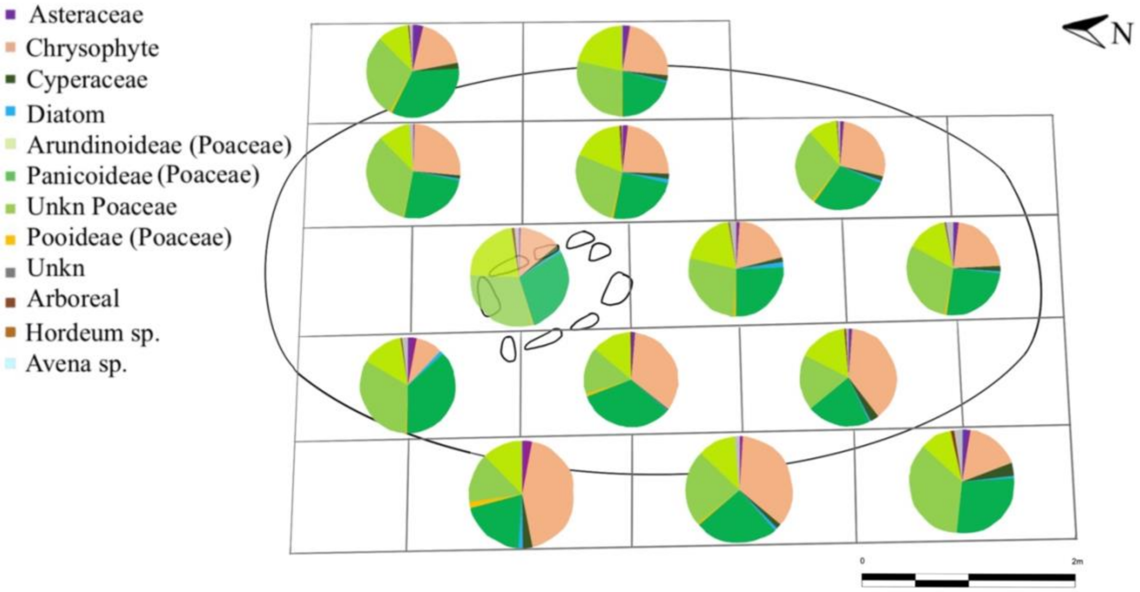

Figure 6.3 Microbotanical and micro-algae spatial representation across the house floor at Tap o'Noth (T16).

The presence of intact floor layers from Cairnmore and Tap o'Noth suggests that these structures were repeatedly used; however, the activities within these structures are challenging to interpret. Regular cleaning of dwellings (e.g., sweeping) results in the dispersal and removal of residues which would indicate various activities. Therefore, in occupational contexts it is seldom that floor residues are indicative of the delineation of activities within dwellings, particularly in cases where multiple activities were carried out in a small space (Noble and Evans 2022:85; Piperno 2015:270; Shahack-Gross et al. 2009). In this study, although there are indications of food processing (e.g., threshing/winnowing), these signatures are not particularly strong, and other activities such as animal housing or human bedding areas were not recovered from these house floors. Given the lack of such indicators it is challenging to understand the use of these buildings. Tentatively, I suggest that the Cairnmore and Tap o'Noth ephemeral structures were multi-functional shelters where cereal grains were processed nearby the houses. At Cairnmore, trace macrobotanical evidence recovered granary weevils (*Sitophilus granarius*) from the floor layer (Niehaus 2021:43) and this possibly indicates that a storage facility was located nearby within the settlement. More could be learned about the use of space in these house floor contexts if soil samples were examined more thoroughly before chemical processing to look for the presence of fecal spherulites – microscopic evidence of domestic animals housed within the structure.

Occupation Layers at Burghead

Within the Burghead upper citadel, a possible 'working space' was identified during the 2020 excavations by the Northern Picts Project, and this area was targeted for horizontal sampling of microbotanical residues (Figure 6.4). Nearby, vertical sampling targeted an excavation trench that revealed a sequence of what appeared to be turf and sandy layers (Figure 6.5). Both sampling strategies within this upper citadel area recovered agricultural processing signatures and marked differences from the assemblages recovered from the house floors at Cairnmore and Tap o'Noth.

The proposed ancient working space was divided into twelve 1m x 1m units to blanket sample the area dated to the Pictish period to determine the character of the space and the activities that may have occurred in the upper citadel. The results showed a high representation of grasses and low representation of chrysophytes at that time, suggesting that a turf walled structure around this area was not likely. Rondel morphotypes, which are representative of the Pooideae subfamily of grasses (which includes cereals) were dominant across this area, and this suggests that leaves and culms of grasses were prominent in this space. Elongate dendritic phytoliths (e.g., cereal inflorescence bract indicators) were concentrated around a group of flat stones located on the eastern side of the area. This suggests that crop residues were deposited in a select area of this space and indicates that the upper citadel could have been a location for storing cereal crops. Macrobotanical cereal grains have been recovered exclusively from the upper citadel and are notably absent from the lower citadel. These findings suggest at least a partial partitioning of space for plant-based activities within this coastal promontory fort.

The vertical sampling from the excavation trench revealed fluctuating patterns of plant microremains in across the seven layers (Fig. 6.5). Within these seven layers I suggest there are three phases signalled in the distribution of grass phytoliths (Unknown Poaceae and Pooideae), sedge phytoliths, and chrysophytes (Fig. 6.6). Beginning from the bottom (oldest layers), the three lower-most samples had similar signatures of mostly rondels, and elongate echinate and elongate entire morphotypes (Poaceae subfamily of grasses). This signature is representative of grasslands, with little difference between the layers although increasing representation of more generalized Poaceae (i.e., not identified as Panicoideae or Pooideae) morphotypes (e.g., elongate entire). In the second phase rondels become less frequent, non-Pooideae grasses remain well represented and chrysophytes, woody phytoliths, and diatoms are more prominent than the previous phase. This suggests a period with wetter plant and micro-algae communities, including sedges. The first instance of elongate dendritic phytoliths within this vertical sampling was retrieved from layer 17, and this could suggest the beginning of crop processing within the Burghead upper citadel. Given the lower signatures of chrysophytes during the first phase I suggest that phase 2 may represent the use of turf and/or a wetter climatic shift at Burghead. The final phase (3) is seen in the uppermost sample – 19. Within this sample a significant change can be seen, chrysophytes are mostly absent, as are non-Pooideae grasses. The highest counts of elongate dendritic phytoliths are captured in this layer and there is a return to high counts of rondels (Pooideae leaves, stems, & culms). Overall, I would characterise the three phases as follows: Phase 1 – grass dominant (samples 13, 14, 15), Phase 2 – increasing moisture & chrysophytes (samples 16, 17, 18), Phase 3 – grass dominant with cereal inflorescences (sample 19).

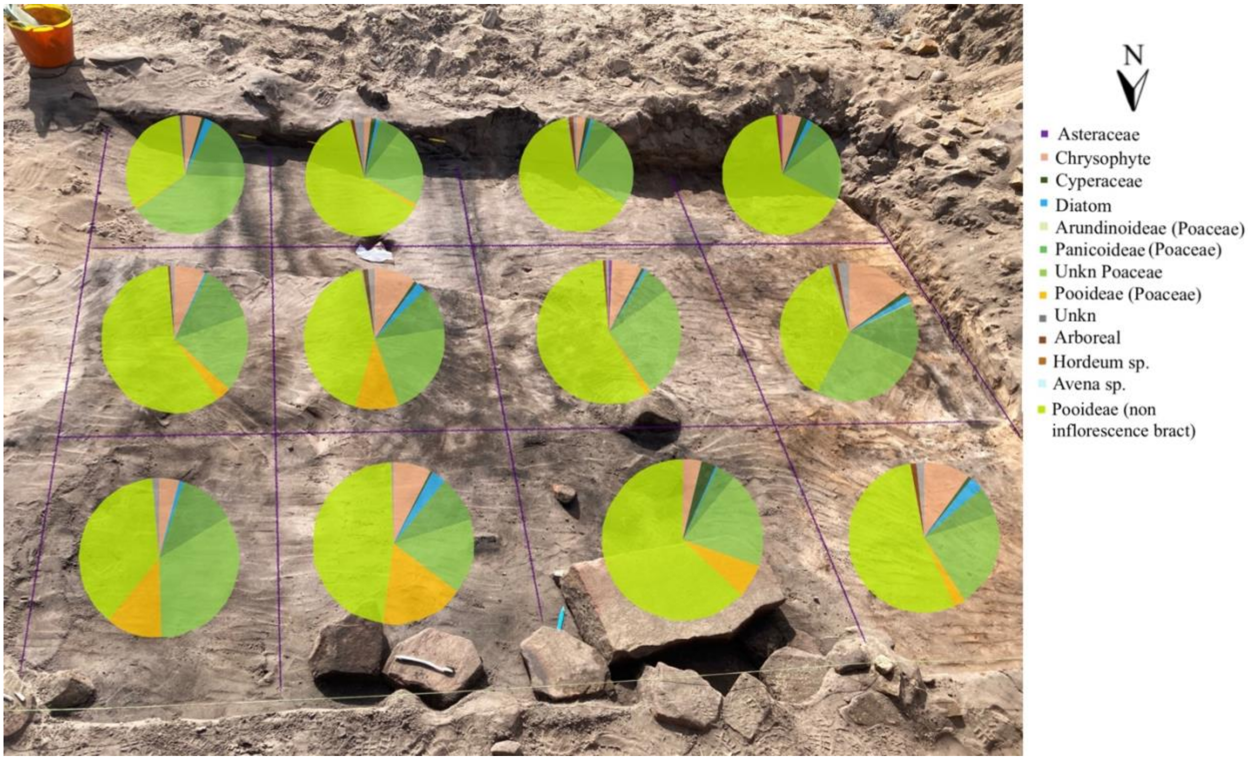

Figure 6.4 Microbotanical and micro-algae spatial representation across the working space area at Burghead Upper Citadel. Samples were procured within this 3m x 4m grid (1m x 1m units).

Figure 6.5 (Left) Vertical sampling layers for microbotanical analysis – Burghead Upper Citadel (Right) North end of the excavation trench. Total depth approximately 0.8 m. Working area located east of this trench.

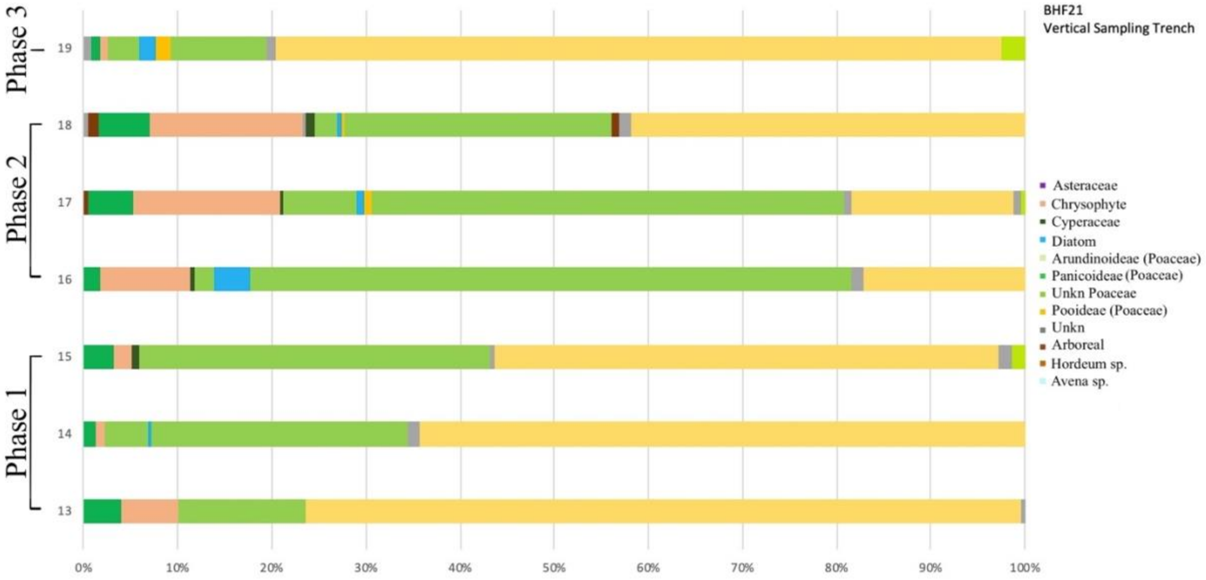

Figure 6.6 Microbotanical and micro-algae residues from Burghead vertical sampling.

Ditch Fill at Balbinny

A ditch fill from Balbinny was the only other context which presented optimal conditions for vertical sampling (> 0.30 m depth) (Figure 6.8). Wood charcoal from the enclosure ditch at Balbinny was dated from the early 5th century AD (basal fill) – mid 7th century AD (upper fill), indicating a chronological sequence of approximately three-hundred years of soil deposition within this ditch fill (Gordon Noble, p.comm 2023). Samples were taken from this ditch fill in 5cm intervals, resulting in fifteen samples from the ditch fill (Figure 6.9). The samples captured similar distributions of microbotanical residues across the ditch fill layers; however, some patterns may be seen in the quantities of elongate dendritic phytoliths (Figure 6.7).

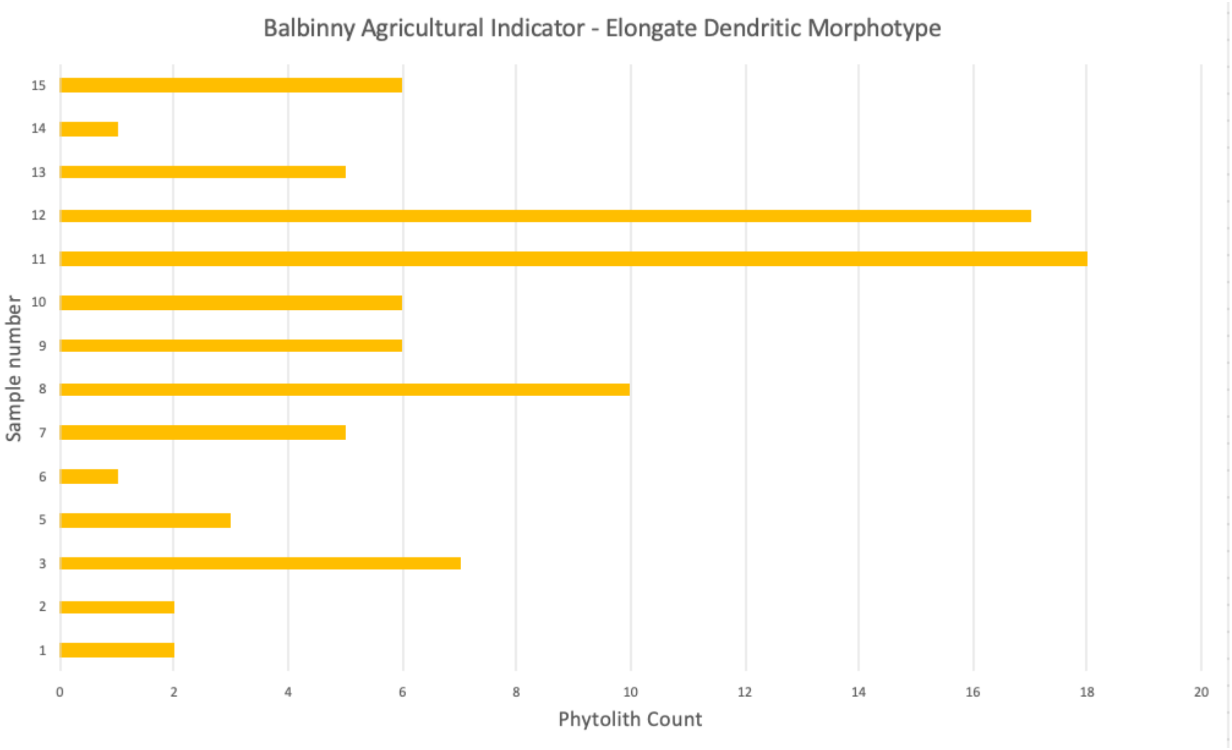

Figure 6.7 Elongate dendritic phytoliths within Balbinny trench samples.

Elongate dendritic phytoliths were recovered across 93% of the samples and were absent only from one sample (4). Peaks and valleys can be seen across the representation of these cereal inflorescence bract phytoliths, potentially indicating distinct phases of agricultural processing and/or occupation at Balbinny. A possible boom in agricultural processing can be seen toward the end of the occupation sequence (samples 11 and 12). This lowland site overall had high values of chrysophytes, even values of Panicoideae and Poaceae grasses, and oscillating distributions of Pooideae grasses (e.g., cereals) (Figure 6.9). The distribution of elongate dendritic phytoliths provides valuable information for understanding agricultural production at Balbinny, which overall appears to be consistent but with marked periods of agricultural prosperity and regression. These data could be further improved by analyzing the elongate dendritic phytoliths using morphometric analysis to identify which cereals were being produced and processed at Balbinny, although given the broader results from across the ten sites examined in this study, I suggest these morphotypes likely represent barley and oats.

Figure 6.8 Balbinny enclosure ditch fill, targeted for microbotanical analysis (Noble et al. 2021:10)

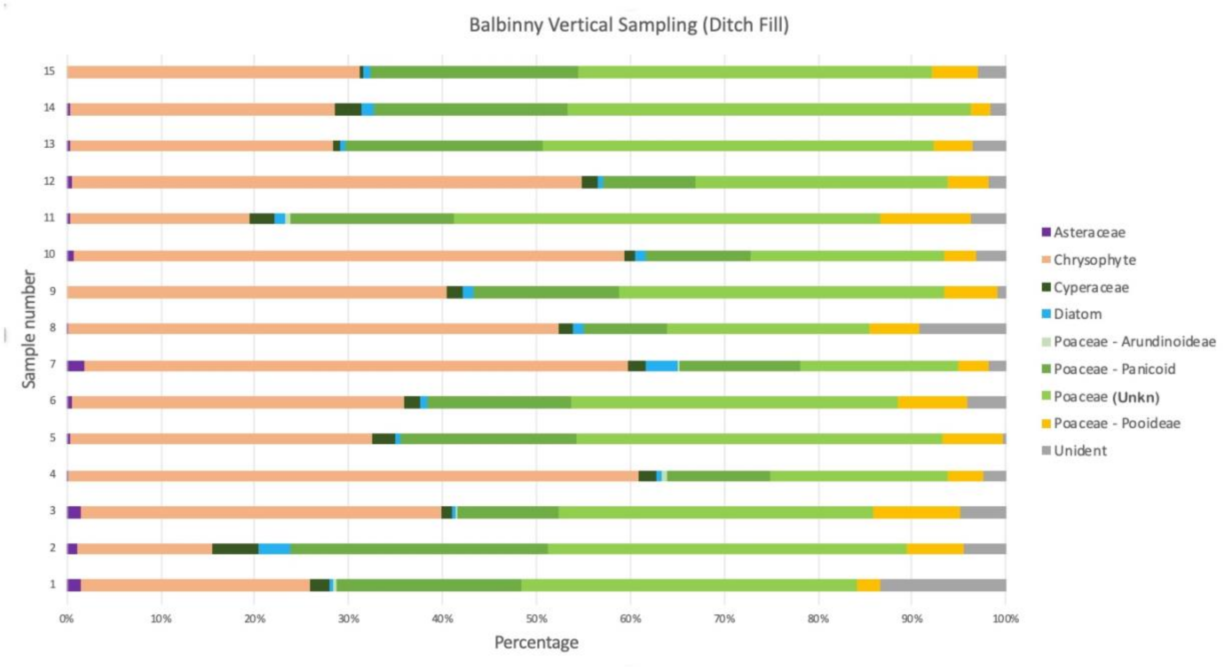

Figure 6.9 Microbotanical and micro-algae residues from Balbinny vertical sampling.

House Platforms – Pot Sherd Residues from Dunnicaer, Tap o'Noth, Mither Tap, and Rhynie

The results from pot sherd analysis further underline the importance of cereal grain agriculture for the Picts living at fortified enclosure settlements and provide direct evidence for food activities within these settlements. Barley and oat starch grains were extracted in both cooked and raw forms from pot sherds retrieved from archaeological investigations at Dunnicaer, Tap o'Noth, Mither Tap, and Rhynie (Figure 6.10). The results are better outlined in Chapter 5, but in regard to use of space, these residues indicate that people were cooking and storing cereal-based foods within these locally made pots. These pot sherds were retrieved during excavations of fortified enclosures by the Northern Picts Project and represent primary deposits (i.e., were retrieved '*in situ*').

The sherds from Tap o'Noth, Rhynie, and more distantly Mither Tap, are useful for contextualizing use of space and foodways in the Upper Strathbogie valley. The Tap o'Noth sherds particularly illuminate household food practices (e.g., cooking) as they were excavated from nearby house platforms (13 and 15) to the platform studied in this chapter (platform 16/House 3). Within these sherds were the residues from barley and oats which point to meals which may include pottage, porridge/oatmeal, and/or stews for consumption within these Tap o'Noth houses. These signatures match the residues from human teeth (n=6) at Lundin Links and Croftgowan, see Chapter 5). This finding suggests that cereals were a staple of Pictish foodways across the study area, and were likely cooked in locally produced pottery. Cereal evidence was recovered from all sites within this study (n=10), and cereal residues had high ubiquity values across all samples (88% total ubiquity across all samples [n=106], see Chapter 5, **Table 5.5**). Specific evidence for barley and oats is slightly more elusive as species level identification was only possible through starch grain evidence. Overall, barley was identified at six sites and oat was identified at five sites. Pot sherds from Rhynie and Tap o'Noth had equal ubiquity values of barley and oat (66% barley and 33% oat) while Mither Tap's ubiquity values show a higher representation of oat (50% barley and 100% oat). Starch residues from Dunnicaer were too damaged for accurate species identification. Agricultural preferences for barley and oat have also been suggested for early Medieval Ireland (McCormick 2014; McCormick et al. 2011; O'Sullivan et al. 2014).

Locally produced pottery is rare across Pictish archaeological contexts and only small assemblages have been recovered from a handful of sites (Noble and Evans 2022:85). Imported pottery evidence is also present at several sites and includes sherds of Late Roman Amphorae, Roman Samian Ware, and Hofheim cup (Noble and Evans 2022:96). These imports point to long-distance trade connections and are associated with feasting activities at elite settlements. Such activities would have been important components for developing hierarchical power networks (Campbell 2007; Noble and Evans 2022:49). Comparative analyses of locally produced and imported pottery assemblages at Pictish sites have yet to be investigated.

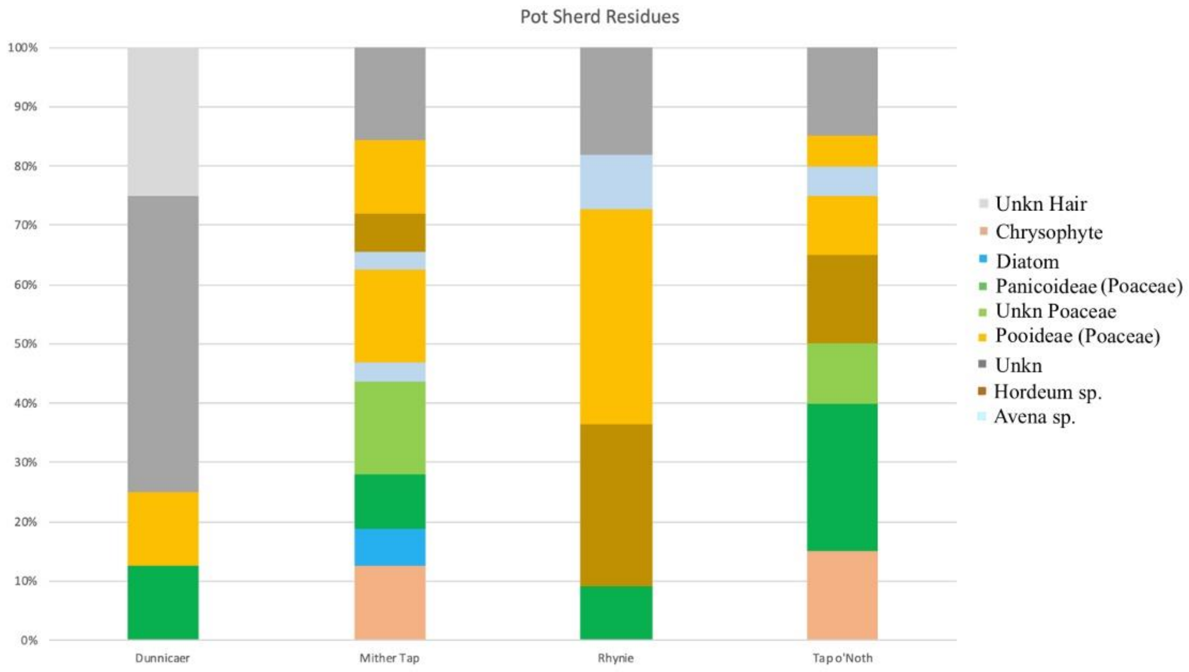

Figure 6.10 Pot sherd residues by site.

Discussion – Activity Areas

Microresidues retrieved from the house floors at Cairnmore and Tap o'Noth, occupation layers at Burghead, the ditch fill at Balbinny, and pot sherd residues (retrieved '*in situ*') point to Pictish architectural traditions (e.g., turf walls, thatched roofs), crop production/processing activities (e.g., threshing), and daily activities (e.g., cooking) at fortified settlements. Horizontal blanket sampling was used to delineate activity areas and understand architectural details in dwellings and workspaces. Vertical sampling of occupation layers and a ditch fill pointed to changes in human-environment relationships over time and was useful to identify soil sequences of heightened agricultural production (as evidenced by high representation of cereal inflorescence bract phytoliths) and wetter turf layers (as evidenced by increased values of sedges, diatoms, and chrysophytes). Microremains such as chrysophytes, diatoms, Cyperaceae cones and Asteraceae opaque perforated plates were important ecological indicators but were more helpful for understanding Pictish architecture (discussed below) and land use (Chapter 7). Agricultural activities were identified across all sites within this study and vertical sampling was able to identify soil horizons that signalled increased agricultural activity.

Agricultural activities were interpreted in this study through the spatial identification of cereal inflorescence bract phytoliths (e.g., elongate dendritic morphotypes). The presence of these phytoliths indicates the processing of cereal grains and includes activities such as threshing or winnowing – practices which remove the outer chaff from the cereal grain. Threshing involves beating the inflorescence bracts and spikelets against the ground or with a handheld implement to release the grain (Dal Corso et al. 2018; McKerracher 2018:73; O’Sullivan et al. 2013). Winnowing is another process to remove the chaff and pests from stored grain. This activity is typically carried out after threshing and uses the wind to blow the outer chaff away from the grain. The threshed inflorescences can be rubbed between the hands loosely, allowing the wind to carry away the chaff, or winnowing screens/baskets may be used (O’Sullivan et al. 2013). Some debate surrounds the identification of threshing areas using phytoliths and is discussed later in the chapter alongside the interpretations.

Through soil sampling, elongate dendritic phytoliths were recovered from 100% of the sites studied and were ubiquitous throughout the sampling areas. The horizontal sampling strategy allows us to see activity areas with higher values of elongate dendritic phytoliths which provides evidence for understanding how grain processing activities were organized within fortified settlements and around dwellings. Vertical sampling, in contrast, facilitates the interpretation of fluctuations in agricultural production/processing over time, and provides important data for understanding the rhythms of occupation at Pictish sites.

Through a relational framework, a network of relations can be traced between the Picts and agricultural cultivars, namely Pooideae cereals such as barley and oats. Evidence of agricultural processing of cereals was particularly strong within the 'working area' in Burghead's upper citadel which suggests that sheaves of cereal grains were brought to the upper citadel to be processed and stored. At other sites, such as Tap o'Noth and Cairnmore, these activity indicators were much weaker, suggesting that crop processing likely occurred nearby to these houses but not within them–crop processing residues could have been tracked into these structures by their occupants and possibly their animals. Finally, the sequence from the Balbinny ditch fill suggests that threshing and/or winnowing of cereal inflorescences occurred within this fortified enclosure and suggested periods of agricultural booms and fallow periods (low production) (discussed further in Chapter 7, see Fig. 7.6).

Other microbotanical studies of threshing, however, have argued that such activities do not leave traceable remains (e.g., Shahack-Gross et al. 2009, Tsartsidou et al. 2008) because of the tendency for threshing areas to be regularly cleaned and for by-products from these activities to be collected and used for other purposes (e.g., using chaff in wattle and daub construction). These investigations also note that "threshing floors also almost never occur within settlements because they require wind for winnowing and the chaff blown from the floor during winnowing may disturb daily life within the settlement" (Shahack-Gross et al. 2009:181). However, these two prior studies were carried out in vastly different temporal and geographic contexts, targeting sites around the Mediterranean from the Iron Age and modern day. Potentially, threshing activities in these contexts are not at all like the threshing traditions that existed in early medieval Scotland. Furthermore, Shahack-Gross et al. (2009) and Tsartsidou et al. (2008) use different methodologies and forms of quantification (e.g., Phytolith Difference Index – Tsartsidou et al. 2008) than this study, and it is challenging to know how these approaches and results might be comparable. Given the spatial patterns of cereal inflorescence bract phytoliths in this study, I argue, at least for the Burghead context, that crop processing areas are indicated through higher-than-average concentrations of elongate dendritic phytoliths. Perhaps we cannot go so far as to argue for threshing floors; however, I maintain that the elongate dendritic phytoliths are useful for identifying cereal crop processing and storage areas in Pictish archaeological contexts.

Based on this spatial analysis, I argue that cereal plants made substantial contributions to Pictish daily life, influencing the movement and rhythms of humans and the life cycles within settlements. The influence of cereal plants is challenging to quantify. However, the results from this study show the importance of cereals to human lifeways as they are well represented within settlement floors, occupation areas, ditch fills, and other contexts such as artifacts and dental residues (discussed below). Crop processing was likely a communal activity, as we see from the microbotanical evidence cereals were brought into the fortified settlements rather than kept closer to agricultural fields for processing. It is possible, however, that field side processing could also have occurred alongside the processing within the settlements. Cereal plants were well tended by the Picts as seen through marked periods of agricultural prosperity (e.g., Balbinny signatures indicating increased periods of agricultural production/processing). The food produced in agricultural fields across Pictland was likely transported to fortified settlements, even within upland settlements such as Cairnmore and Tap o'Noth, as indicated by the presence of cereal inflorescence bracts in upland settlement contexts—where cereals are unlikely to be grown due to challenging environmental conditions and use of uplands for transhumance practices (Costello 2021, 2020). Pooideae plants appear to have been primary plant ingredients and thus the success and failure of these crops would have made substantial differences to the lives of Picts and the prosperity of settlements, especially those that traded surplus cereal crops and those that relied on the import of cereal foods. We can see fluctuations in these relationships through the vertical sampling contexts at Burghead and Balbinny, which provide hints as to how agricultural production was structured at Pictish settlements and how these settlements might have worked together. The present, but low values of elongate dendritic phytoliths in house floors at upland sites such as Cairnmore and Tap o'Noth for example, may indicate periodic connections with lowland agricultural areas, places where cereal crops are more likely to thrive (Cannell and Hawes 1994:248; Costello 2021; Garstang et al. 2010). I suggest that lowland Pictish communities that would have been capable of high production of Pooideae cereals were part of a larger network of fortified settlements, providing staple foods grown in the lowlands which were transported upward to sites such as Cairnmore and Tap o'Noth. Although cereals could have been grown in the lower hills surrounding upland settlements to some degree, the broader literature suggests that uplands were places for grazing domestic livestock (i.e., transhumance, booleying – Costello 2021, 2020). Within the Upper Strathbogie Valley cluster of sites for example, the chronology of these sites suggests enough overlap for this to be possible: Tap o'Noth 3rd–6th centuries AD, Rhynie 4th–6th centuries AD, and Cairnmore 5th–6th centuries AD. If this was the case, Rhynie could have acted as the agricultural provider of cereals for the nearby upland elite settlements. Certainly, more research is needed to understand the character of upland sites and to investigate what the relationships between the upland and lowland settlements might have been during the Pictish period. However, this investigation of use of space at Burghead's upper citadel, houses at Tap o'Noth and Cairnmore, and the lowland fortified enclosure at Balbinny has provided some initial clues.

Lastly, seasonality may be interpreted through the presence of cereal inflorescence bract phytoliths, as these microremains are produced at during summer and early autumn when the cereal grains are harvested. The presence of these phytoliths at Cairnmore, Tap o'Noth, and Burghead could suggest that these sites were occupied during harvest times in the late summer – early autumn and could have carried out agricultural processing activities at that time. However, broader discussions of cereal processing traditions in the British Isles have suggested that unthreshed grains could have been dried and stored to be processed throughout the winter (McKerracher 2018:79). At Burghead, year-round occupation has not been questioned, and continuous dwelling is perhaps supported by the microbotanical signatures which had very high values of Pooideae phytoliths (e.g., rondels, trapeziform sinuate, and elongate dendritic morphotypes). Overall, seasonality is challenging to interpret using the microbotanical evidence from Pictland and no strong signatures of seasonality can be confidently explained in this study.

This study has thus highlighted the central importance of cereal producing plants to Pictish communities. Cereals were sown, germinated, tended, harvested, threshed, winnowed, stored, cooked, and consumed by the Picts and their domestic animals, placing them at the centre of Pictish lifeways. In turn, cereals surged in prominence under the care of the Picts and local ecologies could have been influenced by this increase in cereal communities. For example, this could have created a decline in meadowland and forest communities (see Jones et al. 2021). Here we get a glimpse at the agency of cereal plants, where human communities are motivated to propagate cereal communities as humans benefit from the proliferation (and perhaps colonization) of cereal plants. Cereal plants, among other plants such as flax (not identified in this study, but elsewhere – see Niehaus 2021:37,44) may have been foundational in establishing networks between sites (e.g., lowlands to uplands). Without these plants, Pictland would have been a much different place. Cultivated plants were not the only influential non-human community that contributed to the poiesis of settlements, however, and in the following section I foreground the contributions of heathland plants, bog microalgae communities, and wetland plants to Pictish architecture.

Architecture

Early medieval structures in Scotland are notably rare in comparison to neighbouring areas such as early medieval Ireland or England, where tens of thousands of sites are known (e.g., Carver 2019:139–303; Hamerow 1993, 2012; O'Sullivan 2008, O'Sullivan et al. 2014:47–138;). As described in the previous section, intact floor layers uncovered during excavation allow archaeologists to examine use of space, architectural details, activities, and site formation processes (Borderie et al. 2020:151; Macphail et al. 2004; Milek 2012; Robertson and Roy 2019). However, *in situ* floor deposits are rare for lowland structures within Britain (e.g., for prehistoric roundhouses see Ghey et al. 2007; Webley 2007) and exceptionally uncommon in early medieval eastern Scotland (Ralston 1997; Noble et al. 2020:32). Thus, in areas where recorded settlements are sparse, such as Scotland, our knowledge of architecture is notably deficient compared to that of contemporary nearby cultural groups. For early medieval Scotland, the dearth in visible settlement architecture may have partly been due to a shift away from stone built architecture towards using less durable material such as turf, and architectural traditions where earth-fast structural elements were less common in the late and post-Roman era, though these assumptions are often based on absence of evidence rather than direct evidence of absence (Ralston 1997:24; Noble et al. 2020:320,327–328) (Prado and Noble 2022).

Where preservation is poor and other evidence is lacking, microbotanical methods can provide crucial insights into settlement traditions. Microbotanical analyses target more durable residues like phytoliths, and such analyses are often effective where macrobotanical elements are limited in the archaeological record (Pearsall 2015:253; Piperno 2006:1; Shillito 2013:72). Pictish architecture was investigated in this study through soil sampling at Tap o'Noth, Cairnmore, and the Burghead upper citadel, which targeted microbotanical and micro-algae residues. Similar studies elsewhere in Macedonia, Egypt, and England, have used comparable "piggy-back" approaches to investigate the terrestrial, semi-aquatic, and aquatic components of human-environment relationships, such as the collection and movement of turf, drinking water, and clay (Beneš et al. 2022; Flower 2006; Hill et al. 2019; Juggins and Cameron 2010; Rippon et al. 2000) (Prado and Noble 2022). Within this study, microremains such as chrysophytes, diatom frustules, and opaque perforated plate phytoliths were used as indices of ephemeral architecture present at Pictish sites such as Cairnmore and Tap o'Noth. This combined evidence has suggested the presence of turf walled buildings with thatched roofs of heather and grass, as I discuss further below.

In the following subsections, I detail studies where architectural evidence was strong such as the house platforms at Cairnmore and Tap o'Noth and others where such evidence was absent (e.g., the workspace at Burghead and the ditch fill at Balbinny). I then discuss the results to illuminate ephemeral building traditions in Pictland (i.e., use of turf and thatch) and the contributions of upland plant and algae communities to individual dwellings.

Cairnmore

The roundhouse floor at Cairnmore, a complex bivallate fort that overlooks the Upper Strathbogie valley, was a rare opportunity to investigate upland Pictish architecture. At both Rhynie and Cairnmore, settlement remains were poorly represented in the centres of the settlements where later cultivation had removed most floor layers. These later agricultural activities left behind only fragmentary postholes and other architectural features, as is the case with nearly all lowland early medieval settlements in eastern Scotland (Ralston 1997). However, at Cairnmore the collapse of the outer ramparts had fortuitously preserved a floor layer, located beside the outermost enclosure wall that survived under extensive stone spread from rampart decay (Figure 6.1 and 6.2) (Prado and Noble 2022). Initial observations during excavations at Cairnmore noted that this structure was potentially constructed of turf or other earthen materials (Noble et al. 2022), as has been suggested for other early medieval lowland structures (e.g., Ralston 1997:24; Noble et al. 2020:320). This hypothesis is supported by the absence of postholes and stakeholes surrounding the floor layer, which could have braced an earthfast timber structure and supported the walls and roof (Prado and Noble 2022). To investigate this hypothesis further, horizontal sampling for microbotanical residues was targeted across this floor layer.

The phytolith evidence indicates a consistent presence of sedges across the Cairnmore floor deposit. Although present in lower quantities than Poaceae morphotypes, higher counts of Cyperaceae cones were retrieved from many of the outer floor units where the wall of a superstructure may be expected (Fig. 6.2). This is a remarkable finding as Cyperaceae phytoliths are considered to have relatively low visibility (Dal Corso et al. 2017:16; Novello and Barboni

2015; Ollendorf 1992). The micro-algae assemblage, consisting of diatom frustules and chrysophytes was also ubiquitous across the floor, often in similar counts and concentrations to the Cyperaceae cones. Although these microfossils were retrieved from 90% of the sampling area (each present in 20 out of 21 units), elevated counts around the edge of the floor deposit and from supposed 'natural' units (18 and 21) indicate wetland plants and algae were concentrated around the edge of the structure (Prado and Noble 2022). In a recent publication, I argued (with Gordon Noble) that this indicated a turf walled structure which supported a mixed thatch roof of asters, heather, and grasses (Prado and Noble 2022). Of note is the fact that Cairnmore is situated within a peatland landscape where the Picts could have retrieved some of these plants (Jones et al. 2021:899).

Tap o'Noth

The microbotanical and micro-algae residues from the house platform at Tap o'Noth indicates a similar pattern to the floor at Cairnmore. Again, chrysophytes, diatoms, aster, heather, and sedge microremains are represented across the floor layer and usually at higher quantities around the edge of the structure. This pattern is particularly clear at the south side of the structure, which suggests a concentration of turf/peat, likely indicating the area cut into the hillslope. This structure was designated as House 3 during 2022 excavations of the lower citadel at Tap o'Noth by the excavation team and was estimated to measure at least 7m long by 4.5m wide (Noble and O'Driscoll 2022:10). Within this building, burnt animal bone and a small glass bead were recovered during excavation, indicating this building was likely a residence (e.g., cooking evidence and items of personal adornment). The central hearth was well-built and rectangular in form, again similar to the features in the Cairnmore roundhouse, suggesting some continuity of hearth traditions within turf walled upland dwellings. Comparatively to Cairnmore, the Asteraceae and Ericaceae signatures are slightly more widespread across the floor at Tap o'Noth, and dicotyledonous plants are also better represented. I suggest that these differences are minor, given some of these samples were consolidated because the sample volume was too small (i.e., under 200g), and overall, the structures are likely similar in form.

Burghead

The workspace in the upper citadel at Burghead did not suggest much regarding architectural features. At the west side of this workspace, slightly higher values of wood were identified, possibly indicating an ephemeral fence (e.g., wattle); however, this interpretation is very tentative. Although chrysophytes were retrieved from this area, the spatial pattern does not indicate a high concentration around the edges, perhaps apart from the west side (the location to the wood phytolith signatures). This side is where the contemporary cliff face is situated, and potentially then a low turf/wattle wall was situated here. Overall, this area was more useful for understanding use of space and activity areas at Burghead's upper citadel (as described in the previous section), than the architectural traditions of structures within this area. Samples taken from a house floor in the lower citadel during the 2022 excavations may uncover more details about such traditions at Burghead, but the analysis of these samples were beyond the scope of this dissertation.

Balbinny

As at Burghead, the samples from Balbinny do not provide architectural details about the site, as samples were procured exclusively from a ditch fill context. It is challenging to speculate about the construction of houses and other small buildings at Balbinny might have looked like given that this site is within a lowland context and therefore might have divergent building traditions from what has been suggested for the upland settlements of Tap o'Noth and Cairnmore. Perhaps the evidence from the lowland site at Rhynie provides the best comparative examples for architecture at Balbinny, as the excavations at Rhynie uncovered several buildings within the inner ditched enclosure of the Craw Stane complex. These buildings appear to have been of timber construction (Noble et al. 2013:1142), unlike the structures in the uplands, and this may point to a divergent architectural tradition in lowland contexts. These possible timber structures could also be a special case, however, given the unique high status of the Craw Stane enclosure at Rhynie. At this site, high status was evidenced by metalworking finds, game pieces, elaborate construction (e.g., large post holes), and Pictish symbol stones. To understand the architectural traditions at Balbinny, horizontal sampling of any identified intact floor layers in future excavations could be targeted to investigate this further.

Discussion – Pictish Architecture

Microbotanical residues can be used to interpret architectural details otherwise lacking direct evidence such as certain materials used for walls, flooring, and roofs. These construction materials (e.g., peat turf, sedges, heather and asters) were drawn from wet upland zones and indexed by microalgae (chrysophytes and diatoms), Cyperaceae cone phytoliths, and Asteraceae opaque perforated plate phytoliths. At Cairnmore and Tap o'Noth, the ubiquity of chrysophytes, diatoms, sedges, asters, and heather family plants within these floor layers suggest the use of plant communities from wet ecological zones, such as blanket bogs and fens, to build roundhouses for upland settlements. Materials constructed from these plant communities held physical qualities known by the Picts, who used them to construct roundhouse walls (waterproof and insulative turf) and thatched roofs (waterproof heather and grass thatch). The evidence thus suggests a relationship between the Picts and wet upland environments, drawn into relationships with people who pursued the insulative qualities of nearby plant communities. The relationships between plants and algae, which together made-up turf layers, were identified and used for housing their community members, likely also including their domestic animals. Entanglements between Picts and heathlands is also traced through the emplacement of relations encapsulated in floor layers. At Tap o'Noth and Cairnmore in particular, where contemporary heathlands are still present, heather thatch was likely used for architectural purposes, perhaps exclusively (i.e., no evidence of domestic animals feeding on asters/heather).

At both Cairnmore and Tap o'Noth, microresidues from house floor layers indicate that wetland indicator species (i.e., sedges, chrysophytes) are the residues from a turf/peat wall, with turfs cut from a wet ecological context, likely a blanket bog area. Analogous construction techniques are also known from Viking Age and later historical turf structures in Iceland, where turf was typically cut from lowland bogs and transported to the uplands for house construction (Bathurst et al. 2010; van Hoof and van Dijken 2008). Several diatom genera from the roundhouse floor at Cairnmore appear to overlap with the findings of Bathurst et al. (e.g., *Achnanthes, Eunotia, Navicula,* and *Pinnularia*) and these taxa are notably often found in peatbogs (Bathurst et al. 2010:2925).

Wetland turf has often been a preferred material over grassland turf because of its denser root mat which makes it better suited to absorbing water, making it more suitable for insulation in cool and wet climates (Milek 2012:120–122; van Hoof and van Dijken 2008:1026). Turf walls could be reasonably thick, often comprising two 'faces' and a core, similar in form to our modern cavity walls, with turf constructed in two parallel lines with earth between (van Hoof and van Dijken 2008:1026–1027). Turf structures are thought to be relatively efficient in terms of time and labour investment required for their construction and upkeep (Loveday 2007) and are also excellent structures to use in areas where wood for building is scarce. Turf structures are also particularly valued in cold and wet regions as these structures have excellent insulation properties (Bathurst et al. 2010:2920; Milek 2012:120), a pertinent observation for the northern environments of northeast Scotland. This hillslope setting of Cairnmore would have been an exposed setting and warmth and insultation would have been particularly valued in this context (Prado and Noble 2022).

Interpreting the roof material of this turf walled structure is complicated as the samples in this study were procured from a mixed context of floor and roof material. It is difficult to differentiate collapsed roof material from floor deposits in this context; therefore, to understand the character of the roof I compared the microbotanical signature with broader archaeological and ethnographic evidence. Overall, I did not differentiate between floor material and collapsed roof material as this context was likely a mix of both; however, tentative interpretations for the roof structure can be made. The low counts of reed type phytoliths (e.g., bulliform and saddle phytolith morphotypes) across the floor layer suggests that the roof and the roundhouse structure broadly did not rely on these wetland plants as thatching, as has been argued for some prehistoric roundhouse structures in Britain (Ghey et al. 2007; Pope 2008:17). Instead, the high degree of grass family (Poaceae) and aster family (Asteraceae) phytoliths potentially suggest the roof was thatched using dried grasses and other wild plants (Morell-Hart 2019b:236; Portillo and Albert 2011:3232).

Aster family phytoliths and other dicot morphotypes were recovered across most of the floor layer. Within contemporary Aberdeenshire, aster family species include hawkweed, daisy, yarrow, knapweed, and coltsfoot. However, further research is needed on Asteraceae phytoliths within northern Europe as some phytoliths recovered within this context were semi-translucent and resembled heather family (Ericaceae) microstructures identified by Carnelli et al. (2004:56). Ethnographic and historic research on Scottish shielings and other types of upland dwellings reference the use of heather (*Calluna vulgaris*) for thatched roofs (e.g., the blackhouses from the Outer Hebrides and the Black Barn in Northumberland) (Dower 2015; Scott 2007), and this could potentially explain the representation of Asteraceae and possible Ericaceae morphotypes recovered from this context (Prado and Noble 2022).

Upland plant communities, then, were highly influential in establishing upland communities, as key contributors to Pictish upland architecture. Other non-upland plant communities could have been chosen for upland architecture, but this study suggests they were not, given lack of evidence for lowland wetland plants such as reeds (e.g., bulliform phytolith morphotypes). We thus see strong connections between the people living in uplands settings and non-human communities including peatlands and heathlands, given chrysophyte, diatom, Cyperaceae, and Asteraceae evidence. This study has suggested that people living in upland environments were knowledgeable about the physical qualities present within upland plant communities and used the knowledge gained through human-plant relationships to build their human communities within these uplands.

Less can be said about lowland communities, as this study did not have the opportunity to procure soil samples from lowland house floors. Such opportunities are rare as historical land development and agricultural processes have disturbed lowland sites, and the identification of intact lowland settlements is exceedingly difficult. At coastal Burghead, the working space did not suggest the existence of a superstructure (e.g., walls and roof) and further studies will have to be pursued to understand Pictish architectural traditions in coastal environments. Potentially, turf and heather walls may not have been the preference, given the availability of coastal plant communities such as common reed rather than upland (e.g., heathland) plants. Evidence for timber construction, such as the remains of timber laced ramparts and wooden palisades (as evidenced by postholes), has been identified at most fortified enclosures including Cairnmore, Rhynie, Burghead and Dunnicaer. Wattle construction, such as panels and floor coverings are rarely preserved in Pictish archaeological contexts and have been identified only at a handful of sites such as Dundurn and Bunrannoch (Noble and Evans 2022:56,63). Such materials would have been sourced from woodland plant communities (e.g., hazel copses and oak groves). A detailed study of Pictish wood use by Niehaus (2021) suggests that oak heartwood was the preferred construction material as observed in burnt timbers from Rhynie, beams within stone walls and palisades at Burghead, Dunnicaer and Rhynie, and in large postholes at Rhynie (Niehaus 2021:42).

This preference for oak is an example from the macrobotanical record where we can see a particular plant community, oak forests, were targeted by the Picts for specific architectural purposes (i.e., fortified enclosures). Furthermore, Jones et al. (2019) note that oak pollen was not strongly signalled in the palynological record from the royal site Rhynie in the Upper Strathbogie Valley. Special efforts to procure oak timber from more distant locations would have been needed as these oak communities were not available locally. As the macrobotanical evidence from across Pictland indicates, oak was a preferred construction material and the centrality of oaks to the poiesis of Pictland can be traced in this example.

Conclusions: Peat Walls and Thatched Roofs

The interpretation of practices that deposit micro-remains in intact floor layers is not always straightforward, as taphonomic processes are not always clear and contamination during excavation can complicate these assemblages (Shillito 2013:76). However, the assemblages from the sites within this study do not suggest significant disturbance post-abandonment, nor during the excavation processes, in the contexts sampled. Microbotanical analysis successfully retrieved desired counts of phytoliths across the sampling areas and this methodology was effective in providing new data to interpret activity areas and architectural traditions at Pictish settlements.

Through these understandings of placemaking and other practices in settlements, we see how these settlements emerged through relational connections between humans and specific plant and algae communities, with non-human communities making key contributions in Pictish lifeways (e.g., crop foods and architecture). These relationships are particularly prominent within upland environments, where non-human upland communities of plants and algae contributed to turf walled and grass/heather thatched houses. I note, however, that this finding is possibly reflective of sampling bias, as no lowland or coastal house floor were examined in this study. Picts living in uplands areas also had clear relationships with non-human community members of wet ecological networks (e.g., blanket bogs). Other studies (e.g., Niehaus 2021) have pointed to consistent relationships between humans and various woodland plant communities (e.g., oak and hazel) for the construction of fortified enclosures. Overall, Picts across topographic zones established and maintained relationships with wet ecological zones, as evidenced through the recovery of chrysophytes and diatoms at Tap o'Noth, Cairnmore, Mither Tap, Burghead, Craig Rock, and Balbinny. The implications of these findings will be discussed more thoroughly in the following chapter.

The effect of Pictish communities on non-human communities is not particularly clear from the scope of this study However, the plant and algae communities which contributed to upland architecture (e.g., bog communities, heather communities) are still strongly present in contemporary Scotland's uplands. It might thus be reasonable to suggest that the Picts did not have a clearly negative impact on these plant and algae communities. This discussion is better contextualised through pollen analysis, which suggested, at least in the Upper Strathbogie valley, that the area was "considerably wet," as during AD 220 – 800, heathlands, fen/mire, wet woodland, and aquatic taxa (e.g., Cyperaceae) were well represented (Jones et al. 2021:903). Human activity indicators in the pollen record include ruderal species, such as those in Asteraceae, are often present in areas of soil disturbance; likely crop species, such as those represented by cereal-type pollen grains, which may provide evidence of agriculture; and coprophilous fungi spores (associated with herbivores), identified as pastoral farming signatures. Cereal-type pollen included barley and trace amounts of oats and/or wheat pollen, which corroborate the scarce macrobotanical record from Rhynie (Jones et al. 2021: 904–906; Ramsay 2019). This period of inhabitation of the Upper Strathbogie Valley (containing the sites Tap o'Noth, Cairnmore, and Rhynie) during the beginning-middle of the Pictish period (AD ~220 – 560) is characterized through pollen analysis as a mixed pastoral and cereal agriculture economy within a wet ecological fen/mire context. These findings are consistent with the microbotanical and microalgae residues identified at Cairnmore, Tap o'Noth, and Rhynie, such as Cyperaceae cones, cereal inflorescence bract phytoliths, cereal starch grains, chrysophytes, and diatoms.

Following this period (AD 560 – 800), the pollen record suggests a decline in settlement characterized by fluctuating fire/erosion events and slight increase in arboreal/shrub taxa. This decline, however, does not indicate complete abandonment of the valley, as cereal pollen, pastoral signatures, and agricultural weed pollen are continuously present into the modern period. Later (AD 800–1200), more fire/erosion events are noted, alongside a later increase in pastoral evidence (i.e., coprophilous fungi), and decrease in heather, signalling a change in heath and woodland management, possibly through deliberate burning events (Jones et al. 2021:910). The decline in settlement signalled by palynological data roughly correlates with the final periods of occupation at Cairnmore, the latest site within this cluster of settlements in the Upper Strathbogie Valley. Cereal evidence, although scarce, was present at Cairnmore which corroborates Jones et al.'s finding (2021) that the valley was not completely abandoned at the end of the Pictish period (i.e., cereal cultivation was still practiced until the end of the Cairnmore occupation and likely continued after).

Both phytolith and pollen analyses are useful for understanding the two-way nature of affect in human-plant relational networks, and together these records suggest that the humans within the Upper Strathbogie Valley were establishing and maintaining relationships with woodlands, heathlands, agricultural crops, and grasslands (i.e., for pasturing). The change in heathland and woodland management, as evidenced by a decrease in heather pollen (Jones et al. 2021:910), underlines the significant cultural changes occurring at the end of the Pictish period. Perhaps new forms of land management were being introduced and targeting the heathland and other plant communities with which the Picts had established and maintained relationships over hundreds of years. Such transformations may indicate key changes in social hierarchical order.

This chapter has foregrounded the contributions of plants and algae toward the poiesis of communities, specifically through the analysis of spaces, activity areas, and architecture at Pictish sites. The results have been useful for focusing our investigation of settlement traditions to the site level, which has not been available using other environmental archaeological approaches such as pollen analysis. This multiproxy approach, which targeted phytoliths and micro-algae, has contributed to our understanding of specific sites (e.g., Burghead, Balbinny, Cairnmore, and Tap o'Noth) and has collected complementary site-level data for other established large-scale analyses. This chapter outlined a new understanding of the contributions of plants and algae toward the making of Pictish communities, specifically in regard to how these people organized their settlements, built their architecture, and structured the activities that occurred within these settlements.

To better understand how the Picts established relationships with terrestrial, aquatic, and semi-aquatic non-human communities, the following chapter uses the evidence from microbotanical and microalgae analysis to investigate how human-plant relationships were structured in different ecological contexts (e.g., upland, lowland, and coastal zones). This next chapter thus focuses on the pastoral side of settlement traditions and identifies the plants that contributed toward pastoralism in Pictland.

Chapter 7: Human-plant and Algae Relationships in Lowland, Upland, and Coastal Settlements

Pictish settlements, and Pictland itself, broadly emerged through relational connections between human and non-human communities such as peatlands, heathlands, grasslands, forests, wetlands, and agricultural zones, as well as animals (domesticated). In this chapter, I explore broader ecological considerations, situating settlements within their immediate topographic zones (e.g., lowland, upland, coastal). Using site level data, settlements within these areas are grouped together and examined at a topographic zone scale (e.g., lowland, upland, coastal) using ubiquity values and presence/absence of microalgae to trace human-plant/algae relations. The aim of this section is to better understand similar and divergent settlement traditions across Pictland (e.g., similar construction techniques), and to investigate how human-environment relationships are established in each of these topographic zones.

Within this study, upland settlement sites are the most represented group, with four sites investigated. Settlements within the uplands are the least disturbed by historical and modern land development, and these sites often presented multiple contexts for microbotanical analysis (e.g., *in situ* floor layers). The four upland sites, Tap o'Noth, Cairnmore, Mither Tap, and Croftgowan, are investigated here through soil, artifact residues, and dental residues (human and animal). Lowland settlements in this study include Rhynie, Balbinny, and Craig Rock. These sites are examined through varying proxies, often independently (i.e., one context only), including soil residues, artifact residues, and dental residues (exclusively animal). Finally, coastal settlements are examined using soil, artifact residues, and dental residues (animal and human) from Burghead, Dunnicaer, and Lundin Links.

Each topographic cluster of sites was examined as a set, using the data outlined in Chapter 5 (Table 5.4), and in relation to other topographic clusters using ubiquity values outlined in Table 7.1. Phytoliths, starch grains, diatom frustules, and chrysophytes, recovered from different types of samples, provide information about which plants contributed to settlements. These proxies are then used to understand how human-plant/algae relations emerged and were maintained across ecological and temporal contexts. No evidence of disruption to relations over time was identified in this study. The presence/absence of micro-algae is also addressed to consider relationships with aquatic and semi-aquatic ecological networks. For clarity, each cluster of settlements is examined chronologically from earliest to latest.

Table 7.1. Ubiquity values (derived from number of samples n=106) of prominent plant taxa across ecological zones, arranged by type of topographic zone (Green – Lowland, Purple – Upland, Blue – Coastal). Mean ubiquity value of each taxon, across all sites is also noted. REAP – Rhynie, BAL – Balbinny, CR – Craig Rock, ToN – Tap o'Noth, CM – Cairnmore, MTap – Mither Tap, CG – Croftgowan, BHF – Burghead, DUNC – Dunnicaer, LL – Lundin Links.

	Lowland			Upland				Coastal			
Taxon	REAP	BAL	CR	ToN	CM	MTap	CG	BHF	DUNC	LL	Mean value across all sites (n=10)
Asteraceae	59%			66%				3%			43%
Asteraceae/Ericaceae	0%			19%				0%			9%
Cyperaceae	68%			62%				39%			54%
Panicoideae	86%			82%				82%			80%
Poaceae	81%			90%				79%			82%
Pooideae	90%			94%				88%			88%
Hordeum sp.	18%			11%				3%			10%
Avena sp.	4%			13%				3%			8%

Lowland Settlements

Of the three lowland settlements, Rhynie has secured the earliest dates with confirmed inhabitation from the 4th century AD into the 6th century (Jones et al. 2021; Noble and Evans 2022:99; Noble et al. 2019b). Balbinny emerged shortly after Rhynie, dating from the 5th to 6th centuries AD (Noble and Evans 2022:101; Noble et al. 2021:3). Craig Rock is the latest of the lowland settlements within this study, and has been dated to the early to mid 7th century AD (Zach Hinckley 2023, p.comm). For each of these lowland sites, ecological indicators from grasslands were ubiquitous, and at Balbinny a low ubiquity of microbotanical indicators from wetlands, heathlands, and forests were also represented (Fig. 7.1). Diatoms and chrysophytes were retrieved from both Craig Rock and Balbinny but were absent from Rhynie. Likely this absence of micro-algae at Rhynie points to the sampling strategy, as only pot sherds were available for analysis, whereas Balbinny and Craig Rock were studied through soil and animal dental residues respectively.

One of the most well-known Pictish royal centres is Rhynie, excavated recently by the Northern Picts team as part of the Rhynie Environs Archaeological Project (REAP). Located in the lowlands of the Upper Strathbogie valley, Rhynie is characterized as a royal center based on the multiple symbol stones associated with this fortified enclosure, including the Craw Stane and the Rhynie Man stones. Rhynie is dated from the 4th – 6th centuries AD, and excavations have uncovered architectural remains including large timber postholes, metalworking evidence (including crucibles and moulds), long distance trade items, and gaming pieces characterizing this place as a power center within the valley (Gondek and Noble 2011; Noble et al. 2019b).

Rhynie is the only Pictish site which has been examined using pollen analysis, which points to a mixed economic model of agriculture and pastoral traditions (Jones et al. 2021). An unusual find of fucoid seaweed was identified within the Craw Stane complex at Rhynie, and this has been hypothesized to have been used as fertilizer or for other purposes (e.g., food). In this study, human-plant and human-algae relationships were examined through pot sherd residue analyses, which suggested cereal-based meals consisting of cooked barley, oats, and likely emmer wheat. The identification of emmer wheat is unique to the Rhynie pot sherds, and likely points to the high status of the site.

The small lowland enclosed settlement of Balbinny is the only site within this study located in Angus. This site is dated to the 5th to 6th century AD, and like many Pictish sites was first located through the identification of a cropmark using aerial survey (Noble and Evans 2022:101; Noble and O'Driscoll 2023). Excavations in 2018 and 2021 were unable to locate any settlement remains dating to the Pictish period as much of the site had been ploughed away by historical and modern agricultural practices (Noble and O'Driscoll 2023). The enclosing ditch was the only major feature still intact that dated to the 5th and 6th centuries AD and the ephemeral nature of the site has been hypothesized to suggest a social gathering and/or ceremonial place (Noble and O'Driscoll 2023).

Craig Rock is the final lowland site examined in this study. This nuclear hillfort has evidence of a single rampart and several terraces descending to the east of the hillfort's summit (Hinckley 2018:128). The site has not been extensively excavated and therefore we know very little about its role in broader Pictland. Craig Rock is dated to the 6th century AD (Zach Hinckley 2023, p.comm). In this study microbotanical residues were able to be procured from animal dental residues. Despite this small sample size, diatoms and chrysophytes were also recovered from animal dental surfaces, and a minimum of six plant species were identified for Craig Rock contexts.

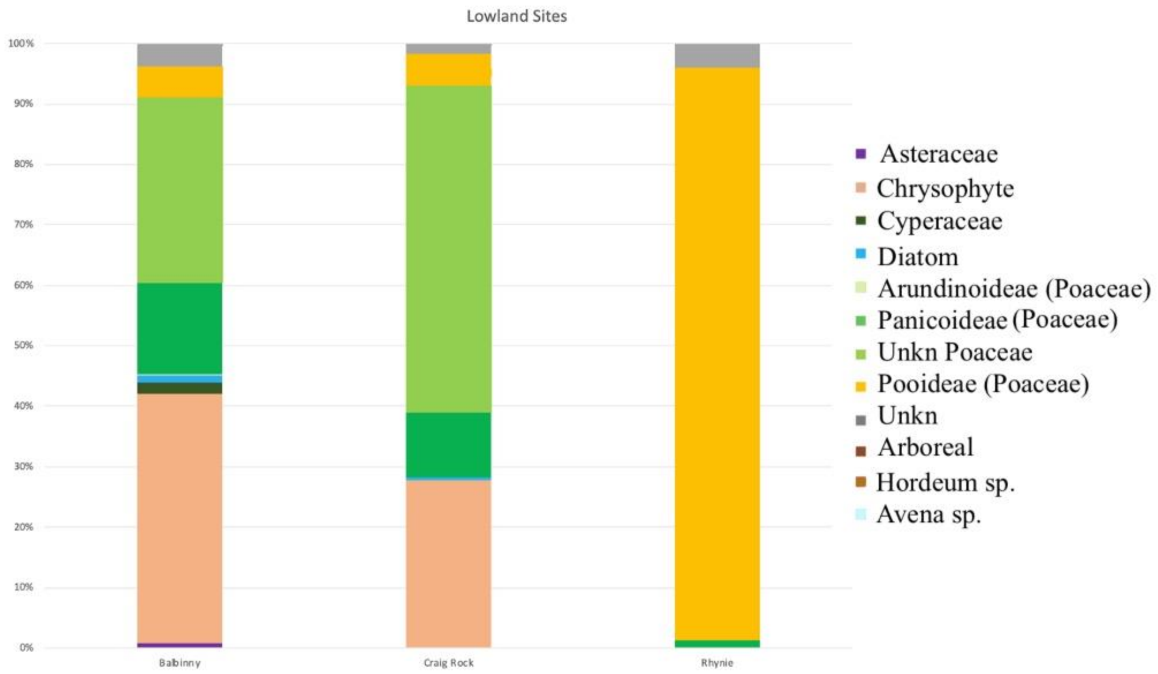

Figure 7.1 Microbotanical and micro-algae residues from Lowland Pictish contexts

Grass Communities and Lowland Sites

Grasses were well represented in this study with over 80% ubiquity for each of the three significant subfamilies (Panicoideae, Unknown Poaceae, Pooideae) across all sites studied. In lowland contexts, lowland grass ubiquity values were on par with the mean grass ubiquity values (i.e., ubiquity values of Unknown Poaceae, Panicoideae, and Pooideae) from across the study area (Table 7.1); however, lowland sites had the highest ubiquity for Panicoideae grasses (86% – versus 80% mean value, 6% higher ubiquity). Although only slightly higher than the mean value, this potentially suggests that Panicoideae grasses were more concentrated in the lowland areas. Panicoideae in this study is represented by bilobate and polylobate phytolith morphotypes. However, in other studies bilobates have been identified as different sub morphotypes such as "*Stipa"* (feather grass) forms (subfamily Pooideae). These "*Stipa*" forms are described as "plateaued bilobates" (Dal Corso et al. 2018:147) and have been a central focus of discussion in recent phytolith studies of steppe environments (Blinnikov 2005; Dal Corso et al. 2018; Fernandez Honaine et al., 2006, 2009; Fredlund and Tieszen 1994; Gallego and Distel 2004). Both bilobates and polylobates have been identified in grasslands where feather grass is dominant and potentially this is the case in the Pictland assemblage, where these morphotypes were retrieved in most sampling contexts (absent from human teeth).

One candidate for *Stipa* species (subfamily Pooideae) in Scotland is Mediterranean Needle-grass, *Stipa capensis*. According to the *National Biodiversity Network Trust* (NBN Atlas) this is the only annual species of *Stipa* local to the United Kingdom and is found living in dry stony hillsides. Certainly, some of the bilobates identified in this study could be identified as "*Stipa"* type. However, the further identification of bilobates and other morphotypes with more detailed identifications (e.g., rondels – keeled, horned) was not pursued for this study. Therefore, providing more nuanced identification of grass short celled phytoliths (GSCP) could be a promising avenue for future phytolith research in Scotland and other northern European contexts.

Sedge Communities and Lowland Sites

Sedge (Cyperaceae) residues were 54% ubiquitous across the sites within this study (mean ubiquity) and are evidence of wet environments such as fens, mires, and other wetlands. In the lowland sites, sedges were highest and well above the mean ubiquity of sedges, reaching 68% ubiquity in lowland contexts (14% over mean ubiquity of sedges). This follows the expectations for lowland contexts outlined in previous chapters. Sedges were indicated through the recovery of Cyperaceae cone phytoliths which were retrieved exclusively through soil samples. This is somewhat surprising as it would be expected that sedges might be recovered from lowland animal dental residues if animals were being pastured within wet lowland environments. Given the absence of sedges in animal dental residues, perhaps domestic animals were not grazed within lowland wetland environments and did not consume sedges as part of their diet.

Forest Communities and Lowland Sites

Forests were not well represented by microbotanical residues in this study. Facetate and conifer phytoliths only provided trace evidence of human-forest relationships across ecological zones, arboreal spheres were very rarely present and did not significantly contribute to this study. Fortunately, other lines of evidence such as wood charcoal, postholes, and serendipitous preservation contexts of timbers and wattle panels have shown how the Picts established relationships with various arboreal communities. As stated previously, oak appears to have been the preferred construction material for fortified enclosed settlements, with birch, hazel, alder, and willow trees also contributing to architecture and fuel (Jones et al. 2021; Niehaus 2021; Ramsay 2019). In lowland sites, little to no microbotanical evidence of human-forest relationships was present across sampling contexts. This is likely representative of low phytolith production in arboreal plant taxa which is typically limited to leaves and woody plant parts in temperate regions (Albert and Weiner 2001).

Algae communities and Lowland Sites

The microalgae evidence from lowland sites was lower than expected, with only trace amounts of diatoms recovered from Balbinny and Craig Rock (Fig. 7.1). This study was unable to qualitatively examine diatom frustules, as a diatomist was not consulted for identification of these micro-remains and therefore species identifications are extremely tentative. However, the diatoms represented included pennate morphotypes (both araphid and raphid) (outlined in Chapter 5, Fig. 5.4) representing sub-aerial and terrestrial species of micro-algae often recovered from peat bogs (Bathurst et al. 2010; Prado and Noble 2022:5). Chrysophytes had a higher representation in terms of raw numbers than diatom frustules in these contexts, and these micro-algae are also typically recovered from wet boggy contexts (Cambra 2010). Based on these data, the micro-algae residues from lowland sites do not suggest strong relationships with coastal, riverine, lacustrine, or brackish aquatic environments.

Animal Dental Residues and Lowland Sites (Pasturing Traditions)

Pasturing traditions in lowland areas can be examined through microbotanical residues from domestic animal teeth. Such studies have been carried out elsewhere using microbotanical residues trapped in dental calculus (e.g., Middleton and Rovner 1999; Weber and Price 2016), but dental calculus is rarely observed upon dental remains in Scotland. Therefore, alternative sampling methods which do not require dental calculus were pursued to gently extract microbotanical and micro-algae residues adhering to the outer surface of animal teeth (detailed in

Chapter 4 – methods). In this study, cattle, pig, sheep/goat, and horse teeth were targeted to understand pasturing and supplemental feeding regimes of these animals. Only one other study has investigated animal feeding regimes through microbotanical analysis of animal teeth, retrieved from archaeological sites in Orkney and England (Armitage 1975). The study by Armitage (1975) which sampled intact teeth within mandibles and individual molars identified similar microbotanical residues to those observed in this study, indicating that sheep, cattle, and horses were grazed on grasslands as evidenced by grass-type phytoliths retrieved from dental surfaces, and occasionally supplemented with cereal production by-products (as evidenced by elongate dendritic phytoliths from cereal inflorescence bracts).

In lowland contexts, only animal teeth from Craig Rock were available for microbotanical analysis, and this included cattle, sheep/goat, and pig teeth (Figs. 7.2 – 7.5). Microbotanical residues from these animal teeth exclusively consisted of grass phytoliths (Poaceae including Panicoideae and Pooideae subfamilies) and cereal grain starches (barley and oat; *Hordeum* sp., *Avena* sp.) (Fig. 7.6). It is important to remember that these residues represent the food eaten shortly before the animals died and were processed for human consumption. Similar studies have investigated last meals of animals through the extraction of starch grains from preserved gut contents and feces (e.g., Cagnato et al. 2021). For cattle at Craig Rock, the microbotanical residues retrieved suggest a diet of mixed grass stems, stalks, leaves, and culms, dicotyledonous plants, barley grains, and one instance of a possible tuber. Sheep/goat and pigs have near identical microbotanical signatures with a mix of grasses and pigs consuming some dicotyledonous plants. Starch grains extracted from cattle and sheep/goat teeth suggest these animals were being supplemented with cereal grains at Craig Rock, likely barley. Diatom frustules were exclusively recovered from cattle teeth, and chrysophytes were identified from both cattle and pig teeth. Overall, the pasturing regimes at Craig Rock indicate grassland grazing, with cattle likely in nearby wet pastures (as evidenced by Panicoid grasses, diatom frustules and chrysophytes) and other animals in similar environments with slight differences. This sample size is small, representing only four individuals and only one lowland site (Craig Rock). To better understand lowland pasturing regimes, future studies would benefit from targeting other lowland sites when available.

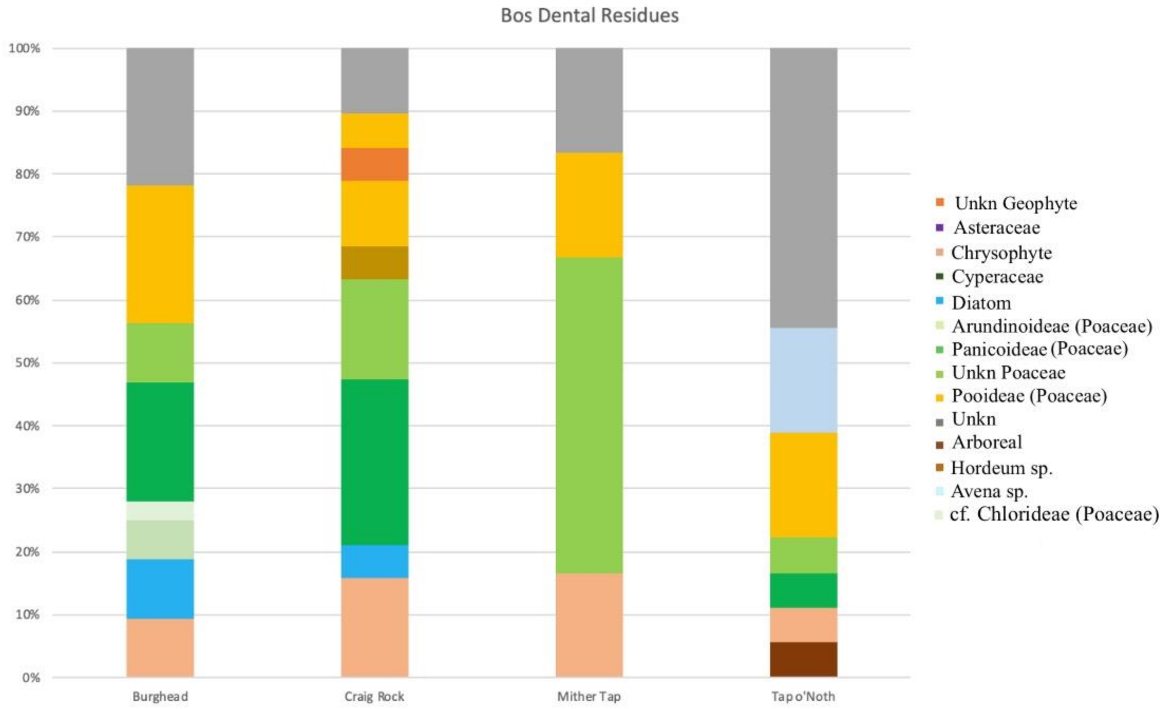

Fig. 7.2 Microbotanical and micro-algae residues from cattle (*Bos taurus*) teeth retrieved from Pictish settlements.

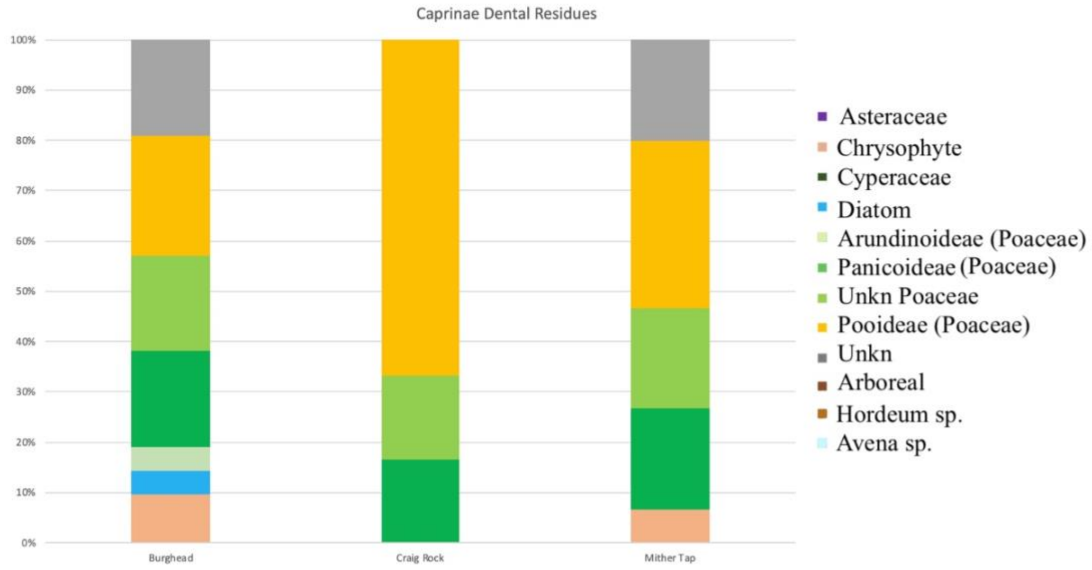

Fig. 7.3 Microbotanical and micro-algae residues from sheep/goat (*Caprinae – Ovis aries/Capra hircus*) teeth retrieved from Pictish settlements.

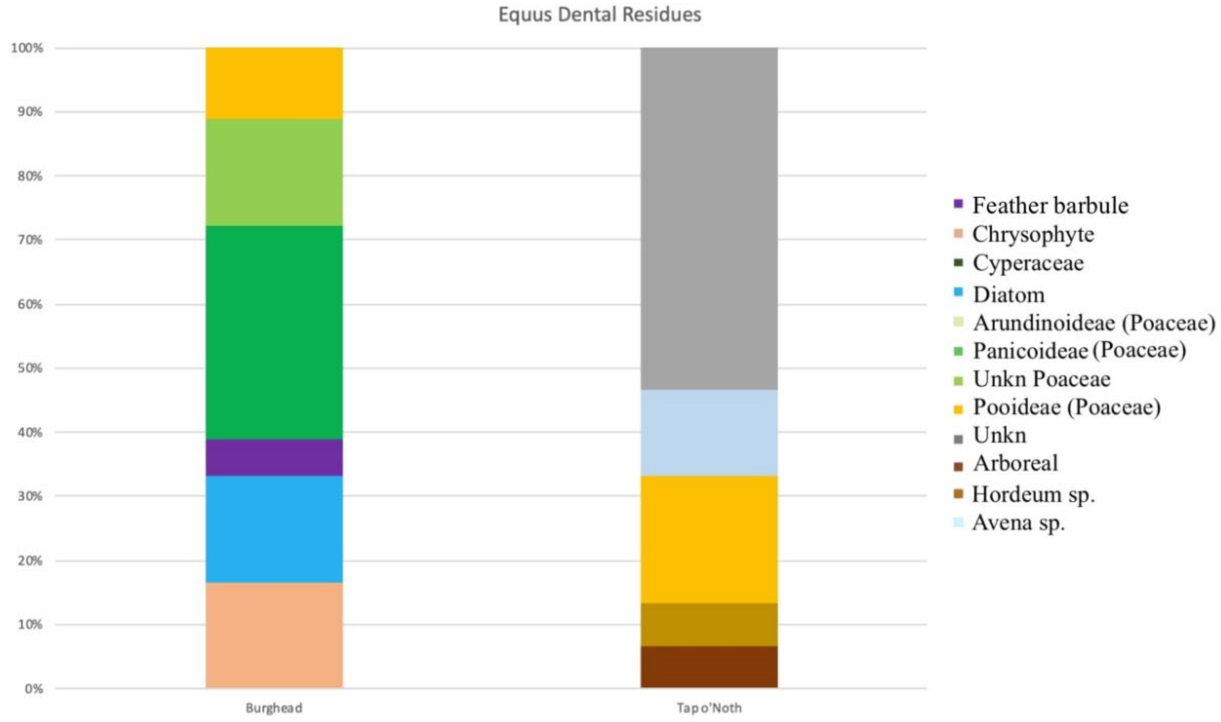

Fig. 7.4 Microbotanical and micro-algae residues from horse (*Equus ferus*) teeth retrieved from Pictish settlements.

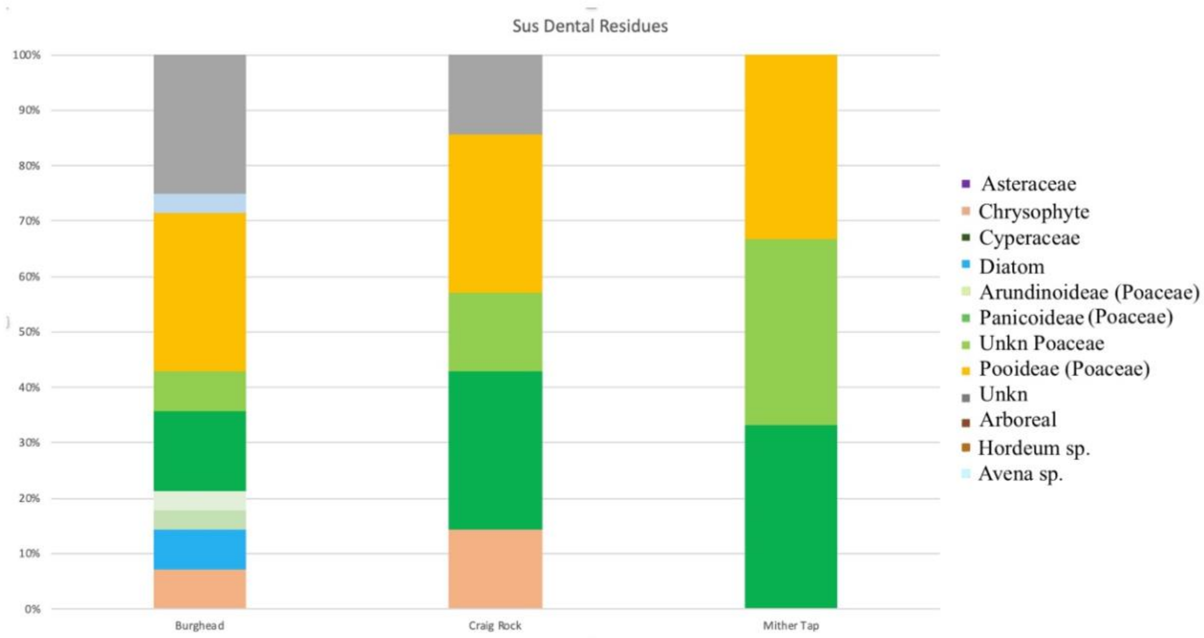

Fig. 7.5 Microbotanical and micro-algae residues from pig (*Sus scrofa*) teeth retrieved from Pictish settlements.

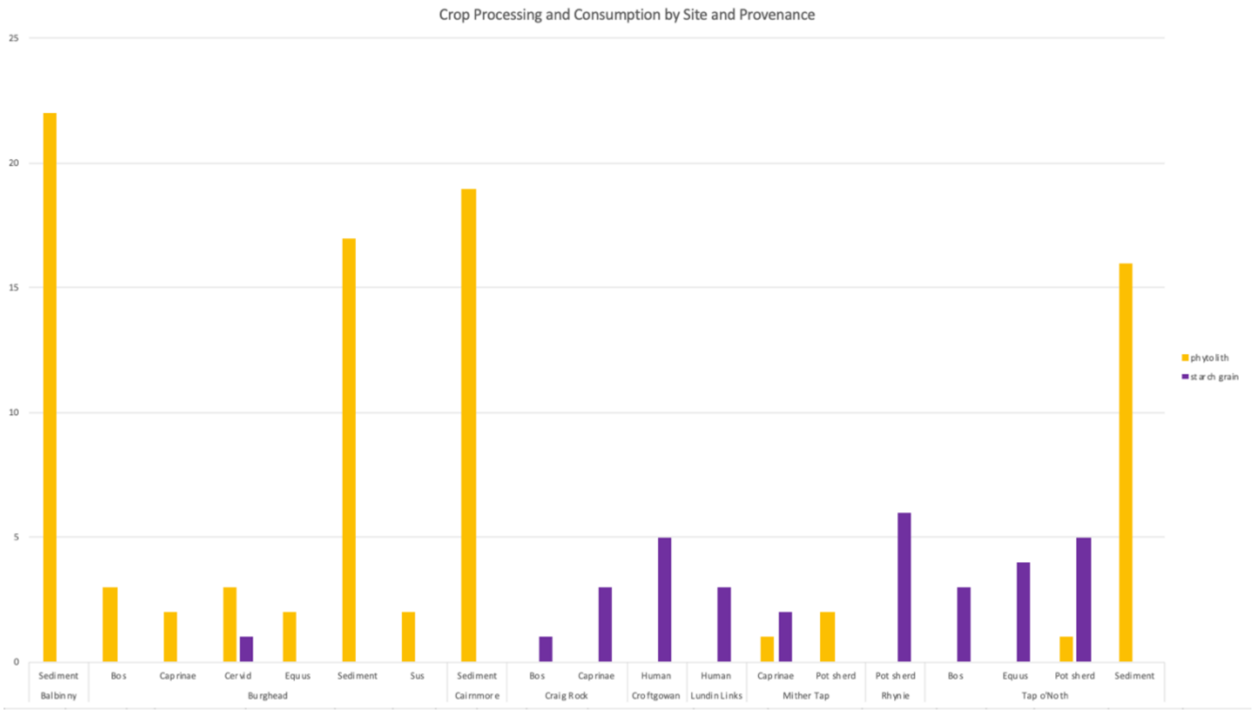

Fig. 7.6 Crop processing and consumption in Pictland by site, provenance, and type of residue (yellow – phytolith, purple – starch grain).

Summary – Human-Plant/Algae Relationships and Lowland Sites

The lowland sites within this study are dated to AD 300 – 660, representing the early to mid-Pictish period. Changes over time from such a small cluster of sites, near enough in date to each other, is challenging to interpret, and these sites do not show distinct enough differences to suggest any patterns across time. Furthermore, slight differences between these assemblages are largely attributed to sampling strategy rather than divergence in settlement tradition. Further investigations of intact floor deposits, animal teeth, and pot sherds would greatly improve our understanding of lowland human-plant/algae relationships as the sample size within this study is not robust.

For lowland Picts, grasses were the main plant community which contributed to the establishment and maintenance of settlements. Various grasses contributed to the diets of domestic animals, and cereal grains from cultivated Pooideae crops (e.g., barley) were shared between humans, cattle, and sheep in lowland contexts. Dicotyledonous plants and sedges also contributed to Pictish settlements; however, to a lesser degree than grasses. The agricultural potential of lowland areas in Pictland was certainly recognized and the production of cereals appears to be the main agricultural endeavour by lowland Picts, possibly to the extent of caring for more challenging cereal crops such as emmer wheat (as evidenced by Rhynie pot sherd residues). Micro-algae, representative of semi-aquatic and aquatic environments, did not contribute to the poiesis of lowland Pictish settlements to the degree expected, given wetlands are commonly found in lowland topographic zones, as these areas as prone to flooding and retain water (Keddy 2013).Through the chrysophyte evidence, we see that peat-turf was likely used at Balbinny and Craig Rock, but due to the frequent truncation through historic and modern agriculture it is challenging to say how turf was used in lowland contexts. Overall, wild and domestic grasses were significant non-human communities that contributed to the creation, rise, and maintenance of lowland settlements, and without them, it is unclear how lowland settlements might have survived.

The evidence collected from this study is unable to address potential impacts humans had on the plant communities; however, when considered alongside the palynological study by Jones et al. (2021) some insights may be considered. The Picts inhabiting the lowlands and focusing on cereal agriculture would have likely influenced the rise and decline of specific plant communities as cereal agricultural practices (as evidenced by cereal type phytoliths and starch grains) typically involve disturbance which allows certain herbaceous taxa to thrive, including arable weeds such as *Plantago lanceolata* (e.g., ribwort plantain) and Asters (e.g., daisies). A rise in herbaceous taxa typically associated with human activities is seen in the pollen residues dated from AD 220–800 (Jones et al. 2021:903–906). After this period is a notable decline in woodland pollen alongside a rise in herbaceous taxa which possibly point to increased farming and grazing where woodlands may have been cleared (i.e. resulting in arboreal pollen decline).

Upland Settlements

Within this study, Tap o'Noth, Cairnmore, Mither Tap, and Croftgowan are representatives of upland Pictish settlements. These sites span a broader chronological sequence (AD 100 – 700) than lowland and coastal settlements and are thought to be the least disturbed sites as historical and modern upland development has been scarce in comparison to lowland and coastal areas. Soil, pot sherd, and dental residues (animal and human) were targeted at these sites, covering all available contexts within this study, although it was not possible for these analyses to be evenly distributed across sites (e.g., Mither Tap: animal dental and pot sherd, Cairnmore: soil). Within upland settlements, grasslands were ubiquitously represented across all sites, and heathlands, wetlands, and forests in half of the sites (Table 7.1). Diatom frustules and chrysophytes were present across most upland sites, apart from Croftgowan where these micro-algae were absent. However, this should be somewhat expected as the Croftgowan sampling context was restricted to human dental residues.

Tap o'Noth is one of the oldest sites studied across this investigation and has been dated from the 2nd to 6th centuries AD (Noble and O'Driscoll 2022). The summit of the hillfort is characterized by a vitrified fort which dates to the Iron Age. Tap o'Noth is classified as the second highest hillfort in Scotland (Noble and Evans 2022:101). This upland settlement is enigmatic, and research focused on this hillfort is continuously shifting our perspective of this place, most notably the recent identification of hundreds of house platforms contained in Tap o'Noth's lower fort (Noble and O'Driscoll 2022:3). Despite recent discoveries, it is unclear if Tap o'Noth could have been occupied year-round or if it was a more seasonal center of occupation (Noble and Evans 2022:66–68). Of all the sites within this study, Tap o'Noth had the highest plant species richness with eleven minimum taxa identified. Again, this is likely representative of the sampling strategy which uniquely was able to target microbotanical and micro-algae residues from multiple contexts including soil, dental residues (animal), and pot sherds. Aster family (Asteraceae) and grass family (Poaceae) morphotypes were ubiquitous across the Tap o'Noth house platform (House 3), and sedges (Cyperaceae) were also well represented. Overall, as outlined in the previous chapter, the house platform residues suggested a turf walled structure, likely with a mixed thatch roof of heather and grasses. The pot sherd residues from nearby house platforms to House 3, also discussed in the previous chapter, indicated cereal-based meals (e.g., pottage) were cooked and consumed within these houses.

Not far from Tap o'Noth is the small ringfort enclosure of Cairnmore. Both Cairnmore and Tap o'Noth are situated within the Upper Strathbogie Valley. Cairnmore is dated from the 4th to 7th centuries AD (Cook 2011; Noble and Masson-MacLean 2018:8), and microbotanical residue analysis of an intact house floor (5th – 6th century AD) located just outside the outermost rampart wall revealed this structure, like House 3 at Tap o'Noth, was likely constructed of turf walls and covered with a mixed heather/grass thatch roof (Prado and Noble 2022). In this study Cairnmore was examined exclusively through soil analysis which recovered phytoliths, diatoms, and chrysophytes from the intact floor layer.

Mither Tap is an early medieval hillfort characterized as a complex citadel type with the main phase of occupation dated to the 7th to 8th centuries AD (Noble and Evans 2022:106–107). This hillfort is situated upon the eastern summit of the well-known Bennachie hill range in Aberdeenshire and consists of a small upper citadel built upon a craggy granitic tor (Noble and Evans 2022: 106). Archaeological excavations at Mither Tap have identified metalworking evidence, midden deposits, and settlement platforms within the fort (Noble and Evans 2022:106; Noble et al. 2019a). Within this study, human-plant and human-algae relationships were investigated through pot sherd and animal dental residue analyses. Like Tap o'Noth, pot sherd residues suggested cooked meals consisting of cereal grains such as barley and oats within these pots.

The last upland site within this study is Croftgowan, a cairn burial site located within Cairngorms National Park and is distinguished as the largest cemetery in northern Pictland, featuring over 40 identified barrows (Mitchell and Noble 2017; Mitchell 2020:111–115; Noble and Evans 2022:204). Other large cemeteries in northern Pictland that are comparable to Croftgowan include Garbeg and Tarradale (Noble and Evans 2022:193). Human teeth from one individual were sampled for microbotanical and microalgae residues, recovering similar signatures to those found within pot sherds (i.e., cereal-based meals). This individual was exhumed from a Pictish barrow and is not linked to any known or documented historical figure. The sampling process was non-destructive, and the human remains were treated gently and with respect. The microbotanical evidence, alongside the human dental residues from the coastal site Lundin Links, represent the first direct evidence of Pictish meals which suggest final foods such as pottage, oatmeal, stew, or bread were consumed before death.

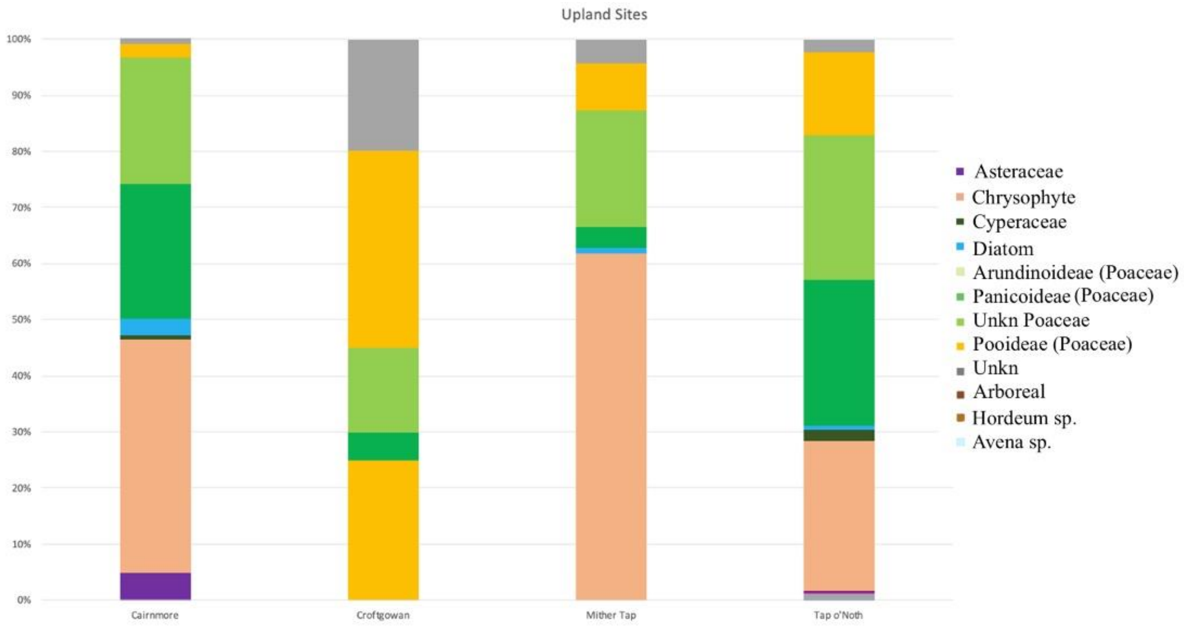

Figure 7.7 Microbotanical and micro-algae residues from Upland Pictish contexts

Heathland Communities and Upland Sites (Asteraceae and Ericaceae)

The relationship between humans and Asteraceae, Cyperaceae, and grassland communities in Pictish upland settlements is striking in this study. The highest ubiquity of Asters and heather family (Ericaceae) plant communities are represented at upland sites, and the use of these plants as architectural resources is indicated within the Tap o'Noth and Cairnmore house floors. These plant communities blanket the upland environments, and ethnographic accounts have continuously pointed toward the importance of these plants for the people living in Scotland (Beith 2018; Dickson and Dickson 2000; Milliken and Bridgewater 2004). Heather, in particular, is an emblematic plant of Scotland, thought to be on par with the thistle in terms of Scottish heritage and symbolism (Dickson and Dickson 2000:261). The valued properties of heather include its fire resistance, springiness, scent, and flavour (Dickson and Dickson 2000:261–262).

Historical accounts often point to the use of heather by the Picts to create a delicious beverage, perhaps as heather ales or beers (Dickson and Dickson 2000:262). As a construction material, heather has been dubbed as “perhaps the most Scottish of thatching materials,” and a well-built heather roof is purported to last 100 years (Kenicer 2018:136; Milliken and Bridgewater 2004:86–87).

Heather grows in damp acidic soils, and heather moorlands are well documented in Scotland’s upland regions (Kenicer 2018:133). Other reported uses for heather include as cleaning materials (i.e., for brooms), bedding (i.e., heather mattress), dye, tanning agent, and domestic animal fodder (Kenicer 2018:136; Milliken and Bridgewater 2004:109,114,185,243). Within the upland settlements, it is no surprise that heather is found in abundance given its many desirable physical qualities and uses, and its local ubiquity on the landscape. Scotland has a long history of managing heather through burning – a practice known as ‘muirburn’ (Milliken and Bridgewater 2004:241). Today such practices are used for ensuring the success of red grouse communities that feed on heather shoots and use mature heather for shelter from predators. Although this study has not identified evidence for heather burning, this is one example of historic human-plant relationships that have continued in Scotland to present day.

As discussed in previous chapters, there are challenges within this study regarding the identification of Ericaceae morphotypes and understanding the distinction between these and Asteraceae perforated plate phytoliths. Asteraceae plants endemic to Scotland include thistles, burdock, knapweed, hawkbit, sow-thistles, dandelion, hawkweed, cudweed, goldenrod, daisy, tansy, yarrow, ragwort, and coltsfoot, to name a few. Several of these plants have been used in Scotland for dyes (e.g., ragwort, yarrow), basketry (e.g., ragwort), food and drink (e.g., burdock, dandelion), and medicine (e.g., daisy, coltsfoot) (Kenicer 2018; Milliken and Bridgewater 2004).

These aster family plants then are somewhat ‘all-rounders’ providing opportune qualities where needed. Regarding the high ubiquity of aster and heather family plants in upland settlements, this suggests a substantial degree of relationship with plants living nearby the upland settlements. While this is unsurprising, I suggest this showcases the connectedness between the upland Picts and proximal plant communities.

Sedge Communities and Upland Sites

Sedges were also highly ubiquitous at upland sites, with 62% ubiquity, which reaches above the mean value across sites studied (54%) but is lower in ubiquity than lowland settlement contexts (68%). Upland flushes, springs, fens, and bogs are likely sources of sedges in these contexts (Keddy 2013:8). Sedge matter could have been part of the plant matter embedded in architectural turf at Tap o’Noth and Cairnmore (Prado and Noble 2022). Other indicators of such environments, such as distinctive horsetail phytoliths (*Equisetum* sp.), were surprisingly not retrieved in this study, despite horsetail pollen being present at Rhynie (Jones et al. 2021). Sedges have been used in Scotland for making cordage (rope) (Milliken and Bridgewater 2004: 108) and are strong indicators for wet and inundated ecological zones of the landscape (Keddy 2013; Preston et al. 2002).

Grass Communities and Upland Sites

Grasslands were also well represented at upland settlements with the highest ubiquity values across all sites studied (Table 7.1). This again suggests a strong relationship between the Picts and grasslands, and this is especially the case given the upland topography and highest levels of ubiquity. Microbotanical residues of cereals were equally ubiquitous in upland and lowland sites which is somewhat unexpected. Upland settlements also had the highest ubiquity of oats (13%.) across the study area. The high ubiquity of grasses possibly suggests the movement of grass and cereal products from lowland production areas for use and possibly storage in upland settlements. It would be expected that given the upland heath moorland context surrounding the upland settlements, Asteraceae and Ericaceae plants might be the most ubiquitous in these settlements, and indeed the highest ubiquity for these plants is seen in the uplands; however, grasses also have the highest ubiquity values in the upland sites (except for Panicoideae subspecies with highest ubiquity in the lowlands). This pattern could potentially point to the significance of upland sites and connection with lowland areas (e.g., long term habitation, transportation of lowland plant resources to the upland settlements).

Algae Communities and Upland Sites

The microalgae evidence largely met the expectations for upland sites, with low representation of microalgae residues overall. Most micro-algae residues were retrieved through soil sampling and the highest counts of these remains were captured in the Cairnmore roundhouse floor. Tentatively, these micro-algae again are thought to represent terrestrial and sub-aerial forms of microalgae which are commonly retrieved from peat bog environments. Chrysophytes were retrieved in the highest quantities across ecological zones, which is unsurprising as they were retrieved from turf wall contexts which were likely sourced from nearby blanket bog environmental zones. Chrysophytes were well represented at Mither Tap which was not targeted for soil sampling, and this potentially suggests that domestic livestock were grazed in the lower mixed grassland/peaty areas near this upland fort.

Animal Dental Residues and Upland Sites (Pasturing Traditions)

Evidence of domestic animal feeding and pasturing regimes in the uplands show a marked difference from lowland contexts (Figs. 7.2–7.5). Microbotanical residues were extracted from pig, cattle, horse, and sheep/goat teeth from Mither Tap and Tap o'Noth to examine animal feeding practices in upland settlements and residues varied more by site than by species. The microbotanical residues at Mither Tap suggest that domestic livestock were fed a diet largely consisting of grasses and some dicotyledonous plants. Only sheep/goats at Mither Tap were supplemented with cereal grains as evidenced by lenticular starch grains recovered exclusively from sheep/goat teeth, which were absent from cattle and pig teeth (Figure 7.6).

At Tap o'Noth domestic animals appear to be fed quite differently to Mither Tap and lowland contexts. Microbotanical residues from horse and cattle teeth suggest that these animals were fed diets with a high representation of cereal grains, including both oats and barley. Additionally, the residues from cattle teeth suggested grasses (Panicoideae, Poaceae, and Pooideae) and dicotyledonous plants were also part of the diet. Unexpectedly, the horse teeth residues from Tap o'Noth did not indicate that horses were fed grass leaves or stems, but their diets mainly consisted of dicotyledonous plants and cereal grains. Furthermore, both horse and cattle teeth residues contained softwood starch grains, which perhaps indicates some browsing activities (e.g., the consumption of woody plants) of these animals within the uplands.

Summary – Human-Plant/Algae Relationships and Upland Sites

It is challenging to determine the reason behind the different patterns observed at Mither Tap and Tap o'Noth. Perhaps the Picts at Mither Tap did not endeavour to supplement their livestock with cereal grains and instead preferred to pasture these animals in nearby grasslands. The Picts at Tap o'Noth then might have preferred to keep their animals closer to the fortified enclosure and therefore needed to supplement the diet of these animals with cereal grains. This potentially might indicate the level of economic productivity at Tap o'Noth to be able to do so (e.g., enough cereal grain for both humans and animals). Another explanation could be the season within which animals were processed at these sites. The high grassland signatures from Mither Tap may indicate that these domestic animals were processed at the end of summer or early autumn when supplemental feed was not necessary. At Tap o'Noth then, potentially the grass-absent signature suggests that these animals were processed during winter or early spring.

In terms of changes over time, the upland sites within this study cover the majority of the Pictish period, from the 2nd – 8th centuries AD. Although upland sites were well represented and spanned multiple contexts in comparison to lowland and coastal sites, there is not much evidence to suggest change over time in the microbotanical record. These upland sites suggest strong relationships between the Picts and upland plant communities (e.g., heather, sedges), grasslands, and agricultural cultivars. Crop processing and/or consumption activities were represented at all upland sites, demonstrating a connection with agricultural production which was likely carried out in the lowlands, as cereals are unlikely to have been grown in the windy and colder upland environments as these crops thrive best in more sheltered, warmer, and flatter areas. Uplands are also historically associated with transhumance practices such as booleying (e.g., upland pastoral grazing of domestic livestock) during summer months (Costello 2021, 2020). With the exception of differential pasturing/domestic animal feeding regimes between Mither Tap and Tap o'Noth, the microbotanical signatures from upland settlements in Pictland suggests consistency rather than changes throughout the Pictish period.

Heathland, upland fen, and grassland plant communities were significant non-human contributors to the poiesis of upland Pictish settlements. Within these upland settlements, heather, asters, and sedges were collected by the Picts to construct upland structures which were likely well-constructed to withstand the harsher weather conditions of living within upland settlements. The insulative and water-resistant properties of these plants were likely known to the Picts and valued, establishing a relationship between these plant and human communities.

Outside of the upland ecological zone, upland Picts also established and maintained relationships with grasslands, which indicates connections with lowland non-human communities, and quite likely their lowland human neighbours. Evidence from dental (animal and human) and pot sherd residues indicate that upland Picts were also storing, cooking, and consuming cereals and were supplementing some of their domestic animals with cereals as well. The microbotanical evidence also suggests divergent traditions for feeding cereal grains to domestic animals as the signatures from Mither Tap and Tap o'Noth suggests variable practices. Overall, several plant communities were important contributors for the establishment, and maintenance of upland settlements such as Mither Tap, Tap o'Noth, Cairnmore, and Croftgowan. Moreover, lowland agricultural plants (e.g., cereal crops) were part of the relational framework which connected lowland and upland ecological zones and settlements. Like in the lowlands, the human-plant/algae relational framework suggests that both wild and cultivated plant communities were essential for the creation and upkeep of upland Pictish settlements. Without these plant communities preferred rhythms of life in the uplands would have been extremely challenging. Terrestrial and sub-aerial algae were also participants within this upland network of relations, as they were essential agents for the creation of turf, used by the Picts for their upland architecture. Heather, asters, sedges, cereals, diatoms, and chrysophytes should be highlighted for their significant contributions to the poiesis of these upland settlements.

Potential human impacts to plant communities might have included upland management of heather communities through practices such as 'muirburn' where established communities of heather are reduced through controlled burning events, which allow new shoots of heather to regenerate (Milliken and Bridgewater 2004:241). Certainly, the extraction of peat turf would have impacted these peatland communities as well, although the extent of peat extraction during the Pictish period is unknown.

Coastal Settlements

The final ecological cluster of settlements are coastal sites which include Burghead, Dunnicaer, and Lundin Links. These sites are mostly dated to the later Pictish period (apart from Dunnicaer) and span from the 3rd – 8th centuries AD. Expectations for these sites included a high representation of coastal plants (e.g., Poaceae-Arundinoideae plants – reeds), marine diatoms, potential long distance trade species (e.g., lentils), and foodstuffs not retrieved from earlier medieval sites (e.g., beans). Soil, pot sherds, and dental residues (animal and human) were targeted to assess human-plant and human-algae relationships in coastal Pictish settlements, however all contexts were not available for sampling at each site (e.g., Burghead: soil and animal teeth, Lundin Links: human teeth exclusively). Remarkably, micro-algae were only retrieved from Burghead and were absent from both Dunnicaer and Lundin Links contexts, an unexpected finding given the proximity to the seascape.

The oldest coastal site assessed within this study is Dunnicaer, thought to be a prototype for the later larger coastal promontory forts such as Burghead (Noble and Evans 2022:98). Dated to the early Pictish period (3rd – 4th centuries AD), Dunnicaer was constructed upon a headland cliff which has now become a sea stack, a type of landform that is partly eroded making it separate it from the mainland and resembles a stack of rock jutting out of the sea. This coastal location therefore likely made Dunnicaer well situated for naval power (Noble and Evans 2022:49,97). Dunnicaer is one of the sites where local pottery has been retrieved, alongside Rhynie, Mither Tap, and Tap o'Noth (Noble and Evans 2022:85). At other sites, pottery has not been recovered, which potentially suggests that wooden and other plant-based vessels were likely more common than pottery in Pictish settlements. Pot sherds were the only context available for microbotanical sampling at Dunnicaer, and two sherds were examined to investigate human-environment relationships at early coastal Pictish settlements.

Lundin Links, a Pictish coastal cemetery dated to the 5th – 6th centuries AD (Greig et al. 2000:611; Noble and Evans 2022:190) is the southernmost site within this study, located near the village of Lower Largo in Fife (Noble and Evans 2022:198). This Pictish cemetery was identified within the coastal dunes during the 1960s after storm erosion revealed six round cairns and unusual monuments such as the 'dumbbell complex' and 'horned cairn complex' (Noble and Evans 2022:199). To understand human-plant and human-algae relationships at Lundin Links, the lower molars of four individuals, which had also been sampled previously for Sr/O isotopic analysis by Kate Britton, were targeted for microbotanical residue analysis. The potential for contamination was considered when sampling, and teeth were selected carefully, to target specimens that had minimal removal of dental enamel.

Lastly, the coastal promontory fort of Burghead is the largest early medieval coastal Pictish site and has been characterized by its notable bull symbol stones, high status personal ornamentation artifacts (e.g., bone cloak pins), feasting evidence (e.g., substantial faunal middens), and the remains of monumental rampart walls. This coastal promontory fort is situated within the modern town of Burghead on the Moray coast and has been dated to the 6th – 8th centuries AD (Noble and Evans 2022:111). It is suggested that Burghead was the probable major centre of power for the kingdom of Fortriu, given its monumental structure (Noble and Evans 2022:63). Macrobotanical remains, including two deposits of cereal grains in the upper citadel, indicate a more diverse representation of crops than seen in the macrobotanical samples from Rhynie. This finding has been used to suggest a possible later strategy to diversify crops in Pictland (Niehaus 2021:45). The two deposits of cereal grains were retrieved from the upper citadel and suggest this space was possibly used for crop processing and storage (Niehaus 2021:45–46).

Grass Communities and Coastal Sites

Microbotanical and microalgae residues were recovered in trace quantities from Dunnicaer and Lundin Links. Therefore, much of the data available for human-environment relationships in coastal settlements come from the Burghead samples. Overall, coastal sites demonstrated low ubiquity values for Asteraceae and Cyperaceae, and grasslands were well represented across all three sites, providing evidence for cereal grains across all settlements. The starch grains recovered from Dunnicaer pot sherds were very damaged and could not be confidently identified for this study. However, given the broader starch assemblage from this study, I suggest that they are likely representative of Pooideae cereal grains, likely barley. These starches consisted of both raw and cooked grains, suggesting these pots were used for both cooking/consumption and storage of cf. cereal grains at this coastal fort. One starch grain from Lundin Links human dental residues could possibly represent a consumed tuber (e.g., pyriform starch grain); however, this is a standalone example.

Although grasslands were well represented across all coastal sites studied, the ubiquity values were lower than in lowland and upland settlements and were overall below the mean ubiquity (except for Panicoideae). This likely reflects the paucity of microbotanical residues recovered from Lundin Links human dental surfaces and Dunnicaer pot sherds, and a larger sampling size is recommended for future investigations of human-plant/algae relationships in coastal settlements.

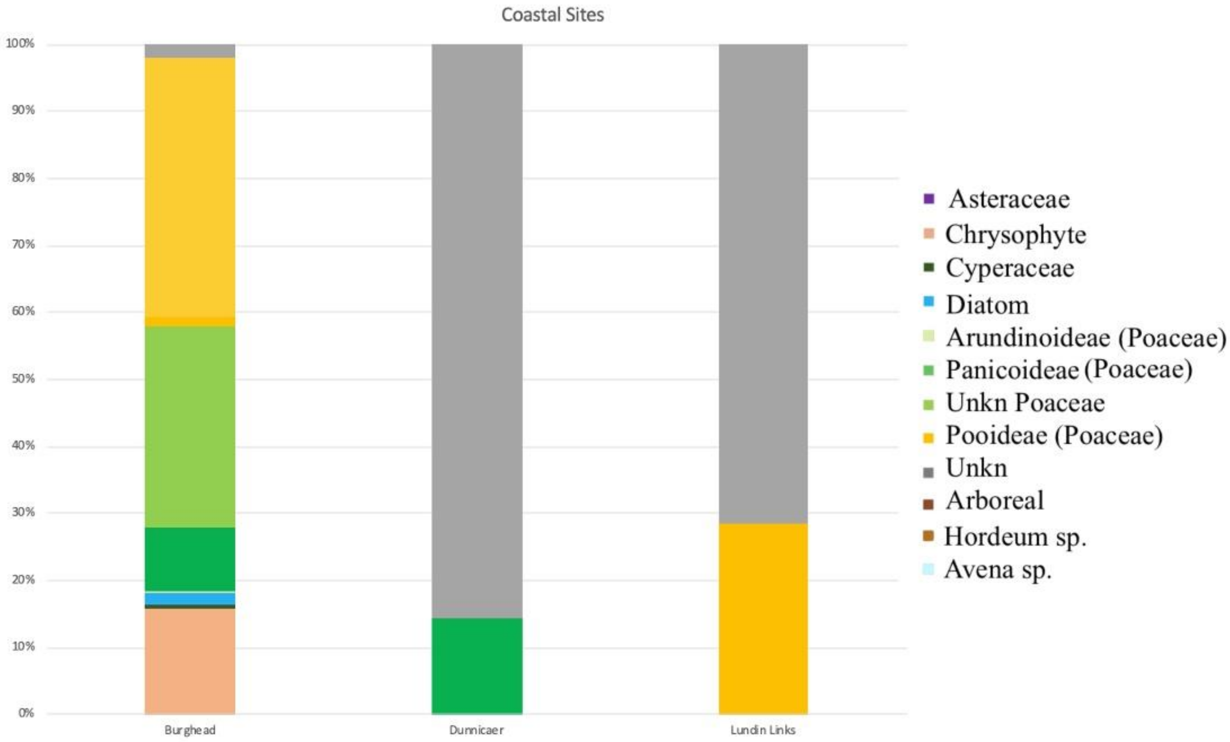

Figure 7.8 Microbotanical and micro-algae residues from coastal contexts.

Sedge Communities and Coastal Sites

Sedges were recovered in trace quantities solely from Burghead soil samples (both vertical and horizontal sampling areas). This suggests that the Picts of Burghead likely visited wetland communities where sedges grew but did not have as strong of relationship with these communities as seen in upland and lowland settlements.

Algae Communities and Coastal Sites

The microalgae evidence from coastal settlements was far below the expectations for this ecological zone. Diatoms and chrysophytes were only recovered from Burghead samples and were absent from both Dunnicaer pot sherds and Lundin Links human teeth. Overall, the absence of microalgae from all human teeth contexts is potentially positive as it may be unusual to recover such residues from human teeth, which would likely not be expected to encounter micro-algae from peaty contexts (i.e., chewing on peat). For the pot residues from Dunnicaer, very tentatively the absence of diatoms suggests that aquatic ingredients (e.g., seafood) were not part of the meals cooked and foodstuffs stored within these vessels. This is speculative however, as no studies to date have examined diatom residues in association with seafood consumption. At Burghead, microalgae were present across all animal teeth contexts and within soil samples, which suggests some relationship with wet terrestrial environments, as no marine-type diatoms were identified.

Animal Dental Residues and Coastal Sites (Pasturing Traditions)

Microbotanical residues from animal dental surfaces reveal pasturing regimes and animal feeding traditions at Burghead which are divergent from the signatures at all other Pictish settlements. This was the only settlement with evidence for pasturing domestic animals in coastal wetlands, as evidenced by bulliform phytoliths retrieved from sheep/goat, cattle, and pig dental residues. Although these phytoliths do not make up a substantial percentage of microbotanical residues retrieved from these animal dental contexts, such morphotypes were not extracted from any other animal teeth across Pictland. These phytoliths suggest that domestic livestock at Burghead were grazed along the coast where Arundinoideae (and possibly Chlorideae) plant communities (e.g., reeds) thrived. This is further supported by the retrieval of diatoms across all domestic animal dental surfaces at Burghead. Grasses and dicotyledonous morphotypes were also extracted from all animal dental contexts. Very few starch grains were recovered from these dental surfaces, which suggests that Picts at Burghead did not typically supplement their livestock with cereal grains, unlike at Mither Tap, Craig Rock, and Tap o'Noth. One exception is a possible oat starch grain extracted from one of the pig teeth. Lastly, residues extracted from a horse hemi-mandible excavated from the lower citadel in 2021 suggested a diet of various types of grasses for this Burghead horse. Within this sample was a singular find of a feather barbule, which was likely deposited with the horse remains.

Isotopic studies of Burghead cattle by Kate Britton and colleagues at the University of Aberdeen have revealed that many Burghead cattle were not local to Burghead, and instead were imported to the site from areas such as the highlands, Orkney, west coast Scotland, and Scandinavia. This presents fascinating opportunities for comparison between the end-of-life microbotanical residues from Burghead cattle teeth and isotopic research. Within this study only two of the sixteen cattle teeth sampled from Burghead were able to be analyzed for this study; therefore, the future analysis of the complete assemblage of samples is expected to further shed light on how microbotanical signatures might correlate to these isotopic results.

Summary – Human-Plant/Algae Relationships and Coastal sites

Like lowland settlements, grassland plants were the major plant contributors for coastal Pictish settlements. The ubiquity of significant plants represented at coastal settlements were the lowest of all the ecological zones, and the plant and algae expectations for these coastal sites were largely unmet. Marine diatoms were not identified, and there was no indication of long-distance trade species or unusual/standout foodstuffs from the other signatures across Pictland (e.g., no beans). Expanding the sampling strategy to other coastal sites would likely improve these results, and this should be an objective for future analyses. One standout signature, albeit to a small degree, is the representation of Arundinoideae phytoliths retrieved from animal dental residues at Burghead, which suggests coastal reed beds, and other Arundinoideae plant communities contributed to the feeding strategies for domestic livestock at Burghead. Such residues are exclusive to Burghead domestic animal feeding regimes. The recovery of Arundinoideae phytoliths (e.g., bulliform) was expected, but to a higher degree than recovered. The contributions of grasslands were once again foregrounded for coastal sites, which confirms the widespread practice of cereal grain agriculture as the primary agricultural pursuit in Pictland. Crop processing residues were recovered across animal dental contexts, and soil samples from the Burghead upper citadel, and a standalone cf. oat starch grain was retrieved from a pig tooth. Grasses, then, were key contributors to life in coastal settlements, and the evidence from this study suggests grasses were essential for feeding domestic animals, and the Picts themselves living along the coast.

Potential impacts to coastal plant communities are challenging to hypothesize based on this data. The effects of grazing livestock on coastal wetlands are highly variable depending on the intensity of grazing and type of livestock. Some studies suggest that non-intensive grazing can be beneficial for wetland habitats as these practices promote plant diversity, improve nutrient cycling, and mediate impacts of climate change (e.g., Pyke and Marty 2005), while other studies point to the destruction of wildlife habitats (e.g., migratory bird nests) and carbon sequestration capabilities when wetlands are grazed by domestic livestock (e.g., Harrison et al. 2017; Limpert et al. 2021).

Conclusions: The Centrality of Cereals

Across topographic zones (lowland, upland, and coastal) the Picts established strong relationships with grasslands, and the results from this study suggest that cereal agriculture was the focus for crop production (e.g., barley and oats). While cereal agriculture was indicated across settlements, upland settlements had the highest ubiquity of Pooideae grasses, followed by lowland and coastal settlements. I suggest that this ubiquity likely reflects agricultural production being focused in the agriculturally rich lowlands and movement of these staple crops for safe storage (and possibly distribution) in large upland settlements (e.g., Tap o'Noth). Coastal sites may also be part of a similar model; however, the results from this study are less clear about how this might have operated within the coastal zone (e.g., were there production-intensive supplier sites, or were coastal settlements both producers and safe storage centers?). The relations between the Picts and cereal producing grasses (e.g., barley crops) were part of the rhythm of life and these rhythms were shared by Picts regardless of which topographic zone they lived in. These relations certainly made a difference for the success or failure of a settlement, as this study showed the importance of cereal grains for human and domestic animal diets. Wild grasslands were also important communities for the success of the pastoral economy (e.g., as animal feed for cattle, sheep/goat, horses, and pigs). Grasslands were central to the relational framework of Pictland, and without wild grasses and cereal crop plant communities, lifeways would have been significantly challenging.

Heathlands, sedges, and micro-algae together contributed to the poiesis of upland settlements to a significant degree and made smaller contributions to lowland and coastal settlements. These communities which thrived in the uplands were sought by the Picts likely because of their physical properties which provided insulative and water-resistant building materials for upland settlements. The microbotanical evidence from this study suggests that heather and asters were essential for upland architecture, shielding the Picts and their animals from the harsher weather conditions of the uplands. Micro-algae which contributed to the creation of turf, also used for architecture (e.g., Cairnmore roundhouse) were also important participants in upland ecological networks, and upland settlements. These relations were not sustained in the lowland and coastal settlements to the same degree as the uplands and therefore heather, asters, and micro-algae (i.e., chrysophytes) were part of a unique relational framework emplaced in upland settlements which was centred on relationships between the Picts, heather moorlands, and peatlands.

In conclusion, notable plant communities such as heathlands, peatlands, wetlands, and cereal crops were essential non-human communities that contributed to the poiesis and continuity of settlements. Without these non-human communities, the story of Pictland would have looked very different in regard to architecture, rhythms of life, and character of relationships between human settlements. Investigating the relations between the Picts and non-human communities (plant and algae) allows us to understand the roles of plant communities in northern coastal human societies. Through their relationship with the Picts, plant and algae communities such as heathlands and peatlands participated in territorializing settlements, and shaped the world in which the Picts lived in. Plant agency is inherently relational as it is "manifested between people and plants" (Elton 2021:108). Sometimes these relationships are mutually beneficial, as is the case for cultivated plants. In this example, crops such as cereals provide food for humans when cared for sufficiently. To reach this potential, human partners are responsible for propagating plant communities through a number of actions: sowing, tending, removing weeds, watering, and saving seeds for another generation of plants (and humans). In this way, plants shape the lives of humans and vice versa.

In the concluding chapter, I retrace the pathways of microresidues across Pictland and situate the results of this study within the broader narratives of the early medieval world in the British Isles and Ireland. Following this I outline suggestions for future research. Finally, I revisit the relations-as-metaphysics framework introduced in Chapter 2 and discuss the strengths and limitations of this theoretical approach for understanding human-plant/algae relations and plant agency in Pictland.

Chapter 8: Conclusions: Human-Plant/Algae Relationships in Pictland and Contemporaneous Northern Coastal Societies

This research has highlighted the active roles of non-human communities in the poiesis of Pictland, suggesting that specific communities of plants and algae influenced human settlement strategies and cultural practices. Plant and algae contributions to settlements across ecological zones are variable; however, distinct impacts can be seen from grassland, peatland, heathland, and wetland non-human communities, in the formation of architecture, the foddering of livestock, and culinary practices. The microbotanical and micro-algae suites of relations, emplaced within each settlement through human practices, have been made visible using paleoethnobotanical approaches targeting microresidues in soil, artifacts, and teeth. This research has provided novel information about which local plant communities were essential non-human community members actively shaping broader rhythms of human-plant/algae relationships and daily lifeways within Pictland.

Aspects of Pictish social organization were mediated by local plant and algae communities which actively engaged with the Picts to territorialize their settlements. These relationships can be traced through the use of peat as a building material for human dwellings in upland topographic zones and the grazing of domestic animals on reeds in coastal topographic zones (i.e., Burghead). Using a relations-as-metaphysics approach it is clear the Picts structured their architecture relationally with local plant communities as relations between the Picts and peatland, heathland, and forest communities facilitated the construction of turf walled architecture, thatched roofs, and various wooden structures (as evidenced through chrysophyte, diatom, Asteraceae, Ericaceae and arboreal microresidues). Within Pictish settlements one meaningful human-plant activity was identified: cereal processing (e.g., threshing, storage, and cooking). This was signalled by cereal inflorescence bract phytoliths (retrieved from *in situ* house floors, a working space area, and an enclosure ditch fill) and cereal starch grains (retrieved from pot sherd residues). Human-environment relationships were relatively consistent across the study area (ten sites total) although unique patterns were signalled occasionally (e.g., evidence for wetland grazing of domestic livestock at Burghead exclusively). Primary thesis questions 1–4 were addressed following a relations-as-metaphysics theoretical approach and using paleoethnobotanical methodologies. However, question 5 was unable to be answered in this study as no strong evidence was retrieved to address how the Picts structured relationships between their settlements.

Overall, phytoliths, starch grains, chrysophytes, and diatoms were successfully retrieved and used to trace relations across Pictland. This study highlights how various plant and algae communities (represented by microbotanical and microalgae residues) in northern coastal environments influenced aspects of human social organization.

Pathways of Microresidues

Phytoliths were retrieved from most archaeological contexts targeted in this study but were most abundant in soil samples taken from *in situ* house floors, a fortified enclosure ditch fill, a likely workspace floor layer, and across successive occupation layers. Phytoliths were used to identify plants corresponding with various families including Poaceae (grasses), Cyperaceae (sedges), Asteraceae (asters), and cf. Ericaceae (heathers), alongside plants designated more generally as arboreal or dicotyledonous. These phytolith data were essential for understanding human-plant relationships in Pictland (e.g., use of space and land use), and the contributions of specific plants to settlement strategies, architecture, foodways, and animal care. Phytolith analysis was useful for understanding Pictish architectural traditions such as turf walls and thatched roofs, identifying activity areas (e.g., cereal inflorescence bracts – threshing), and reconstructing domestic animal pasturing regimes (e.g., coastal grasslands). This analysis was somewhat limited as there are very few comparable studies from the region, and thus this study presents a preliminary framework for phytolith analysis in northern Scotland, and northern Europe more broadly. Further investigations of phytolith assemblages in modern plant communities and in archaeological contexts are needed to understand diagnostic phytolith morphotypes in northern plant communities.

Starch grains were recovered from pot sherd and dental surface residues. These starch grains were mostly representative of Pooideae cereals including *Hordeum* sp. (barley), *Avena* sp. (oat), and *Triticum* sp. (wheat). Rare occurrences of possible geophytes and nut starch grains were also recorded, as evidenced by ellipsoid, pyriform, and triangular starch grains. Starch grains often showed evidence of thermic transformation (likely boiling) with blurry extinction crosses, which suggests that cereals were often cooked and consumed in foods like oatmeal, porridge, pottage and stews. Pot sherd residues revealed mixed assemblages of both cooked and raw starch grains, which indicates that locally made pots were probably used for both cooking and storage functions, that some foods were uncooked or not fully cooked, or that heating did not affect all starch grains equally. Surprisingly, no legume starch grains were identified in this study, which was unexpected given the contemporaneous evidence for the regular consumption of legumes such as peas and beans in medieval Ireland and Anglo-Saxon England (McCormick et al. 2014:24–50; McKerracher 2018:83, 117; O'Sullivan et al. 2014; Van der Veen et al. 2013:160). The sample size of pot sherds from this study was not robust (n=11), and the analysis of the residues from other pot sherds and other food related artifacts such as quern stones could improve our understanding of Pictish foodways.

Micro-algae such as diatom frustules and chrysophytes were often retrieved alongside phytoliths and starch grains, especially within soil samples and domestic animal dental residues. These micro-algae largely represented wet terrestrial and sub-aerial environments and were less useful for understanding Pictish-aquatic interaction as hoped. However, micro-algae were highly useful for identifying turf walled structures and to corroborate microbotanical evidence for coastal wetland/grassland grazing (e.g., Burghead domestic livestock). Within the context of northern Scotland, chrysophytes were especially useful for understanding upland architecture and turf deposits as these micro-algae were retrieved in abundant quantities where turf walls had been constructed. This study highlights the need to consider micro-algae residues as useful proxies of a variety of lifeways, especially in northern coastal environments. More research is needed for the accurate identification of these diverse proxies, to improve qualitative interpretations of past human-environment relationships with aquatic environments.

Overall, microbotanical and micro-algae analyses were useful for tracing human-plant and human-algae relations emplaced in Pictish settlement contexts and made significant contributions to our understanding of how plant and algae communities affect human social organization, settlement strategies, and cultural practices in northern coastal environments. These relations were traced at the site level to interpret each community network of humans, plants, algae, and domestic animals. Site level data were then collated into topographic zone clusters to investigate human-plant and human-algae relationships in lowland, upland, and coastal settlement contexts. Across Pictland, human relationships with grassland communities were fundamental to the success of Pictish settlements, as both wild and domesticated grasses consistently provided food and housing for the Picts and their domestic animals. Heathlands and peatlands were also essential for the Picts but were more impactful contributors to upland settlements. The durable nature and depositional decay-in-place characteristics of microbotanical and microalgae residues led to more direct proxies of Pictish foodways and architecture than pollen analysis, which reflects regional patterns and anemophilous plants, and macrobotanical analysis, which rely on the fortuitous survival of charred or waterlogged botanical remains (e.g., charred cereal grains). It is crucial that each of these paleoethnobotanical lines of evidence be pursued to retrieve complementary and corroborative datasets to answer questions focused on human-environment relationships in northern coasts and other areas with challenging preservation contexts (e.g., acidic soils).

This investigation corroborates evidence from other archaeobotanical analyses (e.g., Jones et al. 2021; Niehaus et al. 2021; Ramsay 2019) and isotopic analyses in Pictland (e.g., Curtis-Summers et al. 2020). Macrobotanical and pollen evidence point to a mixed agricultural–pastoral system of food production, and varied relationships with forest communities with a preference for oak as a building material for monumental architecture in the fortified enclosed settlements of Pictland (e.g., hillforts). Isotopic studies have suggested domestic livestock may have been grazed on coastal marshlands (Curtis-Summers et al. 2020:6), and plant contributions to Pictish human diets largely consisted of C3 plants (e.g., barley) (Curtis-Summers et al. 2020:10–11). This study corroborates several specific claims. Marshland grazing evidence was identified at Burghead (as evidenced by bulliform phytolith morphotypes retrieved from animal teeth) and cereal microbotanical residues were the only recovered agricultural cultivar (ubiquitous across all sites studied). This points to a mixed agricultural-pastoral system of food production where marshland grazing of domestic livestock was a component (at one site). Cereal residues were also retrieved from human teeth (Lundin Links and Croftgowan) and pot sherd residues (Mither Tap, Tap o'Noth, Rhynie, and Dunnicaer) which supports the claim that Pictish human diets largely consisted of C3 plants.

Relations to the South and West: Human-plant Relationships in Anglo-Saxon England and Medieval Ireland

Overall, the dataset from this study suggests a mix of similar and divergent human-environment relationships in comparison to contemporaneous settlements in Anglo-Saxon England and medieval Ireland. Here, I compare my findings to those of these two other regions, to understand how Pictish daily lifeways fit within the broader narratives of early medieval northwestern Europe. Architectural, agricultural, and pastoral traditions are outlined for Anglo-Saxon England and early Medieval Ireland and are compared to the Pictish model. Overall, patterns of human-environment relationships in Pictland appear more closely related to the model present in early Medieval Ireland where transhumance was a central component of the agricultural-pastoral system.

Anglo-Saxon England

To the south of Pictland were Anglo–Saxon communities (5th – 11th centuries AD), whose rise followed the withdrawal of Roman forces from the British Isles after the 4th century AD (Hills 2011; McKerracher 2018:1). Research on Anglo-Saxon human-environment relationships has largely focused on Anglo-Saxon landscapes, agriculture, and settlement structure (e.g., Higham and Ryan 2010; McKerracher and Hamerow 2022). This research has gained increasing traction, with significant studies of Anglo-Saxon archaeology from the past 40 years that have focused primarily on field systems (Hall 2014; Oosthuizen 2013; Williamson 2013) and agricultural practices (e.g., Moffett 2011). The previous low numbers of environmentally oriented studies in Anglo-Saxon contexts is partially explained by "a persistent dearth of evidence" and lack of research programs targeting the medieval countryside (McKerracher 2018:1). Studies focused on activity areas, use of space, and Anglo-Saxon architecture do not often foreground the human-environment relationships of these themes, and instead socio-political and economic narratives are typically applied to these discussions (Williamson 2010:135).

Our knowledge of Anglo-Saxon settlement is relatively recent in comparison to the long-standing research focused on settlements in early medieval France, the Netherlands, and Denmark (Hamerow 2002). This paucity is attributed to the lack of large-scale excavations, organic preservation challenges, and historical disturbance (e.g., ploughing) in British archaeological contexts (Hamerow 2002:7,12). Anglo-Saxon settlements and dwellings follow similar pathways to the examples from the European continent; however, monumental longhouses and enclosed settlements (e.g., farmsteads) are notably absent in the early Anglo-Saxon period. Dwellings in Anglo-Saxon England largely consisted of small and simple form sub-rectangular timber framed buildings and sunken feature buildings. Rectangular large halls were also present and were similar to examples from Germany; however, Anglo-Saxon examples were less imposing and were not constructed until ~AD 600 (Hamerow 2002:92; Higham 2010:8; O'Sullivan et al. 2014:11). During the seventh and eighth centuries, a notable shift occurs where settlements in Anglo-Saxon England become nucleated within the landscape, with the rise of rectangular fenced enclosures, aligned buildings, and great halls (Hamerow 2002:97;

Oosthuizen 2010). Similar structures such as timber halls are few and far between in Pictland (Noble and Evans 2022:60–61) and this study did not retrieve any comparable findings to Anglo-Saxon architecture.

Parallel to the findings of this study, the production of cereal grains is thought to be the primary focus of agriculture in Anglo-Saxon England, with barley and wheat dominating the archaeobotanical assemblages (Banham 2010; Higham 2010:20). Oat and rye are also often retrieved from Anglo-Saxon settlements but to a lesser extent than barley and wheat (Banham 2010:179; McKerracher 2018:95). Legume crops such as peas and beans, and fiber crops such as flax, have also been identified in the archaeobotanical record of Anglo-Saxon England but are generally less common than cereal remains (McKerracher 2018:83; Murphy 2010:214). The finds of this study are comparable with the Anglo-Saxon evidence as barley, oat, and cf. emmer wheat were identified at Pictish sites.

A significant emphasis is placed on the "long eighth century" as a period of agricultural transformation and is the driving narrative of McKerracher's monograph *Farming Transformed in Anglo-Saxon England: Agriculture in the Long Eighth Century* (2018). Following the Roman period, villages and towns returned to the landscape, kingdoms became consolidated, monasteries proliferated, and long-distance trade and craft production were renewed. McKerracher argues that these transformations were all underpinned by advances in Anglo-Saxon farming practices, such as the introduction of the mouldboard plough. During the long eighth-century in particular, the expansion of arable farming had a ripple effect on Anglo-Saxon settlement (e.g., use of space) and land use (e.g., pastoralism regimes), in terms of agricultural productivity and the introduction of closed field systems.

The increase in arable farming led to the emergence of innovative field systems (e.g., hay meadows) and structural changes to settlements such as droveways and paddock complexes (McKerracher 2018:42). The introduction of the mouldboard plough, which was especially effective in areas with clay rich soils, transformed agricultural production as it facilitated the ability to farm in these challenging areas (Banham 2010: 175; Higham 2010: 18–19). This shift in technology resulted in the restriction of available pastoral lands for transhumant practices and required greater control of livestock (e.g., in paddocks) to protect the crops grown in open fields (McKerracher 2018:42). As the potential for increased agricultural production grew, structural evidence of large crop surpluses is evident from the eighth century through the remains of specially built agricultural facilities such as barns, granaries, watermills, and grain ovens (McKerracher 2018:69–93). Overall, McKerracher argues that many of these transformations occurred during the long eighth-century rather than earlier periods as has been argued elsewhere (McKerracher 2018:3). This follows the pattern that can be seen in Ireland, France, Germany, Scandinavia, Italy and the Iberian Peninsula (Hamerow 2002; McKerracher 2018:117; O'Sullivan et al. 2014). McKerracher makes a significant claim that the Anglo-Saxon model suggests ecologically minded decision making by the Anglo-Saxons, with evidence that these people showed efforts to match crops with terrain conditions (McKerracher 2018:120). The findings from this study are not easily linked with the pattern to restrict available pastoral lands by enclosing fields. There is no evidence of enclosed pastures within Pictland and an agricultural-pastoral model with a transhumance component is likely signalled through the consistent presence of grass phytoliths recovered from animal dental residues.

Early Medieval Ireland

Medieval Ireland presents more similar traditions to the Pictish examples. Many investigations of human-environment relationships in early medieval Ireland highlight the socio-economic components of humans within the landscape, like the approaches seen in Anglo-Saxon England. However, more recent research focused on earlier periods (e.g., Bronze Age and Iron Age) have begun to pivot toward relational approaches to human-environment relationships (e.g., Brück 2019). Archaeological evidence for settlements in early medieval Ireland is well supported by historical sources from this period, such as the early medieval law codes which outline details regarding settlement structure, domestic and agricultural activities, animal husbandry, and land use (McCormick 2014:119; O'Sullivan et al. 2014:9). Such historical support is not comparable for Pictland which is limited to fragmented contemporaneous documents (e.g., king lists) and documentation written by cultural outsiders (e.g., Venerable Bede).

Early medieval architecture in Ireland is characterised by enclosed and open settlements (e.g., promontory forts, monasteries) with various dwelling types including huts, crannogs, and roundhouses (McCormick 2014:120; O'Sullivan et al. 2014:9). Discussions of early medieval architecture in Ireland are focused on understanding patterns of daily life, identities, and social relationships (O'Sullivan 2014:34). Theoretical debates largely operate within post-processual frameworks (e.g., phenomenology, Johnston et al. 2014) to examine identity, status, migration, religion and kingship, while new materialist approaches are scarce (Gleeson 2022:89,92). Historical sources provide details regarding the size, construction, and activities within (e.g., cooking) dwellings and archaeological data has corroborated a great deal of this textual source information (O'Sullivan et al. 2014:9). Some scholars caution, however, that this approach signals a significant hurdle within archaeological research in Ireland, often treated subordinately to the historical record (Gleeson 2022:88). Early medieval dwellings (AD 400–800) were often of the roundhouse type and rectangular structures did not become commonplace until the ninth–tenth centuries (Lynn 1978:37; 1994:83; O'Sullivan 2005: 224–226; O'Sullivan et al. 2014:10) Roundhouses were built of stone or post-and-wattle walls with wooden framework to support roofs made of turf or thatched with reed or straw and some cases show examples of cavity walls built of wattle and filled with soft earthen materials packed in between, such as heather, straw and moss (O'Sullivan et al. 2014:10). After AD 800, rectilinear houses were more common, and were built of a stone or turf wall foundation, again with internal wooden frames to support turf or thatch roofs. Floors become more formal within some of these structures implementing paved or stone lined surfaces (O'Sullivan et al. 2014:11). The findings of this study closely match some architectural traditions in early Medieval Ireland such as the use of turf walls (e.g., at Cairnmore and Tap o'Noth) and thatched roofs for roundhouse dwellings (see Chapter 6).

Internal house features such as hearths are used to identify a structure as a dwelling, rather than a more rudimentary building such as a barn. Early medieval hearths in Ireland resemble rectangular boxes lined and edged with stones (O'Sullivan et al. 2014:26) and such hearths are similar to the hearths found in Pictish contexts. Other features of these dwellings include raised bedding areas, delineated by post/stake holes, plant matter such as brushwood, sods and meadow grass, and insect remains (e.g., lice) (Lynn 1989:196; O'Sullivan et al. 2014). Sparse evidence of activities carried out within these early medieval roundhouses and ephemeral dwellings have been retrieved and finds are often limited to small items of personal adornment (e.g., beads and pins), animal bones and botanical residues (e.g., cooking evidence) (O'Sullivan et al. 2014:28). This dwelling pattern consisting of rectangular hearths, items of personal adornment and trace evidence of activities within individual dwellings mirrors the findings of this study. Although cereal processing and cooking activities were identified through the recovery of cereal inflorescence bract phytoliths from house floors at Cairnmore and Tap o'Noth, this was the only activity that could be traced (i.e., no evidence of bedding areas).

These dwellings in early medieval Ireland were often situated in connection to enclosed fortified settlements. As in Pictland, these fortified enclosures are characterised by a variety of monumental features such as ditches, palisades, and earthen embankments, although these were not necessarily always defensive in nature and could have been constructed in regard to symbolic value as well (O'Sullivan and Nicholl 2010; O'Sullivan et al. 2014:38–39). Within the monumental, fortified enclosures where defense was likely part of the intention of these structures, evidence of metalworking and long-distance trade (e.g., imported pottery) has been identified. There is also evidence of delineation of space for specific domestic activities, agricultural processes (e.g., cereal-drying kilns) and crafting work areas (O'Sullivan and Nicholl 2011). Although similar evidence of long-distance trade has been identified in Pictish settlements (e.g., Roman Samian ware pot sherds), this study did not identify any evidence of long-distance trade or specialized architecture for agricultural processes (i.e., no cereal-drying kilns).

Agriculture and land use in early medieval Ireland follows a similar pattern to the model seen in Anglo-Saxon England, albeit with some notable differences in field systems. There is substantial historical and archaeological evidence for dairying, livestock management, and cereal dominant crop cultivation as part of the agro-pastoral food production system across early medieval settlements in Ireland, and an increase in arable production is seen during the transition from the late Iron Age and early medieval period (McCormick 2014; O'Sullivan et al. 2014:70–74). The macrobotanical evidence suggests that oats and barley were the most common cereal cultivars and plant food production was likely also supported by garden plants (e.g., onions, flax, peas, beans) and foraged plants (e.g., wild garlic, nettles, hazelnuts) (McCormick 2014:125; McCormick et al. 2011; Monk 1986; O'Sullivan et al. 2014:75–76). Although there is some evidence for enclosed fields (e.g., paddocks, gardens) generally it is thought that early medieval settlements in Ireland operated with open fields, unlike the later Anglo-Saxon model in England where fields became enclosed (Oosthuizen 2010). Open fields are well suited for practices of transhumance, also known as booleying in Irish contexts, where livestock are seasonally grazed in the uplands during the summer months (~May–November) while in other months livestock could be freely moved within the lowlands after agricultural cultivars were harvested (Costello 2020; McCormick 2014: 121; O'Sullivan et al. 2014:68–69). The findings from this study could indicate transhumance practices, as evidence for various grazing practices were retrieved from animal dental residues (e.g., wetland and grassland grazing regimes).

Human-environment relationships in Pictland likely mirror the model from early medieval Ireland more closely than the Anglo-Saxon model. This hypothesis is based on the similarity between the structure of fortified enclosures, individual dwellings, representation of oat and barley as the main cereal cultivars, and lack of enclosed field systems in both Pictland and early medieval Ireland. However, there are some components from both Anglo-Saxon England and early medieval Ireland that are missing in Pictish settlements. Grain ovens / cereal-drying kilns have not been identified in Pictish settlements, unlike the examples from England and Ireland. Perhaps grain ovens were located at a greater distance from the settlement (e.g., to mitigate the risk of fire as suggested by Hamerow 2012:155; McCormick 2014:126; McKerracher 2018:79), and Pictish archaeological investigations have yet to search for such structures away from the settlement core. Furthermore, the Picts might not have used grain ovens, and instead processed unthreshed grains throughout the winter (McKerracher 2018:79). Chronology and degree of cereal production could also factor into this absence of specialized cereal processing structures. Excavations of pre-7th century Anglo-Saxon communities suggest cereal production was relatively low, at least in comparison to later periods when specialized structures were needed (i.e., after the 7th century, McKerracher 2018:79). The lack of such structures in Pictland possibly suggests the Picts did not require these mechanisms.

Enclosed fields have not been identified in Pictland, which suggests a particular form of transhumance was widely practiced, and a transition to more intricate field systems was not introduced during the Pictish period (Noble and Evans 2022:89). It is also possible that enclosed fields have yet to be identified, as is the case with grain ovens / cereal-drying kilns. However, such boundary features have been identified for early medieval Ireland using aerial survey (O'Sullivan et al. 2014:65), a method which has also been used in Scotland to identify Pictish fortified enclosures (Noble and Evans 2022:99). In lowland contexts, these field boundaries could have been removed through centuries of ploughing as well.

Overall, the Pictish model is more closely aligned to the example of early Medieval Ireland, where open field systems persisted and roundhouses were typical dwellings associated with fortified enclosures (e.g., ringforts). This study may offer insights regarding cereal processing activities within individual dwellings in early Medieval Ireland and Anglo-Saxon England where macrobotanical residues are scarce. Furthermore, the theoretical orientation of this study offers new perspectives to understand human-environment relationships in the British Isles and Ireland where plant and algae agency is considered (i.e., nonanthropocentric investigation).

Suggestions for Future Research

This study has aimed to understand human-environment relationships in northern coasts through an investigation of human-plant/algae relationships in Pictland (AD 300 – 900). The results highlight the contributions of plant and algae communities to Pictish architecture, uses of space, agriculture, animal feeding regimes, and land use. This approach was limited to investigating the influences of plant communities on Pictish settlements and was unable to assess the affect of Pictish settlement on these non-human communities, as broader geographic and temporal environmental data would be needed to pursue such questions (e.g., pollen analysis and offsite sampling). This study thus identifies further opportunities for collaborative methodologies using phytolith, micro-algae, macrobotanical, and pollen analyses in combination.

Sampling strategies were also limited by the collaborative nature and timing of this research. Access to the sites was limited to those under excavation by the Northern Picts project. Apart from two seasons of excavations, I relied on other members of the Northern Picts team to generously procure samples on my behalf. Future sampling strategies could be planned in more detail in advance of excavation, although it is difficult to anticipate which types of features will be uncovered in advance of excavation.

Future studies would also greatly benefit from the examination of phytolith production in modern plant communities in Scotland for comparison with past plant communities. This would help us to understand the phytolith signatures of specific ecological communities (e.g., upland fens) and such studies would be especially beneficial for investigating phytolith production in Ericaceae, Asteraceae, and various grassland communities in Scotland. Furthermore, modern studies of experimental archaeological structures such as roundhouses and crannogs at heritage centres such as The Scottish Crannog Center and Butser Ancient Farm would greatly bolster the interpretive power of microbotanical and microalgae research. Investigations of different phytolith signatures from various thatching techniques and floor residues would be especially valuable for future research.

Conclusions and Broader Impressions

This study has contributed to our understandings of daily life in Pictland, including architectural traditions, foodways practices, animal feeding regimes, and broad patterns of human-plant/algae relationships. Evidence for daily life has been especially elusive in Pictish contexts due to highly acidic soils that prevent the preservation of organic materials, of which the majority of Pictish daily artifacts were likely composed (e.g., baskets). Phytolith, starch grain, and micro-algae evidence from this study have provided more information regarding ephemeral architectural traditions (e.g., turf walled roundhouses), use of space and activities within fortified enclosures (e.g., crop processing), livestock feeding regimes (e.g., coastal grasslands, cereal grain supplements), and Pictish meals (e.g., cooking and direct evidence of cereal consumption). Overall, these microscopic proxies have been used to trace relations between plant communities and the Picts at ten prominent Pictish communities, and across lowland, upland, and coastal contexts.

Furthermore, this study has contributed to identifying the utility of paleoethnobotanical approaches in Scotland and northern Europe by showcasing the strengths and limitations of phytolith, starch grain, and micro-algae analyses in northern coastal contexts. This is the first study to use these approaches in Scotland, and the northernmost study to incorporate all three of these proxies. This methodological work lays a strong foundation for future studies in the North Sea region (e.g., British Isles, Ireland, the Netherlands) and northern Europe. Very few microbotanical studies have been carried out in the British Isles (e.g., Wade et al. 2021; Powers et al. 1989) and this study has shown that microbotanical analysis can be effective for understanding past human-environment relationships, ephemeral architecture, use of space/activity areas, and land use in contexts where macrobotanical residues are scarce.

Lastly, this research presents a case study where terrestrial, aquatic, and semi-aquatic non-human communities are considered together. Although the micro-algae results were not as impactful as hoped across contexts, this study was able to highlight the value of these residues to understand some of the aquatic ecological communities in Pictland. Diatom research is in its infancy within archaeological investigations, and this study is the first to highlight the chrysophytes as other significant micro-algae communities (e.g., peatlands).

The application of a relations-as-metaphysics approach was useful to address most of my primary thesis questions and concerns regarding archaeological approaches to human-environment relationships. By focusing on the relations between entities (i.e., humans and nonhumans) this approach facilitated an emphasis on the interconnectedness of our world, and throughout this dissertation I have emphasized the interconnected nature of humans, plants and algae in Pictland. Although Western ontologies and terminology constrained the ability to truly move past the nature/culture dualism in this study, this approach helped to blur the boundaries between this and other dualisms (e.g., terrestrial/aquatic).

This theoretical approach provided a framework where relations of affect and difference could be traced across Pictland at multiple scales: site-level, topographic zone (e.g., upland), and across the study area). These relations could be traced and used to explain patterns of human-environment relationships, but it was not possible to address the "why" behind these patterns (although this was not the goal of my thesis questions). So, while plants were argued to have influenced Pictish settlements, and made a difference (e.g., peat turf shaped upland dwellings and territorialized upland settlements) the relations-as-metaphysics approach cannot be used to explain why the Picts might have established relations with plant communities. Overall, this approach holds a relational lens up to the microbotanical and microalgae data to focus on the connections (i.e., relations) between humans, plants, and algae. These relations are traced to understand the affect (i.e., agency) of plants and algae to change the capacities of the Picts to act and understands that the plants and algae themselves in turn would also be changed (following Deleuze 1988, 1990; and Harris 2021:22). The data from this study however cannot address the two-way essence of affect. To hypothesize potential effect of human communities on plant communities, broader environmental proxies such as pollen have been leaned on in this dissertation (e.g., Jones et al. 2021).

A relations-as-metaphysics approach offers new ways to investigate interactions between humans and nonhumans. Typically, in the British Isles and Ireland, human-plant relationships are examined in regard to socio-economic functionality using theoretical frameworks such as Historical Ecology and Landscape approaches (Bell et al. 2000; Darvill 2008:62; Fleming 1988). In these approaches, the influences of plants on human communities (i.e., agency) is typically ignored, or at the very least glossed over. For example, 'wild' or non-domesticated plants are often listed and subsequently dismissed when recovered in archaeological deposits. However, if the world is inherently relational (i.e., interconnected – relations-as-metaphysics) then every entity has the capacity to affect another and make a difference. This approach, then, includes a turn away from purely anthropocentric alignments and avoids conventional narratives centered on understanding ways in which humans exploit non-humans (e.g., simple resource use) (Hamilakis and Overton 2013:160).

De-centering humans in archaeology has often been criticized for turning back to environmental determinism. To address such concerns, McKerracher suggests "environmental factors will have determined not only the preservation of archaeological material but also the availability of natural resources and will thus have constrained agricultural strategies in antiquity" (2018:8). This claim points to the need for rural communities to make choices within their ecological network (2018:8) and supports this discussion with a nod to Williamson (2010) whose work pivots from economic-focused narratives toward understanding how the Anglo-Saxons made choices in connection to topography, geology, and climate (among other environmental factors). Williamson emphasizes that approaching the past in this way does not negate the potential for human agency, and that "nature itself cannot 'determine' social practice" but we should consider how people in the past made choices in connection to environmental constraints and opportunities which directly impacted their lifeways (2010:135). Such perspectives have been gaining traction in broader archaeological debates over the past two decades (Costello 2017:192, 2021:153; Oram and Adderley 2008; Schreg 2014; Vésteinsson et al. 2014). I strive to take this discussion a step further and argue that considering the agency of nonhumans such as plant and algae communities does not negate the capacity for human choice, but considers the push and pull of nonhuman communities on humans, in providing both affordances and constraints.

Relational frameworks were suitable for integrating small-scale (e.g., site-level) data, allow for multi-scalar approaches, and do not require large datasets. Using a relations-as-metaphysics approach I was able to study the relations emplaced at each site and could then compare these relations in regard to topography, and then across Pictland. Although several other theoretical frameworks used to investigate human-environment relationships are also multi-scalar (e.g., Historical Ecology) they are used to ask questions that were not the focus of this study (e.g., how do humans adapt to their environment?).

Other approaches to human-environment relationships would have been less suitable for answering the primary thesis questions and achieving theoretical objectives outlined in this dissertation. At the outset, Cultural Ecology is not appropriate as the nature/culture dualism is the strongest out of the approaches outlined here (i.e., how culture adapted to environments). Other approaches such as Historical Ecology, Human Ecology, and Human Ecodynamics address this dualism by emphasizing the interconnectedness between nature and culture (i.e., humans and environment are interdependent). However, these approaches continue to operate predominately from an anthropocentric position where humans are exploitative agents within the environment and the agency of nonhumans is not foregrounded (Hamilakis and Overton 2013:160). Using such approaches, it would have been impossible to examine the active roles of plants and algae in Pictland. Historical Ecology, General Systems Theory, and Human Ecodynamics may have held some useful tools, but these approaches typically focus on environmental changes over time (i.e., long-term) and use large datasets; therefore, these approaches would not have been as suitable as the relations approach which is more flexible in these aspects and focuses on smaller-scale human/nonhuman interactions.

In terms of other relational approaches, ‘relations as methodology’ might have been a more streamlined framework (e.g., entanglement theory) but this approach seemed somewhat limited in terms of interpretive value. Plants, humans, and algae were indeed entangled in Pictland, with nodes present throughout. However, this approach does not foreground the active roles of plants and other nonhuman communities as directly as ‘relations-as-metaphysics’ (i.e., the world is inherently relational – how were relations established?). Although the methods of this dissertation were unable to assess the two-way essence of affect, I suggest my focus on the roles of plants and algae have provided a new way of looking at human-environment relationships in the early medieval period in Scotland. Other approaches such as Historical Ecology, have already made contributions toward our understanding of human impacts on non-human comm. This directional relationship was not the focus of my primary thesis questions.

This study has argued that investigations of human-environment relationships which use relational theoretical frameworks can offer new perspectives that foreground the contributions of non-human communities to human-communities. For example, these new perspectives may foreground the contributions of non-human communities to human-communities. Such perspectives are relatively novel within western contexts and are well known in Indigenous and other non-western communities that operate outside of western ontologies. Through the recovery of micro-botanical and micro-algae residues embedded in Pictish settlements, past human-plant/algae relationships were traced and have facilitated an investigation of plant and algae contributions toward Pictish architecture (e.g., heather, asters, chrysophytes), settlement (e.g., upland plant/algae communities), foodways (e.g., cultivated cereals), animal feeding regimes (e.g., coastal wetlands), and land use (e.g., agro-pastoral traditions). These Pictish patterns of human-environment relationships appear to mirror the relationships and settlement patterns in early Medieval Ireland more closely than the framework from Anglo-Saxon England. These findings also suggest a strong relationship with the ecological rhythms of life, where the theoretical distinction between nature and culture likely did not exist or was blurred through intimate connections. The Picts living within lowland, upland, and coastal contexts all appear to have been connected to seasonal ebbs and flows of their ecological network, and each settlement developed its own interpretation of these rhythms. This study highlights how the poiesis of

Pictland occurred through the establishment and maintenance of relationships between peatlands, heathlands, grasslands (domestic and wild), wetlands, forests, and the Picts themselves.

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Appendix A: Protocols for Sediment / Soil Samples

Processing and Analyzing Sediment Samples for Phytoliths (2018)
McMaster Paleoethnobotanical Research Facility (MPERF)
Developed by Shanti Morell-Hart
(In consultation with Dolores Piperno in 2006; Rob Cuthrell in 2008; MARS representative Jessica Giles in 2017; independent experimentation at UCB and the MPERF)

Phytolith Extraction from Sediments: Basic procedure sequence

(in parentheses, time estimates for a 20 sample batch = 40 processed samples total)
Total time for 20 sample batch (equaling 40 processed samples) = 36 - 58 business days

1) sediment sterilization of pathogens for foreign samples (1 day)
2) deflocculating sediment samples in water (1-10 days—depends on sediment composition)
3a) dividing sediment into a, b, and s fraction sizes (1 day)
3b) removing clay (1-10 days—depends on sediment composition)
4) microwave chemical digestion: removing carbonates with hydrochloric acid (HCl) solution, removing organic materials with nitric acid (HNO_3) solution, removing humics with hydrogen peroxide (H_2O_2) solution (1 day)
5) floating phytoliths with sodium polytungstate (SPT) solution and drying phytolith sample (1 day)
6) clean-up and waste removal (continuous during processing; in total, can take 1-3 days)
7) mounting phytolith sample (1 day)
8) scanning for phytoliths under the microscope (avg. 2-3 hours per slide = 80-120 hours total)

- There are multiple washes and centrifuging steps between stages 3, 4, and 5.

NOTE: ***If extracting phytoliths for dating purposes, boil and sterilize all glassware and glass tubes.***

1) Sediment sterilization for foreign samples, following CFIA requirements

This is to eliminate any potential pathogens. The heating process will also remove some degree of organics and starch grains, so is inappropriate for a piggyback-style extraction process.

- Prepare and label foil envelopes for sediment samples.
- Put ~150mL of sediment from each sample into the appropriately labeled foil packet.
- Place samples held in foil envelopes into muffle furnace
- Note the location of the foil packets in the muffle furnace.
- Heat sediment samples in furnace at 200C for at least 6 hours.
- Soak any used tools, implements, etc. in bleach water solution in marked bucket.
- Allow samples to cool in oven overnight. Samples are likely to clump a bit from the low-firing.
- **Dispose of any contaminated materials (sample bags, packaging materials, gloves, disposables) in the Stericycle or Daniels bin for incineration.**

2) Deflocculating Sediment Samples in Water

- Rinse set of 1000mL beakers.
- Label each beaker with masking tape and sharpie (sample #s)

- Gently break up each sediment sample in the foil placket, then put each sample into the corresponding labeled beaker. Start with ~150 mL of dry sediment per beaker (beaker needs a height of at least 12 cm).
- Add 1-2 tbs. deflocculant (***sodium hexametaphosphate if dating phytoliths, baking soda [sodium bicarbonate] if not dating phytoliths***), and 1000 mL of *very hot* water. Stir.
- Consider sonicating samples for 10 mins each (several batches of 5) in the large sonicating bath, to speed deflocculation (following Lombardo et al. 2016).
    ****Samples from Scotland did not benefit from sonication*
- Stir every 15 min., about 20 times total (takes ~3 days). Mixture should be uniformly cloudy, with NO remaining clumps, and clays should be relatively suspended in solution at the last stir.
- On day of sieving, give one last stir, then wait at least 1 hour before sieving to make sure silts have settled adequately.

3a) Removing Sand (S) Fraction and Larger Sediments (D) Fraction

- Set up a set of sieves in this order (top to bottom): No. 60 (250 um, for D fraction) on top of No.270 (53 um, for S fraction) on top of base pan (for A and B fractions).
- Label a set of 1000 mL beakers with same sample info as current 1000 mL beakers, with the addition of "A/B" to represent fraction.
- Label a 50mL centrifuge tube if collecting S fraction.
- (***To reiterate***) After waiting at least 1 hour for silts to settle, pour off top 500 mL from samples (this is to reduce the liquid volume, so that the remaining water fits in sieve pan).
- Give mixture another vigorous stir, until all sediments are relatively suspended.
- Pour 1/3 of mixture through set of sieves, wait for liquid to go through, pour another 1/3, wait for liquid to go through, pour last portion.
- Keep an eye out for particulate charcoal (can be dated—only 100 micrograms needed for AMS dating, but NOT if sodium bicarbonate was used).
- Add 400 mL of clean water to corresponding labeled "A/B" beaker.
- Using A/B beaker clean "rinse water", rinse off the upper fraction through screens and into the base pan. Pour approximately 100 mL at a time (any silt lumps can be gently "mashed" into the top screen with a clean pipet while rinsing).
- Keep an eye on run-off from screens into base pan-- when this water is fairly clean, remove upper (D) fraction. If D fraction is still not fairly clean, do an early pour-off of base pan liquid into corresponding labeled beaker and continue rinsing process until water is fairly clear.
- Pour contents of bottom pan (A&B fractions) back into corresponding labeled beaker.
- Total contents of beaker are usually +/- 1000 mL, unless more rinsing is needed for in-screen fractions, and more than one beaker has been used.
- If particulate charcoal is needed for dating (or to preserve potential macrobots or fauna or lithics), save the D fraction by overturning screen contents onto a labeled paper towel (wait a few days until fully dry, and bag this sample).
- If not preserving D fraction, dispose of screen No. 60 contents using proper soils protocols
- Clean off No. 60 screen.
- **Replace** upper No. 60 screen, clean No.270 screen under No.60 screen, under running water, until water is completely clear. This is because the No. 270 screen is VERY delicate and can be damaged by too much water pressure.
- Concentrate sand (S) fraction in the No. 270 screen (still UNDER the No. 60 screen) by running tap water onto screen while tilting screen so that water pushes the sand up against one side of the pan.
- Pour sand fraction (S) into labeled 50mL tube. This is messy, and some sand will be lost. Multiple tubes may be necessary.

- Keep adding a bit of water (under No. 60 screen), concentrating sand and pouring into labeled tubes, until most of the sand has been removed from the screen (some particles will remain in the screen).
- Clean off both screens. **Always leave larger No. 60 screen over smaller No. 270 screen to prevent damage.**

3b) Removing Clay from Fine (A) and Course Silt (B) Fractions

- Add water up to 900 mL mark (10 cm in height) to each beaker containing the A and B fractions.
- Stir vigorously-- quickly and sequentially so that everything is approximately at the same stage of stirring.
- Cover in plastic wrap.
- Let sit for 1.5 hours.
- Pour off +/- 400 mL of excess water.
- Add water up to the 900 mL mark and stir vigorously.
- Let sit for 1 hour.
- Rinse, repeat 1 hour sequence (3 to 30 times) until water is fairly clear of suspended clay (whole procedure takes 1-10 days, depending on clay content).
- After the last pour-off, pour the solution into a prepared 500mL beaker (simply move the masking tape label) and let the samples sit in the beakers overnight.
- The next day, pour off excess water and pour samples into labeled centrifuge tubes.

3c) Preparing samples for Chemical Digestion

- Redistribute fractions in labeled 50 mL centrifuge tubes to maximize processing. Coarse silt (B) and fine silt (A), and sand (S) should each have 1.5-2.0 cm of sediment at the bottom of the tubes
- Process one or several tubes of each sample at a time (depending on recovery strategy).
- Centrifuge tubes for 5 min. @ 1,000 rpm to consolidate sediments at the bottom of the tube

Don't use more than 1,000 rpm when sediment is in the tube at any time, but at phytolith isolation, washing, and drying stages, you can go up to 1,500 rpm for 10 min.

- Pour off excess water, leaving only the damp plug at base.
- In some cases you will want to make sure sediments are dried thoroughly (can dry overnight at roughly 65 degrees F in the oven) before weighing sediments and placing in beakers. In other cases, you can leave the sediments as damp samples and record the wet weights.
- Label a set of 600 mL beakers, using the number (1-40) that will eventually correspond to the microwave vessel number on the carousel. **Note which number on the carousel corresponds with which sample in your laboratory notebook.**
- Transfer sediments to labeled 600mL beakers, weighing the material in the beaker (taring for empty beaker weight) to target 10g per sample.
- Record the weight of each unprocessed sediment sample in your laboratory notebook or spreadsheet.

4a) Preparing the microwave equipment

- Ready the microwave vessel carousel—ensure all vessels and fittings are clean. There are 40 microwave vessels on the carousel, each holding a roughly 50 mL volume of material. Pressure sensors are at the base of the microwave.
- Place the vessels in the carousel. **Carousel with tubes will get fairly heavy once full, so be careful!**
- Ensure that you have at least 8 tubes in the carousel for processing. The vessels placed in the microwave carousel should all be filled-- dummy tubes with water work. Otherwise, microwave power will be too concentrated for the few tubes inside. For more than 8 tubes but fewer than 40, you

can leave the carousel slots empty. Make sure to place tubes in the carousel according to p.13 of the manual. This will optimally match tubes to sensors.

4b) Preparation of sediment and solution in microwave tubes

- Take the set of samples in labeled (1-20, etc.) 600mL beakers, and place under fume hood in order. Put a glass stirring rod in each.
- Prepare a bucket in the sink with ~2 gallons of water and 1 box of baking soda. Stir baking soda into solution using one of the large glass stirring rods.
- Prepare a beaker of distilled water (to clean syringe).
- **Put on lab coat, goggles, safety mask, and two pairs of gloves (double up).**
- Under the fume hood, prepare three beakers: nitric acid, hydrochloric acid, and hydrogen peroxide (or potassium chlorate). Have a syringe ready for each.
- Recommended for 10 g of sediment (halve quantities for 5 g of sediment) in each tube:
  1) <u>6 mL hydrochloric acid</u> (10% aqueous solution)
  <u>2) 10 mL nitric acid</u> (68-70% aqueous solution)
  <u>3) 2 mL hydrogen peroxide</u> (30% aqueous solution)
- Using a 50 mL or 15mL syringe, express chemicals, in turn, into each 600 mL beaker, while stirring gently with a glass rod. **Add each chemical slowly, as they may rapidly start to bubble up.** For samples high in carbonates, the hydrochloric will react vigorously. In other cases, the nitric and hydrogen peroxide will react vigorously with organics. Make sure to mark vigorous reactions of various chemicals or any spillage in your lab notebook.

In case of overflow or spillage: stay calm! It's okay if a little material spills onto your double-gloved hands. If you get any material on exposed skin or clothing, neutralize immediately with the baking soda solution, then rinse clean in cool water. You can use paper towels, sponges, and kim wipes dipped in the baking soda solution to clean up the mess under the fume hood, then put all these contaminated materials in the baking soda solution to neutralize the acids. As you clean, be careful not to drip any of this baking soda solution into the beakers as it will neutralize the acids and/or potentially contaminate the sample. While cleaning, also make sure no sample has spilled into another. If you suspect cross-contamination, you'll need to start again with fresh material from the affected samples.

- Use the beaker of distilled water, as needed, to cleanse the syringe if besmirched by accidentally touching material in the beakers.
- Wait for chemical reactions in the beaker to slow down or visibly cease (this may take 15-40 minutes).
- Stir each sample again with the corresponding glass stirring rod.
- Wait for chemical reactions in the beaker to slow down or visibly cease (this may take 15-40 minutes).
- Pour each labeled (1-40) chemical mixture into the corresponding microwave vessel tube (1-40). There may still be slight bubbling, but there should be no danger of bubbling over of the sample.
- Using <u>1-2 mL of nitric acid</u>, rinse remaining sediment mixture adhering to each beaker into each microwave tube. Gently swirl in the beaker, then pour into microwave tube. (There will still be small amounts of sediment residue visible in each beaker.)
- Place pressure plug on each microwave tube, then screw on each cap very tightly, using one click of the white plastic torque wrench (in drawer).
- Place tube in Kevlar sleeve, and fit each vessel tube into corresponding number on microwave carousel.
- Make sure all vessels are flush with the Kevlar sleeves and patted down to base of carousel.
- Place all glass stirring rods gently into the bucket of baking soda solution. Rinse each soiled beaker in this sodium bicarbonate solution before washing each beaker with alconox solution at the sink.

4c) Preparation of microwave

- **Ensure the damper above the microwave is open.** If it isn't, unscrew the screw, slide out the metal sheet, and tighten the screw. Fumes from the microwave and oven go into the fume hood through the hosing attached to each.
- Make sure to place tubes in the carousel according to p.13 of the MARS microwave manual. This will optimally match tubes to sensors. Again, you will need to run a minimum of 8 tubes (some may be dummy tubes with only water).
- Place carousel in the microwave, matching up the divot at the base, to lock carousel securely onto microwave tray.
- With the microwave door open, flip the ON switch on the right side of the microwave. This will turn the carousel a full rotation, once, both clockwise and counterclockwise, to test the internal sensors.
- Close the microwave door.

4d) Setting and running the microwave

- After closing the microwave door, go to the main menu.
- Press the button for "One Touch Methods."
- Find the "ARCH SEDS" stored method for processing archaeological sediments and hit "enter".
- Check to make sure the protocols are correct:

  ARCH SEDS
  Control type: > ramp to temp
  Vessel type: >Xpress
  Sample type: > Organic
  Temp Guard: On; >220C
  Sample prep notes [chemical quantities listed above]
  Ramp time: 20:00
  Hold time: 55:00
  Temp: 180C
  Power: (variable—One Touch method auto corrects with more power for more samples)
  Stirring: Off
- Press "play" icon (>) to start the program. The entire microwaving time should be ~130 minutes. **Do not attempt to uncap the tubes for AT LEAST 5 hours, but ideally you can simply wait until the next day after cooling overnight.**

4e) When microwaving is complete

(to reiterate) **Ideally, leave tubes overnight to cool in microwave. Before removing the tubes from the microwave, make sure the pressure is down to roughly 20 PSI or less.**

- Check the log of the ARCH SED method to ensure all samples heated appropriately. If not, step 4d may need to be repeated.
- Prepare a tub of 2 L water plus 1 box baking soda.
- Remove the carousel of tubes and place under the fume hood. With gloves and goggles on, release/unscrew the cap of each microwave tube slowly. Allow the fumes to ventilate into the fume hood duct (10-80 mins).
- After the fumes have been ventilated, unscrew the caps fully. Remove the pressure plugs, and stir the sediment and solution in each microwave tube with clean glass stirring rods. This will aid removal from tube.
- Pour the mixture from each tube into an empty and **labeled** 50 mL centrifuge tube.

- After pouring the mixture, carefully squirt water (using H2O squirt bottle) into the microwave tube to rinse remainder into the prepared 50 mL tube.
- Put empty microwave tubes, stirring rods, and any acid-residue materials into the prepared tub of water and baking soda to neutralize any remaining acids. Let materials sit for at least 30 minutes before cleaning.
- Centrifuge the 50 mL tubes @3000 rpm for 5 minutes.
- After samples are centrifuged, under the fume hood, pour off / dispose of this supernatant into a (single) beaker, then **transfer the combined beaker contents into the sealable container marked for special removal of hazardous waste with a yellow chemical waste sticker**.
- Send each sample through a series of two rinses using distilled water. In each rinse, add water to the 50 mL mark, agitate until sediments go into solution, then centrifuge @3000 rpm for 5 minutes.
- After each water rinse, pour off supernatant into the tub of baking soda solution to neutralize any remaining acids.

(4f) Running samples again

- If samples need more processing, add more hydrogen peroxide and redo microwave process.

4g) Clean-up of chemical waste

- After soaking for 30 minutes in the baking soda solution: tubes, caps, and pressure plugs (but NOT Kevlar sleeves) may be cleaned with contrex or alconox solution.
- If residues remain in microwave test tubes, they may be cleaned with acetone and rewashed.
- Make sure all chemical waste is in a sealed container, labeled with the chemical waste sticker, and under the fume hood.

5a) Making Heavy Liquid Solution

- Start with 150 mL of water per pound of sodium polytungstate, THEN add 5 mL water at a time, measuring on scale until 2.3 g/mL is reached. *(Final specific gravity: aim for 2.3 (i.e. weight of 1 mL of solution is 2.3 g) Don't go under this specific gravity with too much water!)*
- Use dry sodium polytungstate. One pound of sodium polytungstate will make roughly 175 mL of heavy liquid.
- Start with water, add sodium polytungstate.
- Make solution, shaking slowly, and adding a bit at a time.
- Set scale to zero with an empty 2 mL capsule.
- Add 1 mL liquid, reweigh capsule.
- Add water to solution (5mL at a time) until 2.3g specific gravity is reached. It’s okay to be within 0.05g of the 2.3g requirement.

If you run out of chemicals, and still aren’t at the right specific gravity, you can boil the liquid or let evaporate slowly to increase specific gravity.

5b) Flotation of Phytoliths: Heavy Liquid Solution step

- Label a set of 15 mL centrifuge tubes, one for each 50 mL processed sample.
- Add heavy liquid solution to each centrifuge tube, to about 2 cm above the top of the sediment. This may mean that the surface of the supernatant is a bit more difficult to access with the pipet, if the 50 mL tube has only a little processed material remaining.
- ***If organic material is still present in sample, the heavy liquid will turn red or black. This does not damage the sample, but may mean more organic “background noise” ultimately on the slide.***

- Cap the centrifuge tube, stir, shake, and invert each tube to put all sediment into solution.
- Invert slowly (+/- 5 times) **just before** centrifuging. Put into centrifuge immediately.
- Centrifuge for 5 min. @ 1,000 rpm.
- Lift test tubes out one at a time, **slowly**, to reserve surface tension (milky film atop test tube is phytolith "crust").
- Use a pipet to remove upper "crust" of phytoliths in a circular motion around the sides of the tube, just skimming the surface (first suction step)—add this solution to labeled 15mL tube.
- Use pipet to suction from center of centrifuge tube solution, and "clean" the sides of the tube with the pipet, then quickly remove upper portion of phytolith material in a circular motion around the sides of the tube, just skimming the surface (second suction step)-- add this solution to labeled 15mL tube.

REPEAT (2 centrifuge extractions total):

- Cap the centrifuge tube, stir, shake, and invert each tube to put all sediment into solution. invert slowly (+/- 5 times) **just before** centrifuging.
- Put into centrifuge immediately.
- Centrifuge for 5 min. @ 1,000 rpm.
- Lift test tubes out one at a time, **slowly**, to reserve surface tension (milky film atop test tube is phytolith "crust").
- Use a pipet to remove upper "crust" of phytoliths in a circular motion around the sides of the tube, just skimming the surface (first suction step)—add this solution to labeled 15mL tube.
- Use pipet to suction from center of test tube solution, and "clean" the sides of the tube with the pipet, then quickly remove upper portion of phytolith material in a circular motion around the sides of the tube, just skimming the surface (second suction step)-- add this solution to test tube.

Do not fill labeled 15 mL tube to more than 1/3 of total volume with phytolith/liquid solution.

5c) Isolating Phytoliths: Removal of Heavy Liquid and Drying Phytolith Sample

- Add distilled water to 15mL centrifuge tube containing phytolith/solution extraction (up to the top of line markings)-- this will lower the specific gravity and cause phytoliths to sink.
- Cap the tube, invert, mix, and shake until heavy liquid and water are in solution.
- Centrifuge for 10 min. @ 1,000 rpm.
- Slowly invert test tube to pour off supernatant, leaving behind phytolith 'plug' at base. If plug begins to loosen and go into solution, stop pouring off supernatant immediately and continue to next step.
- Re-add distilled water, repeat entire process.
- Perform 2-3 water washes total, until water emerges clear.
- Pour off last of water supernatant from tube (after centrifuging).
- Invert tube, quickly blot tube on a paper towel.

If drying immediately, add sample to a GLASS or POLYPROPELENE (not polycarbonate!) test tube and complete next 4 steps. Otherwise, skip to next section.

- Add acetone up to bottom of labeled tape.
- Stir, invert with parafilm, until all sediment is dislocated from bottom of tube.
- Centrifuge 10 min. @ 1,500 rpm.
- Slowly pour off acetone supernatant.

With or without acetone step:

- Cover open centrifuge tubes loosely with parafilm or plastic wrap (to prevent blow-ins) and allow to completely desiccate (several days to several weeks) inside the fume hood.
- Samples should eventually appear like a white or beige clay or powder.

6) Clean-up and Waste Removal

- All glassware, stirring rods, etc. should be clean, dry, and placed back on the shelves.
- Microwave tubes, pressure plugs, and caps should be thoroughly cleaned and stored back in the microwave carousel. Store the clean Kevlar sleeves in the drawer next to the microwave.
- Wash all goggles used.
- Launder all lab coats used. The location of the drop off is the 1T area CSS – Customer Support Services; Stores and Linen in Hamilton Health Sciences (behind the yellow elevators). There is a fee of $2.50 for each lab coat laundered, which will be charged directly to an MPERF account.
- Make sure all chemical waste jars are labeled using the yellow chemical waste stickers and waiting on the shelf under the fume hood. These stickers are available at the ABB Stores (B166) and from: www.workingatmcmaster.ca/eohss
- **Schedule waste pick-up using the chemical waste removal forms.**

7) Mounting the Phytolith Concentrate Material

For larger samples (the roughly 10 gram samples), the processing should leave 1-2 grams' worth of material. At this point, the phytolith concentrate will be in the labeled 15 mL tubes.

- When the samples are fully dry, label a set of small 2 mL centrifuge tubes with the same set of labels. This will be the dry archived collection (separate from the wet archived collection and separate from the slides).
- Loosen the material in the 15 mL tubes, with a shaker, by hand, by pipet, or all of the above.
- Remove part of the material from the 15 mL tubes, and archive it in the 2 mL tubes. (A pipet works well for this—but **use separate pipets for individual samples**!
- Break off the end of a clean glass pipet, and use this as the reserved pipet for the immersion oil. If using a plastic pipette be sure to leave it aside and use only for immersion oil.
- Lay out a large kim wipe—the immersion oil is messy. Keep a set of small kim wipe on hand.

(Immersion oil used: Type B from Cargille. Code 1248. Standardized at 23 degrees Celsius. Non-drying for microscopy. Viscosity, cSt = 1250 +/- 10%. Fluorescence = Low, relative to Cedarwood Oil.)

- On a clean small kim wipe, label a slide with the same information listed on the tube, in both Sharpie and pencil.
- In each 15 mL tube, drop by drop, add enough immersion oil (with a clean pipet) to thin the phytolith material sufficiently for a slide. You'll want to be able to transmit light through the slide, and be able to distinguish different materials (vs. overly dark & overcrowded conditions on the slide due to too much material).
- Using the reserved individual pipet, mix the oil with the material.
- Drop one drop of mixture onto the center of the slide. If material seems too filled with phytolith material, add a drop of pure immersion oil. Add, in total, 1-3 drops of liquid.
- Place a coverslip (large) over the mixture, and press very lightly until mixture is evenly dispersed under the coverslip. Try to remove all of the air bubbles.
- Wipe any excess mixture from the sides of the slide.
- After scanning the slide, apply a thick coat of color nail polish to seal the edges. (Opaque Sally Hansen Hard As Nails is the best)
- Make sure to curate the slides on their "backs", not edges.

8) Scanning for Phytoliths under the Microscope: General Notes

Samples are already divided into AB and S fractions, processed, floated, and mounted on slides.

- Counts: 100 in AB fraction and 100 in S fraction = 200 total per sediment sample

- Note: many additional phytoliths of an AB size are sometimes released into S fraction after chemical processing. By analyzing both fractions, this presents a better way to get phytoliths more fully trapped in sediments.
- Magnification power for scanning slides: for S fraction, at 200x, for AB, at 400x.
- Beginning in one corner of the slide, move systematically from top to bottom, left to right (as though reading a book). Moving from left to right, begin by moving to a field of view which overlapped only slightly with the previous, then slowly shift focus in and out. This enables a view "through" the transparent phytoliths, in order to gauge broad morphology. (i.e. starting on top surface, moving through the phytolith, then ending with the bottom surface).
- Morphology is also inspected by gently depressing the slide with a rubber-coated paperclip tip or blunted needle probe, in order to rotate the phytoliths in the immersion oil. This is especially helpful with phytoliths such as rondels, which appear spherical in planar view but like spools in profile.
- In Scottish samples, be sure to count the elongate and bulliform phytoliths. Although in other geographic contexts these morphotypes are incredibly abundant and ubiquitous, and will dominate all slide densities and slow the identifications considerably (i.e., you would needed to bump the counts to 1000 or more per slide), this is not the case in Scottish samples (i.e., bulliforms rare).
- Make sure to photograph each (significant/diagnostic/novel) phytolith at three focal points, at least, then rotate and take additional photos.

Appendix B: Raw Data

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-1	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-1	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-1	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-1	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-1	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-1	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-1	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-1	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-1	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-2	S fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-2	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-2	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-2	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-2	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-2	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-2	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-2	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-2	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-2	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-2	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-3	S fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-3	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-3	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-3	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-3	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-3	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-3	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-3	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-3	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-4	S fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-4	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-4	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-4	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-4	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-4	S fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-4	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-4	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-4	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-4	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-5	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-5	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-5	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-5	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-5	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-6	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-6	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-6	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-6	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-6	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-6	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-6	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-7	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-7	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-7	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-7	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-7	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-7	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-7	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-7	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-8	S fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-8	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-8	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-8	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-8	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-8	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-8	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-8	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-8	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-8	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-8	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-8	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-9	S fraction	UNKN Diatom	UNKN Diatom	diatom

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-9	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-9	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-9	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-9	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-9	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-9	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-10	S fraction	NONE	NONE	NONE
Burghead	BHF21-11	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-11	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-11	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-11	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-11	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-11	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-11	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-12	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-12	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-13	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-14	S fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-14	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-14	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-14	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-14	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-14	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-14	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-14	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-15	S fraction	EMPTY	EMPTY	EMPTY
Burghead	BHF21-16	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-16	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-16	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-16	S fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-16	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-16	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-16	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-16	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-17	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-17	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-17	S fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-17	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-17	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-17	S fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-17	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-17	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-17	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-17	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-18	S fraction	EMPTY	EMPTY	EMPTY
Burghead	BHF21-19	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-19	S fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-19	S fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-19	S fraction	UNKN	UNKN	phytolith
Burghead	BHF21-1	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-1	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-1	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-1	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-1	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-1	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-1	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-1	A/B fraction	UNKN	UNKN	pollen sphere
Burghead	BHF21-2	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-2	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-2	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-2	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-2	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-2	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-2	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-2	A/B fraction	Poaceae	Arundinoideae sp.	phytolith
Burghead	BHF21-2	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-2	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-2	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-2	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-2	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-2	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-3	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-3	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-3	A/B fraction	Poaceae	Poaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-3	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-3	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-3	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-3	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-3	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-3	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-3	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-4	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-4	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-4	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-4	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-4	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-4	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-4	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-4	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-4	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-4	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-4	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-5	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-5	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-5	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-5	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-5	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-5	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-5	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-5	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-5	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-5	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-5	A/B fraction	Poaceae	Chrysophyte	phytolith
Burghead	BHF21-5	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Burghead	BHF21-5	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-6	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-6	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-6	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-6	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-6	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-6	A/B fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-6	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-6	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-6	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-6	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-7	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-7	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-7	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-7	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-7	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-7	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-7	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-7	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-7	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-7	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-7	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-7	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-7	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-8	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-8	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-8	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-8	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-8	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-8	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-8	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-8	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-8	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-8	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-8	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-8	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-8	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-8	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-9	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-9	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-9	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-9	A/B fraction	Poaceae	Panicoideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-9	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-9	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-9	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-10	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-10	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-10	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-10	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-10	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-10	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-10	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-10	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-10	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-10	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-10	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-11	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-11	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-11	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-11	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-11	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-11	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-11	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-12	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-12	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-12	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-12	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-12	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-12	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-12	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-12	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-12	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-12	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-12	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-12	A/B fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-13	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-13	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-13	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-13	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-13	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-13	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-13	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-13	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-14	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-14	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-14	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-14	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-15	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-15	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-15	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-15	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-15	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-15	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-15	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-15	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-15	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-15	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-16	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-16	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-16	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-16	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-16	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-16	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-16	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-17	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-17	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-17	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-17	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-17	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-17	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-17	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-17	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-17	A/B fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	BHF21-17	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-17	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-17	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-18	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-18	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-18	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-18	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-18	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-18	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-18	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-18	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-18	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-18	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Burghead	BHF21-18	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-18	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-18	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-18	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-18	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-19	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Burghead	BHF21-19	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	BHF21-19	A/B fraction	Poaceae	Poaceae sp.	phytolith
Burghead	BHF21-19	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-19	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-19	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-19	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	BHF21-19	A/B fraction	Poaceae	Pooideae sp.	phytolith
Burghead	BHF21-19	A/B fraction	UNKN	UNKN	phytolith
Burghead	BHF21-19	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-1	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-1	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-1	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-1	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-1	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-1	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-1	S fraction	Poaceae	Arundinoideae sp.	phytolith
Balbinny	BAL20-1	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-1	S fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-1	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-1	S fraction	UNKN Diatom	UNKN Diatom	unident
Balbinny	BAL20-1	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-1	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-1	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-2	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-2	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-2	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-2	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-2	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-2	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-2	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-2	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-2	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-2	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-2	S fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-2	S fraction	Pigment?	unident	blue pigment
Balbinny	BAL20-2	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-2	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-3	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-3	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-3	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-3	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-3	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-3	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-3	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-3	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-3	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-3	S fraction	Poaceae	Arundinoideae sp.	phytolith
Balbinny	BAL20-3	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-3	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-3	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-4	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-4	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-4	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-4	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-4	S fraction	Cyperaceae	Cyperaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-4	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-4	S fraction	Poaceae	Arundinoideae sp.	phytolith
Balbinny	BAL20-4	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-4	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-4	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-4	S fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-4	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-4	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-4	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-5	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-5	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-5	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-5	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-5	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-5	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-5	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-5	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-6	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-6	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-6	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-6	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-6	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-6	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-6	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-6	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-6	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-6	S fraction	UNKN	UNKN	hairs
Balbinny	BAL20-6	S fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-6	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-6	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-6	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-7	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-7	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-7	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-7	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-7	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-7	S fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-7	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-7	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-7	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-7	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-7	S fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-7	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-8	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-8	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-8	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-8	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-8	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-8	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-8	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-8	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-8	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-8	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-8	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-8	S fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-9	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-9	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-9	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-9	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-9	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-9	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-9	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-9	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-9	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-10	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-10	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-10	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-10	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-10	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-10	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-10	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-10	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-10	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-10	S fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-10	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-10	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-10	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-10	S fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-10	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-11	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-11	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-11	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-11	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-11	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-11	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-11	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-11	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-11	S fraction	Poaceae	Arundinoideae sp.	phytolith
Balbinny	BAL20-11	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-11	S fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-11	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-11	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-11	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-12	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-12	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-12	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-12	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-12	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-12	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-12	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-12	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-12	S fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-12	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-12	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-12	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-12	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-13	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-13	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-13	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-13	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-13	S fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-13	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-13	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-13	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-13	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-13	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-13	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-14	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-14	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-14	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-14	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-14	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-14	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-14	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-14	S fraction	UNKN Diatom	UNKN Diatom	araphid diatom
Balbinny	BAL20-14	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-14	S fraction	UNKN Diatom	UNKN Diatom	raphid diatom
Balbinny	BAL20-14	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-15	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-15	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-15	S fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-15	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-15	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-15	S fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-15	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-15	S fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-15	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-15	S fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-15	S fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-15	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-1	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-1	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-1	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-1	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-1	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-1	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-1	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-1	A/B fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-1	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-1	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-1	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-1	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-1	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-2	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-2	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-2	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-2	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-2	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-2	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-2	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-2	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-2	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-2	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-2	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-2	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-3	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-3	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-3	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-3	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-3	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-3	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-4	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-4	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-4	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-4	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-4	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-4	A/B fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-4	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-4	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-4	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-4	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-4	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-5	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-5	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-5	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-5	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-5	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-5	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-5	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-5	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-5	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-5	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-5	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-6	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-6	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-6	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-6	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-6	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-7	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-7	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-7	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-7	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-7	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-7	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-7	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-7	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-7	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-7	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-7	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-7	A/B fraction	Poaceae	Arundinoideae sp.	phytolith
Balbinny	BAL20-7	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-8	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-8	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-8	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-8	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-8	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-8	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-8	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-8	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-8	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-8	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-8	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-8	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-9	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-9	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-9	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-9	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-9	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-9	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-9	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-10	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-10	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-10	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-10	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-10	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-10	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-10	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-10	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-10	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-10	A/B fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-10	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-10	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-11	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-11	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-11	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-11	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-11	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-11	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-11	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-12	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-12	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-12	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-12	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-12	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-12	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-12	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-12	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-12	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-12	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-12	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-12	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-13	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-13	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-13	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-13	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-13	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-13	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-13	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-13	A/B fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Balbinny	BAL20-13	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-13	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-13	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-14	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-14	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-14	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-14	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-14	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-14	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-14	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Balbinny	BAL20-14	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-14	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-14	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-14	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Balbinny	BAL20-15	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Balbinny	BAL20-15	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Balbinny	BAL20-15	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-15	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Balbinny	BAL20-15	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-15	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-15	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-15	A/B fraction	Poaceae	Pooideae sp.	phytolith
Balbinny	BAL20-15	A/B fraction	Poaceae	Poaceae sp.	phytolith
Balbinny	BAL20-15	A/B fraction	UNKN	UNKN	phytolith
Balbinny	BAL20-15	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-26-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-26-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	MB-24-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	Poaceae	Arundinoideae sp.	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	Poaceae	Chlorideae sp.	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-24-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-21-BHF21-SW	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-21-BHF21-SW	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-21-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-21-BHF21-SW	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-21-BHF21-SW	Sonicated Wash	UNKN	UNKN	phytolith
Burghead	MB-21-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-21-BHF21-SW	Sonicated Wash	UNKN	UNKN	phytolith
Burghead	MB-21-BHF21-SW	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-21-BHF21-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-21-BHF21-WW	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-21-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-21-BHF21-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-21-BHF21-WW	Wet Wash	UNKN Diatom	UNKN Diatom	diatom
Burghead	MB-21-BHF21-WW	Wet Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-21-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-21-BHF21-WW	Wet Wash	Poaceae	Arundinoideae sp.	phytolith
Burghead	MB-21-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	UNKN Diatom	UNKN Diatom	diatom
Burghead	MB-13-BHF21-SW	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	UNKN	UNKN	starch grain
Burghead	MB-13-BHF21-SW	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-13-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	MB-13-BHF21-SW	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	Poaceae	Arundinoideae sp.	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	UNKN	UNKN	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	UNKN	UNKN	phytolith
Burghead	MB-13-BHF21-SW	Sonicated Wash	UNKN	UNKN	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-33-BHF21-SW	Sonicated Wash	UNKN Diatom	UNKN Diatom	diatom
Burghead	MB-33-BHF21-SW	Sonicated Wash	UNKN	UNKN	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	UNKN	UNKN	starch grain
Burghead	MB-33-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	Poaceae	Chlorideae sp.	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	UNKN	UNKN	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-33-BHF21-SW	Sonicated Wash	UNKN	UNKN	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	UNKN Diatom	UNKN Diatom	diatom
Burghead	MB-14-BHF21-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	UNKN	UNKN	starch grain
Burghead	MB-14-BHF21-WW	Wet Wash	Poaceae	Arundinoideae sp.	phytolith
Burghead	MB-14-BHF21-WW	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Craig Rock	3CR19-T2-(2002)-WW	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Craig Rock	3CR19-T2-(2002)-WW	Wet Wash	Poaceae	Poaceae sp.	phytolith
Craig Rock	3CR19-T2-(2002)-WW	Wet Wash	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Craig Rock	3CR19-T2-(2002)-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Craig Rock	3CR19-T2-(2002)-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Craig Rock	3CR19-T2-(2002)-WW	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Craig Rock	3CR19-T2-(2002)-WW	Wet Wash	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	MB-1-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-1-TAP	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-1-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-1-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-1-TAP	Wet Wash	Arboreal	Arboreal	starch grain
Tap o'Noth	MB-1-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-1-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-1-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-1-TAP	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-1-TAP	Sonicated Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-1-TAP	Sonicated Wash	UNKN	UNKN	hair fragment
Tap o'Noth	MB-1-TAP	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-1-TAP	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-2-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-2-TAP	Sonicated Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	Arboreal	Arboreal	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-3-TAP	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-3-TAP	Sonicated Wash	Poaceae	Poaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	MB-3-TAP	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	MB-3-TAP	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-8-BHF21	Wet Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-8-BHF21	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-8-BHF21	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-8-BHF21	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-8-BHF21	Wet Wash	UNKN Diatom	UNKN Diatom	diatom
Burghead	MB-8-BHF21	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-8-BHF21	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-8-BHF21	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-8-BHF21	Sonicated Wash	Feather	Feather	feather barbule
Burghead	MB-8-BHF21	Sonicated Wash	UNKN Diatom	UNKN Diatom	diatom
Burghead	MB-8-BHF21	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-8-BHF21	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-6-BHF21	Wet Wash	Poaceae	Pooideae sp.	starch grain
Burghead	MB-6-BHF21	Wet Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-6-BHF21	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-6-BHF21	Wet Wash	UNKN	UNKN	phytolith
Burghead	MB-6-BHF21	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-6-BHF21	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-6-BHF21	Wet Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-6-BHF21	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-6-BHF21	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-6-BHF21	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-6-BHF21	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-6-BHF21	Sonicated Wash	UNKN	UNKN	starch grain
Burghead	MB-6-BHF21	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-6-BHF21	Dry Wash	Poaceae	Pooideae sp.	phytolith
Burghead	MB-6-BHF21	Dry Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-6-BHF21	Dry Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-6-BHF21	Dry Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-6-BHF21	Dry Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Burghead	MB-8-BHF21	Dry Wash	Poaceae	Poaceae sp.	phytolith
Burghead	MB-8-BHF21	Dry Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-8-BHF21	Dry Wash	Poaceae	Panicoideae sp.	phytolith
Burghead	MB-8-BHF21	Dry Wash	UNKN Diatom	UNKN Diatom	diatom
Burghead	MB-8-BHF21	Dry Wash	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Burghead	MB-8-BHF21	Dry Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Craig Rock	1CR(B)	Wet Wash	Poaceae	Pooideae sp.	starch grain
Craig Rock	1CR(B)	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Craig Rock	1CR(B)	Wet Wash	Poaceae	Poaceae sp.	phytolith
Craig Rock	1CR(B)	Wet Wash	Poaceae	Pooideae sp.	phytolith
Craig Rock	1CR(B)	Wet Wash	Poaceae	Pooideae sp.	starch grain
Craig Rock	1CR(B)	Wet Wash	Poaceae	Pooideae sp.	starch grain
Craig Rock	1CR(B)	Dry Wash	EMPTY	EMPTY	EMPTY
Craig Rock	1CR(B)	Sonicated Wash	EMPTY	EMPTY	EMPTY
Craig Rock	2CR	Wet Wash	EMPTY	EMPTY	EMPTY
Craig Rock	7CR	Dry Wash	Poaceae	Poaceae sp.	phytolith
Craig Rock	7CR	Dry Wash	Poaceae	Panicoideae sp.	phytolith
Craig Rock	7CR	Dry Wash	Poaceae	Panicoideae sp.	phytolith
Craig Rock	7CR	Dry Wash	UNKN Diatom	UNKN Diatom	diatom
Craig Rock	7CR	Dry Wash	Poaceae	Pooideae sp.	phytolith
Craig Rock	7CR	Dry Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Craig Rock	7CR	Wet Wash	Poaceae	Pooideae sp.	starch grain
Craig Rock	7CR	Wet Wash	UNKN	UNKN	starch grain
Craig Rock	7CR	Wet Wash	Poaceae	Poaceae sp.	phytolith
Craig Rock	7CR	Wet Wash	UNKN	UNKN	starch grain
Craig Rock	7CR	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Craig Rock	7CR	Wet Wash	UNKN	UNKN	phytolith
Craig Rock	7CR	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Craig Rock	7CR	Sonicated Wash	UNKN	UNKN	starch grain
Craig Rock	7CR	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Craig Rock	7CR	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Craig Rock	7CR	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Craig Rock	7CR	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Craig Rock	7CR	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Mither Tap	1MT	Wet Wash	EMPTY	EMPTY	EMPTY
Mither Tap	1MT	Sonicated Wash	EMPTY	EMPTY	EMPTY
Mither Tap	2MT	Wet Wash	EMPTY	EMPTY	EMPTY
Mither Tap	2MT	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	2MT	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Mither Tap	2MT	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Mither Tap	4MT	Wet Wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	4MT	Wet Wash	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Mither Tap	4MT	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Mither Tap	4MT	Wet Wash	Poaceae	Pooideae sp.	phytolith
Mither Tap	4MT	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	4MT	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Mither Tap	4MT	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Mither Tap	4MT	Sonicated Wash	UNKN	UNKN	phytolith
Mither Tap	4MT	Sonicated Wash	UNKN	UNKN	parasite
Mither Tap	4MT	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Mither Tap	4MT	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Mither Tap	4MT	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Mither Tap	5MT	Wet Wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	5MT	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Mither Tap	5MT	Sonicated Wash	UNKN	UNKN	starch grain
Mither Tap	7MT	Wet Wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	7MT	Sonicated Wash	EMPTY	EMPTY	EMPTY
Mither Tap	8MT	Wet Wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	8MT	Sonicated Wash	UNKN	UNKN	starch grain
Mither Tap	8MT	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Mither Tap	8MT	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	8MT	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Croftgowan	MB-1_CR021	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Croftgowan	MB-1_CR021	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Croftgowan	MB-1_CR021	Wet wash	UNKN	UNKN	starch grain
Croftgowan	MB-1_CR021	Wet wash	Poaceae	Pooideae sp.	starch grain
Croftgowan	MB-1_CR021	Wet wash	Poaceae	Poaceae sp.	phytolith
Croftgowan	MB-1_CR021	Wet wash	Poaceae	Pooideae sp.	starch grain
Croftgowan	MB-1_CR021	Wet wash	Poaceae	Pooideae sp.	starch grain
Croftgowan	MB-1_CR021	Wet wash	Poaceae	Panicoideae sp.	phytolith
Croftgowan	MB-1_CR021	Wet wash	UNKN	UNKN	possible radiolaria
Croftgowan	MB-2_CR021	Wet wash	Poaceae	Pooideae sp.	starch grain
Croftgowan	MB-2_CR021	Wet wash	Poaceae	Pooideae sp.	starch grain
Croftgowan	MB-2_CR021	Wet wash	Poaceae	Pooideae sp.	starch grain
Croftgowan	MB-2_CR021	Wet wash	UNKN	UNKN	starch grain
Croftgowan	MB-2_CR021	Wet wash	UNKN	UNKN	starch grain
Croftgowan	MB-2_CR021	Wet wash	cf. Poaceae	cf. Pooideae sp.	starch grain
Croftgowan	MB-2_CR021	Sonicated Wash	UNKN	UNKN	starch grain
Lundin Links	MB-22_LL-1	Wet wash	EMPTY	EMPTY	EMPTY

Site	Context	Sample/Fraction	Family	Taxon	Part
Lundin Links	MB-22_LL-1	Sonicated Wash	UNKN	UNKN	starch grain
Lundin Links	MB-22-LL-2	Sonicated Wash	EMPTY	EMPTY	EMPTY
Lundin Links	MB-22-LL-3	Sonicated Wash	UNKN	UNKN	starch grain
Lundin Links	MB-22-LL-4	Sonicated Wash	UNKN	UNKN	starch grain
Lundin Links	MB-22-LL-4	Sonicated Wash	UNKN	UNKN	starch grain
Lundin Links	MB-22-LL-4	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Lundin Links	MB-22-LL-4	Sonicated Wash	UNKN	UNKN	starch grain
Lundin Links	MB-22-LL-4	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-22_TAP-1	Dry Wash	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	MB-22_TAP-1	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	MB-22_TAP-1	Wet Wash	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	MB-22_TAP-1	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	MB-22_TAP-1	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	MB-22_TAP-1	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-22_TAP-1	Sonicated Wash	EMPTY	EMPTY	EMPTY
Tap o'Noth	MB-22_TAP-2	Wet Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB-22_TAP-2	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-22_TAP-2	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB-22_TAP-2	Sonicated Wash	UNKN	UNKN	starch grain
Tap o'Noth	MB22_TAP-3	Dry Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB22_TAP-3	Dry Wash	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	MB22_TAP-3	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	MB22_TAP-3	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB22_TAP-3	Wet Wash	Poaceae	Pooideae sp.	starch grain
Tap o'Noth	MB22_TAP-3	Wet Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	MB22_TAP-3	Sonicated Wash	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	MB22_TAP-3	Sonicated Wash	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	MB22_TAP-3	Sonicated Wash	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	MB22_TAP-3	Sonicated Wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Dunnicaer	MB-22_DUNC-1	Wet Wash	UNKN	UNKN	starch grain
Dunnicaer	MB-22_DUNC-1	Wet Wash	UNKN	UNKN	starch grain
Dunnicaer	MB-22_DUNC-1	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Dunnicaer	MB-22_DUNC-1	Sonicated Wash	EMPTY	EMPTY	EMPTY
Dunnicaer	MB-22_DUNC-2	Wet Wash	Unident Hair	Unident Hair	hair
Dunnicaer	MB-22_DUNC-2	Wet Wash	UNKN	UNKN	starch grain
Dunnicaer	MB-22_DUNC-2	Sonicated Wash	Unident Hair	Unident Hair	hair
Dunnicaer	MB-22_DUNC-3	Wet Wash	UNKN	UNKN	starch grain

Site	Context	Sample/Fraction	Family	Taxon	Part
Dunnicaer	MB-22_DUNC-3	Wet Wash	UNKN	UNKN	starch grain
Dunnicaer	MB-22_DUNC-3	Sonicated Wash	EMPTY	EMPTY	EMPTY
Rhynie	MB-22_REAP-1	Wet Wash	UNKN	UNKN	starch grain
Rhynie	MB-22_REAP-1	Wet Wash	Poaceae	Pooideae sp.	starch grain
Rhynie	MB-22_REAP-1	Wet Wash	Poaceae	Pooideae sp.	starch grain
Rhynie	MB-22_REAP-1	Wet Wash	UNKN	UNKN	starch grain
Rhynie	MB-22_REAP-1	Wet Wash	Poaceae	Panicoideae sp.	phytolith
Rhynie	MB-22_REAP-2	Wet Wash	EMPTY	EMPTY	EMPTY
Rhynie	MB-22_REAP-2	Sonicated Wash	EMPTY	EMPTY	EMPTY
Rhynie	MB-22_REAP-3	Wet Wash	UNKN	UNKN	starch grain
Rhynie	MB-22_REAP-3	Wet Wash	Poaceae	Pooideae sp.	starch grain
Rhynie	MB-22_REAP-3	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Rhynie	MB-22_REAP-3	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Rhynie	MB-22_REAP-3	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Rhynie	MB-22_REAP-3	Sonicated Wash	Poaceae	Pooideae sp.	starch grain
Mither Tap	MT19_T4_LG_sherd	Sonicated wash	UNKN	UNKN	starch grain
Mither Tap	MT19_T4_LG_sherd	Sonicated wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Mither Tap	MT19_T4_LG_sherd	Sonicated wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	MT19_T4_LG_sherd	Wet wash	UNKN	UNKN	starch grain
Mither Tap	MT19_T4_LG_sherd	Wet wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Mither Tap	MT19_T4_LG_sherd	Wet wash	Poaceae	Pooideae sp.	starch grain
Mither Tap	MT19_T4_LG_sherd	Wet wash	UNKN	UNKN	starch grain
Mither Tap	MT19_T4_LG_sherd	Wet wash	UNKN Diatom	UNKN Diatom	diatom
Mither Tap	MT19_T4_LG_sherd	Wet wash	UNKN	UNKN	starch grain
Mither Tap	MT19_T4_LG_sherd	Wet wash	UNKN	UNKN	starch grain
Mither Tap	MT19_T4_SM_sherd	Wet wash	UNKN	UNKN	pollen
Mither Tap	MT19_T4_SM_sherd	Wet wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Mither Tap	MT19_T4_SM_sherd	Wet wash	UNKN	UNKN	parasite
Mither Tap	MT19_T4_SM_sherd	Wet wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Wet wash	Poaceae	Pooideae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Wet wash	Poaceae	Panicoideae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Wet wash	Poaceae	Panicoideae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Wet wash	UNKN	UNKN	starch grain
Mither Tap	MT19_T4_SM_sherd	Wet wash	Poaceae	Pooideae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Wet wash	UNKN	UNKN	starch grain
Mither Tap	MT19_T4_SM_sherd	Wet wash	UNKN	UNKN	starch grain
Mither Tap	MT19_T4_SM_sherd	Wet wash	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Mither Tap	MT19_T4_SM_sherd	Wet wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Wet wash	UNKN Diatom	UNKN Diatom	diatom
Mither Tap	MT19_T4_SM_sherd	Sonicated wash	Poaceae	Pooideae sp.	starch grain
Mither Tap	MT19_T4_SM_sherd	Sonicated wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Sonicated wash	Poaceae	Poaceae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Sonicated wash	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Mither Tap	MT19_T4_SM_sherd	Sonicated wash	Poaceae	Pooideae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Sonicated wash	Poaceae	Panicoideae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Sonicated wash	Poaceae	Pooideae sp.	phytolith
Mither Tap	MT19_T4_SM_sherd	Sonicated wash	UNKN	UNKN	starch grain
Cairnmore	CM20_17001_1	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	UNKN Dicot	Unident	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	UNKN Dicot	Unident	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_1	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_1	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_1	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_1	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_1	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_1	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_1	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_1	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_1	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_1	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_1	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_2	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_2	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_2	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_2	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_2	A/B Fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_2	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_2	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_2	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_2	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_2	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_2	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_2	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_2	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_2	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_2	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_2	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_2	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_2	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_2	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_2	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_2	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_2	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_3	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_3	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_3	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_3	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_3	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_3	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_3	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_3	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_3	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_3	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_3	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_3	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_3	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_3	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_3	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_3	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_3	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_3	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_3	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_3	S Fraction	UNKN Diatom	UNKN Diatom	diatom

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_3	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_4	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_4	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_4	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_4	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_4	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_4	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_4	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_4	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_4	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_4	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_4	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_4	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_5	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_5	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_5	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_5	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_5	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_5	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_5	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_5	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_5	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_5	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_5	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_5	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_5	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_5	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_5	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_5	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_5	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_5	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_6	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_6	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_6	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_6	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_6	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_6	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_7	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_7	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_7	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_7	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_7	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_7	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_7	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_7	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_7	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_7	S Fraction	UNKN Diatom	UNKN Diatom	diatom

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_7	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_8	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	UNKN Dicot	Unident	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_8	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_8	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_8	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_8	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_8	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_8	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_8	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_8	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_8	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_8	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_8	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_8	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_8	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_8	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_8	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_9	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_9	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_9	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_9	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_9	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_9	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_9	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_9	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_9	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_9	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_9	S Fraction	Asteraceae	Asteraceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_9	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_9	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_9	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_9	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_9	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_9	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_10	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_10	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_10	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_10	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_10	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_10	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_10	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_10	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_10	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_10	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_10	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_10	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_10	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_10	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_10	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_10	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_10	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_10	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_10	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_10	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_10	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_10	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_10	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_10	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_11	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_11	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_11	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_11	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_11	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_11	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_11	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_11	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_11	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_11	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_11	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_11	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_11	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_11	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_11	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_11	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_11	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_11	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_11	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_11	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_12	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_12	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_12	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_12	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_12	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_12	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_12	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_12	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_12	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_12	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_12	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_12	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_12	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_12	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_13	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_13	A/B Fraction	Poaceae	Poaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_13	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_13	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_13	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_13	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_13	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_13	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_13	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_13	S Fraction	Poaceae	Arundinoideae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_13	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_13	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_13	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_13	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_13	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_14	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_14	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_14	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_14	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_14	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_14	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_14	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_14	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_14	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_14	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_14	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_14	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_14	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_14	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_15	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_15	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_15	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_15	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_15	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_15	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_15	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_15	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_15	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_15	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_15	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_15	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_15	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_15	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_15	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_15	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_15	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_15	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_16	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_16	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_16	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_16	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_16	S Fraction	Poaceae	Poaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_16	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_16	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_16	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_16	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_16	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_16	S Fraction	Poaceae	Arundinoideae sp.	phytolith
Cairnmore	CM20_17001_16	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_16	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_16	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_16	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_16	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_17	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_17	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_17	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_17	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_17	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_17	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_17	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_17	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_17	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_17	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_17	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_17	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_17	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_17	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_17	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_17	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_17	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_17	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_17	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_18	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_18	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_18	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_18	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_18	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_18	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_18	S Fraction	Poaceae	Panicoideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_18	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_18	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_18	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_18	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_18	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_18	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_18	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_18	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_18	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_18	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_18	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_18	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_18	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_18	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_19	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_19	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_19	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_19	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_19	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_19	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_19	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_19	A/B Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_19	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_19	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_19	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_19	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_19	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_19	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_19	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_19	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_19	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_19	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_19	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_19	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_20	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_20	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_20	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Cairnmore	CM20_17001_20	A/B Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_20	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_20	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_20	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_20	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_20	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_20	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_20	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_20	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_20	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_20	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_20	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_20	S Fraction	UNKN Dicot	Unident	phytolith
Cairnmore	CM20_17001_20	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_20	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_20	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_20	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_20	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_21	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_21	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_21	A/B Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_21	A/B Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_21	A/B Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_21	A/B Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_21	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_21	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_21	S Fraction	Asteraceae	Asteraceae sp.	phytolith
Cairnmore	CM20_17001_21	S Fraction	Cyperaceae	Cyperaceae sp.	phytolith
Cairnmore	CM20_17001_21	S Fraction	Poaceae	Panicoideae sp.	phytolith
Cairnmore	CM20_17001_21	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_21	S Fraction	UNKN	UNKN	phytolith
Cairnmore	CM20_17001_21	S Fraction	Poaceae	Poaceae sp.	phytolith
Cairnmore	CM20_17001_21	S Fraction	Poaceae	Pooideae sp.	phytolith
Cairnmore	CM20_17001_21	A/B Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_21	A/B Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Cairnmore	CM20_17001_21	S Fraction	UNKN Diatom	UNKN Diatom	diatom
Cairnmore	CM20_17001_21	S Fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-1	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-1	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-1	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-1	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-2	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-2	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-2	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-2	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-2	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-3	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-3	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-3	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-3	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-3	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-3	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-3	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-3	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-3	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-3	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-3	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-4	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-4	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-4	S fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-4	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-4	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-5	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-5	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-5	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-5	S fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-5	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-5	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-5	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-5	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-5	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-5	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-5	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-7	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-7	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-7	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-7	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-7	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-7	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-7	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-7	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-7	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-7	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-7	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-8	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-8	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-8	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-9	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-9	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-9	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-9	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-9	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-9	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-9	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-9	S fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-9	S fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-9	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-9	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-9	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-10	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-10	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-10	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-10	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-10	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-10	S fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-10	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-10	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-10	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-10	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-11	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-11	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-11	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-12	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-12	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-12	S fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-14	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-14	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-14	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-14	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-15	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-15	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-15	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-15	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-15	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-15	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-15	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-15	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-15	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-15	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-16	S fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-16	S fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-16	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-16	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-16	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-16	S fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-16	S fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-16	S fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-16	S fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-16	S fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-16	S fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-1	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	Poaceae	Pooideae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-1	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-1	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-1	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-1	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-1	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-1	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-2	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-2	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-2	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-2	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-3	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-3	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-3	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-3	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-3	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-3	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-3	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-3	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-3	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-3	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-4	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-4	A/B fraction	Poaceae	Poaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-4	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-4	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-4	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-5	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-5	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-5	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-7	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-7	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-7	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-7	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-7	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-7	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-7	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-7	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-7	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-7	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-7	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-8	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-8	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-8	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-8	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-8	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-8	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-8	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-8	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-8	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-8	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-8	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-8	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-8	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-9	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-9	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-9	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-9	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-9	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-9	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-9	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-9	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-9	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-9	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-9	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-9	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-9	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-10	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-10	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-10	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-10	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-10	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-10	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-10	A/B fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-10	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-10	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-10	A/B fraction	UNKN	UNKN	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-10	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-10	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-10	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-11	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-11	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-11	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-11	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-11	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-11	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-11	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-11	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-12	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-12	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-12	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-12	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-12	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-12	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-12	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-12	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-12	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-12	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-12	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-12	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-14	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-14	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-14	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-14	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-14	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-14	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-14	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-14	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-14	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-14	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-14	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-14	A/B fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith

Site	Context	Sample/Fraction	Family	Taxon	Part
Tap o'Noth	TAP22-15	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-15	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-15	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-15	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-15	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-15	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-15	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-16	A/B fraction	UNKN Chrysophyte	UNKN Chrysophyte	chrysophyte
Tap o'Noth	TAP22-16	A/B fraction	UNKN Diatom	UNKN Diatom	diatom
Tap o'Noth	TAP22-16	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Poaceae	Pooideae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Cyperaceae	Cyperaceae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Arundinoideae	arundinoideae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Poaceae	Panicoideae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Poaceae	Poaceae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Asteraceae	Asteraceae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-16	A/B fraction	Asteraceae/Ericaceae	Asteraceae/Ericaceae sp.	phytolith
Tap o'Noth	TAP22-16	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-16	A/B fraction	UNKN	UNKN	phytolith
Tap o'Noth	TAP22-16	A/B fraction	UNKN	UNKN	phytolith