Terrestrial and Aquatic Mollusks as Environmental Indicators at the Brogley Rockshelter, Grant County, Wisconsin

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ABSTRACT
The Brogley rockshelter (47Gt156) is an archaeological site located in southwestern Wisconsin's Driftless Area. It has both an Archaic and Woodland human occupation which, after excavation, resulted in the discovery of a wealth of artifacts and floral, faunal, and aquatic assemblages. Recently, MVAC received sediment samples from a series of units at Brogley rockshelter, permitting a comprehensive analysis of selected site materials. My thesis will contribute an important part to this analysis. It focuses on the aquatic and terrestrial mollusks found in the sediment samples. By analyzing the variety of species from two different samples, and carbon dating each, the environmental fluctuations in the area, along with their respective time period, can be approximated.

INTRODUCTION
The Brogley rockshelter site is located along the Platte River in Grant County, Wisconsin. The rockshelter sits at the base of a sandstone bluff that is located within the Driftless Area of southwestern Wisconsin. This is an area that, because of a lack of glaciation during the Pleistocene, has considerable topographic relief. The area immediately around the site is wooded with mesic forest. This forest type is comprised of maples and basswood. Often growing on the north sides of slopes it provides lots of shade and a forest floor rich with leaf litter (Curtis 1959).

Brogley was discovered in 1966 and first excavated in 1967 by Robert Nelson, a high school teacher from Platteville (Tiffany 1974). Mr. Nelson continued to excavate until 1972, reaching a depth of 2.6 meters below datum. Varied assemblages were recovered which spanned from the Archaic (8000 B.C. to 500 B.C.) to the Woodland (500 B.C. to A.D. 1200).

The Archaic period is characterized as a time devoid of pottery, when people relied upon hunting and gathering for subsistence, manufactured stone spear points and knives, and buried their dead in flat cemeteries rather than in mounds. In southern Wisconsin the Archaic period is divided up into 3 main stages: Early Archaic, Middle Archaic, and Late Archaic, all of which marked the beginning of a less nomadic lifestyle for early peoples. The Early Archaic (8000/5500 B.C. to 4000B.C.) was a time of great environmental change. Glacial sheets were disappearing and plant communities were moving further northwards. Lake levels fluctuated and deciduous hardwood mesic forests began to predominate. Culturally, people lived in small mobile groups and depended upon hunting solitary game animals. For this reason, it is thought that overall population size was lower than it had previously been (Stoltman 1997).

The Middle Archaic (6000/4000 B.C. to 1500/1200 B.C.) is much better represented in the archaeological record. People began to significantly use rockshelters, reuse cemeteries, and make technological advancements. During this phase in Wisconsin polished stone tools, specialized fishing gear, and copper tool manufacture were all developed. There is also evidence for marine shell exploitation and long distance trade of exotic items. The overall population is thought to have increased as the environment continued to fluctuate regionally. There is evidence that a maximum warming and drying trend was reached at the beginning of the Middle Archaic. Paleobotanical evidence indicates a subsequent move in southwestern Wisconsin from mesic forests to open woodlands and prairies. Isostatic rebound caused lake levels in the east to increase considerably (Stoltman 1997).

By the Late Archaic (1500/1200 B.C.-500/100 B.C.) climatic conditions began to level off, and were similar to modern conditions. There was an apparent decline in the use of copper, although new projectile point styles were being developed (Stoltman 1997).

The Woodland period saw the continuation of some of these new patterns. Increasing sedentism brought about a more territorial and structured lifestyle for the Woodland people. Seasonal camps still existed but tended to be larger, especially in the summer when food was more plentiful. In this period pottery first made an appearance, as did a considerable trade network which spanned the current United States. Most notable is probably the development of the garden. Although people still moved seasonally they managed to create gardens where squash, sunflowers, and corn were grown during the summer months (Mississippi Valley Archaeology Center 2004).

Discoveries at Brogley included artifacts, such as projectile points, flakes, and ceramics, large and small mammal bones, microfauna, aquatics, and floral remnants. At the end of excavation all of these components were sent to the University of Wisconsin-Madison (Theler and Boszhardt 2003).

BACKGROUND

In 1972 a graduate student in Anthropology at the University of Wisconsin-Madison, Donna Scott, began to excavate a column from the center of the rockshelter. Some analysis was done on the assemblages retrieved by Mr. Nelson. In 1974 Dr. Joseph Tiffany analyzed the seed and nut shell from Brogley, determining that it was likely to have been primarily occupied in fall and winter. Tiffany also determined that there had been a shift in plant utilization from the Archaic to the Woodland time periods (Tiffany 1974).

Dr. James Theler's analysis of the Brogley site focused on different species of large freshwater mussels present at the site, and how they might have been exploited as a food source, or as tools by the human occupants of the rockshelter. Theler also made some use of mussels as environmental indicators, noting their near absence in present day streams in the area around Brogley (Theler 1986).

The use of mollusks as environmental indicators in Archaeology is by no means a new field. Peter Bobrowsky tells in his article, "The History and Science of Gastropods in Archaeology," that the earliest attempts took place in 1867 in Massachusetts. There, gastropods were used to implicate a loss of hardwood trees over time. It was not until the 1930's and 1940's that some comprehensive archaeological studies were done which set standards for the approach known as "archaeomalacology." In 1942 an archaeologist named Morrison used a method of very fine mesh sieving to retrieve tiny mollusks from the Pickwick Basin site in Alabama. This resulted in important qualitative and quantitative data, along with what was considered an exemplary analysis of terrestrial gastropods. (Bobrowsky 1984).

However, these works went relatively ignored in the larger archaeological community until the 1960's. David A. Baerreis helped to revive gastropod research in archaeology and advocated for the continued use of detailed analysis with a succession of published works from 1969 to 1974. Although there has been very little theoretical development surrounding "archaeomalacology," there has, however, been an increase in the complexity of such studies (Bobrowsky 1984). For example, in 1984 Baerreis was able to apply an equation to the lengths of certain snail species, which indicated the length of growing season for those snails (Baerreis 1980).

Further studies were done on gastropods, which provided cultural, rather than environmental, focus. Snails have been used, by Bobrowsky and Gatus, to distinguish varying degrees of intensity of human occupation at a site in Kentucky (Bobrowsky 1984). Clearly gastropods can, and have, contributed to the study of many different aspects for any site where they are present. Specimen abundance, species diversity, and the diminutive nature of Brogley's snail assemblage make it ideal for the unbiased study of changes to the regional environment. My research focuses on the use of terrestrial and aquatic mollusks from Brogley indicate environmental change, and carbon dating to give approximate dates to these changes.

METHODOLOGY

Two sediment samples were selected from the Brogley site (47Gt156) for comparative analysis of their terrestrial and aquatic mollusk assemblages. By selecting two samples from different depths, it was more likely that two different occupational periods, under different environmental conditions, would be represented. Sample 21 was between 7.95 and 8.15 feet below datum, and was 10.5 liters in volume. Sample 16 was nearer the top of the site, between 7.15 and 7.35 feet below datum, and was 14.5 liters in volume.

Using flotation, a water separating technique which put the samples through #40 mesh (.425 mm) screens, the light fractions were separated from each sample. All mollusks, with the aid of a microscope and forceps, were removed from the light fractions and placed into glass vials. Charred nut and wood fragments were removed and placed into separate vials. They were sent to the Center for Applied Isotope Studies at the University of Georgia for carbon analysis.

To make identification easier, the mollusks were boiled to clean their apertures of sediment. Reference manuals (Burch 1962; Pilsbry 1946; Turgeon et al. 1988) along with a defining characteristic of species, such as the configuration in the aperture, were used to determine species. In this way the minimum number of individuals present, or MNI, could be distinguished. The number of individual specimens present, or NISP, for each sample was also determined.

RESULTS

Sample 16 contained 183 individuals and 21 species, 3 of which made up over 40% of the sample. Sample 21 was more than four times larger than Sample 16, with 845 individuals. This sample was comprised of 29 species, 4 of which comprised 55% of the total MNI.

When first working with my snail data I tabulated the total number of species, the number of individuals per species, and the total number of snails for each of my two samples from the Brogley rockshelter site. These I placed below, in Table 1.

Table 1. Snail count and percent makeup by sample.

Species	Sample 16, Square M 7.15-7.35 ft.	Percent Makeup	Sample 21, Square N 7.95- 8.15 ft.	Percent Makeup
Anguispira alternata	15	8.20%	35	4.14%
Carychium species	0	0.00%	10	1.18%
Carychium exile	24	13.11%	97	11.48%
Carychium exiguum	1	0.55%	11	1.30%
*Cincinnatia cincinnotiensis	0	0.00%	5	0.59%
Discus cronkhitei	1	0.55%	14	1.66%
Gastrocopta armifera	3	1.64%	10	1.18%
Gastrocopta contracta	14	7.65%	86	10.18%
Gastrocopta corticaria	0	0.00%	1	0.12%
Gastrocopta holzingeri	9	4.92%	28	3.31%
Gastrocopta pentodon	2	1.09%	29	3.43%
*Glyphalinia indentata	0	0.00%	1	0.12%
*Gyraulus sp.	7	3.83%	43	5.09%
Haplotrema concavum	0	0.00%	1	0.12%
Hawaiia minuscula	27	14.75%	85	10.06%
Helicodiscus parallelus	14	7.65%	198	23.43%
Helicodiscus singleyanus	1	0.55%	4	0.47%
*Planorbella	0	0.00%	6	0.71%
*Pomatiopsis lapidaria	2	1.09%	16	1.89%
Punctum minutissimum	9	4.92%	22	2.60%
*Pupoides albilabris	0	0.00%	3	0.36%
*Phyella sp.	0	0.00%	13	1.54%
Strobilops labyrinthicus	2	1.09%	2	0.24%
Striatura milium	1	0.55%	0	0.00%
Succineidae	0	0.00%	20	2.37%
Vallonia perspectiva	7	3.83%	25	2.96%
Valvata tricarinata	6	3.28%	26	3.08%
Vertigo ovata	1	0.55%	1	0.12%
Vertigo. tridentata	12	6.56%	7	0.83%
Zonitoides arboreus	25	13.66%	45	5.33%
Zonitoides limatulus	0	0.00%	1	0.12%
Totals	183	100.00%	845	100.00%

Looking at the percentage makeup of these samples was also important, as there was considerable difference in count between them. In doing so I noticed a few trends, highlighted in Table 1. In purple are those species, which made up at least 10% of their sample.

Zonitoides arboreus is one such species, increasing its percent makeup to 13.66% in Sample 16. This made it the second most common species in Sample 16. *Zonitoides* is a terrestrial species and is known to be abundant in the Mississippi Valley, specifically in areas where there is moisture and protection from the sun (Pilsbry 1946). Another considerable change between the two samples was the loss of *Helicodiscus parallelus*. This is a forest species which prefers damp, and shady places (Pilsbry 1946). From Sample 21 to Sample 16 its presence dropped 15.78%, from 198 individuals to a mere 14. *Gastrocopta contracta*, a snail that tolerates various climates, but with a preference for moist habitats, also dropped in presence between samples, from 10.18% to 7.65% (Leonard 1959).

Other notable losses were those of completely aquatic species. Aquatic species of mollusks are denoted by an asterisk before their names in Table 1. There were seven species of such mollusks, only two of which are present in Sample 16. *Gyraulus* and *Pomatiopsis lapidaria* are the only aquatic species present in both samples. Both of these species prefer damp or shallow aquatic environments to lakes or rivers. Although Baker says that *Pomatiopsis lapidaria* is “distinctly an amphibious snail” he goes on to call it “essentially a terrestrial animal.” He cites their more often being discovered on damp ground or in areas that are likely to be subjected to overflow from rivers and streams rather than water bodies themselves (Baker 1928). Although there are aquatic species present in Sample 16, they are significantly diminished when compared to Sample 21, and are species, which can survive without deep waters.

Table 2. Percent change of species presence from Sample 21 to Sample 16.

Sorted Difference
Zonitoides arboreus 8.34%
Vertigo. Tridentata 5.73%
Hawaiia minuscula 4.69%
Anguispira alternata 4.05%
Punctum minutissimum 2.31%
Carychium exile 1.64%
Gastrocopta holzingeri 1.60%
Vallonia perspectiva 0.87%
Strobilops labyrinthicus 0.86%
Striatura milium 0.55%
Gastrocopta armifera 0.46%
Vertigo ovata 0.43%
Valvata tricarinata 0.20%
Helicodiscus singleyanus 0.07%
Gastrocopta corticaria -0.12%
Glyphalinia indentata -0.12%
Haplotrema concavum -0.12%
Zonitoides Limatulus -0.12%
Pupoides albilabris -0.36%
Cincinnatia cincinnotiensis -0.59%
Planorbella -0.71%
Carychium exiguum -0.76%
Pomatiopsis lapidaria -0.80%
Discus cronkhitei -1.11%
Carychium species -1.18%
Gyraulus sp. -1.26%
Phyella sp. -1.54%
Gastrocopta pentodon -2.34%
Succineidae -2.37%
Gastrocopta contracta -2.53%
Helicodiscus parallelus -15.78%

In Table 2 the change in species presence is shown, by percent of change. The top 4 species that are highlighted show an increase in Sample 16. These 4 species that increased in percentage in Sample 16 were those that were opportunistic in nature and able to tolerate a wider range of environmental conditions. *Zonitoides* is an abunadant terrestrial species, as is *Hawaiia minuscula*. *Hawaiia* is found across North America, both in floodplain and upland areas (Leonard 1959). *Anguispira alternata* is also a common and widespread terrestrial species, being found in a wide variety of habitats (Leonard 1959).

The bottom species highlighted, *Helicodiscus parallelus*, shows a significant decrease from Sample 21 to Sample 16. *Striatura milium*, highlighted at center, is the only new species seen in Sample 16. There is little known of this terrestrial species, except that it can be found in leaf litter and has a modern range of the eastern United States (Leonard 1959). The negative numbers, highlighted in orange, in Table 2 are those 9 species which were present in Sample 21 but completely absent in Sample 16.

Table 3. Density differences between the Samples 16 and 21.

Species	Sample 16 Square M 7.15 7.35 ft., 14.5	Density (Snails per L	Sample 21 Square N 7.95 8.15 ft., 10.5	Density (Snails per L
Anguispira alternata	15	1.03	35	3.33
Carychium species	0	0.00	10	0.95
Carychium exile	24	1.66	97	9.24
Carychium exiguum	1	0.07	11	1.05
Cincinnatia cincinnotiensis	0	0.00	5	0.48
Discus cronkhitei	1	0.07	14	1.33
Gastrocopta armifera	3	0.21	10	0.95
Gastrocopta contracta	14	0.97	86	8.19
Gastrocopta corticaria	0	0.00	1	0.10
Gastrocopta holzingeri	9	0.62	28	2.67
Gastrocopta pentodon	2	0.14	29	2.76
Glyphalinia indentata	0	0.00	1	0.10
Gyraulus sp.	7	0.48	43	4.10
Haplotrema concavum	0	0.00	1	0.10
Hawaiia minuscula	27	1.86	85	8.10
Helicodiscus parallelus	14	0.97	198	18.86
Helicodiscus singleyanus	1	0.07	4	0.38
Planorbella	0	0.00	6	0.57
Pomatiopsis lapidaria	2	0.14	16	1.52
Punctum minutissimum	9	0.62	22	2.10
Pupoides albilabris	0	0.00	3	0.29
Phyella sp.	0	0.00	13	1.24
Strobilops labyrinthicus	2	0.14	2	0.19
Striatura milium	1	0.07	0	0.00
Succineidae	0	0.00	20	1.90
Vallonia perspectiva	7	0.48	25	2.38
Valvata tricarinata	6	0.41	26	2.48
Vertigo ovata	1	0.07	1	0.10
Vertigo. Tridentata	12	0.83	7	0.67
Zonitoides arboreus	25	1.72	45	4.29
Zonitoides Limatulus	0	0.00	1	0.10
Totals	183	12.62	845	80.48

Table 3 shows density as snails per liter for each sample. This is notable because of the difference in soil volume between Sample 21, at 10.5 liters, and Sample 16, at 14.5 liters. The numerical difference of snail total is extrapolated further when you see that more snails came from a smaller overall sample.

Sample 21 has an average of 80.48 snails per liter of soil, whereas Sample 16 averages only 12.62 snails per liter of soil. Highlighted again is the species *Helicodiscus parallelus*, whose density fell from 18.86 to 0.97. *Hawaiia minuscula* also displays a considerable loss in density, from 8.1 to 1.86, although this is also the species with the highest density for Sample 16.

In Sample 16, only 4 species manage to have a density greater than one. Whereas, in Sample 21, there were 17 species with a density greater than one, and 13 species with a density greater than that of the highest species density for Sample 16.

An increase in species density from Sample 21 to Sample 16 is even more notable than loss, as only two of the species managed to increase in density. *Vertigo tridentata* raised its density from 0.67 snails per liter, to 0.83. The *Vertigo* species is terrestrial, often found in humid places, sometimes at the edge of marshes or pond. Like other terrestrial snails they seek protection beneath dead wood (Pilsbry 1946).

Aside from specific examples, the biggest trends from Sample 21 to Sample 16 were the extreme drop in the number of individuals, a loss of species diversity, and drop in snail density.

RADIOCARBON DATING

Charred nutshells and charred wood were removed from both samples to be used for the carbon dating of each sample. The carbon samples were comprised primarily of nut shells, with wood sent along to be used if there wasn't enough nut shell to get a date. These samples were sent to the Center for Applied Isotope Studies at the University of Georgia (Appendix A). There they arrived at the corrected radiocarbon dates, which are listed below, in Table 4.

Table 4. Radiocarbon Analysis Report

UGAMS#	Sample I.D.	Material	Radiocarbon ^{13}C Corrected Age (YBP±1s)	$\delta^{13}C$ (°/)
03009	GT-156 Sample 16	Nutshell	3890±40	-24.2
03010	GT-156 Sample 21	nutshell	4370±40	-26.2

A calibration was run on these dates using Calib 14C calibration program. Both new sets of dates were estimated to be older. The program found that the one sigma range of Sample 16 put the calibrated dates from 2462 B.C. to 2310 B.C. The calibrated dates for Sample 21, at one sigma, were from 3021 B.C. to 2919 B.C.

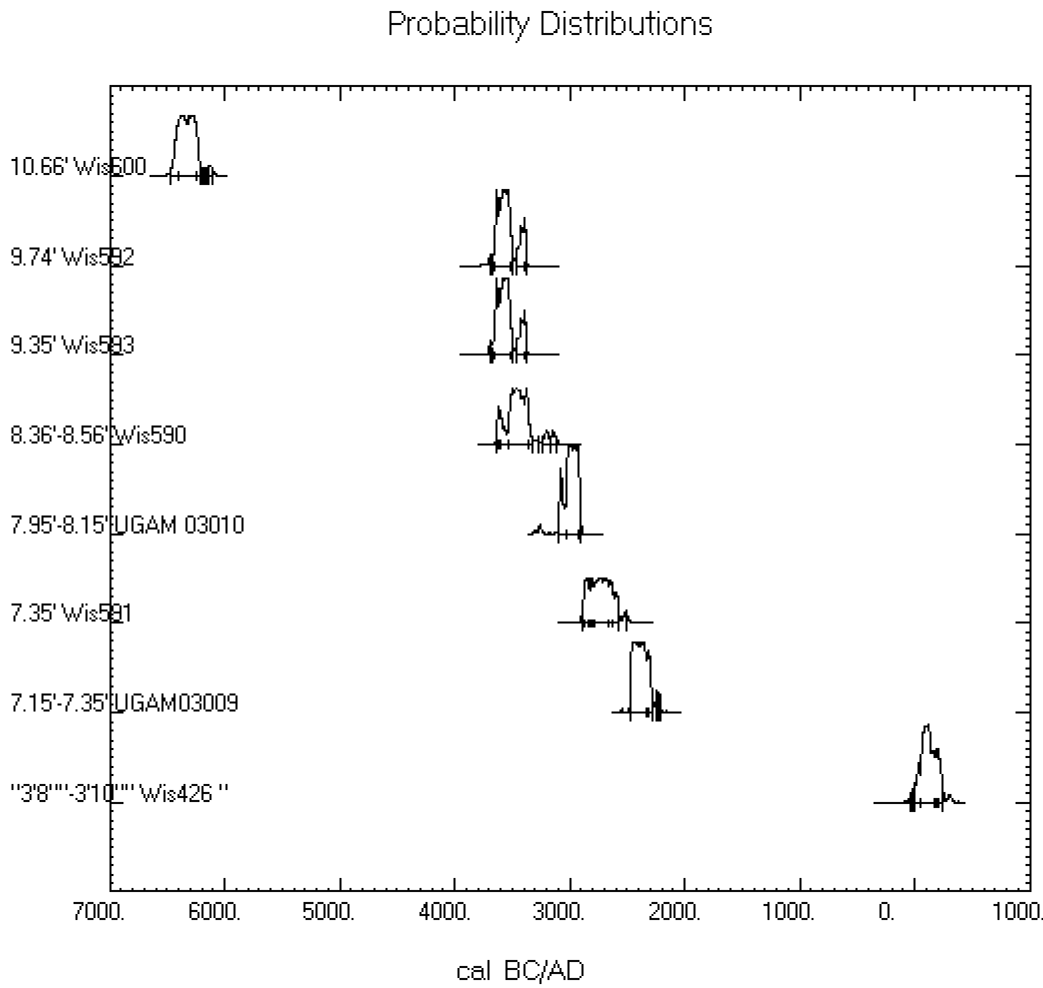

Image 1: Probability Distributions

Image 1 shows the probability distributions for calibrated radiocarbon dates from Brogley. The Y axis shows both the depth of origin and the identifying number of each radiocarbon sample. Here Samples 16 and 21 were put alongside 6 previously existing radiocarbon dates from Brogley (Tiffany 1974), which have also been calibrated. Sample 16 is listed as UGAM 03009, and Sample 21 is listed as UGAM 03010. The image also shows that as depth of the sample increased, the estimated age also increased. This identified Samples 16 and 21 as coming from the Middle Archaic period.

CONCLUSIONS

Using Brogley's mollusks as environmental indicators, a regional environmental change is indicated, specifically from a warm and moist period to cooler and drier conditions. All mollusks are sensitive to moisture and temperature. The extreme drop in numbers of snails, loss of species diversity, and decrease in snail density from Sample 16 to Sample 21, hints at a change to a harsher climate for these creatures. This is further reinforced by a loss of aquatic species and a rise in the presence of more opportunistic species in Sample 16. Radiocarbon analysis puts the time of this change in southern Wisconsin's Middle Archaic period. Calibrating these dates indicate that a warm and moist period occurred in the region around 3021 B.C. to 2919 B.C., while the cooler and drier period occurred around 2462 B.C. to 2310 B.C.

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APPENDIX

Center for Applied Isotope Studies

RADIOCARBON ANALYSIS REPORT

May 9, 2008

Enclosed please find the results of $_{14}C$ Radiocarbon analyses and Stable Isotope Ratio $\delta_{13}C$ analyses for the charcoal samples received by our laboratory on April 21, 2008.

UGAMS#	Sample I.D.	Material	Radiocarbon $_{13}C$ Corrected Age(YBP±1s)	$\delta_{13}C$ (‰)
03009	GT-0156 s.16	nutshell	3890±40	-24.2
03010	GT-0156 s.21	nutshell	4370±40	-26.2

The nutshell sample was treated with 5% HCl at the temperature 80°C for 1 hour, then it was washed and with de-ionized water on the fiberglass filter and rinsed with diluted NaOH to remove possible contamination by humic acids. After that the sample was treated with diluted HCL again, washed with de-ionized water and dried at 60°C. For conventional analysis the cleaned charcoal was combusted in Parr bomb under oxygen pressure. The recovered carbon dioxide has been cryogenically purified and converted to benzene on V-Al-Si catalyst. The sample $_{13}C/_{12}C$ ratios were measured separately using a stable isotope ratio mass spectrometer and expressed as $\delta_{13}C$ with respect to PDB, with an error of less than 0.1‰. The activity of the sample has been measured on the liquid scintillation analyzer Packard Tri-carb 1050 and reported as radiocarbon age.

The quoted uncalibrated dates have been given 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.