Forests, Fields, and Floods: A Historical Ecology of the Cahokia Region, Illinois, USA

By

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A dissertation submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

(Geography)

at the

UNIVERSITY OF WISCONSIN–MADISON

2015

Date of final oral examination: 5/22/2015

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Acknowledgments

This dissertation represents many years of work, and I am indebted to the people that helped me along the way. First, I want to thank my doctoral advisor, Jack Williams, who managed to provide steady and unwavering guidance while allowing me to follow my own research interests. When my focus wandered, or challenges arose, Jack calmly steered me back on course. All of the work presented here benefitted from Jack's intellectual creativity and flexibility, and the countless hours he graciously allowed me to spend in his office talking through the nitty-gritty of doing research.

I also want to thank my committee members: Joe Mason acquainted me with many of the fundamental works in physical geography, and generously allowed me to use his lab equipment – even after my heavy usage of his laser particle-size analyzer contributed to its break-down – and provided guidance on protocols, interpretations, and manuscripts; David Mladenoff introduced me to the field of historical ecology, allowing me to think more broadly about the tools and techniques available to understand land use history, and guided me through many of the challenges associated with writing a review paper; Mutlu Ozdogan helped me to visualize complex problems in simpler terms, and provided valuable advice on modeling flood extent; Sissel Schroeder patiently and enthusiastically acquainted me with North American archaeology, all while learning about lake sediment coring – even on a very cold January day – and helped to disseminate much of this dissertation's contents to archaeologists working in the American Bottom. Finally, thanks to the late and great Jim Knox, whose door was always open, and who early on suggested that our sediment cores might contain information about prehistoric floods.

Thanks also to the students, staff, researchers, and faculty in the Department of Geography, and the broader University of Wisconsin–Madison community. Discussions with fellow geographers, especially Emily Atkinson, Andy Davey, Michael Eggen, Bill Gartner, Kristy Gruley, and Simon Goring, helped me to feel a sense of identity and place here in Science Hall. Participation in the Novel Ecosystems IGERT taught me to better communicate with the public and other scientists, and kept me fed, clothed, and housed for my last two years in Madison; I want to especially thank Volker Radeloff for leading the IGERT, and helping to guide me through the closing stages of graduate school.

Funding for this dissertation came, ultimately, from the citizens of Canada and the United States – thank you for supporting higher education and research. I have made every effort to make this work relevant and interesting to academics and the public alike.

Finally, I want to thank my family: My parents, David and Eeva, who have always supported me and instilled in me an intellectual curiosity that allowed me to pursue my academic interests; my parents-in-law, Karen and Roger, who helped us feel at home in Wisconsin; and finally, my wife, Sierra, who has selflessly encouraged me and given me strength when I needed it most.

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Dissertation Abstract

The decline and abandonment of Cahokia (A.D. 1050–A.D. 1350), a major Late Prehistoric population center in the central Mississippi River valley, has previously been attributed to climatic variability, resource overexploitation, warfare, sociopolitical factionalism, and other factors. The relative importance of sociopolitical and environmental factors in shaping the history of Cahokia, and the trajectories of other early agricultural societies, is debated by archaeologists and geoscientists. Lacustrine sedimentary records offer a means to reconstruct past environmental changes at local- to regional-scales, but few such paleoenvironmental records have been available to understand the role of environmental change in Cahokia's emergence and decline. This dissertation presents multi-proxy sedimentary records from three oxbow lakes in the central Mississippi River valley to establish an ecological and hydro-climatic history of the Cahokia region.

Based on fossil pollen assemblages, charcoal, and stable carbon isotopes ($\delta^{13}C_{org}$), the widespread removal of trees and the expansion of croplands began at the onset of the Late Woodland period (ca. A.D. 400), centuries before the widespread use of maize (*Zea mays* subsp. *mays*) in this region around A.D. 900, and well before the emergence of Cahokia as a regional center at A.D. 1050. Agriculture during the Late Woodland period (A.D. 400–A.D. 900), based on the cultivation of indigenous seed crops, was more extensive than Mississippian agriculture (A.D. 1050–A.D. 1350), which involved more intensive cultivation of maize and other crops around large population centers. Even in the vicinity of the largest prehistoric population center in eastern North American, indigenous land use was not widespread or ubiquitous, but patchy, variable in intensity, and dynamic. The overexploitation of woodland resources near Cahokia and other Late Prehistoric population centers in the floodplain of the central Mississippi River valley and adjacent uplands likely played a role in the agricultural intensification and regional trade patterns that characterize the emergence of Cahokia, but the paleoecological data do not support the hypothesis that severe deforestation alone motivated individuals to abandon Cahokia.

Synchronous shifts in sediment composition and particle-size observed in cores from two oxbow lakes are consistent with deposition of floodwater sediments following inundation of the floodplain by the Mississippi River. At least eight high-magnitude floods (> 10 m stage) are identified over the last 1,800 years, with large floods occurring about once a century between A.D. 300–A.D. 600 and A.D. 1200–A.D. 1850. No large floods occurred from A.D. 600–A.D. 1200, coinciding with a period of midcontinental aridity, together with population growth and

agricultural intensification in the floodplain of the central Mississippi River valley. The onset of Cahokia's depopulation and sociopolitical fragmentation at A.D. 1200 coincides with the return of large floods as midcontinental aridity waned. These findings imply that the emergence, decline, and abandonment of Cahokia were, in part, societal responses to shifts in hydrological conditions caused by late Holocene climatic variability.

This dissertation provides an example of how human societies are closely tied to the landscapes they inhabit, shaping, managing, and responding to environmental change. Polarized debates over the importance of agency versus ecology in the history of Cahokia, and other early agricultural societies, are generally unproductive. Rather, the trajectories of human societies emerge from the confluence of internal and external sociopolitical and environmental factors that are difficult – if not impossible – to understand in isolation.

Preface

Human societies both affect and are vulnerable to environmental change. Today, the environmental consequences of human activities are pervasive, and shape nearly all aspects of the Earth system. Environmental changes, caused both by our own actions and natural events, often have significant social, economic, and political consequences at local, regional, continental, and global scales. As we grapple with how to live harmoniously on the land, and aspire to a course that neither harms ourselves nor the resources upon which we depend, what might we learn from the lessons offered by history? The world we live in today may be an anomaly in the history of our species, but human societies have struggled with the same dilemmas for millennia: How do we feed ourselves now, and ensure that our children, and our children's children, thrive? Where do we live to minimize risks to our welfare? How should we respond to change? These perennial questions have been answered in different ways with different outcomes throughout history; what can we learn from the success stories and cautionary tales of history?

As with all geographers, I am concerned with place, space, and time. This dissertation focuses on a place known to us today as Cahokia, situated in a particularly broad section of the central Mississippi River floodplain known as the American Bottom. We cannot know what Cahokia's prehistoric inhabitants called it because they left no written accounts, but from the area's material culture archaeologists have surmised that Cahokia was important within Midcontinental North America as a center of community, politics, ritual, trade, agriculture, and craftsmanship[1]. Beginning around A.D. 1050, Cahokia emerged as a major population center that drew thousands from across the midcontinent; by A.D. 1200 its cultural prominence and population size began to decline, and just three centuries after its establishment, Cahokia was abandoned[2]. Since its discovery, explorers, scientists and laymen alike have sought explanations for this place: Who created its enormous earthen mounds? Why did they leave? Where did they go? These and other questions continue to keep archaeologists occupied, and their answers are constantly being refined as new tools, techniques, approaches, and data are developed and applied to American Bottom archaeology.

The motivation of this dissertation is to draw on a paleoenvironmental approach that has remained on the fringes of American Bottom archaeology, but is widely used elsewhere, and offers a unique perspective on the environmental dimensions of Cahokia's rise and fall. This approach relies on the sedimentary records deposited in the lakes and wetlands found along the floodplain of the Mississippi River in and around Cahokia, and the fossils and geochemical signatures that are preserved in these deposits.

In a way, it is unsurprising that so little paleoenvironmental work had previously been done in the Cahokia area. This approach has traditionally fallen within the purview of geology, ecology, and physical geography, and, in North America, these fields are not well integrated with archaeology[3]. Moreover, the best sites for paleoenvironmental research in North America are often far from known archaeological sites. At first glance, the American Bottom appears to be an exception – here is a place with a phenomenal archaeological record surrounded by lakes – but these are floodplain lakes, and conventional wisdom says that their sediments are problematic for paleoenvironmental work: they receive inputs of sediment from multiple riverine, terrestrial, and atmospheric sources, may be susceptible to erosion and re-working, and contain few plant macrofossils suitable for radiocarbon dating[4]. Yet, the rewards for overcoming, or at least managing, these issues in a place like Cahokia could be enormous.

In the following chapters, I lean heavily on a paleoenvironmental perspective to answer two questions: (1) How did the indigenous peoples of the American Bottom shape their environment, and (2) What effect did environmental changes have on the region's occupants?

With the help of many, I collected sediment cores from floodplain lakes in and around Cahokia, and did my best to overcome the challenges of doing paleoenvironmental work in a floodplain: we considered both local and extra-local sedimentation and tuned conventional methods accordingly; we studied our cores carefully for unconformities and erosional contacts; and I spent countless hours searching for appropriate material to radiocarbon date. Armed with the cautionary tales of those who had tackled these issues before me, this dissertation presents robust paleoecological and paleohydrological records from floodplain lakes that provide answers – or at least partial ones – to the questions posed above.

I was particularly motivated by two hypotheses that sought to explain Cahokia's decline. The first has to do with human impacts on the environment: Given the high population densities associated with Cahokia, and demands for timber to build, cook, and keep warm, Bill Woods and Neil Lopinot proposed that deforestation created persistent environmental problems, including soil erosion and material shortages[5]. This hypothesis can be seen as part of a larger body of scholarship that rejected the notion of the "ecological Indian" inhabiting a pristine wilderness[6]. Indigenous North Americans, like all people, shaped the ecosystems around them to suit their economic needs and aspirations, but did they do so to their own detriment? Are we, as humans, doomed to destroy the places we live in? Or are we capable of responsible and prolonged stewardship?

The answer, it seems, depends on circumstance and perspective: Many societies, including those in the prehistoric Americas, influenced the environment to such an extent as to affect their behavior[7], but these behavioral changes often defy a better or worse dichotomy. As I show in this dissertation, the American Bottom was an open and agricultural landscape for nearly 1,000 years, maintained by generation after generation of stewardship. Yet, these findings also imply that, as their numbers increased, the inhabitants of the American Bottom were obliged to intensify agricultural production, build up infrastructure, and perhaps rely more heavily on trade. In a way, this behavior may have contributed to the eventual abandonment of the American Bottom, because intensive agriculture, infrastructure, and trade are fickle and susceptible to the whims of weather and politics. Yet, the original narrative proposed by Lopinot and Woods – that Cahokia's founding caused rapid and debilitating environmental degradation, and that I fully expected the paleoecological data to confirm – does not quite pan out. The narrative that humans serve only as destroyers of nature is too simplistic; we are capable of tremendous destruction, but we also exhibit an amazing capacity to adapt to our surroundings and organize ourselves in ways that are resilient to environmental change. We are constantly engaged in an elaborate dance with our surroundings – continuously affecting and responding to change – and the choices we make can lead to both success and misery.

The second hypothesis I wanted to examine was the role of climatic variability and change in Cahokia's decline and abandonment. In the 1960s and 1970s, Reid Bryson and colleagues sought to understand the role of climate change in the rise and fall of historical societies[8], and they proposed that Cahokia's expansion could be attributed to the warmer "Medieval Warm Period" and that its abandonment was the outcome of a cooler "Little Ice Age". Our knowledge of the climate system, and how human societies respond to climatic variability has improved tremendously[9] since Bryson's pioneering work. In paleoclimatology, more recent research has emphasized the importance of moisture variability in the climate of the Holocene[10] (our current interglacial), although the basic climatic phases that Bryson and colleagues proposed to be associated with Cahokia's rise and fall are still widely accepted.

The geography of the greater Cahokia area, where tens of thousands of people lived in the floodplain of the tumultuous Mississippi River, just a few miles away from its main channel, may strike us today as precarious. Historical floods of the Mississippi River have inundated the area around Cahokia under several feet of water[11], but did floods of such a magnitude occur in prehistory? What effect would they have had on Cahokia and its inhabitants, who did not have the protection of modern levees and flood control measures? As Jim Knox and other geomorphologists have shown, rivers are highly sensitive to climatic variability and change[12], so could the Mississippi's behavior have differed – and changed – during Cahokia's tenure?

In the final chapter of this dissertation, I present a new paleo-flood record for the central Mississippi River, and show that large floods occurred about once a century for most of the last 2,000 years. The exception, it turns out, is a 600-year window – from A.D. 600 to A.D. 1200 – that neatly coincides with when prehistoric peoples moved into the floodplain, intensified their agricultural production, and eventually gave birth to Cahokia; the closing of this flood-free window corresponds to Cahokia's decline.

In a way, these findings support Bryson's original hypothesis: the warmer and drier climatic conditions of the Medieval Climate Anomaly suppressed large floods to make the floodplain habitable, and when these conditions collapsed during the Little Ice Age, the lower elevations of the floodplain became a less desirable place to live. The difference, of course, is that climatic variability did not directly affect Cahokia, but instead acted indirectly by altering the very geography its inhabitants had come to depend on. Moreover, it is unlikely that any single flood caused the inhabitants of the American Bottom to permanently abandon the area. Instead, we see that Cahokia's decline occurred gradually over about 150 years, and thus likely resulted from the concatenation of multiple factors – social, political, and environmental[13] – that were specific to Cahokia; this dissertation presents evidence that shifts in the behavior of the Mississippi were important as well. Additional work, involving the collaboration of archaeologists and geoscientists, will be required to understand whether past shifts in flood regime were decisive or simply one factor among many that contributed to Cahokia's rise and fall.

In hindsight, Cahokia's story appears typical – human societies grow, thrive, and die – and yet, the cast of characters, plot, and setting of this story are always unique to a place. It is in these details that we can learn from history. What can we do to continue living in the same place for century after century, as the prehistoric inhabitants of the American Bottom did? How can we avoid succumbing to the inevitable environmental changes that await us? The ruins of once prosperous places continue to intrigue us, perhaps because they remind us of the ephemeral nature of our lives and social institutions; we ought to use this inherent fascination with history to learn from our past, and chart a more prosperous course for the future.

0.1 Notes

[1] For an introduction to Cahokia, see William Iseminger (2010) *Cahokia Mounds: America's First City* (The History Press); and Timothy Pauketat (2010) *Cahokia: Ancient America's great city on the Mississippi* (Penguin). For the more academically inclined, see George Milner (1998) *The Cahokia Chiefdom: The archaeology of a Mississippi society* (Smithsonian Institution Press); and Timothy Pauketat (2004) *Ancient Cahokia and the Mississippians* (Cambridge University Press).

[2] Population histories of Cahokia and the northern American Bottom differ in their estimates of peak population size, but generally agree on a general timeline of growth (ca. A.D. 1000–A.D. 1200) and decline (ca. A.D. 1200–A.D. 1400); for more information see Timothy Pauketat and Neil Lopinot (1997) Cahokian population dynamics in *Cahokia: Domination and Ideology in the Mississippian World* (edited by T.R. Pauketat and T.E. Emerson, University of Nebraska Press, pp. 103-123); and Milner (1998) The Cahokia Chiefdom.

[3] For a few notable exceptions where paleoenvironmental data have been integrated with North American archaeology, see P.A. Delcourt *et al.* (1986) Holocene ethnobotanical and paleoecological record of human impact on vegetation in the Little Tennessee River Valley, Tennessee, *Quaternary Research* 25: 330-349; K.K. McLauchlan (2002) Plant cultivation and forest clearance by prehistoric North Americans: pollen evidence from Fort Ancient, Ohio, USA, *The Holocene* 13: 557-566; and other examples described in Chapter 1 of this dissertation.

[4] As part of her dissertation, *Changing landscapes in the American Bottom (USA): An interdisciplinary investigation with an emphasis on the late-prehistoric and early-historic periods* (1993, University of Minnesota), Amy Ollendorf collected sediment cores from several floodplain lakes in the Cahokia region, illustrating and discussing many of the challenges associated with paleoenvironmental research in floodplains.

[5] See Neil H. Lopinot and William I. Woods (1993) Wood overexploitation and the collapse of Cahokia, in *Foraging and farming in the Eastern Woodlands* (edited by E.M. Scarry, University of Florida Press, pp. 206-231); and Woods (2004) Population nucleation, intensive agriculture, and environmental degradation: The Cahokia example, *Agriculture and Human Values* 21: 255-261.

[6] For discussions of Native American impacts on the environment, see William Denevan (1992) The Pristine Myth: The landscape of the Americas in 1492, *Annals of the Association of American Geographers* 82(3): 369-385; Thomas Vale (2002) The pre-European landscape of the United States: pristine or humanized? in *Fire, native peoples, and the natural landscape* (edited by T.R. Vale, Island Press, pp. 1-40); and Shepard Krech III (2000) *The Ecological Indian: Myth and History* (Norton & Co.). This topic is covered in great length in Chapter 1 of this dissertation.

[7] See discussions on the emergence of agriculture and niche construction by David Rindos (1980) Symbiosis, instability, and the origins and spread of agriculture: A new model and niche construction, *Current Anthropology* 21(6): 751-772; and Bruce Smith (2007) Niche construction and the behavioral context of plant and animal domestication, *Evolutionary Anthropology* 16: 188-199.

[8] See David Baerreis and Reid Bryson (1965) Climatic episodes and the dating of the Mississippian cultures, *The Wisconsin Archaeologist* 46(4): 203-220; Bryson and Barreis (1968) Climatic change and the Mill Creek culture of Iowa, *Journal of the Iowa Archaeological Society* 15-16: 107-191; Wayne Wendland and Bryson (1974) Dating climatic episodes of the Holocene, *Quaternary Research* 4(1): 9-14; Baerreis, Bryson, and John Kutzbach (1976) Climate and culture in the western Great Lakes region, *Midcontinental Journal of Archaeology* 1(1): 39-57.

[9] For recent work describing the complexities of human-climate-environment interactions, see Karl Butzer (2012) Collapse, environment, and society, *Proceedings of the National Academy of Sciences* 109(10): 3632-3639; Guy Middleton (2012) Nothing lasts forever: environmental discourses on the collapse of past societies, *Journal of Archaeological Research* 20(3): 257-307.

[10] Dendroclimatology, the use of tree-rings to reconstruct past climates, has been a key contributor to our current understanding of Holocene climate variability. For North American examples, see Edward R. Cook et al. (2004) Long-term aridity changes in the western United States, *Science* 306(5698): 1015-1018; Cook et al. (2007) North American drought: Reconstructions, causes, and consequences, *Earth Science Reviews* 81(1-2): 93-134. Cook's gridded network of soil moisture developed from tree-rings has also been used to examine the role of drought in the emergence and decline of Cahokia: see Larry V. Benson, Timothy R. Pauketat, and Edward R. Cook (2009) Cahokia's boom and bust in the context of climate change, *American Antiquity* 74(3): 467-483.

[11] See Milner (1998) *The Cahokia Chiefdom,* and Chapter 4 of this dissertation for descriptions of historical Mississippi River floods in the Cahokia region.

[12] See James Knox (1993) Large increases in flood magnitude in response to modest changes in climate, *Nature* 361: 430-432; and Knox (2000) Sensitivity of modern and Holocene floods to climate change, *Quaternary Science Reviews* 19(1-5), 439-457.

[13] For a summary of the multiple hypotheses proposed to explain Cahokia's abandonment, see John Kelly (2009) Contemplating Cahokia's collapse, in *Global Perspectives on the Collapse of Complex Systems* (edited by J.A. Railey and R.M. Reycraft, Maxwell Museum of Anthropology, Anthropological Papers No. 8, pp. 147-168).

Chapter 1: Defining the spatial patterns of historical land use associated with the indigenous societies of eastern North America

Note: This chapter was published as a synthesis article in *Journal of Biogeography*, Volume 41, Issue 12, Pages 2195-2210, and is accessible online at: http://onlinelibrary.wiley.com/doi/10.1111/jbi.12386/full. Co-authors of this chapter include David J. Mladenoff, Sissel Schroeder, and John W. Williams, who helped conceive ideas and provided comments on drafts of the manuscript. Slight modifications have been made to this version of the manuscript.

Abstract

Aim: To review and synthesize multiple lines of evidence that describe the spatial patterns of land use associated with prehistoric and early historical Native American societies in eastern North America in order to better characterize the type, spatial extent and temporal persistence of past land use.

Location: Temperate forests of eastern North America, and the Eastern Woodlands cultural region.

Methods: Ethnohistorical accounts, archaeological data, historical land surveys and palaeoecological records describing indigenous forms of silviculture and agriculture were evaluated across scales ranging from local (10^0 km) to regional (10^2 km) to produce a synthetic description of land-use characteristics.

Results: Indigenous land-use practices created patches of distinct ecological conditions within a heterogeneous mosaic of ecosystem types. At all scales, patch location was dynamic, and patches underwent recurrent periods of expansion, contraction and abandonment. Land-use patches varied in their extent and persistence, and are broadly categorized as silvicultural (management of undomesticated woodland taxa) or agricultural (cultivation of domesticated taxa). Silvicultural patches persisted for centuries and extended kilometres to tens of kilometres around settlements and travel corridors. The dynamics of agricultural patches varied among groups, with persistence ranging from decades to centuries and extent ranging from less than a kilometre to tens of kilometres around settlements. Beyond patch boundaries, human impacts on ecosystems become indistinguishable from other drivers of environmental heterogeneity. These characteristics of patches are evident across scales and multiple lines of evidence.

Main conclusions: Our findings challenge the view that prehistoric human impacts on vegetation were widespread and ubiquitous, and build on previous work showing these impacts to be more localized and heterogeneous by providing quantitative descriptions of land-use patch characteristics. Collaborative efforts that combine multiple data sources are needed to refine these descriptions and generate more precise measures of land-use pattern to further investigate the history of human impacts on the Earth system.

1.1 Introduction

In the Americas, where large regions were long considered void of major human modification prior to settlement by people of European descent (Denevan, 1992; Redman, 1999; Krech, 2000), land use associated with prehistoric and early historical indigenous societies has recently been the subject of intensified scholarly interest because of its significant influence on vegetation composition (Wagner, 2003; Hayashida, 2005; Anderson, 2006; Williams, 2008; Smith, 2009, 2011a; Ellis *et al.*, 2013), with related effects on disturbance regimes (Delcourt & Delcourt, 1997; Keeley, 2002; Bush *et al.*, 2007), soils (Lehmann *et al.*, 2003; Glaser & Woods, 2004; Glaser, 2007), animal populations (Grayson, 2001; Barnosky *et al.*, 2004) and atmospheric chemistry (Dull *et al.*, 2010; Ruddiman, 2013). This perspective calls into question the concept of a natural baseline state of the environment (Cronon, 1996; Peacock, 1998), and has important implications for environmental policy, management, science and public education (Marquardt, 1994; Peacock, 1998; Willis *et al.*, 2004; Jackson & Hobbs, 2009). Substantial progress has been made in identifying the means by which Native American peoples modified ecosystems in prehistoric and early historical times (e.g. Denevan, 2000; Smith, 2011a), but the key challenge of characterizing the spatio-temporal patterns of land use associated with indigenous societies remains unresolved.

Although it is now widely recognized that the indigenous societies of the Americas affected ecosystems in a variety of ways to suit their economic needs (Peacock, 1998; Redman, 1999; Doolittle, 2000; Wagner, 2003; Anderson, 2006; Smith, 2009, 2011a), conflicting interpretations over the spatial pattern and extent of these activities remain. One perspective questions whether any ecosystems in the Americas escaped prehistoric human influences (Kay, 2002; Williams, 2002; Erickson, 2006; Abrams & Nowacki, 2008), arguing that indigenous management affected vegetation 'ubiquitously' (Abrams & Nowacki, 2008, p. 1134). Others have proposed that prehistoric Native American land use created a 'shifting mosaic' of managed areas (Hammett, 1992, p. 4), with different areas affected to varying degrees by human activities, and some areas exhibiting no discernible human impacts (Vale, 1998, 2002; Keeley, 2002; Bush & Silman, 2007;

Meine, 2008). These contrasting interpretations are often based on the extrapolation of data drawn from a narrow range of disciplinary perspectives, evaluated with little consideration of scale, and provide predominately qualitative descriptions of land-use patterns. Ultimately, coherent and quantitative evaluations of Native American land use have been hindered by the limitations of datasets generated by individual studies, together with the challenges of integrating and communicating data across disciplines.

The objective of this study is to evaluate patterns of indigenous land use in the Eastern Woodlands of North America. To achieve this, we use a synthetic approach that integrates ethnohistorical, archaeological and palaeoecological data, examining data sources in terms of spatio-temporal pattern and scale. We employ a conceptual model that views all forms of land use as producing ecologically distinct patches within a heterogeneous mosaic of ecosystem types. Within this framework, we review the evidence of indigenous land use to determine the pattern, extent, and longevity of these patches. The evidence of Native American land use is first evaluated at local to landscape scales to examine the variability of patch characteristics within areas of the Eastern Woodlands, followed by an evaluation of Late Prehistoric land-use patterns across the entire region.

1.1.1 Environmental and cultural context

This paper focuses on the cultural region of eastern North America designated as the Eastern Woodlands, encompassing the area bounded by the Great Lakes–St Lawrence River basin to the north, the Atlantic Ocean and Gulf of Mexico to the east and south, and the Mississippi River valley and Great Plains to the west (Wiley, 1966; Figure 1.1). Among archaeologists, the prehistory of the Eastern Woodlands is commonly divided into four major traditions based on changes in material culture: the Palaeo-Indian tradition (c. 10,000–8000 bc) during the late Pleistocene; the Archaic tradition (c. 8000–1000 bc) in the early and mid-Holocene; and the Woodland tradition (c. 1000 bc to ad 1500), followed by various regionally specific Late Prehistoric traditions (c. ad 1000–1500) including the Mississippian tradition (c. ad 1000–1500) in the late Holocene (Smith, 1986; Steponaitis, 1986; Milner, 2004).

The subsistence strategies, cultural traditions and ecosystems of eastern North America have undergone substantial and recurrent change since settlement of the region began towards the end of the Pleistocene. The earliest inhabitants of the Eastern Woodlands, part of the Palaeo-Indian cultural tradition, were highly mobile foragers in pursuit of mammals, fish and wild plant foods (Anderson, 2012). During the abrupt climatic changes associated with the Pleistocene–Holocene transition, plant species migrated individualistically, many large mammals were extirpated, and the Palaeo-Indian cultural tradition was supplanted by seasonally mobile subsistence strategies associated with the Archaic cultural tradition (Meltzer & Smith, 1986; Williams *et al.*, 2004; Barnosky *et al.*, 2004). Archaic peoples exploited a variety of wild resources, developing or adopting tools (e.g. fishing weirs and hooks; grinding stones) that sought to maximize the yields of undomesticated foods (Smith, 1986; Styles & McMillan, 2009). Although many of these foraging practices continued to be important throughout the Eastern Woodlands, Archaic peoples in and around the floodplains of the central Mississippi River and its tributaries throughout the Midcontinent domesticated several species of starchy- and oily-seed bearing annuals, including squash (Cucurbita pepo), goosefoot (Chenopodium berlandieri), marsh-elder (Iva annua) and sunflower (Helianthus annuus) (Conard, *et al.*, 1984; Smith, 1984, 1987, 2006, 2011b; Crites, 1993; Smith & Cowan, 2003; Smith & Yarnell, 2009). These domesticated plants were differentially integrated into the seasonally mobile subsistence strategies of Archaic peoples living in the Midwest and Midsouth, and became increasingly important resources for people of the Woodland cultural tradition in these areas as they began to pursue more sedentary ways of life (Fritz, 1990, 2000; Simon, 2000; Smith & Cowan, 2003; Smith, 2011b). Subsistence strategies across the Eastern Woodlands continued to evolve in response to technological innovations (e.g. Braun 1983; Buikstra *et al.*, 1987) and environmental changes (e.g. Anderson, 2001; Munoz *et al.*, 2010). Outside the Midwest and Midsouth, people were less dependent on domesticated plant foods until after c. 1000 ad (Crawford & Smith, 2003), when maize (Zea mays) was adopted as a dietary staple for sedentary people and a supplementary resource for seasonally mobile people (Kellner & Schoeninger, 2007; Chilton, 2012). The Late Prehistoric period ended in the 16th and 17th centuries ad with the sustained presence of European explorers and settlers, together with the introduction of new technologies and plant and animal species to the Eastern Woodlands, resulting in pronounced ecological changes together with population declines and social upheaval among Native American groups (Crosby, 1972; Thornton, 1997; Ubelaker, 1988, 2006).

Given the many subsistence strategies that emerged during prehistory in the Eastern Woodlands, and the great variety of cultural practices that evolved, it follows that land-use practices were similarly diverse and dynamic. Despite this inherent complexity, all land-use practices can be united under the niche-construction concept, in which humans and other organisms alter their environment to improve the availability and/or predictability of desired resources (Odling-Smee *et al.*, 2003). Through continued and mutually reinforcing interactions, niche construction may produce changes in individual organisms, social organization and human culture (Laland *et al.*, 2001; Kendal *et al.*, 2011; Smith, 2011a), and is seen as an important process in domestication and the evolution of food production (Smith, 2007, 2009). In the prehistoric Eastern Woodlands, many forms of niche construction were practiced, organized here into two broad categories: (1) silviculture – the management of undomesticated woodland resources to improve foraging and hunting; and (2) agriculture – the cultivation of domesticated plants in areas cleared of wild vegetation communities.

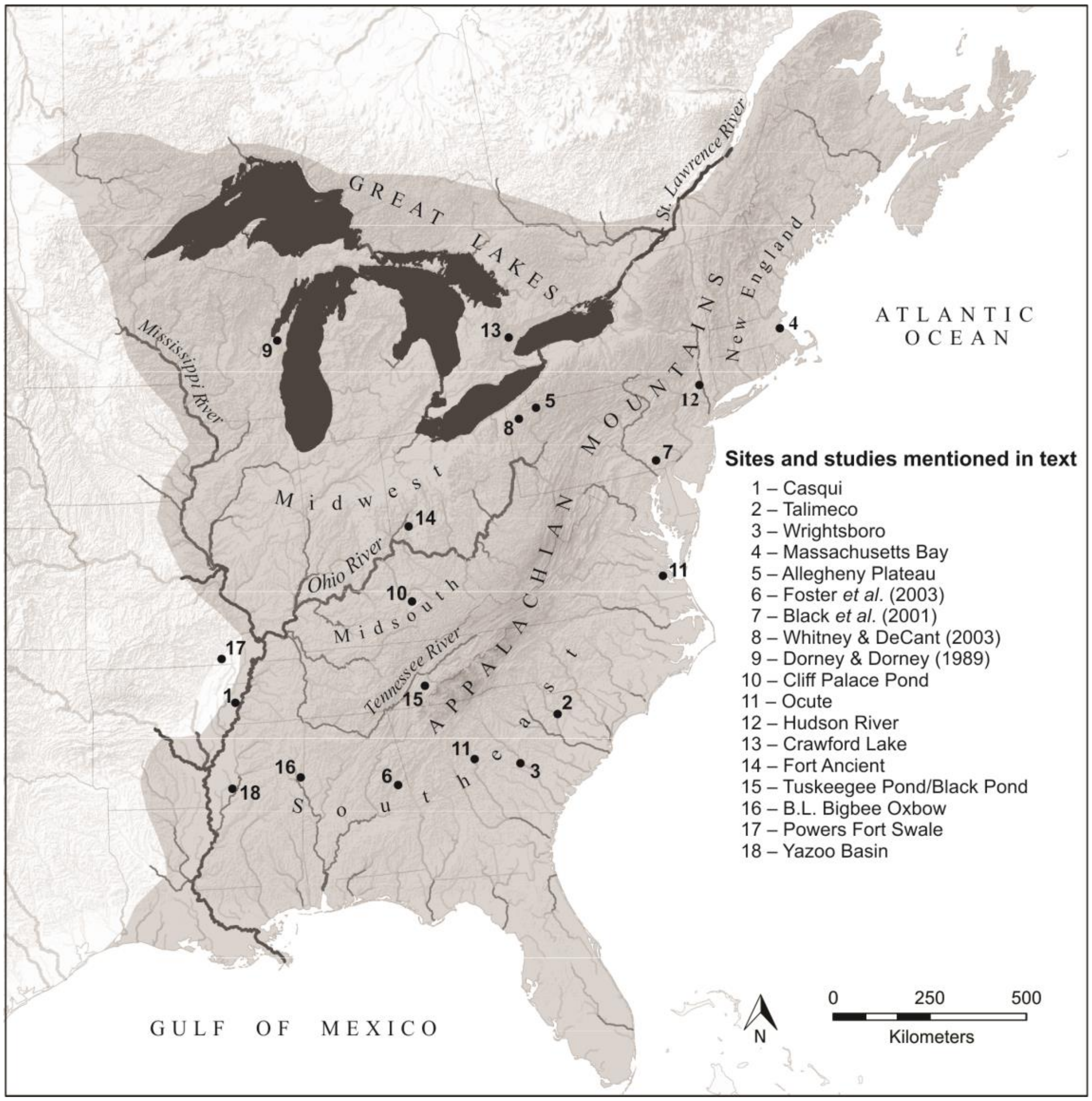

Figure 1.1: The Eastern Woodlands cultural region (shaded area) in North America (Wiley, 1966), overlain by sites and studies mentioned in this chapter.

1.2 Theory and Methodology

1.2.1 Land use as patches: a conceptual model

All features created by anthropogenic activity exhibit non-random and clustered spatio-temporal distributions, because the decision to modify an ecosystem for economic gain – to practice land use – is shaped by a suite of interconnected and unevenly distributed sociocultural and environmental factors (Meyer & Turner, 1994). On the sociocultural side, a group's size, subsistence strategy, technological capabilities, cultural values and relationships with neighbouring groups shape its decisions of where and how to focus land-use efforts. Land-use decisions are also shaped by environmental factors, including an area's climate, relief, biota, soils and hydrology, which influence the distribution or potential distribution of desired resources. In locations where both sociocultural and environmental factors align favourably, land use occurs, creating patches of distinct ecological conditions within a mosaic of ecosystem types (Godron & Forman, 1983; Forman, 1995). Gradients in the type and intensity of land use may create different and overlapping patch footprints (Wiens, 1995; McIntyre & Hobbs, 1999; Vale, 2002). Conceptualizing human modifications to the environment as patches makes no assumptions about patch size or distribution, but recognizes that land use is spatially clustered and temporally dynamic.

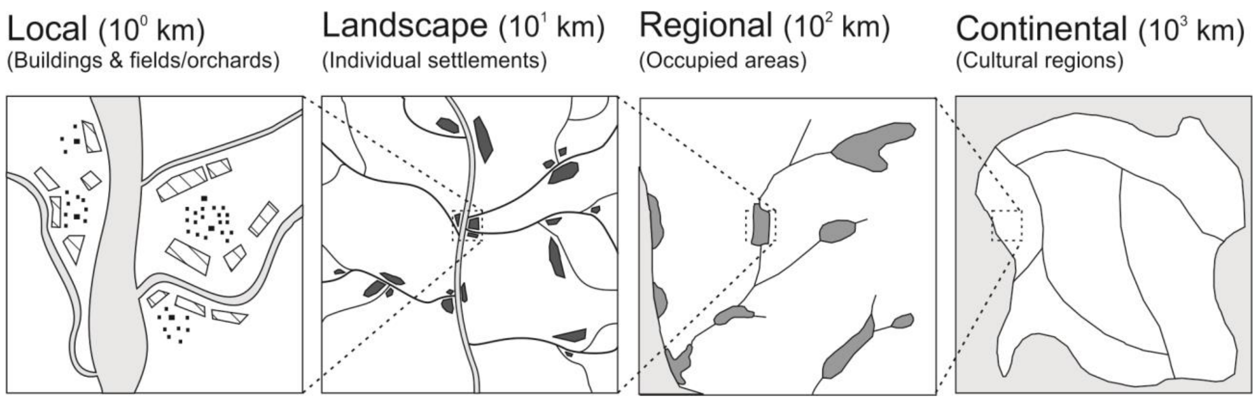

Figure 1.2: Conceptual model of land-use patches at local, landscape, regional and continental scales of analysis, adapted from Forman (1995). Patterns at finer scales exhibit dependence on those at coarser scales, and vice versa.

Patches associated with anthropogenic activity persist across scales and exhibit a scale-based nested hierarchy in which patterns at coarser scales are dependent on those at finer scales and vice versa (Figure 1.2; Wiens, 1989; Wu, 2004). At local spatial scales (on the order of kilometres), smaller extent and higher resolution allow for the differentiation of distinct patch types, including individual buildings, fields, orchards and other components of a settlement. With the larger extent and lower resolution at coarser spatial scales, patches may be aggregated to reflect individual settlements at the landscape scale (on the order of tens of kilometres), and broadly occupied areas at the regional scale (on the order of hundreds of kilometres). At continental scales (on the order of thousands of kilometres), patches demarcate broad cultural regions of similar subsistence strategies and environmental conditions. Patches are also dynamic across temporal scales, varying in their function and intensity of use, and shifting their location, pattern and size over time (Wu & Loucks, 1995; Forman, 1995). Abandoned patches gradually take on the characteristics of the surrounding mosaic elements, although land-use legacies – especially in agricultural settings where soil properties are heavily modified – may persist for centuries (Richter & Markewitz, 2001; Foster *et al.*, 2003a). The patch concept has been widely used to describe spatio-temporal patterns of environmental systems shaped by natural and cultural factors in prehistoric, historical and contemporary settings (e.g. Delcourt & Delcourt, 1988; Hammett, 1992; Medley *et al.*, 1995; Girvetz *et al.*, 2008), and provides a flexible conceptual model to illustrate the spatio-temporal patterns of land use associated with indigenous societies of the Eastern Woodlands.

1.2.2 Data sources

Multiple sources of data are available for reconstructing indigenous land use in eastern North America, each of which draws upon a distinct disciplinary perspective and represents a different range of spatial and temporal scales (Figure 1.3). Here, we group these data sources into four categories: (1) ethnohistorical, the documentation of land-use practices using written descriptions and interviews; (2) archaeological, the use of cultural, biological or geochemical remains accumulated in anthropogenic features; (3) historical land surveys, the documentation of vegetation and other environmental features using written descriptions and systematic measurements; and (4) palaeoecological, the use of fossil biological or geochemical remains preserved in sedimentary deposits, including wetlands, lakes and caves. The first two categories, ethnohistorical and archaeological data sources, are anthropocentric and focused primarily on sociocultural processes, and are more commonly employed by the social sciences (e.g. Doolittle, 2000; Smith, 2011a); in contrast, the latter two categories – palaeoecological data and historical land surveys – are envirocentric in that they focus primarily on environmental processes, and are more commonly employed by the environmental sciences (e.g. Foster *et al.*, 1998; Bush & Silman, 2007; Munoz & Gajewski, 2010). Integrating both anthropocentric and envirocentric data sources enables a more comprehensive description of human activities and their impacts on ecosystems.

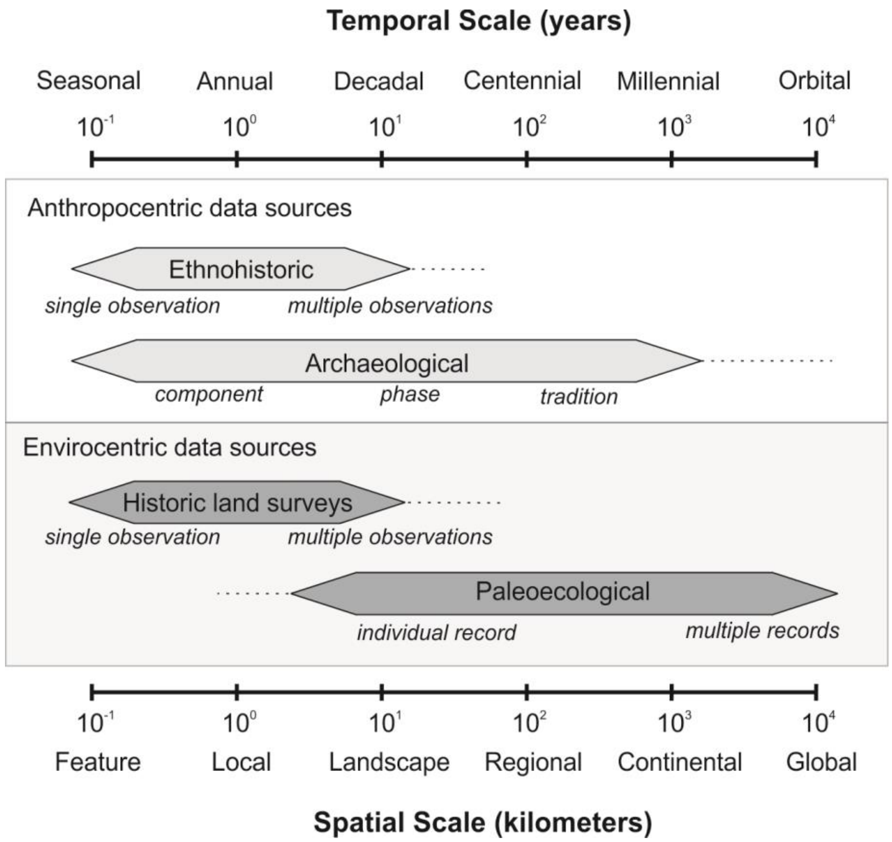

Figure 1.3: Summary of the lines of evidence available for studying past land use in eastern North America, organized into anthropocentric (ethnohistorical accounts and archaeological data) and envirocentric (historical land surveys and palaeoecological records) perspectives, showing the inherent spatio-temporal range provided by each data source.

The data sources describing past land use also provide information at different spatio-temporal scales, with differing potential for aggregating data across scales (Figure 1.3). Both ethnohistorical data and historical land surveys are limited to the period following initial European contact, bear the biases and motivations of the observer, and, except for the earliest records, reflect conditions after the introduction of European technologies and trade and the substantial but variable demographic consequences of contact (Crosby, 1976; Denevan, 1976; Smith, 1987; Thornton, 1997; Ubelaker, 1988, 2006). Despite these shortcomings, individual observations often document processes occurring at very fine spatial and temporal scales, providing details that are not available from other data sources. Historical land-survey points are often aggregated to document vegetation patterns up to the landscape scale, but in many cases, the most detailed ethnohistorical observations were carried out in a non-systematic way, limiting the ease with which individual statements can be combined to document processes that occur at coarser scales. Ethnohistorical accounts are, however, interpreted with more confidence when multiple observations converge to describe similar patterns and processes (Russell, 1997).

Archaeological and palaeoecological data sources extend information on land use over decades to millennia, and describe land-use patterns at coarser spatio-temporal scales (Figure 1.3). Archaeological data are collected and analysed in a hierarchical system that provides information across multiple spatial and temporal scales. Individual components within a site describe properties at local and finer scales, but components can be aggregated to delineate phases existing at coarser scales, and phases can be aggregated into still broader cultural traditions (Stoltman, 1978; Lock & Molyneaux, 2006). The interpretation of archaeological data is complicated by the differential preservation and use of materials, the effects of non-random human selection, long-distance trade and other formation processes (Schiffer, 1972, 1983; Hastorf & Popper, 1988). Palaeoecological data provide continuous records of environmental change over decadal to millennial scales, and past land use is inferred through shifts in the abundances of indicator taxa, geochemical properties and other proxies (e.g. McAndrews, 1988; Lane *et al.*, 2008; Smol, 2008). Palaeoecological records are limited to locations with undisturbed sedimentary deposits; the aggregation of multiple records can be used to evaluate patterns of environmental change at coarser scales.

In the following sections, we draw on ethnohistorical accounts, historical land surveys, archaeological data and palaeoecological records to understand the spatio-temporal characteristics of silvicultural and agricultural patches at local to landscape scales. We then evaluate the aggregated archaeological data to infer land-use patterns at regional to continental scales for the Late Prehistoric period.

1.3 Results and discussion

1.3.1 Local and landscape scales

1.3.1.1 Silviculture

Ethnohistorical accounts provide many descriptions of Native American settlements and their management of forests in order to improve foraging and hunting. For example, in the early 16th century, Pedro Mártir de Anglería noted that the inhabitants of the coastal Southeast 'cultivate orchards' in which they 'cultivate trees ... one that is called the corito ... The other is called guacomine' that were, most likely, persimmons (Diospyros virginiana) and plums (Prunus spp.) (Doolittle, 2000, p. 63). A few decades later, Hernando de Soto's expedition (ad 1539–1542) into the Southeast frequently marched for days between encounters with Native American settlements, like Casqui in eastern Arkansas (Hudson, 1997), where they found that 'in the open fields were many walnut trees' (Gentleman of Elvas, 1993, p. 114). Earlier in their expedition, de Soto's men gathered fruit as they 'journeyed a full league in a garden-like land where there were many trees, both those which bore fruit and others' (Varner & Varner, 1951, p. 314) shortly before encountering the town of Talimeco in South Carolina (Hudson *et al.*, 1985). Writing over two centuries later, the naturalist William Bartram provided greater taxonomic detail in his description of abandoned Native American settlements and fields near Wrightsboro, Georgia:

> I observed, in the ancient cultivated fields, 1. diospyros (persimmon), 2. gleditsia triacanthos (honey locust), 3. prunus chicasaw (Chickasaw plum), 4. callicarpa (beauty berry), 5. morus rubra (red mulberry), 6. juglans exalta (hickory), 7. juglans nigra (black walnut), which inform us, that these trees were cultivated by the ancients, on account of their fruit, as being wholesome and nourishing food.
>
> (Bartram, 1973, p. 38)

The proximity of these nut- and fruit-bearing woody plants, and other early- and mid-successional taxa, to Native American settlements increased the availability and predictability of these resources, but also served to attract game and improve hunting. The practice of managing forests for hunting is frequently described in ethnohistorical accounts, where fire was used by Native American groups to encourage new browse, remove understory growth to facilitate travel while hunting, and drive game (Day, 1953; Waselkov, 1978; Pyne, 1982; Russell, 1983; Patterson & Sassaman, 1988; Hammett, 1992). Deliberate burning for hunting is described by, among others, the 17th-century Massachusetts Bay colonist William Wood, who states that

> ...it being the custom of the Indians to burn the wood in November when the grass is withered and leaves dried, it consumes all the underwood and rubbish which otherwise would overgrow the country, making it unpassable, and spoil their much affected hunting; so that by this means in those places where the Indians inhabit there is scarce a bush or bramble or any cumbersome underwood to be seen in the more champion ground.
>
> (Wood, 1977, p. 38)

Based on these and other ethnohistorical accounts discussed extensively in Doolittle (2000) and elsewhere (Day, 1953; Russell, 1983; Hammett, 1992), we can conclude that as a result of forest management, a variety of economically beneficial plants and animals were often found in greater abundance near Native American settlements than in the surrounding landscape, and that these stands of managed forests were created, managed and maintained by pruning, planting and protecting desired trees, and by burning the forest understory. Individual ethnohistorical accounts of Native American silviculture provide qualitative descriptions of managed forests at local spatial scales, and additional data sources must be used to assess the extent of silviculture at coarser scales.

Historical land surveys, including the original Public Land Survey commissioned by the US General Land Office in the 19th century (Schulte & Mladenoff, 2001), bear the imprint of late prehistoric and early historical Native American silviculture at local to landscape scales. For example, Black *et al.* (2006) used detrended correspondence analysis on witness-tree data from the Allegheny Plateau of north-western Pennsylvania to show that the early historical forest could be separated into two groups: (1) a patch of an oak–hickory–chestnut community centred 5–20 km on Native American settlements; and (2) stands of beech–maple–hemlock forest in the unoccupied hinterland (Figure 1.4). To demonstrate that this pattern was associated with Native American silviculture, Black *et al.* (2006) used a logistic regression to find that, among a number of physiographical variables, proximity to Native American settlements was the strongest predictor of the oak–hickory–chestnut community. Similar patches of anomalous forest composition have been detected in historical land surveys from other areas and associated with the presence of Native American settlements, including eastern Alabama (Foster *et al.*, 2003b), south-eastern Pennsylvania (Black & Abrams, 2001), north-western Pennsylvania (Whitney & DeCant, 2003) and north-eastern Wisconsin (Dorney & Dorney, 1989). In all these cases, the patches of managed forest are on the order of kilometres to tens of kilometres in extent, and are concentrated near Native American settlements within a heterogeneous mosaic of unmanaged ecosystem types.

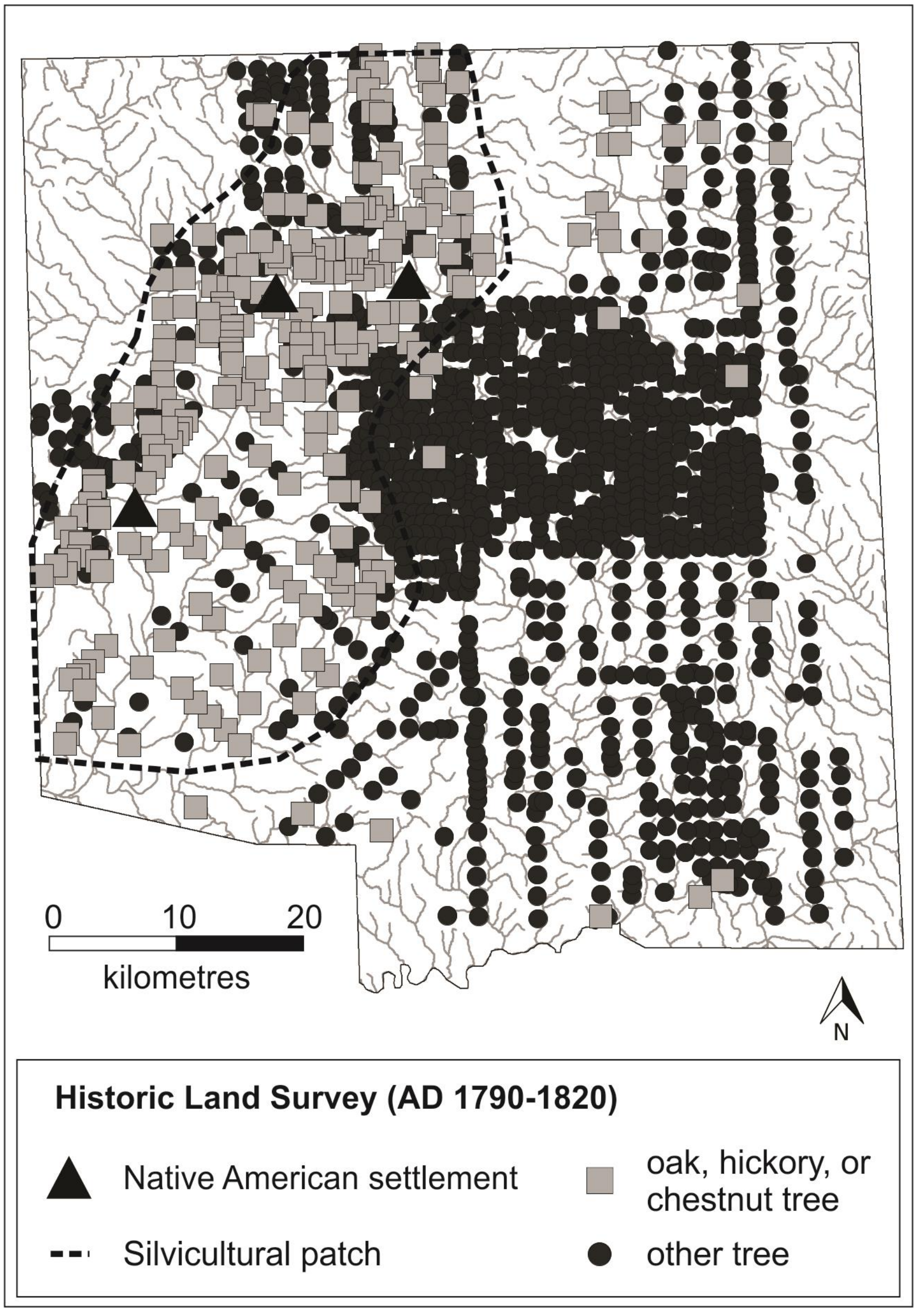

Figure 1.4: The historical distribution of trees c. AD 1790–1820 derived from original warrant maps, in relation to Native American settlements in the Allegheny Plateau of north-western Pennsylvania (adapted from Black et al., 2006). Clustering of mast-bearing trees (oak, hickory, and chestnut) delineate a silvicultural patch extending 5-20 km around three Native American settlements.

Although ethnohistorical accounts and land surveys provide strong evidence of indigenous silvicultural patches persisting into the early historical period, tracking patterns of silviculture in prehistoric contexts using archaeological or palaeoecological data has proven more challenging. Large caches of nut-shell fragments in archaeological contexts are sometimes thought to reflect silvicultural management (Gardner, 1997; Simon, 2000), particularly when historical vegetation communities around the site do not include high abundances of mast-bearing taxa (e.g. Asch & Asch, 1985, 1986). Ethnobotanical assemblages may, however, also reflect trade, differential preservation or vegetation changes unrelated to human management, and provide little sense of silvicultural patch size. Palaeoecological records have also presented little definitive evidence of prehistoric silviculture, due in part to the difficulty of establishing human causality from isolated records in the absence of domesticated taxa. For example, a record of pollen and charcoal from Cliff Palace Pond in eastern Kentucky displays a shift towards fire-tolerant mast-bearing taxa and increased burning beginning around 1000 bc that Delcourt *et al.* (1998) associate with silvicultural activity by Late Archaic and Woodland peoples. Although these ecological changes are consistent with ethnobotanical assemblages from nearby rock-shelters, it is difficult to determine from a single record whether they resulted from land use or other non-human factors (e.g. aridity or pathogenic outbreak). Other palaeoecological studies that attempt to track prehistoric forest management (Delcourt & Delcourt, 1998, Clark & Royall, 1995) face similar challenges, because patterns of biomass-burning at regional to continental scales tend to reflect broad climatic trends (Clark & Royall, 1996; Parshall & Foster, 2002; Marlon *et al.*, 2013) and changes in forest composition often result from the interaction of multiple drivers (McEwan *et al.*, 2011). Ethnohistorical accounts and historical land surveys provide clear evidence of localized silvicultural patches during the early historical period, but the paucity of integrated archaeological and palaeoecological studies limits our ability to track the evolution of silvicultural patches over the prehistoric period; additional studies that pair multiple data sources to compare forest composition in occupied and unoccupied areas within a landscape are needed to better understand the distribution and dynamics of silvicultural patches in the prehistoric period.

1.3.1.2 Agriculture

The indigenous cultivation of domesticated annuals in small domestic gardens and larger out-fields is described in many ethnohistorical accounts from across the Eastern Woodlands, and in some cases these accounts provide information on the location and size of fields, as well as specific agricultural practices. For example, in Hernando de Soto's expedition in the early 16th century encountered 'very good fields along the margins of rivers' (Gentleman of Elvas, 1993, p. 168) near the town of Octue in east-central Georgia (Hudson, 1997), and later 'marched two days through the country of Casqui ..., the greater part of the way lying through fields' (Gentleman of Elvas, 1993, p. 114). Further north, exploring the Hudson River valley in eastern New York in the early 16th century, da Verrazzano noted that 'fields are from XXV to XXX leagues wide' (da Verrazzano, 1910, pp. 192–193), and along the St Lawrence River, Cartier (1906, p. 59) found 'goodly and large fieldes, full of such corne as the countrie yeeldieth'. When considering field preparation, ethnohistorical accounts describe felling trees by girdling, cutting with stone axes, and burning trunks, branches and exposed roots; once established, fields were maintained by weeding, tilling and, at times, left to fallow (Doolittle, 2000). Additional ethnohistorical accounts are discussed at length elsewhere (Woods, 1987; Doolittle, 1992, 2000, 2004; Schroeder, 1999, 2001; Gartner, 2003), but these examples suffice to draw several general conclusions about Native American agriculture in the Eastern Woodlands: (1) fields were at times quite extensive – on the order of square kilometres in size – although these accounts are likely to be biased towards unusually large fields, and it is unclear whether ethnographic descriptions represent single fields or mosaics of multiple fields; and (2) fields were concentrated near settlements and travel corridors, particularly rivers and streams.

Beyond these regional generalizations, however, the ways in which agriculture was integrated into the economies of Native American groups varied substantially within the Eastern Woodlands, with differences in the duration, placement, intensity and extent of agricultural fields (Fritz, 1990, 2000; Simon, 2000; Schroeder, 2001; Gremillion, 2011). Around the lower Great Lakes, for example, archaeological evidence demonstrates that proto-Iroquoian groups began cultivating maize along with other domesticates after c. ad 1000 and, over the following centuries, these groups settled in palisaded villages on loamy upland soils adjacent to small streams and rivers (Figure 1.5; Sykes, 1980; Finlayson, 1998; Warrick, 2000). Archaeological evidence, bone chemistry and ethnohistorical accounts indicate that agricultural products, particularly maize, constituted a significant portion of the Iroquoian diet, and that forest clearances were established around settlements and expanded until the settlement was relocated after a few decades (Heidenreich, 1971; Warrick, 2000; Kellner & Schoeninger, 2007). A palaeoecological record from Crawford Lake in southern Ontario found pollen from domesticates, including maize, sunflower and squash (Cucurbita pepo), together with evidence of forest clearance manifested as declines in beech (Fagus grandifolia) and sugar maple (Acer saccharum) over a period of c. 300 years beginning in the 14th century ad (McAndrews & Boyko-

Diakonow, 1989), and subsequent archaeological excavations have revealed the presence of several contemporaneous Iroquoian villages within 5 km of Crawford Lake (Figure 1.5a; Finlayson, 1998). A re-analysis of fossil pollen and charcoal from Crawford Lake at a higher temporal resolution by Byrne & Finlayson (1998) identified eight distinct periods of forest clearance caused by the establishment, abandonment and relocation of Iroquoian villages, each of which created agricultural patches that persisted for c. 20–40 years within the beech–maple forest matrix. At the landscape scale, an analysis by Munoz & Gajewski (2010) of pollen records previously collected from southern Ontario revealed that other records show similar episodes of prehistoric agricultural activity, but that Iroquoian activity was found exclusively in areas near Lake Ontario, Lake Simcoe and Georgian Bay where Iroquoian villages were located (Figure 1.5b). After Iroquoian villages and agricultural fields were abandoned, these pollen records show that cleared patches underwent secondary succession to be dominated by pine (Pinus spp.); even-aged stands of white pine (Pinus strobus) on the order of square kilometres in size that were recorded in historical land surveys have been shown to be associated with abandoned Iroquoian villages (Bowman, 1974; Marks & Gardescu, 1992; Finlayson *et al.*, 1998). In these ways, Iroquoian groups of the lower Great Lakes created agricultural patches within a beech–maple forest matrix that extended up to kilometres away from villages, but these patches were abandoned after a few decades and underwent a secondary succession characterized by stands of white pine that persisted into the historical period.

Patterns of agricultural land use differed from those of the lower Great Lakes in other areas of the Eastern Woodlands. In New England, for example, Algonquian-speaking groups also began cultivating maize and other crops after c. ad 1000, but unlike the Iroquoian groups of the lower Great Lakes, large nucleated villages were absent, seasonally mobile subsistence strategies remained common, and domesticates were not adopted as dietary staples until the historical period (Chilton, 2002, 2012; Hart & Means, 2002). At local scales, ethnohistorical accounts from New England provide numerous descriptions of agricultural land use by Algonquian-speaking groups (Bennett, 1955; Gookin, 1970; Barbour, 1986; Peterson & Cowie, 2002) but, despite numerous attempts, studies at the landscape scale using historical land surveys and palaeoecological records have provided little definitive evidence of Native American effects on vegetation or fire regimes in New England (e.g. Patterson & Sassaman, 1988; Fuller *et al.*, 1998; Parshall & Foster, 2002; Cogbill *et al.*, 2002; Foster *et al.*, 2004). Given the paucity of large nucleated villages in prehistoric New England, it is likely that the impacts of prehistoric agriculture in New England were highly localized, and that these agricultural patches were not extensive or persistent enough to be detected at coarser spatio-temporal scales.

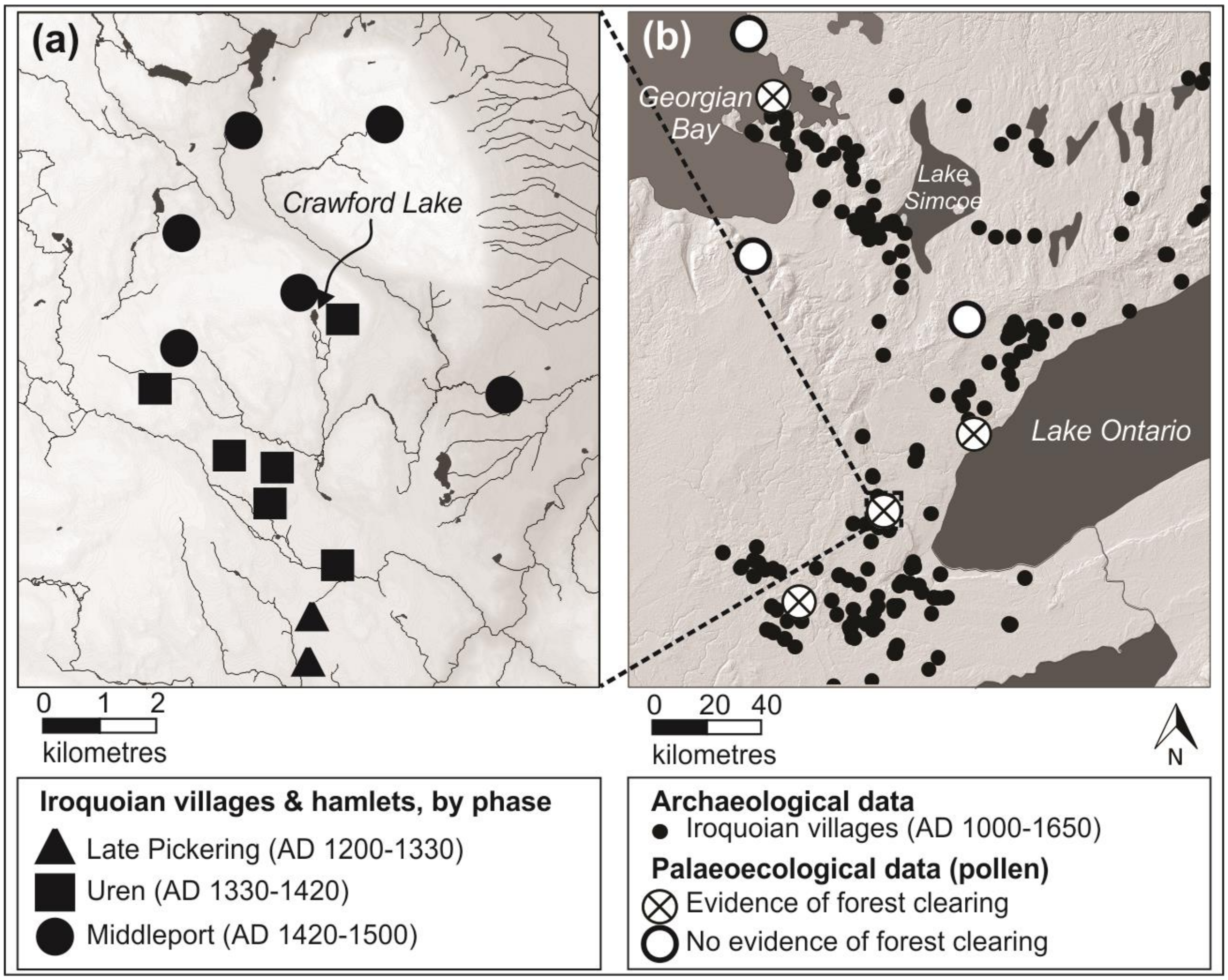

Figure 1.5: Patterns of Late Prehistoric agricultural land use in the lower Great Lakes at (a) local and (b) landscape scales. At the local scale, palaeoecological data from Crawford Lake records multiple episodes of agricultural patch generation and abandonment, with each patch persisting for 20–40 years as a result of Iroquoian village establishment around the lake (Byrne & Finlayson, 1998). At the landscape scale, both archaeological and palaeoecological data show that the distribution of Iroquoian villages is clustered, and that agricultural patches were embedded within a forested mosaic (Munoz & Gajewski, 2010). The locations of Iroquoian villages are adapted from Campbell (1991) and Finlayson (1998).

In contrast to the Northeast, agricultural land use began earlier in the lower Midwest, Midsouth and Southeast, with the domestication of indigenous seed crops beginning during the Late Archaic, followed by the intensification of food production during the Woodland period, and the emergence of large permanent settlements and the widespread cultivation of maize beginning after c. ad 800 (Simon, 2000; Smith & Cowan, 2003; Smith & Yarnell, 2009; Gremillion, 2011). The ethnobotanical assemblages of these areas attest to the cultivation of indigenous seed crops in both floodplain and upland contexts during the Archaic and Woodland periods, but floodplains had become the focal point of food production by the Late Prehistoric period (Fritz, 1990; Gremillion *et al.*, 2008; Smith, 2009). At local scales, palaeoecological records from small upland ponds at Fort Ancient in south-western Ohio (McLauchlan, 2003) and Cliff Palace Pond (Delcourt *et al.*, 1998) document the establishment of small clearings and horticultural activity during the Late Archaic and Woodland periods, with greatly diminished human impact in upland settings by the Late Prehistoric period. In contrast, the long-term expansion and intensification of agricultural land use in floodplains is evident in a palaeoecological record from Tuskegee Pond in eastern Tennessee, where pollen assemblages and wood charcoal assemblages track the deforestation of the floodplain over c. 1200 years, beginning in the Late Archaic period and progressing to extend kilometres up to higher floodplain terraces over the Woodland and Late Prehistoric periods (Delcourt *et al.*, 1986). Whereas prehistoric agriculture created a patchwork of active and abandoned clearings stretching tens of kilometres along the floodplain, an additional palaeoecological record from Black Pond, an upland sinkhole located just 4 km north of the floodplain, demonstrates that deforestation did not extend into the uplands until after Euro-American settlement (Delcourt *et al.*, 1986). Similar instances of prehistoric agricultural expansion and contraction progressing over centuries along sections of floodplain have been documented in other palaeoecological records from the Southeast, including B. L. Bigbee Oxbow in eastern Mississippi (Whitehead & Sheehan, 1985), Powers Fort Swale in southern Missouri (Royall *et al.*, 1991), and an oxbow lake in the Yazoo Basin of western Mississippi (Scharf, 2010). The available data thus indicate that the agricultural patches of the lower Midwest, Midsouth and Southeast were the most extensive and enduring of the Eastern Woodlands, with large out-fields that persisted for centuries, stretching up to tens of kilometres along floodplains.

In summary, multiple lines of evidence consistently indicate that at local to landscape scales, the land-use patches created by indigenous societies were diverse and dynamic, persisting for decades to centuries and extending kilometres to tens of kilometres around settlements into a mosaic of ecosystem types; beyond patch boundaries, indigenous land use becomes difficult to distinguish from other drivers of environmental heterogeneity.

1.3.2 Regional scale

At a regional scale that encompasses the Eastern Woodlands, patterns of shifting patches of occupation are apparent in the distribution of archaeological phases during the Late Prehistoric period (Figure 1.6; Anderson, 1991; see also Milner *et al.*, 2001). These aggregated archaeological data, compiled by Anderson (1991) with input from roughly 50 archaeologists, track the distributions of archaeological phases at four time periods: ad 900–1100, ad 1250–1300, ad 1400–1450 and ad 1540. For each time period, contributors to the dataset delineated (1) areas associated with distinct archaeological phases, some of which are hundreds of kilometres in extent, and, where possible, (2) areas of particularly high site density, typically tens of kilometres in extent. The resulting maps show that Late Prehistoric occupations were spatially clustered and temporally dynamic, and whereas some areas remained occupied throughout the Late Prehistoric period (e.g. the lower Mississippi River valley), others underwent periods of occupation and abandonment (e.g. the central Mississippi River valley). The patchy and dynamic character of occupied areas observed in these data at regional scales (Anderson, 1991; Milner *et al.*, 2001; Milner & Chaplin, 2010) mirrors the prehistoric settlement patterns observed at finer scales (e.g. Finlayson, 1998; Blitz, 1999; Cobb & Butler, 2002; Schroeder, 2004; Warrick, 2008) and is consistent with our assessment of land-use patterns at local to landscape scales. Although these aggregated archaeological data do not explicitly delineate areas of land use, actively managed areas presumably made up part of each occupied area, with differences in the type and intensity of land use among and within occupied areas. Ultimately, evaluating the area under agricultural and silvicultural management at broader scales will require additional integrated studies at local to landscape scales that focus on quantifying the size and persistence of land-use patches in a variety of contexts.

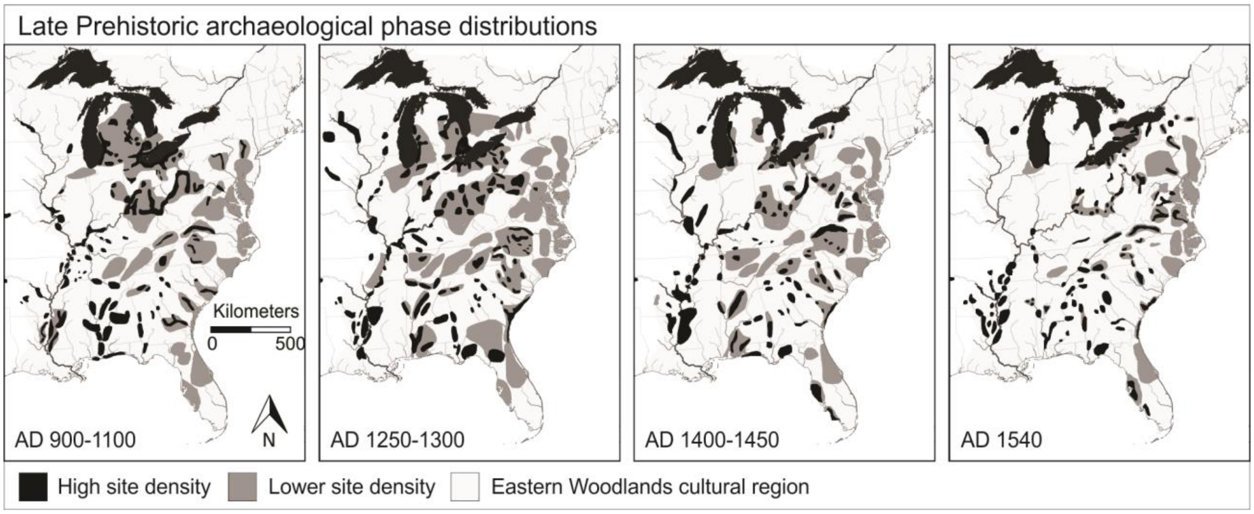

Figure 1.6: Late Prehistoric archaeological phase distributions for the Eastern Woodlands of North America showing areas of high and lower archaeological site density during four periods, compiled by Anderson (1991). The patchy and dynamic nature of occupations at the regional scale mirrors patterns of Native American land use at finer scales.

1.4 Conclusions

By using a synthetic approach that incorporates multiple data sources describing indigenous land use in the Eastern Woodlands of North America, and evaluating these data in terms of spatio-temporal pattern and scale, we can draw three major conclusions. First, indigenous land use created ecologically distinct patches within a heterogeneous mosaic of different ecosystem types. The patchiness of Native American land use persists across multiple scales of analysis. Land-use patches result from different forms of niche construction, and can be categorized broadly as silvicultural (management of undomesticated woodland resources) or agricultural (cultivation of domesticated taxa), with multiple subcategories possible. Second, land-use patches were temporally dynamic, expanding, contracting and shifting their locations over time. Silvicultural patches persisted for at least centuries and possibly longer. The persistence of agricultural patches ranged from decades to centuries, with the most persistent patches along floodplains in southern areas of the Eastern Woodlands. The ecological legacies of indigenous land use at times persisted into the historical period. Third, land-use patches extended as far as kilometres to tens of kilometres around settlements and travel corridors. Beyond this distance, indigenous land use becomes indistinguishable from other drivers of environmental heterogeneity. For those interested in maintaining historical landscapes, reconstructing past environments or using traditional knowledge to develop more sustainable forms of ecosystem management, Native

American land use should be conceptualized as generating discrete and dynamic patches within a heterogeneous landscape.

Our findings challenge the view that prehistoric land use affected vegetation ubiquitously at broad regional scales (e.g. Kay, 2002; Williams, 2002; Abrams & Nowacki, 2008), and instead builds on prior work that argues in favour of patchy, heterogeneous and more localized impacts (e.g. Vale, 1998, 2002; Bush & Silman, 2007; Meine, 2008). Further work is needed to better constrain measures of patch size and persistence. Integrative landscape-scale analyses, conducted in a variety of settings, could address the remaining questions of how patch properties, including its size, pattern, type and intensity of use, evolve over time. This paper has focused exclusively on the Eastern Woodlands of North America, but the synthetic approach and theoretical concepts described in this paper provide a framework to examine patterns of land use in other regions of the Americas with conflicting viewpoints over the scale of prehistoric human impacts.

1.5 Acknowledgments

We thank Bill Gartner, Jim Knox, Jenn Marlon, Curt Meine, Colin Mustaphi and Chad Zirbel for valuable discussion and/or comments on this manuscript; comments from Mark Bush and three anonymous referees greatly improved an earlier draft of the manuscript. This work was supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) through a Post-Graduate Scholarship (PGSD2-392407), the Wisconsin Alumni Research Foundation (WARF), and the National Science Foundation (NSF) through an Integrated Graduate Education and Research Traineeship (IGERT-1144752).

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Chapter 2: A record of sustained prehistoric and historical land use from the Cahokia region, Illinois, USA

Note: This chapter was published as a research article in *Geology* Volume 42, Issue 6, Pages 499-502, and is accessible online at: http://geology.gsapubs.org/content/42/6/499.short. Co-authors of this chapter include Sissel Schroeder, David Fike, and John W. Williams, who helped conceive ideas and provided comments on drafts of the manuscript. Slight modifications have been made to this version of the manuscript.

Abstract

In eastern North America, large prehistoric settlements were concentrated in and along the floodplains of the midcontinent, but few sedimentary records have been examined adjacent to these sites to evaluate the impacts of Native American land use on terrestrial ecosystems. Here, we report a high-resolution and multi-proxy paleoecological record from Horseshoe Lake, an oxbow lake in the central Mississippi River valley that is adjacent to Cahokia (Illinois, USA), the largest prehistoric settlement north of Mexico. Palynological and carbon isotope data document pronounced vegetation changes over the past 1700 yr driven primarily by land use, including 900 yr (A.D. 450–1350) of sustained prehistoric human impacts. Rapid forest clearance was followed closely by the proliferation of indigenous seed crops of the Eastern Agricultural Complex (EAC) beginning at ca. A.D. 450, centuries before the emergence of Cahokia at A.D. 1050. Agricultural intensification that included the use of maize (*Zea mays* subsp. *mays*) followed this initial clearance, with peak land use intensity between A.D. 900 and 1200. A large flood event at ca. A.D. 1200 marks the onset of agricultural contraction and Cahokia's decline. Reforestation follows the abandonment of the Cahokia region around A.D. 1350. The Horseshoe Lake record thus indicates that regional agricultural activity began abruptly at A.D. 450 and intensified over the Late Woodland period, well before the formation of Cahokia and other large prehistoric settlements. The evidence that a major flood coincided with the onset of Cahokia's decline is noteworthy, but will require corroboration from additional records.

2.1 Introduction

Land use is a major driver of change in the earth system (Foley *et al.*, 2005), but preindustrial land use and its impacts on terrestrial ecosystems and atmospheric chemistry remain important sources of uncertainty in earth system models and reconstructions of past environments (Ellis *et al.*, 2013; Ruddiman, 2013). In eastern North America, plant domestication began in the floodplains of the central Mississippi River valley and its tributaries during the mid-Holocene

(Smith and Yarnell, 2009), with major agricultural centers established centuries before Euro-American settlement (Milner, 2012). Documentation of land use patterns associated with the emergence of larger and more socio-politically complex Mississippian societies has been limited in part by a scarcity of paleovegetation records in floodplains, adjacent to large prehistoric settlements. As a result, global reconstructions of Holocene land use continue to estimate negligible cropland areas across prehistoric eastern North America (e.g., Kaplan *et al.*, 2011).

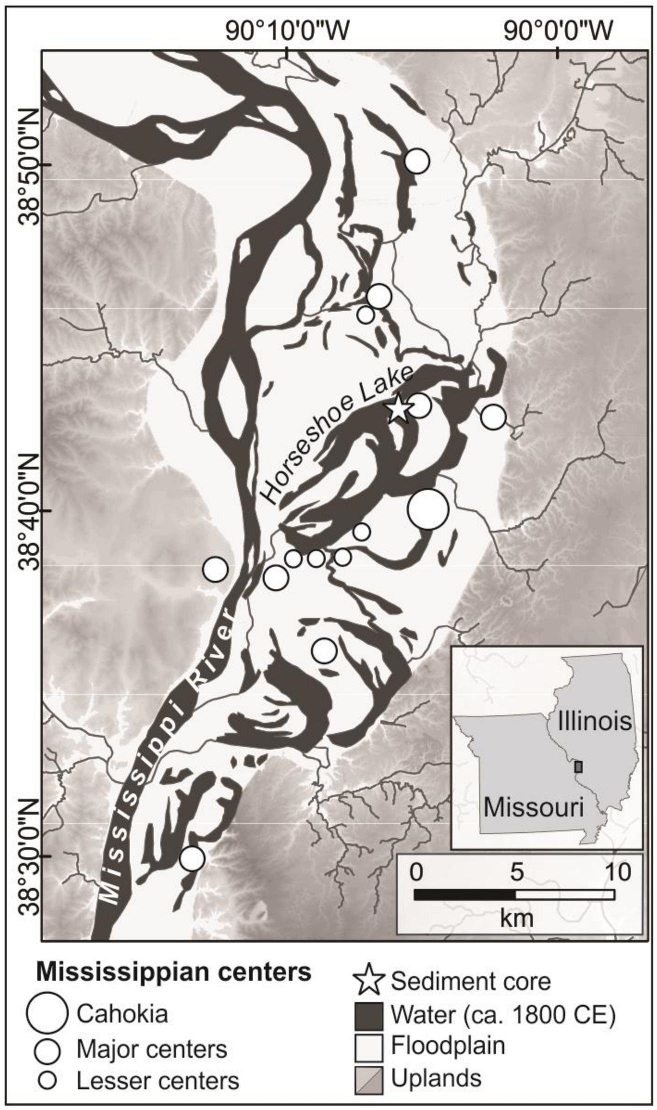

Figure 2.1: Map of study region in the central Mississippi River valley (central eastern United States), showing the locations of Horseshoe Lake core (star) and Mississippian population centers (after Pauketat and Lopinot, 1997); historical (ca. A.D. 1800) positions of the Mississippi River, floodplain lakes, and streams from Milner (1998).

Here, we report sedimentological data, fossil pollen abundances, and organic carbon isotope data from Horseshoe Lake, Illinois, USA (Figure 2.1), a large oxbow lake in the central Mississippi River valley, that describe land use patterns associated with the emergence and decline of Cahokia — the largest prehistoric settlement north of Mexico. Cahokia emerged as a major Mississippian political, cultural, and economic center at ca. A.D. 1050, but by the mid-12th century the cultural prominence and population size of Cahokia began to decline, and by A.D. 1350 Cahokia and the surrounding the region were almost completely abandoned (Milner, 1998). Prior archaeological assessments of land use in the Cahokia region have focused on changes in prehistoric resource use (e.g., Simon and Parker, 2006), and do not provide continuous or comprehensive records of vegetation changes spanning Cahokia's emergence, fluorescence, and decline. Previous paleoecological work in the Cahokia region by Ollendorf (1993) was hindered by few radiocarbon dates and low sampling resolution. We build on this previous work with high-resolution palynological sampling, physical sedimentology, a robust age model, and the inclusion of an additional paleovegetation proxy ($\delta^{13}C_{org}$) to develop a detailed reconstruction of land use and environmental change in the Cahokia region.

2.2 Material and Methods

Four sets of sediment cores were recovered from Horseshoe Lake in May 2012 using a modified Livingston piston corer; this paper focuses on the set of cores (4A, 4B, and 4C) recovered from the in-filled thalweg (90.081279°W, 38.704767°N, water depth 1.09 m) along the eastern channel of Horseshoe Lake (Figure 2.1). The primary core sections (4A), overlapping core sections (4B), and a surface-sediment section (4C), were used to create a continuous composite core based on stratigraphy and magnetic susceptibility (Figure 2.2). This composite core was sectioned at 1 cm intervals for geochemical and pollen analyses.

Sediment composition was determined using loss on ignition (Heiri *et al.*, 2001) to determine organic and inorganic carbon content, respectively. Carbon isotope ratios were measured from the organic carbon fraction at 2 cm resolution by first acidifying sub-samples with dilute acid (1M HCl) to remove carbonate minerals. Isotopic composition was then measured by combusting 1–10 mg of acid-insoluble residue in a Costech 4010 ECS elemental analyzer, and passing the evolved gas through a Thermo Scientific Delta V Plus mass spectrometer. Of 220 samples, 104 were measured at least twice, with an average reproducibility of 0.25‰ and values reported relative to the Vienna Peedee belemnite standard (VPDB). For pollen analysis, sub-samples at 8 cm resolution were prepared using standard techniques described by Faegri and Iversen (1989); a minimum of 300 terrestrial pollen grains were counted in each sample. Horseshoe Lake has a surface area of 8.0 ha, implying a pollen source radius for major taxa on the order of 10^3–10^5 m (Sugita, 1993) that encompasses Cahokia and its surrounding region.

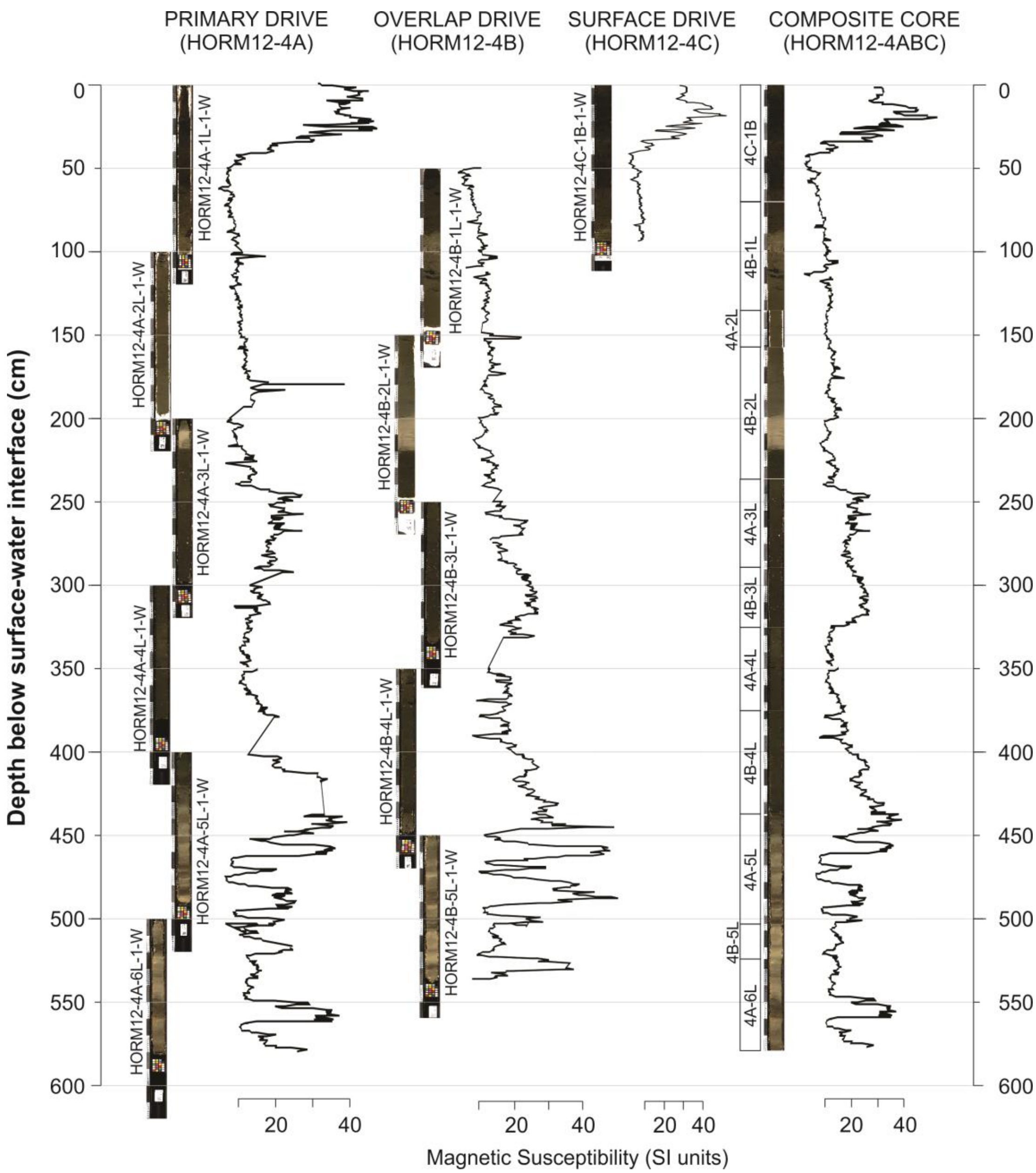

Figure 2.2: Core section names, images, and magnetic susceptibility from Horseshoe Lake (HORM12-A). Sections of the primary driver (4A), overlap drive (4B), and surface drive (4C) taken with a modified Livingston-Wright piston corer were used to create a continuous composite core (on right).

Table 2.1: ^{14}C AGES AND CALIBRATED DATES FROM HORSESHOE LAKE SEDIMENT COMPOSITE CORE (HORM12-4A, HORM12-4B, and HORM12-4C)

Lab number	Sample description	Depth (cm)	^{14}C Age*	Calibrated age (yr BCE/CE) †
UGAMS-13417	wood	111.5	400 ± 25	1439–1518 CE (0.867); 1594–1618 CE (0.133)
UGAMS-13418	wood	197.5	980 ± 40	992–1155 CE (1.000)
UGAMS-14454	wood	225	800 ± 20	1212–1269 CE (1.000)
UGAMS-13419	wood	254.5	1220 ± 25	695–701 CE (0.011); 709–745 CE (0.168); 764–886 CE (0.822)
UGAMS-15039	charcoal	256.5	990 ± 25	991–1050 CE (0.676); 1083–1126 CE (0.259); 1136–1151 CE (0.064)
UGAMS-15040	charcoal	285.5	990 ± 25	990–1050 CE (0.676); 1083–1126 CE (0.259); 1136–1151 CE (0.064)
UGAMS-15041	charcoal	298.5	1370 ± 25	624–681 CE (1.000)
UGAMS-13420	wood	347.5	3560 ± 30	2015–1997 BCE (0.031); 1979–1869 BCE (0.804); 1846–1808 BCE (0.098); 1805–1776 BCE (0.068)
UGAMS-14455	wood	377.5	1620 ± 25	386–475 CE (0.652); 484–535 CE (0.348)
UGAMS-14456	wood	389.5	1650 ± 20	344–425 CE (1.000)

* Uncalibrated ages provided in radiocarbon years before 1950 (years BP), using the ^{14}C half–life of 5568 years. The error is quoted as one standard deviation and reflects both statistical and experimental errors. The date has been corrected for isotope fractionation.

† All ages calibrated using CALIB 7.0 program (Stuiver and Reimer, 1993, *Radiocarbon* v. 25, p. 215-230) using the IntCal09 curve (Reimer et al., 2013, *Radiocarbon* v. 55, p. 1869-1887), with 2-sigma age ranges reported and relative area under probability distribution in parentheses.

2.3 Results and Discussion

The composite sediment core from Horseshoe Lake measures 578 cm in length (Figure 2.3). The basal unit of the record (440–578 cm) consists of clay interbedded with sand layers, and pollen is poorly preserved throughout this mineral-rich unit. The top 440 cm is composed primarily of silty clay (0–218 cm, 325–440 cm) and sandy silt (218–325 cm). With the exception of a mineral-rich pale brown (10YR 6/3) silty unit from 199 to 218 cm, pollen and plant macrofossils are well preserved throughout the top 440 cm.

Our age model for the top 440 cm was developed using a modified smooth spline in *Clam* 2.2 (Blaauw, 2010), and is based on nine accelerator mass spectrometry (AMS) ^{14}C dates on terrestrial plant macrofossils (Table 2.1) calibrated using the IntCal13 calibration curve (Reimer *et al.*, 2013), the pollen-based *Ambrosia* rise (McAndrews, 1988) at A.D. 1825 ± 25, and the year of core collection at the core top (Figure 2.4). We excluded one date (UGAMS-13420) at 347 cm from the age model because it is anomalously old (1900 ± 240 B.C.), most likely due to the misidentification of an aquatic macrofossil as terrestrial. The pale brown unit (199–218 cm) is sedimentologically distinct from the adjacent layers, with silty clay texture of high uniformity, low organic content, and near absence of pollen or plant macrofossils and is inconsistent with a locally-sourced mass wasting event (e.g., Woods, 2004). This layer is present in all four sets of cores across the outer channel. We thus interpret this layer to be the result of a large flood originating from the Mississippi River and treat it as an instantaneous sedimentation event in the age model. This inferred flood event has a modeled age of A.D. 1200 ± 80. Additional, less pronounced, floodwater deposits are apparent as thin (<10 cm) layers with low organic content, and presumably originate from lower magnitude events that created relatively minor increases in sedimentation rate so are not treated as instantaneous events in the age model. The age model places the base of our pollen record (440 cm) at A.D. 270 ± 160, with accumulation rates ranging from 2.5 to 7.5 yr cm^{-1}.

We divided the Horseshoe Lake record into six palynological zones based on constrained hierarchical clustering (Grimm, 1987): HORM-1 to HORM-6, interpreted to represent pre-agricultural, early agricultural, agricultural intensification, agricultural contraction, regional abandonment, and Anglo-American agricultural land use phases (Figure 2.5). The earliest zone, HORM-1 (A.D. 270–450) is characterized by high abundances of pollen from upland trees, including *Quercus* (oak), *Carya* (hickory), and *Juglans* (walnut), as well as from the floodplain trees *Salix* (willow), *Fraxinus* (ash), *Ulmus* (elm), and *Platanus* (sycamore), and increasing abundances of *Ambrosia* (ragweed).

Beginning in A.D. 450, the early agricultural zone (HORM-2) displays a rapid reduction of most arboreal taxa alongside increases in several non-arboreal taxa. These non-arboreal pollen taxa incorporate several cultigens of the Eastern Agricultural Complex (EAC; Smith and Yarnell, 2009), namely Amaranthaceae (amaranth, includes goosefoot [*Chenopodium berlandieri*]), Poaceae (grass, includes maygrass [*Phalaris caroliniana*] and little barley [*Horedum pusillum*]), *Helianthus*-type (sunflower [*Helianthus annuus*]), *Iva*-type (sumpweed [*Iva annua*]), and *Polygonum* (erect knotweed [*Polygonum erectum*]). By zone HORM-3 (A.D. 580–1170), floodplain and most upland arboreal pollen taxa are significantly reduced and replaced by non-arboreal pollen taxa associated with the EAC. Maize (*Zea mays* subsp. *mays*) pollen first appears at A.D. 620 ± 130 and is present in this zone until A.D. 1050 ± 60. Most arboreal taxa begin to increase during zone HORM-4 (A.D. 1170–1350), although several taxa associated with the EAC remain at relatively high abundances until the end of this zone. Arboreal taxa continue increasing in abundance through zone HORM-5 (A.D. 1350–1850), and non-arboreal taxa associated with the EAC decline and remain at low abundances. Zone HORM-6 (A.D. 1850–2010) is characterized by rapid reduction of *Quercus* and *Carya* and increase of *Ambrosia* typical of historic Anglo-American settlement (McAndrews, 1988).

The organic stable carbon isotope ratios ($\delta^{13}C_{org}$) closely track changes in pollen assemblages, and provide additional information on the response of vegetation to prehistoric and historic land use (Figure 2.5). During the Late Woodland (A.D. 400–1050) and Mississippian (A.D. 1050–1350) periods, $\delta^{13}C$ values gradually become more enriched, shifting from relatively depleted values (-27.5‰ to -26.0‰) to more enriched values (-24.8‰ to -23.0‰) by A.D. 900–1200. After A.D. 1200, $\delta^{13}C_{org}$ gradually returns to more depleted values, and remains relatively depleted (-25.8‰ to -24.7‰) until ca. A.D. 1800, when a pulse of enrichment (-24.9‰ to -23.6‰) follows Anglo-American settlement, followed by a return to more depleted values during the 20th century.

The Horseshoe Lake record documents nearly two millennia of environmental change, recording geomorphic activity associated with the Mississippi River and major episodes of prehistoric and historic land use. The mineral-rich basal unit (Figure 2.3) likely represents an initial stage when Horseshoe Lake was still proximal to the Mississippi River, before the main river channel migrated west to its roughly current position 10 km away from our core site (Hajic, 1993). Following this shift in the river's position, Horseshoe Lake became more isolated from the Mississippi River, with floodwaters depositing material in the lake during high magnitude events. The most prominent of these flood events deposited 19 cm of silty clay at A.D. 1200 ± 80 (Figure 2.4). Sediments deposited by floodwaters contain low concentrations of poorly preserved pollen, and do not discernibly alter the relative proportions of pollen taxa.

Following lake isolation, pollen data in the Horseshoe Lake record document a rapid ecological shift from a forested region to a region dominated by agricultural activity (Figure 2.5). Beginning around A.D. 450, the Horseshoe Lake pollen data show rapid deforestation of the floodplain and uplands followed by the proliferation of EAC cultigens. This shift toward an agricultural landscape coincides with the greater use of the EAC documented in ethnobotanical assemblages, but before the intensification of maize production at ca. A.D. 900 and the emergence of Cahokia at A.D. 1050 (Simon and Parker, 2006). In these ways, the pollen data show that the formation of more open cultural landscapes pre-dates the widespread use of maize and the emergence of large nucleated settlements typically associated with significant environmental impacts (e.g., Woods, 2004), and demonstrate that early agricultural activity based primarily on the EAC transformed regional vegetation well before the Mississippian period.

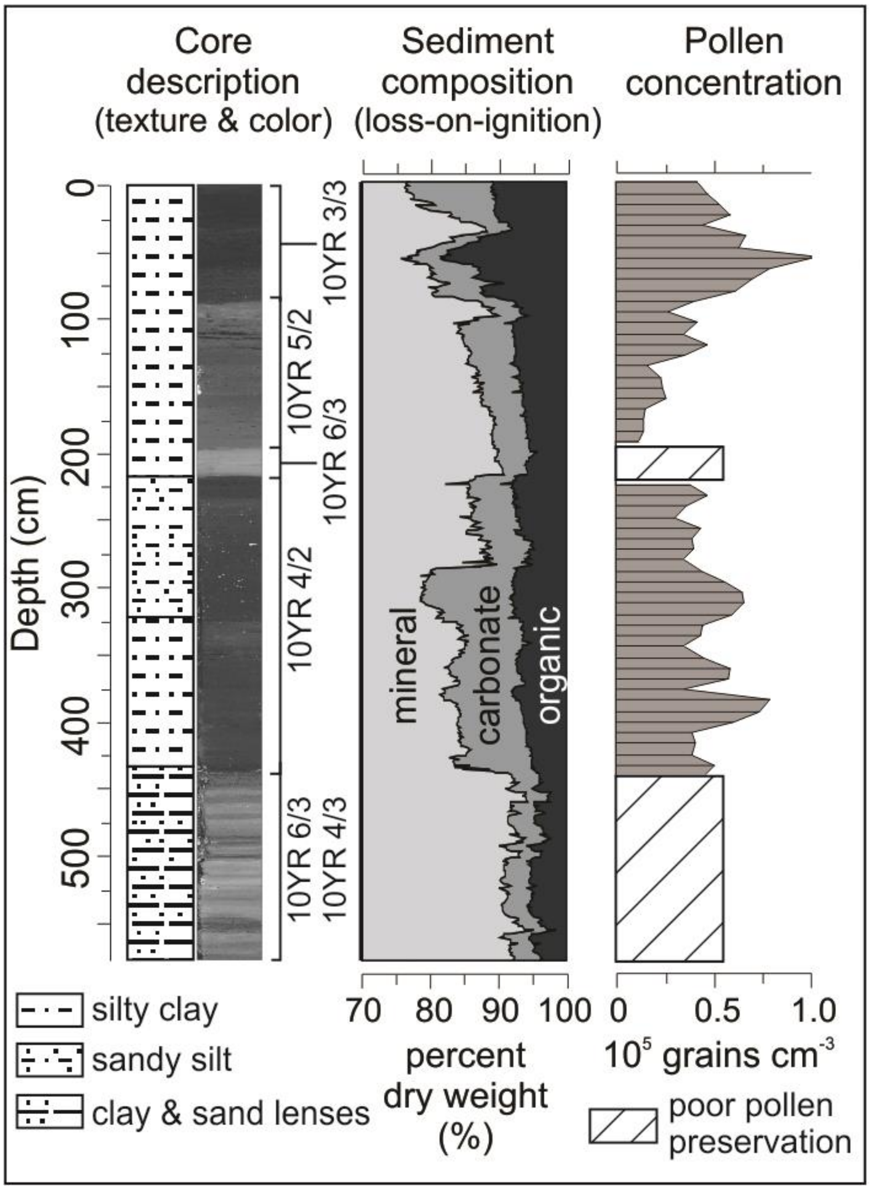

Figure 2.3: Core description (texture, Munsell color), loss-on-ignition, and pollen concentration along core axis of Horseshoe Lake (Illinois, USA) sediment core.

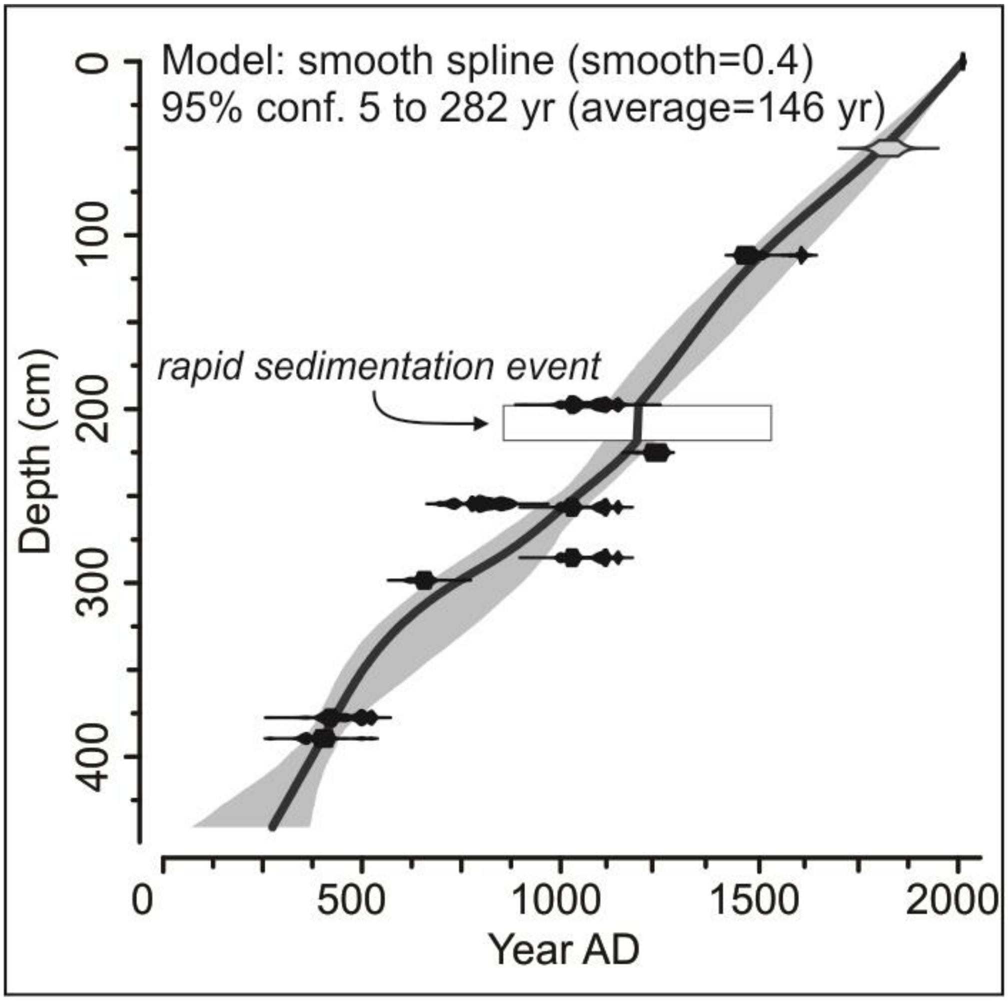

Figure 2.4. Age-depth model for the Horseshoe Lake (Illinois, USA) record based on a smooth spline in Clam 2.2 (Blaauw, 2010), with the best model (black line) bracketed by its 95% confidence interval (gray shading). The model incorporates a rapid sedimentation event from 199 to 218 cm that is interpreted to represent a single Mississippi River flood.

After the initial clearance of forests at A.D. 450, pollen assemblages and $\delta^{13}C_{org}$ of the Horseshoe Lake record document the progressive intensification of land use over the Late Woodland and Mississippian periods (Figure 2.5). The combination of low but stable arboreal pollen abundances, the sustained presence of pollen associated with cultivated taxa, and the gradual enrichment of $\delta^{13}C_{org}$ between ca. A.D. 600 and A.D 1200 together suggest that agricultural activity proceeded primarily from intensification on existing clearings rather than continued agricultural expansion. The enrichment of $\delta^{13}C_{org}$ reaches a stable maximum between A.D. 900 and A.D. 1200, and is consistent with both the gradual intensification of maize cultivation in the Horseshoe Lake watershed (Lane *et al.*, 2008) and/or the expansion of aquatic macrophytes stimulated by increased nutrient delivery to the lake from intensifying land use (Meyers, 2003).

Together, the palynological and isotopic data indicate that agricultural land use intensified over Late Woodland and Mississippian periods, reaching its peak intensity just prior to and during the emergence of Cahokia as a regional center.

The prominent floodwater deposit at A.D. 1200 ± 80 (Figure 2.4) marks the onset of Cahokia's decline, and coincides with a regional sociocultural transformation characterized by decreasing population size and density, and the establishment of defensive palisades (Trubitt, 2000). The construction of levees during the 20th century isolated Horseshoe Lake from Mississippi River floodwaters (Karthic *et al.*, 2013), so it is difficult to compare the magnitude of prehistoric flooding with historic flood events. However, the ca. A.D. 1200 event is the most prominent of all floodwater deposits observed over a 1700-year period, implying that it was deposited by a flood with a high recurrence interval that likely inundated at least some Mississippian settlements in the floodplain.

Following this major flood event, pollen assemblages and the gradual depletion of $\delta^{13}C_{org}$ document diminishing agricultural activity between ca. A.D. 1200–1350 that is associated with Cahokia's declining population size and cultural prominence (Milner, 1998; Figure 2.5). After A.D. 1350, Cahokia is abandoned by Mississippian peoples, pollen assemblages shift back to a largely pre-agricultural state, and $\delta^{13}C_{org}$ shifts to a new stable state 1–2‰ above the pre-agricultural baseline. The Euro-American period begins with initial exploration of the Mississippi River in A.D. 1673, with rapid clearance of upland forest and the proliferation *Ambrosia* by Anglo-American settlers in the 19th century, followed by moderate reforestation associated with industrialization and urbanization of the St. Louis area in the 20th century (Karthic *et al.*, 2013).

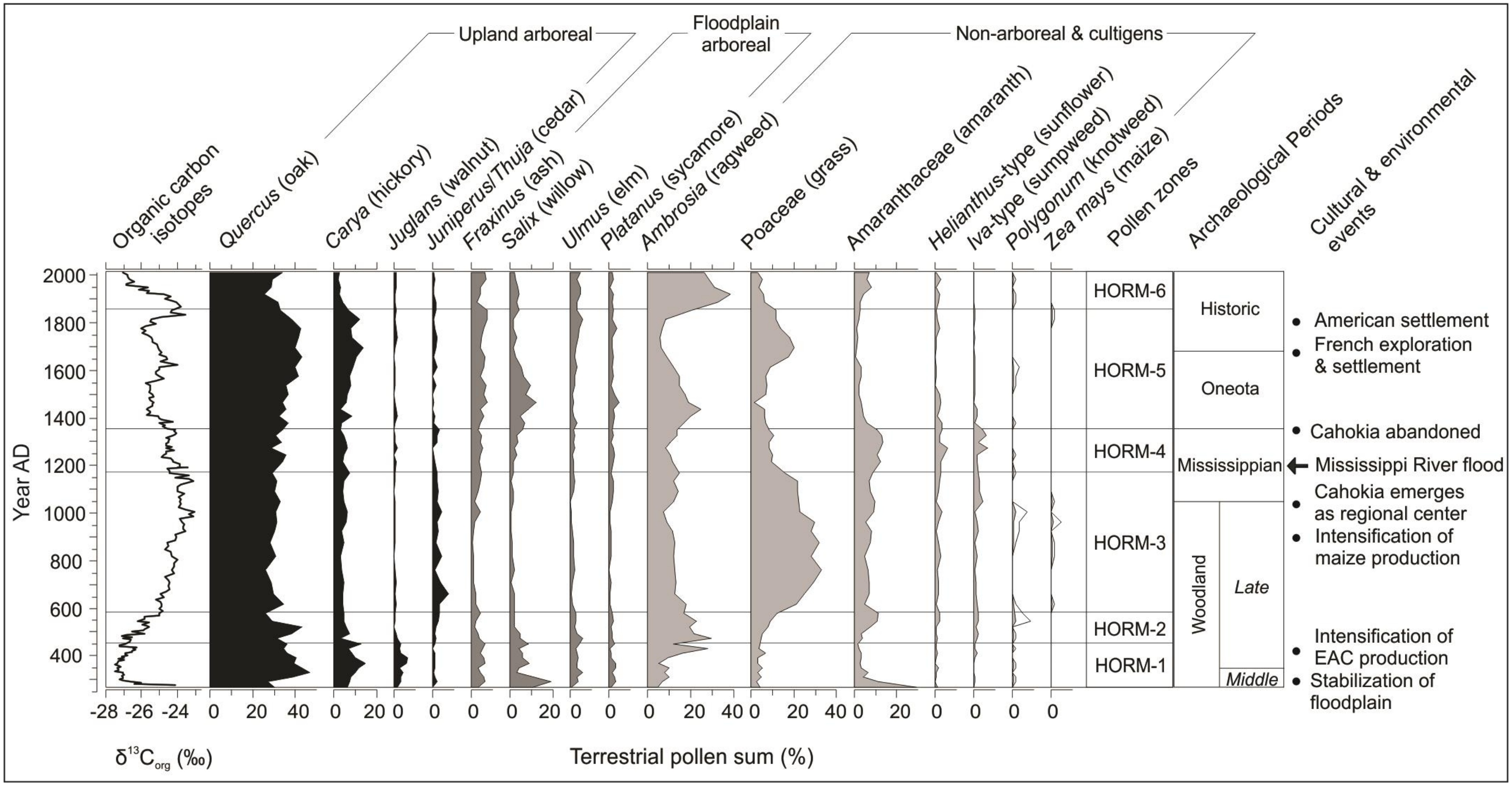

Figure 2.5: Organic carbon isotope ratios ($\delta^{13}C_{org}$) and relative abundances of selected pollen taxa (expressed as a percent of terrestrial pollen sum), and archaeological periods, cultural and environmental events of the Cahokia region (Illinois, USA) after Fortier *et al*. (2006) and Simon and Parker (2006). EAC – Eastern Agricultural Complex.

2.4 Conclusions

The sedimentary record from Horseshoe Lake, an oxbow lake in the central Mississippi River valley, provides a 1700 yr record of regional vegetation change dominated by prehistoric and historic episodes of agricultural expansion and contraction. Floodplain and upland forests were first cleared and replaced with stands of ruderals and EAC crops starting around A.D. 450, well before the emergence of Cahokia as a regional center at A.D. 1050. Agricultural production underwent gradual intensification following this initial period of forest clearance, reaching its peak intensity between A.D. 900 and A.D. 1200. A large flood around A.D. 1200 marks the onset of declining agricultural activity, coeval with the decreasing population size and diminishing cultural prominence of Cahokia. After A.D. 1350, agricultural activity becomes greatly reduced with the abandonment of Cahokia and the surrounding region by Mississippian peoples. Anglo-American settlement in the 19th century is characterized by rapid agricultural expansion. The paleoecological record from Horseshoe Lake documents nearly two millennia of regional vegetation change driven primarily by land use, and demonstrates the ability of indigenous North American land use to profoundly impact regional vegetation long before the emergence of intensive agriculture and large nucleated settlements.

Evaluating the characteristics and spatiotemporal patterns of prehistoric land use at landscape to continental scales is critical to understanding the effects of human activities on global environmental systems (Ellis *et al.*, 2013). Beyond Cahokia, other agricultural population centers flourished in the floodplains of midcontinental North America during the late prehistoric period (Milner, 2012), and the Horseshoe Lake record demonstrates the viability of at least some floodplain lakes to track land use patterns associated with these prehistoric population centers. This study provides clear evidence for the antiquity and significance of prehistoric cultural landscapes in eastern North America that together with additional paleoecological data can be used to improve models of global land use history.

2.5 Acknowledgements

We thank J. Gowen and the Illinois Department of Natural Resources for lake access and R. Brugam for early discussions, and gratefully acknowledge J. Blois, B. Rongstad, G. Schellinger, and C. Zirbel for field and laboratory assistance; K. Brady, A. Myrbo, A. Noren, and R. O'Grady of the National Lacustrine Core Facility (LacCore) for assistance with initial core processing; D. McCay of Washington University for laboratory assistance; and K. Gruley, J. Mason, S. Goring, and three anonymous reviewers for discussions and comments. This study received financial support from the National Geographic Society (YEG-9008-11), LacCore, a National Science Foundation Integrative Graduate Education and Research Traineeship (NSF-IGERT; grant DGE-1144752), and a Packard Fellowship to Fike. All data will be submitted to the Neotoma Paleoecology Database (www.neotomadb.org) and NOAA Paleoclimatology Data Center upon publication.

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Chapter 3: A land use history of the central Mississippi River valley, USA: cultural influences on fire regimes and vegetation communities

Note: This chapter is in preparation for submission to *Quaternary Science Reviews*.

Abstract

Here, we report three new multi-proxy (pollen, charcoal, $\delta^{13}C_{org}$) paleoecological records from the central Mississippi River valley that document the evolution of a cultural landscape over nearly two millennia. We interpret the paleoecological data in the context of five socioecological periods that are based on shifts in subsistence strategies and settlement patterns documented in archaeological and historical records. During Period I (AD 200–400), abundant mast-bearing trees were exploited by seasonally-mobile foragers who may have practiced a form of silviculture, although the effect of these practices on vegetation composition were subtle. Forests across much of the area were cleared by groups practicing spatially extensive shifting cultivation during Period II (AD 400–1050). Sedentary farmers living in and around large nucleated settlements maintained an open and agricultural landscape near their settlements and suppressed fires during Period III (AD 1050–1500). By the onset of Period IV (AD 1500–1800), the area was sparsely populated, and visited periodically by hunting parties that travelled across large territories and expanded prairies in the pursuit of game. Sustained and extensive Anglo-American settlement during Period V (AD 1800–present) converted forests and prairies to permanent agricultural fields and settlements. Indigenous populations generally increased the frequency and extent of fires, but shifting cultivation at intermediate population densities was associated with the highest amount of biomass burning. Our study demonstrates how different cultural practices influence fire regimes and vegetation communities, and provides new insights into the spatiotemporal patterns of indigenous North American land use.

3.1 Introduction

Land use is an important driver of change in the Earth system (Meyer and Turner, 1992; Foley *et al.*, 2005; Ellis and Ramankutty, 2008), and understanding how changes in human subsistence strategies and land-use practices affected ecosystem structure, biogeochemical cycling, and climate in pre-Industrial contexts remains an active area of investigation in Quaternary science and related disciplines (Kaplan *et al.*, 2009; Ellis *et al.*, 2013; Seddon *et al.*, 2014; Ruddiman *et al.*, 2015). As the basis of their livelihood, human societies have practiced various subsistence strategies during the Holocene, including hunting, foraging, silviculture, shifting and permanent cultivation, and in the process altered vegetation patterns (Delcourt and Delcourt, 2004; Hayashida, 2005; Williams, 2008) often by using fire (Pyne, 1994; Bowman *et al.*, 2009; 2011), modified soils (Dambrine *et al.*, 2007; Glaser *et al.*, 2007), animal populations (Grayson, 2001; Barnosky *et al.*, 2004), and atmospheric chemistry (Ruddiman, 2003) to varying degrees. Despite the importance of land use history in contemporary conceptions of the 'natural' environment (Cronon, 1996; Ellis *et al.*, 2013; Ruddiman *et al.*, 2015), and its repercussions for restoration ecology (Willis *et al.*, 2004; Jackson and Hobbs, 2009) and global change science (Ruddiman, 2003; Kaplan *et al.*, 2009; Ellis *et al.*, 2013), the extensiveness, intensity, and characteristics of land use associated with the many subsistence strategies practiced during the Holocene remain unclear.

Among the indigenous societies of eastern North America, a variety of subsistence strategies were practiced that are well documented in archaeological, historical, and ethnographic records (e.g., Denevan, 1992; Hammett, 1992; Peacock, 1998; Doolittle, 2000; Smith, 2011a; Munoz *et al.*, 2014a). Hunting and foraging by both mobile and sedentary groups in the early historical period often involved active management practices, where forests and prairies were manipulated to increase the abundance of desired plants and animals (Waselkov, 1978; Hammett, 1992; Doolittle, 2000; Foster *et al.*, 2004; Black *et al.*, 2006; Foster and Cohen, 2007; Abrams and Nowacki, 2008). Seasonally-mobile groups began cultivating a suite of native domesticates, including goosefoot (*Chenpodium berlandieri*), sumpweed (*Iva annua* var. *macrocarpa*), knotweed (*Polygonum erectum*), little barley (*Hordeum pusillum*), squash (*Cucurbita pepo* ssp. *ovifera*), and sunflower (*Helianthus annuus*) in small clearings during the mid-Holocene (Conard et al., 1984; Smith, 1984; 1987; 2011b; Smith and Yarnell, 2009), and after ca. AD 800 both mobile and more sedentary groups began cultivating Mesoamerican domesticates including maize (*Zea mays* subsp. *mays*) in small gardens as well as in larger fields (Smith, 1989; Fritz, 1990; Doolittle, 2000; Schroeder, 2004a). Fire was used to facilitate hunting, foraging, farming, and several other activities (Russell, 1983; Patterson and Sassaman, 1988; Hammett, 1992; Williams, 1992; Delcourt *et al.*, 1998; Abrams and Nowacki, 2008; 2014), and indigenous populations are often thought to have increased the frequency of fires in the ignition-limited forests and prairies of this temperate region (Guyette *et al.*, 2002; Nowacki & Abrams, 2008;). Paleoecological data, namely biological and geochemical proxies preserved in sedimentary archives, have previously been used to identify times and places where indigenous land-use practices had an effect on vegetation (Delcourt *et al.*, 1986; McAndrews and Boyko-Diakonow, 1989; Clark and Royall, 1995; Delcourt and Delcourt, 1997; 1998; McLauchlan, 2003; Munoz and Gajewski, 2010; Scharf, 2010; Munoz *et al.*, 2014b). Yet, it is unclear how land use patterns evolved as settlement patterns changed and new crops, technologies, and cultural practices were adopted, because, with a few notable exceptions (e.g., Chapman *et al.*, 1982; Delcourt *et al.*, 1986; 1998), few studies have examined paleoecological data in an area with a long occupational history described by detailed archaeological and historical records.

In this study, we present new paleoecological records (fossil pollen, charcoal, and $\delta^{13}C_{org}$) to evaluate how vegetation communities and fire regimes evolved in response to changes in human culture. Our study focuses on the central Mississippi River valley, where the archaeological and historical record associated with the prehistoric population center of Cahokia, and the modern city of Saint Louis, are sufficiently detailed to document shifts in human subsistence strategies and settlement patterns over the last ca. 2,000 years. We examine the response of terrestrial ecosystems to five socioecological periods associated with distinct cultural practices along gradients of population density. Our analysis tracks the distinct ecological conditions brought on by indigenous hunting, foraging, and farming, and demonstrates how land-use extent and intensity vary with these different land-use practices. We conclude that changing cultural practices are an important influence on fire regimes and vegetation dynamics.

3.2 Study Area

This study focuses on the central Mississippi River and its surrounding floodplain and adjacent uplands, a roughly 300 km section of river that flows between the grasslands of the Great Plains to the west and the temperate deciduous forest to the east, bounded to the north and south at its confluences with the Missouri and Ohio Rivers, respectively the major western and eastern tributaries of the Mississippi Basin (Figure 3.1). The floodplain on this section of the river spans up to 14 km at its widest point near Saint Louis, Missouri, and is bounded by loess-capped limestone bluffs that rise as much as 60 m above the floodplain (Grimley *et al.*, 2007). Lateral migration of the Mississippi River across its floodplain since the mid-Holocene has formed a series of oxbow lakes and meander scars underlain by permanently or seasonally inundated fine-grained alluvial deposits bounded by coarser-grained point-bars at higher elevations (White *et al.*, 1984; Hajic, 1993; Milner, 1998; Schroeder, 2004b). Several rivers and streams dissect the uplands, often forming alluvial fans before emptying into the wetlands and lakes of the wide Mississippi River floodplain (Grimley *et al.*, 2007). Vegetation in the study area contains a mixture of wetland, forest, and prairie communities; vegetation composition is strongly influenced by moisture gradients related to elevation, soil texture, and distance from the river, and, historically, low-lying areas have been characterized by a mix of wet prairie, cottonwood (*Populus deltoides*), willow (*Salix* spp.), silver maple (*Acer saccharinum*), bald cypress (*Taxodium distichum*), sweetgum (*Liquidambar styraciflua*), and ash (*Fraxinus* spp.), and higher elevations by oaks (*Quercus* spp.) and hickories (*Carya* spp.) interspersed with dry prairies (Chmurny, 1973; White *et al.*, 1984; Schroeder, 2004b).

Due to its central location along a major waterway with access to a variety of natural resources, the central Mississippi River valley has been occupied over the last 2,000 years by an assortment of human societies with distinct subsistence strategies and settlement patterns, divided here into five Socioecological Periods (Figure 3.2). During Period I (before AD 400), seasonally-mobile groups associated with the Middle Woodland archaeological cultural tradition hunted and foraged for plant foods, especially acorns and nuts from hickories, hazel (*Corylus americana*), and walnut (*Juglans* spp.), available in floodplain and upland forests, and spent little effort cultivating indigenous seed crops relative to later populations (Fortier *et al.*, 1984; 2006; Simon and Parker, 2006). Following a brief period where occupation of the area drops below archaeological visibility, the area was re-occupied by groups associated with Period II (AD 400–1050) that intensified the cultivation of indigenous seed crops, including goosefoot, sumpweed, knotweed, little barley, and sunflower into a mixed and mobile subsistence strategy (Johanessen, 1984; Fortier and Jackson, 2000; McElrath and Fortier, 2000; Koldehoff and Galloy, 2006). During Period II, these groups that archaeologists associate with the Late Woodland tradition grew increasingly dependent on food production, and after ca. AD 800 began cultivating maize more intensively in conjunction with indigenous seed crops (Milner, 1998; Simon and Parker, 2006; Schoeninger, 2009). At the onset of Period III (AD 1050 – AD 1500), the inhabitants of this area, which now numbered in the tens of thousands (Pauketat and Lopinot, 1997; Milner, 1998), began living in larger permanent settlements like Cahokia that were concentrated in the northern part of the study area (Pauktat, 1994; Schroeder, 1997; Milner, 1998). These groups, associated with the Mississippian and Oneota cultural traditions, relied heavily on permanent cultivation, although hunting and foraging for wild foods still occurred (Fritz, 1990; Lopinot, 1997). The central Mississippi River valley began to be depopulated after AD 1200, and by the beginning of Period IV (AD 1500 – AD 1800), the area was lightly settled and sporadically used for hunting, primarily by indigenous peoples of the Illinois confederacy, and was permanently settled around AD 1700 by Franco-American farmers, fur traders, and missionaries (Bauxar, 1978; Esarey, 1984; Brown and Sasso, 2001; Shackelford, 2008). Populations increased rapidly after AD 1800, the beginning of Period V, as Anglo-American peoples settled in and around population centers like Saint Louis with access to the Mississippi River, and established farms in the floodplain and adjacent uplands that raised livestock and cultivated a variety of cereals (Esarey, 1984; Norris, 1997).

Figure 3.1: The central Mississippi River valley, showing the locations of the paleovegetation records from Horseshoe Lake (Madison County, IL; HORM12), Grassy Lake (GRAS13), and Horseshoe Lake (Alexander County, IL; HORX13), Cahokia and associated Mississippian-era (ca. AD 1050–1350) population centers, and the modern cities of Saint Louis, MO and Cape Girardeau, MO. The population history shown in Figure 3.2 applies only to area in the dotted circle at the northern end of the study area.

The central Mississippi River valley has undergone multiple periods of population growth and decline as subsistence strategies and cultural practices shifted over the last ca. 2000 years, and the area thus provides an excellent setting to study how terrestrial ecosystems respond to a variety of land-use practices. To achieve this, we examine paleoecological records from three oxbow lakes that span the study area, but differ in their occupation histories: (1) Horseshoe Lake, Madison County, Illinois (HORM12, 38.704767°N, 90.081279°W), located at the northern end of the study area, adjacent to Cahokia and Saint Louis, where sedentary agricultural Mississippian (Period III) populations were more concentrated; (2) Grassy Lake, Union County, Illinois (GRAS13, 37.431701°N, 89.377466°W), 190 km downstream from Cahokia, and (3) Horseshoe Lake, Alexander County, Illinois (HORX13, 37.145804°N, 89.326795°W), 230 km downstream from Cahokia, where Mississippian population densities were lower (Schroeder, 1997; Milner, 1998). All three lakes are large (historically 800–1100 ha), shallow (1.0 – 1.4 m at their deepest points), and, prior to major modifications to the floodplain, were fed regularly by small streams originating in the uplands, as well as periodic inundation by the Mississippi River during large flood events (Milner and Oliver, 1999; Munoz *et al.*, 2015). These lakes formed as neck cut-offs of the Mississippi River, and are relatively young features of the high-sinuosity meander belt that began forming in the mid-Holocene, before the central Mississippi River became less sinuous and shifted to its present location within the low-sinuosity meander belt (White *et al.*, 1984; Hajic, 1993).

3.3 Materials & Methods

3.3.1 Core acquisition, initial description, and sampling

Sediment cores with primary and overlapping sections were recovered from an anchored floating platform at the approximate location of the thalweg along the outermost channel of HORM12 in May 2012, and from GRAS13 and HORX 13 in June 2013 using a modified Livingston-Wright piston corer; a surface sediment section was recovered from all sites using a Bolivia adapter with polycarbonate tubes. Cores were longitudinally split into two halves, and underwent high-resolution photography and magnetic susceptibility analysis at the National Lacustrine Core Facility (LacCore) at the University of Minnesota. Continuous composite cores that merged primary, overlapping, and surface core sections were assembled using magnetic susceptibility time-series and stratigraphic markers (Supplemental Material). Cores were transported back to the Williams Paleovegetation Laboratory at the University of Wisconsin–Madison, where one half of the composite sediment cores were sampled at 1 cm resolution for loss-on-ignition (LOI), fossil pollen, charcoal, and stable carbon isotope analyses; the other halves were used to collect plant macrofossils for radiocarbon dating. All sediment samples were kept in cold storage (> 0°C) and sealed in plastic when not in use to reduce contamination and desiccation.

3.3.2 Loss-on-ignition

Sub-samples of 1 cm^3 at continuous (1 cm) resolution were collected for loss-on-ignition analysis to measure the relative amounts of organic carbon, inorganic carbon ($CaCO_3$), and other minerals in the sediment (Heiri *et al.*, 2001). Sediment sub-samples were placed in crucibles and dried at 100°C for 12 hours, and then burned in a muffle furnace at 550°C for 4 hours to remove organic carbon, followed by another burn at 1000°C for 2 hours to remove carbonate minerals. The sub-samples were weighed between each treatment, and the percent weight lost during each burn was used to calculate the percent organic, carbonate, and mineral content of each sub-sample.

3.3.3 Pollen

For pollen analysis, 1 cm^3 sediment sub-samples were collected at 8 cm resolution. These sub-samples were processed using a modified version of the protocols of Faegri and Iversen (1989) that includes treatments with hot 10% HCl, 10% KOH, hot 55% HF, acetolysis, and stabilization with ethanol and tert-butanol. To calculate pollen concentrations, 1 mL of synthetic micro-spherules (LacCore batches 5 & 6) of a known concentration (50,000 ± 4,000 spherules/mL) was added to each sub-sample. Pollen samples were mounted on microscope slides with silicone oil, and at least 300 terrestrial pollen grains were counted at 400X with a Zeiss Axiostar Plus light microscope. Pollen abundances are represented as a percent of the terrestrial pollen sum; pollen accumulation rates are available in Supplemental Material.

3.3.4 Stable carbon isotopes

For stable organic carbon isotope ($\delta^{13}C_{org}$) analysis, 0.5 cm^3 sub-samples at 1–2 cm resolution were first acidified with 10% HCl to remove inorganic carbon, rinsed with deionized water, and dried at 50°C for 24 hours. Isotopic composition was then measured by combusting 1–10 mg of the acid insoluble residue in a Costech 4010 ECS elemental analyzer, and passing the evolved gas through a Thermo Scientific Delta V plus mass spectrometer housed at Washington University. Isotope measurements are reported relative to the Vienna Peedee belemnite standard, and duplicate measurements on 104 samples found a mean reproducibility of 0.25‰.

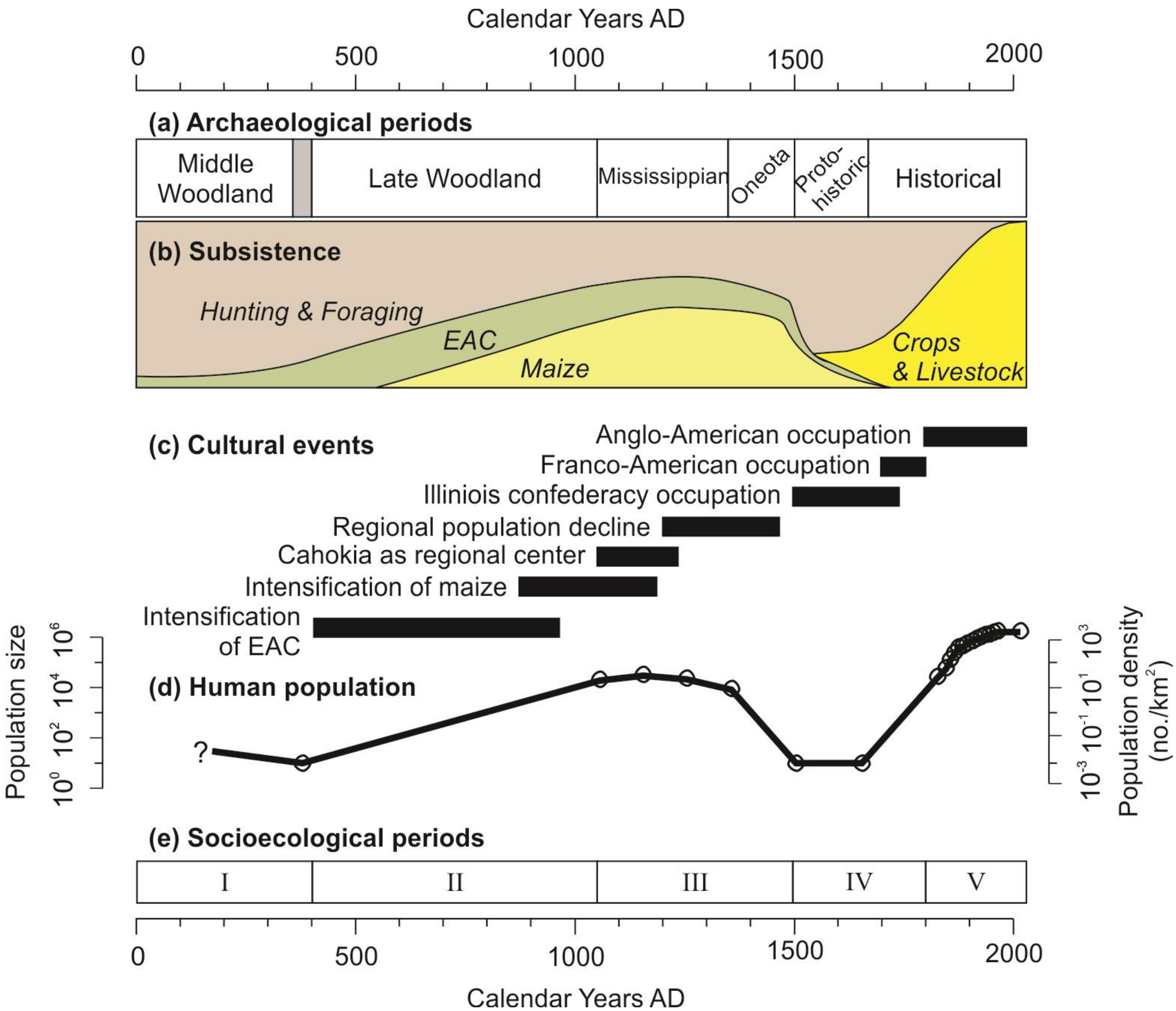

Figure 3.2:The five Socioecological Periods of the central Mississippi River valley, as described by (a) archaeological periods after Fortier et al. (2006), (b) subsistence strategies adapted from Simon and Parker (2006), (c) cultural events after Milner (1998), and (d) human population size and density for the northern part of the study area. Prehistoric population levels after Milner (1998), with archaeological hiatuses from Fortier *et al*. (2006) representing very sparse occupations; historical populations for the study area are based on the historical census.

3.3.5 Macroscopic charcoal

For macroscopic charcoal analysis, 1 cm^3 sediment sub-samples were collected at continuous (1 cm) resolution. These sub-samples were processed using a modified version of the protocols of Whitlock and Larson (2001), including treatment with 6% H_2O_2 at 50°C for 24 hours to bleach coarse organics, followed by passing samples through a 125 µm sieve. The >125 µm fraction was transferred to plastic Petri dishes, and placed in a drying oven at 50°C until all liquid was evaporated. All charcoal fragments on a dish were then counted on a gridded platform at 5-10X with a stereoscope. Charcoal morphotypes based on reference burns (Jensen *et al.*, 2007; Mustaphi and Pisaric, 2014) were used to differentiate charcoal produced by the partial combustion of grasses (i.e., cellular morphotype) and trees (i.e., dark, branched, and bordered pit morphotypes). We represent charcoal as an accumulation rate (CHAR) in fragments/cm^2/yr that includes all fragments (cellular and non-cellular morphotypes), as well as the percent of all fragments that were identified as the cellular morphotype. Charcoal accumulation rates were separated into background and peak components using CharAnalysis v.1.1 (Higuera *et al.*, 2009; 2010); the background component was generated using LOWESS smoother with a 250-year window, and peaks representing local fires were identified using a locally fitted Gaussian mixture model.

3.3.6 Chronologies

We submitted a total 28 plant macrofossils (11 from HORM12, 6 from GRAS13, and 11 from HORX13) to the Center for Applied Isotope Studies at the University of Georgia (UGAMS) and DirectAMS (DAMS) for accelerator mass spectrometry (AMS) radiocarbon dating (Table 1). Plant macrofossils were obtained by collecting 1 cm sections of the archive half, deflocculating the sediment with 0.5% sodium hexametaphosphate and gently agitating, and passing the solution through a 125 µm sieve; identified macrofossils were rinsed with deionized water and dried at 50°C for 12 hours before being placed in glass vials and shipped to an AMS facility.

Age-depth models for each core were generated using clam v.2.2 (Blaauw, 2010), that fit 1000 smooth splines to the full age distribution of radiocarbon dates calibrated with IntCal13 (Reimer *et al.*, 2013) as well as core tops (year of collection) and the historical rise of *Ambrosia*-type pollen that marks Anglo-American settlement at AD 1800 ± 25 in this region (Munoz *et al.*, 2014a). In all cores, sections > 20 cm thickness with low organic content and extremely low pollen concentrations, consistent with sediment deposition from floodwaters (Gilli *et al.*, 2013; Munoz *et al.*, 2015), were treated as rapid sedimentation events in the age model (i.e., "slumps" in clam); additional floodwater deposits were previously identified using particle-size analysis in HORM12 and GRAS13 (Munoz *et al.*, 2015), but these deposits are thinner (< 10 cm) and have relatively minor effects on age estimates, pollen concentrations and assemblages. Four radiocarbon dates were ignored in the age models because they were older than surrounding dates, possibly due to contamination from fragments of aquatic plants or the re-mobilization of older material during flood events, and created reversals in the age models. Two basal dates from HORX13 (DAMS-005570 and DAMS-8291) may be roots from an overlying paleosol, and were also ignored because their young ages created an unrealistically high sedimentation rate in the age model; an additional 'modern' date from HORX13 (DAMS-005564) at 32 cm, also possibly a root fragment, was ignored in that site's age model.

3.4 Results

3.4.1 Sediment core descriptions & age models

The composite sediment core from Horseshoe Lake in Madison County, Illinois (HORM12) measures 578 cm (Figure 3.3a). The basal unit (440–578 cm) is composed of light grey clay interbedded with medium to coarse sands deposited before the main channel of the Mississippi River shifted to its roughly modern position along the western side of the floodplain (Hajic, 1993). Sediments in this basal section have low organic content and poor pollen preservation, consistent with sediment deposition primarily from high-energy floodwaters (Gilli *et al.*, 2013; Munoz *et al.*, 2015). Above 440 cm, sediment organic content and pollen concentrations increase, and sediments are predominately dark brown fine silty clay, with a unit (210–320 cm) of sandy fine silt and abundant gastropod shells. Our age model (Figure 3.4a) focuses on this upper section (0–440 cm), where sedimentation begins at AD 190 ± 200 and is driven primarily by the gradual deposition of local material at 2.8–6.0 yr/cm, punctuated by the periodic deposition of fine-grained sediments from floodwaters that are pale brown to light grey in color with reduced organic content and low pollen concentrations. The thickest of these floodwater deposits, which the age model treats as an instantaneous depositional event, occurs from 190–220 cm (AD 1230 ± 110).

Further downstream at Grassy Lake (GRAS13), the composite sediment core measures 220 cm, and is composed entirely of brown to light grey fine silty clay (Figure 3.3b). Sediment organic content ranges from 7–15% throughout the core, with no thick mineral-rich basal unit like that at HORM12, presumably because formation of this lake occurred by a single neck cut-off of the Mississippi River. Our age model for GRAS13 indicates that sedimentation began at AD 980 ± 160, with gradual sedimentation at 5.1–6.6 yr/cm throughout most of the core (Figure 3.4b). Periodic deposition of floodwater sediments, similar to those at HORM12, are also present in GRAS13; one particularly thick deposit characterized by low organic content and pollen concentrations occurs from 72–115 cm that the age model treats as an instantaneous deposition event at AD 1620 ± 90.

Table 3.1: Radiocarbon dates from HORM12, GRAS13, and HORX13 sediment cores. All 14C ages provided in radiocarbon years before AD 1950 (years BP), using the 14C half-life of 5,568 years. The error is quotes as 1 SD and reflects both statistical and experimental errors. Each date has been corrected for isotope fractionation.

Lab number	Site	Sample description	Depth (cm)	^{14}C age	1-α
UGAMS-13417	HORM12	wood	111.5	400	25
UGAMS-13418	HORM12	wood	197.5	980	40
UGAMS-14454	HORM12	wood	225	800	20
UGAMS-13419	HORM12	wood	254.5	1220	25
UGAMS-15039	HORM12	charcoal	256.5	990	25
UGAMS-15040	HORM12	charcoal	285.5	990	25
UGAMS-15041	HORM12	charcoal	298.5	1370	25
DAMS-005563	HORM12	charcoal	330	1316	24
UGAMS-13420	HORM12	wood	347.5	3560*	30
UGAMS-14455	HORM12	wood	377.5	1620	25
UGAMS-14456	HORM12	wood	389.5	1650	20
DAMS-005571	GRAS13	wood	31.5	91	25
DAMS-005572	GRAS13	wood	92.5	120	28
DAMS-005573	GRAS13	wood	110	309	25
DAMS-005574	GRAS13	wood	120	736*	27
DAMS-005575	GRAS13	wood	146	423	26
DAMS-005576	GRAS13	wood	202	936	24
DAMS-005564	HORX13	wood	32	modern*	-
DAMS-008288	HORX13	wood	75	1065	22
DAMS-005565	HORX13	wood	91.5	1079	28
DAMS-005566	HORX13	wood	121	997	25
DAMS-005567	HORX13	wood	139.5	1086	27
DAMS-005568	HORX13	wood	151.5	2420*	28
DAMS-008289	HORX13	wood	153	1202	28
DAMS-005569	HORX13	wood	192	2547*	29
DAMS-008290	HORX13	wood	230	1526	29
DAMS-005570	HORX13	wood	273.5	1342*	25
DAMS-008291	HORX13	wood	277	1321*	25

* Dates omitted from age models

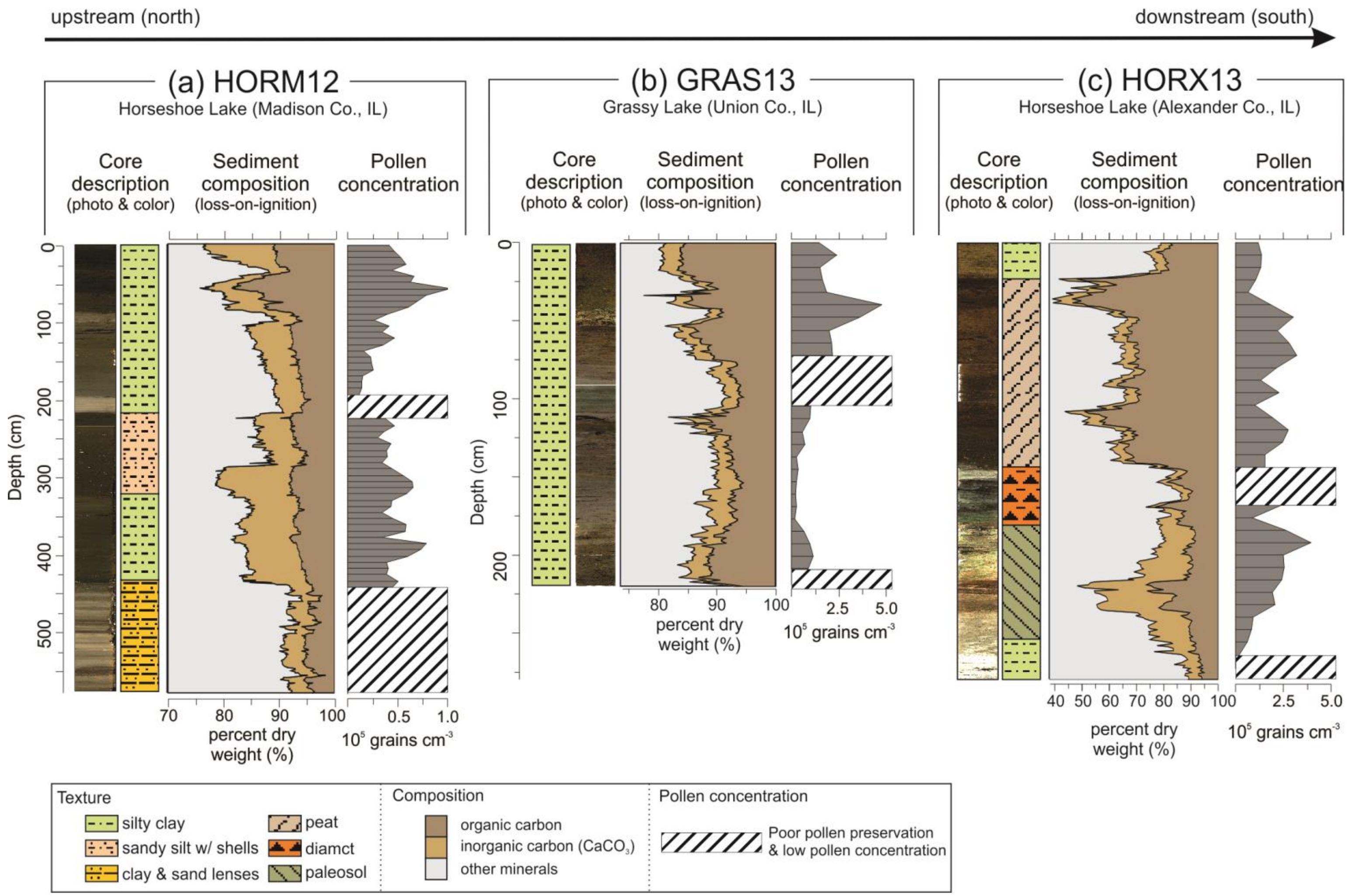

Figure 3.3: Descriptions of composite sediment cores alongside sediment composition and pollen concentrations from (a) HORM12, (b) GRAS13, and (c) HORX13.

At the southern end of the central Mississippi River valley, the composite sediment core from Horseshoe Lake in Alexander County, Illinois (HORX13) measures 278 cm (Figure 3.3b). The basal unit (278–254 cm) is composed of light grey fine silty clay with low organic content, and sits below an organic rich paleosol (254–179 cm) that presumably formed in a seasonally-wet environment. From 179–145 cm, the core contains a unit of low pollen concentrations consisting of coarse sands and cobbles of quartz and greenstone that fines upwards to light grey clay that resembles Illinoian glacial till (Willman and Frye, 1980) eroded and deposited in the lake by a large flood of the Cache River and/or one of the smaller upland streams that drains directly into the lake (Koldehoff and Wagner, 2002). Above this, a thick unit of peat (145–24 cm) sits below organic-rich silty clay (24–0 cm) that has previously been associated with Anglo-American settlement of the surrounding watershed (Brugam *et al.*, 2007). The age model for HORX13 (Figure 3.4c) indicates that sedimentation began at AD 310 ± 240, and includes a rapid sedimentation event that corresponds to the microfossil-poor till unit dated to AD 810 ± 130. The sedimentation rate is lower below the till diamict unit (4.5–4.7 yr/cm), and increases up to 12.0 yr/cm in the upper units.

3.4.2 Pollen & stable carbon isotopes

In the pollen and $\delta^{13}C_{org}$ record from HORM12 (Figure 3.5), pollen assemblages during Period I (AD 200–400) are dominated by arboreal taxa (81-94% of terrestrial pollen sum), especially *Quercus*, *Carya*, *Juglans*, *Salix*, *Fraxinus*, and *Ulmus*, and $\delta^{13}C_{org}$ is relatively depleted (-27.5 to -26.3‰). Arboreal pollen taxa decline during Period II (AD 400–1050), with the exception of *Pinus* and *Juniperus*, $\delta^{13}C_{org}$ values gradually increase to -23.0‰, and non-arboreal taxa increase in abundance to account for 30–54% of the terrestrial pollen sum; *Ambrosia* abundance increases first, peaking at 29% around AD 520, followed closely by increases of Poaceae and Amarathaceae. Additional pollen types associated with indigenous seed crops, including Amaranthaceae, Poeaceae, *Helianthus*-type, *Iva annua*-type, *Polygonum*, as well as *Zea mays* are present in Period II. The abundances of many non-arboreal taxa begin to decline during Period III (AD 1050–1500), although still accounting for › 28% of the terrestrial pollen sum, while $\delta^{13}C_{org}$ values gradually decline to -25.6‰, and many arboreal pollen taxa – with the notable exception of *Juglans* – increase in abundance at this time. During Period IV (AD 1500–1800) arboreal taxa dominate pollen assemblages, and, with the exception of Poaceae, most non-arboreal taxa, including those associated with prehistoric agriculture, are absent or present at relatively low abundances. Upland arboreal taxa, especially *Quercus* and *Carya*, decline again during Period V

(AD 1800–present) at the expense of *Ambrosia*, and $\delta^{13}C_{org}$ values briefly increase to -23.6‰ before declining in the 20[th] century.

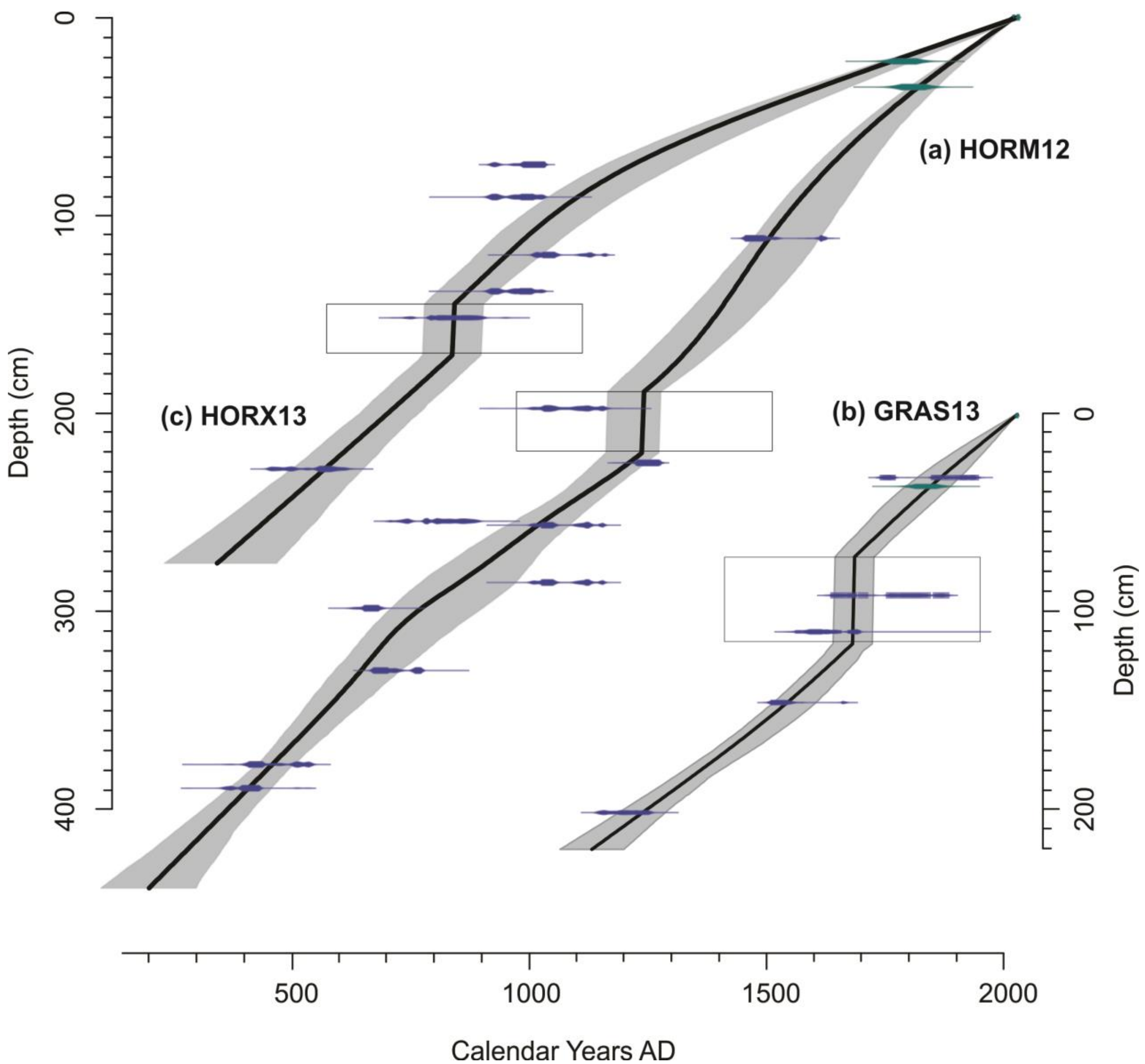

Figure 3.4: Age models with best estimate (black line) and 95% confidence interval (grey shading) for (a) HORM12, (b) GRAS13, and (c) HORX13 developed using clam v.2.2 (Blaauw, 2010). Rapid depositional events (horizontal bars) correspond to core sections with low organic content and poor pollen preservations that we interpret as thick floodwater deposits.

At Grassy Lake (GRAS13), the pollen and $\delta^{13}C_{org}$ record begins at ca. AD 1050 (Figure 3.6), the onset of Period III, and pollen assemblages contain high abundances of upland trees (i.e., *Quercus*, *Carya*, *Pinus*), floodplain trees, especially *Salix*, as well as non-arboreal types *Ambrosia*, Poaceae, and Amarathaceae. Several prehistoric agricultural taxa are present in Period III, although *Zea mays* is not. Stable carbon isotope ratios are relatively enriched in Period III (-25.7 to -23.3‰), peaking around AD 1400, and gradually become more depleted throughout Period IV. Pollen assemblages during Period IV include increased abundances of *Salix*, and after ca. AD 1600, Poaceae, as well as decreased abundances of several non-arboreal taxa, including *Ambrosia*, Amaranthaceae, *Helianthus*-type, and *Iva annua*-type. During Period V, $\delta^{13}C_{org}$ values increase and stabilize around -25‰, upland arboreal taxa generally decline, and the non-arboreal *Ambrosia* and Amaranthaceae increase in abundance.

The pollen and $\delta^{13}C_{org}$ record from HORX13 begins at the onset of Period II (Figure 3.7), with high abundances of pollen from upland trees *Quercus* and *Carya*, as well as from floodplain trees *Platanus*, *Ulmus*, *Fraxinus*, *Liquidambar*, and *Salix*, and the ruderal *Ambrosia* from AD 400–600. Around AD 600, $\delta^{13}C_{org}$ values increase up to -22.4‰ and floodplain trees decrease in abundance at the expense of non-arboreal pollen taxa including *Ambrosia*, Poaceae, and Amaranthaceae; additional pollen taxa associated with indigenous seed crops, namely *Iva annua*-type and *Helianthus*-type, are also present in low abundances in Period II. During Period III, $\delta^{13}C_{org}$ values are lower and stabilize around -26.5‰, and arboreal taxa dominate pollen assemblages, representing up to 80% of the terrestrial pollen sum, although Poaceae also increases up to 26% relative abundance. Floodplain arboreal taxa, including *Taxodium*, increase in abundance during Period IV, and remain abundant throughout Period V. Upland arboreal taxa decline during Period IV and into Period V at the expense of *Ambrosia* and floodplain arboreal taxa, while $\delta^{13}C_{org}$ values increase 1 to 2‰ during the historical period.

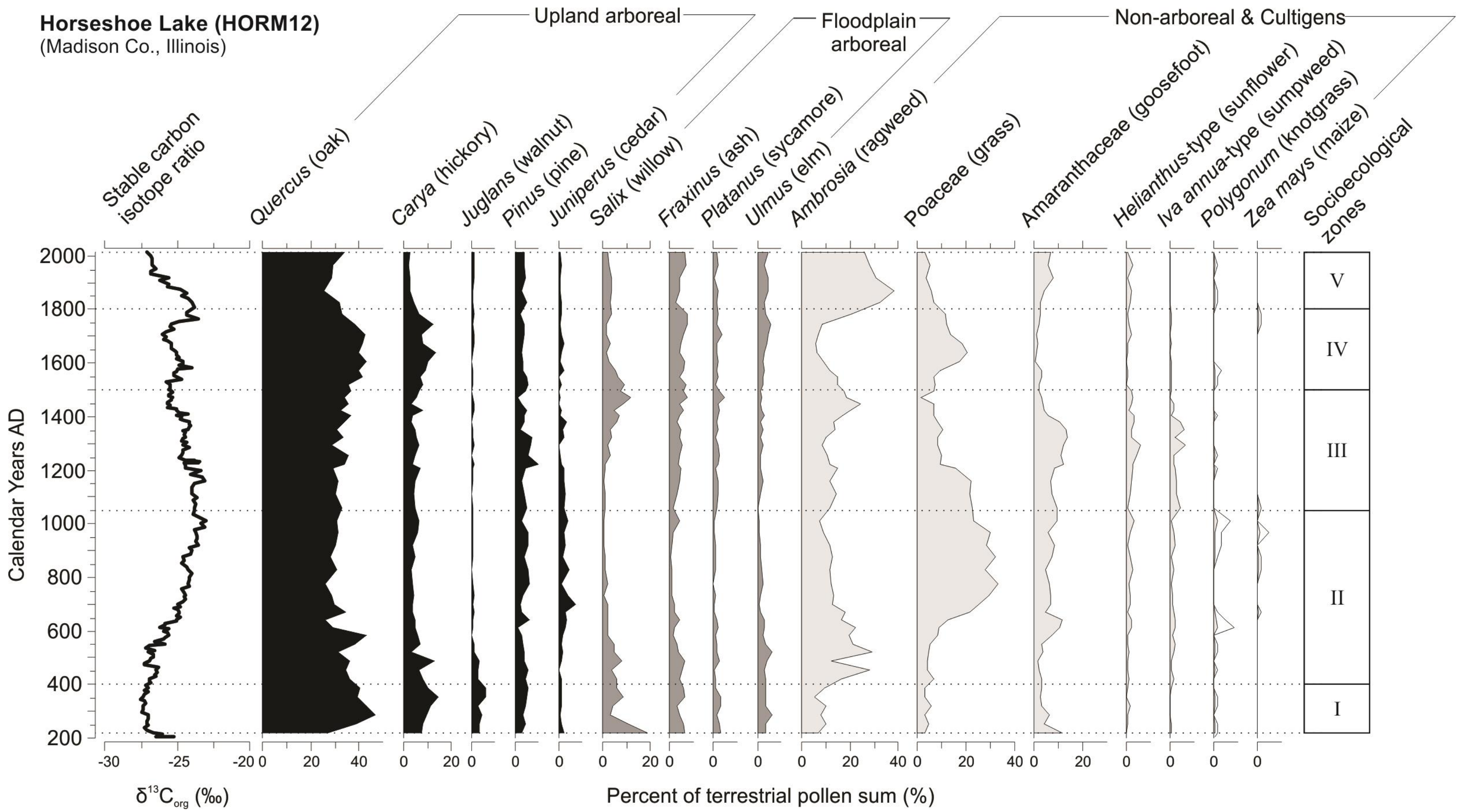

Figure 3.5: Pollen diagram for abundant taxa and stable carbon isotope ratios ($\delta^{13}C_{org}$) from HORM12 plotted alongside Socioecological Periods. Pollen abundances expressed as a percent of the terrestrial pollen sum.

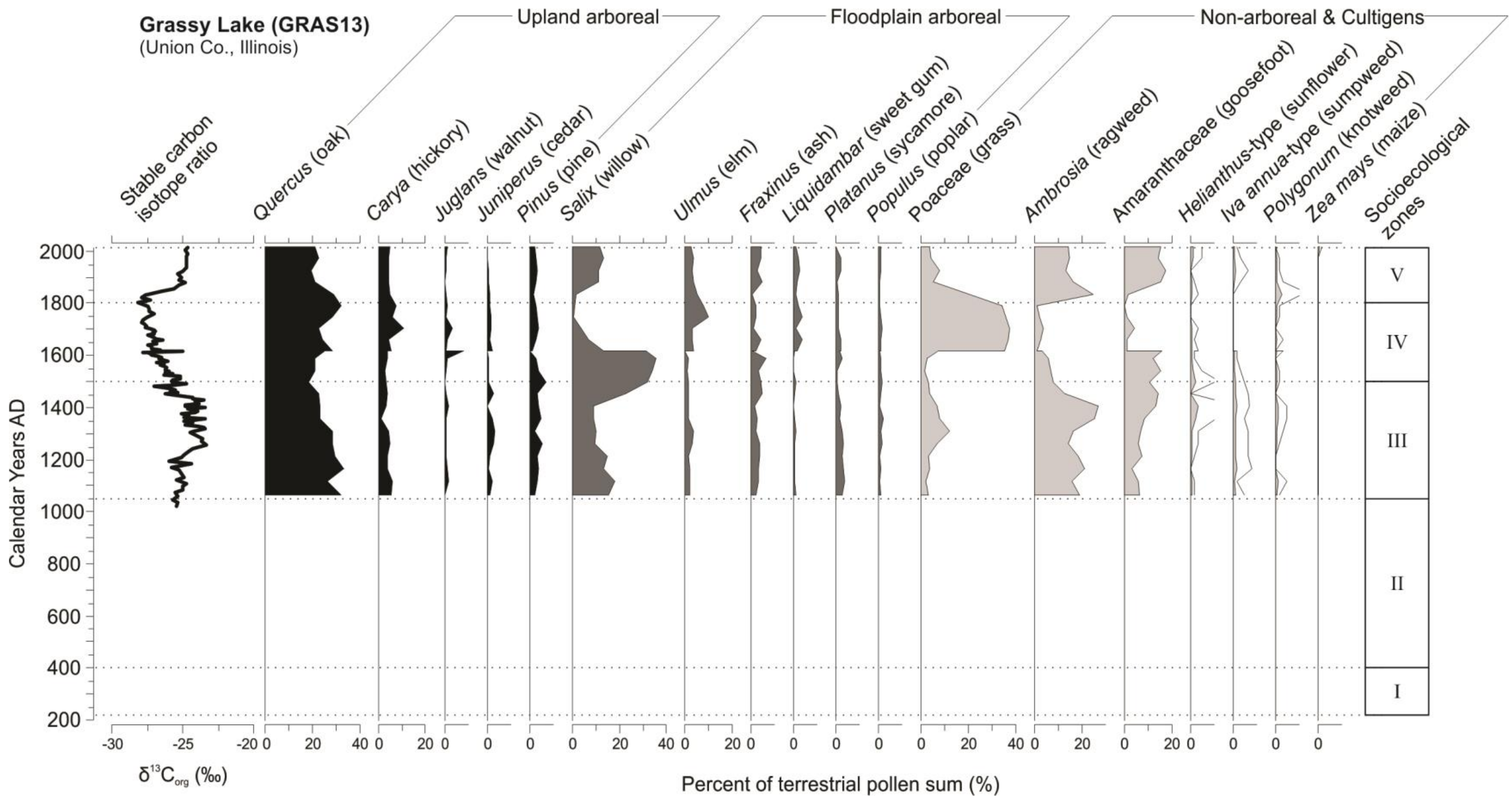

Figure 3.6: Pollen diagram for abundant taxa and stable carbon isotope ratios ($\delta^{13}C_{org}$) from GRAS13 plotted alongside Socioecological Periods. Pollen abundances expressed as a percent of the terrestrial pollen sum.

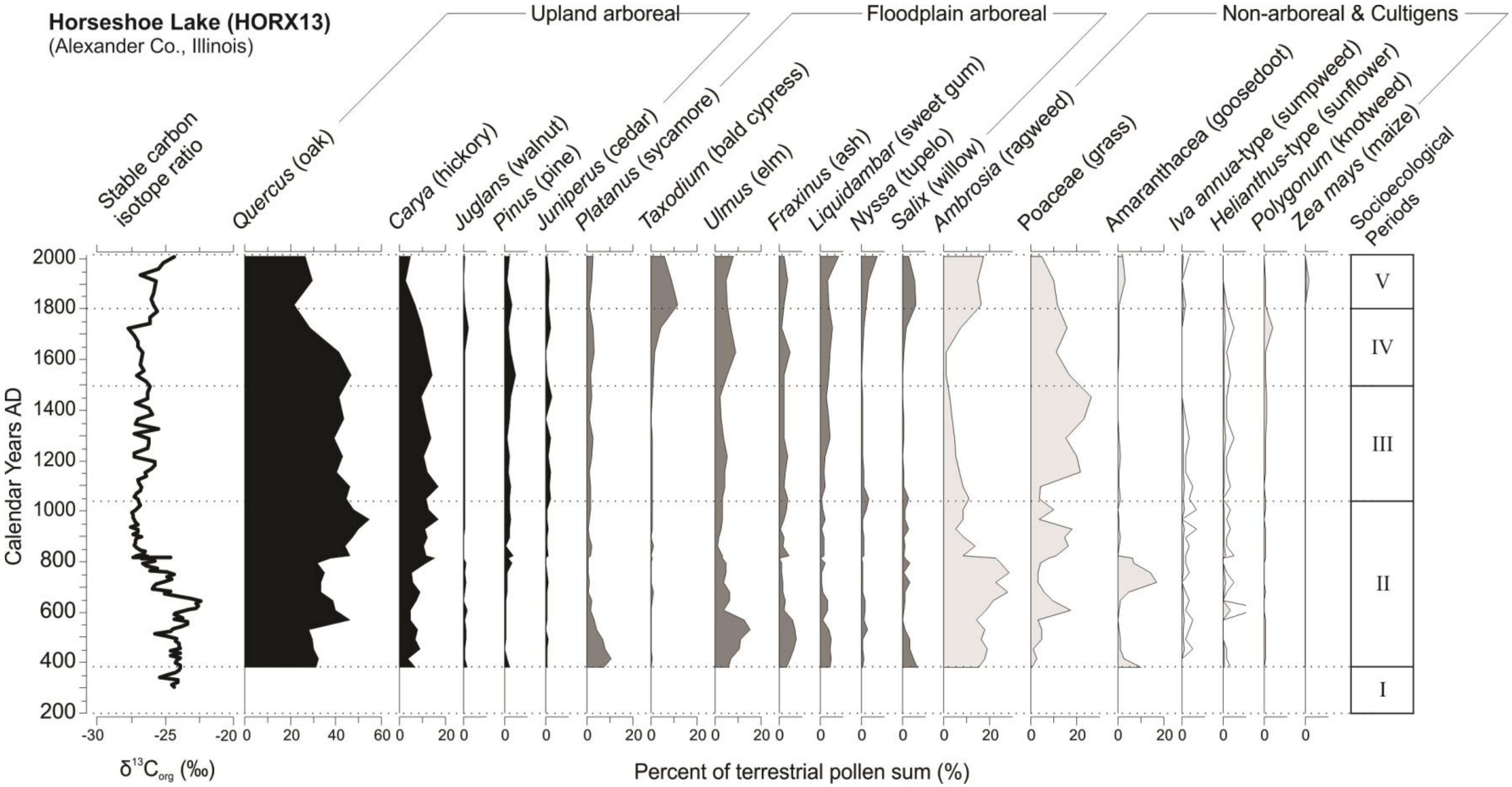

Figure 3.7: Pollen diagram for abundant taxa and stable carbon isotope ratios ($\delta^{13}C_{org}$) from HORX13 plotted alongside Socioecological Periods. Pollen abundances expressed as a percent of the terrestrial pollen sum.

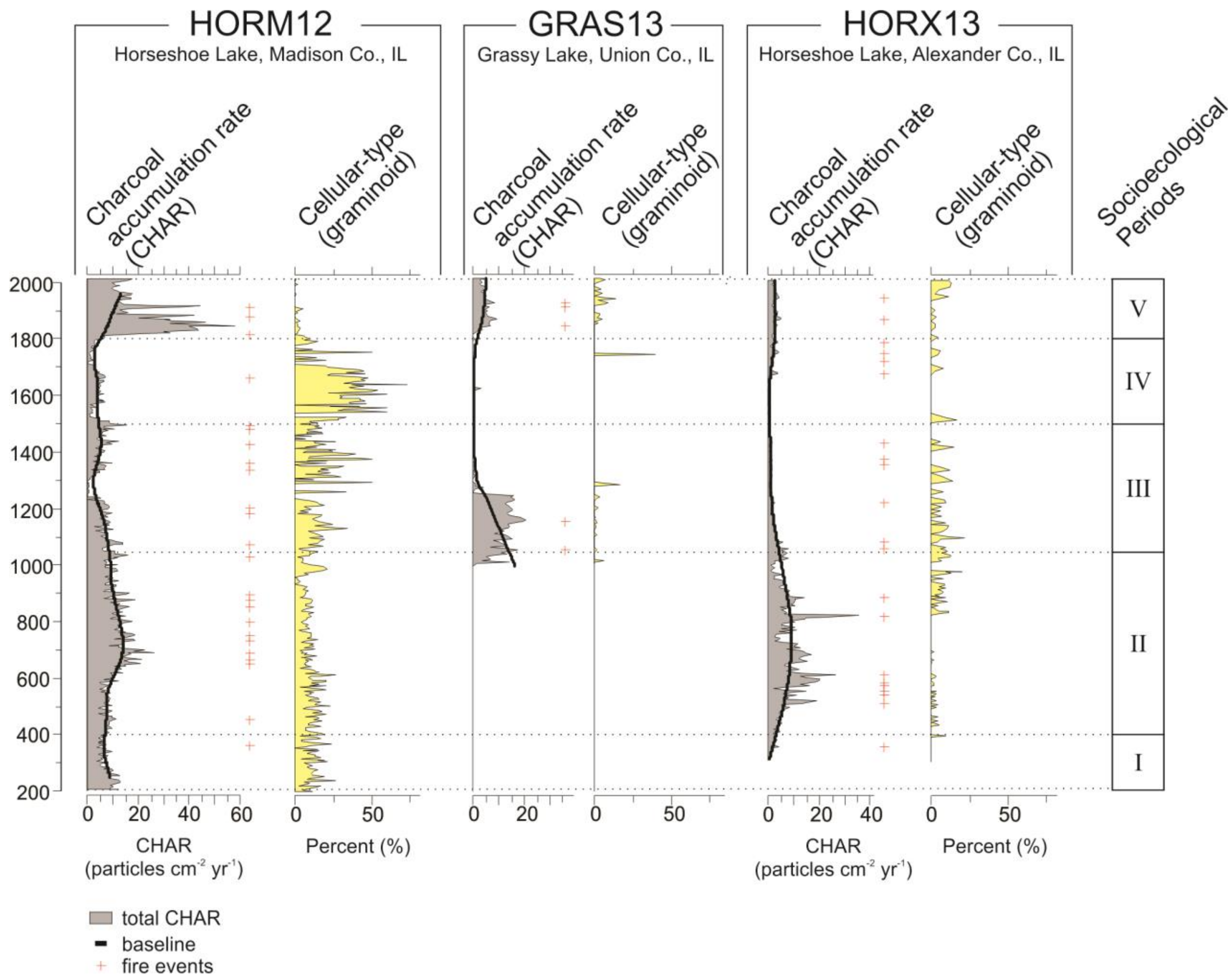

Figure 3.8: Macroscopic charcoal records showing total charcoal accumulation rates (CHAR; grey silhouette), with background (black line) and peak (red crosses) components, and the relative abundance of the cellular charcoal morphotype produced from partially combusted grasses (Jensen *et al.*, 2007; Mustaphi and Pisaric, 2014) from (a) HORM12, (b) GRAS13, and (c) HORX13, plotted alongside Socioecological Periods.

3.4.3 Charcoal

The macroscopic charcoal records from all three sites track shifts in charcoal accumulation rates (CHAR) and charcoal assemblages (i.e., relative abundance of graminoid charcoal) over all five Socioecological Periods (Figure 3.8). During Period I, which is only recorded at HORM12, background charcoal levels moderate (7–10 fragments cm^{-2} yr^{-1}), few individual fires (i.e., significant peaks) are recorded, and graminoid charcoal accounts for no more than 20% of all charcoal fragments. An increase in background CHAR, as well as an increase in the frequency of fire events, is recorded during Period II at both HORM12 and HORX13. Background charcoal levels peak around AD 700 at both HORM12 and HORX13, and gradually decline into Period III. Background charcoal accumulation rates decline at all three sites during Period III, with very low CHAR and infrequent fires at HORX13 and GRAS13. At HORM12, charcoal accumulation rates are relatively low with infrequent peaks during Periods III and IV, but the proportion of charcoal from grasses increases up to 48% of all fragments identified. This increase in the proportion of graminoid charcoal is not observed at the two downstream sites, where charcoal assemblages are dominated by morphotypes associated with trees throughout the records at HORX13 and GRAS13. At all sites, Period V is associated with an increase in CHAR from burning woody material (i.e., not grasses), although accumulation rates are greater at HORM12 than at the two downstream sites during the historical period.

3.5. Discussion

3.5.1 Land use history of the central Mississippi River valley

A suite of human societies with distinctive cultural practices occupied the central Mississippi River valley during the late Holocene, and our paleovegetation records provide new insights into the ways terrestrial ecosystems responded to shifts in settlement patterns and subsistence strategies. In these records, each Socioecological Period is associated with distinct vegetation communities and fire regimes that reflect – to varying degrees – the land-use practices associated with different human adaptations. Agricultural land use, manifested through forest clearance coupled with elevated influxes of woody charcoal, the presence of pollen taxa associated with cultigens (i.e, Poaceae, Amaranthaceae, *Helianthus*-type, *Iva annua*-type, *Polygonum*, *Zea mays*), and elevated stable carbon isotope ratios ($\delta^{13}C_{org}$), is evident during times and in places where agricultural groups were present. For the major pollen taxa encountered in this study, the large surface area of the three lakes sampled implies a pollen source radius on the order of 10^3-10^5 m (Sugita, 1993); the macro-charcoal record, however, originates from a more localized source area, recording biomass burning from within the watershed of each lake (Higuera *et al.*, 2007), although some long-distance transport of large charcoal fragments may occur (Pisaric, 2002). Of all the pollen taxa we encountered associated with prehistoric indigenous agriculture, maize (*Zea mays*) is the most diagnostic indicator of cultivation because it is distinguishable from other genera in the family Poaceae, and undomesticated species of *Zea* do not exist in eastern North America; however, maize pollen is large and poorly dispersed, so its absence in the palynological record may be due to chance, or because cultivation occurred more than ca. 60 m from the lake (Raynor et al., 1972; Lane *et al.*, 2010). We interpret the relative enrichment of $\delta^{13}C_{org}$ as a result of an increase in vegetation openness and higher abundances of maize and other C4 grasses (Lane *et al.*, 2005), and/or increased nutrient inputs and production into the lake (Meyers, 2003), both of which serve as an indicator of land use intensification. Land use associated with silviculture and hunting are manifested more subtly by shifts in the abundances of taxa that were consumed directly or indirectly by the occupying groups, and attributing these changes exclusively to human activities is more challenging and speculative.

Our records begin during Period I (AD 200–400), which is only recorded at the northernmost site (HORM12), when groups occupying the central Mississippi River valley were predominately hunters,foragers, and low-intensity horticulturalists (Fortier *et al.*, 1984; Simon and Parker, 2006). The paleovegetation data from HORM12 (Figure 3.5) indicate that these groups inhabited a largely forested landscape, with floodplain forests in low-lying alluvium and mast-bearing oaks, hickories, and walnuts distributed along higher-elevation ridges, alluvial fans, and colluvial slopes in the floodplain and across the adjacent uplands. Ethnobotanical remains indicate that these Middle Woodland groups in the northern part of the study area collected and processed acorns and a variety of nuts (Johanessen, 1984; Simon and Parker, 2006), so the association of Period I with high abundances of *Quercus* (oak), *Carya* (hickory), and *Juglans* (walnut) may indicate that mast-bearing taxa were protected, or even cultivated, at this time. Ethnohistorical accounts describe the promotion of mast-bearing trees among indigenous groups across North America using a variety of techniques (Doolittle, 2000; Keeley, 2002; Anderson, 2006), and analyses of historical vegetation surveys have documented these silvicultural plant communities in several areas of the Eastern Woodlands (e.g., Foster *et al.*, 2004; Black *et al.*, 2006). Indigenous silviculture has been more challenging to document in paleoecological records (Munoz *et al.*, 2014a), but the high abundances of mast-bearing taxa during Period I, coupled with the decline of these mast-bearing taxa – and the nearly complete absence of *Juglans* – after AD 400 when the subsistence practices of the area's occupants shifted towards a greater focus on food production, may provide some of the clearest evidence of prehistoric Native American silviculture to date.

Recorded at both the northern HORM12 and southernmost HORX13 sites, Period II (AD 400–1050) begins when the central Mississippi River valley was re-occupied by groups that placed a greater emphasis on food production, namely the cultivation of indigenous seed crops (Fortier and Jackson, 2000; McElrath and Fortier, 2000; Koldehoff and Galloy, 2006; Simon and Parker, 2006). Both of our paleovegetation records that document Period II, HORM12 (Figure 3.5) and HORX13 (Figure 3.7), respectively at the northern and southern ends of the study area, indicate that floodplain and upland forests were abruptly replaced with more open vegetation communities containing a mix of ruderals and indigenous seed crops at this time. The timing and characteristics of this vegetation transition imply that it is the product of agricultural land use by Late Woodland groups, who were mobile farmers thought to have practiced a form of shifting cultivation where forest clearings were created and scattered with the seeds of indigenous seed crops (Simon, 2000; Koldehoff and Galloy, 2006). Based on the elevated accumulation rates of woody charcoal during Period II (Figure 3.8), these clearings were evidently created with the aid of fire, perhaps using an approach similar to that of historical Iroquoian groups who facilitated tree removal with stone axes by first stripping the bark and branches off of trees and burning them at the base of the tree (Heidenreich, 1971; Sykes, 1980; Gartner, 2003). Despite their relatively low population densities, the mobile and hroticultural subsistence strategy of the groups associated with Period II had a proportionally extensive influence on vegetation communities and fire regimes by clearing forested areas along much of the central Mississippi River valley.

The onset of Period III (AD 1050–1500), recorded by all three sites, is associated the formation of Cahokia and other large population centers of the Mississippian tradition that drew thousands of individuals to the central Mississippi River valley where they were concentrated around mound centers (Pauketat, 1994; Pauketat and Lopinot, 1997; Milner, 1998). Mississippian population centers were occupied year-round, and both maize and indigenous seed crops were likely cultivated in large permanent outlying fields as well as in smaller domestic gardens (Fowler, 1969; Woods, 1987; Scarry, 1993; Yerkes, 2005; Simon and Parker, 2006). In the central Mississippi River valley, population centers including Cahokia were more concentrated at the northern end of the study region where HORM12 is located, while GRAS13 was surrounded by just two known centers (the Linn-Heilig and Ware sites), and HORX13 has just one known

Mississippian mound center, the Dogtooth Bend site, ca. 10 km southwest of the core site (Figure 3.1). As a consequence of this settlement density gradient, agricultural land use – manifested through the replacement of arboreal pollen with that of ruderals and/or cultigens, and the enrichment of stable carbon isotopes – is most strongly expressed at HORM12 (Figure 5), and more moderately so at GRAS13 (Figure 3.6), but not at HORX13 (Figure 3.7) during Period III. Charcoal accumulation rates are similarly elevated at sites with nearby Mississippian occupations, but decline to very low levels at HORX13 (Figure 3.8), presumably because Mississippian settlement around that site were very sparse. In contrast to the more spatially extensive shifting cultivation associated with the Late Woodland groups of Period II, the permanent cultivation of Mississippian groups appears to have been patchier and more focused around population centers, as it is only discernible in the paleoecological records from HORM12 and GRAS13 that are near large Mississippian mound centers.

The cultural prominence and population size of Cahokia and neighboring Mississippian centers began to decline around AD 1200, and by the beginning of Period IV (AD 1500 – 1800) human occupation in the central Mississippi River valley dropped below archaeological visibility (Milner, 1998; Fortier *et al.*, 2006). In all three of our paleovegetation records (Figures 3.5–3.7), this period is associated with the return of both upland and floodplain trees, an overall reduction of biomass burning, and depleted organic carbon isotope ratios, all of which are consistent with agricultural contraction across the study area. This period, however, is distinct from the pre-agricultural landscape of Period I because of the high abundances of pollen from grasses (Poaceae) observed at all three sites, as well as an increase in the proportion of charcoal produced from grasses at HORM12 (Figure 3.8), both of which indicate that prairie communities expanded at this time. The eastward migration of the prairie-forest border during the early Holocene was associated with a warmer and drier midcontinent (McAndrews, 1966; Webb *et al.*, 1983; Nelson and Hu, 2008; Williams *et al.*, 2009), but the more recent expansion of prairies we observe around AD 1500 does not coincide with regional aridity (e.g., Woodhouse and Overpeck, 1998; Daniels and Knox, 2005; Cook *et al.*, 2010). This expansion of prairies also coincides with an increase in the population of bison (*Bison bison*) in Illinois, when bison remains become prevalent in archaeological sites from the eastern Great Plains to the north and northwest of our study area (Tankersley, 1992; Brown and Sasso, 2001; McMillan, 2006). Thus, a possible interpretation of this prairie expansion is that it resulted from indigenous hunting practices focused on the management of bison herds. Ethnohistorical accounts of the late 17th and 18th centuries describe large communal bison hunts by indigenous groups associated with the Illinois confederacy that often occurred hundreds of kilometers away from villages, in prairies maintained by periodic indigenous burning (Brown and Sasso, 2001; Shackelford, 2008; Morrissey, 2015). The uplands adjacent to the central Mississippi River valley were likely one such hunting ground, as they are described in AD 1750 by the Jesuit missionary Louis Vivier as being regularly burned by indigenous peoples (Thwaites, 1899: vol. 69, p. 207). The land-use practices we interpret as being associated with indigenous hunting involved relatively subtle shifts in vegetation composition that extended across the central Mississippi River valley, and may have been generated by hunting parties that passed through the area periodically (cf. Waselkov, 1978; Foster and Cohen, 2007).

The settlement of the central Mississippi River valley by Anglo-American peoples during Period V (AD 1800–present) is characterized at all sites by an increase in ragweed (*Ambrosia*) pollen spurred by the rapid replacement of forests and prairies with farms and settlements (Figs. 5–7). This episode of land clearance, well documented in paleoecological records across eastern North America (McAndrews, 1988), is also associated with elevated levels of biomass burning at all sites, with the highest charcoal accumulation rates around the more heavily populated Saint Louis area (Figure 3.8). Our paleovegetation records also document the reduction of biomass burning and forest recovery during the 20th century noted elsewhere, which are associated with fire suppression, industrialization, and conservation efforts over the last century (Marlon *et al.*, 2008; 2013).

Our study integrates paleovegetation data with the detailed archaeological and historical records available for the central Mississippi River valley, and offers a unique opportunity to examine a North American land-use history that extends well into prehistory. In our interpretation of the paleovegetation data, we have focused almost exclusively on land use as the driver of ecological changes over the last ca. 2,000 years. Significant climatic variability also occurred in the Midcontinent at this time, and this variability also likely affected vegetation communities in the study area. As with all interpretations, alternative ones are possible, but we have sought explanations of our data that conform to the occupational and environmental histories of our study area. Other locations, both within eastern North America and elsewhere, that were not the focal point of so much human activity, may not be appropriate to examine through the lens of human agency. In the central Mississippi River valley, however, the shifts in vegetation composition and fire regimes we document are consistent with the archaeological and historical record. In short, multiple lines of evidence document forest clearance during times and in places where shifting or more permanent cultivation occurred. When the area was not occupied by agricultural groups, more subtle forms of land use associated with foraging and hunting may have been practiced. Confirming these interpretations will require additional records adjacent to archaeological sites with well-established chronologies, improved taxonomic resolution of pollen taxa associated with prehistoric agriculture, and new proxies that document other dimensions of environmental change.

3.5.2 Indigenous land use: extent, intensity & fire

We propose a generalized model that describes the influence of cultural practices on the extent and intensity of indigenous land use in eastern North America (Figure 3.9). In unoccupied or very lightly occupied areas, land use legacies from prior occupations could persist (e.g., Finlayson *et al.*, 1998; Foster *et al.*, 2003), but human impacts would eventually become indistinguishable from the surrounding environment. When an area was occupied, the extent and intensity of impacts on vegetation communities depended on the type of land use practiced. Hunting and foraging created subtle compositional shifts in plant communities of lower intensity, but their impacts tended to occupy larger territories because they yielded less food per unit area (Binford, 1999; Smith, 2011b; Kelly, 2013). As the efficiency of food production, storage, and distribution increased, the need for large territories declined (Hamilton *et al.*, 2007; Freeman and Anderies, 2015), such that the spatial extent of shifting cultivation and permanent cultivation progressively decreased as the intensity of use increase. Indigenous cultures often practiced multiple forms of land use simultaneously (e.g., cultivation with hunting and foraging), and would have created overlapping land-use footprints with more lightly managed hunting and foraging territories extending away from more intensively managed agricultural fields and gardens.

In addition, we propose that indigenous fire regimes in eastern North America were also strongly dependent on cultural practices (Figure 3.9). Human populations exert control over fire regimes by modifying the timing and frequency of ignitions, but also by altering fuel type and connectivity through land use (e.g., Pyne, 1994; Guyette *et al.*, 2002; Bowman *et al.*, 2011; Archibald *et al.*, 2012). In the temperate deciduous forests of eastern North America, fires were relatively infrequent during times and in places where indigenous groups were absent or nearly absent. When an area was used primarily for hunting and foraging, the frequency of ignitions increased; these fires were allowed to unimpeded burn across large territories, but biomass burning was moderated by the sparse and mobile populations associated with these subsistence strategies. Biomass burning was also moderate in areas where permanent cultivation was practiced because burning was discouraged near densely populated settlements, and because the presence of agricultural fields fragmented fuel loads and limited the spread of fires. The highest levels of biomass burning in occurred in areas used for shifting cultivation, where populations were of moderate density but remained mobile, and regularly used fire to clear forests in preparation for planting crops. Each type of indigenous land use was thus associated with a distinct fire regime, and while indigenous populations did generally increase the frequency of fires, biomass burning could also be suppressed in densely settled areas where permanent cultivation was practiced.

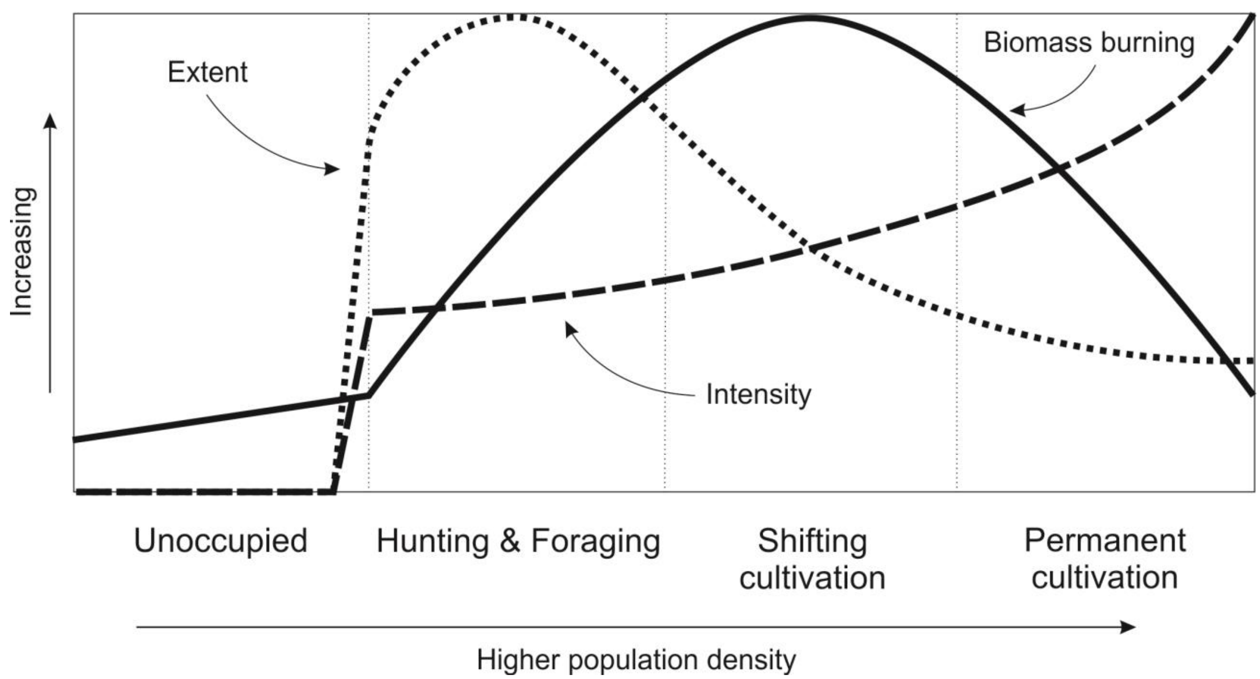

Figure 3.9: A conceptual model of cultural influences on land-use extent (short-dashes), intensity (long-dashes), and biomass burning (solid line) for the indigenous peoples of eastern North America.

3.6 Conclusions

We describe three multi-proxy paleovegetation records that span the central Mississippi River valley in the context of five socioecological periods that are based on shifts in subsistence strategies and settlement patterns documented in archaeological and historical records. The vegetation communities and fire regimes of the central Mississippi River valley have been influenced, to varying degrees, by human activities over nearly the last two millennia. Cycles of occupation, abandonment, and re-occupation by distinct human cultures are associated with shifts in terrestrial ecosystems that reflect different forms of land use. Foraging for wild plant foods was associated with extensive upland forests dominated by mast-bearing trees, and moderate levels of biomass burning, that may be the product of silvicultural land use. Shifting cultivation was characterized by the replacement of forests with cultivars, and high levels of biomass burning. Permanent cultivation was also associated with an open landscape and cultivars, but with lower levels of biomass burning. Hunting may be associated with increased burning of grasses and the expansion of prairies, but the effects on non-agricultural indigenous land use on vegetation communities are harder to disentangle from other drivers of ecological change. Historical agriculture by Anglo-American peoples was associated with high levels of biomass burning and the replacement of forests and prairies with fields and settlements. In these ways, the ecosystems of the central Mississippi River valley have been repeatedly shaped to suit the economic needs of its occupants. Our study traces the evolution of a cultural landscape in eastern North America over nearly two millennia, and shows how different land-use practices are expressed on the landscape.

3.7 Acknowledgments

We wish to thank Richard Brugam, Simon Goring, Eric Grimm, Steve Jackson, John Kelly, Brad Koldehoff, Joe Mason, David Mladenoff, and Mutlu Ozdogan for discussions. We gratefully acknowledge field and/or laboratory assistance by Spencer Atkinson, Jessica Blois, Kevin Burke, Jacquelyn Gill, Johnny Kershner, Sam Knapp, Mason Martinez, Dwight McCay, Grace Schellinger, Brigitta Rongstad, and Chad Zirbel, and thank Kristina Brady, Amy Myrbo, Anders Noren, and Ryan O'Grady for help with initial core processing at the National Lacustrine Core Facility (LacCore). Lake access to all sites was provided by the Illinois Department of Natural Resources. This work was supported by the NSF (grants BCS-1333070 and DGE-1144754), the National Science and Engineering Council of Canada (grant PGSD2-392407), the National Geographic Society (grant YEG-9008-11), the Geological Society of America, LacCore, and a Packard Fellowship to David Fike.

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Chapter 4: Cahokia's emergence and decline coincided with shifts of flood frequency on the Mississippi River

Note: This chapter was published as a research report in *Proceedings of the National Academy of Sciences*, doi: 10.1073/pnas.1501904112, and is accessible online at: http://www.pnas.org/content/early/2015/04/29/1501904112.abstract. Co-authors of this chapter include Kristine Gruley, Ashtin Massie, David Fike, Sissel Schroeder, and John W. Williams, who helped conceive ideas, perform analyses, and/or provided comments on drafts of the manuscript. Slight modifications have been made to this version of the manuscript.

Abstract

Here we establish the timing of major flood events of the central Mississippi River over the last 1,800 years, using floodwater sediments deposited in two floodplain lakes. Shifts in the frequency of high-magnitude floods are mediated by moisture availability over midcontinental North America, and correspond to the emergence and decline of Cahokia – a major late prehistoric settlement in the Mississippi River floodplain. The absence of large floods from A.D. 600–1200 facilitated agricultural intensification, population growth, and settlement expansion across the floodplain that are associated with the emergence of Cahokia as a regional center around A.D. 1050. The return of large floods after A.D. 1200, driven by waning midcontinental aridity, marks the onset of sociopolitical reorganization and depopulation that culminate in the abandonment of Cahokia and surrounding region by A.D. 1350. Shifts in the frequency and magnitude of flooding may be an underappreciated but critical factor in the formation and dissolution of social complexity in early agricultural societies.

Significance Statement

Our paper evaluates the role that flooding played in the emergence and decline of Cahokia – the largest prehistoric settlement in the Americas north of Mexico that emerged in the floodplain of the Mississippi River around A.D. 1050. We use sediment cores to examine the timing of major Mississippi River floods over the last 1,800 years. These data show that Cahokia emerged during a period of reduced mega-flood frequency associated with heightened aridity across midcontinental North America, and that its decline and abandonment followed the return of large floods. We conclude that shifts in flood frequency and magnitude facilitated both the formation and breakdown of Cahokia, and may be important factors in the declines of other early agricultural societies.

4.1 Introduction

The episodic breakdowns of early agricultural societies, many of which were situated in the floodplains of major rivers, are often attributed to episodes of severe drought (deMenocal, 2001; Giosan *et al.*, 2012; Dixit *et al.*, 2014) that correlate with cascading social and environmental feedbacks (Butzer, 2012; Middleton, 2012). The causes of the decline and abandonment of Cahokia, a major late prehistoric population center that emerged in the floodplain of the central Mississippi River (Milner, 1998), remain unclear but have also been attributed to drought (Benson *et al.*, 2009), as well as resource over-exploitation (Lopinot and Woods, 1993), intergroup conflict, and sociopolitical factionalism and upheaval (Pauketat, 1994; Milner, 1998; Kelly, 2009). Here, we present evidence that Cahokia emerged during a multi-centennial period of enhanced midcontinental aridity that inhibited the occurrence of high-magnitude floods on the central Mississippi River, and that Cahokia's decline and abandonment correspond to an increase in the frequency of large floods. These findings imply that the disintegration and dissolution of Cahokia may be, in part, societal responses to enhanced hydrological variability in the form of high-magnitude flooding.

Cahokia's emergence as a regional center can be traced to the population growth and intensified cultivation of native domesticates that began around A.D. 400 in the floodplain of the central Mississippi River near modern-day Saint Louis, Missouri (Milner, 1998; Simon and Parker, 2006; Munoz *et al.*, 2014). By A.D. 1050, Cahokia emerged as a hierarchically-organized cultural and political center in this region, which was inhabited by tens of thousands of individuals supported in part by the cultivation of native domesticates and maize (Pauketat and Lopinot, 1997; Milner, 1998). Settlements affiliated with Cahokia were concentrated on higher-elevation ridges in the floodplain with access to a variety of resources (Schroder, 2004), with no evidence that irrigation canals were constructed in this moist and temperate region. Populations in the Cahokia region continued to grow until ca. A.D. 1200, when the region's population size and cultural prominence began to decline (Milner, 1998; Trubitt, 2000; Kelly, 2009), and by A.D. 1350 Cahokia and the surrounding region were almost completely abandoned (Milner, 1998).

Archaeologists have previously recognized the possibility that large floods could have affected the sociopolitical stability of Cahokia by disrupting food production and storage, damaging houses, and motivating individuals to relocate (Kelly *et al.*, 1984; Milner, 1998; Kelly, 2009). Before the establishment of modern flood control infrastructure in the early 20th century (Dobney, 1978), large floods like the A.D. 1844 event inundated extensive tracts of the central Mississippi River floodplain (Figure 4.4), forcing residents to evacuate and causing widespread destruction (Milner, 1998, see Supplemental Text). Past shifts in the locations of house basins and storage pits along elevational gradients in the Mississippi floodplain have been interpreted as indirect evidence for changing hydrological conditions (Kelly *et al.*, 1984; Milner, 1998; Kelly, 2009), but direct evidence of flooding is rare in archaeological excavations from the Cahokia area (e.g., Kelly, 1980).

Figure 4.1: Locations of Horseshoe Lake, Grassy Lake, Cahokia, and other Late Prehistoric population centers in the central Mississippi River valley. Inset: Mississippi Basin and major tributaries (blue) in the United States.

Here, we reconstruct the timing of major flood events in the Cahokia area using floodwater sediments deposited in floodplain lakes (Gilli *et al.*, 2013). During flood stages that hydrologically connect the main channel with floodplain lakes, floodplain lakes act as sediment traps that allow the suspended load of floodwaters to fall out of suspension (Gilli *et al.*, 2013; Glur *et al.*, 2013). The composition of floodwater sediments usually differs from locally sourced sediment deposited during non-flood conditions, particularly in grain-size distribution (Gilli *et al.*, 2013). Across the wide floodplain of a low-gradient river like the Mississippi, overbank floods deposit well-sorted fine silt- and clay-sized sediments in distal floodplain lakes and depressions (Grover, 1938; Kesel, 1974; Gomez *et al.*, 1997). Analysis of sediment records from multiple basins in similar geomorphic settings along the same river ensures that identified flood events are not due to localized erosion or flooding from tributaries (Glur *et al.*, 2013).

Sediment cores were obtained from two floodplain lakes in the central Mississippi River valley that are abandoned channels of the Mississippi River: Horseshoe Lake (HORM12; Madison County, Illinois; 38.704767°N, 90.081279°W) situated 5 km northwest of Cahokia, and Grassy Lake (GRAS13; Union County, Illinois; 37.431701°N, 89.377466°W) located 190 km downstream from Cahokia (Figure 4.1). Both lakes are young features of the high-sinuosity meander belt that formed before the main channel stabilized during the late Holocene into a narrow low-sinuosity meander belt (Hajic, 1993). Before the 20th century, Horseshoe Lake attained surficial hydrological connectivity with the Mississippi River only during high-magnitude floods (> 10 m stage at Saint Louis), that inundated the majority of the floodplain around Cahokia (Figure 4.5). Modern flood-control infrastructure now isolates Horseshoe Lake from floods (Dobney, 1978; Karthic *et al.*, 2013) including the A.D. 1993 flood (NASA Landsat Program, 1993).

4.2 Results and Discussion

The sediment cores collected from Horseshoe and Grassy Lakes are predominately dark-brown massive silts interbedded with distinct light gray to pale brown layers of well-sorted silty clay that we interpret as floodwater sediments deposited by the Mississippi River (Figure 4.2). These floodwater sediments are similar in texture to the sediments deposited in floodplain lakes and depressions by historical overbank Mississippi River floods (Grover, 1938; Kesel, 1974; Gomez *et al.*, 1997), and their low organic content and low concentrations of microfossils (Munoz *et al.*, 2014) is consistent with floodwater sediments identified in previous paleohydrological studies (Gilli *et al.*, 2013). At both sites, the first principal component (PC1) of grain-size distributions is closely correlated to median grain size and uniformity, and PC1 explains >55% of grain-size variance. We define samples with scores in the upper quartile of PC1 as floodwater sediments. These samples have median grain sizes that are significantly lower ($p < 0.005$; paired t-tests) and more uniform than non-floodwater sediments. To establish the timing of flood events, *bacon* Bayesian age-depth models (Blaauw and Christen, 2011) were constructed for both cores (Figure 4.6) based on seventeen radiocarbon dates from terrestrial plant macrofossils (Table 4.1), core tops, and the timing of Anglo-American settlement based on the recent increase of *Ambrosia*-type pollen (Munoz *et al.*, 2014).

Based on the criteria described above, we identify eight flood events at Horseshoe Lake and five at Grassy Lake (Figure 4.2). The five most recent floodwater deposits (Flood Events I–V) in Horseshoe Lake at A.D. 1810 (A.D. 1780–1880), A.D. 1630 (A.D. 1570–1720), A.D. 1520 (A.D. 1480–1640), A.D. 1400 (A.D. 1340–1510), A.D. 1200 (A.D. 1080–1250) (ages reported as the mode and 95% confidence interval of probability density functions generated by *bacon*) temporally coincide with the five flood events recorded in Grassy Lake at A.D. 1800 (A.D. 1760–1880), A.D. 1570 (A.D. 1530–1730), A.D. 1500 (A.D. 1460–1670), A.D. 1390 (A.D. 1300–1570), 1200 (A.D. 1000–1310); assuming that these five deposits represent the same floods, the joint age estimates for these five floods narrow to A.D. 1800 (A.D. 1780–1870), A.D. 1590 (A.D. 1550–1730), A.D. 1510 (A.D. 1470–1590), A.D. 1400 (A.D. 1340–1460), A.D. 1200 (A.D. 1100–1260) (Figure 4.7; Table 4.2). The topmost event in both lakes corresponds with the large A.D. 1844 flood that inundated most of the central Mississippi River's floodplain (Dobney, 1978; Milner, 1998; see Supplemental Text), including the area around Cahokia (Figure 4.4), but the other seven identified flood events pre-date the instrumental record. The three older floodwater deposits (Flood Events VI – VIII) in Horseshoe Lake at A.D. 580 (A.D. 510–630), A.D. 490 (A.D. 440–560), and A.D. 280 (A.D. 160–320) pre-date the formation of Grassy Lake. The synchronicity of the five most recent flood events at these two distant sites, and the correspondence of Flood Event I to a historically documented flood, strongly indicates that these floodwater sediments originated from the Mississippi River during high-magnitude floods.

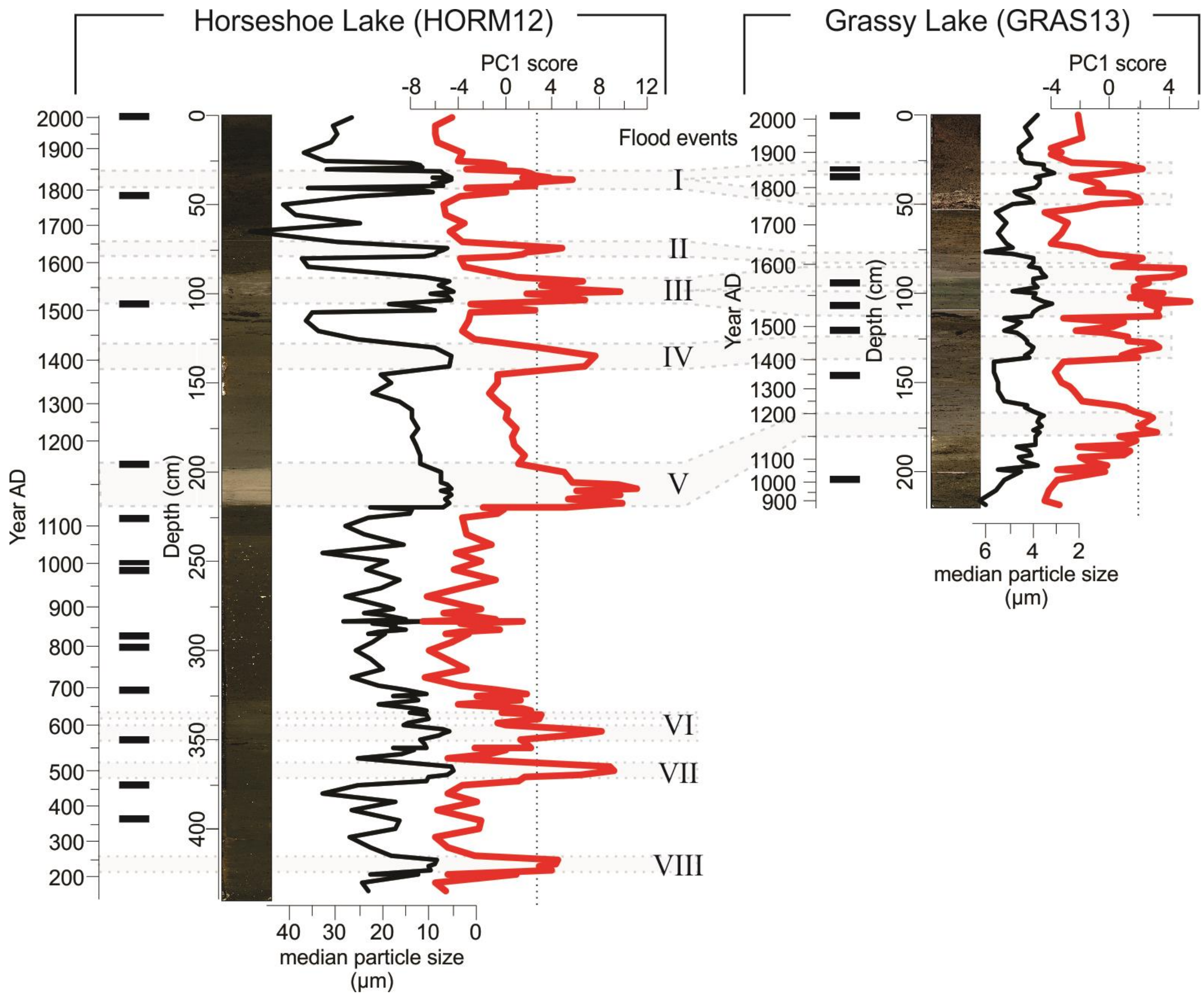

Figure 4.2: Median particle size and first principal component (PC1) scores for Horseshoe Lake (left) and Grassy Lake (right) alongside composite core photographs by depth from surface-water interface. Depths of chronological controls used in age-depth model are marked with black boxes. Flood Events (numbered I – VIII) are denoted with grey horizontal bars.

The frequency of large floods in the central Mississippi River has shifted over the last two millennia (Figure 4.3) as a result of atmospheric circulation patterns that promote or suppress precipitation over midcontinental North America (Knox, 2000; 2003; Montero-Serrano *et al.*, 2010). At Cahokia, large floods are concentrated in two intervals from ca. A.D. 300–600 and ca. A.D. 1200–1850. These intervals correspond to large flood events on the upper Mississippi River (Knox, 2003), and occur during periods of greater moisture availability over the midcontinent (Montero-Serrano *et al.*, 2010; Daniels and Knox, 2005). In contrast, no large floods occur between ca. A.D. 600–1200, when more arid conditions are documented across central North America (Montero-Serrano *et al.*, 2010; Daniels and Knox, 2005; Woodhouse and Overpeck, 1998;

Cook *et al.*, 2010; Trouet *et al.*, 2013). The close correspondence between midcontinental aridity and Mississippi River flood history implies that decreased moisture availability over the Missouri and Upper Mississippi River basins inhibited the intensive run-off from rainfall and/or snowmelt required to generate large floods (Knox, 2000; 2003) that would have inundated Cahokia, neighboring settlements, and croplands in the floodplain of the central Mississippi River.

Shifts in the frequency and magnitude of flood events in the central Mississippi River valley also correspond with changes in settlement patterns, population size, and land use that define Cahokia's emergence and decline (Figure 4.3). Intensified cultivation of native domesticates in the central Mississippi River valley began during the early Late Woodland period, around A.D. 400–650 (Fortier *et al.*, 2006; Simon and Parker, 2006; Munoz *et al.*, 2014), when known settlements were concentrated on higher elevation alluvial fans and terraces along the edge of the floodplain (Kelly *et al.*, 1984; McElrath and Fortier, 2000). The absence of large floods from A.D. 600–1200 corresponds to the expansion of settlements to lower-elevation floodplain ridges that are separated by swales, sloughs, and old meander scars (White *et al.*, 1984; Hajic, 1993; McElrath and Fortier, 2000; Schroeder, 2004), an increase in settlement numbers (Milner, 1998; McElrath and Fortier, 2000), and continued intensification in the cultivation of native domesticates, and, after ca. A.D. 900, maize (Simon and Parker, 2006; Munoz *et al.*, 2014). At A.D. 1050, towards the end of this multi-centennial period of midcontinental aridity and infrequent large floods, Cahokia emerged as a hierarchically-organized regional center that drew thousands of people from across the midcontinent (Milner, 1998; Slater *et al.*, 2014).

At the height of Cahokia's size and cultural prominence, Flood Event V (ca. A.D. 1200) – the first large flood event in over 500 years – was of a magnitude sufficient to inundate croplands, food caches, and settlements across most of the floodplain, and would have forced residents to temporarily relocate to the higher elevations available along the edge of the floodplain and adjacent uplands. Floods in the central Mississippi River valley typically occur during the growing season (Dobney, 1978; Knox, 2003), and unexpectedly high water levels at this time would have made most of floodplain uninhabitable, and created serious and persistent agricultural shortfalls for Cahokia's residents by destroying both crops and the agricultural surpluses from previous years stored in underground pits. After floodwaters receded, considerable effort would be required by the region's residents to rebuild in place, clear fields of the sediment and debris that overbank floods deposit unevenly across the floodplain (Grover, 1938; Kesel, 1974;

Gomez *et al.*, 1997), and restore food production to pre-flood levels. Neighboring communities at higher elevations were not directly affected by flooding, but they likely played an important role during the flood by absorbing refugees from Cahokia and other settlements inundated by floodwaters, and providing labor, materials, and food in the flood's aftermath. Maintaining political authority over this dispersed and fragmented population would have posed a significant challenge to a complex non-state society like Cahokia, as similar societies around the world are typically limited in their ability to exert a strong and persistent hegemony over areas > 40 km in diameter (Hally *et al.*, 1990; Hally, 1993). Through its direct and indirect impacts on the stability of the Cahokia region's economy and the welfare of its inhabitants, this large and unprecedented flood held the potential to reshape the region's sociopolitical dynamics long after the floodwaters receded.

Environmental perturbations often trigger a societal reorganization that either initiates societal breakdown or fosters resilience, with the outcome mediated by the preparedness and response of established social, political, and ideological institutions (Butzer, 2012; Middleton, 2012; Meeks and Anderson, 2013). Extensive inundation of the floodplain was unprecedented for the sociopolitical system established at Cahokia, and the return of large floods at ca. A.D. 1200 at the onset of regional depopulation (Milner, 1998), agricultural contraction (Munoz *et al.*, 2014), political decentralization (Trubitt, 2000), the construction of defensive palisades (Iseminger, 1990), destruction of outlying population centers (Kelly, 2009; Pauketat *et al.*, 2013), and decline of monumental construction at Cahokia (Kelly, 2009), implicate flooding as a factor in the reorganization of Cahokia's sociopolitical structure that initiated its decline. In contrast to the large Mississippi River floods of the 19th century that fostered resilience and motivated legislation aimed at preventing damage from flooding (Dobney, 1978), Cahokia's leaders appear to have been unable to maintain the impression of security and stability following the economic upheaval created by the return of large floods. Sociopolitical disintegration progressed over the following century as the residents of the Cahokia area continued to relocate to other regions; by A.D. 1350 the sociopolitical system centered on Cahokia had completely dissolved (Pauketat, 1994; Milner, 1998).

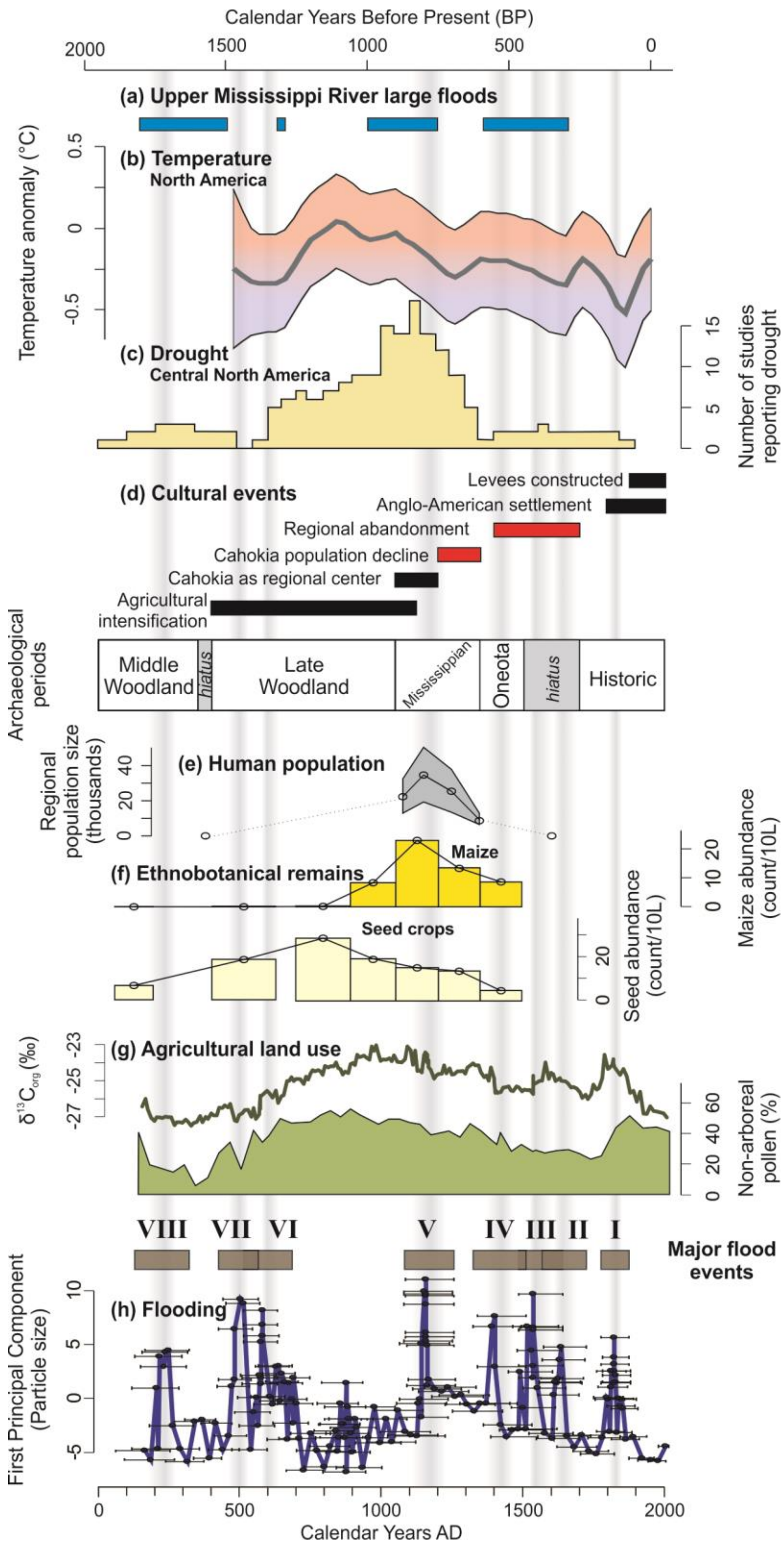

Figure 4.3: Record of major flood events from Horseshoe Lake (H, this study) plotted against paleoclimatological (a-c), archaeological (d-f), and paleoecological records (g) from Cahokia and midcontinental North America. Proxy evidence of large floods on the upper Mississippi River reconstructed from overbank deposits (Knox, 2003), North American temperature (Trouet *et*

al., 2013), and histogram of proxy record (n=21) evidence for aridity in central North America (Daniels and Knox, 2005) track environmental changes over midcontinental North America. Archaeological periods and cultural events (Milner, 1998; Fortier *et al.*, 2006), ethnobotanical data (median abundance of indigenous seed crops and maize by archaeological period; Simon and Parker, 2006), regional population size (Milner, 1998), and non-arboreal pollen and organic carbon isotopic data ($\delta^{13}C_{org}$) from Horseshoe Lake (Munoz *et al.*, 2014) track agricultural intensification/contraction and population growth/decline in the central Mississippi River valley.

The declines of many early agricultural societies in the tropics and sub-tropics, including those of the ancient Puebloans, Classic Maya, Akkadians, and Harappans, are often attributed to drought and water limitation (deMenocal, 2001; Giosan *et al.*, 2012; Dixit *et al.*, 2014). In contrast, our work indicates that Cahokia, a sociopolitical system established in a moist and temperate region, emerged and flourished during a period of heightened midcontinental aridity, and was instead vulnerable to flooding mediated by subcontinental-scale shifts in moisture availability. These findings do not preclude the role of additional factors in Cahokia's decline, including more localized high-frequency hydroclimatic variability recorded by dendroclimatological data (Benson *et al.*, 2009). Instead, our work emphasizes the sensitivity of fluvial systems to climatic variability (Knox, 2000; 2003; Kidder, 2006), and shows that variation in flood frequency and magnitude may be an underappreciated but key factor in the development and disintegration of early agricultural societies, particularly in temperate regions (e.g., Butzer *et al.*, 1983; Kidder *et al.*, 2012). Floodwater deposits may be absent or obscured by post-depositional processes in archaeological contexts (Kelly, 1980; Butzer *et al.*, 1983), but, as demonstrated by this study, can be well-preserved in lacustrine sedimentary records. Hydrological variability – both droughts and floods – appears to have profoundly shaped late Holocene ecosystems and societies (Anderson *et al.*, 1995; deMenocal, 2001; Benson *et al.*, 2009; Cook *et al.*, 2010; Giosan *et al.*, 2012), and given the increase in the frequency of extreme hydroclimatic events projected for the 21st century (Prudhomme *et al.*, 2014), more work is needed to understand the coupled responses of sociocultural and hydrological systems to present and past climatic variability.

4.3 Materials and Methods

4.3.1 Sediment core extraction and sampling

Sediment cores with overlapping 0.5 m offsets were extracted from the in-filled thalwegs of Horseshoe Lake and Grassy Lake in May 2012 and June 2013, respectively, using a modified Livingstone piston corer with a Bolivia adapter for surface sediments. All cores were described, wrapped, and labeled in the field, then taken to the National Lacustrine Core Facility at the University of Minnesota where they were longitudinally split, scanned for magnetic susceptibility, and photographed at high resolution. Primary core sections, overlapping core sections, and surface sediment sections were used to create continuous composite cores based on stratigraphy and magnetic susceptibility. These composite cores measured 5.5 m and 2.2 m for Horseshoe Lake and Grassy Lake, respectively. Only the top 4.4 m from Horseshoe Lake were used in the present study, because the bottom section of core is characterized by interbedded sands and clays that were deposited before the main channel of the Mississippi River migrated to the low-sinuosity meander belt along the western edge of the floodplain (Hajic, 1993; Munoz *et al.*, 2014). Sediment cores were sampled at 1 cm intervals and refrigerated in labeled Whirl-pak bags for future sub-sampling.

4.3.2 Radiocarbon dates

Seventeen wood and charcoal samples from terrestrial plant macrofossils extracted from the Horseshoe and Grassy Lake cores were collected and submitted for Accelerator Mass Spectrometry (AMS) radiocarbon dating (Table 4.1). Plant macrofossils were rinsed with deionized water obtained from an Academic Milli-Q water purifier with filter for organic carbon, and then dried for 24 hours at 60°C before submitted to the Center for Applied Isotope Studies (CAIS) at the University of Georgia, or DirectAMS in Bothell, Washington for AMS dating.

4.3.3 Particle-size analysis

Sediment sub-samples of 0.5 cm^3 from the Horseshoe Lake and Grassy Lake cores were pre-treated with 1M HCl to remove carbonates (i.e., gastropod shells) and rinsed with deionized water. Laser diffraction particle size analysis cannot distinguish coarse organic particles (e.g., roots, wood fragments) from coarse mineral grains, so these organics were removed by ignition at 360°C for two hours in a muffle furnace. Pre-treated samples were then homogenized with mortar and pestle before their particle-size distributions were measured on a Malvern Mastersizer 2000MU laser diffraction particle size analyzer after being dispersed with 10 mL of dispersant (0.5% sodium hexametaphosphate) and sonication for 5–15 minutes (mid-range power, 10 μ-tip displacement). To ensure disaggregation and full dispersion, samples were repeatedly sonicated and re-measured until a reproducible grain-size distribution was observed. A base sampling resolution of 5–6 cm was initially used, with a higher sampling resolution (1–2 cm) used around core depths with lighter sediment color and/or low organic content that represented potential floodwater deposits. In total, 156 and 87 samples were measured at Horseshoe Lake and Grassy Lake, respectively, for a combined mean sampling resolution of 2.7 cm. A principal components analysis was performed on the full particle-size distribution for all samples in each lake in R v. 2.15.1 using the *princomp*() function; the first principal component (PC1) explains >55% of grain-size variance at both sites.

Table 4.1 ^{14}C dates from Horseshoe Lake and Grassy Lake sediment cores.

Lab number	Sample description	Site	Depth (cm)	^{14}C age†
UGAMS-13417	wood	Horseshoe Lake	111.5	400 ± 25
UGAMS-13418	wood	Horseshoe Lake	197.5	980 ± 40
UGAMS-14454	wood	Horseshoe Lake	225	800 ± 20
UGAMS-13419	wood	Horseshoe Lake	254.5	1220 ± 25
UGAMS-15039	charcoal	Horseshoe Lake	256.5	990 ± 25
UGAMS-15040	charcoal	Horseshoe Lake	285.5	990 ± 25
UGAMS-15041	charcoal	Horseshoe Lake	298.5	1370 ± 25
DAMS-005563	charcoal	Horseshoe Lake	330	1316 ± 24
UGAMS-13420	wood	Horseshoe Lake	347.5	3560 ± 30
UGAMS-14455	wood	Horseshoe Lake	377.5	1620 ± 25
UGAMS-14456	wood	Horseshoe Lake	389.5	1650 ± 20
DAMS-005571	wood	Grassy Lake	31.5	91 ± 25
DAMS-005572	wood	Grassy Lake	92.5	120 ± 28
DAMS-005573	wood	Grassy Lake	110	309 ± 25
DAMS-005574	wood	Grassy Lake	120	736 ± 27
DAMS-005575	wood	Grassy Lake	146	423 ± 26
DAMS-005576	wood	Grassy Lake	202	936 ± 24

† Uncalibrated ages provided in radiocarbon years before 1950 (years BP), using the ^{14}C half–life of 5,568 years. The error is quoted as one standard deviation and reflects both statistical and experimental errors. Each date has been corrected for isotope fractionation.

4.3.4 Age-depth modelling

Age models were produced for Horseshoe Lake and Grassy Lake (Figure 4.6) using *bacon* v.2.2, calibrating all radiocarbon dates using IntCal13 (Blaauw and Christen, 2013). Additional chronological controls included the core tops (A.D. 2012 and A.D. 2013 for Horseshoe Lake and Grassy Lake, respectively) and the Euro-American settlement horizon (A.D. 1800 ± 25) identified from the abrupt increase in *Ambrosia* pollen (Munoz *et al.*, 2014) at 44 cm in Horseshoe Lake and 36 cm at Grassy Lake. To model the variable sedimentation rate in these floodplain lakes caused by flood events, we set section thickness to 2 cm, then imposed a high sedimentation rate (0.5 yr/cm) on floodwater deposits > 5 cm in thickness identified from the particle-size analyses and imposed slower sedimentation rates (10 yr/cm) on non-floodwater sediments. Imposing the *bacon* default sedimentation rate of 20 yr/cm on non-floodwater sediments resulted in age models that failed to pass through many calibrated chronological controls, probably because this default sedimentation rate is based primarily on small upland lakes whose geomorphic setting differs substantially from the floodplain lakes used in this study (Goring *et al.*, 2012). Probability density functions (PDF) were obtained for each floodwater deposit using the *Bacon.Age.d()* function in *bacon*, which outputs all ages for a given depth. To develop joint PDFs and more tightly constrained age estimates for Flood Events I-V, the individual PDFs from Horseshoe and Grassy Lakes were multiplied together and re-scaled to sum to a probability of 1 (Figure 4.7; Table 4.2).

Table 4.2: Summary of probability distribution functions for flood events.

Flood Event	Peak depth (cm)	Mode (yr AD)	Min age (yr AD)	Max age (yr AD)
HORM12-I	36	1810	1880	1780
HORM12-II	75	1630	1720	1570
HORM12-III	101	1520	1640	1480
HORM12-IV	136	1400	1510	1340
HORM12-V	210	1200	1250	1080
HORM12-VI	346	580	630	510
HORM12-VII	368	490	560	440
HORM12-VIII	418	280	320	160
GRAS13-I	39	1800	1880	1760
GRAS13-II	81	1570	1730	1530
GRAS13-III	101	1500	1670	1460
GRAS13-IV	131	1390	1570	1300
GRAS13-V	171	1200	1310	1000
JOINT-I	-	1800	1870	1780
JOINT-II	-	1590	1730	1550
JOINT-III	-	1510	1590	1470
JOINT-IV	-	1400	1460	1340
JOINT-V	-	1200	1260	1100

4.4 Supporting Information

4.4.1 Flood extent mapping

Maps delineating the extent of floodwater inundation around Horseshoe Lake were produced using high-resolution LiDAR imagery of the floodplain obtained from the Illinois State Geological Survey and historic records of flooding from gauging stations along the central Mississippi River (Figures 4.4 and 4.5). The large flood in A.D. 1844 described in newspaper accounts crested at 12.6 m above the datum (115.7 m asl) of the USGS gauging station at Saint Louis (EADM7). The nearest upstream and downstream gauging stations at Alton, Illinois (ALNI2) and Chester, Illinois (CHSI2) with datums of 120.5 m asl and 104.0 m asl, respectively, were used to calculate an average north-to-south slope (0.167 m/km) of the datum around Horseshoe Lake, and elevations below this datum plus flood stage were then delineated as inundated. Recent modifications to the floodplain (e.g., levees, highways, buildings, and landfills) that mostly raised the elevation of the floodplain were not removed from the underlying elevation data, so our analysis likely underestimates the extent of prehistoric floods. These maps thus serve to illustrate that only high-magnitude floods (> 10 m stage) inundating the majority of the floodplain will create surficial hydrological connectivity between the Mississippi River and Horseshoe Lake.

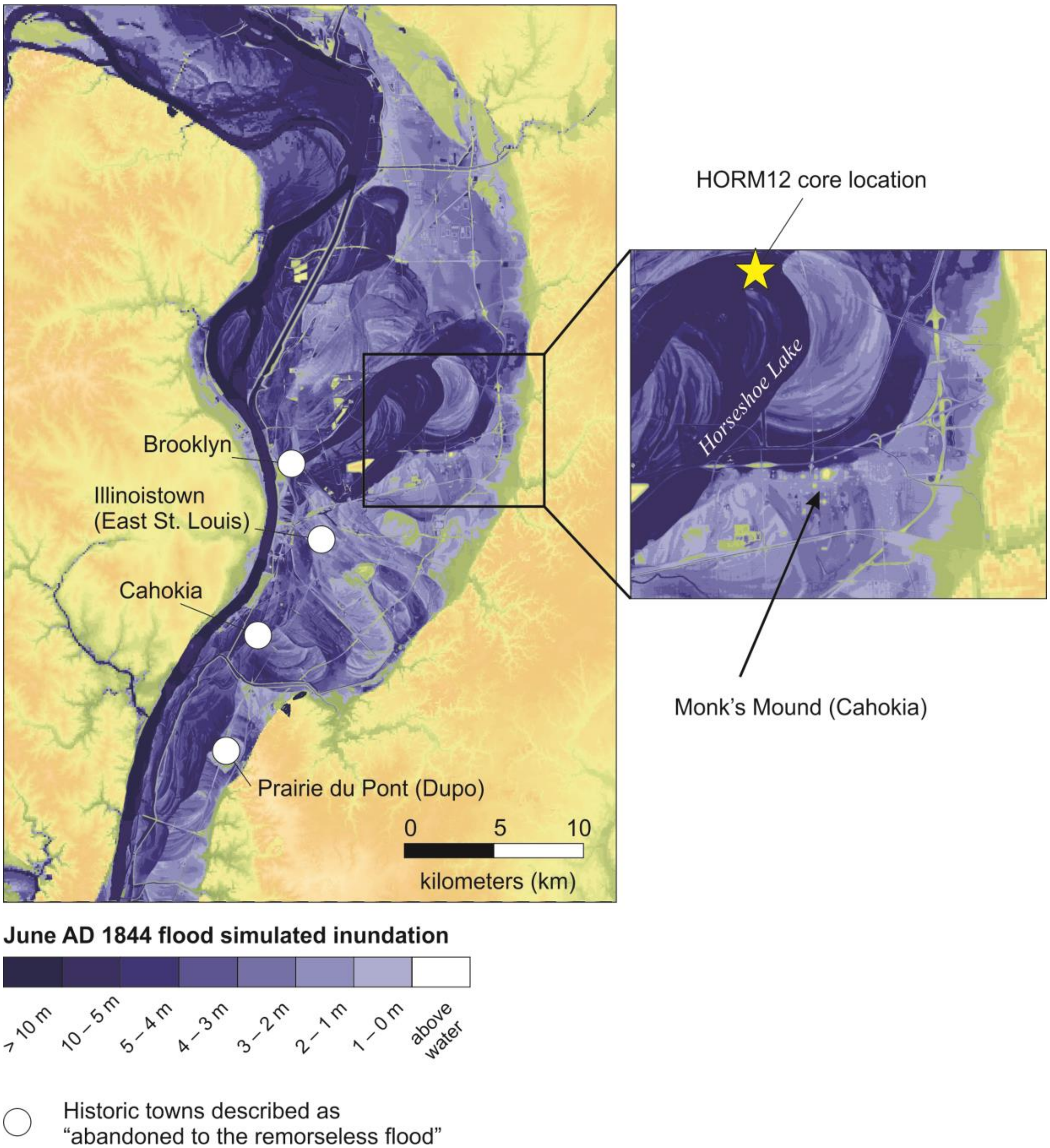

Figure 4.4: Modeled flood extent of June AD 1844 flood event recorded by the gauging station on the Mississippi River at Saint Louis (EADM7) as 12.6 m stage; areas in blue denote elevations below flood stage. The extensive inundation that covered much of the floodplain and historic towns is consistent with newspaper accounts of the AD 1844 flood.

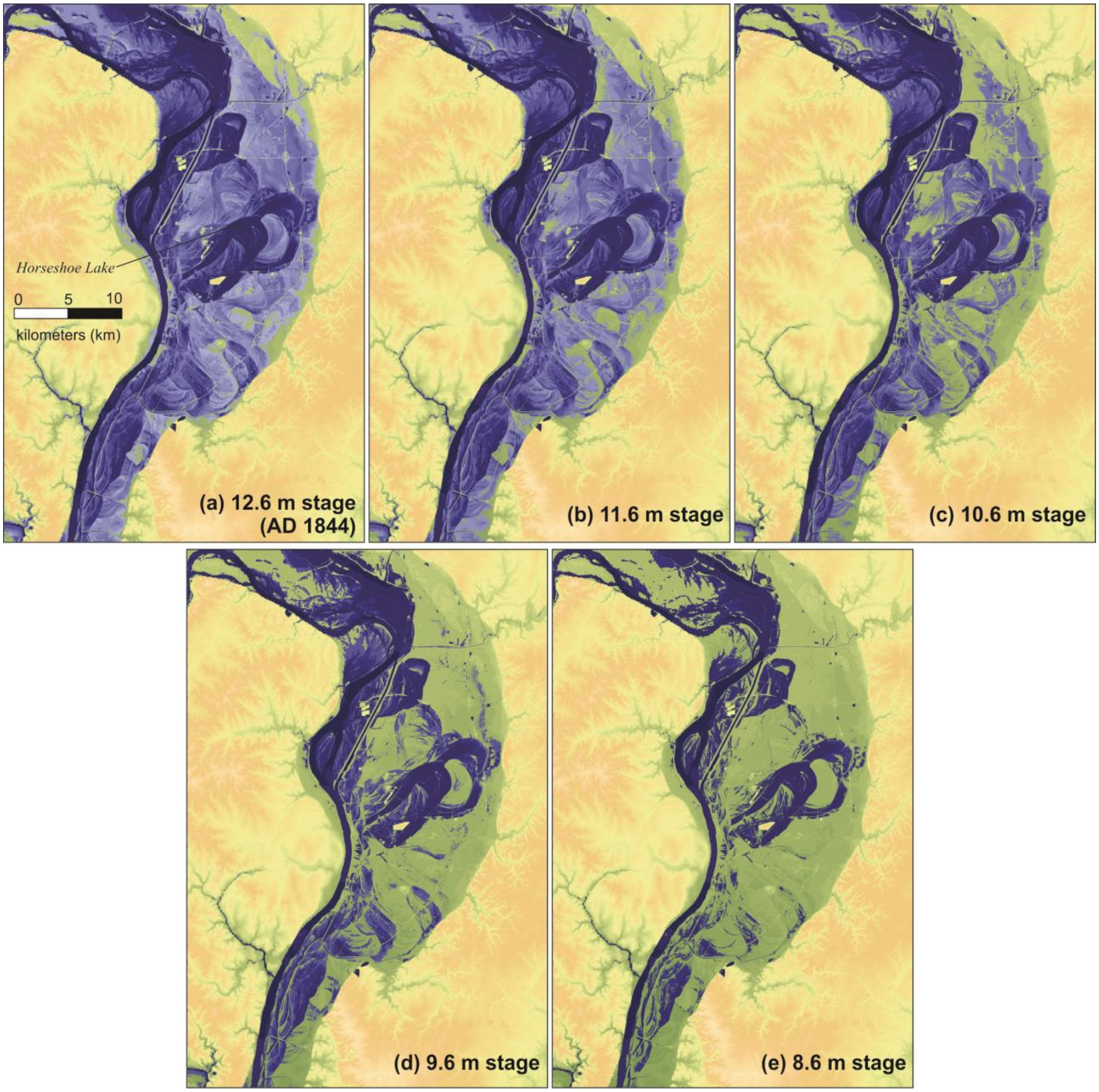

Figure 4.5: Sensitivity analyses of flood extent in the Cahokia region used to test the minimum flood stage required to create hydrological connectivity between Horseshoe Lake and the Mississippi River. Below 10.6 m stage (2 m below the AD 1844 stage), Horseshoe Lake is no longer hydrological connected to the Mississippi River, implying that only high-magnitude floods (> 10 m stage) deposit floodwater sediment in Horseshoe Lake

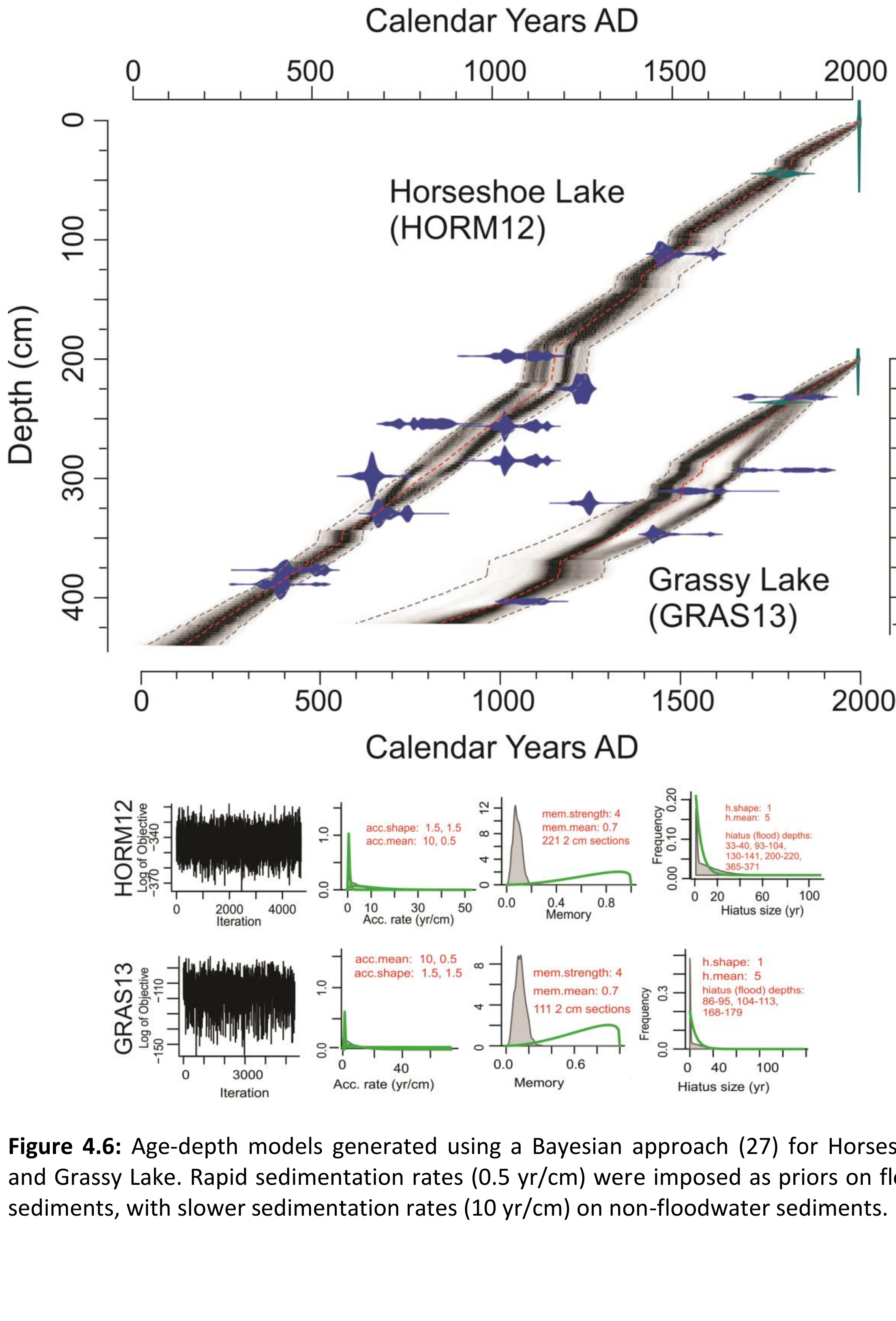

Figure 4.6: Age-depth models generated using a Bayesian approach (27) for Horseshoe Lake and Grassy Lake. Rapid sedimentation rates (0.5 yr/cm) were imposed as priors on floodwater sediments, with slower sedimentation rates (10 yr/cm) on non-floodwater sediments.

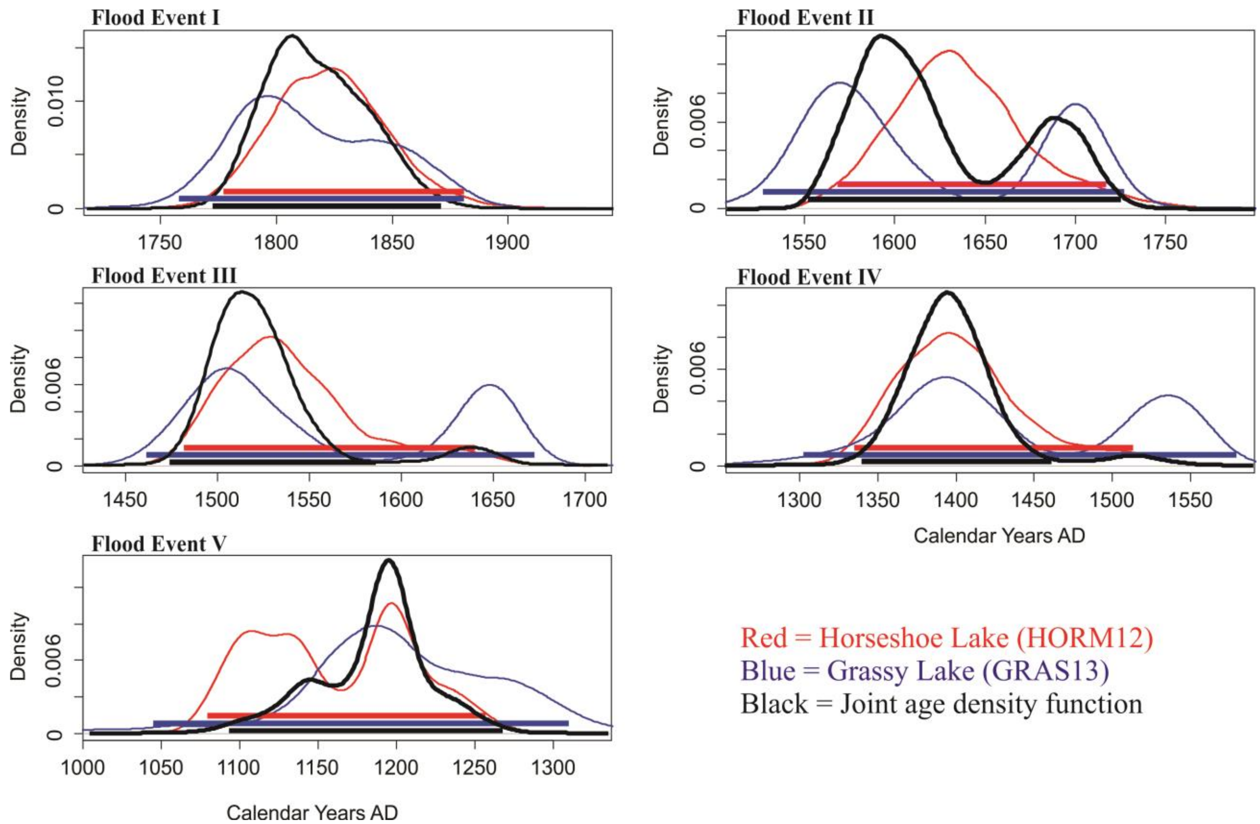

Figure 4.7: Probability density functions for the most recent floodwater deposits (Flood Events I–V) at Horseshoe (red) and Grassy (blue) lakes, with combined density functions (black). Colored boxes indicate the 95% confidence interval of each probability density function.

4.4.2 Historical Accounts of A.D. 1844 Flood

On the 5th of July, 1844, The Ottawa Free Trader (Ottawa, Illinois) published the following:

> Of the Mississippi river, the Belleville Banner of June 25th says, "It is higher by this time, by several feet, than at any previous period, so far as we have any knowledge or history concerning it; and the consequent destruction of life and property is truly appalling. The entire 'American Bottom', with all its towns and villages, is literally inundated from one end to the other; and small steamboats may now pass with facility over the ground which, but a few days since, gave every promise of an ample harvest. The towns of Brooklyn, Illinoistown, Prairie du Pont, Cahokia, Prairie du Roche, and Kaskaskia are entirely abandoned to the remorseless flood. In fact, the inhabitants of nearly the entire bottom have been driven to the hills for refuge; while their fields are laid waste, their stock in many instances drowned, and their valuable improvements destroyed."

On the 4th of June, 1844, the New-York Daily Tribune (New York, New York) published the following:

> Illinois --- Politics --- The Great Flood --- St. Louis in Danger! – Crops, &c. Correspondence of The Tribune, Alton, Ill. May 17th, 1844
>
> The Mississippi is now higher than it was ever known to be by the oldest inhabitant of the place, and it is still rising, while the rain pours down in a continuous current. The water reaches within a few inches of the curb stone on Front Street, and though the river is from 15 to 30 miles wide for a long distance above us, it is still rising more than 12 inches a day. At Madison, five miles below, the Mississippi is forming for itself a new channel; crossing the American Bottom, (which is an alluvial deposit and easily worn away) and finding its old bed again below St. Louis. It is said by those who have examined it that there is no doubt it will ere long be the only course of the stream, and that there is every indication it will be accomplished at this time. If this should be the case, St. Louis will be "high and dry," as the junction of the Missouri is 20 miles above it.
>
> The crops are suffering exceedingly from the wet: many large fields of corn that were growing finely, are now, and have been several days, covered with water, and if it does not immediately subside the corn must be destroyed. Wheat that is just ready to "head out" is beaten down by the continued rains flat to the earth, and two large farmers told me to-day they would be glad to sell their crops for one-half of an ordinary one. Fruit promises to be very abundant, and vegetables begin to come into market plentifully.

4.5 Acknowledgments

We thank the Illinois Department of Natural Resources for lake access, the Illinois State Geological Survey for providing the LiDAR data, R. Brugam, R. Criss, S. Goring, J. Kelly, J. Knox, J. Mason, D. Mladenoff, and M. Ozdogan for comments and/or discussions, J.A. Brown and two anonymous reviewers for comments on an earlier version of this manuscript, and S. Atkinson, J. Blois, K. Burke, J. Gill, J. Kershner, S. Knapp, M. Martinez, D. McCay, G. Schellinger, B. Rongstad, and C. Zirbel for field and/or laboratory assistant, and K. Brady, A. Myrbo, A. Noren, and R. O'Grady of the National Lacustrine Core Facility at the University of Minnesota for help with initial core descriptions. This work was supported by the NSF (grants BCS-1333070 and DGE-1144754), the National Geographic Society (grant YEG-9008-11), the National Lacustrine Core Facility, the Geological Society of America, and a Packard Fellowship to D. Fike.

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Appendix: Data Tables

Appendix Table 1. Composite core sections for Horseshoe Lake, Madison County, Illinois (HORM12).

Section No.	Core Section Name[1]	Section depth top (cm)	Section depth bottom (cm)	Sum depth top (cm)	Sum depth bottom (cm)
1	HORM12-4C-1B-1-W	18.5	88.5	0	70
2	HORM12-4B-1L-1-W	21	86	70	135
3	HORM12-4A-2L-1-W	38.5	60.5	135	157
4	HORM12-4B-2L-1-W	8	87	157	236
5	HORM12-4A-3L-1-W	41.5	93.5	236	288
6	HORM12-4B-3L-1-W	39	75	288	324
7	HORM12-4A-4L-1-W	25	75	324	374
8	HORM12-4B-4L-1-W	25	87	374	436
9	HORM12-4A-5L-1-W	19	86	436	502
10	HORM12-4B-5L-1-W	56	77	502	523
11	HORM12-4A-6L-1-W	23.5	79	523	578

[1] Core section names follow convention of National Lacustrine Core Facility (LacCore); e.g., HORM12-1A-1L-1-W translates to: site name (HORM), year of collection (2012), core location (1), drive location (A), drive section number (1), coring device (L for Livington, B for Bolivia), core section number (1), working (W) or archive half (A). Note: For all cores, working halves were sub-sampled at 1 cm in resolution; archive halves were often used to find plant macrofossils for radiocarbon dating, so few complete archive halves remain.

Appendix Table 2. Pollen counts from Horseshoe Lake, Madison County, Illinois (HORM12) composite sediment core. Neotoma site ID: 8585.

Depth (cm)	Acer	Alnus	Amaranthaceae	Ambrosia	Artemisia	Asteraceae	Betula	Carya	Castanea	Celtis	Corylus	Cupressaceae
0.5		1	21	79	6	2	1	8				1
8.5			18	87	1	8	1	7				4
16.5	1	1	24	96	2	2	2	9				1
24.5			13	117	2	6	2	8				1
32.5	1		8	98	1	4	4	13				4
40.5			8	63	3	2	3	20				4
48.5			7	26	2	3	4	37				1
56.5			3	21	1	6	3	24				3
64.5	1	1	5	18	3	2	4	25				6
72.5		1	3	19		1	3	41				4
80.5			2	28	2		2	32				2
88.5			9	36	1	2	7	27				7
96.5		1	10	45	4	2	1	22	1			
104.5	1	1	7	45	3		2	24	1			4
112.5			7	54	3	6	2	20				
120.5	2		10	57	1	8	2	17	2	2		2
128.5			11	74	2	7	4	9				
136.5		1	13	61	1	3	5	25				3

144.5		1	18	51	2	9	3	11				2
152.5			32	41	1	9	2	10				10
160.5		2	40	43	2	6		15				6
168.5			41	31	1	7	2	17				7
176.5		1	37	26	3	17	4	19				
184.5			33	32	6	12	3	15		1		2
192.5	1		37	35	3	8	1	12		1		3
200.5			92	56	3	17	3	4	1	1		1
224.5	1	2	26	45	3	8	4	22				6
232.5		1	21	36	2	7	4	14				7
240.5		1	23	43	3	4	4	13				8
248.5			29	36	1	2	4	15				6
256.5	1	1	28	22	2	10	5	19				12
264.5			17	27		4	1	18				7
272.5			25	36		2	1	12		1		8
280.5		1	22	38	2	5	1	15	1			5
288.5	1		15	36	2	8	2	10				13
296.5			20	39	1	3	1	12	1	1		4
304.5		1	21	41	1	5	2	14				12
312.5	1	1	21	38		4	3	12		1	1	22
320.5			15	54	1	1	3	12				9
328.5	1		35	51	1	6	2	14		1		10
336.5	1		32	68	1	6		15	1			8
376.5	1	2	7	85	2	1	1	20				
440.5			89	15		3		19				

Appendix Table 2 (continued). Pollen counts from Horseshoe Lake, Madison County, Illinois (HORM12) composite sediment core.

Depth (cm)	Fraxinus	Iva	Juglans cinerea	Juglans nigra	Liquidambar	Morus	Nyssa	Ostrya/Carpinus	Pinus	Plantago	Platanus
0.5	19		1	2	1	1		1	12	3	5
8.5	21		2	2	3				12	7	6
16.5	13		2	2	6			1	13	1	2
24.5	12		1	1	3				8	1	7
32.5	8			1	1				15	1	5
40.5	22	1		3	3				6		6
48.5	22	1		1	2			1	12		5
56.5	18		1	3	3				12		11
64.5	15	1	3	1	1				10		4
72.5	12			2	2				9		5
80.5	20	1							10		7
88.5	18	1	1	1					10		4

96.5	13	2		2				1	15	7
104.5	20	2	1						16	3
112.5	18	2			1			3	13	8
120.5	23		1		1		2		3	14
128.5	12	4	3						8	6
136.5	17	4	1	3	2			2	15	8
144.5	13	2		1	2				11	6
152.5	10	12			1				12	5
160.5	14	18		1	1			1	7	6
168.5	12	7	1	1	1		1	1	22	3
176.5	16	19	2	2					21	7
184.5	13	5							17	8
192.5	11	4	1	2	1				30	6
200.5	4	1	1	1		4		2	52	2
224.5	14	6	1					1	13	3
232.5	12	8		1			2		8	7
240.5	9	8							12	7
248.5	4	12	2						15	4
256.5	12	1		2	1				9	2
264.5	4	5		2	2				17	2
272.5	3	6		1	3				17	4
280.5	2	2	1						11	3
288.5	3	5						1	17	3
296.5	4	2		1	5				19	
304.5	4	4	1	3					11	3
312.5	6	3		2	1			1	7	2
320.5	6	4	1	2	1				8	2
328.5	12	6	1	1	1			1	18	5
336.5	6	7		1	4				4	7
376.5	16	2	2	6	1				17	2
440.5	9		1	4				1	18	3

Appendix Table 2 (continued). Pollen counts from Horseshoe Lake, Madison County, Illinois (HORM12) composite sediment core.

Depth (cm)	Poaceae	Polygonum	Populus	Quercus	Ribes	Rosaceae	Salix	Tilia	Ulmus	Urtica	Viticeae	Zea mays	Spike count	Spike total
0.5	10		4	103			6		14	2			363	50000
8.5	16	1		90			8	2	9				326	50000
16.5	12		3	89			12		14				290	50000
24.5	17	1		77			12		14				261	50000
32.5	20	1	1	97			9		9		1		344	50000
40.5	35		1	100			12		10		1	1	230	50000

48.5	36		2	116			5		17		1	1	241	50000
56.5	42		6	131			5		13	1			150	50000
64.5	55			125			10	1	11				191	50000
72.5	62		2	121		1	5		8		1		217	50000
80.5	53			131			8		7				250	50000
88.5	28	2	1	120			16		9		2		382	50000
96.5	21	1	2	126			19		6		1		572	50000
104.5	22	1	1	107		1	28	2	7		3		365	50000
112.5	21		3	114		1	23	1	3		6		450	50000
120.5	5		2	103			36	1	5	2	1		321	50000
128.5	20		1	107		2	26		3		2		423	50000
136.5	20			99			15		5				960	50000
144.5	21	1	4	111			21		9		2		650	50000
152.5	26		3	103	1		18		4		2		640	50000
160.5	33		1	96			10		7				606	50000
168.5	26		2	102	1		11	1	4				1030	50000
176.5	26		2	87		1	7		6				1078	50000
184.5	30	1	3	107			9	1	3		1		1042	50000
192.5	29		2	103		2	4	1	4		2		1281	50000
200.5	11	2	1	32		1	4		2		2		3663	50000
224.5	48	1	2	89			4		4		1		398	50000
232.5	66		2	95	1		1	1	6				323	50000
240.5	66		1	92		1	4		4				416	50000
248.5	68			101			4					1	505	50000
256.5	70	4	4	93	1		2		2				351	50000
264.5	91	2	1	96			2		2		1	3	391	50000
272.5	86	2	1	92			1		3		1		380	50000
280.5	97	1	2	86			3		4			1	440	50000
288.5	85			93			3		5			1	345	50000
296.5	104			82			6		7		2		280	50000
304.5	91		2	88			1	1	3				240	50000
312.5	76		2	90			6		2				230	50000
320.5	65	1	1	105			7		3			1	256	50000
328.5	38	3	2	80			6		8		1		341	50000
336.5	27	5	2	89		1	7	1	8		2		350	50000
376.5	12	1		104		1	12		8				440	50000
440.5	13			91		1	32		2		1		248	37166

Appendix Table 3. Loss-on-ignition and macroscopic charcoal (> 125 µm) counts for Horseshoe Lake, Madison County, Illinois (HORM12) composite sediment core. Loss-on-ignition data available on Neotoma (site ID: 8585); charcoal data will be submitted to the Global Charcoal Database upon publication.

Depth (cm)	Water content (%)	Organic content (%)	Carbonate content (%)	Mineral content (%)	Total charcoal count	Cellular charcoal count
0.5	67.974	10.728	12.161	77.111	105	1
1.5	68.620	10.843	12.402	76.755	73	0
2.5	68.292	10.718	12.668	76.614	56	0
3.5	68.757	10.921	12.163	76.916	65	1
4.5	69.104	10.908	12.443	76.648	75	0
5.5	68.781	11.079	12.481	76.440	56	0
6.5	69.462	10.785	12.428	76.787	62	0
7.5	70.176	10.989	12.296	76.715	73	0
8.5	67.978	10.998	12.363	76.638	83	0
9.5	67.718	10.699	11.944	77.357	111	1
10.5	66.212	10.218	11.963	77.819	77	0
11.5	67.193	10.692	11.661	77.647	93	0
12.5	65.452	10.378	11.939	77.683	92	0
13.5	67.356	10.553	11.815	77.632	69	0
14.5	67.283	10.665	12.128	77.207	81	0
15.5	65.517	10.312	10.673	79.015	86	0
16.5	62.392	10.381	9.159	80.460	264	0
17.5	62.882	10.552	8.690	80.758	176	1
18.5	66.624	10.540	11.564	77.896	76	4
19.5	66.525	10.535	11.053	78.411	82	1
20.5	65.400	10.461	10.333	79.206	101	2
21.5	66.453	10.507	10.101	79.392	56	0
22.5	64.777	10.640	9.418	79.941	251	0
23.5	64.505	10.538	7.192	82.270	122	0
24.5	64.499	10.612	6.410	82.978	161	3
25.5	64.263	10.584	6.105	83.311	176	6
26.5	63.155	10.308	6.918	82.775	230	2
27.5	63.286	10.071	6.226	83.702	193	4
28.5	62.341	10.006	5.721	84.272	323	5
29.5	61.243	9.888	5.763	84.348	238	4
30.5	62.326	9.988	5.439	84.573	208	8
31.5	60.753	8.876	5.172	85.952	262	6
32.5	60.721	8.484	4.742	86.774	148	3
33.5	61.075	8.560	4.128	87.313	197	3
34.5	58.991	8.060	3.778	88.162	82	0
35.5	58.648	8.002	3.864	88.134	33	2
36.5	58.022	8.052	3.720	88.228	43	3
37.5	57.837	8.908	2.785	88.307	21	2

38.5	58.837	9.556	2.951	87.493	17	1
39.5	59.924	9.816	2.981	87.203	13	2
40.5	65.459	11.852	3.740	84.408	13	1
41.5	64.572	11.333	3.827	84.840	17	0
42.5	68.005	12.930	3.980	83.090	8	0
43.5	67.256	12.660	3.894	83.446	8	0
44.5	66.949	12.982	3.413	83.605	17	2
45.5	66.825	12.648	3.533	83.819	9	0
46.5	70.359	14.422	3.742	81.836	4	2
47.5	70.739	14.702	4.067	81.230	1	0
48.5	70.976	14.864	4.027	81.110	4	0
49.5	70.902	15.190	4.162	80.648	4	0
50.5	72.057	16.336	4.279	79.385	7	1
51.5	73.247	17.486	4.456	78.058	4	0
52.5	74.137	17.081	4.232	78.687	20	4
53.5	74.335	17.404	4.421	78.175	4	0
54.5	74.598	17.515	4.368	78.117	0	0
55.5	74.439	16.717	4.743	78.541	3	0
56.5	75.396	18.234	4.962	76.804	15	3
57.5	75.352	17.801	4.747	77.452	14	3
58.5	74.567	18.450	5.809	75.741	13	4
59.5	74.570	17.895	5.486	76.619	14	6
60.5	72.944	16.087	5.705	78.208	11	5
61.5	72.017	15.140	6.998	77.862	24	8
62.5	70.860	13.796	6.646	79.558	13	6
63.5	70.136	13.717	6.260	80.023	17	4
64.5	69.839	12.618	7.096	80.286	33	7
65.5	68.593	12.718	7.324	79.958	29	11
66.5	69.170	12.904	7.149	79.947	27	13
67.5	68.854	12.639	6.895	80.466	16	7
68.5	69.268	12.536	6.798	80.667	26	12
69.5	69.625	12.591	7.262	80.148	27	10
70.5	68.553	13.127	6.493	80.380	25	8
71.5	68.005	13.698	6.503	79.800	15	11
72.5	69.572	13.729	6.495	79.777	27	10
73.5	68.130	12.647	6.600	80.753	20	9
74.5	64.856	11.762	6.868	81.370	17	6
75.5	66.847	11.571	7.234	81.196	20	8
76.5	65.015	9.170	7.715	83.115	13	7
77.5	65.722	11.710	6.470	81.820	22	11
78.5	65.398	12.393	6.518	81.088	18	5
79.5	65.902	12.521	7.659	79.820	18	4

80.5	66.373	12.506	6.587	80.907	25	15
81.5	65.526	12.260	6.798	80.941	17	5
82.5	65.127	11.777	6.844	81.379	13	4
83.5	65.630	12.601	6.942	80.457	17	5
84.5	66.849	12.304	7.371	80.325	14	6
85.5	66.747	11.821	7.437	80.742	19	8
86.5	64.273	10.591	5.918	83.491	24	11
87.5	63.104	9.972	5.911	84.117	14	5
88.5	60.319	8.559	6.326	85.114	25	9
89.5	59.611	7.990	5.107	86.903	15	7
90.5	57.989	7.566	4.894	87.540	4	0
91.5	58.690	7.324	4.827	87.849	7	3
92.5	58.739	7.407	5.067	87.526	13	3
93.5	58.401	7.835	4.590	87.575	5	3
94.5	53.654	6.493	4.223	89.284	3	1
95.5	55.455	6.900	4.206	88.894	7	2
96.5	56.085	6.947	4.509	88.544	8	3
97.5	56.289	6.885	4.293	88.823	5	3
98.5	54.745	6.687	4.194	89.119	8	0
99.5	53.455	6.615	3.975	89.410	1	0
100.5	54.759	5.751	4.239	90.010	1	0
101.5	59.846	6.921	6.696	86.383	3	0
102.5	60.204	7.429	6.197	86.374	4	0
103.5	58.752	7.184	5.546	87.270	3	1
104.5	59.074	7.683	6.808	85.509	7	2
105.5	64.649	9.283	7.366	83.350	21	6
106.5	59.932	8.091	6.050	85.860	8	2
107.5	60.325	7.953	7.835	84.212	20	2
108.5	60.363	7.817	7.993	84.190	27	3
109.5	59.710	7.943	7.920	84.137	26	4
110.5	59.194	7.779	7.639	84.582	26	1
111.5	59.118	8.037	7.795	84.168	29	4
112.5	60.876	7.777	8.157	84.066	51	8
113.5	60.731	7.837	7.952	84.211	20	3
114.5	59.404	7.700	7.399	84.901	15	2
115.5	59.052	7.922	7.329	84.750	23	4
116.5	59.471	7.636	7.429	84.936	34	3
117.5	61.155	7.747	7.525	84.728	13	1
118.5	61.707	7.669	7.494	84.837	32	3
119.5	60.188	7.657	7.330	85.013	17	3
120.5	60.696	7.685	7.373	84.942	13	1
121.5	59.342	7.603	7.215	85.182	12	1

122.5	57.183	7.704	7.168	85.128	22	4
123.5	59.486	7.526	6.891	85.583	13	0
124.5	59.823	7.538	6.848	85.613	28	3
125.5	59.523	7.446	6.660	85.894	5	0
126.5	59.939	7.442	6.886	85.672	20	0
127.5	60.239	7.472	6.440	86.088	13	0
128.5	60.074	7.470	6.475	86.056	15	1
129.5	60.038	7.492	6.616	85.892	6	0
130.5	60.066	7.730	6.575	85.695	14	0
131.5	60.044	7.635	6.673	85.691	34	9
132.5	60.485	7.640	6.800	85.560	24	3
133.5	59.997	7.647	6.855	85.499	22	3
134.5	59.118	7.661	6.742	85.596	23	3
135.5	61.089	8.207	6.485	85.308	25	5
136.5	59.979	7.605	6.294	86.101	22	3
137.5	59.774	7.657	6.223	86.119	15	2
138.5	57.866	7.026	6.068	86.907	14	1
139.5	57.631	6.948	6.214	86.838	14	2
140.5	56.761	7.034	6.126	86.840	9	0
141.5	57.389	6.834	5.921	87.244	19	5
142.5	57.940	6.838	6.130	87.032	9	2
143.5	57.107	6.850	6.549	86.600	24	6
144.5	56.340	6.978	5.844	87.178	13	1
145.5	59.229	7.805	6.143	86.052	18	1
146.5	56.977	7.034	5.951	87.015	21	5
147.5	57.448	7.113	5.819	87.068	10	4
148.5	57.974	7.000	5.912	87.088	9	3
149.5	56.952	6.846	6.435	86.719	20	5
150.5	55.857	6.410	5.635	87.955	10	1
151.5	56.359	6.626	5.952	87.422	11	1
152.5	57.994	6.873	6.069	87.058	17	7
153.5	56.307	6.641	5.798	87.561	10	5
154.5	56.731	6.595	5.649	87.757	12	1
155.5	57.387	6.688	6.259	87.053	14	3
156.5	58.798	7.975	5.857	86.168	5	0
157.5	56.202	6.498	5.745	87.757	39	8
158.5	53.722	6.349	5.916	87.735	12	2
159.5	55.503	6.512	6.075	87.413	20	0
160.5	55.891	6.572	6.049	87.380	21	1
161.5	55.020	6.431	6.102	87.467	25	8
162.5	54.775	6.467	5.844	87.689	25	7
163.5	55.346	6.567	5.965	87.468	18	3

164.5	55.530	6.629	5.912	87.460	27	6
165.5	54.980	6.567	5.765	87.668	6	1
166.5	55.159	6.594	5.818	87.588	13	2
167.5	55.042	6.564	5.684	87.752	22	5
168.5	53.673	6.181	5.153	88.666	7	1
169.5	52.726	6.079	5.309	88.612	14	1
170.5	51.832	5.918	5.175	88.906	8	2
171.5	53.293	6.162	5.096	88.743	10	3
172.5	54.199	6.280	5.057	88.663	2	0
173.5	53.972	6.266	5.063	88.671	8	1
174.5	53.919	6.851	4.449	88.700	2	0
175.5	54.098	5.960	4.497	89.543	0	0
176.5	55.153	6.132	4.556	89.312	2	1
177.5	54.839	6.075	4.506	89.418	1	0
178.5	54.324	6.082	4.549	89.368	1	0
179.5	53.324	5.955	4.656	89.388	3	0
180.5	52.480	5.842	4.439	89.718	2	0
181.5	52.998	6.045	4.656	89.298	0	0
182.5	52.678	5.925	4.770	89.305	2	0
183.5	53.333	5.846	4.810	89.344	3	1
184.5	52.733	5.698	4.995	89.308	4	0
185.5	53.864	5.967	4.896	89.137	1	0
186.5	53.263	5.956	5.009	89.035	1	0
187.5	53.582	5.847	5.029	89.124	1	0
188.5	53.366	5.868	5.241	88.891	3	0
189.5	53.045	5.818	5.074	89.109	8	0
190.5	53.066	5.929	4.964	89.107	1	0
191.5	51.883	5.867	4.961	89.173	4	1
192.5	52.162	5.468	5.395	89.137	3	0
193.5	50.679	5.529	5.346	89.124	0	0
194.5	51.960	5.572	5.214	89.214	0	0
195.5	51.878	5.662	5.147	89.192	3	0
196.5	49.766	5.578	4.955	89.467	18	2
197.5	51.073	5.579	5.189	89.232	9	2
198.5	52.116	5.569	5.089	89.343	3	1
199.5	50.639	5.422	4.546	90.032	4	0
200.5	51.636	5.423	4.497	90.079	0	0
201.5	50.914	4.173	5.965	89.863	1	0
202.5	51.519	4.828	5.375	89.797	0	0
203.5	51.632	5.114	4.986	89.900	1	0
204.5	51.777	5.466	4.899	89.635	0	0
205.5	51.050	5.623	4.820	89.557	0	0

206.5	49.629	5.621	4.812	89.567	0	0
207.5	49.419	5.646	4.824	89.530	2	0
208.5	48.413	6.013	3.879	90.108	0	0
209.5	49.197	6.004	3.912	90.084	0	0
210.5	49.108	6.141	3.683	90.176	0	0
211.5	50.429	6.008	3.724	90.268	0	0
212.5	50.784	5.966	3.661	90.374	0	0
213.5	51.672	5.889	3.572	90.539	0	0
214.5	50.908	5.785	3.595	90.620	0	0
215.5	50.540	5.859	3.571	90.569	0	0
216.5	50.055	5.791	3.633	90.576	2	0
217.5	48.596	5.719	3.555	90.726	1	0
218.5	52.633	6.739	4.489	88.772	22	3
219.5	56.779	7.643	5.796	86.561	40	4
220.5	56.537	7.488	5.839	86.673	32	4
221.5	56.941	7.543	6.171	86.286	34	5
222.5	58.324	7.781	6.260	85.958	38	6
223.5	58.675	7.928	6.393	85.680	41	8
224.5	63.362	9.841	7.861	82.298	52	3
225.5	58.508	7.953	6.330	85.717	39	4
226.5	58.163	7.972	6.197	85.830	28	1
227.5	57.573	7.792	6.293	85.915	34	3
228.5	58.637	8.010	6.477	85.513	47	1
229.5	57.793	7.752	6.603	85.645	39	7
230.5	57.890	7.787	6.684	85.529	47	8
231.5	58.218	7.477	6.879	85.644	27	3
232.5	58.448	7.768	6.729	85.503	38	5
233.5	58.379	7.780	6.582	85.638	64	10
234.5	58.444	7.883	6.528	85.589	41	10
235.5	56.076	7.036	6.662	86.302	52	7
236.5	56.873	7.716	4.910	87.374	15	3
237.5	58.501	7.842	5.767	86.392	61	21
238.5	59.363	7.792	6.233	85.976	22	2
239.5	59.110	7.991	6.388	85.621	34	4
240.5	56.554	7.470	6.319	86.211	50	7
241.5	56.476	7.184	5.953	86.863	37	7
242.5	58.847	7.770	6.167	86.063	42	4
243.5	58.308	7.506	6.109	86.385	42	8
244.5	58.942	7.470	6.075	86.455	79	13
245.5	58.639	7.542	6.197	86.261	87	13
246.5	58.703	7.520	6.332	86.148	65	6
247.5	59.028	7.501	6.374	86.124	49	9

248.5	58.432	7.445	6.449	86.106	40	1
249.5	57.096	7.304	8.405	84.291	38	2
250.5	56.720	6.911	7.157	85.933	65	10
251.5	56.965	7.123	6.687	86.190	64	6
252.5	60.141	7.520	6.484	85.995	94	9
253.5	58.073	6.908	5.812	87.280	60	1
254.5	58.305	6.925	6.570	86.506	71	4
255.5	57.754	6.899	7.073	86.028	37	2
256.5	58.377	6.837	7.182	85.981	46	2
257.5	55.486	6.446	6.016	87.538	42	3
258.5	58.790	6.793	6.291	86.917	59	7
259.5	62.816	7.586	6.905	85.509	33	6
260.5	60.408	7.440	7.228	85.332	66	14
261.5	62.148	7.417	7.275	85.307	60	11
262.5	57.140	6.616	5.656	87.728	66	9
263.5	55.403	6.105	6.320	87.575	46	3
264.5	55.243	6.254	6.386	87.360	56	5
265.5	53.728	6.342	6.193	87.465	43	0
266.5	52.633	6.133	6.822	87.045	56	1
267.5	45.949	4.974	6.309	88.717	47	1
268.5	46.869	5.096	6.554	88.350	62	2
269.5	46.970	5.256	6.373	88.371	43	1
270.5	48.335	5.372	6.409	88.219	40	0
271.5	45.309	5.036	5.768	89.195	64	5
272.5	49.432	4.912	7.070	88.018	55	4
273.5	47.588	5.555	6.781	87.664	53	3
274.5	49.216	5.524	6.426	88.051	34	3
275.5	51.088	5.885	6.922	87.193	45	3
276.5	47.987	5.406	6.325	88.270	100	7
277.5	47.241	5.328	5.943	88.729	64	4
278.5	51.797	5.869	6.410	87.721	52	2
279.5	46.528	5.477	5.214	89.309	39	4
280.5	51.118	6.107	5.921	87.972	110	13
281.5	47.524	5.948	5.510	88.541	55	6
282.5	49.129	6.749	8.441	84.810	75	5
283.5	45.689	6.144	5.655	88.200	68	5
284.5	39.738	4.956	5.203	89.841	100	12
285.5	45.978	6.362	7.457	86.181	75	4
286.5	48.174	6.575	5.914	87.512	72	3
287.5	46.304	7.654	11.428	80.918	82	10
288.5	46.869	7.335	12.421	80.244	67	6
289.5	47.067	7.569	11.977	80.454	88	9

290.5	47.232	7.553	12.363	80.084	51	4
291.5	48.210	7.715	11.769	80.516	78	6
292.5	46.739	7.461	13.948	78.591	104	5
293.5	46.439	7.632	12.282	80.086	87	5
294.5	46.769	7.820	12.375	79.805	71	6
295.5	46.976	7.796	12.561	79.642	73	5
296.5	46.452	7.801	12.696	79.504	73	7
297.5	46.395	8.042	12.864	79.094	65	2
298.5	45.316	7.803	13.103	79.094	80	4
299.5	46.472	7.960	12.890	79.150	73	8
300.5	46.066	8.042	12.461	79.497	96	10
301.5	46.157	7.686	13.437	78.877	88	9
302.5	46.632	7.716	12.887	79.397	73	6
303.5	46.187	7.888	12.760	79.352	54	8
304.5	46.952	7.698	13.276	79.027	103	7
305.5	46.325	7.757	13.447	78.797	64	3
306.5	46.464	8.052	13.038	78.911	64	8
307.5	47.355	7.949	13.026	79.025	64	6
308.5	47.737	8.199	13.055	78.745	43	5
309.5	48.201	8.049	13.267	78.684	48	6
310.5	48.250	8.228	12.889	78.883	48	3
311.5	47.740	7.925	13.375	78.700	60	8
312.5	47.121	7.787	12.970	79.244	89	3
313.5	46.596	7.873	12.663	79.464	72	4
314.5	46.522	8.126	12.348	79.526	91	4
315.5	46.935	7.633	11.921	80.446	63	5
316.5	47.195	7.640	11.269	81.091	65	4
317.5	47.008	7.564	11.067	81.369	58	8
318.5	46.926	7.846	10.235	81.919	46	3
319.5	47.707	7.881	10.075	82.043	48	2
320.5	49.378	8.120	10.499	81.381	62	6
321.5	48.924	7.529	10.743	81.728	71	8
322.5	49.832	7.593	11.190	81.217	69	5
323.5	51.783	8.707	10.388	80.905	44	4
324.5	47.560	6.949	10.931	82.120	54	4
325.5	48.433	6.936	10.959	82.105	84	5
326.5	47.248	7.004	11.057	81.939	57	4
327.5	48.042	6.280	9.714	84.006	41	3
328.5	48.929	6.439	9.536	84.026	46	5
329.5	48.386	6.533	8.639	84.827	42	4
330.5	48.692	6.745	8.984	84.271	32	1
331.5	48.441	6.585	9.597	83.818	56	6

332.5	49.071	6.706	8.876	84.418	46	6
333.5	48.815	6.137	8.982	84.882	36	5
334.5	48.522	6.386	9.045	84.569	37	6
335.5	50.984	6.386	8.660	84.954	56	4
336.5	51.306	6.439	8.706	84.854	26	7
337.5	50.783	6.508	7.888	85.603	43	7
338.5	49.059	6.381	9.059	84.560	37	4
339.5	50.299	6.478	9.265	84.257	33	3
340.5	50.831	6.460	8.056	85.483	37	4
341.5	50.057	6.280	8.025	85.696	26	3
342.5	49.434	5.458	9.343	85.199	35	7
343.5	48.414	5.890	8.778	85.331	45	9
344.5	51.294	6.540	8.336	85.123	19	2
345.5	50.045	6.614	8.271	85.115	19	3
346.5	50.672	6.557	8.234	85.209	32	3
347.5	50.713	6.836	8.801	84.363	30	6
348.5	50.316	6.760	8.841	84.400	26	1
349.5	50.194	6.935	8.225	84.840	29	4
350.5	51.483	7.505	8.240	84.255	15	3
351.5	50.912	6.846	8.641	84.513	33	2
352.5	52.892	6.993	8.497	84.510	16	2
353.5	53.430	7.340	9.139	83.522	40	4
354.5	52.334	7.313	9.029	83.658	28	3
355.5	53.723	7.554	9.166	83.281	27	2
356.5	53.873	7.370	9.245	83.385	30	3
357.5	53.704	7.448	9.504	83.048	33	5
358.5	53.245	7.394	9.605	83.001	37	6
359.5	54.434	7.357	9.761	82.883	34	4
360.5	53.360	7.230	10.596	82.174	34	3
361.5	53.144	7.327	10.033	82.641	36	6
362.5	52.904	7.337	9.901	82.762	28	4
363.5	53.317	7.295	9.672	83.033	22	3
364.5	52.724	7.037	10.065	82.898	43	10
365.5	51.126	6.730	10.244	83.026	30	5
366.5	50.050	6.678	10.344	82.978	24	2
367.5	48.978	6.495	9.624	83.881	18	1
368.5	50.717	6.484	9.522	83.994	27	4
369.5	50.613	6.696	9.281	84.024	39	7
370.5	49.660	6.564	9.870	83.566	34	4
371.5	48.045	6.238	9.394	84.368	29	6
372.5	47.370	6.086	9.536	84.378	20	4
373.5	46.833	6.137	9.612	84.251	28	2

374.5	54.015	7.591	9.459	82.949	43	6
375.5	53.761	7.496	9.547	82.956	37	6
376.5	55.747	7.863	10.304	81.833	47	6
377.5	56.262	8.030	9.766	82.204	34	6
378.5	55.268	7.831	9.806	82.363	43	5
379.5	54.916	8.023	9.766	82.211	33	3
380.5	54.197	7.870	10.683	81.446	34	3
381.5	54.093	7.719	10.423	81.858	32	4
382.5	53.417	7.774	10.211	82.015	30	5
383.5	52.448	7.459	10.401	82.140	41	3
384.5	53.037	7.433	10.469	82.098	44	3
385.5	52.874	6.938	10.113	82.949	30	2
386.5	53.373	6.918	9.679	83.403	28	3
387.5	52.199	6.760	9.142	84.097	35	6
388.5	52.114	6.716	9.309	83.975	30	5
389.5	52.140	6.664	9.521	83.815	31	6
390.5	52.337	6.678	9.088	84.234	26	1
391.5	51.375	6.765	8.950	84.285	28	4
392.5	51.660	6.689	9.213	84.098	18	3
393.5	51.139	6.553	8.998	84.449	21	1
394.5	52.392	6.541	9.061	84.398	23	1
395.5	51.819	6.492	9.042	84.466	18	2
396.5	50.234	6.426	9.112	84.462	26	3
397.5	49.638	6.434	9.391	84.175	21	5
398.5	49.897	6.347	9.491	84.162	34	4
399.5	50.043	6.307	9.556	84.137	15	1
400.5	50.556	6.266	9.582	84.152	16	0
401.5	50.330	6.353	9.702	83.945	34	5
402.5	51.482	6.270	9.746	83.983	19	1
403.5	50.531	6.213	9.821	83.966	38	6
404.5	49.226	6.240	9.444	84.316	48	5
405.5	48.514	6.148	9.592	84.260	13	1
406.5	47.825	5.919	9.841	84.240	23	3
407.5	47.845	5.895	9.747	84.359	22	3
408.5	46.482	5.771	9.686	84.542	41	7
409.5	48.097	5.897	9.992	84.111	23	1
410.5	47.633	5.901	9.692	84.406	26	5
411.5	47.037	5.899	9.371	84.730	13	2
412.5	48.150	5.951	9.612	84.437	24	5
413.5	48.108	5.962	9.512	84.526	34	2
414.5	48.830	6.012	9.828	84.160	23	2
415.5	49.864	5.967	9.675	84.357	18	2

416.5	49.126	5.995	9.549	84.456	26	2
417.5	48.154	5.850	9.531	84.618	31	3
418.5	48.047	5.935	9.438	84.627	26	4
419.5	47.199	5.788	9.286	84.926	39	6
420.5	44.373	5.199	9.161	85.640	41	5
421.5	44.986	5.246	9.147	85.607	36	4
422.5	44.771	5.405	8.772	85.823	38	4
423.5	44.982	5.142	9.345	85.513	52	6
424.5	44.077	5.125	9.487	85.388	52	10
425.5	45.741	5.334	9.425	85.242	33	4
426.5	45.137	5.269	10.730	84.001	35	4
427.5	44.654	5.109	12.128	82.764	37	3
428.5	44.319	5.132	10.543	84.326	64	17
429.5	45.537	5.254	11.210	83.536	50	3
430.5	43.139	5.121	11.447	83.432	53	5
431.5	43.353	5.130	11.188	83.682	48	3
432.5	41.664	5.044	11.407	83.549	38	1
433.5	40.654	5.165	8.931	85.904	36	6
434.5	43.266	5.163	11.230	83.606	45	6
435.5	33.808	4.736	6.528	88.736	35	3
436.5	40.918	5.065	10.171	84.764	53	3
437.5	33.673	4.591	6.360	89.049	35	4
438.5	32.713	4.516	5.750	89.734	37	3
439.5	29.047	3.994	4.571	91.435	33	2
440.5	28.600	4.039	4.095	91.866	21	2
441.5	28.117	4.064	4.040	91.895		
442.5	28.785	3.962	3.935	92.103		
443.5	29.988	4.061	3.705	92.234		
444.5	29.929	4.002	3.737	92.261		
445.5	30.719	4.146	3.953	91.901		
446.5	30.390	3.773	3.407	92.820		
447.5	33.140	4.070	3.419	92.511		
448.5	36.743	4.563	3.422	92.015		
449.5	41.863	5.052	3.473	91.474		
450.5	42.193	5.167	3.807	91.027		
451.5	41.932	4.682	3.826	91.491		
452.5	35.619	3.823	3.634	92.543		
453.5	24.471	2.441	3.462	94.097		
454.5	24.137	2.504	3.481	94.014		
455.5	25.806	2.909	3.564	93.527		
456.5	28.613	2.987	3.216	93.797		
457.5	26.870	2.839	3.198	93.963		

458.5	27.040	2.873	3.121	94.006
459.5	28.092	2.612	3.202	94.186
460.5	48.967	4.774	3.442	91.785
461.5	48.046	4.786	3.403	91.811
462.5	47.448	4.757	3.436	91.807
463.5	43.293	4.168	3.512	92.320
464.5	47.497	4.666	3.572	91.763
465.5	46.305	4.489	3.594	91.917
466.5	46.173	4.681	3.794	91.525
467.5	34.615	3.780	3.661	92.559
468.5	31.352	3.304	3.585	93.111
469.5	40.954	4.380	3.772	91.847
470.5	42.761	4.698	3.693	91.609
471.5	47.807	4.851	3.839	91.310
472.5	48.919	4.853	3.812	91.335
473.5	50.077	4.789	3.857	91.354
474.5	49.242	4.701	3.844	91.455
475.5	48.037	4.823	3.812	91.365
476.5	44.096	4.410	4.069	91.521
477.5	42.934	4.380	4.081	91.538
478.5	34.766	3.672	4.099	92.229
479.5	33.841	3.619	4.115	92.266
480.5	32.210	3.527	4.182	92.291
481.5	31.906	3.466	4.083	92.451
482.5	34.158	3.544	3.978	92.478
483.5	28.074	3.064	3.899	93.037
484.5	30.841	4.165	4.224	91.612
485.5	26.573	3.325	3.980	92.696
486.5	23.875	2.667	3.933	93.400
487.5	23.882	2.342	3.870	93.788
488.5	27.725	2.949	3.541	93.511
489.5	31.527	3.736	3.820	92.445
490.5	27.573	3.127	3.213	93.659
491.5	39.962	4.126	3.680	92.193
492.5	48.310	5.925	3.979	90.096
493.5	49.803	5.243	3.572	91.185
494.5	48.801	5.130	3.591	91.279
495.5	50.234	5.246	3.606	91.148
496.5	43.212	4.576	3.470	91.954
497.5	32.384	3.610	3.156	93.234
498.5	32.564	3.878	3.232	92.890
499.5	32.178	3.960	3.085	92.955

500.5	30.852	3.793	3.067	93.140
501.5	38.427	4.613	3.363	92.023
502.5	39.151	5.249	3.741	91.010
503.5	41.582	5.469	3.312	91.219
504.5	47.233	6.014	3.275	90.711
505.5	48.547	5.281	3.388	91.332
506.5	48.963	5.365	3.478	91.157
507.5	48.957	5.555	3.636	90.809
508.5	48.011	5.212	3.980	90.808
509.5	48.480	5.148	3.998	90.854
510.5	47.890	5.158	3.959	90.883
511.5	47.599	5.139	3.921	90.940
512.5	47.895	5.318	3.771	90.911
513.5	48.161	5.339	3.740	90.921
514.5	46.236	5.144	3.863	90.993
515.5	49.429	5.178	3.898	90.924
516.5	50.372	5.448	4.077	90.475
517.5	50.091	5.571	4.263	90.166
518.5	51.235	5.674	4.100	90.226
519.5	52.060	5.554	3.957	90.489
520.5	52.271	5.366	3.871	90.764
521.5	48.658	5.187	3.601	91.212
522.5	44.309	4.708	3.624	91.668
523.5	48.105	5.791	3.674	90.535
524.5	46.962	6.044	3.869	90.087
525.5	46.573	5.285	4.061	90.653
526.5	47.320	5.104	3.598	91.298
527.5	46.575	4.866	3.629	91.505
528.5	49.131	5.263	3.494	91.243
529.5	48.460	5.173	3.495	91.332
530.5	46.818	5.210	3.333	91.457
531.5	44.841	5.034	3.625	91.341
532.5	47.836	5.092	3.634	91.274
533.5	49.041	5.307	3.659	91.035
534.5	49.536	5.397	3.804	90.799
535.5	48.897	5.467	3.822	90.711
536.5	49.843	5.701	3.884	90.415
537.5	48.485	5.465	3.875	90.660
538.5	48.437	5.706	3.721	90.573
539.5	49.409	5.509	3.903	90.588
540.5	49.048	5.458	3.896	90.646
541.5	50.842	5.523	3.910	90.567

542.5	51.051	5.416	3.848	90.736
543.5	49.690	5.231	3.744	91.025
544.5	46.022	4.825	3.623	91.552
545.5	46.314	4.978	3.590	91.433
546.5	32.059	3.894	3.244	92.862
547.5	32.379	3.619	3.572	92.809
548.5	33.289	3.859	3.447	92.695
549.5	35.855	4.334	3.556	92.110
550.5	30.147	3.829	3.270	92.901
551.5	31.422	3.808	3.255	92.937
552.5	26.735	3.285	3.211	93.503
553.5	25.248	3.055	3.341	93.603
554.5	24.216	2.985	3.159	93.856
555.5	19.396	1.581	3.300	95.118
556.5	27.374	3.035	3.534	93.431
557.5	36.504	4.275	3.897	91.828
558.5	44.293	5.147	4.020	90.834
559.5	44.169	5.222	4.001	90.777
560.5	46.914	5.619	4.107	90.274
561.5	46.919	5.514	2.917	91.569
562.5	47.381	5.343	2.989	91.668
563.5	46.182	5.135	3.073	91.791
564.5	45.350	5.065	3.169	91.767
565.5	37.872	3.912	3.246	92.842
566.5	41.363	4.809	3.536	91.655
567.5	41.665	4.599	3.697	91.704
568.5	42.021	4.770	3.662	91.569
569.5	41.393	4.741	3.548	91.711
570.5	42.230	4.964	3.508	91.528
571.5	39.389	4.701	3.543	91.756
572.5	38.432	4.437	3.613	91.950
573.5	37.166	4.130	4.034	91.836
574.5	34.793	3.959	3.690	92.351
575.5	31.923	3.874	3.833	92.294
576.5	29.109	3.707	3.933	92.360
577.5	29.017	3.953	4.017	92.030

Appendix Table 4. Organic stable carbon isotope ratios from Horseshoe Lake, Madison County, Illinois (HORM12) composite sediment core.

Depth	$\delta^{13}C_{org}$ (‰)	no. measreuments (n)	standard deviation (σ)	Depth	$\delta^{13}C_{org}$ (‰)	n	σ	Depth	$\delta^{13}C_{org}$ (‰)	n	σ
0.5	-27.04	2		60.5	-25.96	1	0.12	120.5	-25.31	3	0.31
2.5	-26.81	2	0.44	62.5	-25.65	1		122.5	-25.36	2	0.07
4.5	-26.77	2	0.07	64.5	-25.43	1		124.5	-25.38	2	0.09
6.5	-26.71	2	0.26	66.5	-25.35	1		126.5	-25.63	2	0.08
8.5	-26.69	2	0.14	68.5	-25.39	3	0.26	128.5	-25.68	2	0.32
10.5	-26.42	2	0.39	70.5	-25.13	3	0.20	130.5	-25.51	2	0.04
12.5	-26.84	1	0.22	72.5	-25.04	3	0.45	132.5	-25.51	2	0.07
14.5	-26.83	1		74.5	-25.01	3	0.05	134.5	-25.68	2	0.45
16.5	-25.61	2		76.5	-24.85	2	0.07	136.5	-25.07	2	0.24
18.5	-26.17	2	0.26	78.5	-25.02	3	0.32	138.5	-25.00	3	0.30
20.5	-25.57	2	0.48	80.5	-24.64	2	0.37	140.5	-24.88	2	0.07
22.5	-25.67	3	0.17	82.5	-24.56	2	0.28	142.5	-24.26	2	0.09
24.5	-24.76	2	0.09	84.5	-24.91	2	0.29	144.5	-25.01	2	0.30
26.5	-24.34	2	0.19	86.5	-23.98	2	0.31	146.5	-24.70	2	0.10
28.5	-24.67	1	0.12	88.5	-25.00	1		148.5	-24.81	3	0.54
30.5	-24.25	1		90.5	-25.00	1		150.5	-24.53	2	0.57
32.5	-24.03	3		92.5	-25.19	1		152.5	-24.14	2	0.05
34.5	-23.93	2	0.19	94.5	-25.19	1		154.5	-24.15	2	0.19
36.5	-23.81	2	0.07	96.5	-25.03	1		156.5	-24.04	2	0.12
38.5	-24.11	3	0.22	98.5	-24.73	1		158.5	-24.13	3	0.30
40.5	-24.31	2	0.26	100.5	-25.20	1		160.5	-24.26	2	0.19
42.5	-24.35	2		102.5	-25.74	1		162.5	-24.61	2	0.27
44.5	-23.55	2	0.15	104.5	-25.51	1		164.5	-24.46	2	0.52
46.5	-24.86	2	0.35	106.5	-25.53	1		166.5	-24.47	2	0.28
48.5	-25.42	2	0.15	108.5	-25.50	1		168.5	-24.47	3	0.41
50.5	-25.50	3	0.15	110.5	-25.59	1		170.5	-24.64	2	0.27
52.5	-25.21	1	0.24	112.5	-25.36	1		172.5	-24.65	2	0.08
54.5	-25.76	1		114.5	-25.32	2	0.34	174.5	-24.32	2	0.06
56.5	-26.02	1		116.5	-25.58	1		176.5	-24.60	2	0.55
58.5	-25.78	2		118.5	-25.54	1		178.5	-24.15	3	0.23

Appendix Table 4 (continued). Organic stable carbon isotope ratios from Horseshoe Lake, Madison County, Illinois (HORM12) composite sediment core.

Depth	$\delta^{13}C_{org}$ (‰)	n	σ	Depth	$\delta^{13}C_{org}$ (‰)	n	σ	Depth	$\delta^{13}C_{org}$ (‰)	n	σ
180.5	-24.61	2	0.29	240.5	-23.95	1		300.5	-24.67	1	
182.5	-24.62	2	0.49	242.5	-23.59	1		302.5	-24.48	1	
184.5	-24.71	2	0.51	244.5	-23.91	1		304.5	-24.41	1	
186.5	-24.88	2	0.64	246.5	-23.76	1		306.5	-24.48	1	
188.5	-24.39	3	0.45	248.5	-23.84	2	0.11	308.5	-24.41	2	0.24
190.5	-24.25	2	0.04	250.5	-23.82	1		310.5	-24.61	1	
192.5	-24.21	2	0.28	252.5	-23.90	1		312.5	-24.94	1	
194.5	-23.86	1		254.5	-23.50	1		314.5	-24.77	1	
196.5	-23.83	3	0.32	256.5	-23.03	1		316.5	-25.19	2	0.13
198.5	-24.00	2	0.36	258.5	-23.34	2	0.07	318.5	-24.92	2	0.77
200.5	-23.56	1		260.5	-23.10	1		320.5	-24.90	1	
202.5	-23.60	1		262.5	-23.83	1		322.5	-24.90	1	
204.5	-23.79	1		264.5	-23.70	1		324.5	-25.02	1	
206.5	-23.92	1		266.5	-23.61	1		326.5	-24.80	1	
208.5	-23.47	2	0.05	268.5	-23.66	2	0.01	328.5	-25.01	2	0.07
210.5	-23.43	1		270.5	-23.68	1		330.5	-25.02	1	
212.5	-23.70	1		272.5	-23.56	1		332.5	-25.81	1	
214.5	-23.53	1		274.5	-24.13	1		334.5	-25.86	1	
216.5	-23.67	1		276.5	-24.02	1		336.5	-26.24	1	
218.5	-23.56	2	0.61	278.5	-24.08	2	0.42	338.5	-25.55	2	0.49
220.5	-24.54	2	0.34	280.5	-24.57	1		340.5	-25.94	1	
222.5	-24.43	1		282.5	-24.49	1		342.5	-25.68	1	
224.5	-24.46	1		284.5	-24.66	1		344.5	-25.57	1	
226.5	-23.32	2	0.51	286.5	-24.36	1		346.5	-25.84	1	
228.5	-24.11	2	0.59	288.5	-24.29	2	0.53	348.5	-25.89	2	0.07
230.5	-23.31	1		290.5	-23.99	1		350.5	-26.56	1	
232.5	-23.09	1		292.5	-24.19	1		352.5	-25.82	1	
234.5	-23.80	1		294.5	-24.19	1		354.5	-26.88	1	
236.5	-23.99	1		296.5	-24.27	1		356.5	-27.13	1	
238.5	-23.97	2	0.21	298.5	-24.18	2	0.04	358.5	-26.51	2	0.01

Appendix Table 4 (continued). Organic stable carbon isotope ratios from Horseshoe Lake, Madison County, Illinois (HORM12) composite sediment core.

Depth	$\delta^{13}C_{org}$ (‰)	n	σ	Depth	$\delta^{13}C_{org}$ (‰)	n	σ
360.5	-27.01	1		420.5	-27.00	1	
362.5	-26.62	1		422.5	-27.08	2	0.14
364.5	-26.64	1		424.5	-27.04	2	0.39
366.5	-26.80	1		426.5	-27.02	1	
368.5	-26.92	2	0.16	428.5	-27.24	2	0.04
370.5	-27.26	1		430.5	-27.06	1	
372.5	-27.21	1		432.5	-26.60	1	
374.5	-26.29	1		434.5	-26.01	1	
376.5	-26.48	1		436.5	-26.44	1	
378.5	-26.37	2	0.12	438.5	-24.08	4	0.13
380.5	-26.52	1					
382.5	-26.50	1					
384.5	-26.93	1					
386.5	-26.93	1					
388.5	-26.82	2	0.29				
390.5	-27.13	1					
392.5	-27.01	1					
394.5	-27.30	1					
396.5	-26.96	1					
398.5	-27.29	2	0.08				
400.5	-27.36	1					
402.5	-27.50	2	0.10				
404.5	-27.28	1					
406.5	-27.16	1					
408.5	-27.34	2	0.18				
410.5	-27.31	1					
412.5	-27.31	1					
414.5	-27.47	1					
416.5	-27.02	2	0.12				
418.5	-27.02	2	0.02				

Appendix Table 5. Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (µm)											
	0.363	0.417	0.479	0.550	0.631	0.724	0.832	0.955	1.096	1.259	1.445	1.660
1.5	0	0	0.18065	0.291738	0.412349	0.516704	0.624308	0.72985	0.84346	0.966612	1.103819	1.250256
5.5	0	0.077926	0.187142	0.295184	0.39493	0.491241	0.58402	0.676136	0.773567	0.878535	0.994726	1.118223
10.5	0	0.063032	0.177604	0.288652	0.390331	0.488251	0.582349	0.676063	0.775824	0.884172	1.004899	1.13368

15.5	0	0.061107	0.175106	0.28538	0.386507	0.484434	0.579539	0.675705	0.779918	0.895013	1.025041	1.16523
20.5	0	0.07789	0.197259	0.314193	0.421867	0.526219	0.627628	0.729842	0.839917	0.960435	1.095249	1.239012
25.5	0	0.066995	0.170474	0.282773	0.392766	0.501871	0.610577	0.722211	0.845635	0.985096	1.146478	1.324027
26.5	0.049291	0.206675	0.372689	0.546917	0.728063	0.906147	1.089516	1.276547	1.477902	1.693868	1.928228	2.168821
27.5	0.005761	0.21744	0.410673	0.612027	0.817148	1.011125	1.203429	1.391434	1.586911	1.791857	2.012316	2.239026
28.5	0.011392	0.180657	0.366589	0.560754	0.752204	0.942571	1.131113	1.319245	1.516567	1.724754	1.948831	2.178703
29.5	0.005718	0.218076	0.420084	0.632075	0.849082	1.055178	1.259445	1.458547	1.66427	1.878221	2.106332	2.338727
30.5	0	0.067705	0.206346	0.340308	0.463424	0.582873	0.699018	0.81653	0.94387	1.084414	1.242956	1.413389
31.5	0.007934	0.127758	0.288649	0.47668	0.680123	0.896623	1.127244	1.37353	1.65019	1.961005	2.314372	2.693924
32.5	0.010549	0.17024	0.392658	0.630426	0.869987	1.112129	1.354965	1.598972	1.855811	2.127648	2.422264	2.728654
33.5	0.008721	0.333621	0.639848	0.935108	1.222269	1.485539	1.740064	1.983055	2.229074	2.478967	2.737998	2.993321
34.5	0.009869	0.369209	0.679939	0.97859	1.267347	1.528935	1.779981	2.018472	2.260765	2.510028	2.774148	3.042526
35.5	0	0.073272	0.226544	0.414559	0.615581	0.823365	1.035989	1.254455	1.49337	1.759785	2.065998	2.402977
36.5	0.005371	0.214801	0.448281	0.694101	0.946311	1.188841	1.433502	1.680451	1.948612	2.24453	2.579967	2.943455
37.5	0.007199	0.118894	0.317397	0.531068	0.746892	0.965781	1.187081	1.413549	1.659266	1.929828	2.236337	2.57046
38.5	0.005202	0.088134	0.269766	0.464014	0.658168	0.853608	1.050051	1.25093	1.469287	1.710062	1.982138	2.276354
39.5	0.008031	0.132203	0.346633	0.572792	0.796714	1.020444	1.243366	1.468943	1.71108	1.974594	2.268646	2.58279
40.5	0	0.03891	0.144206	0.261261	0.380115	0.501717	0.626576	0.757242	0.902497	1.065443	1.251506	1.453508
41.5	0.009239	0.148574	0.332912	0.54603	0.773115	1.009256	1.250924	1.494221	1.747108	2.007397	2.277876	2.543096
42.5	0.007833	0.127091	0.302293	0.506563	0.726006	0.956643	1.196533	1.443452	1.707289	1.987119	2.286776	2.589668
45.5	0	0.067981	0.210473	0.349459	0.479192	0.607041	0.733284	0.861822	1.000381	1.150812	1.316649	1.490469
50.5	0	0.071395	0.16637	0.261317	0.350115	0.437366	0.523793	0.612452	0.7094	0.816581	0.937043	1.065734
55.5	0	0	0.166419	0.262402	0.366823	0.458649	0.554622	0.650482	0.754954	0.868826	0.995374	1.129258
60.5	0	0	0.110348	0.203141	0.312994	0.414071	0.52345	0.636542	0.764574	0.910593	1.081251	1.271812
65.5	0	0	0.114104	0.203237	0.300373	0.382993	0.468995	0.554391	0.648682	0.754055	0.875264	1.008793
70.5	0	0.061855	0.198415	0.329825	0.450501	0.567555	0.681089	0.795381	0.918254	1.052682	1.203215	1.364432
74.5	0.010645	0.171146	0.383068	0.624746	0.877751	1.136255	1.396134	1.654906	1.924143	2.206309	2.510627	2.827055
75.5	0.005394	0.206164	0.39967	0.607309	0.825515	1.039678	1.25995	1.483536	1.723596	1.981671	2.26486	2.562453
76.5	0.005176	0.20442	0.418083	0.64308	0.873834	1.093997	1.311665	1.522723	1.738787	1.961394	2.197544	2.439114
77.5	0.00697	0.113982	0.285279	0.48299	0.690816	0.903233	1.116729	1.329834	1.553322	1.79098	2.052555	2.331229
78.5	0.005307	0.208	0.420578	0.646542	0.880848	1.106722	1.331776	1.550152	1.771581	1.995236	2.226296	2.456013
79.5	0.010956	0.174023	0.357663	0.548148	0.734301	0.917742	1.097563	1.275675	1.462171	1.660387	1.877606	2.107289
80.5	0	0	0.178461	0.289506	0.409034	0.511605	0.61777	0.723209	0.839214	0.968131	1.114996	1.274406
85.5	0	0	0.180192	0.29711	0.424173	0.534178	0.648948	0.763345	0.888776	1.026912	1.182426	1.349184
90.5	0	0.038116	0.191387	0.363052	0.537767	0.715869	0.897689	1.086899	1.296662	1.532274	1.802573	2.098057
93.5	0	0	0.188264	0.385859	0.590365	0.80866	1.037626	1.283669	1.563443	1.884558	2.260253	2.67985
95.5	0	0	0.237978	0.462703	0.666132	0.866852	1.06315	1.26634	1.49231	1.748637	2.044907	2.370245
97.5	0	0	0.160076	0.33035	0.539612	0.737568	0.957694	1.191826	1.463853	1.781626	2.161039	2.592918
99.5	0	0	0.162986	0.332518	0.540957	0.739913	0.964712	1.209753	1.502261	1.852892	2.28084	2.777388
100.5	0	0	0.127245	0.262886	0.427889	0.582466	0.754479	0.938995	1.156868	1.416035	1.73031	2.091868
101.5	0.008116	0.134213	0.361145	0.603946	0.849751	1.101857	1.360892	1.629751	1.922472	2.2405	2.589581	2.951881
103.5	0	0.068596	0.257535	0.473723	0.700909	0.940632	1.194425	1.465551	1.770126	2.112361	2.502501	2.925993

105.5	0	0	0.237849	0.413291	0.566095	0.720717	0.86696	1.014501	1.171672	1.342604	1.532491	1.733639
107.5	0.006569	0.107082	0.264122	0.432544	0.603724	0.779939	0.962193	1.153001	1.363017	1.593741	1.849523	2.117287
109.5	0.00527	0.087709	0.242928	0.426626	0.62563	0.836889	1.060594	1.297474	1.560615	1.852636	2.180668	2.52907
110.5	0	0	0.194845	0.33505	0.457237	0.582301	0.701829	0.824066	0.955827	1.100161	1.260706	1.43
115.5	0	0	0.196121	0.337087	0.460318	0.586612	0.707039	0.82939	0.959964	1.101513	1.257639	1.421428
120.5	0	0	0.09821	0.189143	0.296824	0.394895	0.50049	0.60906	0.73176	0.871618	1.034768	1.215712
125.5	0	0.035344	0.14913	0.263068	0.394374	0.51371	0.640912	0.770527	0.915217	1.077997	1.265453	1.470801
130.5	0.005666	0.094716	0.268825	0.471987	0.685411	0.902328	1.119044	1.335099	1.563263	1.809401	2.084839	2.382099
135.5	0.009234	0.148928	0.34049	0.561047	0.795119	1.039537	1.294877	1.563867	1.864387	2.203278	2.592711	3.017363
140.5	0.007749	0.127785	0.336366	0.578024	0.831321	1.08905	1.347922	1.608884	1.889092	2.197083	2.547482	2.930099
145.5	0	0.031754	0.158788	0.298737	0.439267	0.581679	0.726862	0.878677	1.048287	1.240204	1.461283	1.702822
150.5	0	0	0.116679	0.232811	0.369602	0.492024	0.622225	0.754776	0.904879	1.078046	1.283935	1.517521
155.5	0	0	0.114249	0.220448	0.343681	0.45226	0.566134	0.680692	0.809941	0.959596	1.139079	1.344936
160.5	0	0	0.127156	0.246649	0.384245	0.503752	0.627601	0.750835	0.889519	1.050819	1.245919	1.47171
165.5	0	0	0.155847	0.290034	0.444995	0.581074	0.722031	0.861163	1.014587	1.188428	1.393336	1.625147
170.5	0	0	0.140159	0.272171	0.424487	0.557127	0.694779	0.831752	0.985527	1.163685	1.378273	1.625675
175.5	0	0	0.170115	0.311633	0.47556	0.621331	0.774723	0.929717	1.104487	1.305875	1.545194	1.816126
180.5	0	0	0.124353	0.253816	0.404256	0.535461	0.672482	0.809942	0.965769	1.147882	1.368629	1.624156
185.5	0	0	0.134294	0.264229	0.414128	0.544345	0.679677	0.8151	0.968778	1.149105	1.368832	1.624511
190.5	0	0	0.135135	0.268955	0.423754	0.558612	0.699389	0.841004	1.002406	1.192303	1.423968	1.693686
195.5	0	0	0.15526	0.295244	0.456224	0.596283	0.741187	0.884843	1.045417	1.230635	1.45275	1.707592
200.5	0	0	0.223462	0.45218	0.658714	0.857222	1.048252	1.242969	1.458935	1.705941	1.99596	2.320695
205.5	0	0	0.149975	0.314948	0.508808	0.679765	0.860132	1.043069	1.252085	1.497589	1.796069	2.142593
207.5	0	0	0.177861	0.371141	0.597661	0.79704	1.00697	1.21902	1.459881	1.740916	2.080575	2.472982
209.5	0	0	0.176976	0.379373	0.618773	0.831987	1.059693	1.293612	1.562871	1.879609	2.263555	2.707061
210.5	0	0	0.178988	0.374485	0.566531	0.758156	0.946971	1.141113	1.35852	1.610931	1.913744	2.261138
211.5	0	0	0.18159	0.391514	0.602626	0.817054	1.034851	1.264833	1.527837	1.83628	2.20719	2.632286
213.5	0	0	0.153301	0.324056	0.532148	0.726226	0.941142	1.170778	1.442504	1.768774	2.170966	2.644357
215.5	0	0	0.281365	0.527826	0.747238	0.963696	1.172279	1.386934	1.625235	1.897111	2.214605	2.567851
217.5	0	0	0.157361	0.339476	0.551552	0.735258	0.927192	1.121178	1.345587	1.615823	1.955388	2.364969
219.5	0	0.067501	0.209294	0.382887	0.569613	0.765832	0.972452	1.19286	1.443765	1.733473	2.075608	2.460552
220.5	0	0	0.117362	0.224558	0.349522	0.4608	0.57868	0.698622	0.834863	0.992924	1.182104	1.398236
221.5	0	0.062461	0.215383	0.380213	0.540463	0.696812	0.848339	0.999065	1.160955	1.340803	1.548369	1.77902
223.5	0	0.077573	0.230596	0.395285	0.55451	0.708853	0.857191	1.003532	1.15974	1.332816	1.532556	1.754688
225.5	0	0	0.203848	0.344474	0.462216	0.579221	0.685852	0.791754	0.904593	1.030073	1.174464	1.333975
230.5	0	0	0.172597	0.286109	0.405689	0.503618	0.601102	0.694027	0.794663	0.907355	1.039043	1.186792
235.5	0	0	0.18046	0.300993	0.425933	0.525469	0.622611	0.713579	0.812098	0.923944	1.057404	1.210373
240.5	0	0.072833	0.260545	0.436942	0.593748	0.740096	0.874921	1.004782	1.140679	1.289233	1.45875	1.645535
245.5	0	0	0.147091	0.249818	0.357762	0.44513	0.53162	0.613461	0.70196	0.801326	0.918117	1.050079
250.5	0	0.061535	0.227248	0.381929	0.51869	0.646059	0.763508	0.877526	0.998563	1.133205	1.289479	1.464341
255.5	0	0	0.142467	0.259138	0.381268	0.477212	0.570177	0.655366	0.745846	0.847202	0.967895	1.107199
260.5	0	0	0.147328	0.266101	0.401421	0.518871	0.639301	0.757316	0.887521	1.0363	1.214307	1.419735

265.5	0	0	0.178919	0.324189	0.44582	0.559278	0.658822	0.753573	0.853313	0.966226	1.101174	1.257082
270.5	0	0	0.132551	0.23138	0.331174	0.405454	0.473638	0.532826	0.594985	0.66671	0.756486	0.865172
275.5	0	0	0.193574	0.334788	0.44887	0.555404	0.64666	0.733159	0.824393	0.929252	1.057177	1.208383
277.5	0	0	0.195172	0.348074	0.473271	0.588001	0.684951	0.774208	0.865976	0.969987	1.096729	1.247309
279.5	0	0	0.163781	0.273958	0.385322	0.469931	0.548718	0.618367	0.691533	0.77478	0.877063	0.999225
280.5	0	0	0.193448	0.338567	0.457148	0.567224	0.660667	0.747431	0.83697	0.938321	1.061084	1.205728
281.5	0	0	0.196005	0.348544	0.474276	0.591194	0.692213	0.787472	0.887124	1.00033	1.137128	1.29778
282.5	0	0.033002	0.168545	0.313827	0.452498	0.583735	0.705722	0.822387	0.944864	1.081562	1.243836	1.432058
283.5	0	0	0.119943	0.222375	0.327446	0.40658	0.480586	0.545765	0.614271	0.692256	0.788017	0.901954
284.5	0	0.073985	0.249877	0.437817	0.617453	0.788387	0.94781	1.099432	1.255548	1.424544	1.618403	1.835889
285.5	0.00812	0.130441	0.294416	0.440516	0.564728	0.67571	0.773956	0.866561	0.963782	1.072856	1.201772	1.348732
286.5	0	0	0.20373	0.37133	0.513994	0.648679	0.768142	0.881159	0.997181	1.123603	1.268998	1.431696
287.5	0	0	0.184727	0.334962	0.459493	0.573874	0.671901	0.762951	0.857092	0.963464	1.092073	1.243553
288.5	0	0.062722	0.211464	0.371442	0.525574	0.673218	0.81162	0.943071	1.077135	1.219978	1.381206	1.560054
289.5	0	0	0.189946	0.324478	0.430975	0.528403	0.607957	0.679859	0.752883	0.83633	0.939848	1.065295
290.5	0	0	0.163015	0.267015	0.371065	0.449335	0.521371	0.584577	0.651253	0.728188	0.824274	0.940631
291.5	0	0	0.180462	0.303924	0.429656	0.525702	0.615051	0.693461	0.774752	0.866113	0.977655	1.110833
295.5	0	0	0.163913	0.269026	0.373104	0.44955	0.518167	0.576799	0.638566	0.711465	0.805448	0.922468
300.5	0	0	0.120862	0.21598	0.312156	0.383316	0.448377	0.504384	0.562916	0.630482	0.71555	0.819485
305.5	0	0	0.147909	0.24711	0.345775	0.418321	0.483647	0.539362	0.597624	0.665707	0.752879	0.861195
310.5	0	0	0.153593	0.265118	0.378819	0.465327	0.54612	0.617429	0.69216	0.777173	0.882164	1.008933
315.5	0	0	0.104001	0.19628	0.289952	0.358801	0.421951	0.476476	0.533978	0.600975	0.685866	0.789878
320.5	0	0	0.136534	0.248125	0.363154	0.451012	0.533931	0.607702	0.685282	0.773194	0.880799	1.009331
322.5	0	0.028404	0.156067	0.293444	0.424881	0.549245	0.664538	0.774129	0.888225	1.014638	1.164183	1.337926
324.5	0	0.080088	0.251605	0.436014	0.61366	0.784161	0.94473	1.098349	1.256415	1.426102	1.618353	1.831467
325.5	0	0	0.177892	0.325332	0.449533	0.565407	0.667532	0.764772	0.867003	0.982464	1.120425	1.280381
326.5	0	0.055685	0.209663	0.375483	0.535326	0.688234	0.8313	0.967057	1.105731	1.254153	1.422712	1.610822
328.5	0	0.080531	0.213421	0.354543	0.488675	0.617283	0.740382	0.863136	0.997672	1.152302	1.337978	1.553047
330.5	0	0	0.155748	0.272176	0.392896	0.487635	0.579753	0.665854	0.760212	0.869419	1.002463	1.15784
332.5	0	0.047478	0.194059	0.351169	0.501643	0.644922	0.779124	0.908296	1.044257	1.19562	1.374247	1.580018
334.5	0	0.056316	0.220874	0.398174	0.569575	0.734674	0.891384	1.043469	1.203214	1.378513	1.580786	1.807854
335.5	0	0	0.140025	0.259617	0.394557	0.509551	0.626726	0.741646	0.870425	1.021038	1.205602	1.423012
336.5	0	0.067272	0.238874	0.422722	0.598854	0.766658	0.923477	1.073165	1.228247	1.397443	1.593128	1.814476
338.5	0	0.06135	0.236054	0.424555	0.607087	0.78304	0.949822	1.110803	1.278233	1.459744	1.666774	1.896968
340.5	0	0	0.132897	0.254015	0.393383	0.514747	0.640628	0.765885	0.906538	1.069702	1.266861	1.495591
342.5	0	0.034827	0.168124	0.313934	0.457437	0.598168	0.73493	0.870786	1.016246	1.177374	1.363299	1.570803
344.5	0.008956	0.146379	0.367839	0.59637	0.81603	1.028326	1.231408	1.429554	1.637111	1.861967	2.116342	2.395419
345.5	0.008193	0.134629	0.347341	0.590214	0.840205	1.089542	1.33394	1.574716	1.828941	2.106777	2.424303	2.774978
346.5	0	0.074593	0.23978	0.441211	0.654468	0.872081	1.090942	1.31167	1.549204	1.811958	2.114842	2.453088
348.5	0.005458	0.093304	0.298546	0.514221	0.723791	0.927879	1.124649	1.318449	1.523829	1.749017	2.006432	2.290996
350.5	0	0.08301	0.24153	0.413644	0.582369	0.7485	0.910831	1.072409	1.24442	1.432445	1.645727	1.879676
352.5	0.005274	0.088904	0.265701	0.45044	0.6294	0.803374	0.970764	1.135117	1.308449	1.497372	1.712056	1.948243

354.5	0.005127	0.086888	0.26679	0.456207	0.641509	0.823535	1.000686	1.175981	1.361136	1.561792	1.787457	2.032801
355.5	0	0	0.20172	0.364308	0.505515	0.64362	0.771746	0.898589	1.033313	1.181693	1.350758	1.53601
356.5	0	0.082159	0.236632	0.403695	0.567844	0.730957	0.892555	1.055648	1.230815	1.422411	1.638327	1.872519
358.5	0	0.065949	0.216604	0.381808	0.546138	0.710023	0.872006	1.033816	1.204741	1.38779	1.58913	1.801486
360.5	0	0	0.160682	0.277343	0.400693	0.501542	0.603036	0.70095	0.808296	0.92937	1.071018	1.229385
365.5	0.005623	0.094741	0.277713	0.515421	0.786526	1.07634	1.377633	1.683337	2.006519	2.351125	2.730747	3.134273
367.5	0.005568	0.094359	0.284597	0.532746	0.815692	1.117189	1.42887	1.742786	2.072135	2.421389	2.805448	3.21449
370.5	0	0.086685	0.237038	0.444706	0.688388	0.954567	1.236818	1.527701	1.838807	2.172062	2.537286	2.919018
371.5	0.006212	0.10195	0.261272	0.440088	0.623728	0.810244	0.999745	1.195312	1.410726	1.651874	1.928126	2.22884
373.5	0.006612	0.110672	0.318644	0.538057	0.753189	0.963973	1.166957	1.363266	1.563341	1.770905	1.993895	2.225391
375.5	0	0	0.173167	0.295422	0.425391	0.532821	0.641531	0.746913	0.862285	0.991704	1.141947	1.308542
380.5	0	0	0.121049	0.221455	0.32844	0.415594	0.503699	0.588956	0.683058	0.790092	0.916535	1.059445
385.5	0	0.073812	0.247148	0.411117	0.558308	0.697791	0.829539	0.960064	1.100197	1.255675	1.433707	1.628937
390.5	0	0	0.160219	0.280362	0.407893	0.511881	0.615707	0.714243	0.820143	0.937322	1.072396	1.221708
395.5	0.005685	0.095348	0.280192	0.450035	0.601635	0.744786	0.879775	1.013224	1.155906	1.31324	1.492126	1.686877
400.5	0	0	0.232961	0.40375	0.550135	0.695853	0.830729	0.964771	1.106659	1.261956	1.43732	1.627532
405.5	0	0	0.148472	0.262243	0.381503	0.476466	0.569674	0.656849	0.750775	0.856369	0.980885	1.121702
410.5	0	0	0.191776	0.327752	0.438318	0.544145	0.637348	0.727893	0.824	0.932552	1.060789	1.206758
415.5	0	0	0.223553	0.388046	0.525761	0.659022	0.778366	0.89444	1.016735	1.152664	1.31025	1.486168
417.5	0	0.064458	0.222371	0.417499	0.626469	0.841293	1.058509	1.277558	1.511696	1.767111	2.05568	2.369653
420.5	0	0.063134	0.234612	0.442854	0.659853	0.876014	1.086688	1.292265	1.506999	1.739283	2.002464	2.291056
421.5	0	0.087585	0.280816	0.488362	0.68873	0.882118	1.065931	1.24371	1.428224	1.626608	1.849595	2.092344
423.5	0.009016	0.144075	0.310538	0.479798	0.638877	0.791358	0.939852	1.091489	1.260813	1.45671	1.691509	1.961967
425.5	0	0	0.166574	0.289984	0.417805	0.517655	0.613443	0.70057	0.792745	0.895877	1.01842	1.158972
426.5	0	0.089287	0.260272	0.447642	0.630975	0.808585	0.977053	1.138286	1.303116	1.477569	1.671066	1.879504
430.5	0	0	0.148942	0.263716	0.382277	0.473601	0.559795	0.636239	0.715487	0.803241	0.907603	1.028136
435.5	0	0	0.154426	0.272434	0.392523	0.482881	0.566787	0.640498	0.718067	0.806765	0.916005	1.045811

Appendix Table 5 (continued). Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (µm)											
	1.906	2.188	2.512	2.884	3.311	3.802	4.365	5.012	5.754	6.607	7.586	8.710
1.5	1.399617	1.539649	1.661356	1.758812	1.830015	1.87653	1.903048	1.917685	1.92954	1.94822	1.980787	2.032893
5.5	1.243698	1.360795	1.461943	1.542293	1.600345	1.637458	1.657447	1.666904	1.673553	1.686172	1.712637	1.760894
10.5	1.264594	1.386637	1.492129	1.576638	1.63936	1.682519	1.710839	1.731786	1.753124	1.783087	1.827057	1.889873
15.5	1.308871	1.443355	1.55925	1.650478	1.71529	1.755809	1.777388	1.788418	1.797775	1.813939	1.84211	1.885232
20.5	1.384342	1.517792	1.629154	1.711704	1.763164	1.785184	1.783143	1.765469	1.742306	1.723072	1.715658	1.72427
25.5	1.508012	1.679576	1.823164	1.927931	1.989402	2.008947	1.993839	1.955672	1.90861	1.86485	1.834526	1.821473
26.5	2.400312	2.597745	2.742654	2.8242	2.840083	2.795075	2.702281	2.578942	2.447065	2.323448	2.224005	2.152194
27.5	2.458932	2.648734	2.79028	2.872017	2.890202	2.84809	2.757757	2.636355	2.506884	2.388121	2.297994	2.241789
28.5	2.400782	2.591578	2.733179	2.814649	2.833133	2.79253	2.704683	2.585618	2.456579	2.33465	2.237045	2.169831

29.5	2.561738	2.751469	2.889749	2.965722	2.976698	2.926617	2.827504	2.69539	2.551813	2.413618	2.298163	2.210693
30.5	1.586978	1.747407	1.881681	1.980414	2.039263	2.058646	2.043896	2.004353	1.952508	1.899919	1.857779	1.831596
31.5	3.074933	3.412881	3.670066	3.819917	3.85094	3.765435	3.582183	3.328702	3.043266	2.755214	2.496961	2.277923
32.5	3.031304	3.299739	3.507582	3.634182	3.668098	3.607402	3.46295	3.253897	3.010653	2.75855	2.527578	2.329154
33.5	3.228962	3.419569	3.547451	3.603104	3.58469	3.495909	3.348587	3.157584	2.944841	2.725968	2.520441	2.332289
34.5	3.300556	3.522023	3.68647	3.779812	3.79534	3.732662	3.600213	3.411146	3.187391	2.94636	2.711811	2.492329
35.5	2.753116	3.078627	3.344927	3.524779	3.602982	3.576347	3.455848	3.261606	3.023874	2.766641	2.516853	2.281228
36.5	3.316915	3.664393	3.955856	4.168003	4.28633	4.304267	4.225574	4.062603	3.838183	3.573291	3.297477	3.023887
37.5	2.918822	3.251207	3.541072	3.765896	3.910312	3.966356	3.934932	3.825194	3.654461	3.438518	3.199038	2.943683
38.5	2.578894	2.861979	3.102584	3.282587	3.390466	3.42103	3.377267	3.26944	3.115506	2.93221	2.741419	2.552618
39.5	2.901531	3.194537	3.43683	3.609416	3.701235	3.708714	3.637831	3.501945	3.322554	3.117933	2.910229	2.706239
40.5	1.66077	1.852871	2.012929	2.128656	2.19437	2.21048	2.183546	2.124462	2.047327	1.963558	1.884	1.811299
41.5	2.783501	2.968959	3.078096	3.101452	3.041619	2.910088	2.729058	2.523299	2.323152	2.149345	2.020819	1.939806
42.5	2.874204	3.106226	3.261074	3.326978	3.305512	3.207967	3.056161	2.874579	2.691624	2.525408	2.390816	2.285363
45.5	1.663006	1.818374	1.945033	2.035744	2.08836	2.105205	2.093214	2.062947	2.027353	1.998307	1.985996	1.995642
50.5	1.196023	1.316128	1.417308	1.493843	1.543711	1.568163	1.571704	1.561942	1.548394	1.541012	1.548991	1.579248
55.5	1.263929	1.387792	1.492701	1.573798	1.630036	1.663552	1.6792	1.684406	1.68722	1.695395	1.714167	1.746383
60.5	1.474767	1.67335	1.85365	2.004861	2.121139	2.201428	2.248584	2.270229	2.275407	2.274039	2.274025	2.280194
65.5	1.149563	1.286572	1.411069	1.516206	1.598175	1.65624	1.692204	1.711205	1.719271	1.723116	1.727787	1.736233
70.5	1.529039	1.683273	1.817028	1.923436	1.999462	2.045507	2.065231	2.06567	2.055085	2.041395	2.030634	2.025086
74.5	3.141	3.423212	3.650576	3.807071	3.884415	3.880778	3.803256	3.665404	3.488519	3.290775	3.094598	2.908923
75.5	2.860924	3.134375	3.362652	3.530914	3.631048	3.660925	3.625334	3.534833	3.405854	3.253047	3.09445	2.937651
76.5	2.67535	2.885388	3.053572	3.169529	3.228647	3.231183	3.183717	3.097514	2.988927	2.872059	2.761969	2.663174
77.5	2.615396	2.878772	3.098425	3.256566	3.343469	3.357626	3.307304	3.208147	3.082182	2.948097	2.824092	2.714986
78.5	2.674461	2.86334	3.009879	3.106264	3.149574	3.140837	3.086644	2.997352	2.888011	2.771448	2.662405	2.56663
79.5	2.339932	2.555624	2.738459	2.87674	2.964389	3.000632	2.990687	2.945101	2.878333	2.803674	2.733924	2.673478
80.5	1.438761	1.593507	1.727338	1.83219	1.904368	1.944249	1.955924	1.946842	1.92581	1.900748	1.877894	1.859147
85.5	1.519153	1.677477	1.813025	1.918199	1.989744	2.028078	2.036939	2.023203	1.995286	1.960761	1.926107	1.893163
90.5	2.403862	2.690443	2.932987	3.112886	3.220605	3.254821	3.222393	3.136419	3.015157	2.873916	2.7293	2.586385
93.5	3.125768	3.558165	3.940369	4.239747	4.433376	4.509105	4.467236	4.320516	4.095132	3.818767	3.529999	3.252196
95.5	2.708257	3.027104	3.299924	3.50523	3.630244	3.670497	3.630044	3.519913	3.357957	3.159264	2.943488	2.717174
97.5	3.060507	3.5229	3.941226	4.279604	4.511744	4.622662	4.610033	4.484951	4.271213	3.993722	3.687438	3.371806
99.5	3.325135	3.878244	4.391607	4.820867	5.130457	5.296964	5.311618	5.183732	4.940074	4.61295	4.249642	3.879724
100.5	2.485313	2.873966	3.222407	3.498186	3.67812	3.749931	3.713606	3.580872	3.374867	3.118048	2.840678	2.55708
101.5	3.30415	3.607447	3.831028	3.954492	3.97042	3.882827	3.709544	3.475452	3.215504	2.957198	2.731832	2.552048
103.5	3.362227	3.769757	4.112119	4.359228	4.492782	4.506611	4.408657	4.218166	3.967032	3.684062	3.404914	3.145829
105.5	1.935347	2.118538	2.268936	2.377439	2.441066	2.461853	2.446587	2.405398	2.350693	2.293183	2.243404	2.207239
107.5	2.380092	2.610045	2.78629	2.896077	2.935648	2.908573	2.826817	2.706927	2.57043	2.434601	2.318171	2.229642
109.5	2.874969	3.178062	3.405252	3.534627	3.558496	3.481659	3.323395	3.110329	2.877885	2.653539	2.466083	2.326476
110.5	1.597968	1.747673	1.866621	1.947275	1.987751	1.990652	1.963056	1.914942	1.858732	1.804838	1.762722	1.73577
115.5	1.583626	1.728265	1.843319	1.921135	1.959379	1.960235	1.930571	1.880371	1.822303	1.767093	1.724658	1.698844

120.5	1.405415	1.585462	1.740209	1.857964	1.933072	1.965583	1.961101	1.930035	1.886093	1.842543	1.811993	1.801827
125.5	1.683437	1.882564	2.051078	2.176756	2.254148	2.28404	2.273393	2.233969	2.180395	2.125483	2.080569	2.050257
130.5	2.686816	2.967833	3.197869	3.356528	3.433213	3.42688	3.348162	3.21594	3.057264	2.896162	2.758788	2.659137
135.5	3.45178	3.846988	4.160106	4.35864	4.42483	4.355571	4.167734	3.892469	3.578146	3.269441	3.018528	2.854787
140.5	3.32459	3.687673	3.980179	4.171909	4.246431	4.201082	4.050489	3.820919	3.551976	3.278253	3.039395	2.85538
145.5	1.95123	2.180881	2.37067	2.505843	2.58033	2.595796	2.561618	2.492512	2.407094	2.320995	2.248451	2.193903
150.5	1.768885	2.015227	2.236417	2.416302	2.545718	2.622565	2.651259	2.642764	2.611272	2.570962	2.534315	2.507383
155.5	1.569244	1.792504	1.997414	2.169892	2.301608	2.390178	2.438485	2.455405	2.451923	2.439629	2.427614	2.420075
160.5	1.719737	1.968423	2.198476	2.394177	2.546079	2.651088	2.711752	2.737553	2.740566	2.734419	2.730533	2.73627
165.5	1.8747	2.120134	2.342734	2.52823	2.669215	2.76489	2.820149	2.846243	2.856297	2.864266	2.880506	2.911198
170.5	1.896474	2.166889	2.415487	2.624508	2.782925	2.886796	2.938843	2.949419	2.932352	2.902799	2.874676	2.857011
175.5	2.106198	2.388114	2.63844	2.839251	2.980808	3.061082	3.085404	3.066264	3.019827	2.961926	2.907135	2.862292
180.5	1.9044	2.184156	2.440405	2.653987	2.813147	2.913879	2.959378	2.960801	2.933393	2.893804	2.857912	2.836048
185.5	1.906401	2.189623	2.451643	2.673936	2.845364	2.962429	3.028358	3.054176	3.053503	3.0409	3.027927	3.020738
190.5	1.991201	2.290287	2.567062	2.801659	2.981903	3.103673	3.170008	3.192148	3.184156	3.160729	3.13361	3.108224
195.5	1.98492	2.259996	2.511306	2.722294	2.884195	2.995745	3.061988	3.094906	3.107844	3.114311	3.123388	3.139379
200.5	2.665956	3.001667	3.302535	3.548151	3.726149	3.831932	3.86763	3.842444	3.769292	3.66014	3.52766	3.374901
205.5	2.524327	2.908122	3.263477	3.564367	3.794177	3.946302	4.022838	4.035654	4.000146	3.931453	3.842101	3.734453
207.5	2.903352	3.333772	3.728992	4.058619	4.303301	4.456391	4.523759	4.524953	4.486553	4.436505	4.397928	4.379897
209.5	3.192448	3.675838	4.116153	4.478047	4.73962	4.89426	4.950184	4.930689	4.866592	4.787698	4.716966	4.658392
210.5	2.639102	3.013644	3.35401	3.634653	3.839594	3.962587	4.006621	3.984751	3.916047	3.820815	3.720563	3.628532
211.5	3.094192	3.551399	3.965454	4.302679	4.540314	4.667818	4.687421	4.614863	4.476089	4.298249	4.112158	3.933697
213.5	3.175326	3.72149	4.239146	4.683237	5.016007	5.211442	5.257883	5.162901	4.95182	4.65738	4.326337	3.989212
215.5	2.940627	3.299222	3.614452	3.861831	4.025336	4.097199	4.0779	3.975774	3.806764	3.585553	3.333836	3.060528
217.5	2.836676	3.33682	3.830229	4.279599	4.65229	4.924245	5.08074	5.123988	5.0671	4.932345	4.749108	4.5373
219.5	2.869759	3.262	3.599119	3.84962	3.994445	4.027997	3.960323	3.814155	3.623452	3.419581	3.236279	3.090136
220.5	1.632611	1.864475	2.075205	2.249139	2.376302	2.452987	2.48177	2.471941	2.436533	2.38916	2.342752	2.304166
221.5	2.02326	2.259366	2.468932	2.637844	2.758067	2.827189	2.84842	2.830957	2.787928	2.733764	2.684374	2.652196
223.5	1.990001	2.217411	2.419212	2.582134	2.69892	2.767768	2.792238	2.781565	2.748295	2.70584	2.667801	2.643883
225.5	1.5018	1.663687	1.808582	1.9288	2.020952	2.085413	2.125571	2.148483	2.162052	2.175153	2.194781	2.226775
230.5	1.344828	1.500057	1.64192	1.762531	1.857832	1.927467	1.974111	2.004443	2.02607	2.047849	2.076046	2.115192
235.5	1.37735	1.544873	1.701976	1.840218	1.954689	2.04401	2.109627	2.157384	2.193674	2.226752	2.262202	2.305049
240.5	1.842297	2.032729	2.203897	2.346314	2.45498	2.528997	2.571081	2.588521	2.590519	2.588062	2.591751	2.611295
245.5	1.192378	1.333592	1.464541	1.578286	1.671078	1.742338	1.793995	1.83157	1.860953	1.889259	1.920927	1.95949
250.5	1.651343	1.835438	2.004487	2.149212	2.264301	2.348162	2.402204	2.432167	2.445022	2.449383	2.452664	2.46089
255.5	1.261443	1.419518	1.572245	1.71233	1.835475	1.940506	2.028285	2.104011	2.172509	2.241282	2.313956	2.395384
260.5	1.646622	1.877458	2.096602	2.290706	2.450995	2.573752	2.659525	2.715374	2.749859	2.774003	2.795793	2.820791
265.5	1.429168	1.604517	1.772817	1.926276	2.060369	2.173657	2.266583	2.343709	2.408673	2.467164	2.52093	2.572374
270.5	0.990423	1.123541	1.257574	1.387443	1.510323	1.625176	1.731019	1.829544	1.92016	2.005245	2.083958	2.160044
275.5	1.379478	1.558822	1.736632	1.904524	2.056324	2.188233	2.297743	2.387069	2.458373	2.518369	2.572727	2.630974
277.5	1.418848	1.599819	1.780247	1.95127	2.105923	2.239481	2.348779	2.436139	2.5051	2.565041	2.625187	2.699045
279.5	1.139107	1.287653	1.437334	1.581741	1.71603	1.836911	1.941468	2.030423	2.103877	2.166378	2.221965	2.27993

280.5	1.368933	1.539379	1.707813	1.86691	2.011927	2.140562	2.251506	2.347474	2.430045	2.504363	2.572586	2.640061
281.5	1.478847	1.668214	1.855748	2.032732	2.192649	2.331252	2.445388	2.536679	2.606833	2.662483	2.709788	2.759009
282.5	1.642459	1.860423	2.072913	2.268625	2.439558	2.581375	2.692518	2.777536	2.841681	2.894228	2.941772	2.991426
283.5	1.031436	1.1675	1.303182	1.433585	1.556216	1.670477	1.775868	1.874485	1.965853	2.051851	2.130135	2.201801
284.5	2.070957	2.305235	2.522489	2.709333	2.857236	2.962899	3.028146	3.061611	3.074496	3.080139	3.089407	3.109475
285.5	1.508332	1.667489	1.81562	1.944576	2.049187	2.127385	2.180366	2.214109	2.23601	2.255443	2.279782	2.314201
286.5	1.606741	1.78126	1.945451	2.092346	2.218287	2.322609	2.40669	2.476023	2.535595	2.592496	2.649883	2.711038
287.5	1.414839	1.59458	1.77338	1.943312	2.09855	2.235476	2.351469	2.448402	2.527607	2.594876	2.65451	2.715283
288.5	1.752744	1.946293	2.129916	2.294578	2.433659	2.543135	2.621614	2.673275	2.704584	2.72649	2.75029	2.788714
289.5	1.210985	1.367945	1.528607	1.686229	1.83515	1.971002	2.089746	2.19163	2.276638	2.350424	2.418565	2.493465
290.5	1.075359	1.21991	1.367241	1.511412	1.648006	1.774322	1.888272	1.99186	2.086231	2.177375	2.269266	2.371915
291.5	1.263982	1.427894	1.594798	1.757734	1.911077	2.050705	2.172808	2.278009	2.36674	2.445394	2.520123	2.603831
295.5	1.060887	1.211836	1.367682	1.521778	1.668972	1.805743	1.928917	2.039631	2.138469	2.23195	2.325607	2.43222
300.5	0.940723	1.071674	1.206362	1.340351	1.471045	1.597331	1.717663	1.833223	1.942591	2.048341	2.149963	2.253826
305.5	0.989704	1.13107	1.279282	1.42909	1.576213	1.717593	1.850108	1.974694	2.090865	2.203911	2.316938	2.440962
310.5	1.156535	1.316841	1.482839	1.647899	1.806536	1.954862	2.089225	2.210628	2.319399	2.42221	2.524427	2.639006
315.5	0.911229	1.042061	1.176202	1.309298	1.439334	1.566352	1.690383	1.814296	1.937588	2.062737	2.186389	2.310423
320.5	1.157366	1.316532	1.480044	1.641899	1.797298	1.942776	2.074723	2.193596	2.298708	2.39511	2.486422	2.583349
322.5	1.533675	1.739784	1.946398	2.144845	2.328459	2.493008	2.635649	2.759314	2.866225	2.963718	3.055032	3.146415
324.5	2.059916	2.287217	2.499897	2.687475	2.843498	2.965556	3.054902	3.118963	3.166269	3.207952	3.250981	3.299695
325.5	1.458403	1.642269	1.822083	1.989847	2.140249	2.27059	2.379434	2.469842	2.544532	2.610422	2.672526	2.739283
326.5	1.814424	2.01934	2.213335	2.38596	2.529698	2.64025	2.716444	2.762903	2.786577	2.798308	2.809195	2.831102
328.5	1.79158	2.036173	2.272064	2.486787	2.671316	2.820403	2.932441	3.013387	3.071314	3.119715	3.170793	3.237386
330.5	1.33048	1.507227	1.677703	1.83434	1.973189	2.093539	2.196352	2.286743	2.368481	2.447932	2.526934	2.608884
332.5	1.80848	2.043497	2.270577	2.476794	2.652395	2.791337	2.891087	2.956423	2.995351	3.02195	3.051263	3.100325
334.5	2.053111	2.297992	2.527056	2.728246	2.894305	3.022813	3.115611	3.181102	3.228656	3.270014	3.312616	3.361523
335.5	1.667251	1.919532	2.16278	2.382292	2.56827	2.716304	2.826151	2.904603	2.959481	3.002036	3.040401	3.082032
336.5	2.055993	2.299824	2.530299	2.734137	2.902103	3.029428	3.115738	3.168072	3.196786	3.217078	3.243709	3.291072
338.5	2.143648	2.388171	2.61507	2.812129	2.97153	3.089757	3.167446	3.211839	3.23274	3.243455	3.256323	3.282303
340.5	1.748739	2.0063	2.250418	2.465745	2.641756	2.773182	2.859403	2.906972	2.924848	2.925037	2.918665	2.915164
342.5	1.793025	2.012728	2.215866	2.391478	2.532482	2.635241	2.699334	2.729742	2.733709	2.721472	2.704261	2.692552
344.5	2.689131	2.972828	3.225323	3.429345	3.573683	3.653618	3.672176	3.640959	3.577858	3.502755	3.437196	3.395921
345.5	3.142554	3.489335	3.781626	3.99444	4.115626	4.145463	4.098086	3.998198	3.878283	3.767844	3.692998	3.663676
346.5	2.814727	3.167764	3.482053	3.731261	3.897198	3.971501	3.958624	3.876377	3.754048	3.623259	3.518083	3.460082
348.5	2.59177	2.882258	3.138929	3.342338	3.480295	3.548689	3.552859	3.50803	3.437312	3.366001	3.32005	3.317105
350.5	2.126059	2.365223	2.580879	2.759838	2.893127	2.975744	3.007274	2.993734	2.946381	2.880278	2.815435	2.770459
352.5	2.197225	2.438089	2.653184	2.828634	2.955976	3.03198	3.058985	3.045782	3.005629	2.954149	2.909331	2.886558
354.5	2.288383	2.532563	2.747278	2.918442	3.037598	3.10164	3.113403	3.082326	3.023162	2.95262	2.890167	2.851197
355.5	1.729917	1.916602	2.083901	2.223238	2.330523	2.405589	2.451496	2.475483	2.485882	2.491996	2.501203	2.51907
356.5	2.115431	2.346138	2.547082	2.704535	2.810697	2.863648	2.867748	2.833642	2.776582	2.712292	2.657148	2.621539
358.5	2.014314	2.207629	2.366231	2.480494	2.547307	2.569272	2.555149	2.518477	2.475784	2.442049	2.429364	2.442715
360.5	1.397638	1.561399	1.70951	1.834264	1.932383	2.004475	2.054043	2.08821	2.114156	2.139532	2.168687	2.204456

365.5	3.541219	3.907097	4.191871	4.366716	4.42032	4.359223	4.210219	4.011282	3.809151	3.640718	3.536208	3.502573
367.5	3.628868	4.003328	4.295379	4.472879	4.522195	4.449513	4.283771	4.066924	3.850578	3.674521	3.569248	3.538301
370.5	3.2925	3.612881	3.844876	3.969101	3.983296	3.898372	3.740164	3.541239	3.341702	3.173667	3.066722	3.032001
371.5	2.535803	2.814563	3.036678	3.183305	3.247131	3.231136	3.150618	3.028663	2.894529	2.77312	2.688469	2.651814
373.5	2.454541	2.659517	2.823067	2.933934	2.988255	2.988556	2.944485	2.870565	2.785845	2.707442	2.651941	2.627586
375.5	1.484001	1.652981	1.803436	1.9268	2.019077	2.080505	2.115002	2.13054	2.136148	2.141044	2.151792	2.172101
380.5	1.213222	1.365213	1.505143	1.625174	1.721098	1.792274	1.840917	1.873161	1.895877	1.917037	1.942011	1.974575
385.5	1.832523	2.026626	2.197322	2.334776	2.434343	2.495853	2.522971	2.523432	2.506685	2.48245	2.459793	2.445025
390.5	1.378778	1.530072	1.665241	1.77734	1.863449	1.923925	1.961589	1.982297	1.992354	1.998708	2.007028	2.022601
395.5	1.888445	2.078965	2.244574	2.37552	2.467147	2.519323	2.536269	2.526571	2.501099	2.470889	2.446514	2.435336
400.5	1.824311	2.010932	2.174542	2.306052	2.401051	2.459282	2.484316	2.483883	2.467772	2.446605	2.430928	2.429312
405.5	1.273	1.421837	1.558169	1.675269	1.770464	1.844428	1.899946	1.942714	1.977805	2.011075	2.04564	2.085072
410.5	1.365367	1.524278	1.673731	1.806291	1.91733	2.004798	2.068614	2.11241	2.140321	2.158964	2.175112	2.198239
415.5	1.673293	1.855881	2.021511	2.161138	2.26984	2.346382	2.3928	2.415533	2.422591	2.423782	2.428599	2.446462
417.5	2.693948	2.995509	3.245307	3.422177	3.51676	3.531055	3.479207	3.383931	3.274495	3.177267	3.116325	3.103364
420.5	2.591766	2.874138	3.111412	3.283859	3.381772	3.40555	3.367273	3.288094	3.196049	3.11769	3.077537	3.089619
421.5	2.344691	2.583529	2.789458	2.948239	3.052737	3.102702	3.10542	3.075265	3.031569	2.994556	2.983498	3.011992
423.5	2.258959	2.557093	2.831863	3.060456	3.225319	3.317433	3.34068	3.313519	3.264066	3.223522	3.221196	3.276598
425.5	1.31273	1.467503	1.613775	1.744904	1.857596	1.951251	2.026709	2.088066	2.138946	2.185505	2.232311	2.286912
426.5	2.094408	2.29682	2.471867	2.609603	2.70564	2.760507	2.780223	2.776539	2.764558	2.760814	2.780153	2.83387
430.5	1.161344	1.297293	1.42839	1.549404	1.657535	1.751762	1.83167	1.899673	1.957596	2.010656	2.063583	2.126187
435.5	1.192309	1.344139	1.492178	1.629844	1.753537	1.862205	1.955991	2.038538	2.112382	2.183127	2.253894	2.332067

Appendix Table 5 (continued). Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (μm)											
	10.000	11.482	13.183	15.136	17.378	19.953	22.909	26.303	30.200	34.674	39.811	45.709
1.5	2.105248	2.20112	2.31912	2.466205	2.643503	2.85949	3.109499	3.389294	3.67758	3.951885	4.179304	4.327698
5.5	1.835675	1.94535	2.093106	2.290984	2.540943	2.852113	3.213038	3.612175	4.013787	4.38134	4.666221	4.825436
10.5	1.971589	2.076393	2.204579	2.367026	2.569457	2.826649	3.137888	3.50191	3.893419	4.281978	4.618964	4.854095
15.5	1.941621	2.012022	2.095579	2.200841	2.336177	2.518785	2.756275	3.055444	3.402383	3.77623	4.136101	4.435083
20.5	1.749674	1.791827	1.848595	1.922613	2.015344	2.133483	2.27711	2.446153	2.629793	2.815717	2.984006	3.114333
25.5	1.826086	1.846657	1.881914	1.936266	2.016885	2.137732	2.306755	2.530083	2.797004	3.089504	3.372057	3.602908
26.5	2.107729	2.082662	2.072207	2.076462	2.104802	2.174879	2.303104	2.502494	2.767614	3.08021	3.397863	3.666104
27.5	2.218855	2.219338	2.231633	2.246921	2.263042	2.28713	2.330803	2.407829	2.526676	2.690374	2.8871	3.090852
28.5	2.135992	2.131218	2.151287	2.194631	2.262631	2.363051	2.499774	2.676499	2.88514	3.113368	3.335386	3.518604
29.5	2.154389	2.124237	2.117353	2.132684	2.174484	2.252833	2.375308	2.547963	2.763405	3.006962	3.247143	3.443528
30.5	1.824239	1.834892	1.861851	1.90573	1.967626	2.052712	2.161831	2.295844	2.447826	2.61072	2.772145	2.919767
31.5	2.107165	1.975451	1.882241	1.825489	1.816209	1.870423	2.003574	2.226235	2.528689	2.887146	3.251388	3.559211

32.5	2.175511	2.062147	1.989981	1.955352	1.961973	2.015651	2.119473	2.272735	2.462335	2.670566	2.869152	3.026013
33.5	2.168858	2.02446	1.904338	1.810686	1.758205	1.761192	1.832081	1.975528	2.181348	2.430534	2.688248	2.912562
34.5	2.3018	2.138933	2.012659	1.924928	1.88666	1.905338	1.983705	2.116167	2.283454	2.460491	2.613554	2.709149
35.5	2.069636	1.874804	1.702766	1.553072	1.440568	1.37679	1.375604	1.444218	1.58259	1.785419	2.035548	2.30747
36.5	2.772203	2.542263	2.347413	2.190009	2.085459	2.042123	2.065292	2.146959	2.263493	2.381189	2.458593	2.45814
37.5	2.688359	2.433884	2.200654	2.001335	1.86741	1.823549	1.891623	2.078367	2.365513	2.714077	3.055198	3.308061
38.5	2.378997	2.220102	2.085943	1.980832	1.920248	1.917295	1.98318	2.121319	2.320909	2.562818	2.813454	3.034365
39.5	2.515912	2.334208	2.168705	2.021686	1.911545	1.854968	1.870946	1.969952	2.149181	2.39376	2.66829	2.923524
40.5	1.747697	1.690027	1.640734	1.603883	1.592198	1.621772	1.708258	1.86451	2.09107	2.380767	2.707548	3.033627
41.5	1.903838	1.901186	1.919803	1.950572	1.98905	2.038334	2.102693	2.188884	2.300563	2.442298	2.613284	2.807929
42.5	2.203428	2.130603	2.061312	1.995866	1.951948	1.956012	2.039146	2.229667	2.539023	2.96054	3.445515	3.907571
45.5	2.027761	2.08118	2.151625	2.240562	2.348444	2.482971	2.645773	2.840073	3.05828	3.291933	3.522959	3.730527
50.5	1.633959	1.714703	1.8169	1.941196	2.082754	2.243769	2.418855	2.606308	2.79639	2.982494	3.154508	3.305215
55.5	1.790491	1.845616	1.908428	1.981812	2.06847	2.177767	2.314356	2.483921	2.682185	2.903377	3.132419	3.351498
60.5	2.294055	2.316649	2.349486	2.39975	2.476793	2.595335	2.762758	2.983203	3.243397	3.523177	3.78663	3.993175
65.5	1.748574	1.764203	1.782167	1.804839	1.836608	1.885647	1.958351	2.061121	2.194299	2.357206	2.542599	2.740776
70.5	2.024387	2.026969	2.032923	2.046634	2.076753	2.136193	2.23477	2.379992	2.568235	2.791521	3.030525	3.261499
74.5	2.747288	2.61234	2.517901	2.474374	2.497831	2.598509	2.769209	2.984128	3.188752	3.318304	3.306404	3.10905
75.5	2.794545	2.668262	2.572898	2.520018	2.527932	2.610209	2.76622	2.979087	3.204753	3.387008	3.460973	3.374087
76.5	2.579163	2.5047	2.439804	2.383907	2.345095	2.332062	2.352668	2.408761	2.494308	2.599079	2.706837	2.798657
77.5	2.623885	2.544927	2.479349	2.429659	2.408645	2.431287	2.510014	2.65045	2.843278	3.069303	3.291353	3.461173
78.5	2.490201	2.431924	2.395115	2.382393	2.400505	2.456499	2.551632	2.681607	2.830059	2.976461	3.093035	3.152463
79.5	2.624287	2.582283	2.547284	2.52143	2.515192	2.543312	2.619684	2.753507	2.939697	3.162564	3.387881	3.570629
80.5	1.844459	1.831742	1.821288	1.81667	1.826985	1.865352	1.943751	2.072298	2.251318	2.476351	2.730485	2.990612
85.5	1.862608	1.832444	1.804442	1.782862	1.778602	1.805687	1.877035	2.002238	2.179884	2.402497	2.64978	2.895718
90.5	2.45254	2.325662	2.213855	2.122966	2.070084	2.070675	2.136815	2.271005	2.459576	2.678969	2.891429	3.055679
93.5	3.016345	2.833739	2.723586	2.691497	2.741001	2.862975	3.02547	3.178957	3.256232	3.196916	2.964998	2.56259
95.5	2.494038	2.273828	2.071895	1.895166	1.765941	1.69948	1.708872	1.792993	1.934917	2.10722	2.272034	2.391396
97.5	3.077339	2.815277	2.613315	2.484884	2.450082	2.514217	2.662363	2.85611	3.029655	3.111985	3.041271	2.786946
99.5	3.542105	3.2462	3.011776	2.834781	2.716382	2.640078	2.580591	2.496323	2.345508	2.097563	1.754219	1.348151
100.5	2.290098	2.044141	1.839236	1.683901	1.599608	1.600907	1.69747	1.887085	2.146607	2.440025	2.71267	2.906984
101.5	2.431279	2.36882	2.366877	2.425299	2.542551	2.716333	2.926222	3.141287	3.310184	3.381904	3.31323	3.084569
103.5	2.927182	2.749548	2.622444	2.545398	2.523981	2.556838	2.631723	2.72227	2.786985	2.781905	2.670502	2.434982
105.5	2.191305	2.202529	2.251768	2.356603	2.53274	2.798918	3.151615	3.578023	4.031357	4.456085	4.778946	4.933669
107.5	2.177528	2.164839	2.198459	2.290529	2.453797	2.705858	3.044255	3.455274	3.887211	4.274188	4.532203	4.590286
109.5	2.244817	2.220721	2.256472	2.356553	2.52341	2.761781	3.054354	3.371229	3.65148	3.828417	3.836244	3.636457
110.5	1.724965	1.728177	1.744139	1.775257	1.826847	1.908863	2.026829	2.18416	2.372092	2.577346	2.775912	2.941261
115.5	1.690947	1.698916	1.720665	1.757319	1.811993	1.892434	2.002384	2.144422	2.310847	2.490844	2.66506	2.812747
120.5	1.815993	1.85587	1.920224	2.011868	2.130963	2.28283	2.463361	2.667723	2.878089	3.076225	3.238231	3.344054
125.5	2.036612	2.038904	2.058441	2.10152	2.177707	2.301689	2.479752	2.713128	2.982691	3.260242	3.501208	3.659314
130.5	2.610621	2.619769	2.693778	2.843078	3.070549	3.378589	3.73704	4.096855	4.370364	4.466302	4.308908	3.871911
135.5	2.800417	2.855624	3.005078	3.224882	3.468294	3.686353	3.810539	3.776206	3.534434	3.07416	2.447514	1.748197

140.5	2.745707	2.713947	2.761881	2.886199	3.071997	3.297935	3.514063	3.657315	3.65183	3.44016	3.007973	2.394214
145.5	2.158202	2.135584	2.122012	2.116068	2.122962	2.152321	2.212115	2.305735	2.425334	2.556197	2.674196	2.753066
150.5	2.492714	2.489116	2.49658	2.518531	2.561948	2.637319	2.748906	2.895424	3.060449	3.219982	3.338752	3.379658
155.5	2.417166	2.416554	2.417227	2.422356	2.440393	2.48378	2.561497	2.677122	2.820622	2.973277	3.10371	3.175792
160.5	2.754547	2.786759	2.83313	2.898918	2.989299	3.113269	3.269049	3.448354	3.624968	3.766142	3.831054	3.782369
165.5	2.95633	3.015619	3.086234	3.17245	3.277694	3.410271	3.566818	3.736901	3.891585	3.99514	4.005544	3.886373
170.5	2.85585	2.874966	2.91811	2.993398	3.107777	3.270868	3.477229	3.712445	3.938399	4.108723	4.168674	4.072184
175.5	2.830791	2.810725	2.802559	2.810137	2.842739	2.912762	3.02522	3.175938	3.341319	3.487088	3.568034	3.541523
180.5	2.835028	2.858135	2.907126	2.986974	3.100119	3.251223	3.430894	3.622334	3.789951	3.893795	3.891236	3.749974
185.5	3.021155	3.028814	3.044583	3.074247	3.126744	3.213512	3.335832	3.484718	3.631018	3.735648	3.751981	3.639883
190.5	3.086315	3.066256	3.049529	3.041269	3.052402	3.094985	3.173171	3.279667	3.388997	3.465291	3.46542	3.350872
195.5	3.161532	3.189123	3.222707	3.270109	3.341705	3.450635	3.59707	3.769045	3.931266	4.037593	4.034644	3.878219
200.5	3.208628	3.026165	2.839226	2.65441	2.494561	2.37504	2.310124	2.296494	2.316944	2.342041	2.337321	2.271617
205.5	3.610295	3.463274	3.299419	3.122734	2.954171	2.808354	2.699754	2.624047	2.565029	2.493785	2.379801	2.197403
207.5	4.377352	4.371008	4.3343	4.237753	4.061404	3.787623	3.41782	2.953421	2.421885	1.858488	1.310206	0.836144
209.5	4.600806	4.514053	4.366172	4.121721	3.771304	3.311158	2.773542	2.18519	1.603771	1.060502	0.631191	0.280193
210.5	3.557643	3.513025	3.501168	3.524483	3.580524	3.657876	3.725913	3.739583	3.646496	3.404964	3.003767	2.46797
211.5	3.777718	3.641151	3.524686	3.418792	3.319415	3.213502	3.085163	2.90654	2.655178	2.316655	1.903874	1.451014
213.5	3.68419	3.421365	3.217838	3.066734	2.962864	2.883623	2.799228	2.668128	2.45634	2.144161	1.74631	1.298733
215.5	2.784984	2.510323	2.25813	2.037045	1.871536	1.774	1.753213	1.800237	1.890938	1.991343	2.062156	2.068815
217.5	4.319624	4.09879	3.884263	3.667059	3.446968	3.208459	2.941497	2.624902	2.254058	1.831438	1.388179	0.95812
219.5	2.995295	2.952083	2.961276	3.021509	3.129123	3.278916	3.447229	3.597435	3.673686	3.620194	3.39579	2.99022
220.5	2.277821	2.264147	2.265789	2.288811	2.343033	2.441712	2.590288	2.788024	3.0153	3.243633	3.430596	3.533179
221.5	2.649974	2.690244	2.785788	2.955092	3.207132	3.550931	3.962125	4.400813	4.786884	5.03386	5.054747	4.795299
223.5	2.643128	2.674676	2.749331	2.884665	3.093001	3.388405	3.757155	4.171313	4.563916	4.857209	4.963594	4.816606
225.5	2.273739	2.340569	2.430339	2.553944	2.718422	2.936443	3.205027	3.517267	3.842896	4.14606	4.377333	4.490062
230.5	2.164958	2.226165	2.297136	2.383258	2.489016	2.625184	2.794216	2.996515	3.216779	3.434409	3.616966	3.730575
235.5	2.356313	2.419613	2.497028	2.598588	2.732145	2.910733	3.133955	3.396541	3.671622	3.925644	4.112382	4.187836
240.5	2.654445	2.73114	2.848248	3.018946	3.245985	3.53393	3.862029	4.202346	4.501061	4.703576	4.753687	4.612313
245.5	2.004648	2.058367	2.12173	2.20348	2.312132	2.462102	2.657934	2.900901	3.173152	3.449985	3.691598	3.855964
250.5	2.47843	2.511426	2.567497	2.661233	2.805222	3.014685	3.28595	3.605795	3.932521	4.216142	4.394639	4.414452
255.5	2.484669	2.585604	2.697758	2.830339	2.988281	3.18362	3.415612	3.681811	3.960939	4.227515	4.443244	4.568802
260.5	2.849939	2.884941	2.927996	2.988657	3.078043	3.211265	3.390998	3.61061	3.839562	4.036285	4.146255	4.118382
265.5	2.620718	2.670496	2.728888	2.814141	2.946124	3.15011	3.434383	3.797125	4.203102	4.602709	4.923129	5.091798
270.5	2.236005	2.323986	2.437723	2.603912	2.843681	3.183061	3.62013	4.142587	4.696334	5.215785	5.612915	5.808681
275.5	2.701057	2.797343	2.931664	3.124527	3.384293	3.720306	4.110925	4.52409	4.894865	5.156093	5.238305	5.094715
277.5	2.797049	2.935322	3.121756	3.371245	3.679185	4.041321	4.420912	4.775356	5.038754	5.152979	5.071448	4.776371
279.5	2.349826	2.449656	2.596262	2.816454	3.123288	3.530906	4.017325	4.549984	5.056713	5.462674	5.68583	5.667511
280.5	2.709695	2.791646	2.89615	3.044185	3.250841	3.534294	3.887217	4.291367	4.693672	5.032167	5.23171	5.229488
281.5	2.819715	2.90775	3.036903	3.228671	3.49146	3.833046	4.228434	4.641141	5.001346	5.23762	5.278752	5.079034
282.5	3.045995	3.111554	3.192877	3.30291	3.450845	3.648533	3.888665	4.153614	4.399675	4.575848	4.624556	4.500413
283.5	2.266111	2.331406	2.410045	2.528293	2.71299	2.997994	3.395427	3.90736	4.493282	5.095382	5.622291	5.979765

284.5	3.142041	3.187845	3.245409	3.318487	3.408929	3.520672	3.645593	3.768229	3.859163	3.886173	3.817571	3.630806
285.5	2.357601	2.407293	2.456841	2.505361	2.554593	2.614831	2.697474	2.81627	2.977717	3.184498	3.426678	3.685365
286.5	2.774361	2.842299	2.916476	3.00792	3.127211	3.290719	3.502373	3.760258	4.039677	4.306705	4.5111	4.601204
287.5	2.78531	2.880757	3.016686	3.217623	3.495002	3.859572	4.2867	4.738907	5.142079	5.419746	5.493881	5.312819
288.5	2.852272	2.955119	3.106427	3.322201	3.603086	3.949207	4.326425	4.688687	4.960889	5.073023	4.968771	4.626777
289.5	2.587869	2.724672	2.92274	3.210914	3.596441	4.085261	4.638068	5.203789	5.690584	6.009636	6.075464	5.837829
290.5	2.492748	2.649663	2.855416	3.135607	3.49814	3.954356	4.476828	5.028931	5.53355	5.911506	6.077526	5.971126
291.5	2.708618	2.856238	3.062658	3.353475	3.732129	4.20127	4.720412	5.238457	5.66687	5.920817	5.921365	5.624402
295.5	2.562404	2.737519	2.971497	3.290062	3.696102	4.194232	4.745659	5.30269	5.77884	6.091029	6.158746	5.933598
300.5	2.365107	2.501564	2.679731	2.930918	3.273299	3.729543	4.284009	4.909526	5.530478	6.06204	6.400904	6.461774
305.5	2.584257	2.767433	3.004283	3.322287	3.727508	4.228893	4.791948	5.372083	5.882245	6.235246	6.342112	6.144829
310.5	2.776091	2.95642	3.192029	3.505804	3.897141	4.366642	4.873317	5.367767	5.765833	5.987902	5.96097	5.645671
315.5	2.432288	2.561266	2.706004	2.891667	3.138747	3.476404	3.908349	4.429464	4.992205	5.534258	5.964633	6.194069
320.5	2.695094	2.841493	3.037707	3.310181	3.666362	4.114351	4.621457	5.143778	5.598141	5.901644	5.971947	5.75739
322.5	3.23855	3.338604	3.45104	3.590661	3.765912	3.987435	4.243079	4.50871	4.732601	4.856386	4.819297	4.577878
324.5	3.351181	3.402877	3.450257	3.495699	3.543203	3.600084	3.665859	3.73158	3.775262	3.768694	3.682003	3.490575
325.5	2.81665	2.91726	3.051205	3.238231	3.48733	3.809384	4.185732	4.58718	4.951452	5.212144	5.298129	5.158092
326.5	2.874913	2.955089	3.083571	3.278676	3.54481	3.884517	4.265219	4.639913	4.929146	5.055916	4.955637	4.601546
328.5	3.325364	3.441896	3.585819	3.762809	3.967133	4.195303	4.420986	4.608228	4.70149	4.647549	4.407832	3.973084
330.5	2.691778	2.779381	2.874221	2.990635	3.142178	3.349948	3.619763	3.950252	4.310389	4.656698	4.925385	5.053483
332.5	3.182885	3.315812	3.506698	3.767775	4.088071	4.452082	4.804992	5.080622	5.19321	5.074472	4.692323	4.064251
334.5	3.415094	3.472902	3.532937	3.600701	3.680972	3.780088	3.890769	3.994368	4.054971	4.031127	3.884246	3.590281
335.5	3.130066	3.190852	3.270897	3.38609	3.549325	3.775938	4.057861	4.37196	4.660406	4.853226	4.872727	4.661158
336.5	3.368228	3.485193	3.6427	3.845256	4.079432	4.328531	4.547039	4.680438	4.66408	4.449507	4.023122	3.411854
338.5	3.328417	3.402589	3.508478	3.653996	3.835254	4.044765	4.248693	4.40101	4.43988	4.311692	3.988047	3.477042
340.5	2.922657	2.950577	3.0105	3.121059	3.297496	3.556077	3.886848	4.263909	4.622861	4.887194	4.971154	4.810106
342.5	2.696779	2.728383	2.799809	2.928646	3.125097	3.398028	3.72739	4.077256	4.376828	4.549791	4.522807	4.253923
344.5	3.389833	3.4228	3.492158	3.592498	3.707224	3.815154	3.879093	3.856627	3.707862	3.408889	2.967033	2.417111
345.5	3.677224	3.717428	3.757431	3.768964	3.725614	3.606711	3.402395	3.105927	2.730604	2.297469	1.845458	1.409664
346.5	3.462483	3.525252	3.635085	3.773273	3.905727	3.99577	3.995509	3.860402	3.56566	3.11517	2.554625	1.95125
348.5	3.366177	3.468087	3.609464	3.775286	3.934502	4.056121	4.097645	4.020561	3.800057	3.433229	2.950629	2.400917
350.5	2.765761	2.820177	2.948921	3.168464	3.475546	3.86023	4.270662	4.640265	4.874972	4.895379	4.652797	4.150046
352.5	2.900775	2.965774	3.090707	3.286721	3.548254	3.865974	4.19702	4.487201	4.659844	4.64828	4.408727	3.937799
354.5	2.850859	2.90211	3.014802	3.201383	3.459423	3.782416	4.128469	4.441509	4.63945	4.649275	4.42191	3.951818
355.5	2.548789	2.596075	2.668038	2.781029	2.949978	3.194872	3.515559	3.902067	4.310324	4.684343	4.949176	5.035458
356.5	2.613784	2.639217	2.702933	2.814585	2.979468	3.204915	3.47777	3.775679	4.050127	4.247541	4.308867	4.188835
358.5	2.48015	2.536796	2.604151	2.680137	2.763567	2.860983	2.974655	3.10683	3.251056	3.399555	3.536983	3.642955
360.5	2.246101	2.295937	2.357462	2.444141	2.57147	2.762873	3.029733	3.378439	3.786926	4.22023	4.616991	4.909147
365.5	3.530507	3.593952	3.653097	3.667474	3.601574	3.432618	3.159727	2.792616	2.368025	1.926619	1.516814	1.167098
367.5	3.566179	3.619456	3.65328	3.62654	3.512459	3.30101	3.00643	2.646203	2.254133	1.855389	1.476769	1.123692
370.5	3.068996	3.165127	3.295314	3.437212	3.562097	3.649254	3.672494	3.605264	3.42473	3.119648	2.70533	2.214441
371.5	2.666624	2.727822	2.824067	2.949157	3.094535	3.260544	3.437149	3.609873	3.746694	3.812282	3.773136	3.611135

373.5	2.63822	2.683831	2.762007	2.875842	3.025189	3.214773	3.434199	3.667035	3.876243	4.021877	4.062335	3.967291
375.5	2.201882	2.241681	2.291725	2.359094	2.452178	2.585774	2.766879	2.999783	3.270383	3.556865	3.820479	4.017665
380.5	2.014463	2.062871	2.120259	2.194649	2.295151	2.438069	2.632103	2.884104	3.181965	3.505546	3.815506	4.066074
385.5	2.444379	2.465821	2.521064	2.629694	2.809357	3.080606	3.440247	3.87359	4.328594	4.741358	5.028743	5.11595
390.5	2.050401	2.099751	2.18242	2.320035	2.531139	2.840001	3.247745	3.747941	4.295988	4.835863	5.285592	5.564762
395.5	2.443888	2.479878	2.552906	2.680246	2.875289	3.154587	3.510575	3.925282	4.345821	4.710169	4.941651	4.97488
400.5	2.449541	2.501167	2.594051	2.745658	2.966911	3.27173	3.647997	4.074014	4.493672	4.843878	5.049473	5.048778
405.5	2.131417	2.192494	2.27841	2.41079	2.60962	2.901708	3.292382	3.779299	4.321875	4.866144	5.329548	5.628375
410.5	2.239798	2.318706	2.455544	2.681431	3.014731	3.475031	4.041101	4.677825	5.300411	5.816397	6.119124	6.126433
415.5	2.486166	2.560397	2.681033	2.868232	3.131819	3.483657	3.904626	4.36528	4.799998	5.138671	5.303462	5.235985
417.5	3.141061	3.224968	3.342143	3.484038	3.635633	3.78719	3.914877	3.988223	3.965854	3.810201	3.501565	3.042663
420.5	3.158284	3.281964	3.446244	3.639443	3.83507	4.009143	4.121532	4.132313	4.005978	3.726823	3.312033	2.803
421.5	3.086212	3.20969	3.374579	3.576682	3.796431	4.016614	4.20015	4.307738	4.294512	4.128801	3.803606	3.338354
423.5	3.393351	3.565567	3.765467	3.967269	4.132287	4.234323	4.247172	4.153784	3.948795	3.639209	3.251771	2.818634
425.5	2.35632	2.45587	2.601077	2.819685	3.128494	3.547686	4.061372	4.641554	5.214419	5.69738	5.991593	6.016762
426.5	2.925413	3.05785	3.224122	3.424411	3.646971	3.885763	4.115617	4.307639	4.417711	4.40614	4.244988	3.927953
430.5	2.209078	2.33306	2.517701	2.795146	3.180744	3.692387	4.30415	4.977894	5.625009	6.151124	6.448877	6.437103
435.5	2.423623	2.5442	2.707861	2.941363	3.25882	3.677871	4.180139	4.736197	5.273465	5.712806	5.962368	5.950166

Appendix Table 5 (continued). Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (μm)											
	52.481	60.256	69.183	79.433	91.201	104.713	120.226	138.038	158.489	181.970	208.930	239.883
1.5	4.365488	4.269237	4.029737	3.661986	3.195766	2.685898	2.174706	1.719108	1.34293	1.071993	0.892887	0.789824
5.5	4.823684	4.644047	4.2937	3.813375	3.259682	2.713104	2.229819	1.864676	1.624094	1.495092	1.422274	1.341496
10.5	4.937465	4.832841	4.52771	4.045559	3.432484	2.769604	2.122746	1.574203	1.16023	0.909838	0.798974	0.786897
15.5	4.621306	4.651221	4.502568	4.185762	3.737059	3.223361	2.700523	2.234758	1.850171	1.563995	1.347226	1.170182
20.5	3.185581	3.181098	3.09421	2.933996	2.722276	2.496159	2.288678	2.13737	2.062862	2.074222	2.158039	2.279063
25.5	3.736439	3.736356	3.589157	3.315062	2.959471	2.59127	2.265498	2.03451	1.91568	1.906244	1.9716	2.054763
26.5	3.823151	3.817329	3.625023	3.265258	2.788291	2.273002	1.775664	1.349433	1.000323	0.731471	0.51703	0.34823
27.5	3.259279	3.342653	3.299906	3.113971	2.79503	2.384599	1.924271	1.47373	1.06401	0.731913	0.477467	0.306712
28.5	3.622829	3.609227	3.452816	3.155932	2.744314	2.272475	1.785215	1.339257	0.956774	0.662423	0.445083	0.298717
29.5	3.548015	3.516981	3.325933	2.984846	2.532184	2.03855	1.56123	1.161243	0.855386	0.649109	0.511066	0.409786
30.5	3.039759	3.120442	3.157467	3.156042	3.130693	3.098691	3.071299	3.050973	3.026305	2.973451	2.855023	2.638935
31.5	3.74016	3.731016	3.494607	3.038982	2.412892	1.687175	0.985565	0.28244	0.017488	0	0	0
32.5	3.103895	3.068862	2.902518	2.612637	2.226461	1.793676	1.353229	0.946568	0.60547	0.312233	0.128168	0
33.5	3.055604	3.074348	2.942119	2.658564	2.242908	1.748723	1.203107	0.723247	0.206362	0	0	0
34.5	2.716124	2.61305	2.394055	2.076128	1.686459	1.273687	0.855398	0.512799	0.149538	0	0	0
35.5	2.564607	2.766222	2.880781	2.893573	2.812858	2.662956	2.46863	2.258751	2.044019	1.831154	1.599242	1.334159
36.5	2.35335	2.137446	1.827035	1.463429	1.100409	0.751173	0.456049	0.112969	0	0	0	0
37.5	3.392417	3.254624	2.887763	2.344752	1.713637	1.099245	0.599732	0.202761	0.043796	0	0	0

38.5	3.183609	3.225241	3.140813	2.938597	2.646626	2.307354	1.94542	1.585711	1.229276	0.885647	0.563924	0.274962
39.5	3.098302	3.134279	2.994896	2.683053	2.23772	1.734806	1.239448	0.821386	0.504298	0.299689	0.181123	0.12201
40.5	3.308359	3.47977	3.511351	3.394719	3.154105	2.845105	2.52563	2.260991	2.087161	2.023273	2.051989	2.13205
41.5	3.009204	3.186923	3.302507	3.314874	3.193343	2.927236	2.523241	2.031419	1.504955	1.02658	0.634911	0.36488
42.5	4.225867	4.280924	4.003193	3.413402	2.617011	1.775919	1.0591	0.381488	0.079287	0	0	0
45.5	3.888148	3.968185	3.948553	3.818573	3.579078	3.247422	2.838734	2.388901	1.918042	1.469073	1.054936	0.70984
50.5	3.426932	3.51212	3.555942	3.55789	3.523654	3.461458	3.374436	3.262694	3.114806	2.922059	2.666191	2.350791
55.5	3.537194	3.664588	3.714451	3.678411	3.562786	3.388585	3.178867	2.965913	2.768426	2.603367	2.460088	2.321083
60.5	4.09908	4.068559	3.884463	3.558901	3.123937	2.636417	2.139915	1.69018	1.30973	1.02461	0.825487	0.707476
65.5	2.936885	3.11342	3.255701	3.353142	3.405803	3.4186	3.400639	3.36227	3.310876	3.249258	3.165899	3.044536
70.5	3.454403	3.578382	3.61017	3.540331	3.376419	3.144447	2.872676	2.601584	2.354472	2.15317	1.98722	1.840683
74.5	2.720514	2.182616	1.574175	0.996295	0.526454	0.108892	0.00565	0	0	0	0	0
75.5	3.099552	2.649578	2.07347	1.46258	0.885874	0.480955	0.090194	0	0	0	0	0
76.5	2.851653	2.841784	2.749679	2.569374	2.306759	1.984123	1.616808	1.239132	0.861564	0.539403	0.24384	0.029995
77.5	3.521298	3.41959	3.128194	2.665637	2.08839	1.491905	0.954924	0.533771	0.159986	0	0	0
78.5	3.130338	3.011877	2.796433	2.502228	2.152046	1.775028	1.383044	0.988177	0.61834	0.250539	0.034162	0
79.5	3.657111	3.597681	3.363032	2.962481	2.436042	1.858019	1.290379	0.795568	0.418936	0.128501	0	0
80.5	3.225651	3.402738	3.496691	3.494909	3.402574	3.240599	3.033545	2.815795	2.609366	2.436853	2.296147	2.181421
85.5	3.107846	3.254248	3.313074	3.27816	3.162569	2.996884	2.814618	2.655097	2.540995	2.482684	2.462503	2.446503
90.5	3.130855	3.087566	2.917341	2.639901	2.291315	1.923292	1.570107	1.267536	1.023099	0.844284	0.716267	0.630001
93.5	2.033721	1.452889	0.895618	0.4601	0.112867	0.017571	0	0	0	0	0	0
95.5	2.431223	2.369735	2.203861	1.955189	1.660233	1.371013	1.12654	0.963505	0.893284	0.912444	0.996722	1.105991
97.5	2.361137	1.818696	1.230109	0.718448	0.14223	0.011567	0	0	0	0	0	0
99.5	0.935574	0.573344	0.306265	0.12279	0.055701	0.007416	0	0	0	0	0	0
100.5	2.969904	2.869283	2.606188	2.223788	1.788339	1.384168	1.067902	0.882905	0.835754	0.915349	1.090028	1.299529
101.5	2.706272	2.218291	1.677834	1.158093	0.708681	0.385626	0.147112	0.043486	0	0	0	0
103.5	2.082977	1.648007	1.181214	0.742146	0.397579	0.124228	0.026353	0	0	0	0	0
105.5	4.868945	4.565111	4.03995	3.35756	2.595605	1.85705	1.196701	0.694875	0.303077	0.108069	0	0
107.5	4.405265	3.979108	3.359807	2.643372	1.928182	1.312125	0.831925	0.49711	0.280082	0.121721	0.030821	0
109.5	3.231022	2.667434	2.023797	1.399162	0.865229	0.470291	0.209133	0.061972	0.003289	0	0	0
110.5	3.045238	3.065606	2.993743	2.841148	2.636349	2.424754	2.246927	2.142323	2.128227	2.200306	2.330485	2.466729
115.5	2.912155	2.946688	2.911445	2.817611	2.690044	2.564673	2.472757	2.440658	2.477248	2.56955	2.685794	2.773637
120.5	3.377967	3.33345	3.216099	3.046064	2.848646	2.652466	2.471143	2.315917	2.182749	2.068854	1.961331	1.857643
125.5	3.692277	3.575501	3.311926	2.940261	2.517032	2.114201	1.77668	1.538346	1.394019	1.325891	1.296983	1.273784
130.5	3.195133	2.378738	1.536509	0.851875	0.211279	0.031431	0	0	0	0	0	0
135.5	1.091899	0.55385	0.103124	0.00957	0	0	0	0	0	0	0	0
140.5	1.686181	0.993612	0.434067	0.043782	0	0	0	0	0	0	0	0
145.5	2.767564	2.701177	2.553534	2.347125	2.118529	1.915142	1.769293	1.702303	1.709338	1.764088	1.824215	1.840693
150.5	3.309114	3.108355	2.781344	2.364126	1.905597	1.469697	1.094386	0.814075	0.630402	0.541967	0.532962	0.59212
155.5	3.15299	3.009603	2.741384	2.377616	1.9679	1.58339	1.276794	1.095773	1.056325	1.155941	1.369398	1.637001
160.5	3.592932	3.256374	2.792047	2.254677	1.708298	1.230258	0.863086	0.637735	0.547416	0.574957	0.688219	0.838155
165.5	3.615173	3.194067	2.652325	2.054092	1.465506	0.95898	0.564685	0.301096	0.148573	0.083212	0.072988	0.099203

170.5	3.792143	3.332739	2.731346	2.06602	1.418905	0.879576	0.488542	0.264331	0.179183	0.200038	0.293438	0.416209
175.5	3.376196	3.063503	2.622905	2.109985	1.588942	1.132597	0.774546	0.533203	0.388302	0.314883	0.278549	0.254834
180.5	3.456058	3.022232	2.486447	1.915866	1.372375	0.916603	0.565813	0.32655	0.17565	0.093488	0.055943	0.05257
185.5	3.376139	2.965507	2.441956	1.87391	1.330734	0.884513	0.563882	0.38064	0.313499	0.337696	0.423298	0.53182
190.5	3.097645	2.707011	2.207827	1.66281	1.1374	0.701723	0.385575	0.202672	0.131848	0.151259	0.245102	0.393477
195.5	3.545815	3.048806	2.432349	1.779675	1.171176	0.685131	0.346261	0.155885	0.074967	0.06258	0.08313	0.110029
200.5	2.12423	1.890993	1.585405	1.24291	0.903012	0.611993	0.394318	0.268648	0.232295	0.273968	0.373309	0.501568
205.5	1.935042	1.600681	1.220617	0.841651	0.50589	0.252737	0.088742	0.014252	0	0.016591	0.207114	0.37631
207.5	0.457519	0.109264	0.007745	0	0	0	0	0	0	0	0	0
209.5	0	0	0	0	0	0	0	0	0	0	0	0
210.5	1.855025	1.237585	0.731618	0.193306	0.027558	0	0	0	0	0	0	0
211.5	1.007447	0.619742	0.346842	0.066136	0.00575	0	0	0	0	0	0	0
213.5	0.858233	0.460715	0.065109	0	0	0	0	0	0	0	0	0
215.5	1.986998	1.809056	1.546109	1.232062	0.907786	0.623467	0.411075	0.298211	0.290967	0.381662	0.549895	0.756858
217.5	0.585844	0.315392	0.011182	0	0	0	0	0	0	0	0	0
219.5	2.435799	1.804663	1.180456	0.673625	0.189083	0.03292	0	0	0	0	0	0
220.5	3.513925	3.353756	3.060583	2.677016	2.261109	1.884377	1.591069	1.41345	1.347866	1.37232	1.44444	1.51122
221.5	4.251201	3.47826	2.579163	1.684962	0.920531	0.128814	0	0	0	0	0	0
223.5	4.389093	3.710875	2.862931	1.980836	1.168888	0.597016	0.104959	0	0	0	0	0
225.5	4.445001	4.222575	3.829404	3.307954	2.715282	2.130707	1.60498	1.188896	0.887121	0.697153	0.584594	0.520075
230.5	3.742649	3.631372	3.393075	3.051273	2.645394	2.236301	1.87065	1.598043	1.435484	1.385681	1.420771	1.497019
235.5	4.115696	3.879157	3.486933	2.982609	2.423607	1.888491	1.429201	1.096004	0.896949	0.826772	0.850818	0.925145
240.5	4.265175	3.731092	3.057711	2.326568	1.616411	1.007087	0.550876	0.229508	0.079358	0	0	0
245.5	3.902085	3.801568	3.5475	3.164408	2.695955	2.211755	1.766919	1.42323	1.206874	1.132649	1.182618	1.32135
250.5	4.239274	3.863375	3.31426	2.659929	1.976448	1.355896	0.849577	0.500187	0.301726	0.236097	0.261451	0.335131
255.5	4.565517	4.405453	4.079387	3.609286	3.034627	2.424539	1.831325	1.322114	0.923915	0.66271	0.520316	0.469865
260.5	3.915168	3.527551	2.980773	2.342942	1.690951	1.114046	0.657642	0.353634	0.186291	0.131033	0.155132	0.237838
265.5	5.046262	4.753947	4.222335	3.511252	2.701619	1.907413	1.197772	0.664179	0.273389	0.094478	0	0
270.5	5.74379	5.398882	4.800408	4.028256	3.177468	2.366146	1.663067	1.128796	0.757242	0.531379	0.39483	0.303101
275.5	4.71145	4.116678	3.372705	2.577385	1.81906	1.187594	0.716257	0.421159	0.266495	0.208722	0.176123	0.127259
277.5	4.283462	3.640826	2.914037	2.187508	1.526177	0.992029	0.599892	0.355284	0.22934	0.184049	0.17282	0.142995
279.5	5.382057	4.848382	4.123581	3.304378	2.48212	1.755124	1.166298	0.747487	0.477089	0.325427	0.2414	0.178245
280.5	4.985992	4.500253	3.81064	3.000973	2.163114	1.394806	0.785192	0.297193	0.081261	0	0	0
281.5	4.628939	3.962829	3.147118	2.292325	1.460702	0.860882	0.171646	0	0	0	0	0
282.5	4.18092	3.677376	3.032443	2.328862	1.629259	1.039444	0.357071	0.072593	0	0	0	0
283.5	6.080673	5.870457	5.342472	4.553454	3.59244	2.598261	1.659756	0.920658	0.320184	0.059718	0	0
284.5	3.31853	2.893217	2.385308	1.849261	1.335838	0.893821	0.540913	0.131627	0	0	0	0
285.5	3.927788	4.110055	4.187116	4.123604	3.904496	3.542214	3.05642	2.494533	1.881691	1.274084	0.687166	0.192224
286.5	4.530045	4.269625	3.820828	3.222509	2.546581	1.831885	1.22212	0.329175	0	0	0	0
287.5	4.862306	4.17503	3.326352	2.402762	1.58062	0.447056	0.060419	0	0	0	0	0
288.5	4.067272	3.350708	2.558829	1.800702	1.099174	0.44624	0.041414	0	0	0	0	0
289.5	5.292237	4.487651	3.520024	2.480697	1.602268	0.257497	0	0	0	0	0	0

290.5	5.568458	4.895559	4.019183	3.062355	2.091904	1.370183	0.454403	0.070665	0	0	0	0
291.5	5.031753	4.197848	3.216262	2.207181	1.282968	0.186571	0	0	0	0	0	0
295.5	5.409744	4.63217	3.681878	2.689384	1.723431	1.030612	0.208206	0	0	0	0	0
300.5	6.191088	5.587908	4.703658	3.657146	2.551374	1.583584	0.309749	0	0	0	0	0
305.5	5.629058	4.835673	3.849521	2.800283	1.776438	0.630045	0.015896	0	0	0	0	0
310.5	5.046618	4.217936	3.251928	2.254197	1.368644	0.207849	0	0	0	0	0	0
315.5	6.146277	5.782295	5.112508	4.211457	3.183233	2.153895	1.091504	0.185031	0	0	0	0
320.5	5.248104	4.484851	3.549726	2.552334	1.648276	0.727168	0.073109	0	0	0	0	0
322.5	4.119173	3.472309	2.703155	1.922807	1.189231	0.516751	0.058218	0	0	0	0	0
324.5	3.182065	2.763303	2.261066	1.735375	1.215982	0.776883	0.26911	0.055676	0	0	0	0
325.5	4.771307	4.158394	3.375293	2.518989	1.660341	0.770753	0.091908	0	0	0	0	0
326.5	4.014297	3.261764	2.441343	1.647866	0.970001	0.218154	0.013922	0	0	0	0	0
328.5	3.371251	2.664341	1.936061	1.244519	0.640336	0.083673	0	0	0	0	0	0
330.5	4.987545	4.700022	4.197161	3.530835	2.768355	2.010583	1.298019	0.751949	0.215622	0	0	0
332.5	3.259707	2.384182	1.539908	0.830851	0.081843	0	0	0	0	0	0	0
334.5	3.149841	2.592739	1.972825	1.360785	0.836073	0.242546	0.038855	0	0	0	0	0
335.5	4.199121	3.52025	2.706211	1.864645	1.137985	0.320114	0.047834	0	0	0	0	0
336.5	2.683435	1.92956	1.236885	0.653269	0.062915	0	0	0	0	0	0	0
338.5	2.828551	2.122736	1.437613	0.854971	0.201477	0.025951	0	0	0	0	0	0
340.5	4.37843	3.70546	2.869157	1.996859	1.195985	0.598172	0.155972	0.023049	0	0	0	0
342.5	3.74709	3.058012	2.278012	1.52618	0.892222	0.439714	0.160008	0.025783	0	0	0	0
344.5	1.81599	1.226816	0.711827	0.16249	0.020102	0	0	0	0	0	0	0
345.5	1.013976	0.662803	0.367816	0.079883	0.008725	0	0	0	0	0	0	0
346.5	1.376231	0.866241	0.451435	0.088481	0.008594	0	0	0	0	0	0	0
348.5	1.842602	1.326964	0.886157	0.537893	0.293811	0.109516	0.028172	0	0	0	0	0
350.5	3.444613	2.635567	1.832018	1.142659	0.621404	0.29732	0.104073	0.030134	0	0	0	0
352.5	3.278203	2.511329	1.737266	1.042009	0.568528	0.084971	0	0	0	0	0	0
354.5	3.284193	2.506149	1.70781	1.024775	0.257828	0.037134	0	0	0	0	0	0
355.5	4.890083	4.494216	3.868588	3.088397	2.230271	1.456269	0.658448	0.075849	0	0	0	0
356.5	3.866785	3.359516	2.72104	2.045627	1.423402	0.937904	0.612411	0.441948	0.383498	0.380239	0.376398	0.303312
358.5	3.688388	3.639908	3.470356	3.175408	2.773514	2.314786	1.844472	1.420475	1.064931	0.788168	0.569137	0.370646
360.5	5.027689	4.921654	4.572909	4.011208	3.297204	2.533397	1.80222	1.199372	0.762879	0.517182	0.428361	0.443886
365.5	0.879596	0.628431	0.398014	0.126601	0.020642	0	0	0	0	0	0	0
367.5	0.793349	0.485653	0.166898	0.021785	0	0	0	0	0	0	0	0
370.5	1.691176	1.177779	0.70399	0.323844	0.043706	0	0	0	0	0	0	0
371.5	3.326952	2.936672	2.463917	1.94698	1.420588	0.918891	0.48114	0.097895	0	0	0	0
373.5	3.71812	3.308209	2.744447	2.03259	1.309871	0.385599	0.061688	0	0	0	0	0
375.5	4.102616	4.039199	3.811482	3.435224	2.947996	2.417454	1.899643	1.463145	1.138733	0.950282	0.88021	0.898223
380.5	4.207293	4.198004	4.017951	3.679198	3.219035	2.707125	2.204747	1.785825	1.485716	1.328195	1.293525	1.344889
385.5	4.948632	4.512503	3.837511	3.015149	2.121052	1.353983	0.273672	0	0	0	0	0
390.5	5.602137	5.35678	4.8296	4.077283	3.183743	2.274095	1.439797	0.781199	0.330845	0.105987	0.065327	0.149065
395.5	4.766747	4.312655	3.647397	2.861064	2.020172	1.315808	0.271507	0	0	0	0	0

400.5	4.803634	4.313888	3.61792	2.800139	1.950389	1.175054	0.533566	0.087891	0	0	0	0
405.5	5.686121	5.456032	4.934662	4.177262	3.269814	2.342364	1.491545	0.82212	0.367418	0.142126	0.099175	0.172297
410.5	5.795297	5.14045	4.230009	3.188267	2.127765	1.064713	0.150181	0	0	0	0	0
415.5	4.90811	4.334703	3.566941	2.711606	1.817058	1.162732	0.246708	0	0	0	0	0
417.5	2.461907	1.807705	1.130354	0.558771	0.051206	0	0	0	0	0	0	0
420.5	2.255811	1.721216	1.229401	0.792035	0.437109	0.102443	0.010173	0	0	0	0	0
421.5	2.776609	2.172483	1.574169	1.008633	0.511388	0.065672	0	0	0	0	0	0
423.5	2.368622	1.912884	1.443095	0.950791	0.479975	0.0603	0	0	0	0	0	0
425.5	5.724984	5.120349	4.25818	3.252333	2.211129	1.218953	0.203609	0	0	0	0	0
426.5	3.472574	2.915274	2.298195	1.678028	1.082189	0.561103	0.089702	0	0	0	0	0
430.5	6.074871	5.379593	4.421913	3.328838	2.217632	1.09882	0.151932	0	0	0	0	0
435.5	5.636456	5.030511	4.18848	3.218296	2.234433	1.350134	0.681917	0.144485	0	0	0	0

Appendix Table 5 (continued). Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (µm)										
	275.423	316.228	363.078	416.869	478.630	549.541	630.957	724.436	831.764	954.993	1096.478
1.5	0.731433	0.692988	0.650752	0.590482	0.497332	0.390174	0.22789	0.091548	0	0	0
5.5	1.1861	0.913616	0.575858	0.053446	0	0	0	0	0	0	0
10.5	0.813935	0.823868	0.777035	0.635158	0.456055	0.08895	0	0	0	0	0
15.5	0.990735	0.790751	0.553013	0.320345	0.039587	0	0	0	0	0	0
20.5	2.395466	2.457935	2.425872	2.26489	1.966504	1.509739	1.044754	0.317868	0	0	0
25.5	2.093959	2.034159	1.839624	1.509002	1.058078	0.575168	0.105206	0	0	0	0
26.5	0.216264	0.132042	0.100035	0.120338	0.174406	0.233867	0.20378	0.096267	0	0	0
27.5	0.20745	0.173531	0.192393	0.247266	0.301336	0.327014	0.237346	0.10327	0	0	0
28.5	0.2047	0.155379	0.140525	0.150886	0.164197	0.169292	0.089322	0.025419	0	0	0
29.5	0.310794	0.208882	0.078146	0.012631	0	0	0	0	0	0	0
30.5	2.297111	1.844123	1.284011	0.758929	0.096291	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0	0	0	0	0
32.5	0	0	0	0	0	0	0	0	0	0	0
33.5	0	0	0	0	0	0	0	0	0	0	0
34.5	0	0	0	0	0	0	0	0	0	0	0
35.5	1.013988	0.6527	0.294168	0.02098	0	0	0	0	0	0	0
36.5	0	0	0	0	0	0	0	0	0	0	0
37.5	0	0	0	0	0	0	0	0	0	0	0
38.5	0.029643	0	0	0	0	0	0	0	0	0	0
39.5	0.092834	0.076973	0.060972	0.049101	0.011202	0	0	0	0	0	0
40.5	2.210067	2.229385	2.145157	1.930492	1.585517	1.130275	0.677964	0.177302	0	0	0
41.5	0.203625	0.132805	0.122617	0.151668	0.185147	0.197186	0.096186	0.023316	0	0	0
42.5	0	0	0	0	0	0	0	0	0	0	0
45.5	0.442093	0.27318	0.202709	0.218467	0.28627	0.361158	0.383152	0.34823	0.146422	0	0

50.5	1.978464	1.590444	1.225276	0.938046	0.75306	0.671641	0.627226	0.587061	0.317271	0.047451	0
55.5	2.150791	1.924506	1.622584	1.232071	0.835609	0.275219	0.048734	0	0	0	0
60.5	0.653109	0.65233	0.690709	0.741606	0.769207	0.710419	0.569565	0.221371	0.018071	0	0
65.5	2.860086	2.603008	2.26101	1.852686	1.354556	0.913684	0.223022	0	0	0	0
70.5	1.680477	1.485378	1.235076	0.913644	0.560788	0.096229	0	0	0	0	0
74.5	0	0	0	0	0	0	0	0	0	0	0
75.5	0	0	0	0	0	0	0	0	0	0	0
76.5	0	0	0	0	0	0	0	0	0	0	0
77.5	0	0	0	0	0	0	0	0	0	0	0
78.5	0	0	0	0	0	0	0	0	0	0	0
79.5	0	0	0	0	0	0	0	0	0	0	0
80.5	2.070634	1.945904	1.78187	1.560163	1.261158	0.892634	0.463343	0.083585	0	0	0
85.5	2.391041	2.260119	2.023902	1.683403	1.227291	0.774736	0.174153	0	0	0	0
90.5	0.572037	0.538364	0.523162	0.515147	0.49472	0.427162	0.309576	0.089493	0	0	0
93.5	0	0	0	0	0	0	0	0	0	0	0
95.5	1.201069	1.242985	1.204001	1.071436	0.82874	0.543075	0.122824	0	0	0	0
97.5	0	0	0	0	0	0	0	0	0	0	0
99.5	0	0	0	0	0	0	0	0	0	0	0
100.5	1.479419	1.557623	1.489575	1.239474	0.889628	0.31591	0.064393	0	0	0	0
101.5	0	0	0	0	0	0	0	0	0	0	0
103.5	0	0	0	0	0	0	0	0	0	0	0
105.5	0	0	0	0	0	0	0	0	0	0	0
107.5	0	0	0	0	0	0	0	0	0	0	0
109.5	0	0.116979	0.353912	0.609095	0.820293	0.870284	0.785837	0.273458	0	0	0
110.5	2.558415	2.557198	2.432025	2.17116	1.787393	1.297438	0.831613	0.237051	0	0	0
115.5	2.784312	2.678957	2.433881	2.06157	1.559365	1.070658	0.397261	0.076244	0	0	0
120.5	1.757685	1.674579	1.613053	1.563723	1.491528	1.343675	1.068771	0.646756	0.158696	0	0
125.5	1.234116	1.179562	1.126557	1.096004	1.089944	1.087402	1.013448	0.85183	0.4147	0.065709	0
130.5	0	0	0	0	0	0	0	0	0	0	0
135.5	0	0	0	0	0	0	0	0	0	0	0
140.5	0	0	0	0	0	0	0	0	0	0	0
145.5	1.779935	1.636924	1.430283	1.203393	0.994198	0.83062	0.712016	0.619222	0.510355	0.374514	0.184066
150.5	0.714714	0.895208	1.127436	1.375694	1.579576	1.65637	1.504331	1.153505	0.480835	0.033239	0
155.5	1.894165	2.062139	2.087698	1.943321	1.645235	1.23407	0.828431	0.374604	0.111737	0	0
160.5	0.9735	1.039	1.000746	0.836404	0.603521	0.23865	0.05889	0	0	0	0
165.5	0.153859	0.231856	0.330492	0.434473	0.521738	0.54158	0.490887	0.25589	0.073156	0	0
170.5	0.520866	0.561453	0.506243	0.384283	0.135958	0.028288	0	0	0	0	0
175.5	0.229981	0.208141	0.204035	0.234788	0.310779	0.41947	0.527813	0.561792	0.501415	0.243005	0
180.5	0.08598	0.172551	0.331564	0.555362	0.800188	0.981211	0.981927	0.788887	0.287888	0	0
185.5	0.626695	0.673707	0.657088	0.567849	0.439184	0.229949	0.075801	0	0	0	0
190.5	0.570994	0.738006	0.862569	0.910898	0.866668	0.722438	0.525592	0.255113	0.085327	0	0
195.5	0.122949	0.114482	0.091662	0.068685	0.057608	0.064327	0.088739	0.118951	0.139341	0.118597	0.069501

200.5	0.636343	0.751856	0.830174	0.848897	0.791918	0.642405	0.426309	0.114089	0	0	0
205.5	0.557996	0.7135	0.820118	0.852389	0.795531	0.638691	0.419437	0.112195	0	0	0
207.5	0	0	0	0	0	0	0	0	0	0	0
209.5	0	0	0	0	0	0	0	0	0	0	0
210.5	0	0	0	0	0	0	0	0	0	0	0
211.5	0	0	0	0	0	0	0	0	0	0	0
213.5	0	0	0	0	0	0	0	0	0	0	0
215.5	0.969221	1.143953	1.250275	1.256064	1.14132	0.898106	0.550801	0.130228	0	0	0
217.5	0	0	0	0	0	0	0	0	0	0	0
219.5	0	0	0	0	0	0	0	0	0	0	0
220.5	1.530116	1.478009	1.35465	1.177911	0.968621	0.741052	0.530177	0.281803	0.109485	0	0
221.5	0	0	0	0	0	0	0	0	0	0	0
223.5	0	0	0	0	0	0	0	0	0	0	0
225.5	0.476901	0.447763	0.435321	0.442596	0.465138	0.465416	0.442448	0.240226	0.065831	0	0
230.5	1.569393	1.598649	1.561337	1.444725	1.249662	0.964922	0.662649	0.196432	0	0	0
235.5	1.009532	1.071423	1.092837	1.059078	0.96597	0.787379	0.589755	0.18958	0	0	0
240.5	0	0	0	0	0	0	0	0	0	0	0
245.5	1.509562	1.700108	1.855476	1.933282	1.898894	1.735439	1.423446	1.042429	0.489297	0.108391	0
250.5	0.426266	0.515925	0.60009	0.672074	0.719596	0.721938	0.642043	0.487884	0.175487	0	0
255.5	0.466631	0.469833	0.435827	0.367946	0.154927	0.036873	0	0	0	0	0
260.5	0.363336	0.508134	0.652343	0.764698	0.817445	0.764845	0.62841	0.303786	0.081387	0	0
265.5	0	0	0	0	0	0	0	0	0	0	0
270.5	0.219051	0.132153	0.015807	0	0	0	0	0	0	0	0
275.5	0	0	0	0	0	0	0	0	0	0	0
277.5	0.071324	0	0	0	0	0	0	0	0	0	0
279.5	0.109414	0.007075	0	0	0	0	0	0	0	0	0
280.5	0	0	0	0	0	0	0	0	0	0	0
281.5	0	0	0	0	0	0	0	0	0	0	0
282.5	0	0	0	0	0	0	0	0	0	0	0
283.5	0	0	0	0	0	0	0	0	0	0	0
284.5	0	0	0	0	0	0	0	0	0	0	0
285.5	0	0	0	0	0	0	0	0	0	0	0
286.5	0	0	0	0	0	0	0	0	0	0	0
287.5	0	0	0	0	0	0	0	0	0	0	0
288.5	0	0	0	0	0	0	0	0	0	0	0
289.5	0	0	0	0	0	0	0	0	0	0	0
290.5	0	0	0	0	0	0	0	0	0	0	0
291.5	0	0	0	0	0	0	0	0	0	0	0
295.5	0	0	0	0	0	0	0	0	0	0	0
300.5	0	0	0	0	0	0	0	0	0	0	0
305.5	0	0	0	0	0	0	0	0	0	0	0
310.5	0	0	0	0	0	0	0	0	0	0	0

315.5	0	0	0	0	0	0	0	0	0	0	0
320.5	0	0	0	0	0	0	0	0	0	0	0
322.5	0	0	0	0	0	0	0	0	0	0	0
324.5	0	0	0	0	0	0	0	0	0	0	0
325.5	0	0	0	0	0	0	0	0	0	0	0
326.5	0	0	0	0	0	0	0	0	0	0	0
328.5	0	0	0	0	0	0	0	0	0	0	0
330.5	0	0	0	0	0	0	0	0	0	0	0
332.5	0	0	0	0	0	0	0	0	0	0	0
334.5	0	0	0	0	0	0	0	0	0	0	0
335.5	0	0	0	0	0	0	0	0	0	0	0
336.5	0	0	0	0	0	0	0	0	0	0	0
338.5	0	0	0	0	0	0	0	0	0	0	0
340.5	0	0	0	0	0	0	0	0	0	0	0
342.5	0	0	0	0.08001	0.41622	0.840215	1.185842	1.360976	1.274486	0.946256	0.416424
344.5	0	0	0	0	0	0	0	0	0	0	0
345.5	0	0	0	0	0	0	0	0	0	0	0
346.5	0	0	0	0	0	0	0	0	0	0	0
348.5	0	0	0	0	0	0	0	0	0	0	0
350.5	0	0	0	0	0	0	0	0	0	0	0
352.5	0	0	0	0	0	0	0	0	0	0	0
354.5	0	0	0	0	0	0	0	0	0	0	0
355.5	0	0	0	0	0	0	0	0	0	0	0
356.5	0.145011	0.009146	0	0	0	0	0	0	0	0	0
358.5	0.172886	0.01083	0	0	0	0	0	0	0	0	0
360.5	0.496385	0.528089	0.481476	0.403085	0.062486	0	0	0	0	0	0
365.5	0	0	0	0	0	0	0	0	0	0	0
367.5	0	0	0	0	0	0	0	0	0	0	0
370.5	0	0	0	0	0	0	0	0	0	0	0
371.5	0	0	0	0	0	0	0	0	0	0	0
373.5	0	0	0	0	0	0	0	0	0	0	0
375.5	0.962344	1.031746	1.073341	1.05591	0.960435	0.765388	0.520547	0.148543	0	0	0
380.5	1.435509	1.517168	1.549183	1.495166	1.322902	1.024791	0.57245	0.106548	0	0	0
385.5	0	0	0	0	0	0	0	0	0	0	0
390.5	0.287583	0.414861	0.474084	0.459546	0.250328	0.070843	0	0	0	0	0
395.5	0	0	0	0	0	0	0	0	0	0	0
400.5	0	0	0	0	0	0	0	0	0	0	0
405.5	0.287327	0.379737	0.399553	0.354406	0.136419	0.0292	0	0	0	0	0
410.5	0	0	0	0	0	0	0	0	0	0	0
415.5	0	0	0	0	0	0	0	0	0	0	0
417.5	0	0	0	0	0	0	0	0	0	0	0
420.5	0	0	0	0	0	0	0	0	0	0	0

421.5	0	0	0	0	0	0	0	0	0	0	0
423.5	0	0	0	0	0	0	0	0	0	0	0
425.5	0	0	0	0	0	0	0	0	0	0	0
426.5	0	0	0	0	0	0	0	0	0	0	0
430.5	0	0	0	0	0	0	0	0	0	0	0
435.5	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 6. Composite core sections for Grassy Lake, Union County, Illinois (GRAS11/13).

Section No.	Core Section Name	Section depth top (cm)	Section depth bottom (cm)	Sum depth top (cm)	Sum depth bottom (cm)
1	GRAS13-2D-1B-1-W	19	71	0	52
2	GRAS11-1B-1L-1-W	2	40	52	90
3	GRAS13-2C-1L-1-W	41	59	90	108
4	GRAS11-1A-2L-1-W	8	51	108	151
5	GRAS11-1B-2L-1-W	1	29	151	179
6	GRAS13-2A-2L-1-W	72	93	179	200
7	GRAS13-2A-3L-1-W	0	20	200	220

Appendix Table 7. Pollen counts from Grassy Lake, Union County, Illinois (GRAS11/13) composite sediment core. Data will be submitted to Neotoma upon publication.

Depth (cm)	Acer	Alnus	Amaranthaceae	Ambrosia	Artemisia	Betula	Brassicaceae	Carya	Castanea	Celtis	Cephalanthus	Cornus
0.5			48	45		2		16		5	9	8
8.5			45	46			1	13	2	2	5	7
16.5			55	41			1	13	4	2	3	4
24.5	1		48	51	1	1		13	1	2	4	5
32.5			5	77	1		1	15			1	2
40.5				4				24		4		
48.5			4	6				18		1		
56.5		1	14	12		2		35		1		
64.5			3	9	2	3		13		4	1	
72.5			3	3				18			1	
105.5			10	13		1		22	1		1	
113.5		1	48	9		2		11			1	
121.5			39	18	2	1		12	1		5	
129.5			46	21	1	2		9			3	4
137.5		1	31	24		3		10			1	2
145.5		1	44	39	3	2		11		1		2
153.5			40	81	1			9				
161.5		1	25	76	2	5		4				3
169.5			21	50	1	3		13				1

177.5		1	18	44	7	2	15	2			3
185.5	1		23	57	2	1	11	3	2	2	5
193.5			9	65	1	1	12	3	1	1	5
201.5	1		18	49	4		19	6		2	4
209.5			20	59			17	5			

Appendix Table 7 (continued). Pollen counts from Grassy Lake, Union County, Illinois (GRAS11/13) composite sediment core.

Depth (cm)	Corylus	Fraxinus	Helianthus-type	Iva	Juglans cinerea	Juglans nigra	Liquidambar	Nyssa	Ostrya/Carpinus	Pinus	Planera aquatica	Plantago
0.5		13	3	1	2	2	4	2	2	7	1	1
8.5		13	3	2	1		7	1		8		1
16.5		8		4		2	8	1	2	10	1	1
24.5		15	1	2			5	3	1	8		1
32.5		2	2		1	1	4			5		
40.5	2	6			2	1	7	2	2	8	1	
48.5		6				1	12	1	1	10	1	
56.5		3	2		6	4	3			12		
64.5		14	1			3	11			8		
72.5		7	2			1	5			3		
105.5		11					2			7		
113.5		2	1	1	19	5	2					
121.5		20	1	1	1	2				8		
129.5		9	3	2	1	1				11		
137.5		12	7	3			3		1	21		
145.5		14		4		1	2	1		10		
153.5		5	10	4	3	2		1		11	1	
161.5		8	7	3	1	1	1			14		
169.5		7	2	4		2	3	1	1	7		
177.5		11	2	4		1	2			17		
185.5		11	1	4		1	2	1	1	10		
193.5	1	9		5		3	1	1		11		
201.5		10	1	1	1	4	1	2	1	9		
209.5	1	7	1	3			4		3	7		

Appendix Table 7 (continued). Pollen counts from Grassy Lake, Union County, Illinois (GRAS11/13) composite sediment core.

Depth (cm)	Platanus	Poaceae	Polygonaceae	Populus	Quercus	Rosaceae	Rumex	Salix	Taxodium	Thuja/Juniperus

0.5		12		3	67	7	1	37	5	
8.5	6	14	1	3	71	3		43	5	
16.5	7	25	1	4	61	4		36	2	1
24.5	1	17	2	1	65	4		35	4	2
32.5	3	63	8	2	89	1		5	1	3
40.5	4	106	1	2	100			4	1	3
48.5	3	113	1	4	90			2	2	5
56.5	3	123		6	75			12		5
64.5	7	116	2	4	76			22		4
72.5	7	115		4	92			44		6
105.5	8	27		2	127			54		2
113.5	4	22	2	1	76			95		
121.5	8	8		4	68			114		1
129.5	2	5	1	3	63			103		2
137.5	2	10	1	5	56	1		97		1
145.5	3	11		3	69			70		8
153.5	6	21	3	2	69			27		
161.5	5	24	3	7	70			28		6
169.5	8	37	2	3	87			31		9
177.5	9	21	1	5	87	1		30		8
185.5	8	10		2	92	2		47		4
193.5	10	11		3	102	1		42		2
201.5	12	7	3	1	81	2		56		6
209.5	8	9	1	4	100			48		3

Appendix Table 7 (continued). Pollen counts from Grassy Lake, Union County, Illinois (GRAS11/13) composite sediment core.

Depth (cm)	Tilia	Ulmus	Viticeae	Zea mays	Spike count	Spike total
0.5	1	9	4	1	81	37166
8.5		12	2		49	37166
16.5		10	3		77	37166
24.5		12	3		71	37166
32.5		16	2		62	37166
40.5		25	1		24	37166
48.5		32	1		32	37166
56.5		11			82	50000
64.5		10			74	50000
72.5		12	1		74	50000
105.5		16	4		149	50000
113.5			2		159	50000
121.5		5	2		278	50000

129.5	1	3	6		219	50000
137.5		5	4		593	50000
145.5		5	2		436	50000
153.5		4	1		616	50000
161.5		4	3		663	50000
169.5		11	2		610	50000
177.5	3	10	4		880	50000
185.5		5	3		176	37166
193.5		7	3		121	37166
201.5		6	3		101	37166
209.5		6	4		129	37166

Appendix Table 8. Loss-on-ignition and charcoal counts for Grassy Lake, Union County, Illinois (GRAS11/13) composite sediment core. Data will be submitted to Neotoma and the Global Charcoal Database upon publication.

Depth (cm)	Organic content (%)	Carbonate content (%)	Mineral content (%)	Total charcoal count	Cellular charcoal count
0.5	14.629	3.330	82.041	26	1
1.5	15.044	3.297	81.660	15	1
2.5	15.160	3.194	81.646	25	1
3.5	15.710	3.104	81.187	13	
4.5	15.691	3.378	80.932	16	
5.5	15.564	3.175	81.261	24	
6.5	15.350	3.141	81.508	34	1
7.5	15.345	3.188	81.467	24	1
8.5	15.633	3.100	81.267	18	
9.5	15.313	3.218	81.469	19	1
10.5	15.147	3.100	81.753	33	1
11.5	15.824	3.066	81.110	30	
12.5	15.378	3.110	81.512	18	1
13.5	15.212	3.236	81.551	29	4
14.5	15.506	3.200	81.294	35	1
15.5	15.840	3.135	81.025	44	4
16.5	15.793	3.007	81.200	32	2
17.5	16.029	3.045	80.925	25	
18.5	14.629	2.990	82.381	35	
19.5	15.462	2.156	82.383	25	
20.5	14.664	2.242	83.094	34	
21.5	13.053	2.060	84.888	26	
22.5	13.913	2.030	84.058	32	1
23.5	13.587	2.140	84.273	26	1
24.5	12.753	2.202	85.045	38	1

25.5	10.435	2.254	87.311	46	1
26.5	10.492	3.250	86.258	58	3
27.5	11.299	1.830	86.872	31	
28.5	10.050	1.731	88.219	37	1
29.5	9.369	1.699	88.932	36	
31.5	13.717	1.896	84.387	37	
32.5	10.583	1.839	87.577	18	
33.5	11.000	3.525	78.392	21	
34.5	13.852	2.646	83.502	11	
35.5	5.827	2.006	83.500	7	
36.5	13.648	2.724	83.628	1	
37.5	14.304	2.655	83.041		
38.5	15.233	2.763	82.004	2	
39.5	14.069	2.611	83.319	2	
40.5	12.960	2.566	84.475	2	
41.5	11.587	2.660	85.753	1	
42.5	8.860	1.838	89.302	1	
43.5	9.084	1.978	88.939		
44.5	8.663	1.951	89.386		
45.5	9.049	1.961	88.990	1	
46.5	9.583	1.934	88.483	1	
47.5	8.757	2.116	89.127	1	
48.5	10.308	1.627	88.065		
49.5	10.808	1.710	87.482	5	2
50.5	11.828	1.788	86.384	1	
51.5	12.269	1.790	85.941	1	
52.5	14.949	2.369	82.682	2	
53.5	15.283	2.888	81.829	1	
54.5	13.360	2.601	84.039		
55.5	13.016	2.775	84.208	1	
56.5	12.663	2.553	84.785		
57.5	13.468	2.812	83.720	2	
58.5	14.013	2.755	83.232	1	
59.5	13.850	2.789	83.362	3	
60.5	13.437	2.741	83.822	3	
61.5	12.192	2.563	85.244	1	
62.5	12.362	3.042	84.596		
63.5	12.266	2.391	85.343		
64.5	11.993	2.765	85.242		
65.5	10.477	2.514	87.009		
66.5	11.194	2.619	86.187		
67.5	11.017	2.419	86.564	3	

68.5	10.820	2.728	86.452		
69.5	12.373	2.707	84.920		
70.5	10.558	2.892	86.550	1	
71.5	10.627	3.910	85.463	1	
72.5	10.130	3.145	86.725	1	
73.5	10.078	3.021	86.900		
74.5	10.288	2.901	86.811	1	
75.5	7.256	2.576	90.169		
76.5	6.465	2.482	91.053		
77.5	6.323	2.614	91.062		
78.5	6.417	2.738	90.845		
79.5	7.011	3.375	89.614	1	
80.5	7.800	3.136	89.064	43	
81.5	7.253	2.937	89.810	1	
82.5	7.989	3.289	88.723		
83.5	7.826	3.269	88.905		
84.5	7.159	3.273	89.568	2	
85.5	7.571	2.895	89.534		
86.5	6.482	2.823	90.695		
87.5	6.439	2.739	90.822		
88.5	6.404	2.681	90.915		
89.5	6.613	2.854	90.534		
90.5	5.909	2.486	91.605		
91.5	5.933	2.447	91.619		
92.5	6.137	2.457	91.406		
93.5	6.071	2.491	91.438		
94.5	6.311	2.514	91.175	1	
95.5	5.895	2.514	91.592	1	
96.5	5.942	2.561	91.497		
97.5	5.769	2.344	91.887	2	
98.5	5.319	2.117	92.565		
99.5	5.943	2.320	91.737	1	
100.5	6.218	2.360	91.421	1	
101.5	5.956	2.763	91.282	3	
102.5	6.121	2.662	91.217	1	
103.5	6.366	2.420	91.214		
104.5	6.173	2.499	91.329		
105.5	6.872	2.744	90.384		
106.5	8.925	2.666	88.409	12	1
107.5	8.578	2.674	88.747	9	1
108.5	7.680	2.691	89.628	1	
109.5	10.715	2.809	86.476		

110.5	8.059	2.797	89.144	1	
111.5	14.289	3.332	82.380	2	
112.5	11.324	3.261	85.415	1	
113.5	10.661	2.893	86.447		
114.5	10.229	2.917	86.854		
115.5	13.308	3.283	83.409		
116.5	9.757	2.876	87.367	1	
117.5	10.912	2.859	86.229	2	1
118.5	10.044	2.565	87.391	3	
119.5	8.822	2.464	88.714		
120.5	8.751	2.542	88.707	1	
121.5	11.311	2.792	85.898	1	
122.5	9.233	2.747	88.020	4	
123.5	7.284	2.414	90.302	2	
124.5	7.567	2.491	89.942	1	
125.5	7.261	2.494	90.244	1	
126.5	7.726	2.468	89.805		
127.5	8.346	2.500	89.154		
128.5	7.893	2.435	89.672		
129.5	7.749	2.382	89.870		
130.5	8.617	2.562	88.821	2	
131.5	7.886	2.435	89.679		
132.5	7.310	2.400	90.290		
133.5	7.052	2.336	90.612		
134.5	8.331	2.357	89.313	1	
135.5	7.297	2.411	90.292		
136.5	6.988	2.478	90.534		
137.5	6.967	2.360	90.673		
138.5	6.774	2.461	90.764		
139.5	8.102	2.374	89.524		
140.5	7.124	2.258	90.618	1	
141.5	7.013	2.208	90.778		
142.5	7.312	2.344	90.344	1	
143.5	8.071	2.423	89.506		
144.5	7.288	2.573	90.139		
145.5	6.732	2.665	90.602	1	
146.5	6.758	2.982	90.259	1	
147.5	6.374	3.214	90.412	3	
148.5	6.442	3.954	89.604		
149.5	6.084	3.824	90.092		
150.5	6.648	3.473	89.879	1	
151.5	5.979	3.330	90.692	1	

152.5	5.575	3.890	90.535	6	
153.5	5.346	4.145	90.508	2	
154.5	5.876	4.251	89.872	1	
155.5	5.758	3.804	90.438		
156.5	5.601	3.599	90.799	1	
157.5	6.362	4.478	89.160		
158.5	7.287	4.631	88.082		
159.5	6.895	4.893	88.213		
160.5	7.395	4.576	88.028	2	
161.5	6.648	3.994	89.358		
162.5	6.932	3.947	89.121	2	
163.5	7.802	3.412	88.785	4	
164.5	6.590	3.043	90.367		
165.5	7.325	5.442	87.234		
166.5	7.771	5.565	86.664	1	
167.5	7.489	4.510	88.001	5	
168.5	7.205	4.626	88.169		
169.5	7.017	3.754	89.229	6	
170.5	6.357	3.892	89.751	3	
171.5	6.898	4.295	88.807	1	
172.5	7.448	3.710	88.842		
173.5	7.019	4.325	88.657	1	
174.5	7.042	3.978	88.980	6	1
175.5	6.768	3.701	89.531	6	
176.5	6.425	3.861	89.714	28	
177.5	6.203	3.574	90.224	2	
178.5	6.739	3.286	89.975	3	
179.5	7.496	2.113	90.391		
180.5	7.427	2.211	90.362	56	
181.5	8.285	3.899	87.815	121	4
182.5	8.462	3.378	88.160	75	1
183.5	7.538	3.524	88.938	113	1
184.5	8.256	2.987	88.758	84	
185.5	8.569	4.091	87.340	77	
186.5	10.151	3.788	86.061	78	
187.5	10.036	3.585	86.379	88	1
188.5	8.140	2.946	88.914	88	2
189.5	8.949	3.299	87.752	110	
190.5	8.853	3.289	87.858	87	
191.5	7.961	3.458	88.581	73	
192.5	9.565	3.481	86.954	92	
193.5	12.078	3.138	84.784	91	1

194.5	10.391	2.865	86.745	129	
195.5	10.090	3.337	86.573	121	1
196.5	10.343	3.091	86.566	113	2
197.5	10.364	3.525	86.111	99	
198.5	10.743	2.664	86.593	81	1
199.5	10.115	3.063	86.822	100	1
200.5	11.396	2.124	86.480	52	
201.5	10.909	2.744	86.347	90	
202.5	11.124	2.544	86.332	40	
203.5	11.084	3.450	85.466	72	1
204.5	10.876	3.561	85.563	94	
205.5	11.912	4.129	83.959	100	
206.5	10.540	4.290	85.170	46	
207.5	10.872	3.618	85.510	61	
208.5	10.762	3.455	85.783	62	
209.5	10.632	3.300	86.068	89	
210.5	10.436	3.322	86.242	50	
211.5	10.634	3.565	85.802	80	1
212.5	10.516	4.107	85.377	106	2
213.5	12.670	3.226	84.104	68	
214.5	10.284	2.288	87.428	80	
215.5	9.205	2.214	88.581	47	
216.5	11.880	2.288	85.832	33	
217.5	8.510	1.975	89.515	50	
218.5	7.399	2.199	90.402	17	1
219.5	5.264	1.578	93.158	98	

Appendix Table 9. Organic stable carbon isotope ratios from Grassy Lake, Union County, Illinois (GRAS11/13) composite sediment core.

Depth (cm)	$\delta^{13}C_{org}$	Depth (cm)	$\delta^{13}C_{org}$	Depth (cm)	$\delta^{13}C_{org}$	Depth (cm)	$\delta^{13}C_{org}$	Depth (cm)	$\delta^{13}C_{org}$	Depth (cm)	$\delta^{13}C_{org}$	Depth (cm)	$\delta^{13}C_{org}$
0.5	-24.6	48.5	-27.6	74.0	-26.5	102.5	-23.8	127.0	-26.1	151.0	-23.9	176.5	-23.7
2.5	-24.8	50.5	-27.8	75.0	-26.6	103.5	-23.0	128.0	-26.2	152.0	-24.8	178.5	-23.3
4.5	-24.6	52.0	-27.9	76.0	-25.2	104.5	-23.5	129.0	-26.0	153.0	-24.9	180.5	-24.3
6.5	-24.8	53.0	-27.7	77.0	-25.4	105.5	-25.2	130.0	-26.2	154.0	-23.4	182.5	-24.5
8.5	-24.8	54.0	-27.5	78.0	-25.2	106.5	-23.3	131.0	-25.7	155.0	-24.7	184.5	-24.9
10.5	-24.7	55.0	-27.6	79.0	-25.4	107.5	-24.3	132.0	-26.3	156.0	-23.9	186.5	-25.1
12.5	-24.7	56.0	-27.3	80.0	-25.5	108.5	-26.5	133.0	-25.2	157.0	-24.1	188.5	-26.0
14.5	-24.8	57.0	-27.0	81.0	-25.8	110.0	-26.5	134.0	-25.2	158.0	-25.1	190.5	-24.4
16.5	-25.0	58.0	-27.0	82.0	-26.2	111.0	-27.4	135.0	-25.7	159.0	-24.6	192.5	-25.8
18.5	-25.3	59.0	-27.1	83.0	-26.1	112.0	-26.2	136.0	-25.8	160.0	-24.9	194.5	-25.3
20.5	-25.1	60.0	-27.0	84.0	-26.3	113.0	-23.8	137.0	-25.7	161.0	-23.4	196.5	-25.1

22.5	-25.2	61.0	-27.5	85.0	-25.9	114.0	-27.8	138.0	-24.8	162.0	-24.2	198.5	-24.9
24.5	-24.8	62.0	-27.0	86.0	-26.0	115.0	-27.8	139.0	-25.5	163.0	-24.9	202.5	-25.5
26.5	-25.3	63.0	-26.9	87.0	-25.3	116.0	-27.5	140.0	-27.0	164.0	-24.3	204.5	-24.8
28.5	-25.6	64.0	-26.4	88.0	-26.3	117.0	-27.3	141.0	-25.8	165.0	-24.8	206.5	-25.0
30.5	-26.5	65.0	-27.1	89.0	-25.4	118.0	-27.2	142.0	-25.6	166.0	-24.0	208.5	-25.0
32.5	-27.6	66.0	-26.9	90.0	-25.0	119.0	-26.7	143.0	-25.9	167.0	-23.6	210.5	-25.5
34.5	-27.9	67.0	-26.9	90.5	-23.4	120.0	-26.5	144.0	-25.4	168.0	-23.4	212.5	-25.3
36.5	-27.3	68.0	-27.5	92.5	-21.4	121.0	-26.7	145.0	-26.2	169.0	-24.2	214.5	-25.7
38.5	-28.1	69.0	-27.2	94.5	-22.3	122.0	-26.0	146.0	-25.6	170.0	-24.4	216.5	-25.4
40.5	-27.4	70.0	-27.2	96.5	-22.7	123.0	-26.9	147.0	-24.3	170.5	-23.9	218.5	-25.4
42.5	-27.4	71.0	-26.5	98.5	-23.3	124.0	-26.3	148.0	-24.3	172.5	-24.1		
44.5	-27.4	72.0	-26.9	100.5	-22.8	125.0	-26.6	149.0	-23.5	174.5	-23.6		
46.5	-27.0	73.0	-27.0	101.5	-22.6	126.0	-26.3	150.0	-24.2				

Appendix Table 10. Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (µm)												
	0.316	0.363	0.417	0.479	0.550	0.631	0.724	0.832	0.955	1.096	1.259	1.445	1.660
0.5	0.018299	0.17308	0.501353	0.841316	1.200984	1.57629	1.941241	2.30342	2.647821	2.982068	3.297595	3.595939	3.861987
6.5	0.008184	0.079203	0.2472	0.453173	0.692771	0.965415	1.258719	1.584679	1.937542	2.329948	2.75329	3.205433	3.654696
12.5	0	0.064272	0.254441	0.504969	0.805279	1.149616	1.513644	1.901664	2.297485	2.708305	3.120993	3.531856	3.912099
18.5	0	0.009488	0.154532	0.375753	0.645142	0.949255	1.282816	1.642413	2.017879	2.414276	2.818558	3.226828	3.612485
20.5	0	0.036427	0.205458	0.425641	0.686219	0.982572	1.295947	1.63327	1.984081	2.358511	2.748186	3.153076	3.548319
22.5	0	0.007294	0.284594	0.572716	0.88624	1.219666	1.549664	1.886513	2.219219	2.558195	2.896188	3.233922	3.551474
24.5	0	0.010347	0.167605	0.39402	0.662337	0.956565	1.271647	1.604985	1.951165	2.320839	2.709274	3.119881	3.53089
26.5	0	0	0.212834	0.479572	0.77437	1.0868	1.398729	1.721027	2.048506	2.396762	2.763898	3.154692	3.548154
28.5	0.011626	0.114525	0.374652	0.642039	0.927644	1.234574	1.550152	1.891157	2.25453	2.657812	3.096668	3.573421	4.059329
30.5	0	0	0.084685	0.291282	0.561015	0.871381	1.21542	1.59371	2.00389	2.465191	2.978585	3.55466	4.166204
32.5	0	0.066382	0.381168	0.727052	1.103945	1.508315	1.915604	2.33854	2.765553	3.211144	3.666529	4.131651	4.575576
34.5	0.012221	0.119699	0.385295	0.654371	0.937194	1.235479	1.535693	1.853441	2.185658	2.548651	2.938637	3.357358	3.778547
36.5	0	0.006513	0.264031	0.565891	0.898937	1.25923	1.624998	2.008079	2.397533	2.805217	3.221127	3.643617	4.044863
38.5	0	0.039105	0.305407	0.596219	0.913081	1.25499	1.603399	1.970849	2.348003	2.747145	3.159447	3.584871	3.998135
40.5	0	0.005696	0.236017	0.520764	0.826995	1.149509	1.469526	1.799554	2.135129	2.494003	2.876817	3.292588	3.724488
42.5	0	0	0.085389	0.320408	0.588041	0.862676	1.140865	1.418844	1.697707	1.993609	2.313276	2.670888	3.058738
44.5	0	0	0.025774	0.185627	0.397841	0.635459	0.887045	1.150429	1.425067	1.728821	2.071338	2.472541	2.929681
46.5	0	0	0.03103	0.191824	0.412766	0.672612	0.961572	1.279092	1.62207	2.007325	2.438163	2.928597	3.463701
48.5	0	0.005342	0.08931	0.25255	0.456467	0.691037	0.954702	1.252314	1.587066	1.980042	2.436759	2.970795	3.56186
50.5	0	0.006418	0.109095	0.339564	0.5859	0.832789	1.082701	1.335584	1.595611	1.879323	2.193368	2.551232	2.945274
52.5	0	0.008325	0.137779	0.372545	0.622784	0.873343	1.125749	1.378385	1.633191	1.903877	2.194656	2.516527	2.861866
54.5	0	0.00891	0.146666	0.384068	0.637515	0.89191	1.148579	1.405603	1.664146	1.936898	2.226375	2.541234	2.871182

60.5	0	0.011606	0.186753	0.422257	0.674295	0.929903	1.191073	1.456898	1.727856	2.01604	2.322254	2.654025	2.999734
66.5	0	0	0.091036	0.309132	0.554161	0.804899	1.061499	1.322424	1.589165	1.87558	2.184643	2.525282	2.885191
72.5	0	0.007722	0.129616	0.378142	0.6478	0.922155	1.201784	1.48435	1.770201	2.072302	2.391897	2.736563	3.092531
74.5	0	0.042273	0.22471	0.419452	0.627798	0.850144	1.076985	1.321818	1.585949	1.887732	2.230953	2.625321	3.055402
76.5	0	0	0	0.226444	0.453674	0.672822	0.890189	1.098096	1.304006	1.524169	1.770034	2.058111	2.386675
78.5	0	0	0	0.252776	0.514008	0.772628	1.035868	1.296767	1.562778	1.852201	2.175184	2.548071	2.963607
80.5	0	0.005001	0.088499	0.326916	0.592839	0.871438	1.165272	1.476524	1.809456	2.183887	2.604854	3.084655	3.605007
82.5	0	0	0.087885	0.32701	0.60019	0.886533	1.187522	1.504217	1.839873	2.213703	2.630653	3.103628	3.615962
84.5	0	0.005442	0.095719	0.345101	0.623606	0.914136	1.216966	1.531427	1.859266	2.217906	2.611357	3.051538	3.52297
86.5	0	0	0	0.21762	0.473071	0.749139	1.051278	1.380539	1.743797	2.164041	2.648467	3.212607	3.836675
88.5	0	0	0.055658	0.270584	0.514946	0.772777	1.049952	1.354014	1.695169	2.10042	2.581144	3.156751	3.810454
90.5	0	0	0.085822	0.310144	0.566272	0.838826	1.134849	1.462587	1.831628	2.268474	2.781183	3.384753	4.054407
92.5	0	0	0.088754	0.312375	0.567406	0.835611	1.120537	1.425989	1.757774	2.137213	2.570243	3.069522	3.615364
94.5	0	0	0.022714	0.176043	0.387277	0.634786	0.910647	1.218257	1.560179	1.959939	2.426921	2.979645	3.600255
96.5	0	0	0.083611	0.332755	0.618125	0.918156	1.234348	1.567984	1.922383	2.317484	2.757693	3.255232	3.790544
98.5	0	0	0	0.115656	0.279729	0.497405	0.712679	0.955622	1.218546	1.529976	1.903337	2.361859	2.89741
100.5	0	0	0.057949	0.210881	0.409444	0.637946	0.894502	1.185394	1.516895	1.914732	2.390281	2.963464	3.61648
102.5	0	0.007027	0.120742	0.394288	0.695922	1.007439	1.329498	1.660756	2.002634	2.372364	2.773003	3.215203	3.681498
104.5	0	0	0	0.141706	0.323374	0.576985	0.848789	1.174979	1.547278	1.998588	2.5394	3.192489	3.937004
106.5	0	0.00623	0.259759	0.582622	0.948254	1.349334	1.759164	2.187716	2.622067	3.076356	3.542399	4.022954	4.49238
108.5	0	0	0.053508	0.232717	0.474114	0.757502	1.074761	1.426437	1.810101	2.244757	2.733369	3.289712	3.893147
110.5	0	0	0.023287	0.164789	0.36232	0.59709	0.86138	1.15846	1.490815	1.882003	2.34241	2.892044	3.515387
112.5	0	0	0.017947	0.164219	0.367751	0.606546	0.872148	1.167641	1.495483	1.87885	2.328097	2.863408	3.470999
114.5	0	0.006941	0.116181	0.333696	0.572226	0.81741	1.069322	1.326556	1.590398	1.875104	2.185016	2.531549	2.905376
116.5	0	0	0.036312	0.208774	0.432912	0.68163	0.944782	1.221252	1.512151	1.837502	2.207602	2.641954	3.133258
118.5	0	0	0.04004	0.191075	0.390168	0.616552	0.861665	1.124287	1.403649	1.716684	2.071042	2.484087	2.949006
120.5	0	0	0.049379	0.247895	0.473894	0.708224	0.950632	1.200983	1.462397	1.751471	2.07492	2.446473	2.857215
122.5	0	0.006213	0.104537	0.308647	0.531941	0.763296	1.006045	1.262697	1.537829	1.84902	2.202083	2.609723	3.059999
124.5	0	0	0.052991	0.264239	0.505464	0.757484	1.021359	1.298802	1.594598	1.928545	2.3084	2.74933	3.238995
126.5	0	0	0.075479	0.282733	0.517767	0.762277	1.018679	1.29016	1.583586	1.921105	2.312794	2.775803	3.297669
128.5	0	0	0.058785	0.1991	0.376125	0.5753	0.796644	1.047179	1.335164	1.686106	2.113425	2.638463	3.248526
130.5	0	0	0.066643	0.237535	0.448959	0.68054	0.930675	1.204965	1.511293	1.8755	2.310493	2.836718	3.439781
132.5	0	0.011457	0.185881	0.444457	0.722893	1.00567	1.294518	1.589441	1.893856	2.226031	2.592235	3.006064	3.455287
134.5	0	0	0.04551	0.285485	0.555167	0.829375	1.107782	1.390566	1.683541	2.007873	2.373391	2.796437	3.265704
136.5	0	0.005518	0.095701	0.325415	0.583147	0.853106	1.135788	1.432496	1.747475	2.100555	2.497792	2.951822	3.446248
138.5	0	0.005146	0.087836	0.2784	0.485571	0.696321	0.912123	1.13388	1.366413	1.626663	1.922659	2.268104	2.654824
144.5	0	0	0.077235	0.276515	0.49863	0.724021	0.95346	1.186831	1.428351	1.694756	1.993788	2.339036	2.721921
150.5	0	0	0.042011	0.233515	0.450486	0.673949	0.904051	1.141654	1.391716	1.67261	1.993171	2.368327	2.788758
152.5	0	0	0.060367	0.261045	0.482524	0.704065	0.92675	1.151861	1.38684	1.651927	1.958204	2.321154	2.731152
154.5	0	0	0.044747	0.270114	0.518005	0.763145	1.004919	1.242317	1.481523	1.741935	2.034729	2.376168	2.759206
160.5	0	0	0.032996	0.176719	0.360425	0.562222	0.775914	1.003524	1.250311	1.53816	1.880404	2.297509	2.782283
162.5	0	0	0.081775	0.30264	0.552617	0.812682	1.085566	1.373878	1.683098	2.033581	2.432121	2.892096	3.396998

164.5	0	0	0.041628	0.25874	0.508558	0.770422	1.044492	1.33226	1.638382	1.983192	2.374373	2.826668	3.325548
166.5	0	0	0.039429	0.264355	0.524116	0.798467	1.089007	1.399273	1.735459	2.120481	2.562291	3.075888	3.642375
168.5	0	0	0.087154	0.345404	0.640841	0.951114	1.278226	1.624445	1.99476	2.412033	2.882952	3.422179	4.009114
170.5	0	0.006865	0.114957	0.331171	0.567332	0.814854	1.081565	1.375965	1.70853	2.105189	2.575354	3.134667	3.761877
172.5	0	0	0.05967	0.280119	0.531465	0.795013	1.073941	1.372989	1.700418	2.081282	2.526421	3.053945	3.647357
174.5	0	0	0.069484	0.321183	0.613697	0.923671	1.250388	1.594701	1.960372	2.369766	2.829835	3.355541	3.92723
176.5	0	0	0	0.213456	0.448725	0.694665	0.958864	1.241863	1.553979	1.920067	2.35287	2.872443	3.465248
178.5	0	0	0.032296	0.263266	0.530759	0.813255	1.112387	1.432563	1.781324	2.184074	2.650854	3.199159	3.810195
180.5	0	0.009648	0.159919	0.435115	0.739398	1.054881	1.380806	1.715005	2.057868	2.426392	2.823927	3.261798	3.723318
182.5	0	0	0.091379	0.297008	0.598396	0.979455	1.422258	1.911219	2.410913	2.904672	3.353899	3.740216	4.039665
184.5	0	0	0.068913	0.275434	0.547831	0.860578	1.202675	1.570673	1.95816	2.379133	2.830881	3.320081	3.82277
186.5	0	0.007292	0.122427	0.357108	0.616383	0.885713	1.165721	1.455526	1.75604	2.082145	2.436303	2.828115	3.242852
188.5	0	0	0.073297	0.257147	0.496437	0.769307	1.067685	1.390031	1.733415	2.114292	2.535766	3.011011	3.524267
190.5	0	0	0.054103	0.255766	0.515628	0.804771	1.112704	1.43756	1.778562	2.155237	2.574198	3.051088	3.570594
192.5	0	0	0.080791	0.278488	0.524009	0.790666	1.071088	1.36394	1.670063	2.008224	2.385671	2.817353	3.289505
194.5	0	0	0.205473	0.436265	0.696751	0.977324	1.260831	1.55807	1.864824	2.197056	2.554656	2.944768	3.350448
196.5	0	0	0.206866	0.505413	0.840141	1.197488	1.55454	1.919351	2.283312	2.66153	3.051307	3.458603	3.863658
198.5	0	0	0.032582	0.168415	0.350185	0.560284	0.791891	1.045583	1.321246	1.63518	1.992748	2.407096	2.865073
200.5	0	0	0.057838	0.24082	0.474729	0.73437	1.011149	1.303803	1.612295	1.954989	2.338635	2.778342	3.261072
204.5	0	0	0.085969	0.321977	0.582812	0.845272	1.110437	1.377403	1.65002	1.945095	2.268472	2.631484	3.021437
210.5	0	0	0.09064	0.299982	0.537917	0.78417	1.038258	1.29849	1.565713	1.853736	2.165989	2.512574	2.88223
216.5	0	0.005621	0.093816	0.265655	0.45216	0.64286	0.839926	1.045241	1.263746	1.511505	1.795607	2.128127	2.499829
218.5	0	0	0.02703	0.201594	0.39959	0.601807	0.807086	1.015396	1.231353	1.472081	1.747523	2.073706	2.446292

Appendix Table 10 (continued). Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (µm)												
	1.906	2.188	2.512	2.884	3.311	3.802	4.365	5.012	5.754	6.607	7.586	8.710	10.000
0.5	4.081599	4.233994	4.308059	4.302446	4.223473	4.082087	3.897555	3.691069	3.490435	3.315321	3.184427	3.098647	3.051887
6.5	4.065124	4.385949	4.583449	4.644335	4.574211	4.39275	4.138512	3.856714	3.59945	3.404027	3.300976	3.293665	3.36222
12.5	4.232645	4.456237	4.563582	4.554735	4.445085	4.258005	4.026374	3.781998	3.559839	3.381401	3.264021	3.204943	3.191499
18.5	3.95032	4.206033	4.359502	4.404505	4.347217	4.201486	3.990782	3.739797	3.479527	3.230346	3.015032	2.837999	2.705849
20.5	3.907212	4.190768	4.373423	4.444214	4.405883	4.270302	4.061133	3.8062	3.542376	3.297915	3.103551	2.969913	2.902287
22.5	3.828412	4.035721	4.156009	4.183814	4.124066	3.988363	3.79738	3.573277	3.344278	3.12933	2.948606	2.80452	2.698162
24.5	3.91708	4.237622	4.462446	4.574088	4.568997	4.454454	4.251084	3.985032	3.692443	3.400623	3.141767	2.927925	2.774034
26.5	3.919206	4.228162	4.446584	4.558605	4.561568	4.462998	4.282812	4.045963	3.785901	3.527178	3.296818	3.101506	2.948494
28.5	4.521003	4.90675	5.177469	5.308382	5.291575	5.1341	4.862876	4.514427	4.139302	3.776188	3.467571	3.225214	3.053525
30.5	4.774709	5.309762	5.709503	5.927921	5.944242	5.762769	5.417865	4.959789	4.458873	3.968728	3.545332	3.202489	2.948556
32.5	4.962704	5.241714	5.37589	5.347798	5.160636	4.833643	4.407322	3.927063	3.453447	3.028588	2.69687	2.467683	2.34339
34.5	4.171781	4.49164	4.704932	4.791699	4.745873	4.572744	4.29421	3.939797	3.554172	3.173249	2.842733	2.583322	2.415402

36.5	4.396149	4.657896	4.805133	4.828269	4.731808	4.529376	4.247133	3.91363	3.567456	3.234713	2.946013	2.707541	2.526773
38.5	4.373538	4.672825	4.869494	4.948608	4.907837	4.755104	4.512368	4.207327	3.879521	3.558798	3.279973	3.053434	2.887812
40.5	4.151556	4.53402	4.838582	5.038147	5.115438	5.063567	4.8906	4.615621	4.274097	3.897764	3.530051	3.190903	2.906262
42.5	3.464489	3.857437	4.211628	4.504662	4.719955	4.846051	4.876741	4.813348	4.664366	4.43985	4.159309	3.830847	3.47756
44.5	3.434119	3.951586	4.44781	4.887375	5.239759	5.481959	5.599289	5.59158	5.46918	5.248763	4.957442	4.610476	4.236513
46.5	4.022068	4.555544	5.021176	5.381831	5.611605	5.696508	5.63743	5.44983	5.164758	4.812861	4.435688	4.05165	3.687317
48.5	4.180774	4.768506	5.27202	5.64487	5.853892	5.881645	5.732891	5.432693	5.029324	4.569963	4.11637	3.699252	3.351679
50.5	3.364268	3.778861	4.163803	4.495378	4.754142	4.92608	5.003373	4.98836	4.890766	4.724715	4.512496	4.267365	4.010374
52.5	3.22079	3.568897	3.88696	4.158576	4.371488	4.517662	4.593459	4.602691	4.553247	4.45558	4.32353	4.164035	3.988772
54.5	3.203447	3.512059	3.777452	3.98481	4.124587	4.191961	4.18797	4.119558	3.999163	3.839187	3.658069	3.466374	3.283303
60.5	3.346305	3.667654	3.94455	4.162711	4.313671	4.393778	4.404698	4.354098	4.254426	4.118154	3.961812	3.79267	3.622289
66.5	3.248459	3.584352	3.869817	4.089205	4.235295	4.306909	4.308093	4.247373	4.136386	3.984254	3.80285	3.593017	3.362974
72.5	3.4428	3.756149	4.009199	4.186311	4.280522	4.291351	4.225463	4.094258	3.915251	3.702257	3.474528	3.238478	3.00984
74.5	3.500712	3.921432	4.284297	4.561609	4.734004	4.790826	4.733645	4.576433	4.347031	4.075504	3.803741	3.557545	3.363638
76.5	2.748794	3.120957	3.484074	3.82283	4.127701	4.395019	4.623774	4.820669	4.987532	5.128421	5.23412	5.290367	5.270837
78.5	3.407977	3.845802	4.2454	4.578608	4.825088	4.973247	5.020845	4.977031	4.858671	4.683511	4.473236	4.235867	3.98464
80.5	4.14027	4.639712	5.059673	5.36523	5.536007	5.565998	5.465612	5.258566	4.982526	4.670919	4.361755	4.066035	3.792575
82.5	4.143946	4.638353	5.055002	5.355991	5.516612	5.52697	5.395758	5.147133	4.822757	4.460782	4.107287	3.780714	3.499573
84.5	4.004053	4.450514	4.823926	5.092731	5.237287	5.249902	5.137516	4.918963	4.627198	4.291635	3.950323	3.618448	3.317229
86.5	4.492	5.118349	5.661276	6.073835	6.325694	6.40419	6.315676	6.08247	5.742043	5.325248	4.869852	4.381299	3.875554
88.5	4.515238	5.208423	5.829067	6.318238	6.63021	6.736718	6.631273	6.32897	5.869363	5.291702	4.656584	3.991471	3.344661
90.5	4.753573	5.409725	5.954848	6.329046	6.492977	6.431483	6.15995	5.716884	5.168629	4.573544	4.003916	3.488815	3.058946
92.5	4.179968	4.709079	5.155697	5.481213	5.661206	5.686029	5.564138	5.318597	4.988474	4.608433	4.222047	3.845489	3.499654
94.5	4.257532	4.883765	5.415299	5.798948	6.002904	6.018181	5.861016	5.565322	5.18173	4.75121	4.319953	3.90063	3.512355
96.5	4.336194	4.838279	5.249186	5.529773	5.656341	5.621216	5.43636	5.127889	4.740176	4.31198	3.892981	3.503695	3.169745
98.5	3.488398	4.078399	4.611859	5.040518	5.334749	5.485939	5.506177	5.426111	5.286539	5.123807	4.966367	4.814797	4.655151
100.5	4.317412	4.995247	5.58131	6.014489	6.253065	6.278659	6.102989	5.76335	5.322203	4.836175	4.370049	3.948013	3.589722
102.5	4.148371	4.571321	4.914376	5.151364	5.268996	5.265732	5.154134	4.956434	4.70525	4.426932	4.151008	3.883699	3.632033
104.5	4.735229	5.502893	6.156532	6.622199	6.852849	6.832831	6.58262	6.149304	5.606588	5.015474	4.443016	3.906576	3.42454
106.5	4.924495	5.278746	5.52715	5.651266	5.640689	5.49149	5.214618	4.831306	4.384342	3.912179	3.468777	3.077186	2.762065
108.5	4.51365	5.089256	5.56315	5.887632	6.033674	5.993029	5.783346	5.44145	5.025412	4.58481	4.173883	3.808132	3.497992
110.5	4.183863	4.831766	5.39605	5.821755	6.073006	6.134797	6.015875	5.745101	5.371544	4.940299	4.505283	4.086869	3.707536
112.5	4.12509	4.763994	5.328201	5.76463	6.03688	6.127654	6.04235	5.80708	5.467197	5.064211	4.646265	4.228547	3.829757
114.5	3.293258	3.664601	3.99351	4.258031	4.442843	4.539177	4.54569	4.469443	4.32511	4.127894	3.899757	3.650909	3.400331
116.5	3.665691	4.195378	4.679961	5.079041	5.360399	5.503272	5.502477	5.370774	5.13746	4.834571	4.503605	4.164885	3.844183
118.5	3.45237	3.955281	4.420983	4.815167	5.111331	5.292194	5.351319	5.296816	5.148094	4.927859	4.665766	4.375798	4.078593
120.5	3.292886	3.718562	4.102825	4.417359	4.641422	4.762914	4.779582	4.700709	4.545657	4.335647	4.098941	3.850019	3.609187
122.5	3.535946	3.999038	4.415202	4.753749	4.99216	5.117609	5.128723	5.037017	4.864898	4.636301	4.382644	4.119603	3.866611
124.5	3.757964	4.261622	4.709394	5.065261	5.304148	5.413457	5.394961	5.265269	5.054287	4.792038	4.51444	4.235972	3.971207
126.5	3.857025	4.403801	4.890173	5.271394	5.514035	5.599357	5.527602	5.318236	5.010788	4.646566	4.278794	3.934603	3.640639
128.5	3.918034	4.58449	5.186597	5.667535	5.985049	6.115256	6.057975	5.837001	5.498237	5.088996	4.668744	4.265767	3.906642
130.5	4.092427	4.731859	5.297939	5.736596	6.009476	6.097638	6.006588	5.763875	5.417055	5.010847	4.598403	4.200087	3.835729

132.5	3.921927	4.366777	4.75668	5.063966	5.269408	5.362201	5.342124	5.219934	5.016885	4.753887	4.459671	4.144268	3.823128
134.5	3.761962	4.241673	4.666042	5.001714	5.225961	5.327243	5.306541	5.177586	4.966133	4.697995	4.406733	4.107182	3.819238
136.5	3.958571	4.444271	4.866997	5.197279	5.415138	5.509691	5.481521	5.343267	5.119323	4.83384	4.520068	4.191938	3.869024
138.5	3.068949	3.477374	3.851592	4.167101	4.406092	4.557447	4.617349	4.591954	4.493957	4.338079	4.144118	3.921039	3.68402
144.5	3.127572	3.52132	3.872682	4.15611	4.354689	4.460031	4.472853	4.40366	4.270579	4.091645	3.889062	3.671828	3.45412
150.5	3.237628	3.675089	4.064105	4.371656	4.57461	4.661277	4.633421	4.506265	4.307531	4.065263	3.8142	3.57207	3.359847
152.5	3.170048	3.59768	3.978798	4.284487	4.496357	4.606597	4.618815	4.54858	4.420497	4.260393	4.097772	3.948051	3.82304
154.5	3.168777	3.568741	3.926941	4.216795	4.421631	4.535076	4.561551	4.516866	4.424338	4.307508	4.189482	4.07944	3.981103
160.5	3.315793	3.84781	4.327709	4.708517	4.956514	5.054796	5.006798	4.835742	4.58262	4.289047	4.003593	3.751928	3.557616
162.5	3.922095	4.416811	4.835803	5.140564	5.306108	5.322784	5.200336	4.96471	4.659184	4.32409	4.006607	3.727056	3.502348
164.5	3.847996	4.344728	4.771295	5.090623	5.280394	5.334091	5.262807	5.092604	4.862852	4.609258	4.368734	4.152694	3.965235
166.5	4.232487	4.786415	5.249024	5.57337	5.730015	5.708533	5.521439	5.199416	4.795174	4.357219	3.944175	3.581674	3.293508
168.5	4.612732	5.170415	5.623923	5.923167	6.036342	5.952203	5.685993	5.272579	4.772694	4.240356	3.742102	3.305524	2.958045
170.5	4.424647	5.056829	5.595951	5.985007	6.18307	6.169811	5.952774	5.563194	5.060863	4.503284	3.965522	3.485185	3.101007
172.5	4.278757	4.886321	5.409973	5.794292	5.99988	6.007436	5.823553	5.477575	5.025459	4.521106	4.032916	3.59411	3.23888
174.5	4.514899	5.057996	5.500925	5.796485	5.914745	5.844543	5.598712	5.207744	4.726279	4.202982	3.700512	3.246087	2.871468
176.5	4.106214	4.735318	5.29256	5.720419	5.976129	6.036781	5.904375	5.604519	5.189215	4.711134	4.237649	3.802587	3.440774
178.5	4.453456	5.064413	5.582214	5.953327	6.142199	6.1336	5.937243	5.583369	5.127069	4.619321	4.124074	3.668691	3.282411
180.5	4.184883	4.600328	4.929901	5.142895	5.223121	5.168758	4.995591	4.731337	4.418779	4.094453	3.799499	3.548022	3.350076
182.5	4.254561	4.404562	4.530635	4.669567	4.830107	4.988981	5.103025	5.128997	5.037404	4.823514	4.515055	4.142577	3.752676
184.5	4.309743	4.732088	5.054246	5.255057	5.327362	5.273818	5.110223	4.86083	4.562584	4.246557	3.949509	3.682999	3.457076
186.5	3.660715	4.042549	4.355021	4.571701	4.677482	4.668911	4.557016	4.364082	4.125431	3.87379	3.647171	3.464025	3.339279
188.5	4.052553	4.546877	4.964061	5.268953	5.440151	5.470566	5.370674	5.165051	4.891702	4.582802	4.273162	3.9702	3.681961
190.5	4.107518	4.608244	5.02444	5.317066	5.463264	5.457024	5.312481	5.058248	4.737643	4.386363	4.044054	3.721738	3.432688
192.5	3.778297	4.232961	4.60689	4.862219	4.976902	4.945636	4.78352	4.519968	4.199626	3.859687	3.541302	3.258105	3.024237
194.5	3.75241	4.116953	4.419986	4.643582	4.774489	4.803433	4.730649	4.567101	4.337388	4.067591	3.794469	3.537341	3.316918
196.5	4.243718	4.561789	4.792444	4.921761	4.946387	4.869745	4.704788	4.469343	4.191893	3.895884	3.612746	3.353934	3.133592
198.5	3.345269	3.801141	4.190335	4.478039	4.643369	4.679784	4.597122	4.418376	4.178823	3.909509	3.645184	3.399329	3.187893
200.5	3.765227	4.243297	4.652509	4.957007	5.133488	5.172802	5.083725	4.89006	4.630031	4.338439	4.054473	3.793135	3.568529
204.5	3.419302	3.787204	4.093524	4.314447	4.437339	4.459562	4.389341	4.243189	4.046514	3.821583	3.595405	3.379035	3.187553
210.5	3.259258	3.610813	3.909557	4.134185	4.27248	4.320725	4.284582	4.177718	4.021164	3.833487	3.636457	3.437686	3.249044
216.5	2.895892	3.283141	3.633194	3.922434	4.135027	4.262802	4.305689	4.273474	4.182512	4.050827	3.89992	3.740441	3.583976
218.5	2.85494	3.269202	3.661145	4.004983	4.28097	4.476321	4.584827	4.61097	4.56503	4.461706	4.319606	4.149764	3.967522

Appendix Table 10 (continued). Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (µm)												
	11.482	13.183	15.136	17.378	19.953	22.909	26.303	30.200	34.674	39.811	45.709	52.481	60.256
0.5	3.025214	2.998073	2.948522	2.861897	2.725898	2.53742	2.291374	1.994467	1.653672	1.289897	0.922997	0.57562	0.264314
6.5	3.464841	3.540683	3.53565	3.415596	3.176099	2.847627	2.463281	2.063862	1.669285	1.293274	0.930534	0.575239	0.245246

12.5	3.198589	3.197427	3.160828	3.070241	2.913127	2.689621	2.398464	2.052219	1.664259	1.263726	0.878068	0.535851	0.257278
18.5	2.613552	2.563845	2.557483	2.597506	2.681018	2.787157	2.877295	2.895092	2.787137	2.523251	2.111331	1.597823	1.052807
20.5	2.889093	2.913036	2.952465	2.984563	2.98961	2.947709	2.838404	2.647708	2.368771	2.013114	1.605099	1.179347	0.770869
22.5	2.618229	2.558617	2.511331	2.475725	2.450929	2.434756	2.418004	2.386788	2.324781	2.218517	2.058299	1.839135	1.560299
24.5	2.67956	2.648299	2.676985	2.757239	2.870527	2.975379	3.014389	2.923611	2.658098	2.222016	1.664836	1.081194	0.579738
26.5	2.82954	2.743513	2.683948	2.64987	2.633992	2.62	2.577981	2.472751	2.273552	1.971426	1.582377	1.146277	0.712691
28.5	2.926887	2.817914	2.689931	2.522166	2.29978	2.028026	1.707334	1.355817	0.976005	0.625714	0.283915	0	0
30.5	2.756869	2.604851	2.45747	2.295064	2.098648	1.861541	1.574994	1.230107	0.858519	0.427183	0.118191	0	0
32.5	2.299999	2.307653	2.329627	2.331066	2.283083	2.164931	1.961596	1.67553	1.320809	0.931652	0.549351	0.206493	0
34.5	2.334233	2.33229	2.392036	2.490245	2.601333	2.688195	2.709931	2.62509	2.404653	2.051859	1.596103	1.100803	0.645527
36.5	2.391741	2.29741	2.232407	2.192975	2.172815	2.162582	2.144062	2.093505	1.986505	1.808753	1.559658	1.25617	0.927191
38.5	2.769151	2.685018	2.613273	2.537176	2.437448	2.299898	2.108224	1.856707	1.548075	1.197344	0.839516	0.493781	0.173259
40.5	2.674384	2.501397	2.375074	2.288112	2.222065	2.155324	2.057896	1.904634	1.678642	1.386763	1.048437	0.698043	0.374652
42.5	3.105538	2.74811	2.421379	2.161655	1.983772	1.897021	1.884334	1.911219	1.930137	1.89294	1.764196	1.532744	1.216266
44.5	3.841679	3.454109	3.07539	2.723722	2.390108	2.070867	1.74318	1.401068	1.038941	0.692848	0.369342	0.133274	0
46.5	3.339098	3.019608	2.717903	2.439517	2.171668	1.907763	1.625325	1.315565	0.969998	0.622753	0.286096	0.047688	0
48.5	3.066804	2.842901	2.653379	2.480224	2.29379	2.069515	1.780547	1.406888	0.986424	0.497404	0.150002	0	0
50.5	3.744537	3.485876	3.231258	2.98821	2.745306	2.494037	2.211518	1.886659	1.517559	1.124008	0.747694	0.39868	0.082345
52.5	3.798551	3.605238	3.408155	3.21482	3.016085	2.801891	2.547263	2.237413	1.86515	1.451847	1.032776	0.654188	0.321367
54.5	3.118597	2.9937	2.920189	2.909278	2.955518	3.031221	3.086903	3.058985	2.892556	2.564841	2.097495	1.553181	1.012927
60.5	3.4504	3.287024	3.132389	2.99483	2.869844	2.748428	2.605567	2.416461	2.159796	1.834914	1.458656	1.062128	0.678858
66.5	3.109465	2.849414	2.591547	2.365108	2.187909	2.079144	2.03876	2.054541	2.101081	2.144843	2.150082	2.083646	1.921103
72.5	2.792624	2.608563	2.471169	2.403203	2.413973	2.496232	2.619209	2.728039	2.760874	2.664234	2.41157	2.015087	1.524819
74.5	3.222757	3.132851	3.074919	3.029257	2.969843	2.870921	2.702797	2.446962	2.09693	1.679924	1.239729	0.821725	0.444149
76.5	5.146661	4.901063	4.521486	4.031901	3.453989	2.8362	2.221522	1.633066	1.099922	0.552031	0.162846	0	0
78.5	3.715351	3.440159	3.156979	2.881504	2.613365	2.356917	2.097988	1.82775	1.535912	1.230251	0.923745	0.635078	0.375898
80.5	3.51977	3.236647	2.917236	2.562837	2.170798	1.761252	1.351871	0.952685	0.591102	0.216575	0	0	0
82.5	3.250166	3.025082	2.79812	2.558767	2.289464	1.988608	1.649002	1.284542	0.908923	0.566928	0.232342	0	0
84.5	3.041658	2.799686	2.581578	2.390991	2.21885	2.057989	1.887505	1.690653	1.453747	1.182597	0.893541	0.614907	0.361175
86.5	3.333485	2.772397	2.187868	1.625861	1.102308	0.683151	0.150209	0	0	0	0	0	0
88.5	2.71793	2.147359	1.632112	1.203684	0.866075	0.629427	0.477693	0.390295	0.339585	0.300345	0.256604	0.196453	0.118251
90.5	2.695914	2.390838	2.108424	1.835048	1.549806	1.254424	0.93378	0.627354	0.277379	0.065751	0	0	0
92.5	3.173616	2.871717	2.579106	2.302105	2.034821	1.780538	1.524836	1.259382	0.965088	0.662076	0.342143	0.083761	0
94.5	3.142454	2.799524	2.473005	2.175446	1.902529	1.654946	1.412858	1.162819	0.88742	0.606642	0.324459	0.112391	0
96.5	2.883457	2.646837	2.440464	2.256688	2.076445	1.886733	1.665334	1.404775	1.097214	0.781326	0.458632	0.184124	0.005842
98.5	4.44833	4.164646	3.771253	3.278679	2.702751	2.099295	1.509686	0.984793	0.562105	0.187433	0	0	0
100.5	3.269694	2.97	2.651572	2.303673	1.913642	1.50282	1.077705	0.701435	0.330694	0.108113	0	0	0
102.5	3.379174	3.121263	2.841253	2.544041	2.22563	1.896979	1.554987	1.210804	0.865021	0.555012	0.27179	0.044019	0
104.5	2.967714	2.529865	2.083223	1.639858	1.208014	0.809413	0.473267	0.156708	0.020697	0	0	0	0
106.5	2.509457	2.308665	2.127552	1.946268	1.740838	1.501434	1.218814	0.892158	0.551954	0.189315	0	0	0
108.5	3.214988	2.938697	2.631701	2.28583	1.893126	1.479828	1.056667	0.686146	0.322667	0.104809	0	0	0
110.5	3.35135	3.015934	2.675848	2.330623	1.969924	1.603194	1.232034	0.868207	0.544144	0.245858	0.059154	0	0

112.5	3.433429	3.044064	2.645052	2.249863	1.858977	1.488472	1.138073	0.81173	0.52642	0.257645	0.081329	0	0
114.5	3.152151	2.927598	2.736071	2.598837	2.522	2.501175	2.509107	2.502527	2.432736	2.262565	1.978657	1.598783	1.167502
116.5	3.53892	3.258771	2.990575	2.734159	2.47263	2.196973	1.887977	1.543564	1.171674	0.800719	0.471386	0.210575	0.022253
118.5	3.77312	3.474835	3.179593	2.89838	2.622121	2.345181	2.044874	1.710396	1.339582	0.95257	0.589644	0.28174	0.048137
120.5	3.378297	3.171524	2.989028	2.841042	2.723724	2.627762	2.526016	2.387559	2.183119	1.902865	1.558236	1.181517	0.813999
122.5	3.619786	3.38475	3.149814	2.917199	2.676741	2.425085	2.145596	1.830585	1.476695	1.097697	0.730005	0.383709	0.070807
124.5	3.707154	3.440383	3.150189	2.836819	2.491482	2.12379	1.73182	1.333147	0.935631	0.569469	0.21989	0	0
126.5	3.387444	3.168541	2.955376	2.732314	2.476552	2.181637	1.83652	1.454407	1.045124	0.666917	0.320452	0.04365	0
128.5	3.574938	3.26108	2.930951	2.575283	2.179476	1.755852	1.314504	0.878143	0.50224	0.172394	0	0	0
130.5	3.485675	3.142512	2.776776	2.388289	1.969416	1.543409	1.113878	0.736948	0.366158	0.135317	0	0	0
132.5	3.485387	3.13789	2.769589	2.396922	2.023571	1.669136	1.334374	1.026623	0.745931	0.502794	0.308959	0.174662	0.098299
134.5	3.537645	3.26896	2.999708	2.731266	2.450493	2.155023	1.831505	1.485463	1.119777	0.775357	0.436965	0.161003	0
136.5	3.542658	3.218588	2.881612	2.538547	2.183035	1.824422	1.461568	1.096633	0.75947	0.411969	0.155506	0	0
138.5	3.433731	3.188825	2.958262	2.767909	2.629458	2.548212	2.5042	2.461273	2.3739	2.205953	1.942488	1.597644	1.209282
144.5	3.235963	3.033206	2.85328	2.717353	2.634986	2.607676	2.614952	2.619346	2.574231	2.438322	2.188154	1.829225	1.397845
150.5	3.178967	3.039123	2.938638	2.881616	2.862078	2.863348	2.851819	2.784027	2.618599	2.334772	1.941255	1.477866	1.002987
152.5	3.716543	3.622978	3.527754	3.421862	3.290029	3.118352	2.883023	2.56983	2.172283	1.715364	1.239445	0.801723	0.419448
154.5	3.883147	3.775864	3.643052	3.478989	3.27366	3.02516	2.722329	2.36602	1.959033	1.526847	1.09926	0.716227	0.382117
160.5	3.418195	3.330959	3.278421	3.242191	3.194431	3.101205	2.92077	2.624287	2.202458	1.690232	1.147307	0.654331	0.287364
162.5	3.318749	3.16383	3.009532	2.839054	2.631883	2.380429	2.071775	1.713308	1.307165	0.906074	0.506512	0.170863	0.005277
164.5	3.782824	3.584664	3.337851	3.031406	2.654422	2.22286	1.751814	1.271167	0.833124	0.377258	0.065039	0	0
166.5	3.065756	2.88575	2.719802	2.544736	2.333187	2.074027	1.756269	1.394879	1.00343	0.641496	0.31102	0.046057	0
168.5	2.684303	2.472906	2.28919	2.111045	1.912199	1.682061	1.409737	1.103812	0.774313	0.455126	0.161013	0	0
170.5	2.803119	2.582307	2.400088	2.226781	2.026319	1.777414	1.464694	1.088801	0.696117	0.283643	0.025246	0	0
172.5	2.957486	2.741887	2.556983	2.376554	2.167252	1.909655	1.590156	1.20791	0.813127	0.38256	0.083553	0	0
174.5	2.567975	2.335009	2.148006	1.993681	1.850132	1.702374	1.530995	1.328249	1.095391	0.849189	0.616273	0.391289	0.177264
176.5	3.143393	2.904328	2.689306	2.47489	2.23001	1.940276	1.59708	1.204813	0.816914	0.406379	0.112754	0	0
178.5	2.950668	2.666539	2.397255	2.129064	1.842539	1.538557	1.21719	0.887	0.580798	0.263287	0.045584	0	0
180.5	3.187771	3.044458	2.890107	2.707047	2.475793	2.193326	1.854754	1.477943	1.080257	0.711359	0.346215	0.055253	0
182.5	3.360361	2.991872	2.639564	2.3096	1.98681	1.666062	1.330824	0.967215	0.602929	0.214023	0	0	0
184.5	3.254752	3.064417	2.860239	2.632156	2.365647	2.063005	1.720827	1.35522	0.977618	0.630923	0.319496	0.096479	0
186.5	3.266579	3.234919	3.221669	3.201187	3.143082	3.016907	2.792285	2.457927	2.024247	1.531287	1.047337	0.588309	0.159614
188.5	3.390523	3.095234	2.783947	2.472126	2.166143	1.882571	1.615999	1.358046	1.089906	0.799891	0.494365	0.199882	0
190.5	3.163562	2.91524	2.674668	2.447771	2.230497	2.023786	1.811524	1.576885	1.301086	0.976096	0.622596	0.275308	0
192.5	2.830007	2.67592	2.553497	2.466386	2.413271	2.389525	2.376387	2.343958	2.255768	2.079648	1.797052	1.411492	0.953219
194.5	3.128991	2.974045	2.838643	2.718273	2.601757	2.479612	2.330454	2.133556	1.869133	1.539967	1.163952	0.780301	0.435212
196.5	2.942923	2.779373	2.626465	2.477629	2.319123	2.142658	1.932196	1.680392	1.386819	1.066236	0.752137	0.457041	0.181834
198.5	3.008627	2.870929	2.776793	2.736778	2.753051	2.813449	2.884132	2.910541	2.834751	2.615526	2.246209	1.758057	1.209363
200.5	3.369924	3.193554	3.02203	2.849664	2.662711	2.453236	2.203788	1.907167	1.56394	1.191778	0.82671	0.490028	0.198355
204.5	3.020685	2.888414	2.792406	2.740556	2.730698	2.748805	2.763321	2.730362	2.606407	2.365036	2.007946	1.566538	1.091864
210.5	3.069691	2.912306	2.78316	2.699269	2.668411	2.687754	2.733583	2.762964	2.724804	2.575738	2.294734	1.894554	1.421543
216.5	3.428787	3.282883	3.148623	3.040146	2.964155	2.921067	2.891175	2.840304	2.727438	2.522703	2.217632	1.830963	1.401251

218.5	3.776469	3.592102	3.419405	3.272339	3.149551	3.04142	2.917363	2.74236	2.48403	2.134127	1.709843	1.252772	0.814536

Appendix Table 10 (continued). Laser diffraction particle-size results (percent in each mesh size class) for Horseshoe Lake, Madison County, Illinois (HORM12) composite core.

Depth (cm)	Mesh size (µm)					
	69.183	79.433	91.201	104.713	120.226	138.038
0.5	0.00824	0	0	0	0	0
6.5	0.00715	0	0	0	0	0
12.5	0.035315	0	0	0	0	0
18.5	0.575536	0.141857	0.019487	0	0	0
20.5	0.430829	0.118659	0.01784	0	0	0
22.5	1.229	0.852165	0.509163	0.076638	0	0
24.5	0.144533	0.016446	0	0	0	0
26.5	0.331282	0.019659	0	0	0	0
28.5	0	0	0	0	0	0
30.5	0	0	0	0	0	0
32.5	0	0	0	0	0	0
34.5	0.181976	0.021926	0	0	0	0
36.5	0.596534	0.315225	0.03054	0	0	0
38.5	0.013839	0	0	0	0	0
40.5	0.056886	0	0	0	0	0
42.5	0.846494	0.517441	0.145574	0.024494	0	0
44.5	0	0	0	0	0	0
46.5	0	0	0	0	0	0
48.5	0	0	0	0	0	0
50.5	0.00547	0	0	0	0	0
52.5	0.010543	0	0	0	0	0
54.5	0.555908	0.037673	0	0	0	0
60.5	0.348693	0.0225	0	0	0	0
66.5	1.651992	1.292974	0.869269	0.461856	0.075268	0
72.5	0.994961	0.573469	0.060502	0	0	0
74.5	0.06828	0	0	0	0	0
76.5	0	0	0	0	0	0
78.5	0.111541	0.013751	0	0	0	0
80.5	0	0	0	0	0	0
82.5	0	0	0	0	0	0
84.5	0.098317	0.011645	0	0	0	0
86.5	0	0	0	0	0	0
88.5	0.010399	0	0	0	0	0
90.5	0	0	0	0	0	0

92.5	0	0	0	0	0	0
94.5	0	0	0	0	0	0
96.5	0	0	0	0	0	0
98.5	0	0	0	0	0	0
100.5	0	0	0	0	0	0
102.5	0	0	0	0	0	0
104.5	0	0	0	0	0	0
106.5	0	0	0	0	0	0
108.5	0	0	0	0	0	0
110.5	0	0	0	0	0	0
112.5	0	0	0	0	0	0
114.5	0.748681	0.385186	0.036099	0	0	0
116.5	0	0	0	0	0	0
118.5	0	0	0	0	0	0
120.5	0.487571	0.129874	0.018672	0	0	0
122.5	0	0	0	0	0	0
124.5	0	0	0	0	0	0
126.5	0	0	0	0	0	0
128.5	0	0	0	0	0	0
130.5	0	0	0	0	0	0
132.5	0.066356	0.063667	0.074836	0.0879	0.076636	0.027825
134.5	0	0	0	0	0	0
136.5	0	0	0	0	0	0
138.5	0.820734	0.485539	0.10459	0.01099	0	0
144.5	0.944642	0.551921	0.10929	0.008913	0	0
150.5	0.581854	0.125417	0.014422	0	0	0
152.5	0.014361	0	0	0	0	0
154.5	0.013236	0	0	0	0	0
160.5	0.0089	0	0	0	0	0
162.5	0	0	0	0	0	0
164.5	0	0	0	0	0	0
166.5	0	0	0	0	0	0
168.5	0	0	0	0	0	0
170.5	0	0	0	0	0	0
172.5	0	0	0	0	0	0
174.5	0.014929	0	0	0	0	0
176.5	0	0	0	0	0	0
178.5	0	0	0	0	0	0
180.5	0	0	0	0	0	0
182.5	0	0	0	0	0	0
184.5	0	0	0	0	0	0
186.5	0.011851	0	0	0	0	0

188.5	0	0	0	0	0	0
190.5	0	0	0	0	0	0
192.5	0.503937	0.080785	0	0	0	0
194.5	0.088561	0.008766	0	0	0	0
196.5	0.014938	0	0	0	0	0
198.5	0.699579	0.205466	0.032294	0	0	0
200.5	0.016347	0	0	0	0	0
204.5	0.673436	0.222007	0.037146	0	0	0
210.5	0.929974	0.54152	0.11263	0.010512	0	0
216.5	0.974274	0.599787	0.323636	0.133421	0.038334	0
218.5	0.434483	0.028754	0	0	0	0

Appendix Table 11. Composite core sections for Horseshoe Lake, Alexander County, Illinois (HORX13).

Section No.	Core Section Name	Section depth top (cm)	Section depth bottom (cm)	Sum depth top (cm)	Sum depth bottom (cm)
1	HORX13-1A-1B	6	29	0	23
2	HORX13-1B-1L	33	88	23	78
3	HORX13-1C-1L	39	63	78	102
4	HORX13-1B-2L	2	45	102	145
5	HORX13-2A-2L	29	60	145	176
6	HORX13-2B-2L	32	73	176	217
7	HORX13-2A-3L	16	80	217	281

Appendix Table 12. Pollen counts from Horseshoe Lake, Alexander County, Illinois (HORX13) composite sediment core. Data will be submitted to Neotoma upon publication.

Depth (cm)	Acer	Agoseris	Alnus	Ambrosia	Artemisia	Betula	Carya	Caryophyllaceae	Castanea	Celtis	Cephalanthus	Amaranthacea
0.5	1	1		54	1	2	15					6
8.5				45	1		8			1	3	9
16.5		1		51			21		1	2		2
24.5			1	23	2		32			2	2	1
32.5			2	3	1	1	36			3	1	1
40.5				4			43			2		
48.5			1	8	1		30			2	2	
56.5				11	2		36			4	2	
64.5				15			42			1		1
72.5				16			34				1	4
80.5				22		1	39			1		2
88.5				26	2		53			3	1	1
96.5				34	2	1	35				3	3

104.5			1	25			39				2	
112.5				25	2		51		1			1
120.5				16			35			1	2	2
128.5				27			37		1	1	2	3
136.5				42	2		32				1	2
144.5				25	3		35		1	3	2	
168.5			1	68	1		46		2		1	19
176.5				75	4		35		2		2	21
184.5				88			16		2		2	44
192.5				70	2		18			1	1	52
200.5		1		87	2		28		1	1		14
208.5			1	67			22		1	1	1	3
216.5				57			15	1				2
224.5	1			44			14		1	5		
232.5	2			55			24	2		8		1
240.5				49	1		21	1		4		3
248.5	1			58	1		27	1		5	1	4
256.5				56	1	1	12		1	1		8
264.5				47	1	1	21			2	1	31

Appendix Table 12 (continued). Pollen counts from Horseshoe Lake, Alexander County, Illinois (HORX13) composite sediment core.

Depth (cm)	Corylus	Cyperaceae	Fagus	Fraxinus	Helianthus	Iva	Juglans cinera	Juglans nigra	Liquidambar	Nyssa	Ostrya/Carpinus	Pinus
0.5				7		2	1	1	24	21	1	7
8.5		1		11					9	10	3	4
16.5				7	1	1		1	11	7	2	9
24.5				3	3			7	16	4		5
32.5				15	1			1	13	2	2	8
40.5	1	2		6	2			2	11		1	14
48.5	1	2		7	1			1	8	1	1	8
56.5		1		6	1	1		2	11	1	1	6
64.5	2	2		7	3	2	1	1	13	2	3	4
72.5	1	3		12	1	1	1		6	2	1	6
80.5		7		8	1	1	1		5	3	1	5
88.5		7		7	2	3	1		6	3	4	8
96.5	1	3		11		2	1		1	10	1	7
104.5		2		9	2	4	1	1	4	6	2	6
112.5	1	2		6	1			1	6	1	2	8
120.5				2	2	4		1	2	1	1	7
128.5	1			7	1	1			5	4	3	7
136.5		2		5	1	2			5	4	2	2

144.5	1	1	12	3	1			5	3		11
168.5					1						5
176.5	1		4		1	1	2	6	1		10
184.5	1		3	1	2		1	1	2	1	3
192.5		2	5	3			4	2	2		4
200.5		2	5	1	1		2	4	2	1	3
208.5	3	2	8		2			9	5	1	2
216.5	1		6	9	1	1	4	10	5	2	1
224.5	2		18		3	1	1	3	3	3	1
232.5	1		21		2		3	11	8	1	1
240.5	1		22		1		3	15	2	5	2
248.5			19	1	3		2	13	1		
256.5	3		14	1			1	15	4	4	4
264.5	1		10	2		2	3	13	2	2	7

Appendix Table 12 (continued). Pollen counts from Horseshoe Lake, Alexander County, Illinois (HORX13) composite sediment core.

Depth (cm)	Planera aquatica	Plantago	Platanus	Poaceae	Polygonum	Populus	Quercus	Rosaceae	Salix	Taxodium	Thuja/Juniperus	Tilia
0.5		1	8	14		6	83		9	18	1	
8.5		1	6	30	2	8	91		16	28	5	
16.5	1	1	3	36	2	8	67		18	36	4	
24.5			9	51	11	9	91		5	13	6	1
32.5			9	33	1	9	125		2	5		
40.5			5	51	1		144			3	1	
48.5			7	82	3	4	129			1	8	
56.5	1		3	73	4	3	136		1			
64.5	4		9	47	2	8	123		1	2	6	1
72.5			7	64	1	1	137			1	4	
80.5	3		3	69	1		128		1	1	7	
88.5	4		5	13		2	143		1	2	5	1
96.5	11		5	11	2	1	136		8	1	7	
104.5	2		5	30	1	2	146		3	1	1	
112.5	2		3	11		1	166		3	1	1	
120.5			2	55	1		154		8	1	3	1
128.5	2		4	45	1	2	144		2		1	
136.5	4		7	50	2		136		3	3	2	
144.5	4		4	34	2		140		2		3	
168.5			2	24	1	3	115		3	2		
176.5			2	13		2	98		9			1
184.5			2	9		1	108	1	2		2	
192.5			3	9		3	103	1	10		3	

200.5		2	18	1	3	104		3	3	2	1
208.5		7	30		1	119	1	3	1	1	
216.5		5	53			123		1		1	
224.5	1	9	9	1	3	141				2	
232.5	1	13	14	2	2	87	1	3			
240.5		21	15	1	1	91		9		3	
248.5		25	4	1	3	93	1	10		1	
256.5		33	8	1	2	100		15	1	2	
264.5		22	1		2	96		19		2	

Appendix Table 12 (continued). Pollen counts from Horseshoe Lake, Alexander County, Illinois (HORX13) composite sediment core.

Depth (cm)	Ulmus	Viticeae	Zea mays	Spike count	Spike total
0.5	24	3		132	50000
8.5	15	1	1	113	50000
16.5	17			116	50000
24.5	22			150	50000
32.5	27			232	50000
40.5	16			83	50000
48.5	7			52	50000
56.5	9			72	50000
64.5	12			56	50000
72.5	17			50	50000
80.5	13			73	50000
88.5	13	1		116	50000
96.5	10	1		67	50000
104.5	10	1		148	50000
112.5	9	2		79	50000
120.5	8	1		56	50000
128.5	5			62	50000
136.5	3			102	50000
144.5	10			98	50000
168.5	10			64	50000
176.5	15	1		173	50000
184.5	14	1		58	50000
192.5	11			39	50000
200.5	20	1		62	50000
208.5	20			61	50000
216.5	11			64	50000
224.5	39			79	50000
232.5	47			76	50000

240.5	33		163	50000
248.5	32		187	50000
256.5	21	1	257	50000
264.5	17		905	50000

Appendix Table 13. Loss-on-ignition and charcoal counts for Horseshoe Lake, Alexander County, Illinois (HORX13) composite sediment core. Data will be submitted to Neotoma and the Global Charcoal Database upon publication.

Depth (cm)	Organic content (%)	Carbonate content (%)	Mineral content (%)	Total charcoal count	Cellular charcoal count
0.5	17.17713028	3.445172901	79.37769682	26	12
1.5	16.4289836	3.876504241	79.69451216	22	14
2.5	17.5523173	3.80952381	78.63815889	32	13
3.5	17.16154446	3.813198152	79.02525738	38	5
4.5	19.03634136	4.064958644	76.89869999	42	2
5.5	19.52273109	4.455677732	76.02159118	54	11
6.5	22.22569309	4.347826087	73.42648082	24	
7.5	19.98554254	4.983120156	75.03133731	18	
8.5	19.57870673	4.187817259	76.23347601	34	
9.5	19.7291618	4.159394997	76.1114432	45	2
10.5	18.57609789	4.111986002	77.31191611	32	
11.5	19.15299894	4.065795023	76.78120603	61	3
12.5	18.4180313	4.103399748	77.47856895	28	
13.5	17.83297574	3.766194637	78.40082962	43	2
14.5	19.07497637	3.873112868	77.05191077	34	3
15.5	18.35760518	3.978792984	77.66360184	35	
16.5	18.11409884	4.109163523	77.77673764	21	
17.5	17.57534148	3.955248091	78.46941043	25	4
18.5	20.56437634	4.084838963	75.35078469	46	
19.5	20.2787479	4.177990508	75.54326159	14	
20.5	24.62406773	4.663849815	70.71208246	29	
21.5	28.90557537	4.731727926	66.3626967	52	6
22.5	36.71389162	5.482083487	57.8040249	22	5
23.5	50.69083609	6.226799186	43.08236473	11	
24.5	47.38013127	6.458773784	46.16109494	27	
25.5	39.97856377	6.479591837	53.54184439	18	
26.5	37.79231558	5.878198085	56.32948634	13	8
27.5	36.28848224	5.953909576	57.75760818	42	2
28.5	42.96253074	4.932407746	52.10506152	4	
29.5	45.8546169	6.875907112	47.26947599	2	
30.5	39.9476484	6.467941507	53.58441009	3	
31.5	40.87417092	6.262609959	52.86321912	5	

32.5	47.01979725	7.303145662	45.67705709	1	
33.5	45.39969834	6.319060773	48.28124089	2	
34.5	47.50049106	6.678514638	45.8209943	2	
35.5	50.419976	6.868733433	42.71129057	2	
36.5	52.18047635	7.143692272	40.67583138	1	
37.5	48.85505709	6.929364402	44.21557851	0	
38.5	51.97192721	6.983059615	41.04501318	4	
39.5	48.26817777	7.236923077	44.49489916	3	
40.5	46.64638427	3.84244232	49.51117341	2	
41.5	42.15933413	3.675684565	54.16498131	11	9
42.5	39.16368658	3.724828309	57.11148511	6	17
43.5	37.73094571	4.003912618	58.26514167	9	
44.5	33.22557703	3.800348567	62.9740744	8	
45.5	35.27303183	4.259613892	60.46735428	6	
46.5	34.30678686	3.986164663	61.70704848	6	
47.5	32.7188787	4.067729674	63.21339162	4	
48.5	28.79529285	3.866098908	67.33860825	12	
49.5	28.19454586	3.974710408	67.83074373	17	6
50.5	29.13050053	4.152263901	66.71723557	3	
51.5	29.01270473	4.17888563	66.80840964	13	15
52.5	30.81999875	4.15804158	65.02195966	7	
53.5	30.81273781	4.558065795	64.6291964	13	
54.5	32.71528636	4.791794244	62.49291939	12	
55.5	32.09083119	4.765833536	63.14333527	16	
56.5	31.92503639	4.869834821	63.20512879	7	
57.5	30.79379991	4.69209538	64.51410471	16	
58.5	30.94445866	4.785952557	64.26958878	15	7
59.5	34.21727688	5.241567912	60.54115521	8	13
60.5	32.01581028	4.603507434	63.38068229	14	
61.5	32.6964606	5.470959321	61.83258008	13	8
62.5	32.49592059	4.502190663	63.00188875	10	10
63.5	32.63343109	4.549016194	62.81755272	7	14
64.5	28.77555901	4.75111223	66.47332876	6	
65.5	28.61510519	4.67305572	66.71183909	6	
66.5	29.99633297	4.662126768	65.34154027	10	
67.5	30.23375377	4.917710636	64.84853559	13	8
68.5	28.3896231	4.568238779	67.04213812	11	
69.5	28.2661446	4.708821834	67.02503357	8	
70.5	28.29656164	4.651426841	67.05201152	11	9
71.5	29.56765831	4.993552925	65.43878877	20	10
72.5	29.82679323	4.999302747	65.17390402	14	
73.5	29.62510519	5.014658232	65.36023658	15	7

74.5	28.47450891	4.949001865	66.57648922	8	
75.5	29.28752464	5.185185185	65.52729017	17	6
76.5	29.57829723	5.413344524	65.00835825	5	
77.5	32.33868989	5.520554775	62.14075533	15	7
78.5	28.44323629	5.510395817	66.04636789	16	
79.5	28.52103121	5.429005315	66.04996348	15	
80.5	30.04397592	3.727151137	66.22887294	21	10
81.5	26.61406026	3.6285435	69.75739624	10	
82.5	26.07654844	3.781731557	70.14172	18	11
83.5	26.76237624	4.150331215	69.08729255	19	11
84.5	27.74214448	4.070653636	68.18720189	13	8
85.5	30.38560897	4.380685161	65.23370587	20	5
86.5	29.90597308	4.444122756	65.64990417	22	
87.5	31.80713009	4.377335796	63.81553411	19	11
88.5	34.22599608	4.728015006	61.04598891	18	22
89.5	33.25369089	4.733664583	62.01264452	17	6
90.5	35.81987173	4.905680543	59.27444773	42	5
91.5	36.24213836	5.131818449	58.62604319	20	
92.5	34.58047377	5.025380711	60.39414552	17	
93.5	28.54984455	4.721239478	66.72891597	21	10
94.5	28.09002143	4.553734062	67.3562445	47	6
95.5	29.65595928	4.104803493	66.23923723	30	10
96.5	29.59186698	4.184382235	66.22375079	37	11
97.5	27.80161572	4.127387491	68.07099679	43	7
98.5	29.02463842	4.695100097	66.28026148	31	13
99.5	28.90408728	4.699954191	66.39595853	32	13
100.5	28.34378503	4.66748404	66.98873093	42	5
101.5	28.20200691	4.664803189	67.1331899	37	5
102.5	29.20500265	4.674214723	66.12078263	15	7
103.5	31.70471191	4.758925779	63.53636231	13	
104.5	34.25121583	5.320614192	60.42816998	14	
105.5	37.69861711	5.603256376	56.69812651	6	
106.5	34.35850655	5.499305142	60.14218831	9	
107.5	42.31844082	6.078147612	51.60341156	13	
108.5	47.81523096	6.953748006	45.23102103	5	
109.5	46.21805633	6.529090436	47.25285323	5	20
110.5	42.54131695	6.385061366	51.07362168	10	10
111.5	41.28219308	6.101580895	52.61622603	38	13
112.5	39.83242502	5.970793025	54.19678196	8	
113.5	40.61594079	6.070526074	53.31353313	17	
114.5	42.48801759	6.22846043	51.28352198	6	
115.5	40.33594953	6.03639046	53.62766001	13	8

116.5	41.25208555	6.493255018	52.25465944	32	
117.5	38.50379816	6.253446564	55.24275528	27	
118.5	32.77978111	6.070302574	61.14991632	26	4
119.5	31.40886927	5.682917596	62.90821314	35	9
120.5	32.96261971	3.686635945	63.35074435	23	9
121.5	29.58636127	3.714509667	66.69912907	18	6
122.5	30.97103918	3.858924886	65.17003593	21	10
123.5	28.48881682	3.876433339	67.63474984	25	4
124.5	30.65514423	3.974402156	65.37045362	42	7
125.5	29.78736221	3.989361702	66.22327609	36	8
126.5	30.24318644	3.978767156	65.7780464	29	7
127.5	33.55354178	4.226745094	62.21971312	34	3
128.5	35.80418583	4.371008053	59.82480612	35	6
129.5	31.69671658	4.160866972	64.14241645	35	
130.5	31.98282896	4.339662007	63.67750903	60	10
131.5	33.01755761	4.487452148	62.49499025	44	
132.5	33.97974494	4.68723368	61.33302138	50	4
133.5	33.31975711	4.19234827	62.48789462	48	10
134.5	33.04543609	4.062844542	62.89171937	45	4
135.5	32.17200028	4.37807302	63.4499267	36	
136.5	30.70887913	4.429369513	64.86175135	45	4
137.5	30.17201147	4.625960758	65.20202777	25	
138.5	30.96595484	4.628376802	64.40566836	33	3
139.5	33.50025587	4.985433958	61.51431018	27	4
140.5	30.10422006	4.673673918	65.22210602	19	5
141.5	29.13898212	4.67858869	66.18242919	35	11
142.5	21.14117319	3.954685891	74.90414091	34	12
143.5	17.78074866	3.821138211	78.39811313	25	4
144.5	20.53592233	4.147525494	75.31655218	24	
145.5	13.41996663	3.878060159	82.70197321	21	10
146.5	11.06091588	3.666078526	85.2730056	1	
147.5	11.28682944	3.718144616	84.99502595	2	
148.5	12.25407714	3.958771251	83.78715161	1	
149.5	12.89729958	3.988726295	83.11397412	0	
150.5	14.71025813	4.09707383	81.19266804	7	
151.5	12.8635882	3.855884833	83.28052697	16	
152.5	16.46542261	3.702025466	79.83255192	4	
153.5	18.1360849	3.761101642	78.10281346	2	
154.5	15.99481839	3.918027798	80.08715381	0	
155.5	14.29665281	4.103382259	81.59996493	0	
156.5	12.49792861	4.054617074	83.44745431	0	
157.5	12.33258929	4.156941792	83.51046892	4	

158.5	10.5575962	4.785321489	84.65708231	2	
159.5	9.196423007	5.00814961	85.79542738	0	
160.5	9.792786907	3.03058439	87.1766287	0	
161.5	10.92253295	2.576501155	86.5009659	7	
162.5	10.85283773	2.671526415	86.47563585	3	
163.5	10.2969641	2.735119163	86.96791674	1	
164.5	10.52677865	2.604678592	86.86854276	3	
165.5	11.00604751	2.613081755	86.38087074	2	
166.5	15.39348818	2.648158476	81.95835335	1	
167.5	17.84514285	2.887744035	79.26711312	1	
168.5	19.75329377	2.909234669	77.33747156	1	
169.5	22.72156392	3.125588845	74.15284724	0	
170.5	16.8853656	2.858863984	80.25577042	4	
171.5	14.15948322	4.942994488	80.89752229	70	
172.5	11.57113492	9.806220686	78.62264439	74	
173.5	13.17300401	4.608858391	82.2181376	66	
174.5	12.99559471	3.719571568	83.28483372	37	
175.5	12.15192778	4.628379849	83.21969237	57	
176.5	12.92557585	7.069083628	80.00534053	30	
177.5	15.15046995	6.709857724	78.13967233	22	
178.5	13.5620787	7.440321008	78.9976003	24	
179.5	14.47994698	7.481858958	78.03819406	46	
180.5	14.81450056	6.755646306	78.42985313	47	
181.5	13.48026064	6.350507243	80.16923212	21	
182.5	9.050532001	11.8419405	79.10752749	52	
183.5	9.978343615	10.9732094	79.04844698	22	
184.5	8.588868941	11.73894257	79.67218849	45	
185.5	8.392099249	11.68766371	79.92023704	17	
186.5	8.129174064	12.46480299	79.40602295	12	
187.5	8.115413424	11.32021974	80.56436684	17	
188.5	8.533154294	11.51560698	79.95123873	25	
189.5	8.636612286	10.29479097	81.06859674	12	
190.5	9.369309102	10.43016485	80.20052605	13	
191.5	8.139315433	10.50596739	81.35471718	42	
192.5	8.590089451	11.13505747	80.27485308	56	
193.5	10.1344787	10.53390232	79.33161897	52	
194.5	11.17706748	10.31396965	78.50896287	50	
195.5	9.852820932	10.49985211	79.64732695	55	
196.5	11.92401587	11.64789952	76.42808461	37	
197.5	12.47327726	10.13741782	77.38930492	64	
198.5	11.3412835	10.77214634	77.88657016	56	2
199.5	12.91313581	10.87172688	76.21513731	73	

200.5	10.6600478	11.22612776	78.11382444	86	
201.5	9.519895059	11.95971546	78.52038948	56	
202.5	9.720590041	12.64012745	77.63928251	69	
203.5	9.235420853	16.37676534	74.38781381	58	
204.5	9.871671699	18.05497392	72.07335438	53	2
205.5	10.76080989	18.25537389	70.98381622	67	
206.5	8.890035108	18.70229008	72.40767482	85	1
207.5	8.912035011	18.79924665	72.28871834	36	
208.5	9.273539633	18.06806989	72.65839047	26	
209.5	10.02385653	16.57142857	73.4047149	31	
210.5	10.94456175	17.86421084	71.19122742	45	
211.5	10.82869135	19.18493762	69.98637103	52	
212.5	9.674560733	17.61223316	72.71320611	38	
213.5	12.18606154	13.94840905	73.86552941	49	
214.5	10.39377143	16.3710802	73.23514837	73	
215.5	12.01437674	20.09803922	67.88758405	122	2
216.5	11.13907446	18.85373934	70.0071862	63	3
217.5	22.48855809	21.77556437	55.73587754	68	3
218.5	24.18575092	21.52201898	54.29223009	99	
219.5	25.57977506	20.87401364	53.5462113	82	
220.5	23.8990176	26.45633936	49.64464304	95	
221.5	22.98087382	24.95954335	52.05958282	97	2
222.5	19.45403262	16.13037516	64.41559222	53	2
223.5	25.3877551	18.94105165	55.67119324	67	1
224.5	23.16770828	20.78249471	56.04979701	81	1
225.5	16.11297201	26.16190268	57.7251253	9	
226.5	14.90237894	25.8231075	59.27451356	11	
227.5	15.86178682	24.0751246	60.06308858	35	
228.5	16.55500917	22.96872754	60.47626329	80	4
229.5	16.39019964	23.04369533	60.56610504	33	
230.5	17.93032584	22.85652373	59.21315043	27	4
231.5	19.5285267	23.15900247	57.31247083	52	
232.5	19.49240772	23.85321101	56.65438127	35	3
233.5	20.54677573	22.72170719	56.73151708	40	
234.5	21.27594959	21.68857292	57.03547749	35	
235.5	19.75684507	22.07158214	58.17157278	80	4
236.5	15.80672348	23.85941497	60.33386155	79	
237.5	10.23360858	18.46843305	71.29795836	28	
238.5	11.13307173	16.56358058	72.30334769	23	4
239.5	13.20123557	16.24218968	70.55657475	41	
240.5	11.89276297	14.8265771	73.28065993	30	3
241.5	11.12934335	15.09183376	73.77882289	38	

242.5	9.36959487	14.8549263	75.77547883	24	
243.5	9.513332747	12.52350386	77.9631634	20	
244.5	9.878344835	13.42181328	76.69984188	17	
245.5	10.27189434	14.75483208	74.97327358	30	
246.5	10.547365	14.52799683	74.92463816	27	
247.5	10.2494485	14.17349903	75.57705247	24	4
248.5	10.25957453	11.29654806	78.44387741	15	
249.5	10.48243545	14.29833954	75.21922501	16	
250.5	10.05324101	14.29819029	75.6485687	24	4
251.5	10.14961312	14.56316526	75.28722162	22	
252.5	9.038129186	11.79456731	79.1673035	27	4
253.5	10.15198529	12.77640099	77.07161372	18	6
254.5	9.717431193	14.5988131	75.6837557	20	
255.5	10.0130833	11.76860198	78.21831472	17	
256.5	7.983881735	8.749159115	83.26695915	8	
257.5	7.864317744	8.359657909	83.77602435	19	
258.5	9.366058462	12.47560879	78.15833275	25	
259.5	8.15583733	9.768519843	82.07564283	10	
260.5	7.765220561	8.063241107	84.17153833	9	
261.5	8.185932897	7.793671163	84.02039594	21	10
262.5	10.77739086	12.04307681	77.17953233	11	
263.5	8.702938219	7.81479442	83.48226736	12	
264.5	6.905805766	6.206473342	86.88772089	19	
265.5	6.505133287	5.28917155	88.20569516	3	
266.5	6.992908961	4.573258808	88.43383223	15	
267.5	6.256880082	4.520373246	89.22274667	8	
268.5	7.148466448	5.057892981	87.79364057	10	
269.5	6.45388876	6.500669766	87.04544147	24	
270.5	5.895217677	9.770003091	84.33477923	5	
271.5	5.620611715	6.285270251	88.09411803	10	
272.5	7.213165778	5.260877465	87.52595676	4	
273.5	5.460429258	4.593870812	89.94569993	8	
274.5	6.331573545	4.982582489	88.68584397	2	
275.5	5.112135063	4.371403168	90.51646177	6	
276.5	6.958946553	4.661049874	88.38000357	3	
277.5	6.937577827	5.04358655	88.01883562	2	
278.5	5.949721276	4.735931734	89.31434699	3	
279.5	5.781425212	4.602664701	89.61591009	1	
280.5	5.907943172	4.60624872	89.48580811	2	

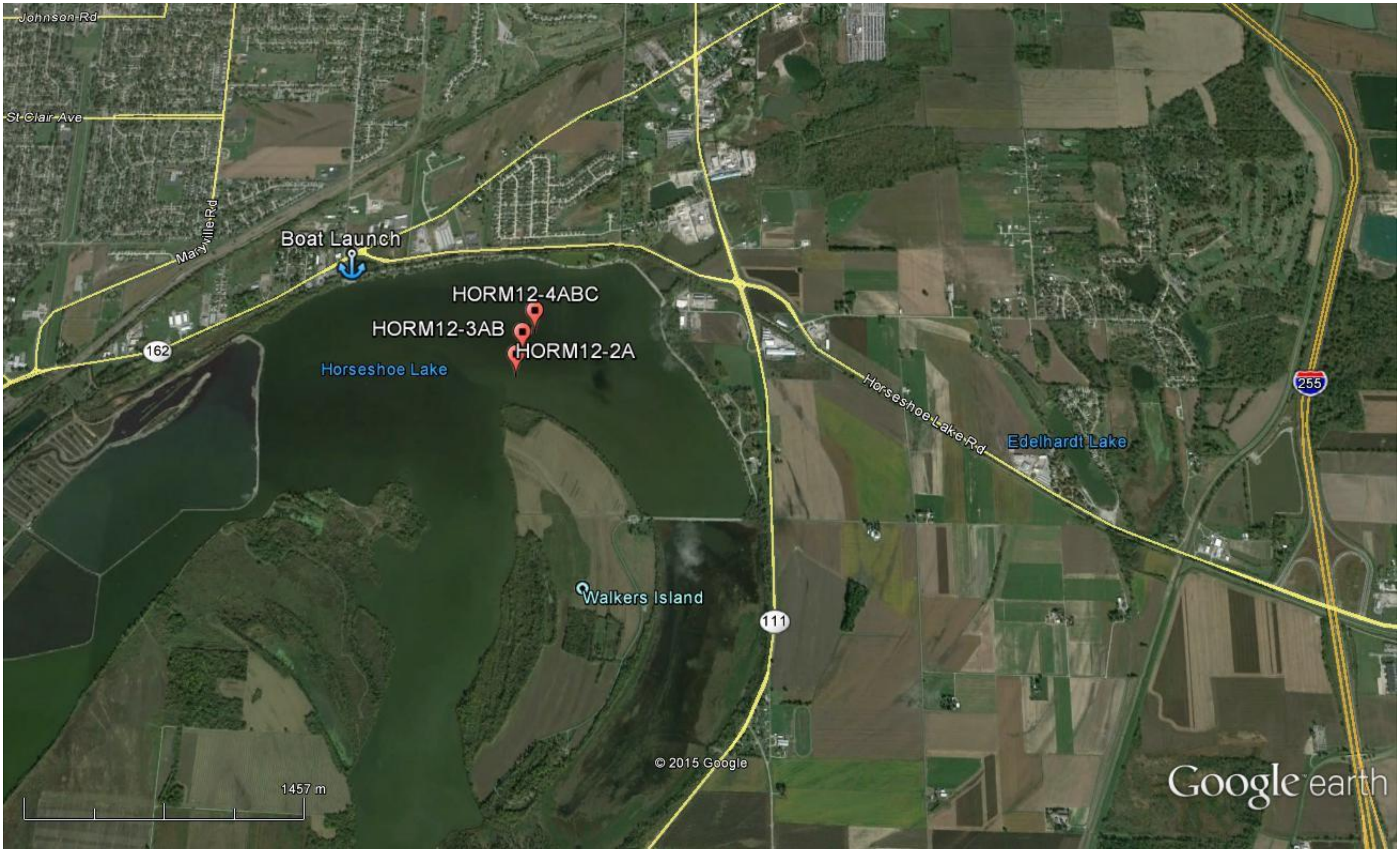
Appendix Table 14. Organic stable carbon isotope ratios from Grassy Lake, Union County, Illinois (GRAS11/13) composite sediment core.

Depth (cm)	$\delta^{13}C_{org}$ (‰)	Depth (cm)	$\delta^{13}C_{org}$ (‰)	Depth (cm)	$\delta^{13}C_{org}$ (‰)	Depth (cm)	$\delta^{13}C_{org}$ (‰)	Depth (cm)	$\delta^{13}C_{org}$ (‰)
0.5	-24.3	58.5	-27.1	116.5	-27.0	174.5	-25.8	232.5	-24.4
2.5	-25.2	60.5	-25.5	118.5	-27.6	176.5	-26.6	234.5	-24.6
4.5	-25.4	62.5	-27.3	120.5	-27.0	178.5	-26.3	236.5	-25.7
6.5	-26.8	64.5	-26.2	122.5	-27.0	180.5	-25.6	238.5	-24.9
8.5	-25.7	66.5	-26.2	124.5	-27.3	182.5	-26.1	240.5	-24.1
10.5	-25.8	68.5	-26.3	126.5	-26.8	184.5	-24.9	242.5	-24.3
12.5	-25.8	70.5	-27.2	128.5	-27.0	186.5	-24.4	244.5	-24.0
14.5	-26.1	72.5	-27.3	130.5	-27.2	188.5	-24.9	246.5	-24.0
16.5	-25.9	74.5	-25.8	132.5	-27.2	190.5	-24.5	248.5	-23.9
18.5	-25.6	76.5	-25.7	134.5	-27.3	192.5	-25.0	250.5	-24.6
20.5	-26.1	78.5	-26.0	136.5	-27.1	194.5	-25.6	252.5	-23.9
22.5	-26.1	80.5	-26.4	138.5	-26.8	196.5	-25.9	254.5	-24.6
24.5	-27.7	82.5	-26.4	140.5	-26.5	198.5	-25.9	256.5	-23.9
26.5	-27.3	84.5	-27.0	142.5	-26.6	200.5	-24.6	258.5	-24.1
28.5	-27.0	86.5	-26.9	144.5	-27.1	202.5	-25.1	260.5	-24.2
30.5	-26.9	88.5	-26.7	146.5	-26.7	204.5	-24.1	262.5	-23.9
32.5	-26.7	90.5	-26.8	148.5	-26.6	206.5	-23.1	264.5	-23.9
34.5	-26.7	92.5	-27.1	150.5	-26.3	208.5	-22.4	266.5	-24.0
36.5	-26.8	94.5	-27.3	152.5	-26.5	210.5	-22.7	268.5	-24.2
38.5	-26.6	96.5	-27.0	154.5	-27.4	212.5	-22.5	270.5	-24.9
40.5	-27.1	98.5	-26.9	156.5	-27.0	214.5	-22.8	272.5	-25.4
42.5	-26.3	100.5	-26.8	158.5	-26.2	216.5	-23.3	274.5	-24.1
44.5	-26.1	102.5	-27.0	160.5	-24.6	218.5	-24.2	276.5	-24.1
46.5	-26.3	104.5	-27.2	162.5	-25.8	220.5	-24.4	278.5	-24.5
48.5	-26.3	106.5	-27.4	164.5	-26.2	222.5	-23.7	280.5	-24.4
50.5	-27.2	108.5	-27.3	166.5	-25.9	224.5	-24.3		
52.5	-26.2	110.5	-27.3	168.5	-26.8	226.5	-23.4		
54.5	-25.9	112.5	-27.2	170.5	-26.1	228.5	-23.3		
56.5	-27.0	114.5	-27.1	172.5	-25.9	230.5	-23.8		

Appendix Table 15. Sediment core metadata from Horseshoe (HORM12), Grassy (GRAS11/13), and Horseshoe (HORX13) lakes.

Site Name	Date	Water Depth (m)	State	County	Latitude	Longitude	Core Section ID	Core Length (cm)	Depth of Core Top (m)	Depth of Core Bottom (m)
HORM12	5/22/12	0.62	Illinois	Madison	38.702386	-90.082356	2A-1L	91.5	0	0.915
HORM12	5/22/12	0.62	Illinois	Madison	38.702386	-90.082356	2A-2L	100	0.79	1.75
HORM12	5/23/12	1.15	Illinois	Madison	38.703597	-90.082011	3A-1L	97	0.11	1.17
HORM12	5/23/12	1.15	Illinois	Madison	38.703597	-90.082011	3A-2L	93.5	1.1	2.1
HORM12	5/23/12	1.15	Illinois	Madison	38.703597	-90.082011	3A-3L	82	2.1	3.07
HORM12	5/23/12	1.15	Illinois	Madison	38.703597	-90.082011	3A-4L	38.5	3	3.5
HORM12	5/23/12	1.095	Illinois	Madison	38.703597	-90.082011	3B-1L	95	0.55	1.55
HORM12	5/23/12	1.095	Illinois	Madison	38.703597	-90.082011	3B-2L	95	1.55	2.55
HORM12	5/23/12	1.095	Illinois	Madison	38.703597	-90.082011	3B-3L	59	2.55	3.33
HORM12	5/23/12	1.09	Illinois	Madison	38.704775	-90.08125	4A-1L	98	0	1
HORM12	5/23/12	1.09	Illinois	Madison	38.704775	-90.08125	4A-2L	95	1	2
HORM12	5/23/12	1.09	Illinois	Madison	38.704775	-90.08125	4A-3L	94	2	3
HORM12	5/23/12	1.09	Illinois	Madison	38.704775	-90.08125	4A-4L	79	3	4.01
HORM12	5/23/12	1.09	Illinois	Madison	38.704775	-90.08125	4A-5L	87	4	5
HORM12	5/24/12	1.09	Illinois	Madison	38.704775	-90.08125	4A-6L	77.5	5	5.63
HORM12	5/24/12	1.11	Illinois	Madison	38.704775	-90.08125	4B-1L	92	0.5	1.5
HORM12	5/24/12	1.11	Illinois	Madison	38.704775	-90.08125	4B-2L	98	1.5	2.49
HORM12	5/24/12	1.11	Illinois	Madison	38.704775	-90.08125	4B-3L	82	2.5	3.49
HORM12	5/24/12	1.11	Illinois	Madison	38.704775	-90.08125	4B-4L	96	3.5	4.5
HORM12	5/24/12	1.11	Illinois	Madison	38.704775	-90.08125	4B-5L	80	4.5	5.51
HORM12	5/25/12	1.08	Illinois	Madison	38.704775	-90.08125	4C-1S	96	-0.2	0.94
GRAS11	5/22/11	1.07	Illinois	Union	37.431632	-89.376857	1A-1L	74	2.51	3.51
GRAS11	5/22/11	1.07	Illinois	Union	37.431632	-89.376857	1A-2L	60	3.51	4.51
GRAS11	5/22/11	1.07	Illinois	Union	37.431632	-89.376857	1B-1L	45	3.01	4.01
GRAS11	5/22/11	1.07	Illinois	Union	37.431632	-89.376857	1B-2L	28.5	4.01	5.01
GRAS11	5/22/11	1.07	Illinois	Union	37.430267	-89.379256	2A-1L	75	2.4	3.4
GRAS11	5/22/11	1.07	Illinois	Union	37.430267	-89.379256	2A-2L	17	3.4	4.4
GRAS13	6/20/13	1.07	Illinois	Union	37.430762	-89.378891	1A-1L	79	0	79
GRAS13	6/20/13	1.07	Illinois	Union	37.430762	-89.378891	1A-2L	32	100	132
GRAS13	6/20/13	1.07	Illinois	Union	37.429969	-89.379639	2A-1L	93	0	93
GRAS13	6/20/13	1.07	Illinois	Union	37.429969	-89.379639	2A-2L	93	100	193
GRAS13	6/20/13	1.07	Illinois	Union	37.429969	-89.379639	2A-3L	21	197	218
GRAS13	6/20/13	1.07	Illinois	Union	37.429969	-89.379639	2B-1L	85	50	135
GRAS13	6/20/13	1.07	Illinois	Union	37.429969	-89.379639	2C-1L	73	50	123
GRAS13	6/20/13	1.07	Illinois	Union	37.429969	-89.379639	2D-1B	65	0	65
HORX13	6/18/13	1.43	Illinois	Alexander	37.14805	-89.32875	1A-1B	112	0	112
HORX13	6/18/13	1.43	Illinois	Alexander	37.14805	-89.32875	1B-1L	100	0	100
HORX13	6/18/13	1.43	Illinois	Alexander	37.14805	-89.32875	1B-2L	101	100	201

HORX13	6/18/13	1.43	Illinois	Alexander	37.14805	-89.32875	1C-1L	94	50	144
HORX13	6/18/13	1.43	Illinois	Alexander	37.14805	-89.32875	1C-2L	43	150	200
HORX13	6/19/13	1.43	Illinois	Alexander	37.146683	-89.32795	2A-1L	98	0	98
HORX13	6/19/13	1.43	Illinois	Alexander	37.146683	-89.32795	2A-2L	100	100	200
HORX13	6/19/13	1.43	Illinois	Alexander	37.146683	-89.32795	2A-3L	80	202	282
HORX13	6/19/13	1.43	Illinois	Alexander	37.146683	-89.32795	2B-1L	85	32	117
HORX13	6/19/13	1.43	Illinois	Alexander	37.146683	-89.32795	2B-2L	97	132	229
HORX13	6/19/13	1.43	Illinois	Alexander	37.146683	-89.32795	2C-1L	95.5	50	145.5
HORX13	6/19/13	1.43	Illinois	Alexander	37.146683	-89.32795	2C-2L	55	149	204



Appendix Figure 1. Core locations at Horseshoe Lake, Madison County, Illinois (HORM12).

Appendix Figure 2. Core locations at Grassy Lake, Union County, Illinois (GRAS11/13).

Appendix Figure 3. Core locations at Horseshoe Lake, Alexander County, Illinois (HORX13).