



# PALEONTOLOGY FIELD SCHOOL AT THE GRAY FOSSIL SITE, APPALACHIAN HIGHLANDS, TENNESSEE

Course ID: TBA

June 28 – July 25, 2020

Academic Credits: 8 Semester Credit Units (Equivalent to 12 Quarter Units)

School of Record: Connecticut College

## FIELD SCHOOL DIRECTOR:

Dr. Blaine W. Schubert, Center of Excellence in Paleontology ([schubert@etsu.edu](mailto:schubert@etsu.edu))

## INSTRUCTORS:

Dr. Chris Widga, Dr. Steven Wallace, Dr. Josh Samuels, April Nye, Shawn Haugrud, Keila Bredehoeft, Brian Compton, and Laura Gilmore Emmert



## **INTRODUCTION**

Between 17-15 million years ago, during the middle Miocene, Earth was much warmer than it is today (4-5 °C or 7-9 °F). A trend of global cooling began after this warm episode, and open habitats such as grasslands spread across most of the North America. As grasslands expanded over millions of years, forest ecosystems disappeared or were reduced significantly. Thus, there was a rise in plants and animals with adaptations to open habitats, and fossil sites across western North America record the evolution of these organisms. In eastern parts of the continent there are few Miocene or Pliocene sites outside Florida, and these are primarily coastal deposits. The lack of inland fossil sites, or those that represented past forests, left a significant gap in the fossil record and our understanding of Appalachian ecosystems through time. The discovery of the extraordinary Gray Fossil Site (GFS) changed this, giving us an in-depth look at Appalachia from ~5 million years ago. Since the site was exposed in a road

construction project in 2000, our discoveries have dramatically changed the paleontological story of North America.

As part of the field school, participants will learn all about GFS and the discoveries we have made so far. This story continues to evolve as we excavate and pursue our primary research questions. These questions are: 1) how did forested ecosystems such as the Appalachians persist and evolve in the midst of grassland expansion elsewhere, 2) to what extent did GFS serve as a forest refugia for organisms that once had a wider distribution, and 3) are unique species or range extensions recorded, and if so what are the implications? To summarize discoveries so far, and the overall significance of the Gray Fossil Site, some highlights are listed below:

- It represents the only fossil site in North America that preserves an extensive record of plants and animals from a forested environment during the Miocene or Pliocene epochs. Because grasslands were expanding and forests were shrinking throughout the Miocene, GFS does represent a forest refugia in the Appalachian highlands.
- It contains numerous species that indicate a forested connection between North America and Asia in the past (including our red panda and extinct Asian plants).
- Because such a site hasn't been discovered for this time frame, many of our species are new to science. Seven new species of plants and seven new animals have been published so far, including two turtles, a snake, the red panda, rhino, wolverine, and badger. Other new species have been recognized but haven't been published yet (e.g., shrews, bear, and alligator).
- Only two fossil sites in North America record red panda. The other site is in Washington where a single tooth has been discovered. From GFS we now have complete skeletons.
- It is huge (the deposit is over 40 meters deep and up to 5 acres in area) and so far we have excavated less than 2% of the fossil site.
- Many recovered species represent the first occurrence of genera and species by millions of years, including some salamanders, our bear, and wolverine.
- We have the largest accumulation of tapirs in the world, with over 150 individuals recovered. Numerous studies are underway examining this sample to examine population dynamics.
- Our "elephant" is enormous and fossils from the site represent the most complete early mastodon material from North America. It has an unusual combination of characters and will likely represent a new species as well.

Excavations at the Gray Fossil Site have yielded tens of thousands of plant and animal remains from the latest Miocene or earliest Pliocene. Students will excavate and prepare fossils of tapirs, turtles, rhinos, and if we are lucky, red pandas and sabertooth cats, as well as small- and medium-sized animals and plants. In addition to forming the basis for active research projects at the fossil site, fossils collected during this field season will be integrated with the >25,000 specimen collection in the ETSU Museum of Natural History to be used by researchers at ETSU and around the world to better understand life through time in this region.

During the 2020 field school, students will participate in at least two active excavations at the Gray Fossil Site. This includes the cat pit and the tapir/turtle pit. The cat pit represents a new exploratory excavation in search of additional sabertooth cat (*Machairodus*) fossils. The original sabertooth material was found on the surface in this general area and no additional remains of the cat have been recovered elsewhere on site. Because of the limited material, we are still uncertain what species of *Machairodus* is represented at GFS. The turtle/tapir pit was discovered when a portion of the site was being prepared for a museum building. This particularly rich pocket of fossil material was set aside as a future target and will be excavated in 2020.

### ACADEMIC CREDIT UNITS & TRANSCRIPTS

**Credit Units:** Attending students will be awarded 8 semester credit units (equivalent to 12 quarter credit units) through our academic partner, Connecticut College. Connecticut College is a private, highly ranked liberal arts institution with a deep commitment to undergraduate education. Students will receive a letter grade for attending this field school (see grading assessment and matrix). This field school provides a minimum of 160 direct instructional hours. Students are encouraged to discuss the transferability of credit units with faculty and registrars at their home institution prior to attending this field school.

**Transcripts:** An official copy of transcripts will be mailed to the permanent address listed by students on their online application. One more transcript may be sent to the student home institution at no cost. Additional transcripts may be ordered at any time through the National Student Clearinghouse: <http://bit.ly/2hvurkl>.

### PREREQUISITES

There are no academic prerequisites for participation in this field school. Students should come prepared for physically demanding, outdoor work in high temperatures. Students should be able to follow directions and adhere to safety standards and excavation protocols. Most of the excavation and lab work takes place on public view at the Fossil Site and Museum. There will be many opportunities to interact with the public, and it is therefore important that students possess good communication skills. Good interpersonal skills and an ability to work productively in teams are imperative.

### DISCLAIMER – PLEASE READ CAREFULLY

Our primary concern is with education. Traveling and conducting field research involves risk. Students interested in participating in any IFR program must weigh whether the potential risk is worth the value of education provided. While risk is inherent in everything we do, we take risk seriously. The IFR engages in intensive review of each field school location prior to approval. Once a program is accepted, the IFR reviews each program annually to make sure it complies with all our standards and policies, including student safety.

All fieldwork carries certain risks, including physical injury, illness, animal bites and stings, and exposure to the elements. In our preparation lab we use alcohol and acetone as solvents, and diluted hydrogen peroxide (3%) for some screen-washing. While precautions will be taken to minimize contact with these substances, it is impossible to prevent all exposure. Field school participants will be required to follow proper handling procedures as instructed by Museum staff.

The Gray Fossil Site and Museum is a high-profile destination that generates substantial media interest, and most activities, including excavation and lab work, will be conducted in public view. All participants will be required to sign a media waiver.

The IFR does not provide trip or travel cancellation insurance. We encourage students to explore such insurance on their own as it may be purchased at affordable prices. [insuremytrip.com](http://insuremytrip.com) or [Travelgurad.com](http://travelgurad.com) are possible sites where field school participants may explore travel cancellation insurance quotes and policies. If you do purchase such insurance, make sure the policy covers the cost of both airfare and tuition. See this [Wall Street Journal article about travel insurance](#) that may help you with to help to decide whether to purchase such insurance.

We do our best to follow schedule and activities as outlined in this syllabus. Yet local permitting agencies, political, environmental, personal or weather conditions may force changes. This syllabus,

therefore, is only a general commitment. Students should allow flexibility and adaptability as research work is frequently subject to change.

If you have any medical concerns, please consult with your doctor. For all other concerns, please consult with the project director.

### **COURSE OBJECTIVES**

Students will develop skills in paleontological field techniques including excavation in a grid system, collection of three-dimensional positional data on fossils with a total station, screen-washing, fossil identification, and data recording. In the preparation lab, students will learn techniques including sediment removal, bone preparation and restoration, and sorting and identification of micro-fossils (plants and animals). Students will complete a module in vertebrate skeletal osteology, where they will become versed in anatomy, identification, functional morphology, and taphonomy. Students will also be instructed in museological topics through lectures and hands-on training in collections management and scientific communication. Finally, they will gain experience with technologies such as photogrammetry and 3D scanning that are being used for new research projects focused on our fossils. Students will have the opportunity to practice their communication skills through public engagement inside the museum and at the excavation site.

Through lectures, readings, and discussions, students will learn about the wealth of scientific information that the Gray Fossil Site has produced over the past eighteen years, and how new fields and technologies are spawning new avenues of investigation. Topics will include broad overviews of paleoecology, and paleobiology, as well as specific topics spanning the breadth of paleontological research conducted by Museum researchers. Lecturers will represent a wide variety of paleontological positions, including academic faculty, museum personnel, and professional paleontologists.

In addition to working at the Gray Fossil Site and Museum, students will participate in two field trips that exemplify other fossil sites in the region. As the Museum serves as a repository for fossils from the southern Appalachians and Tennessee, and our scope extends to developing a better understanding of ecosystems in the region through time, it is important to incorporate these field excursions. One trip will focus on a trip to local caves that formed in the same Ordovician limestone as the Gray Fossil Site, but the sediments and fossils in the caves date to the late Pleistocene. The other trip will be to Saltville, Virginia, where ETSU conducts annual excavations on Pleistocene valley deposits that contain mammoths, mastodons, giant ground sloths, musk-ox, and giant short-faced bears. This will include a trip to the Museum of the Middle Appalachians in Saltville where Ice Age exhibits are on display.

### **LEARNING OUTCOMES**

On successful completion of the field school, students will be able to:

- Understand the different elements of excavation, processing, preparation, and collections management as it pertains to paleontology and the Gray Fossil Site
- Apply standard excavation methods to paleontological contexts
- Use standard recording techniques to document excavation results
- Use standard fossil preparation techniques
- Sort microfossils accurately and efficiently
- Identify specific types of plant and animal fossils

### **GRADING MATRIX**

65% Participation: Participation in all scheduled activities (excavation, lab work, collections work, field trips, lectures, discussions) and mastery of fossil excavation and preparation techniques.

- 5% Midterm Exam: A written exam covering both lecture topics and field, lab, and collections methods, will be given at the end of the first two weeks.
- 10% Osteology quizzes: Students will rotate stations on two-minute intervals and answer questions about skeletal specimens and real fossils placed at each station.
- 5% Final Exam: A written exam covering lecture topics and field, lab, and collections methods, will be given at the end of the four weeks.
- 10% Field Notebooks: While working in excavations students will keep a standard Field Notebook as instructed. This will be collected weekly and feedback will be provided.
- 5% Presentation and Science Communication: Part of student training will comprise spoken science communication; students will have the opportunity to demonstrate these skills throughout the course and during their final presentation.

### **TRAVEL AND MEETING POINT**

We suggest you hold off on purchasing your airline ticket until six (6) weeks prior to departure date. Natural disasters, political changes, weather conditions and a range of other factors may require the cancelation of a field school. The IFR typically takes a close look at local conditions 6-7 weeks prior to program beginning and make Go/No Go decisions by then. Such time frame still allows the purchase deeply discounted airline tickets while protecting students from potential loss if airline ticket costs if we decide to cancel a program.

Students are responsible for their own travel to Johnson City and should plan to arrive no later than June 28<sup>th</sup>. Students are expected to arrive at Ross Hall on the ETSU campus by 8:15 am each morning, Monday – Friday. We will meet in the second-floor lobby at 8:00 AM and leave for the Gray Fossil Site at 8:10 AM. Our daily transportation to and from the Gray Fossil Site will be a 15 passenger van.

If your travel plans change unexpectedly or you are delayed, please call, text or email the Project Director immediately. A local emergency cell phone number will be provided to all enrolled students.

### **ACCOMMODATIONS**

Students are responsible for their own accommodations but one option is staying in student housing on the East Tennessee State University main campus. Price varies depending on the dorm, but sharing a room with one other person typically ranges from \$19 to \$22 per person (per night). A limited number of housing stipends will be available to help defray housing costs.

Students are also responsible for providing their own food, including lunches. One option is to set up a meal plan with ETSU. Breakfast, lunch and dinner are available. If you decide to do this it may be best to start out with one week of meals, and then add more if needed. This will allow some flexibility and variety to your meal planning. Students should plan to bring their lunch to the Museum (refrigerator and microwave are available in the staff kitchen). There are not any food options at the Museum, and very few in the town of Gray. However, the van will travel to local restaurants once per week, and it will be optional to go on these outings.

### **EQUIPMENT LIST**

The Gray Fossil Site & Museum will provide all necessary field equipment and lab supplies for the project. Students should bring warm-weather field clothes including rugged pants or shorts, short- and long-sleeved shirts, socks, hats, sun glasses with UV protection, water bottle, daypack or backpack, sunscreen, and writing utensils for taking notes (field books will be provided). Closed-toed shoes are required for working in the field.

### **COURSE SCHEDULE**

All IFR field school begins with safety orientation. This orientation includes proper behavior at the field area, proper clothing, local cultural sensitivities and sensibilities, potential fauna and flora hazards, review IFR harassment and discrimination policies and review of the student Code of Conduct.

**Monday, June 29**

By 8 am	Students arrive on ETSU campus for van shuttle to fossil site
8:30 – 9:30	Breakfast; meet-and-greet with staff (Education Classroom)
9:30 – 12:00	Introduction to Gray Fossil Site and Field School. (Education Classroom) Field school logistics, safety, paperwork, and photos. Tour of the Gray Fossil Site
12:00 – 1:00	Lunch [provided for students and staff]
1:00 – 2:00	Lecture about the Gray Fossil Site
2:00 – 5:00	Tour and discussion of fossil site and Museum
5:00	Van loads for trip back to Johnson City.

**Tuesday, June 30 – Friday, July 24** (with exceptions on \*Fridays and Special Dates below)

By 8 am	Students arrive on ETSU campus for van shuttle to fossil site
8:30 – 9:30	Osteology (Education Classroom)
9:30 – 12:00	Excavation OR lab work (week 3 and 4 will also include collections work)
12:00 – 1:00	Lunch (independent)
1:00 – 2:00	Lecture (Education Classroom)
2:00 – 5:00	Excavation OR lab work (week 3 and 4 will also include collections work)
5:00	Van loads for trip back to Johnson City.

*\*Friday the 3<sup>rd</sup>, 9<sup>th</sup>, and 17<sup>th</sup>: No lectures, excavation/lab/collections time will be from 1:00-3:30, and 3:30-5:00 will be for end of the week review and discussions. Friday the 24<sup>th</sup> is the last day, and will have a unique schedule (noted below under Special Dates)*

**Special Dates**

Sat., July 4	Field trip to Saltville, Virginia (TBA)
Thurs., July 9	8:30 – 9:30 am Osteology Quiz
Friday, July 10	8:30 – 9:30 am Midterm Exam
Sat., July 18	Field trip to Pleistocene caves sites (TBA)
Thurs., July 23	8:30 – 9:30 am Osteology Quiz
Thurs., July 23	3:30 – 5:00 am Final Exam
Friday, July 24	8:30-10:00 Breakfast [provided for students and staff] 10:00 – 1:00 Presentations and lunch 1:00 – 3:00 Complete, scan, and turn in field notebooks 3:00 – 5:00 Discussion, pictures, and closing comments

**LECTURE SCHEDULE**

Monday, June 29	An Overview of Research at the Gray Fossil Site <i>Blaine Schubert, Steven Wallace, Josh Samuels &amp; Chris Widga</i>
Tuesday, June 30	Fieldwork and Excavation at the Gray Fossil Site <i>Steven Wallace &amp; Shawn Haugrud</i>
Weds., July 1	Micro-fossil Processing at the Gray Fossil Site <i>Shawn Haugrud, Steven Wallace &amp; Blaine Schubert</i>
Thurs., July 2	An Overview of Paleontological Research at Saltville, Virginia <i>Blaine Schubert &amp; Chris Widga</i>

Monday, July 6	Fossil Preparation at the Gray Fossil Site <i>Shawn Haugrud &amp; Keila Bredehoeft</i>
Tuesday, July 7	Surveying, Field Mapping, and Spatial Data <i>Chris Widga &amp; Brian Compton</i>
Weds., July 8	Theory and Practice in Collections Management <i>April Nye, Josh Samuels &amp; Chris Widga</i>
Thurs., July 9	Research on Mammals from the Gray Fossil Site <i>Steven Wallace, Blaine Schubert, Josh Samuels &amp; Chris Widga</i>
Monday, July 13	3D Surface Scanning, Photogrammetry, and 3D Printing <i>Chris Widga &amp; Keila Bredehoeft</i>
Tuesday, July 14	Research on Amphibians and Reptiles of the Gray Fossil Site <i>Blaine Schubert</i>
Weds., July 15	Conservation Paleobiology and the Gray Fossil Site <i>Steven Wallace &amp; Josh Samuels</i>
Thurs., July 16	Cave and Karst Paleontology <i>Blaine Schubert</i>
Monday, July 20	Paleobiological Methods, with Examples from the Gray Fossil Site <i>Josh Samuels</i>
Tuesday, July 21	Isotopic Paleocology in Paleontology <i>Chris Widga</i>
Weds., July 22	Sinkholes, Cenotes, Underwater Caves, and Paleontology <i>Blaine Schubert</i>

#### MANDATORY READINGS

- Barnosky AD et al. (2017). Merging Paleontology with Conservation Biology to Guide the Future of Terrestrial Ecosystems. *Science* 355: eaah4787
- Bourque JR., Schubert BW. 2015. Fossil musk turtles (Kinosternidae, Sternotherus) from the late Miocene–early Pliocene (Hemphillian) of Tennessee and Florida. *Journal of Vertebrate Paleontology* 35:1–19. DOI: 10.1080/02724634.2014.885441.
- DeSantis LRG., Wallace SC. 2008. Neogene forests from the Appalachians of Tennessee, USA: Geochemical evidence from fossil mammal teeth. *Palaeogeography, Palaeoclimatology, Palaeoecology* 266:59–68. DOI: 10.1016/j.palaeo.2008.03.032.
- Hulbert RC., Wallace SC., Klippel WE., Parmalee PW. 2009. Cranial morphology and systematics of an extraordinary sample of the late Neogene dwarf tapir, *Tapirus polkensis* (Olsen). *Journal of Paleontology* 83:238–262.
- Steven E. Jasinski and David A. Moscato (2017) Late Hemphillian Colubrid Snakes (Serpentes, Colubridae) from the Gray Fossil Site of Northeastern Tennessee. *Journal of Herpetology*: June 2017, Vol. 51, No. 2, pp. 245-257.
- Liu YSC., Jacques FMB. 2010. *Sinomenium macrocarpum* sp. nov. (Menispermaceae) from the Miocene--Pliocene transition of Gray, northeast Tennessee, USA. *Review of Palaeobotany and Palynology* 159:112–122.
- Mead, J. I., B. W. Schubert, S. C. Wallace, and S. L. Swift. 2012. Helodermatid lizard from the Mio-Pliocene oak-hickory forest of Tennessee, eastern USA, and a review of monstersaurian osteoderms. *Acta Palaeontologica Polonica* 57(1):111–121.
- Ochoa D., Whitelaw M., Liu YSC., Zavada M. 2012. Palynology of Neogene sediments at the Gray Fossil Site, Tennessee, USA: Floristic implications. *Review of Palaeobotany and Palynology* 184:36–48.

DOI: 10.1016/j.revpalbo.2012.03.006.

- Parmalee PW., Klippel WE., Meylan PA., Holman JA. 2002. A late Miocene-early Pliocene population of *Trachemys* (Testudines: Emydidae) from east Tennessee. *Annals of Carnegie Museum* 71:233–239.
- Samuels JX., Bredehoeft KE., Wallace SC. 2018. A new species of *Gulo* from the Early Pliocene Gray Fossil Site (Eastern United States); rethinking the evolution of wolverines. *PeerJ* 6:e4648. DOI: 10.7717/peerj.4648.
- Short, R. A., S. C. Wallace, and L. G. Emmert. 2019. A new species of *Teleoceras* (Mammalia, Rhinocerotidae) from the late Hemphillian of Tennessee. 5:183–260
- Schubert, B.W. and S.C. Wallace. Giant Short-faced bears, Mammoths, and Large Carcass Scavenging in the Saltville Valley of Virginia. *Boreas* 38:482-492.
- Schubert, B.W. and J.I. Mead. 2012. Paleontology of Caves. Pp. 590-598 in Encyclopedia of Caves. W. B. White and D. C. Culver (eds.), Chennai: Academic Press.
- Schubert, B.W., J.C. Chatters, J. Arroyo-Cabrales, J.X. Samuels, L.H. Soibelzon, F.J. Prevosti, C. Widga, A. Nava, D. Rissolo, P. Luna Erreguerena. 2019. Yucatán carnivores shed light on Great American Biotic Interchange. *Biology Letters* 15: <https://royalsocietypublishing.org/doi/10.1098/rsbl.2019.0148>
- Shunk AJ., Driese SG., Clark GM. 2006. Latest Miocene to earliest Pliocene sedimentation and climate record derived from paleosinkhole fill deposits, Gray Fossil Site, northeastern Tennessee, U.S.A. *Palaeogeography, Palaeoclimatology, Palaeoecology* 231:265–278. DOI: 10.1016/j.palaeo.2005.08.001.
- Wallace SC., Wang X. 2004. Two new carnivores from an unusual late Tertiary forest biota in eastern North America. *Nature* 431:556–559.

#### RECOMMENDED READINGS

- Doughty, E.M, S.C. Wallace, B.W. Schubert, and L.M. Lyon. First occurrence of the enigmatic peccaries *Mylohyus elmorei* and *Prosthennops serus* from the Appalachians: Latest Hemphillian to Early Blancan of Gray Fossil Site, Tennessee. *PeerJ* 6: e5926 <http://doi.org/10.7717/peerj.5926>
- Keen, S.W. 2017. Reconstructing diagenetic conditions of bone at the Gray Fossil Site, Tennessee, USA. *Palaeogeography, Palaeoclimatology, Palaeoecology*, Volume 471, 1 April 2017, Pages 48-57
- Moore, H. 2004. *The Bone Hunters: The Discovery of Miocene Fossils in Gray, Tennessee*. The University of Tennessee Press.
- Tedford RH., Albright III LB., Barnosky AD., Ferrusquia-Villafranca I., Hunt Jr RM., Storer JE., Swisher III CC., Voorhies MR., Webb SD., Whistler DP., others. 2004. Mammalian biochronology of the Arikareean through Hemphillian interval (late Oligocene through early Pliocene epochs). In: *Late Cretaceous and Cenozoic mammals of North America: biostratigraphy and geochronology*. Columbia University Press New York, 169–231.
- Whitelaw JL., Mickus K., Whitelaw MJ., Nave J. 2008. High-resolution gravity study of the Gray Fossil Site. *Geophysics* 73:25–32.
- Zobaa, M. K., M. S. Zavada, M. J. Whitelaw, A. J. Shunk, and F. E. Oboh-Ikuenobe. 2011. Palynology and palynofacies analyses of the Gray Fossil Site, eastern Tennessee: their role in understanding the basin-fill history. *Palaeogeography, Palaeoclimatology, Palaeoecology* 308:433–444