A Window to the Past: An Artistic Reconstruction of Miocene Tennessee

by
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Abstract

Paleoart is the reconstruction of landscapes and organisms from Earth's prehistoric past. It is an essential part of educating the public of paleontological discoveries, and can serve to raise awareness and cultivate interest in the geological sciences. In this project, the environment and species of plants and animals present in Tennessee during the Miocene, a period of time spanning from 23 to 5 million years ago, were studied. Fossil remains and observations of extant species were combined to recreate the plants and animals of the time. These recreations were then used to create a scene of a riparian forest, which was painted digitally utilizing Adobe Photoshop Elements and printed on canvas.

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INTRODUCTION

The night is quiet aside from the unending murmur of rain. A convoy of jeeps sit motionless, their fluorescent green flanks a jarring contrast to the mud that pools around their tires. The camera pans to cup of water on one of their dashboards, where rhythmic ripples portend the approach of something enormous. Within moments it becomes apparent to whom those footfalls belong, as the metallic twang of snapping cables gives way to telltale roar of a monster that would haunt the nightmares of kids – and parents alike – for years.

Steven Spielberg's 1993 film *Jurassic Park* would go on to become one of the most iconic films in American sci-fi cinema. Although Michael Crichton's novels as a rule need no help in building suspense or driving home their unnerving plausibility, the visceral horror lent to his story by the masterful use of animatronics and CGI in Spielberg's films is undeniable. So successful, in fact, were those reconstructions of extinct creatures, that entire generations now picture Spielberg's gaunt, draconic *T. rex* whenever the subject of dinosaurs is broached. In the public consciousness, dinosaurs remain scaly, cold-blooded reptiles.

However, researchers continue to discover evidence to the contrary. The astounding discovery of the fossilized *Archaeopteryx* painted a picture to the world of an extensively feathered, birdlike dinosaur. But *Archaeopteryx* was miniscule compared to the likes of dinosaurs that dominate popular culture. Its small size made it easy to picture as something that could be soft and feathered. It is harder to imagine, however, something as big as *T. rex* being covered in a layer of fluff. Except, we've discovered almost exactly that. Dubbed *Yutyrannus huali*, the fossil find revealed a massive, carnivorous, tyrannosaur-like dinosaur with "long filamentous feathers, [a discovery which provides] direct evidence for the presence of extensively feathered gigantic dinosaurs" (Cheng et al., 2012).

Even with the growing evidence that even the largest dinosaurs touted insulating layers of down, why is it that, if you asked people on the street to describe what they picture when they imagine *T. rex*, most would give you a description reminiscent of Godzilla? Why is that image so powerfully ingrained in our collective consciousness? The answer is simple. It is because, somewhere along the line, a paleoartist did a good job.

Somewhere, in the pages of a textbook, or in the scenes of a film or documentary, we have all seen a paleoartist's reconstruction of a dinosaur or some other extinct animal. From that image, one's brain set its definition of what that animal, plant, or place is supposed to look like. Things that deviate from that perceived truth, once set, are sometimes ignored or regarded with skepticism, and struggle to be integrated or accepted. Sometimes this is a personal choice; the more recent *Jurassic Park* films dismiss their decidedly un-feathered dinosaurs with theatrical hand-waving about genetic recombination resulting in their dinosaurs' altered appearances. The simple reality is that scaly, alien beasts make for better horror movie fodder than something more akin to an oversized emu. But the perceptions of those who don't keep up with the latest and greatest paleontological research, as a result, can only be molded by what they see in the mainstream cinematic media. In this way, paleoart and creative license make for odd bedfellows. On one hand, paleoart in itself is entirely dependent on creative license; there are no more extant saber-toothed cats, mastodons, or pterosaurs that can be photographed and used as reference. The reconstructions of many extinct animals must be based solely on what little remains can be recovered, a bounty often as scant as mere fragments of skeletons. As such, analogies to living animals are imperative. Muscles, bones, limbs and tails may have changed size and shape over the millennia, but at their core, the bodies of vertebrates are essentially variations of the same tetrapod body plan that arose millions of years ago. A joint must still have arrangements of muscles that allow for its movement, an animal's stance and stature must be able to support its weight and allow its locomotion. Beyond this however, the artist's reconstruction relies on his or her imagination, and it is at this point that the science becomes an art. This is also where the art may abandon the science. Creative license in application to paleoart can be visionary at its best, and misguidedly fantastical at its worst. And yet, paleontology remains dependent on paleoart for the dissemination of its discoveries.

For example, even the least paleontologically inclined among us likely have an idea of what a saber-toothed cat like *Smilodon* looked like. In addition to the saturation of *Smilodon* in popular media, most people have seen at least photographs of big cats alive today. From there, imagining a slightly more primal version of a lion or tiger with unusually long canines takes little exercise of the imagination. But what of the lesser known creatures? What of *Gnathabelodon* or *Megacerops*? Aside from those already involved in the paleontological community, few would know how to imagine these animals without first resorting to an online search engine. Without paleoart, even the most well-read would struggle to match the names of extinct animals to much more than photographs of skeletal remains. Therefore, as someone with both a passion for paleontology and art, I decided to immerse myself in the world of painting the past.

The initial hurdle I faced when planning this project was the selection of exactly which subject or subjects I wanted my piece to portray. All around the world, rock layers have enlightened researchers to the millions of years of evolution that have shaped the biological world we live in today. Millions of iterations of ecosystems in countless locations make for an endless number of potential environments and organisms to study. However, instead of focusing on an exotic locale, or a subject that has been made commonplace in mainstream media, I wanted to focus on something a little less well-known. In the end, I decided to examine the rich paleontological history of my own state. Though that narrowed my choices geographically, in terms of time I still had millions of years of history from which to choose. Middle Tennessee is a hotbed for Ordovician fossils, with fragments of brachiopod shells, crinoids, and bryozoans inundating the pale gray limestone. To the west lies the Coon Creek Formation, where fossil remains from the Cretaceous range from the iridescent shells of bivalves and gastropods to the monstrous skeletons of mosasaurs, carnivorous marine reptiles that could grow to be larger than a school bus. Nashville's own hockey team, the Predators, is named for the *Smilodon* fossil uncovered by construction; their mascot is a rendition of the big cat itself. And, nestled in the mountains of East Tennessee, the Gray Fossil Site has revealed a plethora of remarkably well-preserved plants and animals from the Miocene.

As my goal was to construct an entire scene, I would need to choose a time period with enough fossil data with which I could work. This narrowed my choices to the main fossil sites and prolific fossil-producing time periods in Tennessee. The Coon Creek Formation and the Ordovician limestone of Middle Tennessee would provide me with significant amounts of fossil data on organisms, but underwater landscapes generally offer little in the way of scenery. This, in combination with the wide variety and remarkable quality of preservation seen in the fossils recovered at the Gray Fossil Site, made my choice clear. My reconstruction of Tennessee's history would focus on the Miocene.

THE GRAY FOSSIL SITE

The Miocene, the first epoch in the Neogene Period, spanned from approximately 23 to 5 million years ago (see Figure 1).

Eon	Era	Period		Epoch	Start Date (mya)
Phanerozoic	Cenozoic	Quaternary		Holocene	0.01
				Pleistocene	1.64
		Tertiary	Neogene	Pliocene	5.2
				Miocene	23.3
			Paleogene	Oligocene	35.4
				Eocene	56.5
				Paleocene	65

Figure 1. Location of the Miocene in the geologic time scale. Note that "mya" stands for "million years ago" (Carleton University, 2005).

It heralded warmer average global temperatures than the epochs preceding and following it, which in turn led to drier climates and the expansion of grasslands in the interior of the North American continent. These environmental changes led to the diversification of grassland-dwelling animals, grazing herbivores, and smaller mammals and birds. The eastern portions of Tennessee and forests surrounding the Appalachians, however, remained a relative refuge from the encroaching grasslands, providing a haven for forests and the animals that relied on them (Kunimatsu et al., 2007; Polly, 1994).

To the northwest, the Bering land bridge connected what are now Siberia and Alaska, allowing the exchange of plant and animal species between the Asian and North American continents. By the end of the Miocene, most modern plant families had evolved, and though the ancestors of modern humans had only recently diverged from the rest of the Great Apes, other organisms had evolved forms very similar to their modern-day descendants (Kunimatsu et al., 2007; Polly, 1994).

Discovered in May of 2000 during excavations for a road-widening project in Gray, Tennessee, the Gray Fossil Site was evidently located in one such forested location, and the discovery of both fossil pollen and other plant macrofossils have revealed it to have been a rather lush environment. The site, formed from the infilling of several closely associated sinkholes, was primarily dominated by *Quercus* (oak) and *Carya* (hickory) and as such displays a similarity to modern day oak-hickory forests, a species assemblage that in modern times is common in the Appalachian region. Supporting evidence for the forested environment surrounding the Gray Fossil Site can be found in the scarcity of equines, which were diversifying during the Miocene and spreading with the expansion of the grasslands, and the presence of forest-dwelling taxa such as tapirs, red pandas, and various amphibians (Ochoa et al., 2012; Worobiec, 2013).

In addition to red pandas, other taxa that today are found exclusively in East Asia, such as the plants *Sargentodoxa* and *Sinomenium*, were discovered at the site, suggesting extensive floral and faunal exchange between the two continents (Worobiec, 2013).

These East Asian influences were taken into account when assembling references for my final reconstruction.

Correspondence with several of the researchers who worked on the Gray Fossil Site, as well as a visit to the museum itself, allowed me to compile a working list of possible organisms to include in my final painting. Flora species ranged from trees and shrubs to grasses and climbing vines. However, some species are known from pollen alone and display little variation between even morphologically distant species. This conundrum is exemplified by the family *Poaceae* (grasses) (de Klerk and Joosten, 2007). Extant members of this family range from the grasses one would find comprising a suburban lawn to wheat, corn, barley, and even bamboo. As such, despite having sufficient information on the types of plants present at the time the Gray Fossil Site was deposited, I had to narrow my list down to only those species whose identities could be more accurately described. This meant focusing primarily on plant species with identified from macrofossil remains.

My research approach varied slightly when researching the fauna of the site. Remains discovered included mammals that ranged from the large browsing herbivores such as *Teloceras* to small arboreal squirrels and red pandas, birds, amphibians, and reptiles. As the information on the vertebrates of the site comes almost exclusively from their skeletal remains, I had much more information to study.

THE FLORA AND FAUNA OF MIOCENE TENNESSEE

The warm subtropical environment of Miocene Tennessee lent itself to an exciting array of artistic possibilities; a rich variety of landscapes converged in what would one day become this state, from the lush, mountainous forests of eastern Tennessee's slice of the Appalachians to the expansive grasslands that stretched to the west. As someone who grew up in Chattanooga's rolling green mountains, I was excited to paint a landscape that despite being separated from our environment today by millions of years, was remarkably familiar. This also meant that I would have plenty of references when designing the layout and composition of my final painting. I drew inspiration from the mountains around Chattanooga, as well as local state parks, photographs of oak-hickory forests from other states, and reconstructions already displayed at the Gray Fossil Site Museum.

My initial plan was to create my painting with acrylics on canvas, as it is a medium that not only am I familiar with, but among traditional painting mediums it is one of the more forgiving. Unlike oil paint, acrylics dry quickly and mistakes can be painted over with relative ease. Additionally, compared to other traditional art methods, acrylics are relatively inexpensive and readily available. My main expense would come from the purchase of the canvas, though unprepared canvases are less expensive than their primed counterparts, and I already possessed the supplies necessary to gesso a canvas in preparation for painting. My mother, a professional artist who critiqued my artwork as it progressed, is also familiar with the medium and, as such, would know best how to offer me pointers on my process.

However, taking into consideration the fact that I would be required to complete the majority of my final painting on campus, I realized the limitations imposed by utilizing a traditional medium. Transport of the in-progress work back and forth between my house and campus would not only pose an additional burden, it would also create the possibility for the painting to be damaged en route. As a result, I decided instead to utilize a digital medium for the painting. I was a little hesitant to make the switch from traditional to digital, as I have had only limited experience with the medium, but the advantages of easy transport and the ability to make multiple backup copies for safekeeping outweighed the hassle of overcoming the learning curve. I elected to use Adobe Photoshop, since I was already somewhat familiar with its functionality and it is a common program, so that transfer of my in-progress painting file between computers for continued work in multiple locations would be nearly seamless. I already possessed a Wacom Bamboo Fun drawing tablet, and with the installation of its drivers onto my home computers and a new laptop, I was capable of working on my painting regardless of location. With my method of painting decided, and the hardware and software I needed set up, I could begin work on researching the visual side of my project.

FLORA

The first step in painting my forest landscape was to study the organisms that dominate any forest scene: the plants. However, as this project was primarily an artistic endeavor, it was essential that I find a balance between variety and clutter. Too few plants, and the educational value of the painting is diminished. Too many, however, would not only create a cluttered foreground, making it difficult for viewers to distinguish specific species, but would also require a level of detail work that could end up exceeding what was feasible for this project. Therefore, I settled on what I hoped would be a compromise between the two: a small number of trees, shrubs, and small plants. By varying the sizes of species I intended to showcase, my hope was that viewers will have a much easier time picking out those identified species from the larger work.

TREES

Oak (*Quercus sp.*)

As the fossils discovered at the Gray Fossil Site indicate a primarily oak-hickory forest, I would be remiss not to include at least one of the two dominant species. Having photographed some well-preserved fossil oak leaves from the Gray Fossil Site museum (see Figure 2), I set about comparing them to modern oaks in an attempt to find species that were close enough to use as references.

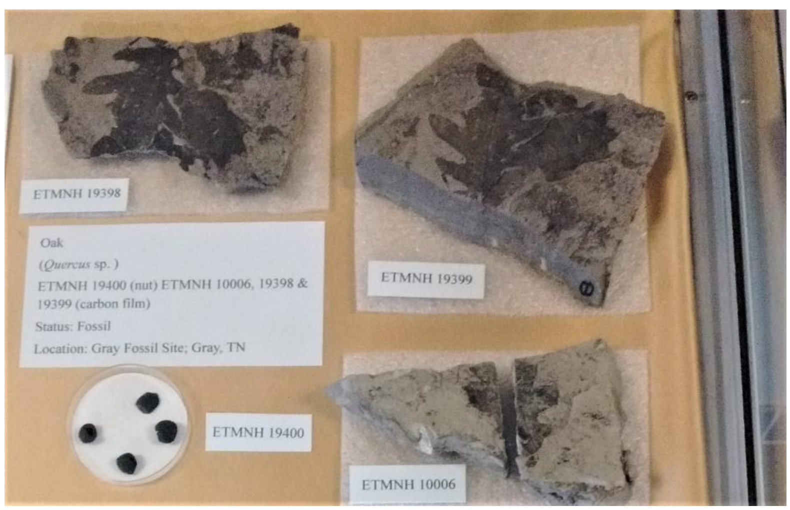

Figure 2. Oak (*Quercus sp.*) leaf fossils, photographed at Gray Fossil Site museum. These specimens appear to be created by carbonization, where the shape of the original material is preserved as a thin film of carbon on the rock.

Oak trees today are a successful group, with dozens of species and subspecies occurring in North America alone. Of these species, most can be divided into two main categories: red oaks and white oaks. Members of these two categories are distinguished from each other by the shape of their leaves, the texture of the inner shell of the acorn, the palatability of the nut flesh, and the color and texture of their bark (Mercker et al., n. d.). However, my information on the species of oak discovered at the Gray Fossil Site is limited to a) the geographic location of the site, b) the climate of the site at the time, and c) the shape of the leaves.

As the Gray Fossil Site is known for the presence of organisms that today are restricted to Southeast Asia, I began by compiling a list of extant Asian and North American oak species. Taking into account the climate of the site at the time, I narrowed my list down, excluding those species that today are restricted to more northern latitudes. At the same time, I began to make note of those species that prefer mountainous, temperate environments. Once I had a manageable list of species that live in similar environments as the fossil species would have experienced, I began comparing morphological traits.

It became immediately apparent from the shape of the leaves that the fossil species had belonged to the white oaks. Red oaks display leaves that end in sharp points, known as "bristle-tipped lobes," while white oaks display rounded lobes (Mercker et al., n. d.). This narrowed down my search considerably, and after examining modern white oaks that fit my other parameters, I found a strong match in *Quercus alba*, commonly known as the white oak, the species for which the group is named.

Combining my observations of the fossil *Quercus sp.* with the modern *Quercus alba*, I was able to create a small reference sheet for later use in my main painting, highlighting the features that would distinguish it from surrounding trees (bark texture, leaf shape, *etc*.) (see Figure 3).

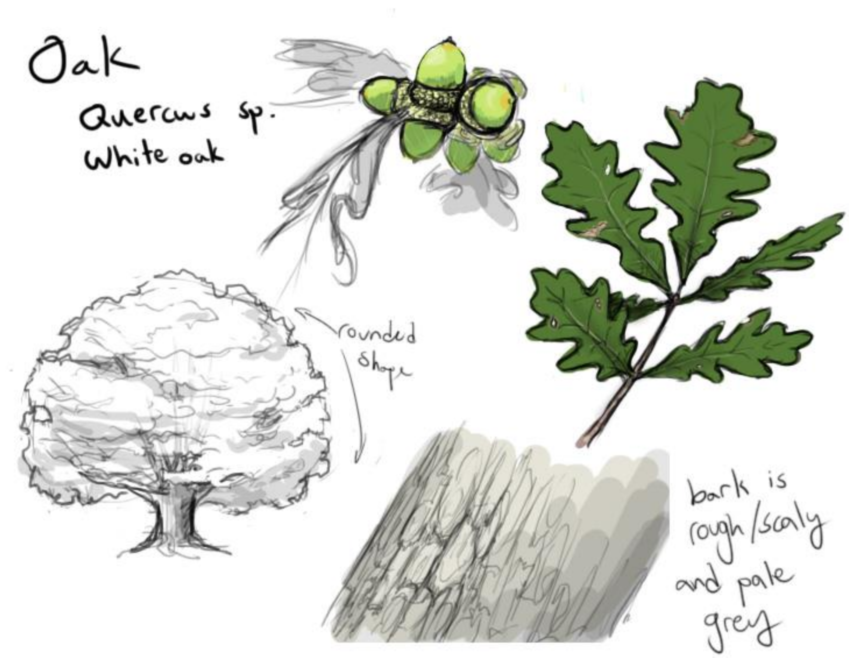

Figure 3. Detail study of bark, leaves, and acorns, and growth habit study. Bark, acorns, and growth habit are based on *Quercus alba*, while the leaf study combines the visible structures of the fossil *Quercus sp.* with observations of *Quercus alba* leaves.

Hickory (*Carya tennesseensis*)

The second eponymous member characteristic of Oak-Hickory forests proved more of a challenge. Unlike the fossil oaks discovered at the site, I could find no information on macrofossils (in the case of plants, this refers to leaves, bark, fruit, etc., as opposed to pollen) of *Carya tennesseensis* aside from preserved fruits. Additionally, morphological studies of those preserved fruits have determined them to be different enough from both known fossil and extant *Carya* species to warrant their description as a new species altogether; they are likely an ancestral *Carya* species from before the genus diversified and spread to its modern range (Huang et al., 2014). Without fossil leaves to compare to extant species, I was left with little to base my reconstruction on aside from extant *Carya* species. Morphological comparisons of *C. tennesseensis* nuts to extant hickories appear to show more similarities between *C. tennesseensis* nuts and nuts of Southeast Asian hickory species (Huang et al., 2014), though the most similar, *C. kweichowensis* and *C. hunanensis* appear poorly documented, and I could find no pictures of the two species.

Studying the features of *Carya* species from climates matching what would have been experienced during the Miocene, with attention in particular to North American and other Southeast Asian species, it soon became apparent that there exists little variation in appearance between various hickory species. Leaves of all observed species are elongated and elliptical, with finely toothed leaf margins and opposite arrangement. Bark varies to some extent, but with the exception of the local Shagbark Hickory, it is generally smooth or vertically furrowed and a light brown-grey, with a lattice-like pattern of growth. Observations were recorded in a detail sketch (see Figure 4 on the following page).

Figure 4. Detail sketch of *Carya sp.* displaying common features of hickory species.

Katsura (*Cercidiphyllites minimireticulatus*)[1] (*Cercidiphyllum sp.*)

The decision to include a katsura tree in my painting came about from my desire to highlight the East Asian influences present in the environment of the Gray Fossil Site. As the presence of *C. minimireticulatus* is known at the site from pollen instead of macrofossils, much like hickory, my reconstruction could not rely on observation of preserved leaves or bark, and would have to focus on extant katsuras. Unlike hickories, however, there are only two extant species of katsura on which to base my reconstruction, *Cercidiphyllum japonicum* and *Cercidiphyllum magnificum*. Their morphological

[1] *Cercidiphyllites minimireticulatus* is not the genus of the species itself, but in this case, a palynological designation. In other words, the *Cercidiphyllites* discovered at the site is a type of fossil pollen that would have been produced by a plant belonging to or very similar to a species in the genus *Cercidiphyllum*.

similarity further simplified the key characteristics needed to take into consideration for the reconstruction of *C. minimireticulatus*.

Both species of katsura display rounded to heart-shaped leaves with gently rounded serrations on the leaf margins. Leaves are arranged opposite on stems, and bark is medium grey, rough, and occasionally peels to reveal a reddish interior. Leaf color tends to be more yellow-green than blue-green, and fall foliage ranges from soft pink to red and orange. Growth habit can vary between cultivars, with some forms displaying weeping growth habits, where branches remain thinner, grow outwards, and droop downwards. Other cultivars display a stiffer, fan-shaped growth habit. Observations on both forms, as well as leaf and bark detail are recorded in Figure 5 on the following page.

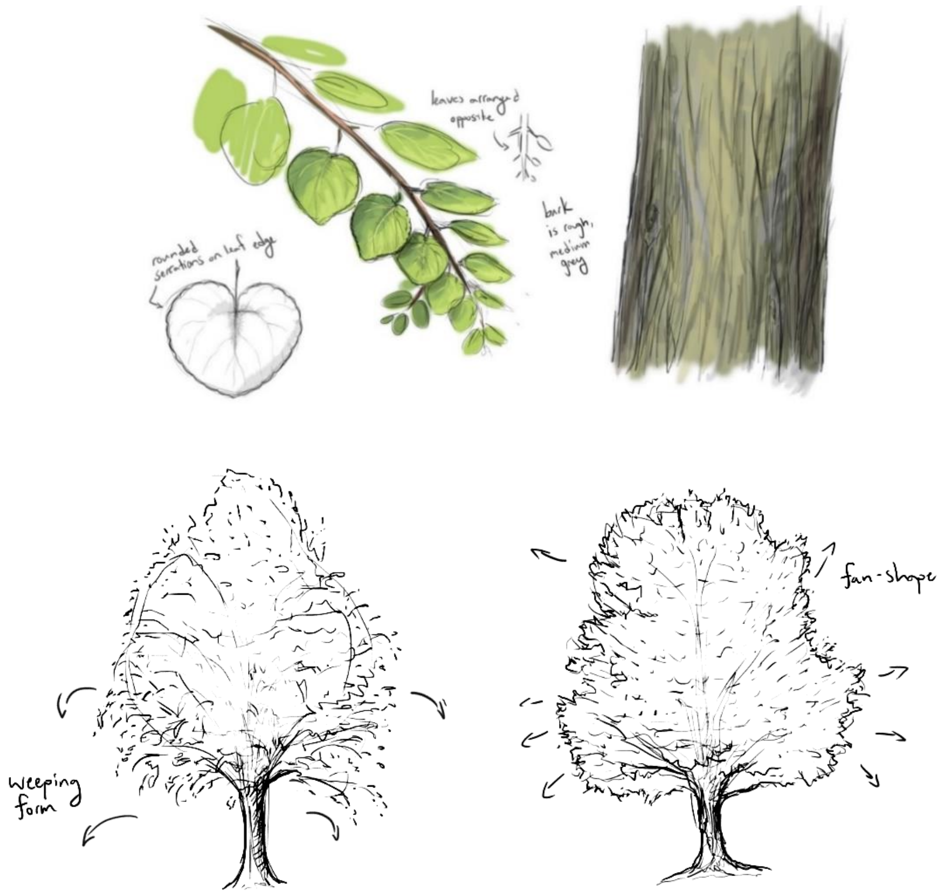

Figure 5. Leaf and bark detail (top) and growth habit study (bottom) of *Cercidiphyllum*.

Birch (*Trivestibulopollenites betuloides*) *(Betula sp.*)

Like the hickory and katsura, the most detailed classification provided by the palynology of this pollen is to place it in the genus *Betula*. Thus, like the preceding trees, it is likely the species is not extant, has undergone morphological change between the Miocene and present day, or that pollen of species in the genus is too similar to assign the fossil pollen to any one species with certainty. However, there are numerous extant species in the genus *Betula*, meaning that the appearance of *T. betuloides* can be based with relative confidence on inference from extant taxa, or represented as one of these extant taxa.

With the prevalence of East Asian species of both flora and fauna recovered from the Gray Fossil site, species examined in the reconstruction of *T. betuloides* could draw from both North American and East Asian taxa. However, as North America alone plays host to more than a dozen species of birch, and dozens more Asian species have been described, I decided to base the reconstruction's main attributes primarily on universal characteristics. These include pointed, oblong, alternate leaves with toothed margins; the presence of lenticels and "papery," thin, smooth bark (Encyclopedia Britannica, 2016; Jensen et al., 2003).

Birch species native to Tennessee today are by no means exact representatives of those found in Miocene Tennessee. However, as Tennessee's Miocene climate has been interpreted to be superficially similar to the modern subtropical climate, and the influence of the mountainous topography of eastern Tennessee remains similar as well, it is not unreasonable to draw from current species for the reconstruction of *T. betuloides*. Currently in Tennessee and the surrounding states, extant birch species include the Yellow Birch (*Betula alleghaniensis*), the Sweet Birch (*Betula lenta*), the River Birch (*Betula nigra*), and the Paper Birch (*Betula papyrifera*) (U.S. Department of Agriculture, n. d.). A few East Asian species include the Asian Black Birch (*Betula dahurica*), the Chinese Red Birch (*Betula albosinensis*), and Erman's Birch (*Betula ermanii*) (Flora of China, n. d.; McAllister, 2013; Oregon State University, 2015).

For my reconstruction of the birch tree, I followed approximately the same method as I used when narrowing down oak species. I mainly paid attention to species of birch that currently reside in moist, temperate to subtropical mountainous forests. As a result, my reconstruction is based primarily on *B. lenta*, the Sweet Birch. Details and growth habit are recorded below in Figure 6. The sketches I produced for *Betula sp.* are the only ones to have been completed traditionally, utilizing graphite on paper.

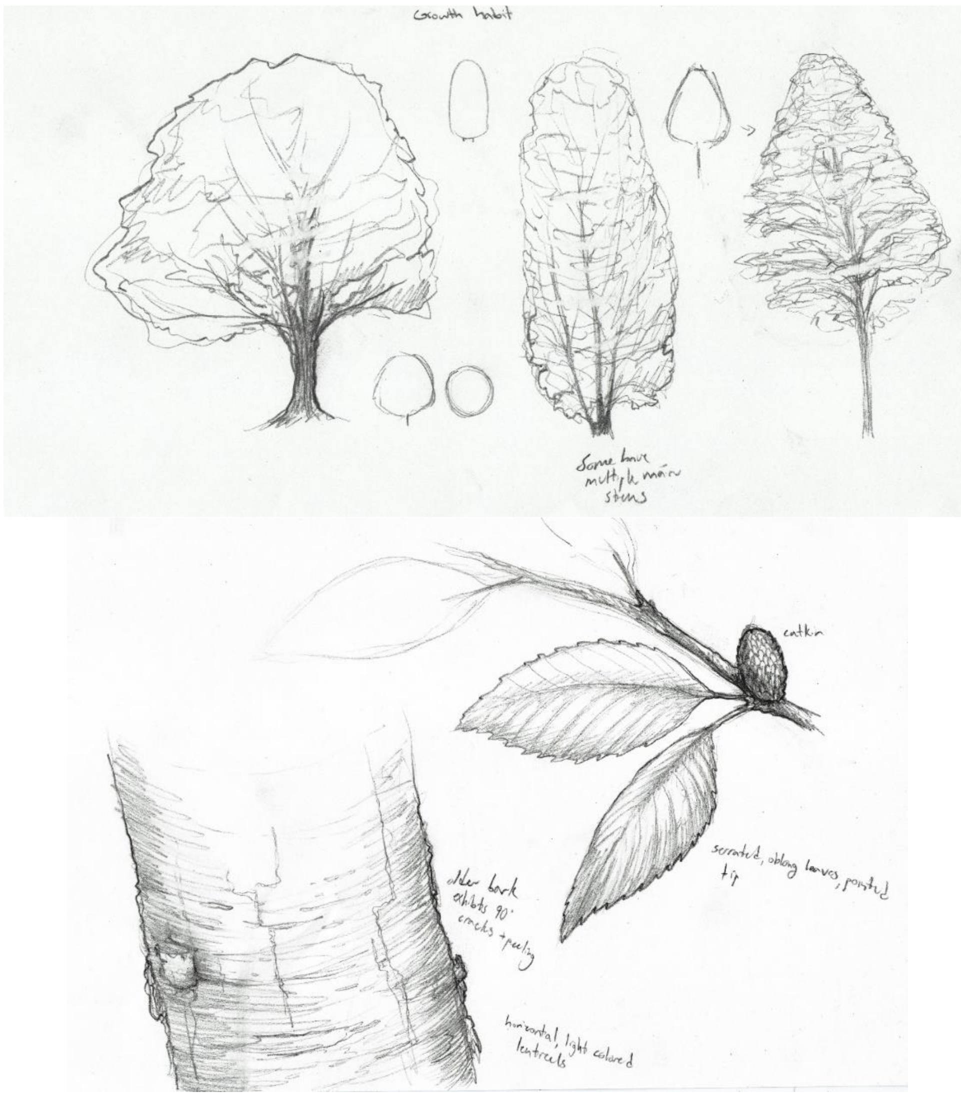

Figure 6. Growth habit (above) and bark and leaf detail (below) of *Betula lenta*.

SHRUBS AND OTHER SMALL PLANTS

Bladdernut (*Staphylea levisemia*)

Although there are several extant species of bladdernut, much like the katsura tree, extant species are very similar in morphology. This allowed for a sketch of their typical characteristics to be completed with relative ease. Additionally, macrofossil remains of *S. levisemia* have been recovered from the Gray Fossil Site. Unfortunately, the remains are restricted to seeds, as opposed to leaves, bark, or branch impressions. Still, this does allow for comparison to extant species in an attempt to find those most similar to the extinct *S. levisemia*. Analysis of these fossil seeds has indicated that, at least in terms of seeds, *S. levisemia* most closely resembles *S. bumalda*, the Japanese bladdernut (Huang et al., 2015).

Taking this into account, I primarily based my reconstruction on *S. bumalda*, with some observations coming from *S. trifolia*, a bladdernut native to eastern North America (see Figure 7 on the following page). Leaves are trifoliate compound, oblong, and toothed, with a blue-green tinge in some specimens. Flower clusters hang downwards and are pale pink- or yellow-white. Seedpods are papery, two-pronged, and contain several small, nut-like seeds.

Figure 7. Detail of *Staphylea*, including leaves, flowers, and growth habits at various levels of maturity.

Grapevine (*Vitis lanatoides*)

Species in the genus *Vitis* in modern times are distributed between two main regions of high diversity and abundance. Those two regions, interestingly enough, are North America and East Asia, calling to mind the East Asian influence on the taxa discovered at the Gray Fossil Site (Aradhya et al., 2013).

Evidence for the existence of these two regions of high *Vitis* diversity even during the Miocene is provided by the fossils recovered at the Gray Fossil Site from which three previously undescribed species of *Vitis* have been recovered: *V. lanatoides, V. grayensis,* and *V. latisulcata*. All three species have similar extant analogs, and as such I decided to spend my time researching *V. lanatoides* for its resemblance to the East Asian species *V.*

lanata (Gong et al., 2010). Details of the leaves, mature bark, fruit, and growth habits are summarized in Figure 8.

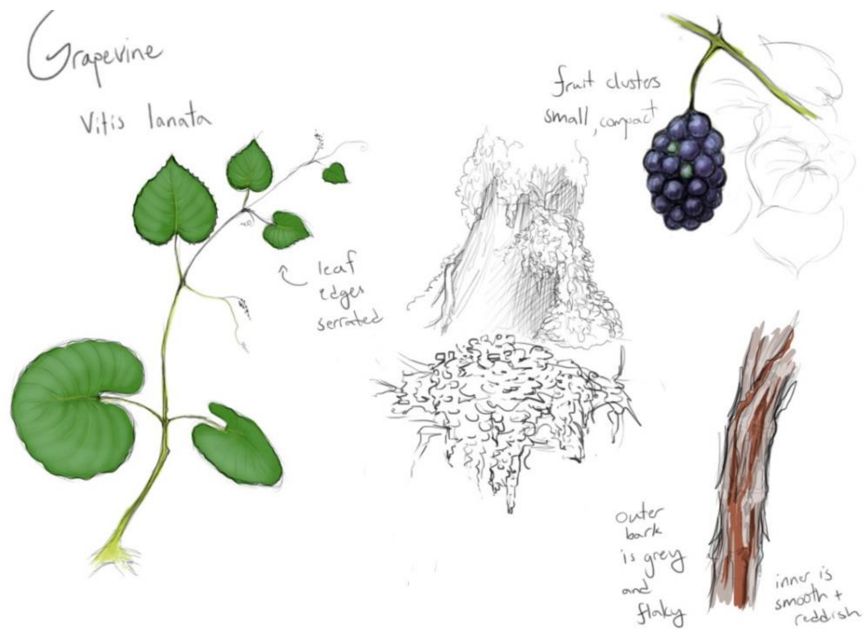

Figure 8. Detail sketch of *V. lanata*.

Polypod Fern (*Laevigatosporites sp.*) (*Polypodium sp.*)

The presence of a polypod fern at the Gray Fossil Site is known only from fossilized spores, and the unspecific nature of its description made the reconstruction of this plant one of the most initially daunting to research. "Polypod" can refer to any fern in the order Polypodiales, which by no means narrows down the list of possible candidates to base my reconstruction on, as the order contains more than 1,000 species (U.S. Department of Agriculture, n. d.). I therefore decided to take the type species approach, and began researching ferns in the genus *Polypodium.*

From there, I followed my method of narrowing down species based on geographic distribution and environmental preferences. This led me to two species, *Polypodium appalachianum* and *Polypodium virginianum*, both of which are very similar in morphology and can even produce a hybrid species, *P. incognitum*. Appearance and growth habit sketches are recorded below in Figure 9.

Figure 9. Leaf and growth habit sketch of *Polypodium appalachianum*.

FAUNA

When I first began planning for my painting, I envisioned a scene with animals of all sizes, ranging from small snakes, frogs, and birds to the largest mammals. However, as I began planning my composition and working on my reconstruction sketches, it became apparent I would have to sacrifice some of my planned biodiversity in the interest of both canvas space and time spent researching. The animals that made it into the final painting are detailed in this section.

Barn Owl (*Tyto sp.*)

The genus *Tyto* encompasses the barn owls, grass owls, sooty owls, and masked owls, and is nearly worldwide in its distribution. Owls in this genus are by no means morphologically identical, though they do share some defining characteristics. Species in *Tyto* possess a flat, generally light-colored, heart-shaped facial disc, a lack of ear tufts, lighter chest and abdominal plumage, a rim of darker feathers around their facial disc, and flecked or mottled brown, gray and white plumage on their backs and the upper sides of their wings (Lewis, 2015). A detail and color sketches are recorded in Figure 10.

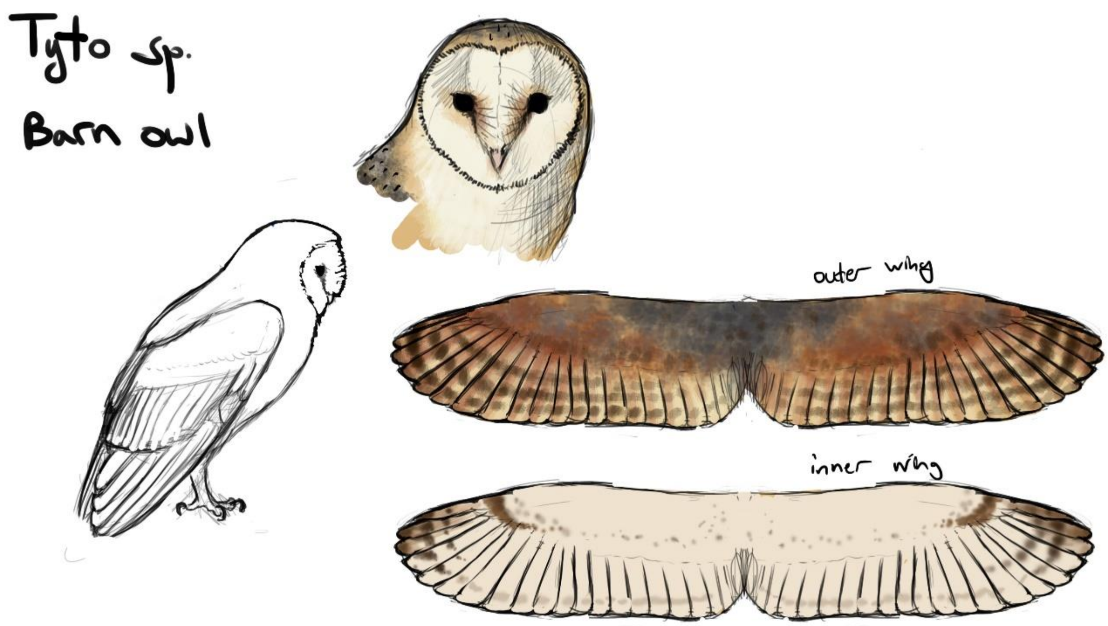

Figure 10. *Tyto sp.* profile, face, and inner and outer wing color sketch.

Bristol's Appalachian Panda (*Pristinailurus bristoli*)

Figure 11. Skeleton and body outline sketch of *P. bristoli*.

Bristol's Appalachian panda is one of the Gray Fossil Site's most well-known fossil discoveries. As such, finding adequate information on *P. bristoli* was much easier than with several of the other animal and plant species I included in my painting. The complete skeleton, or at least, a mold of it, is on display at the Gray Fossil Site Museum, allowing me a great visual reference when it came to reconstructing *P. bristoli.*

To begin my reconstruction, I examined several pictures of the panda skeleton, both ones I had taken myself and those I could find online. For those pieces of the skeleton that I could not see very well from the images, I found images of extant red panda skeletons. The sketch I produced of the complete skeleton is displayed above in Figure 11. To complete the outline sketch, I used pictures of extant red pandas and adapted the shapes of their fur and stance to the somewhat composite skeleton sketch I had rendered of *P. bristoli*. Compared to modern day red pandas, *P. bristoli* is larger, displays a slightly longer snout, body, and back legs.

Once the basic body shape of *P. bristoli* had been sketched, I needed to decide on a color scheme and markings. To paint *P. bristoli* with the same markings and coloration as the extant red panda, as has been done so many times before, I felt would be unchallenging, and unlike the other animal species I examined in my painting, there are not several extant species to compare for shared characteristics. Had there been another extant species of red panda aside from the modern day *Ailurus fulgens* in a geographically distant location that displayed identical or similar markings, I would have reconsidered. However, *P. bristoli* already possessed considerable skeletal differences from *A. fulgens*, and as such, may very well have possessed a color scheme far removed from today's red pandas.

For inspiration, I began by studying the colors and markings of other animals in the same superfamily, Musteloidea, particularly the most closely related: Mephitidae (skunks), Procyonidae (raccoons), and Mustelidae (weasels). Many species in these families display stark black or brown and white stripes or spots on their tails and faces, an underbelly that is darker than their back, and dark markings under or around the eyes. Since many species of animals possess darker colored markings under their eyes for help in reducing glare, and the trend is common among members of Musteloidea, I decided this would be a key characteristic to include in my reconstruction. Rings of darker and lighter fur around the tail and a darker underbelly were also common enough for me to consider significant. Based on these parameters, I composed several possible color sketches as seen in Figure 12 on the following page.

Figure 12. Color tests for *Pristinailurus bristoli*. Topmost color test is of the extant red panda, *Ailurus fulgens*. Final painting uses the color test second from the top.

Dwarf Tapir (*Tapirus polkensis*)

Much like the reconstruction of *P. bristoli*, I first started by studying pictures of skeletons I photographed at the Gray Fossil Site Museum. The museum actually has a very good skeleton on display, and as a result, I only needed to look at one reference to draw the entire skeleton.

After the skeleton sketch was completed, I studied numerous photographs of extant tapirs, particularly the smaller species, in order to complete the body outline (see Figure 13).

Figure 13. Skeleton and body outline sketch of *T. polkensis*.

After completing the body outline, I moved it to a separate file to create a color sketch, much like the color tests of *P. bristoli*. Unlike *P. bristoli,* however, there are several extant species of tapir I was able to compare to in order to reconstruct *T. polkensis.* Of them, the only species that deviated from a muted color scheme of solid dark brown to black was the Malayan tapir, the largest species. Juvenile coloration is almost identical amongst all extant tapir species. As such, I kept the juvenile coloration like that of modern tapirs, and decided on a dark brown color scheme with lighter face and underbelly markings similar to *Tapirus bairdii*. These sketches are shown in Figure 14 on the following page.

Figure 14. Juvenile and adult coloration sketches of *T. polkensis*.

Short-Faced Bear (*Plionarctos sp.*)

The short-faced bear was, similar to several of the plant reconstructions and *Tyto sp.*, difficult to reconstruct due to lack of accessible macrofossils. As the fossils discovered at the Gray Fossil Site are limited to fragments of the skull, most of my skeletal reconstruction of *Plionarctos* would have to come from the skeletons of extant bears. According to the exhibit at the Gray Fossil Site Museum, the *Plionarctos* at the site was smaller even than today's black bears, so I began to study skeletons of black bears and the most closely related bear to *Plionarctos*, the spectacled bear. Combining aspects of the fossil skull with the skeletal features of spectacled bears and American black bears, I was able to construct a possible sketch (see Figure 15 on the following page).

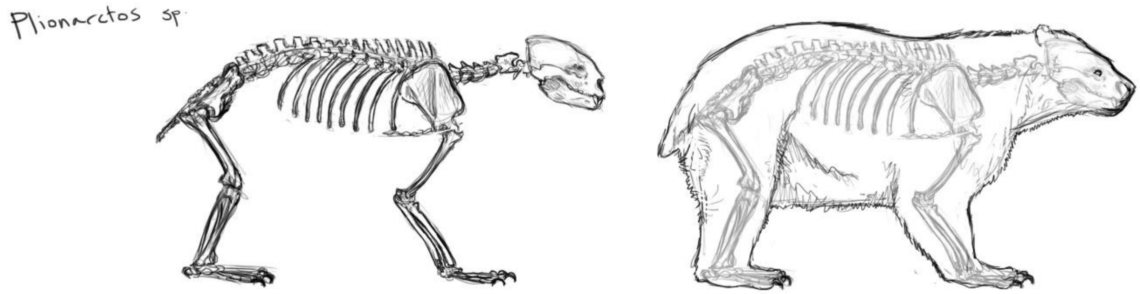

Figure 15. Skeletal reconstruction sketch of *Plionarctos.*

After I had sketched the skeleton and body outline, like the animals before, I began working on color tests (see Figure 16 on the following page). Aside from polar bears, whose colorations are specially adapted to their snowy habitats, most bears range from tan to dark brownish-black, with limited lighter chest and face markings. My final design combined aspects of the spectacled bear, Asiatic black bear, and American black bear.

Figure 16. Color tests for *Plionarctos*.

COMPOSITION

Researching the subjects of my painting was one of the most time-consuming aspects of completing this project. However, that in no way diminishes the importance of the other steps. After I had a good idea of the sizes, shapes, and colors of my subjects, I began to work on planning the composition. It was during this stage that I planned the best way to showcase each animal and plant in a way that both felt natural and allowed for a relatively unobstructed view of the organism. Too tightly clustered, and the balance of the painting would be off, leaving large sections with nothing to draw the viewer's eye. Too spread out, and the same issue would be encountered in the spaces between subjects. A well-balanced picture provides a number of well-spaced objects of interest, sections of the image where viewers' gaze can linger without feeling as though they have seen it all in one glance. As the goal of my painting was not to evoke an emotional response, unnerve, or create tension in the viewer, I strove to find a composition that encouraged the viewer's gaze to wander comfortably from place to place, creating a sense of calm.

There are many techniques to create the sense of balance and action in an image. My initial plan was to have a stream flow through the foreground, a line that would "guide" the viewer's eye from one side of the painting to the other. However, I also found that this did not give the painting very much depth (see Figure 17 on the following page). I then tried a scene where the viewer is given the sense of being in the forest, and looking outwards into a brighter clearing. This gave the painting more depth, but I decided that I did not like the rock outcrop and lake (see Figure 18 on the following page). Both iterations I tested with a shaded version, which allowed me to see the regions of the image that would be darkest. Due to the atmosphere, objects that are further from the viewer under a constant light source (the sun, in this case) are lighter than closer objects.

Figure 17. Initial composition sketch (left) and shaded version (right).

Figure 18. Second composition sketch (left) and the same sketch shaded (right).

I eventually decided to keep the depth provided by having the trees open into a clearing, but I substituted a stream and a small grassy area for the pond and rock formation I sketched in my second mock-up. After a few small tweaks to this basic layout, I created a quick colored version to get a better idea of how the final painting would look with that composition (see Figure 19). This would become my guide for making the final painting.

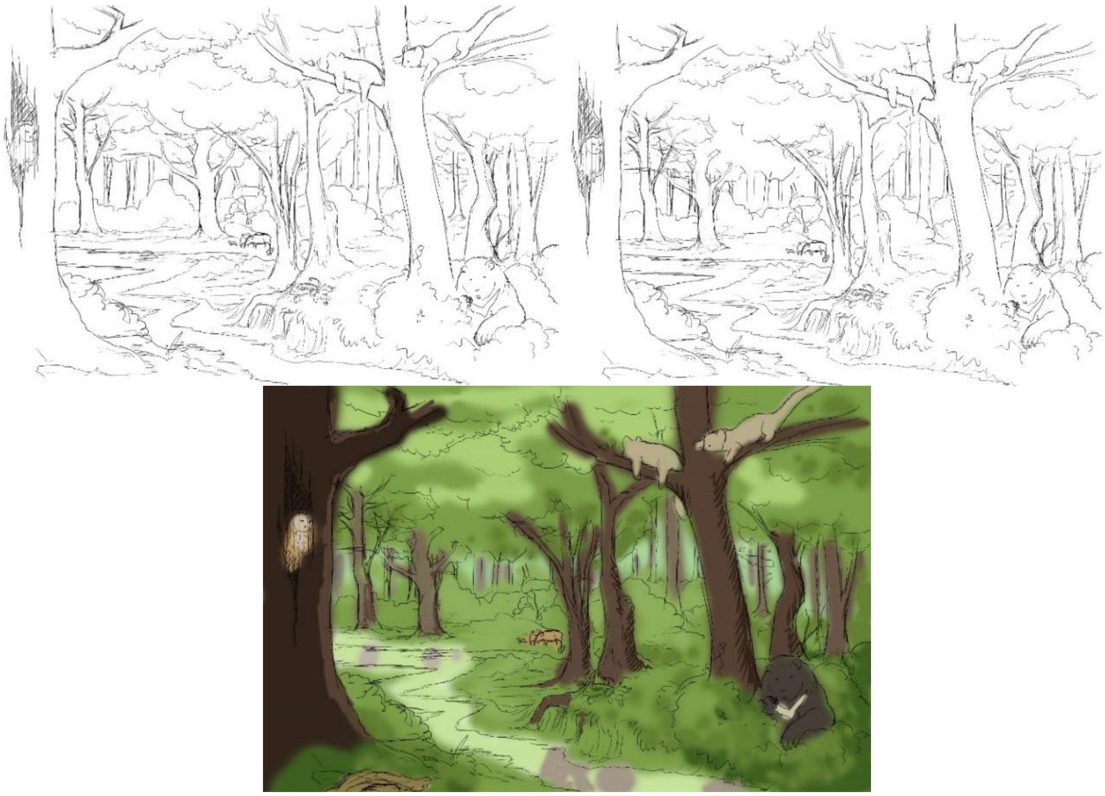

Figure 19. Third composition sketch (top left), minor tree placement edits to create balance (top right), and color test (bottom).

CREATING THE FINAL PAINTING

Once I had finalized my base sketch, I began work on the individual sketches. Each individual animal and plant sketch was created in a new layer, allowing me to keep them separate while the work was in progress. This precaution would ensure that in the case I made an error painting one section of the image, the background or any overlapping objects would remain unaffected, and mistakes could be cleanly corrected.

Once the new layer containing an animal or plant had been created and labeled, I began work on the polished sketch. Wherein the quick figures denoting their placement on the base sketch took less than a minute and were essentially there to give me a guideline for spacing and pose ideas, the polished sketch took longer. I did not spend as much time on the polished sketches as I would have if I wasn't going to paint over them, but I did spend a significant amount of time looking at references of extant animals and plants in order to get perspective and proportion correct.

After completing my sketch, I added a new layer underneath the sketch layer and created a clipping mask. This is a function that creates an area of the canvas that is bounded by the extent of a designated region – in other words, once a clipping mask is created, you don't have to worry about "coloring inside the lines." Once the clipping mask had been created, I painted the base color of the animal that I had decided upon from my previous color tests. Starting with basic highlights and shadows, I worked to make each figure look 3-dimensional. To do so, I used a relatively low opacity brush for this stage, building up colors to make the shading gradient smooth. Since my light source in this image is the sun, I made sure to shift the hue of my highlights towards yellow, to give the sense of warm, filtered sunlight. To give my shadows depth, I gave them a blue-green tint. Shifting the hues of highlights and shadows away from simply black and white gives images a more organic, rich appearance, which was my goal with this painting. Once the plant or animal's basic colors and lighting had been completed, details were painted on top. Figure 20 on the following page shows this process with the oak tree. Note the use of reference photos for texture and color.

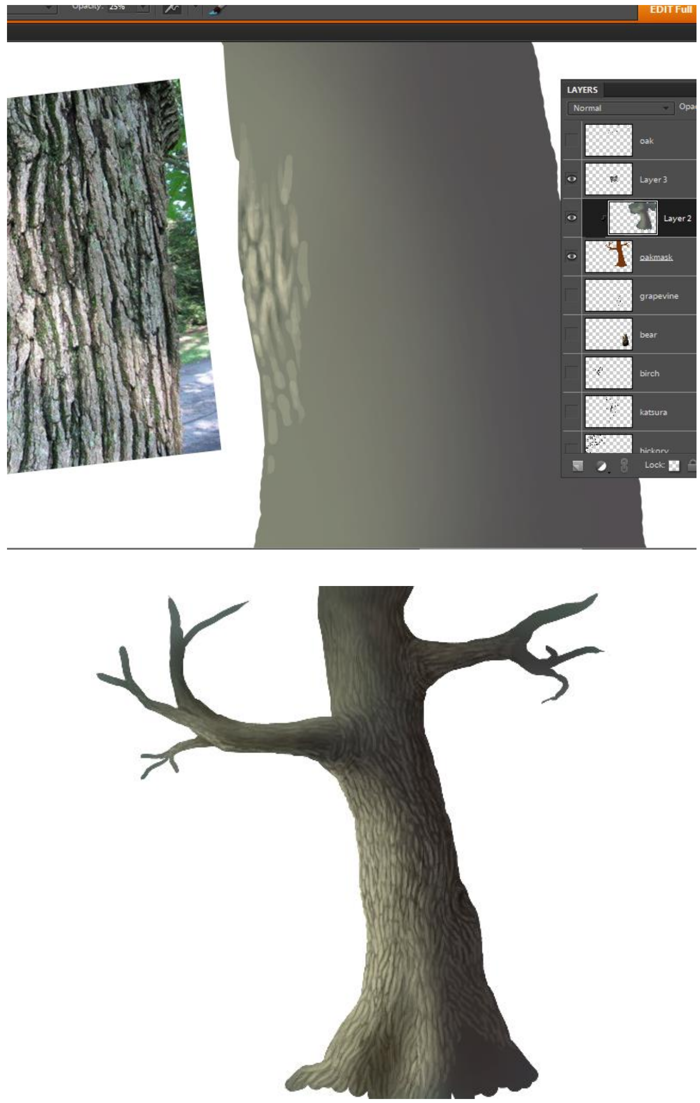

Figure 20. Process of painting *Quercus sp.* (oak tree), showing application of texture to initial shadow and highlight figure (left) and final bark texture (right).

When it came time to paint the foliage, I created what is called a "custom brush." This is done by drawing a shape that you will use as the "brush," and saving it to Photoshop's brushes. This can be used to create textures that look more like a traditional brush stroke, a watercolor effect, or the like. In my case, I needed to make a brush that I could use to paint my foliage. To do this, I drew the basic shape of the leaves of each plant and saved it as a separate brush (see Figure 21). This allowed a greater degree of texture to be applied to the foliage of the trees and bushes.

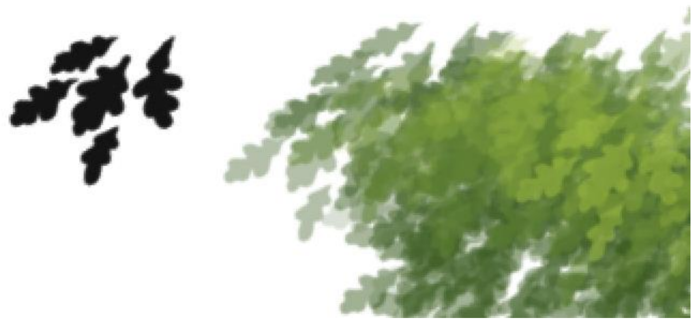

Figure 21. Oak brush (left, black shape) and example of its usage (right).

Figure 22 on the following page shows the steps in painting *Plionarctos*, from the polished sketch to the final painting. I knew that the lower half of the animal was going to be obscured by foliage, so most of the detail declines below the chest.

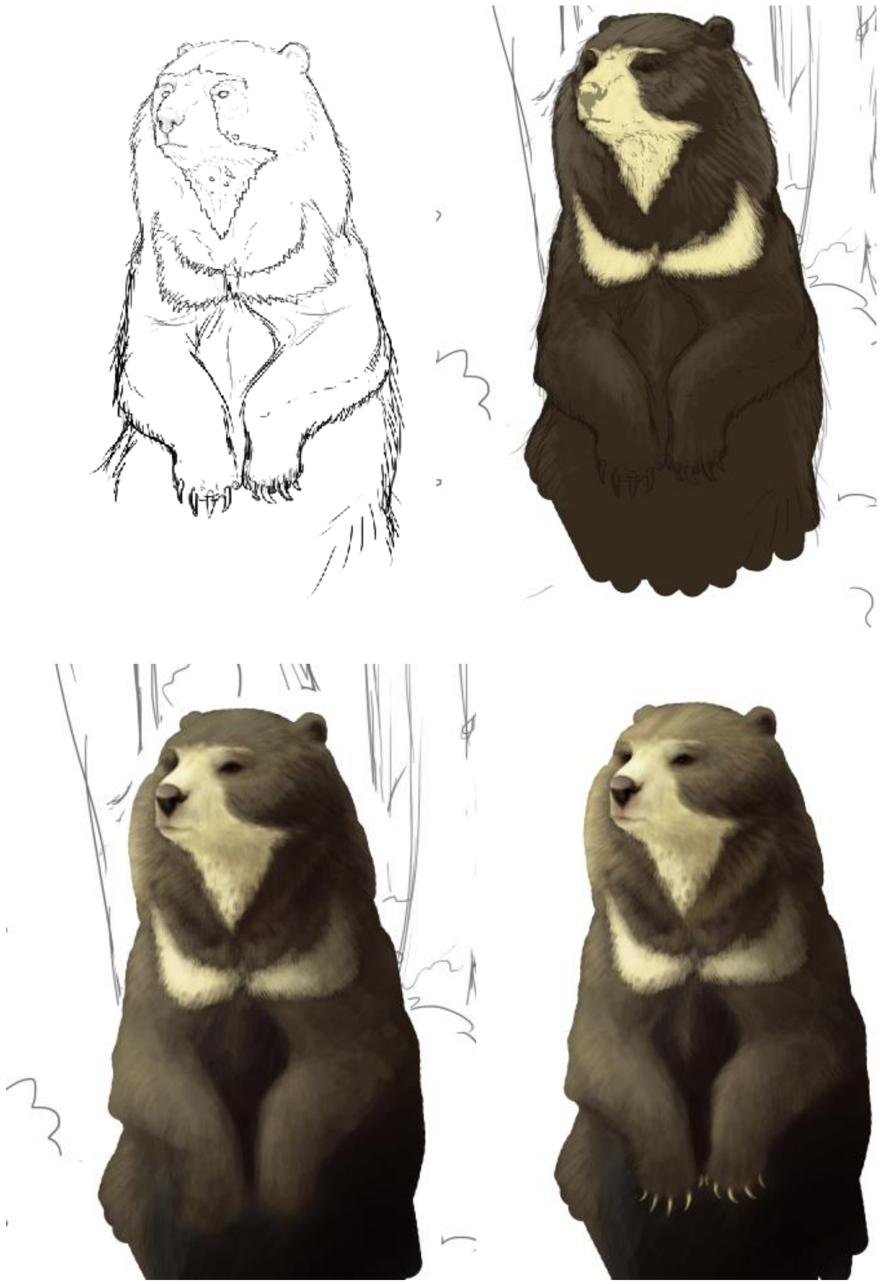

Figure 22. Progression of steps in painting *Plionarctos*, including polished sketch (top left), base color and beginning of highlights (top right), completion of majority of painting (bottom left), and final lighting and detail (bottom right).

Figure 23. Work in progress detail of *Plionarctos'*s nose and muzzle. Cheek fur in background shows basic highlights.

Figure 23 shows a work in progress close-up of the detail put into *Plionarctos* as I worked on painting its nose and face. Each animal and plant took between 2 and 6 hours to completely paint, from sketch to final touch-ups.

Once each individual specimen species was completely painted, I began work on the background and foreground landscape and foliage. This was done a bit differently than the individual specimen paintings. To create the background and foreground, I first painted large swaths of color: light blue-green for the area above the underbrush, shades of green for the underbrush, and shades of brown and green for the relatively exposed area of the clearing. The water started out as a pale turquoise where it would reflect the sky, with sections of dark brown and green where shadows and the reflections of plants would be seen. Detail was then added on top of this base color sketch in the same manner as the smaller details on plants and animals.

Finally, the lighting and a foreground layer were adjusted to give the entire painting a "soft" feel, to help the scene feel more sunlit and serene. A few small finishing touches were applied to various parts of the painting, and the final file was printed on canvas.

ANALYSIS

Going into this process as a primarily fantasy and pixel artist, I had never before painted a landscape or realistic animals and was quite daunted by the idea. The sheer amount of research and time spent on each facet of the painting has made this project, without a doubt, the most challenging artwork I have ever undertaken. However, I think it has also been one of the most rewarding. To attempt something that I had never attempted before, and complete it to a standard that I was afraid I would be unable to reach has been an incredible journey. As such, at least in the way of my emotional response to the project, I would consider it a success. During this process, I learned much about painting that I did not know before, both from hours spent researching techniques and from figuring out things by simply putting pen to paper. I have much more confidence now in both my ability to take on projects of this style and of this magnitude.

My other goal in creating this artwork was to produce a piece that was scientifically accurate. As there was only so far my individual research could take me, I also reached out to paleontologists and curators at the Gray Fossil Site Museum. They work every day with the fossils of animals and plants that I was restricted to reading articles about, and could offer insight into the accuracy of my portrayal of the flora and fauna of the time. Thankfully, the feedback I received was very positive, and none of the researchers who responded to my inquiry advised me of any inaccuracies in the painting.

It is through the work of paleoartists that the public may first learn about the world of the past. Without them, interest in researching our planet's fascinating history might have never become as prevalent, and it is my hope that, in some way, I have helped contribute to the world of paleoart.

At the start of this project, my main objective was to create a piece of artwork that would inspire my viewers to learn more about the prehistoric world. I want them to develop a sense of curiosity – a curiosity that will drive them to never stop learning and to share what they've learned with others. I hope that seeing a world that existed millions of years in the past and yet is so remarkably like our own will inspire them. Perhaps those who are inspired by the paleoart they see in books, movies, or paintings like my own will go on to make their own discoveries. And, when the fossils have been cleaned and the papers have been published, those discoveries will need someone to paint them.

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