Vertebrate Species Response to Little Ice Age Climate Change In Ohio River Valley

Nichelle Flashette Lyle & Kenneth Barnett Tankersley

Introduction

This study examines vertebrate and invertebrate taxa identified from chronometrically dated archaeological contexts in the Ohio River valley to examine animal species response to changes in climate during the Holocene. The Ohio River valley includes the tributary streams of the Scioto, Little Miami, Licking, Great Miami, and Kentucky rivers. For almost 300 years, faunal remains have been collected from archaeological sites in this region (Willey and Sabloff, 1980).

In order to examine species response to climate changes during the Holocene, we obtained data on the location, age, and taxa of vertebrate and invertebrate remains from archaeological sites. While there are many thousands of sites documented in this region, the quality of data vary greatly, from the types of data reported to the ways they are reported. Although synchronic cultural summaries have written for the region, there has been no attempt to examine faunal data diachronically in terms of species response to Holocene climate change.

Following the standard set by Graham and Lundelius (1994), archaeological site criteria for this study includes: (1) a known geographic location; (2) chronological controls including radiocarbon dates, stratigraphy, and known cultural affiliation; (3) species level animal taxa; (4) data that can be found in published peer-reviewed scientific literature, theses, or accessible cultural resource management reports; and, (5) faunal remains that are curated in public institutions. Using these parameters, we filtered the data into standardized taxonomic classifications and established temporal periods, eliminated mixed assemblages, and calibrated radiocarbon dates.

Because this study focuses on species response to Holocene climate change, the data have been specifically collected from sites with precise temporal control. For this reason, many sites were excluded. Chronometric dating is one of the most important aspects of any archaeological investigation. In order to accurately interpret species response to climate change, it is crucial to document faunal taxa within a temporal framework. The most precise and trustworthy chronologies in the Ohio River valley are those developed from calibrated radiocarbon dates, using samples of known composition from well-documented archaeological, geological, and environmental contexts.

Between ~CE 1400 and 1850 the Ohio River valley experienced a significant cooling and drying event known as the Little Ice Age. The peak of this cold dry climate occurred ~CE 1500 and 1600. Although the decline in global mean annual temperatures was only 0.5°C, winters in the Ohio River valley were harsh winters, the growing seasons shorter, and the climate overall dryer, which resulted in a significant lowering of the water table. Well-dated Protohistoric Fort Ancient sites with well-preserved faunal remains in the Ohio River valley that date to the Little Ice Age include: Augusta, Bracken County, Kentucky; Big Bone Lick, Boone County, Kentucky; the Lower Shawnee Town Complex, Greenup and Lewis counties, Kentucky; Madisonville site, Hamilton County, Ohio; Snag Creek, Bracken County, Kentucky; and Wynema, Hamilton County, Ohio.

Sites:		Archaic	Woodland	Fort Ancient	Proto-Historic
Taxa	Type				
Accipiter cooperii	Bird	0	0	1	0
Actinonair ligamentina	Invertebrate	1	0	1	1
Aix sponsa	Bird	1	0	0	0
Amblema plicata	Invertebrate	1	1	1	1
Ambystoma sp.	Amphibian	1	0	0	0
Anas carolinensis	Bird	0	0	0	1
Anas discors	Bird	1	1	0	0
Anas platyrhynchos	Bird	0	1	1	0
Anas sp.	Bird	1	0	0	1
Anguispira picta	Invertebrate	1	0	1	0
Anguispira alternata	Invertebrate	0	0	0	1
Anguispira kochi	Invertebrate	1	0	1	0
Anodonta sp.	Invertebrate	0	1	1	0
Anser caerulescens	Bird	0	1	1	0
Aplodinotus grunniens	Fish	1	1	1	1
Ardea herodias	Bird	0	0	1	1
Asio flammeus	Bird	0	0	1	0
Bison bison	Mammal	0	0	0	1
Blarina brevicauda	Mammal	1	1	1	0
Branta canadensis	Bird	1	1	1	1
Bubo virginianus	Bird	1	0	1	1
Bufo americanus	Amphibian	1	0	0	0
Bufo sp.	Amphibian	1	0	0	0
Buteo jamaicensis	Bird	0	0	1	1
Buteo sp.	Bird	1	0	0	0
Campostoma anomalum	Fish	1	0	0	0
Canis familiaris	Mammal	1	1	1	1
Canis latrans	Mammal	0	0	0	1
Canis lupis	Mammal	1	1	0	1
Canis sp.	Mammal	1	1	0	0
Cardinalis cardinalis	Bird	0	0	1	0
Castor canadensis	Mammal	1	1	1	1
Catostomidae	Fish	1	0	1	1
Catostomus sp.	Fish	0	1	0	0
Catostomidae	Fish	0	0	0	1
Centrarchidae	Fish	1	0	0	0
Cervus canadensis	Mammal	1	1	1	1
Chelydra serpentina	Reptile	1	1	1	1
Chrysemys picta	Reptile	0	1	0	0
Chrysemys sp.	Reptile	1	0	0	1
Colinus virginianus	Bird	1	1	0	0
Colubridae	Reptile	1	1	1	1
Corvus brachynchnchos	Bird	1	1	1	1
Corvus corax	Bird	0	0	1	1
Crotalidae	Reptile	1	1	1	1
Crotalus horridus	Reptile	1	0	0	0
Crotalus sp.	Reptile	0	0	0	1
Cryptobranchus sp.	Amphibian	1	0	1	0
Cryptotis parva	Mammal	1	0	0	0
Cycalnaias tuberculata	Invertebrate	0	1	1	1
Cyprinidae	Fish	0	0	1	1
Cyprogenia stegaria	Invertebrate	1	0	1	1
Didelfis virginiania	Mammal	1	1	1	1
Didelphis virginianus	Mammal	0	0	1	0
Dryocopus pilleatus	Bird	0	0	1	1
Dynamnia torulosa	Invertebrate	0	1	1	0
Estapistes migratorius	Bird	1	0	1	1
Elliptoria lineolata	Invertebrate	0	0	1	0
Elliptio crassidens	Invertebrate	0	1	1	1
Elliptio dilatata	Invertebrate	1	1	1	1
Epioblasma flexuosa	Invertebrate	0	0	1	1
Epioblasma sampsoni	Invertebrate	0	0	0	1
Epioblasma torulosa	Invertebrate	0	0	1	1
Erethizon dorsatum	Mammal	1	0	1	0
Esox sp.	Fish	0	0	0	1
Falco sparverius	Bird	0	0	1	0
Felis concolor	Mammal	0	1	1	1
Fusconaia ebena	Invertebrate	0	1	1	1
Fusconaia maculata	Invertebrate	0	0	0	1
Fusconaia sp.	Invertebrate	1	0	0	0
Fusconaia subrotunda	Invertebrate	0	1	1	0
Gastropoda	Invertebrate	1	0	0	1
Gavia immer	Bird	0	1	1	0
Glaucomys volans	Mammal	1	0	1	0
Gonidea sp.	Invertebrate	1	0	0	0
Graptemys sp.	Reptile	1	1	1	0
Grus canadensis	Bird	0	0	1	0
Haliaeetus leucocephalus	Bird	0	1	1	1
Hapiotrema concavum	Invertebrate	1	0	0	0
Hybopsis biguotata	Fish	0	1	0	0
Ictaluridae sp.	Fish	1	0	0	0
Ictalurus furcatus	Fish	0	0	1	0
Ictalurus punctatus	Fish	1	1	1	1
Ictalurus sp.	Fish	0	1	1	1
Ictiobus bubalus	Fish	1	0	1	0
Ictiobus sp.	Fish	0	0	0	1
Kinosternidae	Reptile	1	0	0	0
Lampsilis abrupta	Invertebrate	1	0	0	1
Lampsilis ovata	Invertebrate	1	1	1	1
Lampsilis sp.	Invertebrate	1	0	0	0
Lampsilis teres	Invertebrate	0	0	0	1
Lampsilis ventricosa	Invertebrate	0	1	1	0
Lasmigona complanta	Invertebrate	0	1	1	0
Lasmigona costata	Invertebrate	0	1	1	0
Lepisosteus osseus	Fish	0	1	0	0
Lepisosteus platostrams	Fish	0	0	1	0
Lepisosteus sp.	Fish	1	1	0	1
Leptoxis carinata	Invertebrate	0	1	0	0
Ligumia recta	Invertebrate	1	1	1	1
Ligumia ventricosa	Invertebrate	1	1	0	0
Lithasia obovata	Invertebrate	1	0	0	0
Lontra canadensis	Mammal	0	0	0	1
Lophodytes cucullatus	Bird	0	1	1	0
Lynx rufus	Mammal	1	1	1	1
Magnonas nervosa	Invertebrate	0	0	1	0
Marmota monax	Mammal	1	1	1	1
Martes americana	Mammal	0	1	0	1
Megalonaias giganteon	Invertebrate	1	0	0	0
Meleagris gallopavo	Bird	1	1	1	1
Mephitis mephitis	Mammal	1	1	1	1
Mergus sp.	Bird	1	0	0	0
Mesodon clausus	Invertebrate	0	0	1	0
Mesomphix sp.	Invertebrate	1	0	0	0
Micropterus dolomieu	Fish	0	0	1	1
Micropterus sp.	Fish	0	1	1	0
Microtus ochrogaster	Mammal	0	1	1	0
Microtus pennsylvanicus	Mammal	0	1	1	0
Microtus sp.	Mammal	1	0	1	1
Moxostoma carinatum	Fish	1	0	1	1
Moxostoma erythrurum	Fish	1	0	0	0
Moxostoma sp.	Fish	1	1	1	1
Mustela frenata	Mammal	1	0	0	0
Mustela vison	Mammal	1	0	0	1
Neotoma floridana	Mammal	1	0	0	0
Numenius americanus	Bird	0	1	0	0
Obliguaria reflexa	Invertebrate	1	0	1	1
Obovaria olivaria	Invertebrate	0	1	1	1
Obovaria retusa	Invertebrate	1	1	1	1
Obovaria subrotunda	Invertebrate	0	1	1	1
Odocoileus virginianus	Mammal	1	1	1	1
Olor buccinator	Bird	0	1	1	1
Ondontra zibethicus	Mammal	1	1	1	1
Oryzomys palustris	Mammal	1	0	1	1
Otis asio	Bird	0	0	1	0
Passeriformes	Bird	0	0	1	0
Perca flavescens	Fish	0	0	0	0
Perciformes sp.	Fish	1	0	0	0
Peromyscus leucopus	Mammal	1	0	0	0
Peromyscus sp.	Mammal	0	1	1	1
Plagiola lineolata	Invertebrate	0	0	0	1
Plethobasus cicatricosus	Invertebrate	0	0	0	1
Plethobasus cyphyus	Invertebrate	0	0	0	1
Pleurobema clava	Invertebrate	0	0	1	1
Pleurobema cordatum	Invertebrate	1	0	1	1
Pleurobema plenum	Invertebrate	1	0	0	0
Pleurobema rubrum	Invertebrate	1	0	1	0
Pleurobema sintoxia	Invertebrate	0	0	1	0
Pleurobema sp.	Invertebrate	1	0	0	0
Plyodictis olivaris	Fish	1	0	0	0
Podilymubs podiceps	Bird	0	0	1	0
Potamilius alatus	Invertebrate	0	0	1	1
Procyon locator	Mammal	1	1	1	1
Procyon lotor	Mammal	0	0	1	0
Proptera alata	Invertebrate	0	1	1	0
Prychobranchus fusciolaris	Invertebrate	0	0	1	0
Pseudemys scripta	Reptile	0	1	1	0
Ptychobranchus fasciolaris	Invertebrate	0	0	0	1
Quadrula cylindrical	Invertebrate	0	0	1	1
Quadrula metanerva	Invertebrate	1	0	1	1
Quadrula pustulosa	Invertebrate	1	0	0	1
Quadrula quadrula	Invertebrate	0	0	0	1
Rana catesbeiana	Amphibian	1	0	0	0
Rana pipiens	Amphibian	1	0	0	0
Rana sp.	Amphibian	1	1	1	1
Scalopus aquaticus	Mammal	1	1	1	1
Scaphirhynchus platyrynchos	Fish	0	1	1	0
Scaphirhynchus sp.	Fish	0	0	1	0
Sciurs carolinensis	Mammal	1	1	1	1
Sciurs niger	Mammal	1	0	1	1
Sciurus niger	Mammal	1	1	0	0
Sorex sp.	Mammal	1	0	0	0
Stenotrema hirsutum	Invertebrate	1	0	0	0
Sternotherus minor	Reptile	0	0	0	0
Sternotherus odoratus	Reptile	1	1	1	1
Sternotherus sp.	Reptile	1	0	0	0
Stizostedion canadense	Fish	0	0	1	0
Stizostedion sp.	Fish	1	0	0	0
Strigiformes sp.	Bird	0	0	0	0
Strigidae	Bird	1	0	0	0
Strix varia	Bird	1	1	1	0
Sylvlagus aquaticus	Mammal	1	0	0	0
Sylvlagus floridanus	Mammal	1	1	1	1
Symbos cavifrons	Mammal	0	0	0	1
Tamias striatus	Mammal	1	1	1	0
Tapris hayesii	Mammal	0	0	0	1
Taxadea taxus	Mammal	0	1	0	0
Terrapene carolina	Reptile	1	1	1	1
Timias striatus	Mammal	0	0	0	0
Tringa sp.	Bird	1	0	0	0
Trionyx sp.	Reptile	1	0	0	0
Triodopsis albolabris	Invertebrate	1	0	0	0
Triodopsis denotata	Invertebrate	1	0	0	0
Trionyx sp.	Reptile	1	0	0	0
Trionyx spiniferus	Reptile	1	1	1	1
Tritogonia verrucosa	Invertebrate	1	0	0	0
Turdus migratorius	Bird	0	0	1	0
Unio sp.	Invertebrate	1	1	0	0
Urocyon cinereoargenteus	Mammal	1	1	1	1
Ursus americanus	Mammal	0	1	1	1
Viperidae	Reptile	1	0	0	0
Vulpes sp.	Mammal	0	1	0	0
Zapus hudsonius	Mammal	0	1	0	0

Faunal Distributions

Archaeological faunal remains in the Ohio River valley result from the procurement animal resources, which were available to ancient human populations and ultimately reflect the composition of ancient ecosystems. Climate change causes changes to occur in the ecosystem, which changes the composition of available animal resources.

The decisions people made concerning what animal resources were procured and processed and how they were used directly affected their adaptability. These decisions are archaeologically preserved as patterns in the exploitation of animal resources. An important economic dimension of human adaptability to climate change is the availability of species required to sustain or maintain human livelihood.

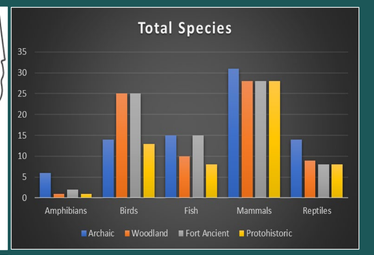
In the Ohio River valley, mammals and freshwater mussels are the predominate taxa represented in archaeological sites, which date to the Holocene. More than 50% of the mammals and freshwater mussels available during the Holocene were exploited. This high percentage of exploited species may be the result of their adaptability and sustainability throughout the climatic changes of the Holocene. However, there were temporal variations in other taxa.

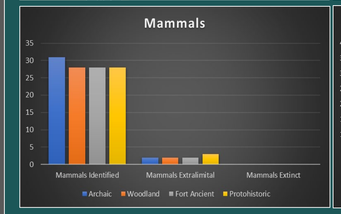
During the Holocene Climatic Optimum, Archaic populations exploited a greater number of amphibians and reptiles (e.g., aquatic turtles) than other cultural periods as well as a greater diversity of mammals. This emphasis on aquatic species is likely a result of the warm and moist conditions of the Holocene Climatic Optimum. A similar exploitation pattern occurs during the Medieval Warming. Fort Ancient populations exploited a greater number of fish and migratory water foul than other cultural periods.

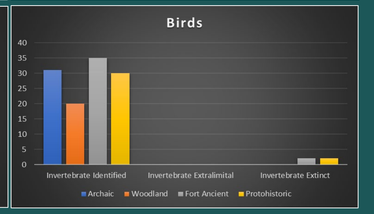
The occurrence of extralimital bird and mammal species from well-dated archaeological contexts may be the best indicator of climate change during the Holocene. Extralimital species from Archaic archaeological sites, which date to the Holocene Climatic Optimum include both southern species such as *Oryzomys palustris* (Rice Rat) and *Sylvlagus aquaticus* (Swamp Rabbit) as well as northern species such as *Anser caerulescens* (Snow Goose) and *Erethizon dorsatum* (Porcupine).

The occurrence of northern extralimital species are also present on Woodland archaeological sites, which date to the post-Holocene Climatic Optimum including *Anser caerulescens* (Snow Goose), *Gavia immer* (Common Loon), *Lophodytes cucullatus* (Hooded Merganser), and *Martes Americana* (Pine Martin), as well as the western *Olor buccinator* (Trumpeter Swan) and *Taxadea taxus* (Badger). Similarly, northern extralimital species dominate on Fort Ancient archaeological sites, which date to the Medieval Warming including *Anser caerulescens* (Snow Goose), *Gavia immer* (Common Loon), *Lophodytes cucullatus* (Hooded Merganser), and *Podilymbus podiceps* (Pied-billed Grebe) as well as the western *Olor buccinator* (Trumpeter Swan) and southern *Oryzomys palustris* (Rice Rat).

The greatest biogeographic diversity of extralimital species occur on Protohistoric Fort Ancient sites, which date to the Little Ice Age including the western *Bison bison* (Modern Bison), *Olor buccinator* (Trumpeter Swan), and Taxadea taxus (Badger), the northern *Erethizon dorsatum* (Porcupine) and *Martes americana* (Pine Martin), as well as the southern *Oryzomys palustris* (Rice Rat).

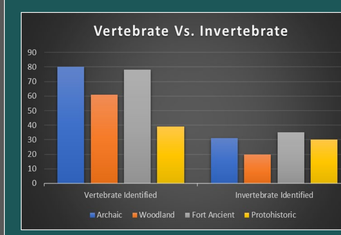


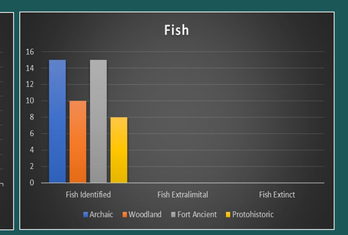


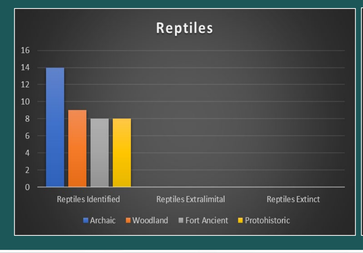


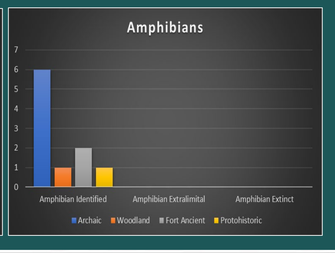
Extralimital Taxa

Taxa	Common Name
Archaic	
Oryzomys palustris	Rice Rat
Anser caerulescens	Snow Goose
Erethizon dorsatum	Porcupine
Sylvlagus aquaticus	Swamp Rabbit
Woodland	
Martes americana	Pine Martin
Anser caerulescens	Snow Goose
Gavia immer	Common Loon
Laphodytes cucullatus	Hooded Merganser
Olor buccinator	Trumpeter Swan
Taxadea taxus	Badger
Prehistoric Fort Ancient	
Anser caerulescens	Snow Goose
Gavia immer	Common Loon
Laphodytes cucullatus	Hooded Merganser
Olor buccinator	Trumpeter Swan
Podilymbus podiceps	Pied-billed Grebe
Oryzomys palustris	Rice Rat
Protohistoric Fort Ancient	
Bison bison	Modern Bison
Erethizon dorsatum	Porcupine
Martes americana	Pine Martin
Olor buccinator	Trumpeter Swan
Oryzomys palustris	Rice Rat
Taxadea taxus	Badger









Discussion

Global climatic changes during the Holocene created changes in the amount of sea-ice cover, which produced marked regional alterations in the ecosystems of the Ohio River valley and ultimately exploited animal resources. These climatic changes caused individualistic shifts or disharmony in the biogeographic distributions of Holocene birds and mammals.

During the Holocene, the presence or absence of individual bird and mammal species and the composition of species communities was highly variable because of their individual adaptation to climatic change. Most of the extralimital vertebrates from archaeological sites in the Ohio River valley are well south of their present biogeographic ranges (e.g., common loon, hooded merganser, pine martin, pied-billed grebe, porcupine, and snow goose). However, there are also species, which are well east (e.g., badger, bison, and trumpeter swan) and north (e.g., rice rat) of their present ranges.

Bird and mammal species with biogeographic distributions north, south, and west of the Ohio River valley occur in direct stratigraphic association with species that have present day temperate, mid-latitude biogeographic distributions. The stratigraphic association of these presently allopatric species is an example of non-analog associations, which are characteristic of periods of profound global climate change.

The temporal distributions of extralimital bird and mammal species suggests that the Holocene climate was by no means homogenous. Rather, bird and mammal remains from Archaic through Protohistoric Fort Ancient archaeological sites in the Ohio River valley are indicative of taxa that changed constantly and non-analogously. Amphibians, invertebrates, and reptiles appear to have been unaffected by natural changes in climate.

Funding

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- Between 1400 and 1850 the Ohio River valley experienced a significant cooling and drying event known as the Little Ice Age
- Looking for a vertebrate “signal” for this period in the archaeological record
- Examined vertebrates and invertebrate identified from the Ohio River valley during an excavation as well as artifacts housed at C.A.R.F.
- Examined animal species response to changes in climate during the Holocene.
- Location, age, and taxa of vertebrate and invertebrate remains from archaeological sites
- Looked for patterns in the data to identify a presence/absence “signal”

- Animal remains result from resources that were available to ancient human populations
- Shows the composition of ancient ecosystems
- Climate change causes changes to occur in the ecosystem, which changes the composition of available animal resources
- Mammals and freshwater mussels are the most represented in archaeological sites dating to the Holocene
- More than 50% of the mammals and freshwater mussels available during the Holocene were used
- The occurrence of extralimital bird and mammal may be the best indicator of climate change during the Holocene

Archaic archaeological sites, which date to the Holocene Climatic Optimum

- Rice Rat
- Swamp Rabbit
- Snow Goose
- Porcupine

Woodland archaeological sites, which date to the post-Holocene

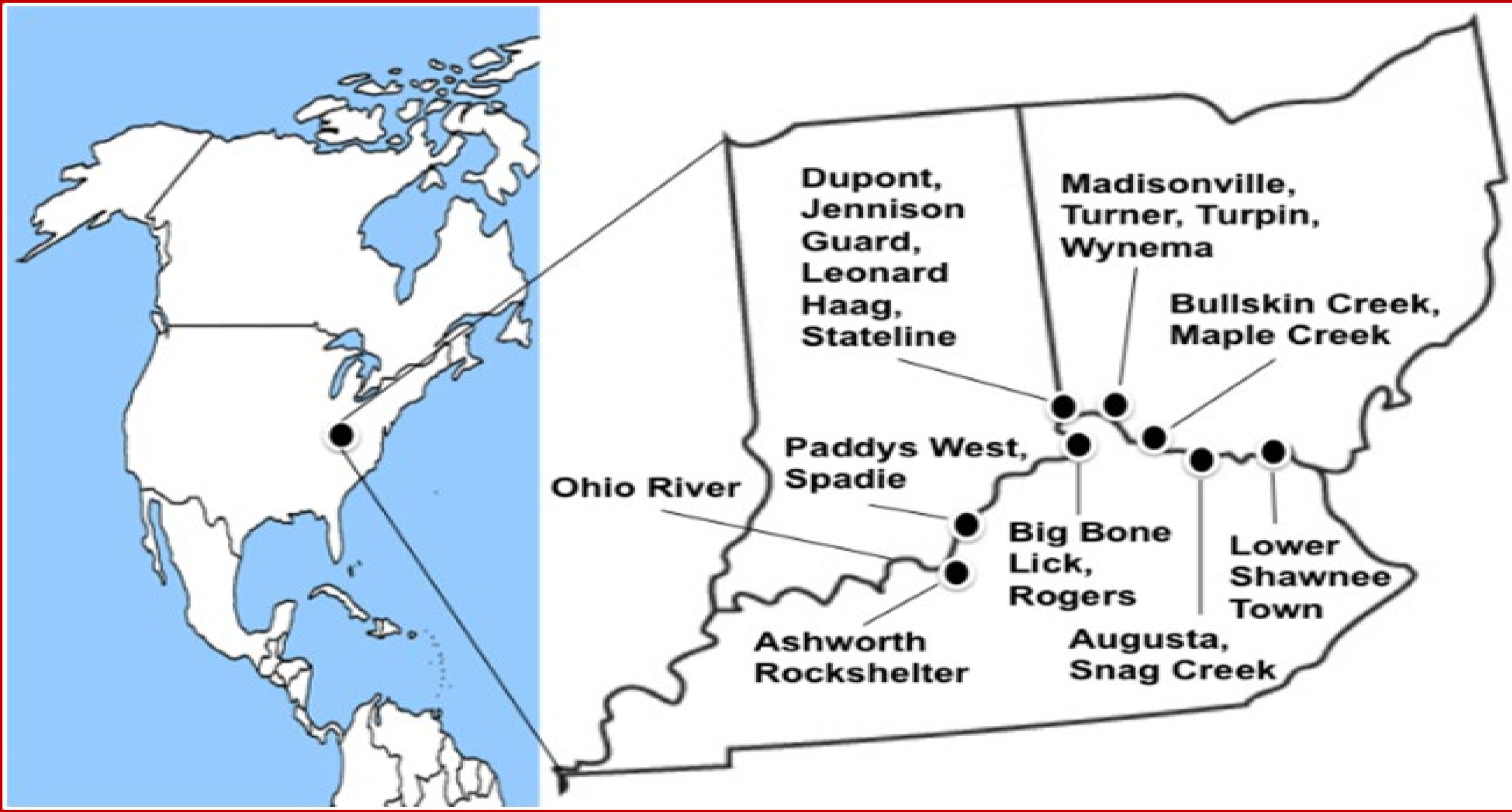
- Snow Goose
- Common Loon
- Hooded Merganser
- Pine Martin
- Trumpeter Swan
- Badger

Fort Ancient Sites

Snow Goose
Common Loon
Hooded Merganser
Pied-billed Grebe
Trumpeter Swan
Rice Rat

Protohistoric Fort Ancient Sites

Bison
Trumpeter Swan
Badger
Porcupine
Pine Martin
Rice Rat


Dupont,
Jennison
Guard,
Leonard
Haag,
Stateline
Madisonville,
Turner, Turpin,
Wynema
Bullskin Creek,
Maple Creek
Paddys West,
Spadie
Ohio River
Big Bone
Lick,
Rogers
Lower
Shawnee
Town
Ashworth
Rockshelter
Augusta,
Snag Creek

- These climatic changes caused shifts in the biogeographic distributions of Holocene birds and mammals
- The presence or absence (signal) of bird and mammal species is highly variable because of their individual adaptation to climatic change
- Most of the extralimital vertebrates from archaeological sites in the Ohio River valley are well south, east, and north of their present biogeographic ranges
- Distribution shows characteristics of a period of profound global climate change.
- The temporal distributions of extralimital bird and mammal species suggests that the Holocene climate was by no means the same
- Rather, bird and mammal remains from Archaic through Protohistoric Fort Ancient archaeological sites in the Ohio River valley are indicative of taxa that changed constantly and non-analogously. Amphibians, invertebrates, and reptiles appear to have been unaffected by natural changes in climate

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